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Royal Docks Infrastructure Study

ROYAL DOCKS AND CANNING TOWN
ENERGY INFRASTRUCTURE REPORT

RAMBOLL

ROYAL DOCKS AND CANNING TOWN

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EXECUTIVE SUMMARY

Ramboll Energy has been appointed as a sub consultant to WSP Ltd to deliver the energy workstream for the Royal Docks Infrastructure Study being commissioned by London Borough of Newham (LBN). The objectives of the study have been to:-

- Produce an Energy Master Plan (EMP) for an area-wide decentralised energy scheme for the Royal Docks and Canning Town area identifying major heat consumers, major existing and potential future heat suppliers (including Waste to Energy facilities) and the scope and extent of a district heating network.
- Establish an outline business case for the heat network and identify potential funding streams.
- Establish the associated carbon savings for the heat network.
- Identify key risks and opportunities.
- Identify a development programme and next steps.

The areas that have been included in the study comprise West Silvertown, Canning Town and Custom House, Royal Victoria, North Woolwich, Royal Albert and Royal Albert Basin. These areas collectively comprise the Royal Docks and Canning Town.

The scale and density of consented and planned development coming forward in the Royal Docks and Canning Town over the coming decades presents an opportunity to bring forward a strategic heat network extending across the Royal Docks and into Canning Town on the basis of heat captured from one or more major low carbon heat sources located within the Royal Docks. The strategic heat network could ultimately connect existing and new developments in West Silvertown, Canning Town and Custom House, Royal Victoria and Royal Albert and Royal Albert Basin.

The strategic heat network would form the critical link between the existing Olympic Park scheme (OPDES) and future opportunities to the east of the Royal Docks including developments that may emerge in the Sustainable Industries Park, the planned Biossence Facility in Havering and/or any future additional supply capacity that may come forward at Barking Power Station.

Heat Demand Assessment

The study has considered opportunities for supplying space heating and domestic hot water to major existing and future planned developments within the Royal Docks and into Canning Town, focusing on opportunities in the context of a strategic heat network. Development timescales to 2050 have been considered, using development growth projections provided by London Borough of Newham and Greater London Authority (GLA). These projections span a 10-15 year development timeframe, beyond which no further development has been modelled[1].

Diversified demand and consumption projections for the developments included in the study have been calculated. These are shown in Figure 1, Figure 2 and Figure 3 below, categorised by consumer type and by geographical location within the study area. The peak diversified demand at full build out has been calculated to be 60 MW. The annual consumption at full build out has been calculated to be 106 GWh.

[1] The study is based on the known development forecasts only. Heat mapping has not been carried out as part of the study. The heat mapping analysis being conducted by GLA has not been available at the time of carrying out the present study.

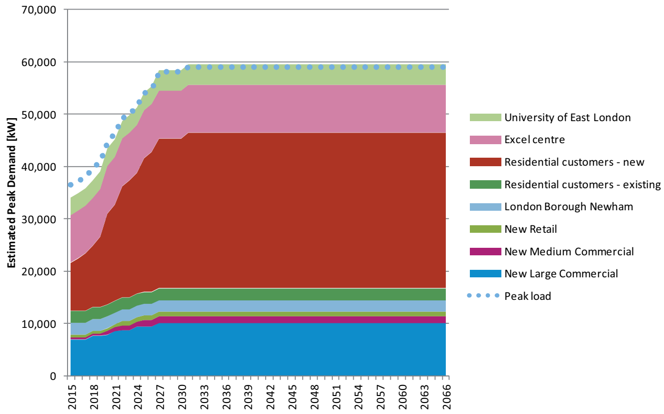

Figure 1: Space Heating and Domestic Hot Water Diversified Demand Growth Projections to 2050

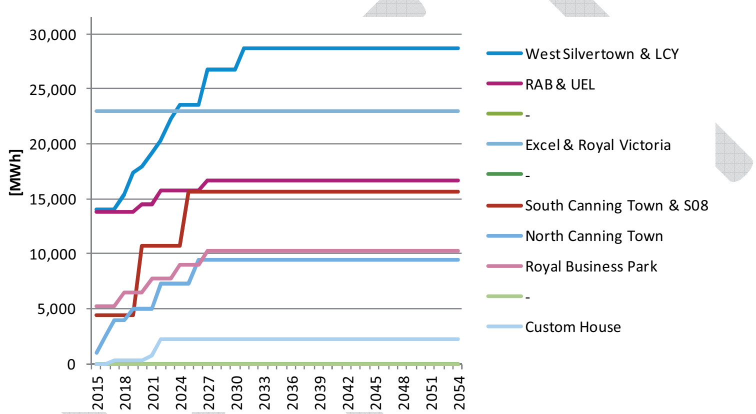

Figure 2: Space Heating and Domestic Hot Water Consumption Growth Projections to 2050

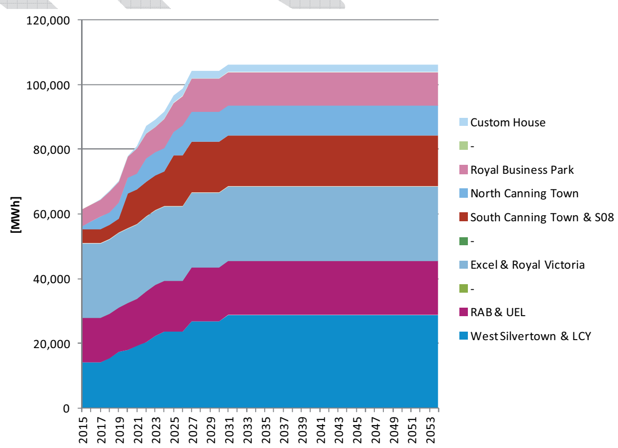

Figure 3: Space Heating and Domestic Hot Water Cumulative Consumption Growth Projections to 2050

Evaluation of Heat Production Opportunities

An assessment of existing, planned and potential future heat production assets within the Royal Docks and Canning Town has been carried out. The assessment has drawn on a combination of previous work commissioned by LDA, along with consultations with key stakeholders including Tate and Lyle, Thames Water, Excel and 2OC.

The major heat supply opportunities that have been identified as part of this study are Thames Water Sludge Power Generator (SPG) in Beckton, a waste to energy facility that could potentially come forward at the Beckton Waste Treatment Facility and the existing Tate & Lyle facility. The study has also identified less significant, incidental opportunities including the CHP plant at Excel, which could catalyze an early heat network growth opportunity as well as other Thames Water supply opportunities (the consented enhanced sludge treatment facility and the existing desalination facility) and the planned 2OC facility adjacent to the gas works, which would be unlikely to catalyse a heat network in their own right but which could potentially connect into a heat network established on the back of Thames Water SPG or a future waste to energy facility at Beckton Waste Treatment Facility.

Longer term heat supply opportunities involving industrial heat pumps have also been identified as potential opportunities in relation to a future heat network. These include Wood Wharf, Beckton Sewage treatment works and Tate & Lyle. It is noted that the GLA are currently investigating the feasibility of using heat pumps in connection with heat network opportunities in the Royal Docks.

The long term role for gas CHP as part of the strategic heat network is considered to be negligible.

Outline Business Case Assessment

Based on the work carried out in this study there appears be a reasonable business case around developing and operating a strategic heat network for the Royal Docks and Canning Town. This rests on the ability to integrate large scale generation facilities capable of delivering low cost, low carbon heat.

There is uncertainty around the long term future of the major heat production opportunities identified in this study. A strategic heat network opportunity has therefore been planned and sized on what are considered to be the most likely development scenarios. These assume that heat production assets would be centred around Beckton through the existing Thames Water SPG and/or a waste to energy plant that could potentially come forward at the Beckton Waste Treatment Facility. However, it is recognised that the Tate & Lyle facility clearly represents a existing major heat supply opportunity going forward and a safeguarding strategy has been adopted to allow this facility to play a role in the future, should a long term commercial future exist for the plant.

The strategic heat network has been sized on the basis of delivering baseload capacity from the waste to energy plant at Beckton Waste Treatment Facility or Thames Water SPG, with peaking capacity being provided at the new developments in Silvertown Quays and Thameside West[2].

The required investment in the strategic heat network would be between £33.0M (Beckton Waste Treatment Facility) and £34.4M (Thames Water SPG) in today's prices. This assumes a 25 year[3] project life and includes required investment in the heat network, connections to all indicated developments, connection to the baseload heat production facilities and provision of accumulators, peaking and back up plant within the network. The heat network would be built in discrete phases based on individual business cases being formed as new development opportunities come forward.

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[2] where energy centres will be developed in advance of the strategic heat network being constructed and would subsequently be adopted as part of the strategic heat network.

[3] with one reinvestment cycle

The business case assessment has been presented from the perspective of a Project Company that would own and operate the strategic heat network assets, contracting with one or more major heat suppliers to purchase heat and selling this heat to the indicated consumer base within the Royal Docks and Canning Town.

The business case has been assessed under the options that Thames Water SPG and a waste to energy plant at Beckton Waste Treatment Facility would form the basis of the strategic heat network. In each case, scheme IRRs have been calculated on the basis delivering heat to consumers at prevailing market prices and on the basis that heat would be purchased from the heat production facilities at their marginal cost of production, including the impact of forfeited electricity generation costs.

The prevailing market price for heat has been calculated to lie within the range 3.4 p/kWh and 5.7 p/kWh for the range of customers considered in the study. This reflects current and expected future heat generation costs under the business as usual alternative case to these customers and includes fuel costs, operations and maintenance costs and plant reinvestment costs over the life of the scheme. The cost of purchasing heat from the heat production facilities has been calculated on the basis of the forfeited cost of electricity production as well as the marginal operations and maintenance costs associated with extracting and delivering heat into the strategic heat network. Heat purchase costs have been calculated to be 2.0 p/kWh and 1.5 p/kWh for Thames Water SPG and Beckton Waste Treatment Facility respectively (rounded figures to the nearest 0.5 p/kWh).

The nature, governance and ownership structure of the Project Company has not been considered in any detail within this study. However, it is assumed that the Project Company would invest in connections to the heat production assets, strategic heat network assets, pipework and accumulators and connections to customers at development level. Ownership of the peaking plant that would be adopted under the proposed delivery strategy could be transferred to the Project Company or could remain with individual developments, with the Project Company operating them and paying for fuel and running costs only. It is noted that the heat production assets identified in this study are predominantly based around industrial heat sources. As such they represent a potential risk to the project (in terms of security and cost of heat supply) and would need to be integrated into the strategic heat network under well defined commercial arrangements and with adequate back up capacity to protect the Project Company from heat supply risk.

Under the scenario that Thames Water SPG provides the baseload capacity, the scheme could create a business that would yield IRRs of 5.77 % and 7.57 % over 25 and 40 operational years respectively based on selling heat at the current market rate and achieving a heat purchase price from Thames Water SPG of 2 p/kWh. At full build out of the scheme (at 25 years) annual revenues from the scheme would be expected to amount to £7.2M per annum, with an operating margin of £4.1M. The NPV for the scheme assuming a 6% discount factor would be £-0.9M. The NPV for the scheme assuming a 3.5% discount factor would be £10.9M.

Under the scenario that a 100,000 tpa Waste to Energy plant at Beckton Waste Treatment Facility provides the baseload capacity, the scheme could create a business that would yield IRRs of 6.88 % and 8.45 % over 25 years and 40 years respectively based on selling heat at the current market rate and achieving a heat purchase price from Beckton Waste Treatment Facility of 1.5 p/kWh. At full build out of the scheme (at 25 years) annual revenues from the scheme would be expected to amount to £7.2M per annum, with an operating margin of £4.20M. The NPV for the scheme assuming a 6% discount factor would be £3.2 M. The NPV for the scheme assuming a 3.5% discount factor would be £15.5M.

The business case for safeguarding for a wider area heat network needs to be explored to better understand the basis of the wider strategic opportunity that this might provide. London Borough of Newham should consider safeguarding for connecting the strategic heat network to the Olympic Park District Energy Scheme (OPDES) and to future opportunities to the east of the Royal Docks, with appropriate land allocation for interfacing connections / booster pumping stations at each end of the Royal Docks heat network. Further analysis will be required to verify the size and physical location of these interface stations, once clearer commercial proposals are in place. London Borough of Newham should engage with relevant stakeholders to pursue these opportunities.

Projected Energy Supply Capacity and CO_2 savings

Based on the analysis undertaken, the strategic heat network could ultimately deliver 106 GWh of heat per year at full build out, supplying the equivalent of around 29,250 Code Level 4 apartment dwellings[4].

Under the scenario that Thames Water SPG provides the baseload capacity, the scheme could save 14.5 kt of CO_2 per year at full build, relative to the business as usual case.

Under the scenario that a 100,000 tpa Waste to Energy plant at Beckton Waste Treatment Facility provides the baseload capacity, the scheme could save 5.7 kt of CO_2 per year at full build out, relative to the business as usual case. It is noted that a larger Waste to Energy facility would potentially increase CO_2 savings.

The projected CO_2 savings per year under the Thames Water SPG scenario represent 0.04% of London's projected energy supply emissions under the Business as Usual case by 2025 and around 0.45% of the committed CO_2 emissions reductions from Mayoral action by 2025[5].

London Borough of Newham's Role in the Project

The high investment costs and expected payback periods, together with uncertainty around securing a customer base for the scheme are likely to deter the private sector from investment in the early years.

London Borough of Newham potentially has a crucial role to play in bringing forward a heat network in the Royal Docks and Canning Town and needs to consider how it can further the development of the project by acting as guarantor or an equity investor in the project (which could be divested at a later stage, when the scheme has repaid its investment).

If London Borough of Newham wishes to take a proactive role in developing the project with the intention of securing a stake in the infrastructure assets, it should consider the following measures:-

- Go to the market for potential waste to energy providers for the Beckton Waste Treatment Facility site.
- Use its planning powers to require potential Waste to Energy providers to implement CHP and place a requirement on them to commit to connecting to the heat network as part of their planning approval.
- Conduct feasibility work to establish the appetite amongst major stakeholders such as Thames Water, Tate & Lyle to engage in the project and establish the commercial basis on which this could be achieved.
- Conduct further feasibility work to establish a customer base for the heat network, including engaging with the projects identified in this scheme as well as identifying further opportunities for connecting existing head loads not assessed so far under this study. Included in this, London Borough of Newham should identify and safeguard anchor loads within its ownership and control
- Examine its role in business planning for a heat network, developing a project steering group and engaging with heat customers to develop a business case on which to take the project forward.
- Use its planning powers to require individual developments constructed ahead of the heat network to safeguarded for future connection into the heat network.

[4] Based on average modelled energy usage for a Code 4 development comprising a mix of 1,2 and 3 bed apartments

[5] Based on "Delivering London's Energy Future. The Mayor's Climate Change Mitigation and Energy Strategy" October 2011, GLA

- Consider using Community Infrastructure Levy, S106 and Allowable Solutions mechanisms to raise contributions towards funding the heat network.
- Safeguarding locations for future peaking plants at the time when the heat network comes forward.
- Pursuing the case for interconnecting the heat network to OPDES.
- Taking a proactive role in de risking the heat network route through further feasibility assessment work.

It is noted that support is available from GLA under the Decentralised Energy Project Delivery Unit (DEPDU) programme for conducting further feasibility work and carrying out business case planning, which it is recommended that London Borough of Newham pursues if it wishes to take the scheme forward.

Alternatively London Borough of Newham may decide to adopt a limited role, leaving the market to bring forward the strategic opportunity. However, this approach risks failing to deliver the true scheme potential because of long term nature of the investment, the long payback time scales and the complex stakeholder engagement process that will be required.

If London Borough of Newham chooses not to progress the development of a strategic heat network now or in the future, then decentralised energy opportunities should continue on a site specific basis. London Borough of Newham should use its planning powers to ensure that this take place.

Summary of Delivery Opportunities

Based on the phasing of new developments identified in this study and the development timescales associated with establishing a heat off-take from Beckton SPG or a future waste to energy plant the Beckton Waste Management, a single heat network could potentially be constructed from Beckton to West Silvertown and Canning Town in a continuous phase.

The minimum total construction timescale for the heat network is expected to be between 1 and 2 years (excluding development and planning timescales) and 2017 is considered to be the earliest date at which heat could be provided to customers (based on a construction start date of 2015 and availability of heat from Thames Water SPG or Beckton Waste Treatment Facility in 2017).

However, construction of the heat network in a single phase would require significant capital outlay which is likely to be difficult to secure. London Borough of Newham might therefore wish to consider opportunities to progress initial cluster schemes in advance of the longer term heat network development in order act as catalysts for the wider development opportunity.

Based on the work carried out in this study, there appear to be two distinct network clusters that could form commercially viable project opportunities.

The first opportunity involves connection of London City Airport and the Tate & Lyle facility to the existing and new developments in West Silvertown. The investment required would be £6.6M and the scheme would achieve an IRR of 7.2% over 25 years. This assumes a heat purchase price of 2.7 p/kWh from Tate & Lyle, which reflects the cost of heat generation from this facility and assumes selling heat to customers at the prevailing market price. The NPV of the scheme would be £0.9M based on a 6% discount factor. However, it is noted that the uncertainty around the long term future of Tate & Lyle, makes this project unlikely to come forward before early 2016, the time by which the future of the plant will have been determined (end 2014) and construction of the heat network could have been completed. The case for developing the project at this time will also depend on whether the strategic opportunities at Thames Water SPG or Beckton Waste Treatment Facility come forward.

The second potential cluster opportunity is focused around the existing CHP plant at Excel, which is underutilised and could potentially become a catalyst for a local heat network in Royal Victoria. Initial modelling suggests that this could be a viable investment proposition, based on construction of a local heat network westwards towards Silvertown Way, picking up existing and new developments in the area. If taken forward, the network would need to be dimensioned for future back-feeding to Excel under the future strategic heat network scenario. The IRR for the investment would be 25% over 25 years based on selling heat to new medium sized commercial customers at the prevailing market price for heat. The NPV for the scheme would be £4.1M, based on a discount factor of 6%.

There appears to be no case for developing cluster networks in Canning Town, Royal Albert or Royal Albert Basin ahead of 2017, which is the date by which connection to Beckton SPG or a Waste to Energy facility is considered likely to be available.

Extension of the strategic heat network eastwards from Tate & Lyle does not appear to be viable based on the initial assessment carried out. Further feasibility assessment should be carried out once heat mapping results have been obtained.

Funding Opportunities

A combination of funding streams will be required due to the limitation of each singular funding stream in relation to the scale of investment required by the project and the timescales over which investment will be required.

London Borough of Newham needs to explore these funding opportunities further to minimise the need to inject its own capital reserves into the development opportunity.

London Borough of Newham should consider using borough-specific structures such as Community Infrastructure Levy (CIL) and S106 to support funding the project, both for establishing the Project Company and to help fund construction of the heat network.

CIL/S106 payments from plot developers can be expected to contribute only a limited amount towards the costs of the infrastructure. Consideration should therefore be given to using CIL funds both from within the Royal Docks and Canning Town and from elsewhere across Newham in order to maximise the funding opportunity. The basis of charging CIL payments will need to be established. For developments connecting to the heat network, this could reasonably be levied on the basis of avoided costs of meeting carbon compliance from alternative methods.

CIL/S106 could also be collected from other developments in the area, including potential waste to energy providers, whose contributions could also be used to help establish a Project Company and fund construction of the heat network.

Funding through the London Green Fund is considered to be unlikely, due to the limited fund remaining. However, the waste Urban Development Funds (UDF) could potentially support the development of a waste to energy plant and should be explored futher.

Access to funding through the Green Investment Bank is likely to require aggregation of the project with other projects due to the minimum size of loans it offers and its preference for larger projects. Whilst the GIB has a pool of around £750m to lend in the next financial year, the terms surrounding the loan are not yet guaranteed and the GIB's appetite for investment in this type of project remains unclear.

The government's proposed Allowable Solutions framework will require developers of zero carbon homes to meet on-site requirements for Carbon Compliance whilst also accounting for the carbon emissions that are not achievable on site through Allowable Solutions. Where approved Local authority policies are in place, developers will be able to pay into a local Community Energy Fund accordingly. In the absence of an established policy, developers will pay into Private Energy Fund without any geographical constraint over where the carbon-savings are realised. London Borough of Newham should therefore develop Allowable Solutions policies within its local plan in time for adoption by 2016 in order to be able to offer developers a local Community Energy Fund delivery route and thereby capture the benefit of Allowable solutions.

1. ANALYSIS

1.1 Background and Scope

Ramboll Energy has been appointed as a sub consultant to WSP to deliver the energy workstream for the Royal Docks Infrastructure Study being commissioned by London Borough of Newham (LBN). The project forms part of the wider Infrastructure study being carried out by WSP, who are carrying out studies into Waste, Transport, Drainage and Telecommunications infrastructure.

The objective of the energy workstream has been to:-

- Produce an Energy Master Plan (EMP) for an area-wide decentralised energy scheme for the Royal Docks and Canning Town area identifying major heat consumers, major existing and potential future heat suppliers (including Waste to Energy facilities) and the scope and extent of a district heating network.
- Establish an outline business case for the heat network and identify potential funding streams.
- Establish the associated carbon savings for the heat network.
- Identify key risks and opportunities.
- Identify a development programme and next steps.

Due to the present uncertainty around the long term future of the various heat production assets identified in this report, a strategic heat network has been planned and sized on what is considered to be the most likely development scenario. A phasing strategy that aims to minimise risk to the project has been developed and this has identified strategically highly significant elements of opportunity as well as less significant, incidental opportunities that represent opportunities to construct early network developments.

The scenario that has been developed assumes that heat production assets would be centred around Beckton through existing (and consented) Thames Water assets and/or a waste to energy plant that could potentially come forward at the Beckton Waste Management Facility.

However, it is recognised that the Tate & Lyle facility clearly represents a existing major heat supply opportunity going forward (although it is unclear at the present time for how long this will remain in commercial operation) and a safeguarding strategy has been adopted to allow this facility to play a role in the future, should a long term commercial future exist for the plant.

Other potential opportunities to supply low carbon heat have been identified but not safeguarded for at the present time within the heat network, These include possible waste to energy facilities that could potentially come forward at the safeguarded Thames Barrier Site or in lieu of the Covanta plant at the Tate & Lyle site and low grade waste heat recovery opportunities using industrial heat pumps that could come forward at Wood Wharf or at Beckton Sewage treatment works. The modelling uses the demand and consumption projections presented in Section **Error! Reference source not found.** of this report as the basis for development to 2050. Capacity beyond these projections has not been designed into the heat network.

The basis and assumptions for the investment appraisal are presented in Appendix 5.

The areas that have been included in the study comprise:-

- West Silvertown
- Canning Town and Custom House
- Royal Victoria
- Royal Albert
- Royal Albert Basin
- North Woolwich

These areas collectively represent the Royal Docks and Canning Town. Further details of the major existing and new developments within these areas are provided in [8] and [10].

2. PROJECT FEASIBILITY

2.1 Introduction

2.1.1 Systems Concept Outline

This study has considered opportunities for supplying space heating, domestic hot water, electricity and cooling to major existing and future planned developments within the Royal Docks.

The study has focused on opportunities in the context of an area wide heat network. Development timescales to 2050 have been considered, using development growth projections provided by London Borough of Newham and Greater London Authority (GLA) as detailed in subsequent sections of this chapter. These projections span a 10-15 year development timeframe, beyond which no further development has been identified. The study is based on the known development forecasts only.

The scope of opportunity to supply each form of energy to the buildings and developments considered in the report has been assessed. The baseline assumptions arising from this assessment have been used to take forward the design of the heat network. The basis in respect to energy demand on which the heat network has been developed is set out below.

2.1.2 Space Heating and Domestic Hot Water

All new mixed use (residential, retail commercial) developments will have their space heating and domestic hot water requirements through communal heat networks.

Purely large commercial led developments are likely to adopt alternative systems such as ground source heat pumps with top up gas boilers.

All new mixed use developments will safeguard to connect to a district scale heat network when it becomes available.

Existing developments that are economically and technically viable to connect to the district network will retrofit their existing heating systems at an appropriate time to enable them to connect to the heat network. Existing developments with insufficient heat loads or those that are too remote from the heat network to justify connection from an economic perspective will continue to have their space heating and domestic hot water requirement met through existing assets, with periodic plant upgrades and, in some cases through adoption of new LZC heating technologies such as micro CHP, mini chp, solar thermal, biomass heating or heat pumps.

2.1.3 Electricity

All new developments will have their electricity requirements met through extensions to the public electricity network. Existing developments will continue to be served through their existing connections to the public electricity network.

New developments with embedded generation such as CHP, mini CHP, micro CHP and solar PV[6] will export any excess energy not used within the development to the public electricity network (as applicable). This includes new mixed use residential developments with energy centres serving community heat networks.

2.1.4 Cooling

A district cooling network is not considered to be viable for the area, since there is inadequate cooling demand within the study area to provide sufficient return on investment. This is driven mainly by the predominantly residential nature of the developments coming forward and the large distances over which cooling would need to be provided. The low temperature differences over which a cooling network would need to operate would result in large diameter pipework with very high investment cost requirements.

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[6] As applicable

The alternative cooling strategies that are considered to be feasible for developments within the Royal Docks are identified below.

Cooling to new mixed use commercial, retail, offices will be provided through a combination of passive and active design measures. Active cooling would generally implement VRV air source or ground source heat pump systems with top up heating and cooling from gas boilers and dry air coolers respectively. Condenser water loops might be also adopted in some cases, particularly where cooling to new residential would be required. Low temperature loops[7] could potentially be adopted on a community scale to balance simultaneous heating and cooling loads between buildings requiring heating and those requiring cooling. This would allow a proportion of the total energy demand to be met through heat exchange before any need to inject energy from a heat network. Clearly the widespread integration of such systems could act as a barrier to heat network development, reducing heat demands seen by the network. The present modelling has not tested the impact of the widespread uptake of such systems. Further work would be required to establish this.

Cooling to existing developments will continue to be provided through existing technologies with upgrades to more efficient options in the future, when asset renewal is required. This might include adoption of absorption chillers through tri-generation, air or ground source heat pumps, or simply upgrading of chillers.

Cooling to commercial, retail and offices (new or existing) through absorption chillers is unlikely to be deployed at any scale across the study area. The proposed operating temperatures of the heat network in the cooling season[8] will require single effect chillers delivering poor COPs and there is unlikely to be insufficient cooling demand to justify higher network operating temperatures. The associated carbon savings will also be low. The modelling has assumed no provision of absorption cooling.

2.1.5 Heat Demand Assessment for Existing Consumers

Heat mapping has not been carried out as part of the study. The heat mapping analysis being conducted by GLA has not been available at the time of carrying out the present study.

An assessment of the major existing consumers within the study area that could potentially connect to the scheme has therefore been carried out based on previous work undertaken by GLA [12][23] and on a high level review of the area using tools such as OS maps, Google Earth etc. The following customer base has been included in the study:

- London City Airport
- University of East London
- London Excel Centre
- Newham Dockside

There are also a number of private non-municipally owned buildings within the study area that could potentially connect to the proposed heat network. These include:-

- existing developments to the west of Excel in the vicinity of Seagull Lane
- existing developments along University way to the eastern end of Royal Albert Way
- existing developments along Woodman St in North Woolwich
- existing developments at Wards Wharf and Pier Barrier Point road in West Silverton

London Borough of Newham, through its housing stock, schools and other municipally owned buildings has a considerable quantity of heat demand. There are likely to be opportunities to incorporate many of these buildings in the vicinity of the study area as part of any heat network coming forward locally. A list of the buildings of possible relevant has been provided by London Borough of Newham, taken from its NI185 database. Since these buildings have not been

[7] This would involve making use of very low temperature heat networks and enabling the use of very low grade heat (e.g heat rejection from air-conditioning). The system relies on the fact that different types of buildings (retail, residential, offices) often have demand for different types of thermal energy simultaneously. For example retail and office buildings may require cooling energy at the same time of year as residential buildings require energy for space heating and hot water. Each building would be equipped with a heat pump which either rejects or extracts heat to, or from, the low temperature loop, depending on its need for cooling or heating.

[8] when the bulk of the cooling demand is present

physically heat mapped at the time of writing this report, it has not been possible to identify and model these on an individual basis.

The decision to connect these buildings will ultimately depend on a number of factors including their annual heat consumption, the design of their internal heating systems, cost of connection to the heat network and the cost of distributing heat internally within each development. The viability of connecting these buildings has not been assessed as part of the present study as it has been beyond the scope of the present study to do so. Further work should be carried out to establish the technical and economic viability of connecting these buildings.

However, the following general observations are made:-

1. Electrically heated buildings may be viable to connect, although the high conversion costs and practicalities around conversion mean that further assessment would be required. The development cluster in Gallions 1, Royal Albert Basin is an example of such a building.

2. Social housing, town halls, libraries, schools, community centres etc with wet heating systems are likely to be viable to connect in many cases, depending on connection distances and costs. Existing heating systems will generally be designed on 82/71 ^{0}C or similar and will therefore be suboptimal for the heat network. These heating systems can potentially be modified to operate at lower temperatures under part load conditions in conjunction with a series of insulation measures to reduce heat losses as necessary. However, in the absence of any modifications, these buildings are likely to require heat at temperatures of around 90 ^{0}C in all conditions requiring them to operate above the proposed off peak condition of 80 ^{0}C. In addition internal circuits can potentially be modified to provide lower return temperatures to the network in part load conditions. The impact on the heat network of not doing so will be to increase operating costs and reduce network capacity. The scope for reducing delivery temperatures to these buildings therefore needs to be established as part of the further feasibility assessments carried out. Connections will generally need to take place at the time of refurbishment of internal plant and heating systems to make this economically viable. Avoided refurbishment costs should ideally be diverted into the costs of connecting to the heat network.

3. Individual existing residential housing is unlikely to be viable to connect due to their low linear heat density.

4. Recently constructed and existing older commercial, retail and offices may be viable to connect, depending on their location relative to the planned heat network. Assessment on a case by case basis will be required.

2.1.6 Heat Demand Assessment for Future Consumers and Development Opportunities

A heat demand assessment of the major consented and planned development opportunities within the study area has been carried out. This has drawn on information provided by London Borough of Newham [4] along with previous work commissioned by GLA [2].

In addition, relevant stakeholders have been consulted as appropriate to obtain latest information regarding particular developments and sites, for which London Borough of Newham has not had the relevant information.

Information has generally been provided in the form of development quantums or as kWh figures provided from previous studies. Phasing information has been provided to varying degrees of resolution. In the absence of detailed phasing information, linear construction phasing assumptions have been applied.

2.2 Total Heat Demand and Consumption Forecasts

A list of identified developments is provided in Appendix 1.

The key customer types of significance in the context of the heat network are those with significant and/or continuous heating or domestic hot water demands such as mixed use residential developments such as those in Canning Town, Silvertown Keys, Royal Albert Basin, due to the complementary heating and domestic hot water profiles that they provide. Similarly new hotels and the new leisure complex at UEL will provide large domestic hot water demands (as well as significant space heating demands), making them attractive to connect. Commercial developments such as the Royals Business Park, Siemens Pavilion etc will be less attractive to connect due to their modest heating and domestic hot water requirements, and feasibility work should be carried out to assess this on a case by case basis.

2.2.1 Results

The modelling carried out in this study has assumed that the developments as identified in Appendix 1 would connect to the heat network.

Diversified demand growth projections and consumption projections for space heating and domestic hot water are shown below. These include identified existing and new developments and are shown as a function of geographical location. Diversified demands as shown represent demands seen by the heat network at each connection point to the network. Also shown are cumulative consumption projections over the period and the average demand seen by the heat network at the location of the main heat production assets at full build out of the scheme. Averaging represents all days in a particular month for a particular hour.

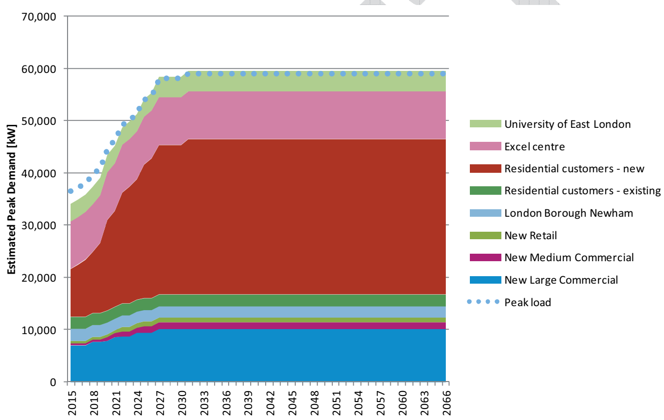

Figure 4: Space Heating and Domestic Hot Water Diversified Demand Growth Projections to 2050

Year	Diversified peak
	[kW]
2015	36,446
2016	37,243
2017	37,972
2018	39,608
2019	40,929
2020	44,641
2021	46,481
2022	49,177
2023	50,019
2024	51,655
2025	54,034
2026	54,941
2027	58,114
2028	58,114
2029	58,114
2030	58,114
2031	58,955

Table 1: Space Heating and Domestic Hot Water Diversified Demand Growth Projections

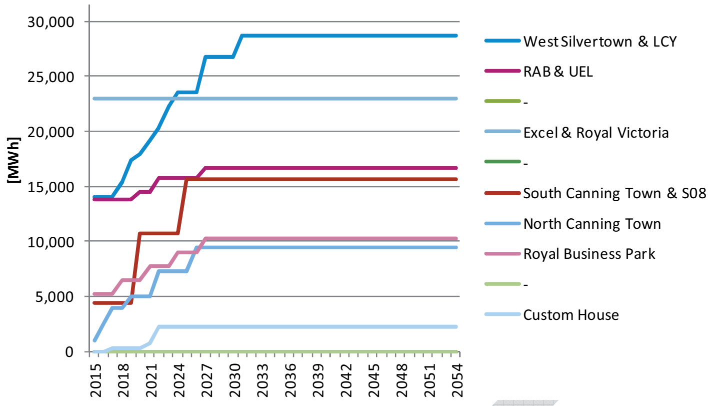

Figure 5: Space Heating and Domestic Hot Water Consumption Growth Projections to 2050

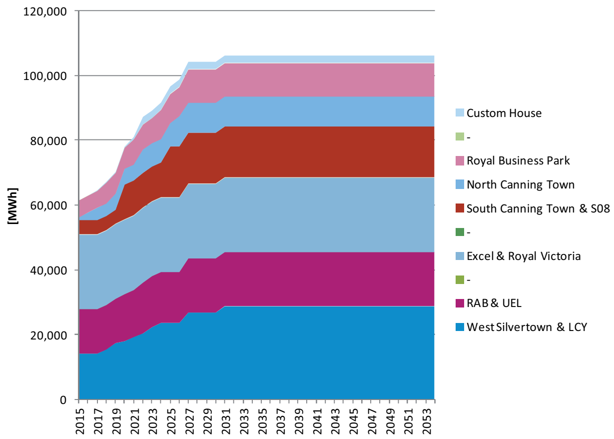

Figure 6: Space Heating and Domestic Hot Water Cumulative Consumption Growth Projections to 2050

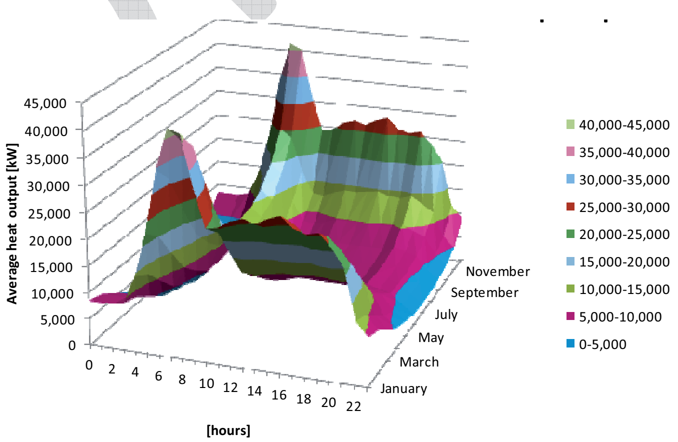

Figure 7: Averaqe Diversified Space Heating and Domestic Hot Water Demand seen by Heat Production Assets at full Scheme Build out

Year	Domestic Hot Water	Space Heating
	[kWh]	[kWh]
2015	20,780,124	40,741,929
2016	21,705,959	41,309,376
2017	23,205,720	41,494,740
2018	24,471,373	42,757,992
2019	27,191,584	43,094,198
2020	33,343,934	44,638,173
2021	35,028,993	45,953,262
2022	39,795,772	47,346,866
2023	41,527,853	47,560,943
2024	42,793,506	48,824,195
2025	46,721,170	49,819,935
2026	48,587,637	50,050,622
2027	51,776,891	52,294,032
2028	51,776,891	52,294,032
2029	51,776,891	52,294,032
2030	51,776,891	52,294,032
2031	53,508,973	52,508,110

Table 2: Space Heating and Domestic Hot Water Consumption Growth Projections

2.3 Heat Production Assets

An assessment of existing and planned heat production assets for the study area has been carried out. The assessment has drawn on a combination of previous work commissioned by GLA [2] along with consultations with identified key stakeholders for each heat production asset described below.

A description of the heat production assets is provided in the following sections.

It is noted that the heat production assets identified in this section of the report are predominantly based around industrial heat sources. As such they represent a potential risk to the project (in terms of security and cost of heat supply) and would need to be integrated into the scheme under well defined commercial arrangements and with adequate back up capacity to protect the Project Company from heat supply risk and heat price risk.

2.3.1 Existing Assets

2.3.1.1 Tate & Lyle, North Woolwich

The Tate & Lyle sugar factory has on site steam raising and power generation facilities to meet its sugar refining process requirements. Electricity is generated for use at the refinery through a 6.5 MWe gas turbine and through a 15 MWe steam turbine. Under normal operating conditions, the Tate & Lyle facility typically consumes the bulk of this capacity, only exporting between 2 MWe and 4 MWe to the grid at any given time.

Steam is currently generated at a 45 bar g, 375ºC in two Aalborg gas fired water tube boilers, each rated at 80 te/h, two twin-furnace biomass boiler units, each rated at 40 te/h of steam at 45 bar g and 375ºC and one boost fired heat recovery boiler, served by the exhaust gases from a gas turbine generator, which is rated to produce 12 te/h of steam when unfired and 65 te/h when fully fired. The biomass boilers are currently not operated for economic reasons.

High pressure steam is also supplied to the steam turbine for the generation of additional electricity.

Previous work carried out by LDA [12] has identified two main options for extracting heat from the plant:-

- Heat recovery by tapping process steam from the existing 3.5 bar g back pressure manifold and feeding it through a heat exchanger station to obtain DH water at between 110 and 80 ^{0}C.
- Heat recovery from the crystallisation pans[9] through via industrial heat pumps.

The site demand for steam is understood to be around 60 MJ/s. Based on the findings of previous LDA work [12], up to 10MJ/s of additional heat[10] could be made available by tapping process steam from the existing 3.5 bar g back pressure manifold serving the site. Since site operations are heat led and the steam turbine also operates in heat led mode, it has been assumed that heat extraction to the heat network would require supplementary firing of the HRSG in order to avoid a reduction in process steam available to the facility. The carbon burden of the heat extracted would therefore be equal to the carbon burden of natural gas factored by the efficiency of the HRSG, which is taken to be 95%. In the event that biomass boilers are fired to generate steam (as may be the case in future), carbon burden would be associated with that of biomass factored by the efficiency of the biomass boilers, which is taken to be 85%.

Extraction of heat from the steam turbine would require installation of new heat recovery infrastructure including a dedicated heat exchanger station with associated controls. Work carried out by LDA indicates costs in the region of £0.5M for these modifications (refer to [12]).

Based on the findings of previous LDA work (refer to [12]), further heat recovery from the sets of crystallisation pans could take place via two 5MJ/s heat pumps along with additional flash steam recovery, providing a further 2.7 MJ/s of heat. The associated development costs would be around £10.8M [12]. It has been assumed that the carbon burden associated heat recovery through the heat pumps would relate to electricity consumption with a COP of 4.

Although the Tate and Lyle plant has historically operated continuously at peak capacity, production since 2009 has been reduced to a downturn in the market and uncertainty over EU proposals in relation to sugar production quotas and sources. The plant currently operates at around 60 % of capacity, equivalent to around 4 days per week at full output.

Discussions with Tate & Lyle indicate that, whilst they continue to have an appetite for supplying heat into a heat network that may come forward in the Royal Docks, the plant's future is uncertain and will depend on determination of EU Legislation, which is expected in 2014.

For the purpose of this study, it has been assumed that heat recovery from process steam could be made available from 2015, if the outcome of the EU Legislation were to be positive. However, in view of ongoing uncertainty around the longer term commercial viability of the site additional heat recovery from heat pumps has not been considered further in this report.

2.3.1.2 Thames Water Sludge Power Generator (SPG) Facility - Beckton Sewage Treatment Works

Thames Water Utilities Ltd (Thames Water) operates a Sludge Power Generator Facility at the Beckton site. Electricity is recovered as part of this process through a steam turbine connected to an electrical generator with an electrical capacity of 12 MWe. The electrical output of this process is 9MWe with around 35% supplying the parasitic load to the process and 65% being delivered to the site to supply process loads that would otherwise require imported electricity. There is no electricity exporting from the facility to the public electricity network.

The output from the SPG facility is continuous, except for a three week annual shutdown in May for preventative maintenance. The long term operation of the facility is uncertain and dependent on approval and funding from Ofwat under the upcoming AMP6 investment programme for 2015 to 2020. This will be determined in 2014/2015 and would take place during the period from 2015 to 2020. Providing that the ongoing commercial viability of the operation can be assured, the

[9] which are boiled to produce water vapour at sub-atmospheric pressure, the condensation of which results in the rejection of substantial quantities of heat.

[10] MJ/s is a measure of thermal capacity and is equivalent to MWe in relation to electricity production.

facility is expected to receive approval and funding and can be expected to continue to operate at the site. For the purpose of this study, it has been assumed that heat could be made available by 2017.

The steam turbine is configured as an extraction turbine. Based on discussions with Thames Water, we understand that Thames Water currently bleed low pressure steam from the turbine in order to feed parasitic heat loads as part of the treatment process. Steam from the outlet of the turbine enters the condenser at approx 100 ^{0}C. This heat could potentially be recovered from the condensers (at a lower temperature) and supplied at around 90-95 ^{0}C for the majority of the year with boosting through supplementary firing in peak periods to achieve 110 ^{0}C in the peak condition.

Alternatively, heat could be extracted at low pressure from the turbine at the expense of electricity production. This could be used to boost the temperature of heat from the condenser in peak mode operation or to supply the site directly in extraction mode, which is what has been assumed for the present study. A third option could be to reconfigure the back end of the turbine to increase delivery temperature to the condenser. However this would result in a lower extraction efficiency, which would need to be compensated for financially over the operational life of the plant. Further work is required to analyse and evaluate the preferred option for extracting heat from the facility.

The facility currently co fires with around 10% input from natural gas. Thames Water are in the process of modifying the design of the facility to reduce co firing requirement, which is expected to be virtually zero by the time the facility could supply heat to the network. The carbon burden of the heat extracted from the plant is therefore taken to be zero.

The cost of installation of a heat exchanger station with associated controls has been estimated to be £1.25M.

2.3.1.3 Thames Water Desalination Plant - Beckton Sewage Treatment Works

Thames Water operate a desalination plant adjacent to Sludge Power Generation facility. This is powered by five 1.6 MWe biofuel generators which, under a S106 agreement with Newham Council, are required to deliver carbon neutral operation of the desalination facility over the operating life of the plant.

Based on discussions with Thames Water, we understand that the desalination plant is operated in standby mode for large periods during the year. In this mode of operation, an average of two of the five engines operate, offsetting the energy consumption of the facility and generating around 1,500 MWh/month. Typically one engine is run continuously with the second being brought on line as required to maintain an energy balance and as determined by the prevailing value of electricity. The desalination facility is called into full scale operation only during periods of excessive demand and when alternative supplies are inadequate. In this condition, all five generators operate generating around 8MWe from the facility.

Waste heat is not currently recovered from the facility, other than a small amount to pre heat the fuel in the storage tanks. The gensets are currently equipped with jacket heat recovery and associated pipework ready for future heat off-take. The engines could be converted to CHP (subject to further feasibility work being carried out) by recovering heat from the engine jacket, and from the exhaust systems (and intercoolers if fitted). This could potentially deliver up to 1800 MWh/month at a temperature of between 90 and 95 ^{0}C on the heat network side of the heat exchanger interface. In addition low grade heat from the remaining three gensets could be recovered when operating to support normal operation of the desalination of the plant. However this has not been modelled in the study, due to the uncertain and intermittent nature of the availability of this heat.

It is estimated that conversion of the engines to CHP mode would cost in the region of £120K per unit[11]. This would include for exhaust heat recovery and heat exchanger controls etc upto the point of connection of the heat network. In view of the operating regime of the facility, it is likely that it would be most cost effective to recover heat from only two of the five units, operating these as the lead units in standby mode. This has been assumed for the present study. Allowing for a further £150 K for pipework, pumps, power supplies, controls etc to interface to the heat network, a total cost of 390K has been estimated, excluding civils and structural works. Further work is required to verify this cost estimate.

The carbon burden of the heat extracted from the biofuel generators is taken to be zero, since this represents recovered waste heat without an associated penalty in electricity operation.

Discussions with Thames Water suggest an uncertain future for the biofuel generators, due to the poor economics of operation resulting from the high cost of biofuel and difficulties in sourcing ROCable fuel. Thames Water are currently trying to obtain accreditation under OFGEM in which case the long term future of the facility might be viable. However, they are also considering alternative strategies for powering the facility from carbon neutral sources, which could potentially include accepting renewable electricity from other renewable facilities located in the vicinity of the site. In this scenario, the biofuel generators would be retained for standby capacity only and it would not be worthwhile to recover heat from them for the few operating hours that they would operate under.

It has been assumed for the present study that heat would not be recovered from the biofuel generators due to their uncertain future.

2.3.1.4 Thames Water Enhanced Sludge Digestion Facility - Beckton Sewage Treatment Works

Thames Water has planning permission for an Enhanced Sludge Digestion Facility at their Beckton Sewage Treatment Works. This comprises new sludge treatment infrastructure, a Thermal Hydrolysis Plant (THP) a Sludge Cake Storage Building with associated plant as well as the refurbishment of existing digesters on site.

The proposed scheme will include an on-site anaerobic digestion facility producing biogas to feed three 1.4MWe CHP engines. Power from the engines will be used within the existing Thames Water site and heat from the CHP will be used on site to raise steam for the Thermal Hydrolysis Plant (THP) and to maintain the temperature within the digestion tanks.

Based on discussions with Thames Water, it is understood that high grade heat will not be available from the generator sets, since this will be recycled into the AD process. However, low grade heat could be recovered from the engine jackets at around 90-95 ^{0}C and made available for supply into the heat network. Based on continuous operation of the plant, the quantity of heat available from the engine jackets would be of the order of 2.4 MJ/s in normal operation.

It is estimated that conversion of the engines to CHP mode would cost in the region of £70K per unit[12]. This would include for jacket and exhaust heat recovery and heat exchanger controls etc upto the point of connection of the heat network. Allowing for a further £150 K for pipework, pumps, power supplies, controls etc to interface to the heat network, a total cost of £370 K has been estimated, excluding civils and structural works. Further work is required to verify this cost estimate.

The facility is due to be operational by 2014. The gas engines would operate continuously, except for maintenance down time. It has been assumed for the present study that heat recovery would be fitted to all three units at the time of conversion of Thames Water SPG.

The carbon burden of the heat extracted from the gas engines is taken to be zero, since this represents recovered waste heat without an associated penalty in electricity operation.

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[11] Based on consultation with major CHP supplier

[12] Based on consultation with major CHP supplier

2.3.1.5 Excel Centre – Gas Fired CHP

The Excel Exhibition centre is currently supplied from an energy centre consisting of a 1,350 kW gas fired CHP in conjunction with three 6 MJ/s gas boilers, two 2.5 MJ/s absorption chillers and an additional 3.9 MJ/s vapour compression chillers. In addition, two 3 MWe diesel generators are operated as backup generation.

Discussions with Excel indicate that the gas CHP is not currently operated for economic reasons and chilled water is generated through the absorpotion chillers by firing gas boilers, as opposed to the gas CHP. Excel are currently conducting feasibility analysis to establish options around replacing the existing CHP and potentially decentralising supply to the Excel Centre through three local plantrooms located around the site. The existing energy centre is understood to have surplus space availability to install additional plant and Excel would in principle be interested in exploring opportunities to connect into and supply a local heat network.

2.3.2 Potential Future Assets

2.3.2.1 Beckton Waste Treatment Facility EfW Plant

WSP has undertaken an evaluation of the waste and waste derived fuels that may be available for use by the Energy from Waste (EfW) plant. The work recommends that the most likely option for the development of an EfW facility within the Royal Docks is to develop an incineration or gasification plant with an annual processing capacity of 100,000 tonnes. It is also recommended that such a facility would operate on a merchant basis with a feedstock comprising a mixture of Commerical and Industrial (C&I) waste, Solid Recovered Fuel (SRF) and imported waste from other areas of London. We are unable to verify the waste arising and its availability and we therefore assume that the recommended merchant facility is reflective of the waste volumes that can be secured.

On this basis, the technology proposed for the facility is EfW using moving grate technology. EfW plants are widely used in the UK, Europe, USA, China and a number of other areas. Ramboll Energy does not recommend the alternative gasification based technology option identified in the study as a way forward for the project. Gasification plants are relatively unproven on municipal waste or waste derived fuels and in our view represent a risk in terms of bankability.

Using moving grate technology, a single process line can have a capacity of up to 300,000 tonnes per annum (tpa). Grate technology allows a range of calorific value waste fuels to be combusted. This can typically be a range of 7 to 12 MJ/kg for air cooled grates and 10 to 16 MJ/kg range for water cooled grates. The latter may be more appropriate for the C&I and SRF fuels that WSP has identified for the Beckton Waste Treatment Facility.

Ramboll Energy can confirm that a 100,000 tpa EfW plant based on moving grate technology firing a mixture of C&I waste, SRF and similar or municipal waste like fuels is technically viable. However a 100,000 tpa plant is at the smaller end of a processing line capacity and significant capital costs have to be covered by a smaller waste tonnage. It is noted that a plant at this scale may, in Ramboll Energy's experience, therefore struggle to achieve commercial viability.

It is expected that the facility would be configured as an extraction condensing turbine to allow operation in power only mode and to decouple the business case for bringing forward the facility from the ability to sell heat into the heat network and the uncertainty around future heat network coming forward. This configuration is flexible as it is optimised for electrical output but also capable of producing a certain amount of DH water when needed. The amount of steam which can be extracted for heating purposes depends on the design of the turbine. This solution offers by far the highest achievable electricity efficiency but it calls for a way of dissipating the excess heat (at a low temperature) from the process.

Various options exist for extracting useful heat from the process to deliver into a heat network. Heat could be taken at very low pressure (eg 1 bar) in order to minimise lost electricity production in heat extraction mode. This would deliver heat into the network at temperatures below 100 ^{0}C, and this would be adequate to supply the heat network for the majority of the year. Supplementary firing could be used to allow the network to operate at the design temperature of 110 ^{0}C during peak periods, which could be provided through gas boilers (additional to the back-up boilers located at the facility) or by blending steam extracted at higher pressure. Supplementary firing using gas would increase the carbon burden of the plant. Alternatively, heat could be extracted at higher pressures throughout the year (around 2 bar g). This would deliver heat at up to 110 ^{0}C throughout but would incur a greater loss in electrical production and therefore a higher economic penalty.

The modelling carried out in this report assumes heat off-take at 2 bar g. Further work would be required to establish the optimal heat off-take arrangement, both in carbon and lifecycle cost terms (additional CAPEX investment vs operational costs).

The calorific value of the fuel into the process has been taken to be 10 MJ/kg, consistent with a blend of C&I and SRF as identified in the WSP report.

On this basis, the available thermal output of 100,000 tpa facility would be 11 MJ/s.

The carbon burden of the heat extracted from the plant is taken to be the carbon burden of the electricity generated factored by the z factor of the turbine. The carbon burden of the electricity generated is set to the Carbon Intensity Floor (400 g/kWh) introduced into London's policy in November 2011 [16].

2.3.2.2 Future Merchant EfW Facility Opportunity

The Royal Docks is highly unlikely to support more than one energy from waste opportunity. However, in the event that a plant at the Beckton Waste Treatment facility does not come forward, an alternative facility could potentially come forward on another site in the Royal Docks.

The Mayor's Municipal Waste Strategy [16] indicates that there are over 10 million tpa of municipal and C&I waste arising in London. 1.8 million tpa of MSW is currently being land filled. The equivalent figure for C&I waste is not provided, but given the UK recycling achievements and incineration capacities a significant proportion of this waste is also likely to be land filled. With the need for London and the UK to move away from land filling and EfW plants offering a suitable and proven means to achieve this as an alternative, it is conceivable to assume that a merchant EfW plant may be realized in the Royal Docs area. This will be somewhat helped with encouragement and backing from London Borough of Newham and other bodies.

The Mayor's Municipal Waste Management Strategy					
	Waste Arising (2009/10)	Landfill	Incineration	Recycling and Composting	Other
MSW London (%)	100%	49%	21%	27%	3%
MSW London (tonne)	3,822,000	1,872,780	802,620	1,031,940	114,660
C&I London (%)				52%	
C&I London (tonne)	6,496,000			3,377,920	

Table 3: Municipal Waste Arisings

EfW plant developments are most likely to commercially succeed at the 300,000 to 500,000 tpa capacity. Larger plants will of course bring about more advantageous economies of scale, but these face additional challenges such as securing suitable sites, planning, the presence and development of infrastructure for logistics and securing the much higher volumes of fuel for bankability. Plants of up to 500,000 tpa can be implemented as twin line plants. Such developments will require a 3 ha site as a minimum with a river based fuel delivery system. An area of 4 to 5 ha or more will be required by road delivery based plants.

A twin line plant with a processing capacity of 400,000 tpa is considered to represent a suitable conceptual level plant for the purpose of the present study.

The design of the 400,000 tpa facility is taken to be equivalent to that for the 100,000 tpa facility. The available thermal output for the 400,000 tpa, would be around 48.9 MJ/s.

The carbon burden of the heat is taken to be as per the 100,000 tpa facility.

2.3.2.3 2OC Plant Gallions Reach, Beckton Gas Works

20c has planning permission to construct a power production facility at the site of the gas works in Beckton. Construction is expected to start in summer 2012 and the plant is due to be operational by early 2014.

The plant will extract energy from gas pressure reduction through a Turbo Expander coupled to a grid connected bioliquid generator. The gas pressure reduction process requires heat injection to pre heat the gas, prior to expansion to prevent freezing of the pipework at the reduced gas pressures following expansion.

Baseload electricity will be generated from the process by a low speed 2 stroke static compression ignition diesel engine powered by renewable bioliquid coupled to a generator set. This engine will simultaneously inject heat into the gas pressure reduction process. Waste heat from the process will be recovered from the exhaust stack and fed through an Organic Rankine Cycle plant to generate electricity. This electricity, together with the electricity generated by the bioliquid engine driven a generator will be sold to the grid or via private wire to a local customer within in the area.

Upto 1MJ/s of waste heat can potentially be recovered from the exhaust system of the bioliquid generator without incurring any loss of electricity production. The heat could be available to the heat network at temperatures between 80 ^{0}C -100 ^{0}C. Additional heat could potentially be recovered at the expense of generation of electricity from the Organic Rankine cycle plant. The heat available in this situation could be in the order of 5 MJ/s and would be available at comparable temperatures.

An additional 1 MJ/s of low grade heat is available downstream of the ORC heat exchanger as a bi product of the process. Lower grade heat from the condensing cycle of the ORC and the engine cooling circuits is also rejected via fan coolers. These heat streams would potentially be available at up to 70 ^{0}C but would vary in capacity during the year according to demand for gas preheating, which would be greatest in the winter months. The waste stream would therefore be mostly available for export in the spring and summer periods. Heat could potentially be extracted from this process and used in the heat network via heat pumps. However further feasibility work would be required to establish the economic and carbon case for this approach and this form of heat recovery does not form part of the current supply strategy for the scheme.

The plant will operate 24 hours per day with a 95% availability factor. As the heat is generated by a single engine, the supply would be either be fully available or not available, depending on outages. Expected plant downtime would be around one 8 hour per month preventative maintenance outage and a 1 week outage during summer period.

Estimated infrastructure costs for heat exchanger, pumps, valves, controls, bypass arrangement to allow variable heat off-take for the 1st MJ/s of heat is £500,000, based on information provided by 2OC.

The process is an OFGEM accredited renewable process. The carbon burden of the first 1 MJ/s heat extracted would be zero, since this represents recovered waste heat without an associated penalty in electricity operation. For the subsequent 5 MJ/s of heat extraction, there would be a carbon burden associated with forfeited electricity production from the ORC.

2.3.2.4 Covanta SRF Facility

Covanta Energy was planning to construct an SRF waste treatment facility adjacent to the Tate & Lyle sugar refinery as part of a bid under the NLWA waste contract. However, in late January 2012, Covanta announced its intention to suspend its bid and pull out of the bidding process.

On this basis, the Covanta facility is has not been considered further in this report.

2.3.2.5 Carlsberg Tetley West Silvertown – Proposed Gasification Facility

Quintain Estates and Development PLC have previously developed proposals for a large scale, waste wood gasification facility on the Carlsberg Tetley Wharf site. The proposed plant was intended to process around 150,000 tonnes of contaminated waste wood and generate around 25MW of electricity and 40 MJ/s of low grade steam heat. Consultation with Quintain indicates that this opportunity is no longer being progressed and indeed the site is now being developed with residential use in min. This opportunity has not been considered further.

2.3.3 Longer Term Opportunities from Industrial Heat Pumps

As grid decarbonisation occurs over the coming decades, industrial heat pumps can be expected to play an increasing role in delivering low carbon heat into the area. The technology has been applied elsewhere in Europe with considerable success (notably in many projects in Scandanavia see for example [30]).

Applications in the context of the Royal Docks could include heat recovery from sewage effluent at Thames Water Beckton and heat recovery from industrial processes including data centres and hotels coming forward in the area of Wood Wharf to the West of the Royal Docks. If captured economically, these quantities of heat could provide a vast contribution towards the annual heating (and potentially cooling) requirements in the Royal Docks.

The extent to which industrial heat pumps can play a role in future depends on:-

- their design and performance in relation to the prevailing heat network temperatures,
- the carbon burden and costs associated with their operation

Heat could potentially be extracted and distributed using low temperature networks carrying water at temperatures in the range 0-10°C and 10-25°C in the flow and return pipes. Whilst this would deliver heat with relatively high COPs, it would be deployable only at a scale allowing balanced cooling and heating demands, which is likely to be modest for the Royal Docks in view of building mix and based on current growth projections. Pumping energy and capital costs associated with developing low temperature networks at this scale would also be significantly higher due to low operating temperature differences.

Alternatively, heat could be extracted and delivered at temperatures appropriate to the temperatures defined in the draft District Energy Design Manual for London [31]. Recovery of this heat at these temperatures would incur a higher carbon burden due to lower achievable COP’s but, based on DECC’s projections for decarbonisation of the grid [27], could be considered to be comparable to heat produced through thermal waste treatment facilities meeting the Mayor’s current carbon intensity floor by around 2031.

The present study has not modelled heat recovery from heat pumps under the business case. However, the longer term opportunity is recognised and a strategic long term ambition to integrate the technology should be adopted at a time to coincide with decarbonisation of the grid.

Further work would be required to establish the economic case for developing a low temperature network in the Royal Docks. This is beyond the scope of the present study.

2.3.3.1 Thames Water – Heat Recovery from Sewage Treatment

Based on initial discussions with Thames Water, there appears to be considerable potential for heat recovery from treated effluent via industrial heat pumps[13]. Treated flows at Beckton are understood to average around 1,300,000 m^3/day with temperatures ranging from approx 12 ^{0}C in January to 20 ^{0}C in August. Assuming heat recovery through a temperature difference of 1 ^{0}C, around 60MJ/s of heat could potentially be recovered.

2.3.3.2 Wood Wharf - Heat Recovery from Commercial Waste Heat

A range of opportunities to recover heat from Wood Wharf to the west of the Royal Docks

British Waterways has reported a number of current and future possible cooling water discharges from such sources into the dock basins at the Royal Docks. Discussions with GLA suggest that between 1.5 MJ/s and 3 MJ/s of low grade heat is potentially recoverable from an existing hotel which currently rejects heat into the River Thames and that a further 3 MJ/s of heat is likely to become available from a data centre being planned at the Wharf. Based on work carried out by British Waterways, total thermal discharges could feasibly reach 35 MJ/s and possibly even 89 MJ/s over the longer term.

2.3.3.3 Small Scale gas fired CHP plants Operational, Consented Developments under Construction

A number of existing and planned gas fired CHP schemes have been identified within the study area. These are shown the table below.

Small Scale gas fired CHP Assets within Study Area	
Barrier Park ~ Operational 2011 under 25 year concession	185 kWe gas fired CHP 300 kJ/s Biomass Boiler 3 nr 1750 kW natural gas boilers
Canning Town Site 3 ~ Due to be operational 2012 under 25 year concession	185 kWe gas fired CHP 600 kW biomass boiler 3 nr natural gas boilers (size unknown)
Canning Town Site 7 ~ Phase 1 due to be operational in late 2014 under a 40 year concession. Phase 3, 4, 5 planned for 2015, 2016, 2018 respectively.	Phase 1 and 2 635 kWe natural gas CHP 2 nr 2,000kJ/s natural gas boilers 1 nr 3000kJ/s Auxiliary Gas Boiler Phase 3 635 kWe natural gas CHP 1368 kWe natural gas CHP 1 nr 2,000kW natural gas boiler 1 nr 3000kJ/s kW natural gas boiler 1 nr 7000kJ/s kW natural gas boiler Phase 4 and 5 635 kWe natural gas CHP 1368 kWe natural gas CHP 3 nr 7,000 kW natural gas boilers

Table 4: Small Scale gas fired CHP Assets within Study Area

[13] Thames water have looked at options for heat recovery for use on site in the past and have developed designs based on temperature differences of around 1 ^{0}C.

2.3.4 Summary of Heat Production Unit Capacity, Quantity, Grade and Availability of Main Heat Production Assets

A summary of the capacity, quantity of heat from the main heat production asset opportunities of relevance to the heat network opportunity are shown below. Refer to Appendix 4 for further information.

Summary of Supply Opportunities	Thermal Capacity [MJ/s]	Supply Capability [MWh/a] @ 10% Offtake	Maximum Supply Capability [MWh/a]	Date of Heat Availability	Forfeited ROCS	Cost of Heat [p/kWh] in today's prices	Carbon Burden of Heat kg/kWh
Tate & Lyle	10.0	7884	78,840	2015 (1)	[-]	2.72	0.208
Thames Water SPG	30.4	25094	250,940	2017	1.50	1.98	0.018
Thames Water Desalination Facility	3.9	2167	21,666	current	[-]	0.15	0.000
Thames Water Enhanced Digestion Facility	2.4	2035	20,352	2014	[-]	0.15	0.000
20C Plant	1.0	832	8,322	early 2014	[-]	0.15	0.000
Beckton Waste Treatment Facility	11.0	9154	91,542	unknown	0.50	1.36	0.056
Merchant W2E facility	48.9	40695	406,946	unknown	0.50	1.42	0.056
Excel	1.593	1326	13,257	current	[-]	4.70 0.14	0.129 in 2012, 0.385 in 2040

Table 5: Summary of Heat Production Assets

2.4 Heat Network Route Appraisal

2.4.1 Basis

An indicative route for the proposed Royal Docks heat network has been developed. This is based on a combination of previous work carried out by LDA for the Royal Docks [21] area and a preliminary assessment by Ramboll Energy of sections of the route not covered under the previous study. The heat network assessment has been carried out on the basis of a design in accordance with the design parameters set out the draft District Heating Manual for London being prepared by GLA[31] (due to be published in Final Version in March 2012). Refer to Section 6.1.6 for further information.

The heat network route has been developed on the basis of the full scheme build out. Refer to Section 4 for a description of the construction phasing.

A number of barriers / constraints may potentially affect the route proposals identified in this report. These include:-

- Existing utilities
- land ownership,
- archaeological inheritance
- traffic management
- nature conservation
- ground contamination

The layout in Appendix 3 assumes the preferred routes identified for the Royal Docks under the previous work carried out [21] and under the options appraisal presented in Appendix 2.

It is beyond the scope of this report to address these in any detail and further feasibility work is required to evaluate the route options in relation to these barriers.

2.4.2 Route within Royal Victoria, Royal Albert, Silvertown and North Woolwich

A high level assessment of the route to Royal Victoria, Royal Albert, Silvertown and North Woolwich has been carried out. Previous work carried out by LDA [21] highlights a number of route options through the Royal Docks and identifies major constraints/barriers to implementation. These are summarised in Appendix 2.

The proposed dock crossing along Connaught bridge might be very expensive to construct. A preferable solution might be to route the heat network through West Silvertown and back feed Royal Albert, Royal Victoria and Royal Albert Basin from Silvertown Way. This option may be particularly attractive if a merchant Waste to Energy facility is developed in West Silvertown, at the site of the safeguarded Wharf adjacent to Thameside West[14]. This present study assumes the proposed crossing along Connaught Bridge, but it is noted that a further evaluation of this option should be conducted at the next stage, once associated costs of traversing the dock have been established and once there is greater certainty around the heat production assets coming forward.

2.4.3 Route from Royal Docks to Canning Town and Customs House

A high level assessment of options for extending the heat network into Canning Town and Custom House has been carried out. A range of options have been identified. These are presented in Appendix 2.

2.4.4 Route from Royal Docks to Royal Albert Basin and North towards LTHGHN

A high level assessment of the route to Royal Albert Basin and north towards the potential heat production facilities at 20C and Thames Water has been carried out. Two options have been identified. These are presented in Appendix 2.

[14] It is noted that the section would need to be sized to supply the entire demand for the Royal Docks and Canning town over a greater distance than would be necessary if crossing the docks at Connaught Bridge.

2.4.5 Route Proposals used in this study

The report assumes the route identified in Appendix 3 and shown graphically below in Section 3 of this report.

2.5 Strategic Heat Network Network Hydraulic Concept

The operating concept of the strategic heat network is likely to be based on a variable flow, variable temperature design, in accordance with the design parameters set out the draft District Heating Manual for London being prepared by GLA[31].

The working pressure will be controlled within the system to ensure the pressure and flow characteristics are met at critical locations in the network at all times. This will be achieved through distribution pumps operating to maintain a minimum pressure difference between flow and return at each customer, controlling to maintain a minimum pressure difference across the index point of the circuit. This will guarantee the required flow of heat to customer substations and ensure that heat demand is met at all times.

In addition to volume control, heat network delivery temperature will also be controlled on the basis of ambient temperature in order to minimise heat losses throughout the year and maximise capacity and lowest investment cost. The delivery temperature from heat production units into the heat network will be controlled through local mixing circuits at the heat production plants. The primary flow temperate into the heat network will be controlled between[15] 80 °C and 95 °C when outdoor temperature exceeds +5°C. The primary flow temperate will then be increased to a maximum of 110 °C when the outdoor temperature reaches the design temperature of -5°C.

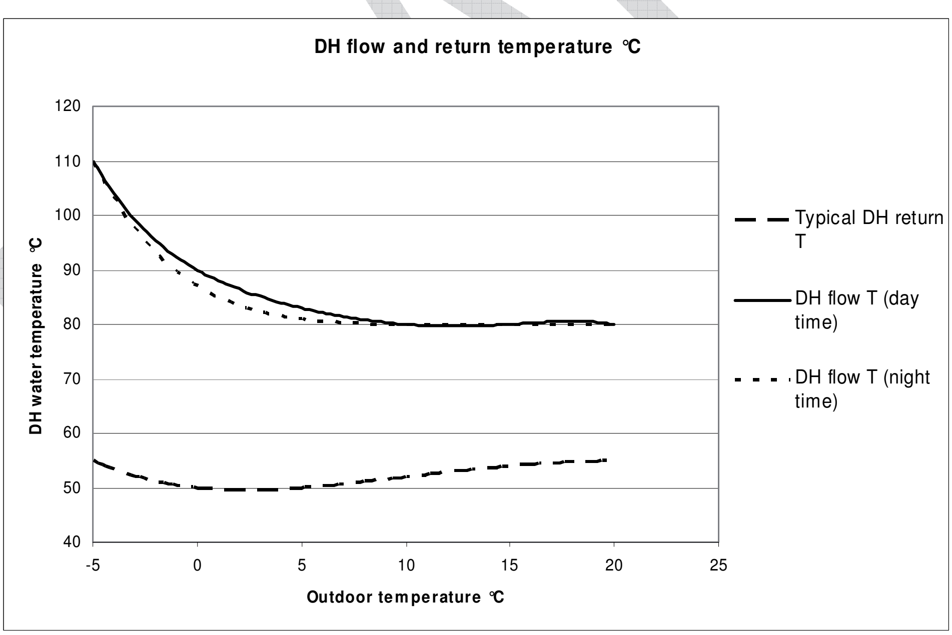


Figure 8: Typical Flow and Return Temperature Characteristics (image courtesy LDA/GLA)

The heat network will be pressurised at a single point. This should be located at the primary substation within the heat network, which will need to be determined once heat production assets have been committed to the scheme. The primary substation should also house the primary distribution pumps, water treatment and pressurisation and expansion systems for the heat network. In Ramboll Energy's view, the static pressure in the heat network should be maintained at the mid-point between the flow and return lines as illustrated below. This will facilitate the

[15] dependent on requirements of existing buildings connected to the heat network.

connection and control of multiple heat production units to the heat network. Heat accumulators will typically be located at the main heat production units. In Ramboll Energy's view, additional water treatment, pressurisation and expansion systems should be provided at a second heat production unit for redundancy purposes.

Heat flow into customer substations will be controlled by 2-port control motorised valves so that customers can take all the heat they need at any moment in time.

The concept is illustrated in the figure below.

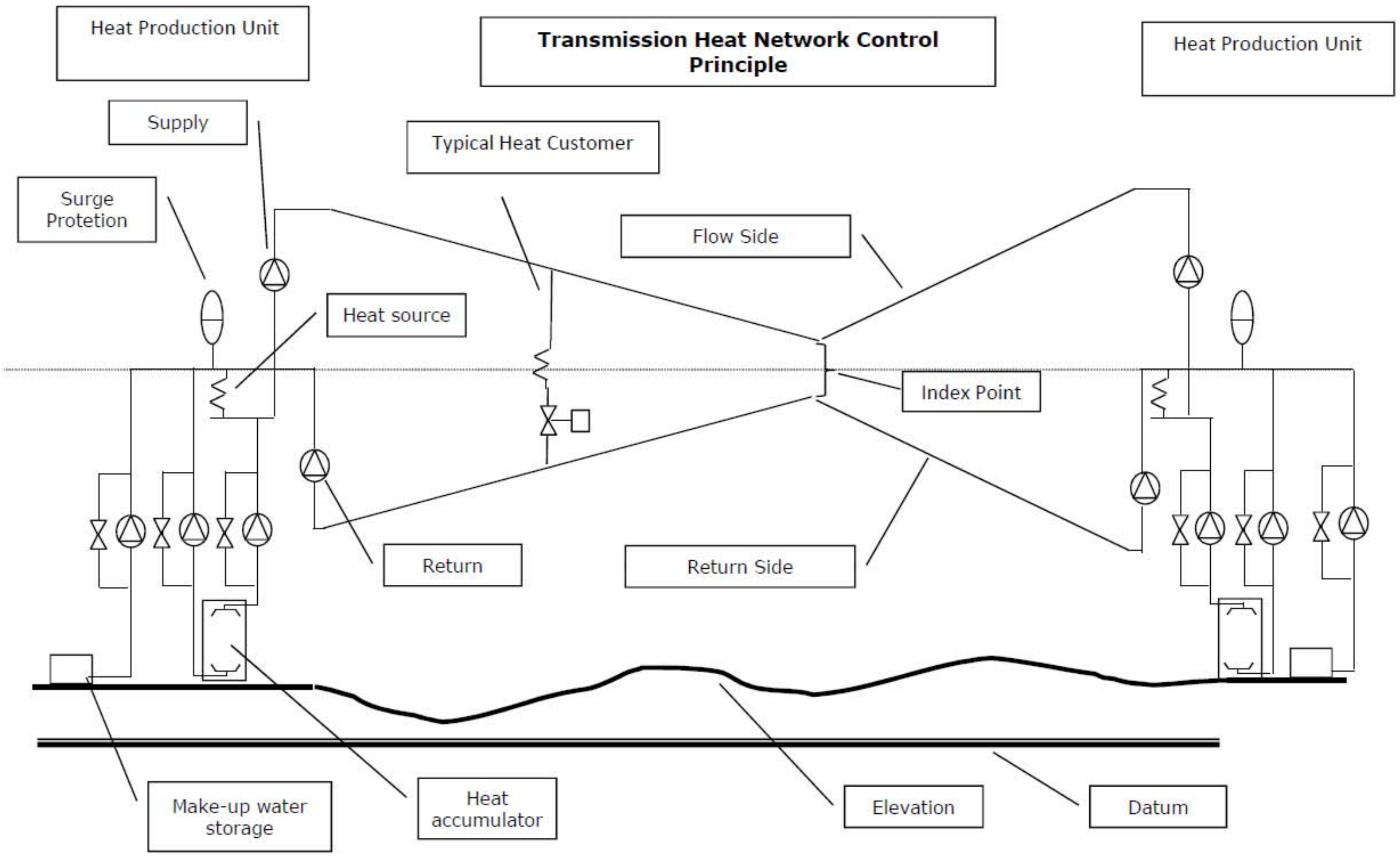


Figure 9: Network Hydraulic Concept

2.6 Connection of Heat Production Assets

Heat production units will connect to the heat network through heat exchanger stations. These will typically be housed adjacent to the heat production facility within the energy centre / boiler house plantrooms.

Heat production units based on steam turbine cycle will typically comprise a steam to water shell and tube heat exchanger[16] along with associated controls, valves, fittings and heat metering as required to provide fully automated operation.

This is shown schematically below for a condensing turbine with stream extraction, which is the design expected to be taken forward for any new Energy from Waste facilities coming forward.

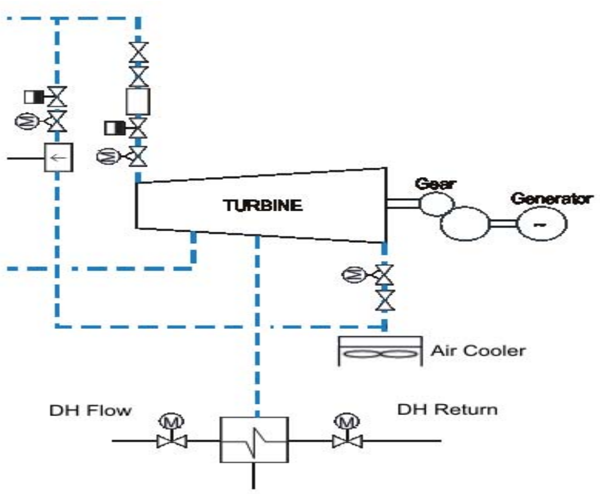


Figure 10: Condensing Turbine, with extraction for DH production

Heat will be delivered into the strategic heat network via inverter driven distribution pumps located in the flow and return lines (on the heat network side of the heat exchanger stations). Distribution pumps will be regulated automatically through a central control system located at the primary substation. Heat exchanger conversion efficiencies of around 95% - 98% are expected.

Heat will be sold at the interface of the heat exchanger station on the basis of measurements from the heat meters installed on the secondary (heat network) side of the installation. The heat exchanger station will typically be operated and maintained by the heat production facility. It is assumed that the Project Company will invest in the heat exchanger station and lease it to the heat production facility[17]. Other financing options are also possible and options should be explored further at the next stage with the relevant stakeholders.

Heat recovery from internal combustion engines will be through water to water heat exchangers taking heat from the engine jacket, oil cooler and exhaust systems. These will be connected to the heat network via a water to water heat exchanger circuit, with heat being delivered into the network via a set of distribution pumps. A typical arrangement detail of the heat recovery system including the heat exchanger station is shown below.

[16] Except in the case of heat that might be recovered from Thames Water Enhanced Digestion facility. 20C or Thames water Desalination facility which will be water to water and gas to water respectively.

[17] Refer to Section 3.7.2 for further information on the nature of the assumed Project Company

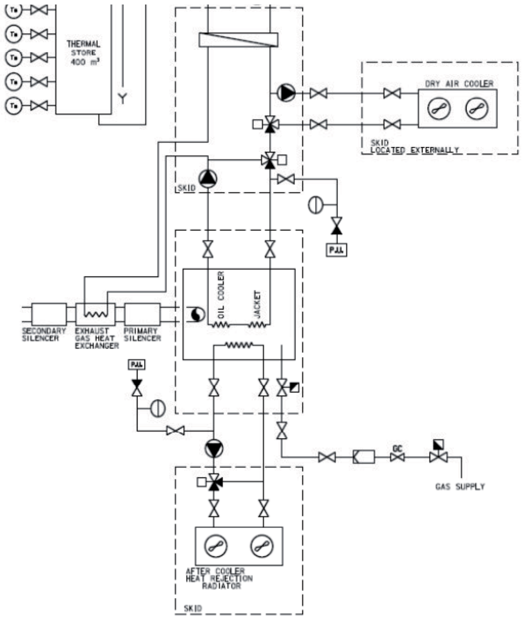


Figure 11: Typical Arrangement for Heat Recovery from Internal Combustion Engine CHP

2.7 Peaking Plant and Back up Plant

Embedded peaking plants are proposed in the strategic heat network as identified in Table 6 below. Further information on the location of these is provided in Sections 3 and 4.

Peaking Plant Location	Capacity	Year of Construction (earliest)
S08 Thameside West	12 MW[18]	2017
S21 Silvertown Keys	18 MW	2017

Table 6: Proposed Peaking Plant for Royal Docks Heat Network

The peaking plants should be sized to supply the developments to which they are connected (with provision for redundancy).

These should be designed to run on natural gas as the primary fuel with dual fuel capability. Consideration could be given to safeguarding the peaking boilers to run on biofuel in the future, although it is noted that this would incur very high maintenance requirements and may present issues in relation to ongoing cost and sustainability credentials of sourcing biofuel to operate them.

Boilers should be fitted out in a modular fashion in line with the construction phasing of the developments they serve. Space provision for additional boilers and retrofitting of gas CHP in the event that the heat network is never built out should also be provided.

Boilers should be decoupled from the heat network through heat exchanger stations and should be specified to deliver heat at 110 ^{0}C on the secondary (heat network side) of the heat exchanger station.

[18] This assumes 150% of the peak load for this development

Back up boiler plant should be provided at each of the main heat production assets connected to the network. These should be designed to run on natural gas as the primary fuel with dual fuel capability. These should also be decoupled from the heat network through heat exchanger stations and specified to deliver heat at 110 ^{0}C on the secondary (heat network side) of the heat exchanger. The appropriate level of redundancy at each heat production facility will depend on the number of heat production assets connected to the network and cannot be determined at this stage.

2.8 Strategic Heat Network Pipework

District heating systems can employ a number of different pipe systems ranging from rigid steel pipes to flexible plastic produced as a pre-insulated bonded pipe system. A pre-insulated pipe consists of the medium pipe that can be of steel, copper, plastic (PEX - cross linked polyethylene) or Aluminium PEX. Common to each is a layer of polyurethane foam insulation and an outer protective casing. The insulating foam thickness can vary to provide lower heat losses.

Pipe systems have developed significantly over the last 30 years and now European standards for their construction (EN253) and installation (EN13941) are in place to ensure that the highest quality pipe systems are developed.

Pre-insulated bonded pipe systems are today by far the most commonly used system for heat networks. Insulated steel pipes in concrete ducts or outer steel casing can also be used for special applications or in systems with special requirements along the route.

In most cases alarm wires, made of copper, are contained within the insulation for leakage monitoring.

Twin pipes have two medium pipes within the same outer casing.

Rigid steel pipes are envisaged for the scheme. These employ standard steel pipe, in standard pipe sizes, e.g. DN50, DN65. They are manufactured in straight lengths of 6m, 12m and 16m for general purpose use. There are two options of rigid steel pipes; one suitable for use in systems rated at 120°C; 16bar and one for use in systems rated at 120°C; 25bar. Pipes can be operated at higher temperatures but this reduces the life expectancy of the insulating foam.

Pipe Type	Insulation	Max. Operating Parameters	Pipe Sizes
Steel	Option 1	120°C ; 25 bar	DN20 - DN1200
		120°C ; 16 bar	
	Option 2	120°C ; 25 bar	DN20 – DN600
		120°C ; 16 bar	
	Option 3	120°C ; 25 bar	DN20 – DN500
		120°C ; 16 bar	

Table 7 – Rigid Steel Pipe Options

The different insulation options provide an increased thickness of the polyurethane foam. This increased foam thickness reduces the heat losses from the pipe system.

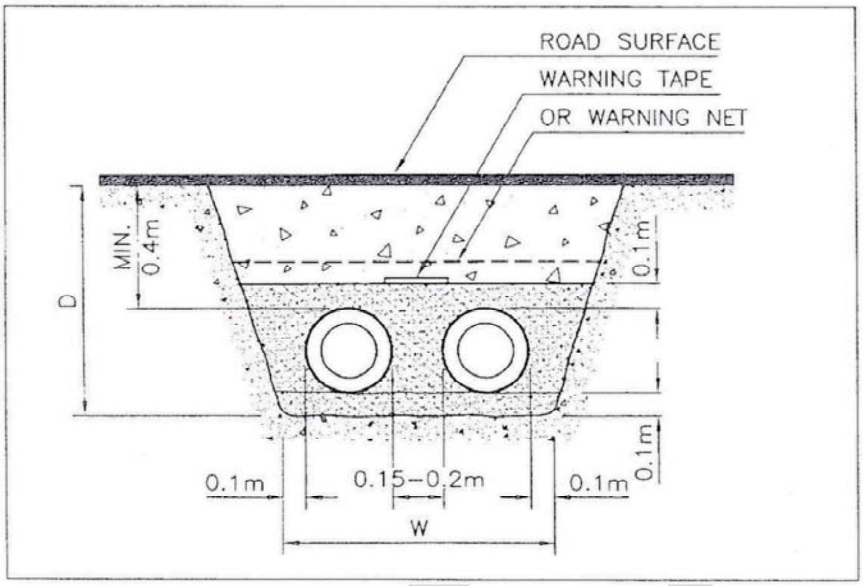
Figure 12: Rigid Steel pipes for District Heating (image courtesy of Ramboll)

Twin pipes are constructed using the same materials as single pipes but both flow and return pipes are contained within one outer casing. This design reduces heat losses and operational costs and can in some circumstances be cheaper to install.

Due to the production technology twin pipes are presently limited to a maximum pipe size of DN200, which limits their use in larger networks.

Figure 13: Twin Pipes for District Heating (image courtesy of Ramboll)

Typical pipework dimensional requirements are shown below for various pipework diameters assuming single pipe technology.



Nominal Diameter mm	Casing diameter mm	W_{min} m	D m
32	90	0.7	0.65
40	110	0.7	0.65
50	125	0.7	0.65
65	140	0.8	0.65
80	160	0.8	0.70
100	200	0.9	0.75
125	225	1.0	0.80
150	250	1.1	0.90
200	315	1.2	1.00
250	400	1.4	1.00
300	450	1.5	1.00
350	500	1.6	1.10
400	560	1.8	1.20

Figure 14: Pipework Trenching Details (image courtesy District Heating Handbook, EDHPMA)

Typical installation requirement details are shown below.

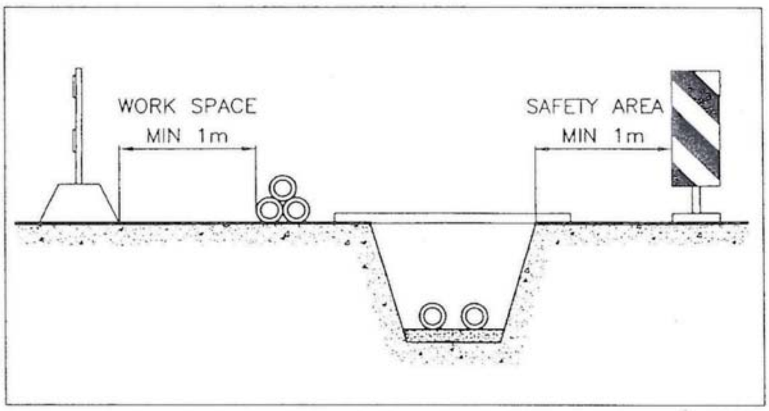


Figure 15: Pipework Installation Working Space (image courtesy image courtesy District Heating Handbook, EDHPMA)

Services pipes connecting buildings to community heat networks can in principle be supplied as flexible pipes. The types of pipes available for service pipes are:

1) Flexible pre-insulated DH pipe with medium pipe of copper (cu-flex)
2) Flexible pre-insulated DH pipe with medium pipe of PEX or AluPEX material
3) Flexible pre-insulated DH pipe with medium pipe of steel (steelflex)
4) Traditional non-flexible pre-insulated DH pipes with medium pipe of steel

However, flexible pipes have operational limits in relation to maximum allowable pressure and temperatures, making them unsuitable for direct connection to the proposed strategic heat network.

2.8.1 Pipe Surveillance System

A pipe surveillance system is built into the most of the pipe systems. The surveillance system comprises two un-insulated copper wires embedded in the insulation. The copper wires run the entire length of the pipe system and are connected to monitoring stations. The monitoring stations continuously undertake an ohmic resistance measurement to detect the presence of moisture in the foam. This surveillance system will create an alarm which will allow early detection of faults or damage to the pipe system. These faults can be corrected and repaired often without disruption to the heat supply.

2.9 Heat Accumulators

Heat accumulators can be integrated into heat networks for several reasons. The present study has considered the use of accumulators to:-

- store heat generated from the baseload capacity plants at off peak times when heat production costs are low
- discharge this heat during peak demand conditions and when heat production costs would otherwise be high.

Sizing and location of accumulators will depend on a trade-off between investment cost and operational cost savings. Based on the modeling carried out at this stage, approximate capacities to provide up to four hours storage of the baseload heat production plant are envisaged. Options for locating accumulators include at the base load heat production facilities and at the peaking plant locations. Further analysis is required to establish sizing and location once heat production assets have been assigned to the scheme.

It is envisaged that accumulators will be hydraulically separated from the heat network to allow them to be designed to lower pressure ratings than the network. A design pressure of 3 bara or below is expected. Pressure would be maintained during operation through steam generators located adjacent to each accumulator. They should be charged and discharged through a series of variable speed booster pumps and pressure reduction valves along with shut off valves. Sizing should allow for them to take up expansion in the heat network. This will improve pressure control in the heat network and reduce the capacity requirement and cost of additional pressurization and expansion equipment.

A typical heat accumulator arrangement is shown below.

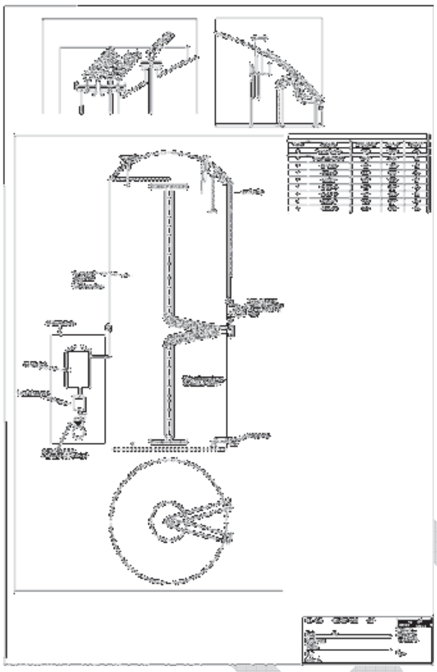


Figure 16: Typical Accumulator Configuration

It is assumed that accumulators would be owned, operated and maintained by the Project Company. Other financing and ownership models are also possible and options should be explored further at the next stage with the relevant stakeholders.

2.10 Consumer Connections

2.10.1 Local Heat Networks Serving New Developments

Heat distribution to customers within new residential, mixed use or commercial developments will take place via local heat distribution networks. These will be supplied from newly constructed energy centres located on the site of each development.

Residential customers within local heat distribution networks will either be connected directly to their local energy centres via individual plate heat exchanger stations (HIUs') at each dwelling or they will be connected via communal heat exchangers at block level, which will typically be located within plantrooms at basement or ground floor level for example.

Non residential customers will be connected via heat exchangers located in eg basement level or ground floor plantrooms (new developments) or, in the case of existing buildings, in existing plantrooms located at basement, ground or roof level.

2.10.2 Point of Connection to Strategic Heat Network

The point of connection between the strategic heat network and the individual developments will generally be as follows:-

- within newly constructed energy centres for new residential, mixed use or commercial developments
- within basement level, ground floor level or roof level plantrooms for existing buildings and new single building developments.

Connections to existing building will typically be connected at the point where the existing heating assets reside.

In each case, heat sold will be metered at the point of connection through newly installed heat meters.

Connection between local heat networks serving multiple customers and the network can be either direct or indirect. Direct connections are preferred in order to avoid temperature reductions across heat exchanger stations with consequent reductions in achievable temperatures differences across the network. However, this will require local distribution networks and energy centres to be designed for 16 bar conditions, which will potentially increase costs.

We would recommend further analysis of the options at the design stage of the project, with reference to the principles set out in the Design Manual for London (draft in publication [31]).

Figure 17 – Heat Exchanger Substation

(photo courtesy of Danfoss)

Figure 18 - Typical HIU without front cover

(photo courtesy of Danfoss)

2.10.3 Description of Heat Exchanger Interface Equipment

The typical design connection for commercial and industrial customers will comprise a heat exchanger station containing two heat exchangers complete with all necessary pumps, controls, valves and heat metering. One heat exchanger will provide heating and one will provide centralised, instantaneous domestic hot water production. Indicative assembly and schematic arrangements for such a consumer substation are shown below ([29]).

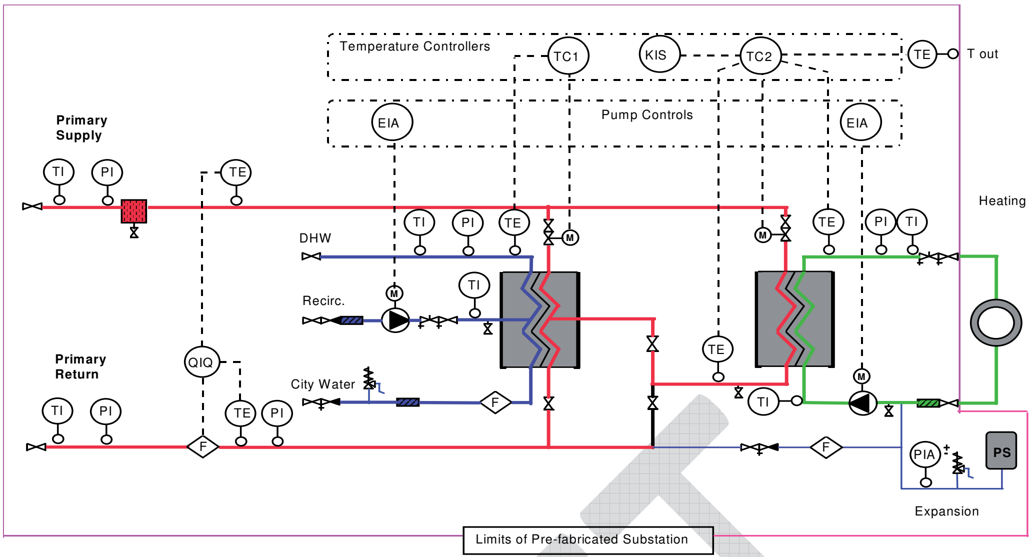


Figure 19: Typical Substation Connection Arrangement (image courtesy of LDA/GLA)

For residential developments a range of connection options are possible. For example, residential blocks could be directly connected, with heat exchanger stations (HIUs) located at apartment level only, with a direct connection at the building interface and at the incoming supply to the energy centre. This would maximise temperature difference in the system, reduce internal heat gains and make use of the available pressure in the network thereby minimising additional circulation pumping at block level. Alternatively, a communal heat exchanger station could be located at block level to provide a hydraulic break and a clear commercial demarcation point between the network operator and the maintenance company responsible for the individual buildings. Individual developers will have their own preferences and may choose to adopt either strategy.

2.10.4 Size and Cost Considerations

Heat exchanger station costs will typically be in the range £35K for a MW scale installation rising to 50K for a 5MW installation.

Consumer substations are significantly smaller than conventional boiler plants and consequently, a lot of space can be saved in new developments or taken to other use when existing boilers are removed. A heat exchanger substation can take as little as 10% of the space required by conventional boiler plant. Heat exchanger sizes vary from building to building. The following table provides a guide to the space requirements of a typical floor mounted heat exchanger. The space identified does not include for any equipment required for distribution, e.g. circulating pumps, pressurisation system.

Heat Exchanger Size (kW)	Packaged Brazed Plate	Gasket type
200	2.5m x 2m	3.5m x 2m
500	3m x 2m	4m x 2m
750	3.5m x 2m	4m x 2m
1000	3.5m x 2.5m	4.5m x 2.5m
1500	4m x 2.5m	4.5m x 2.5m
2000	4m x 3m	5m x 3m

Table 8: Heat Exchanger Space Requirements

Each heat exchanger space allocation allows for a minimum working space to all four sides of the unit.

Heat exchanger stations for individual residences are comparable in size to wall mounted boilers.

2.10.5 Metering Control and Communication

There are three main types of heat meter;

- Ultrasonic
- electro-magnetic
- turbine or impeller

Ultrasonic heat meters are likely to be employed. The turbine and impeller types are not recommended for metering hot water being insufficiently sensitive to low flow.

Each building connection will have a single point of heat metering. The heat meter should be located on the heat network return pipe and be linked back to a dedicated central point of meter data collection. Proprietary software is available to manage the data collection and billing process but the incumbent network operator may have their own facilities. The heat meter will therefore be capable of communicating through a number of protocols.

Control of the network should be carried out using strategically placed pressure transmitters in the network and in such a way that will allow build out of the scheme without the need for modification to the control system.

Communication is likely to be provided through a site-wide internet based system linking heat exchanger control systems and heat meters back to a central data retrieval system in the main energy centre at the primary heat production facility. A hard wired back up facility should also be provided that will operate in tandem with the internet based system to provide redundancy in operation. The hard-wired system should run in the trench of the strategic heat network pipework in dedicated communication ducts. A radio based system is not advised due to the density and height of buildings in the area that could prevent data transfer.

2.10.6 Role of Local Heat Storage

Heat accumulators are proposed for the heat network as described in Section 2.8. Local heat storage for domestic hot water supply within individual building is not generally proposed for the scheme.

Where individual developments install gas CHP schemes (ie if the heat network does not come forward), thermal storage could be adopted at local energy centres.

Existing larger buildings connecting to the heat network are likely to have local domestic hot water storage in place already. There may be a case for retaining / replacing local domestic hot water storage in these buildings where calorifiers are already in operation (depending on system design) although it will be preferable to remove these and replace with instantaneous hot water from suitably sized plate heat exchangers and this is generally the recommended approach. We would recommend evaluation on a case by case basis at the design stage of the project.

Individual developers may choose to design their communal heat networks to provide local storage of domestic hot water at block level. This could potentially reduce the peak demand on the local network and can give rise to savings in community heat network costs. Individual developers will have their own preferences in this respect and, providing that designs are compatible with design of the strategic heat network, they should be free to adopt this strategy if they choose to.

2.11 Interfacing to Olympic Park Scheme and to Opportunities to the East of the Royal Docks

Previous development proposals for the London Thames Gateway Heat Network have envisaged construction of a heat network linking Barking and Dagenham to the Royal Docks in two phases

- Phase 1 which would supply heat from Barking Power Station to the Sustainable Industries Park (SIP) and to Barking and Dagenham.
- Phase 2 which would supply heat from Tate & Lyle to the Royal Docks area including Excel and London City Airport.

The present heat network opportunity represents Phase 2 of the original vision, which has always been intended to connect into Phase 1 and into opportunities to the west of the Royal Docks under a future phased build out of the wider heat network vision.

The concept for safeguarding for interconnection of current heat network to future phases of LTGHN and to the Olympic Park DE Scheme (OPDES) is based around newly constructed dedicated sub stations comprising motorized isolation valves and heat meters.

Consideration has been given to how this could be achieved, although it is noted that any form of design work has not been carried out as part of this study. On the basis of an initial overview only:-

- a substation connecting the present scheme into Olympic Park District Energy Scheme (OPDES) could be placed in the vicinity of the POC under development in the Southern Olympic Fringe [13].
- a substation connecting into a future phase of LTGHN heat network emerging to the east of the Royal Docks could be placed in the vicinity of whichever major heat production facility in Beckton in forms part of the heat network.

The size and cost of these substations would need to be established through further hydraulic analysis, taking into account available locations and capacity requirements. Booster pumping or hydraulic separation through a heat exchanger station may also be required, depending on the hydraulic gradients in the heat network under the varying design conditions and the commercial arrangements and requirements for the companies trading heat into eachother's networks.

The technical details and feasibility of providing the necessary heat exchange interface has not been investigated as part of this study. It is recommended that further work is carried out at the design stage of the project.

2.12 Local Electricity Generation Arrangements

2.12.1 Connection of new generating capacity to the electricity network

Small embedded generating plant with connection capacities below 2MW, are likely to be connected at 400 V via step up transformers to the local 11kV network. This is likely to be the case for new gas CHP installed in individual developments as well as the new biogas generators installed at the Thames Water enhanced digestion facility.

Connection of new build large scale generation facilities will depend on capacity. A 100,000 t.p.a plant coming forward at the Waste Treatment site, may be able to connect at 11 kV, depending on access to 11KV grid, fault levels and the DNO's upgrading costs. Above 100,000 t.p.a, connection at 33kV or 132 kV, is likely to be required.

2.12.2 Electricity Generation and Sale Arrangements

Heat production assets connected to the heat network will simultaneously generate electricity. Some of this electricity may be available for export, depending on the requirements on site in each particular case. Options for selling this surplus electricity could be as follows:

1) Supply into the wholesale market
2) Supply to individual customers under a private wire arrangement
3) Supply to the retail market under the an Electricity Licence Lite arrangement

Electricity supply into the wholesale market

Generating companies will little surplus capacity to export (which is also variable in nature) represent intermittent suppliers on the electricity network and therefore can increase rather than reduce imbalance risk to licenced suppliers. Depending on the scale of the generator, supplying electricity directly into the wholesale market would therefore typically result in a relatively low value for the electricity being generated. Electricity suppliers with whom the generator would need to contract would attach little value to the electricity due varying nature of the electricity supply, since electricity trading arrangements would require them to manage electricity imbalance between generation and supply and therefore purchase electricity from elsewhere to make up the shortfall or pay imbalance charges.

Electricity supply to individual customers under a private wire arrangement

Generating companies could supply directly to a local customer under a private wire connection. This would allow the generating company to realise additional value for its electricity, although it would need to undercut licenced suppliers to incentive customers to connect. By separating the generation and demand aspects of a project from the electricity trading arrangements, such an arrangement would avoid exposure of the generating company to network charge price variations within the electricity trading arrangements. However, establishing a private wire connection can be expensive and such an arrangement would require customers to adopt long term electricity supply contracts in order to guarantee the generator payback on the investment. A higher value could be realised for the electricity than under wholesaling arrangements but additional risk would arise associated with creating a stranded asset over time in the event that the customer choose to change supplier or ceased to exist (for example commercial customers) for whatever reason.

It is likely that customers would be unwilling to tie themselves into private wire contracts for extended periods, preferring instead to retain their ability to purchase the cheapest power available from licenced suppliers. Under the Citiworks ruling, it would not be possible to bind customers legally into supply contracts over extended periods and provisions would need to be made for alternative supply arrangements to allow customers to source their electricity from other suppliers.

Private wire contracts for generating companies would be best suited to larger single users in order to minimise the associated logistical and commercial burden. These might include industrial, commercial and large retail customer and entities such as UEL, London Borough of Newham, City Airport and Thames Water. Contracts with such customers would typically be between three and five years in duration and the generator would therefore need to expect to renegotiate the supply contract many times during the lifetime of the scheme. Connection would need to be local to the generator to minimise connection costs. Reliability of supply to customers under a private wire arrangement would be no different to their alternative licensed supply arrangements, since a parallel connection to the grid would need to be in place.

Local generating companies that could potentially benefit from trading under a private wire arrangement might include Tate & Lyle, 20C and potential future waste to energy providers with surplus electricity to export[19].

Local embedded CHP generators (installed by individual plot developers) might also adopt private wire arrangements in some situations. This might include supply to single users (schools, retail etc) within a development and supply to residential customers within Housing Associations (HAs), where the HA acts as a single entity responsible for delivering heat and electricity to its tenants. Supply to private residential customers would be logistically more complicated and commercially

[19] Thames Water SPG does not export electricity and would therefore be a viable opportunity.

more challenging since customers could exercise options around choice of supplier thereby increasing risk of a stranded asset, reducing payback on the investment. All connections would require alternative supply connections to the public electricity network.

Electricity supply to the retail market under the proposed Electricity Licence Lite Arrangements

In 2009, Ofgem introduced new Electricity Supply Licence (Licence Lite) proposals, intended to make it easier for embedded generators, include decentralised energy schemes, to operate as licensed suppliers across the public electricity network. Licence Lite proposals allow both private organisations and public sector/local authority bodies to become Licence Lite holders. Under the proposed 'Licence Lite' arrangements, Licence Lite holders can enter into a 'supplier services agreement' with a licensed third party supplier and benefit from being able to retail electricity generated whilst avoiding many of the fixed and operating costs associated with setting up and operating a full electricity supply licence.

There are currently no Licence Lite schemes in operation, although GLA and Ofgem are working together with selected London Boroughs to finalise scheme proposals and establish the first Licence Lite schemes in London[20]. It is anticipated that by 2015 the concept of Licence Lite will have been successfully proven and that local generators including Local Authorities and private commercial organisations would be operating under such licences at that time in London and beyond.

In the context of the Royal Docks heat network, Licence Lite offers would allow generators to realise additional value for surplus electricity. This could potentially be recycled into the scheme in the form of reduced heat prices.

The potential customer base under Licence Lite could include residential, industrial, commercial and local authority consumers within the local distribution network. Retailing into the strategic network would probably be un-economic due to the transmission UoS charges arising[21]. The electricity supply customer base would not necessarily need to be the same customer base receiving heat from the scheme and the customer base could therefore be matched to the export capacity of the scheme.

The margins associated with retailing to residential, small scale commercial and retail customers could be substantial. The margins for larger commercial and retail customers[22] would be less attractive due to their lower purchasing prices under bulk supply agreements.

The cost of administrating the Licence Lite remains unproven at this stage and the GLA is currently conducting work in this area to and is due to report on the findings at the end of March 2012. The intention is to pool the administrative burden of setting up and operating a Licence Lite across a number of schemes and applicants so that the operating margins would be acceptable to small generators[23]. However, the licence lite holder would continue to carry imbalance risk and would therefore be exposed to imbalance charges on varying amounts of export capacity, albeit that these would be aggregated by the licenced supplier so that the generator would see a reduced exposure. Such an arrangement would therefore penalise a generator operating a turbine in extraction mode, where heat extraction incurs a reduction in electricity production. On the other hand, heat extraction from the condenser circuit of a turbine would not impact on electricity production and would therefore not suffer from exposure to the same extent.

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[20] A group of six London supervisory councils (WF, Hackney, Haringey, Camden, Islington) are currently working with GLA to establish Licence Lite and after March 2012, one or more boroughs are intending to apply for License Lite licences. If successful, this will set a precedent for other local authorities to follow. Work is ongoing between GLA and Ofgem to finalise implementation of the scheme. This includes resolving various regulatory issues surrounding the proposed licence arrangements, (including the development of inter-industry off-take agreements (to set the parameters of engagement between the parties to such agreements) and understanding and resolving key risks to potential licensees).

[21] Information based on discussions with GLA

[22] such as Excel and London City Airport and large retailers with multi site supply contract agreements

[23] Information based on discussions with GLA

In order to establish a Licence Lite, the relevant entity would need to enter into a Supplier Services Agreement with a Licenced Third Party Supplier. Thereafter it would have a light administrative role in maintaining and operating the Licence Lite, with the Licenced Third Party Supplier carrying out the administration of the Licence Lite holder's obligations under the Electricity Supply Regulations.

There would be no reduction in security of supply from the perspective of customers purchasing electricity under Licence Lite. On the other hand, the Licence Lite holder would incur risks associated with bad debt and exposure to new customers under the universal obligation to supply[24]. Managing a licence lite would not readily fit within the business model of a generator and would need to be carefully managed. The appetite for doing so amongst local generators remains to be seen, as would be the appetite amongst licensed suppliers for contracting with generators under reasonable affordable commercial terms.

Local generators that could potentially benefit from trading under a Licence Lite would include potential future waste to energy providers[25] and Tate & Lyle.

[24] Under the universal obligation to supply, unnamed customers have the right to request a supply from a supplier operating in the area. In order to prevent exposure to new customers without the ability to supply them from directly connected assets under this universal obligation to supply, it would be important for the Licence Lite holder to manage its exposure to unnamed customers by carefully defining its local customer base under a declared "scope of supply". This scope of supply would need to be declared with Ofgem at the time of Ofgem's granting of the licence and could be renegotiated at future points in time as new generation capacity allowed the customer base to be extended.

[25] Thames Water SPG does not export electricity and would therefore be a viable opportunity.

3. COST ANALYSIS AND INVESTMENT APPRAISAL

3.1 Basis

The basis of the costing analysis and investment appraisal assumes the future design of the heat network to be a 16 bar network in accordance with the design parameters set out the draft District Heating Manual for London being prepared by GLA[31] (due to be published in Final Version in March 2012). An operating temperature difference of 55 degree C at the design condition has been assumed.

3.2 Heat Network Investment Appraisal

The most cost effective design approach is likely to be to size the strategic heat network to deliver the baseload capacity from Beckton with additional provision to meet the diversified peak demands for Royal Albert and Royal Albert Basin and to use embedded peaking plants at Thameside West and Silvertown to meet the peak demands in Canning Town, West Silvertown and North Woolwich. This avoids the need to size the entire heat network to allow Beckton to meet the peak demand across the network.

This approach results in a total network cost of £23.2M (based on Beckon Waste Treatment Facility) and a capital cost saving in the region of 10% compared to sizing the network to deliver the entire system's peak demand from Beckton.

The business case for the scheme has been assessed around heat off-take opportunities from Thames Water SPG and Beckton Waste Treatment Facility. In each case, scheme IRRs have been calculated on the basis delivering heat to consumers at the current market price and on the basis of the expected cost of purchasing heat from the heat suppliers.

The market price for heat has been calculated to lie within the range 3.4 p/kWh and 5.7 p/kWh for the range of customers considered in the study. This reflects their current heat generation costs under the business as usual case and includes for fuel costs, operations and maintenance costs and plant reinvestment costs over the life of the scheme. Refer to Appendix 6 for further details of the derivation of these costs.

The cost of purchasing heat from Thames Water SPG and Beckton Waste Treatment Facility have been taken to be 2.0 and 1.5 p/kWh respectively, based on an assessment of heat production costs presented in Appendix 4 (rounded to the nearest 0.5 p/kWh).

The calculated cost plan for the heat network is shown in Appendix 8. Capital expenditure would arise mainly over the period from 2017 to 2020.

The network dimensioning is shown below, based on supply from Beckton Waste Treatment Facility. This identifies the major heat production facilities within the network in its fully built out state.

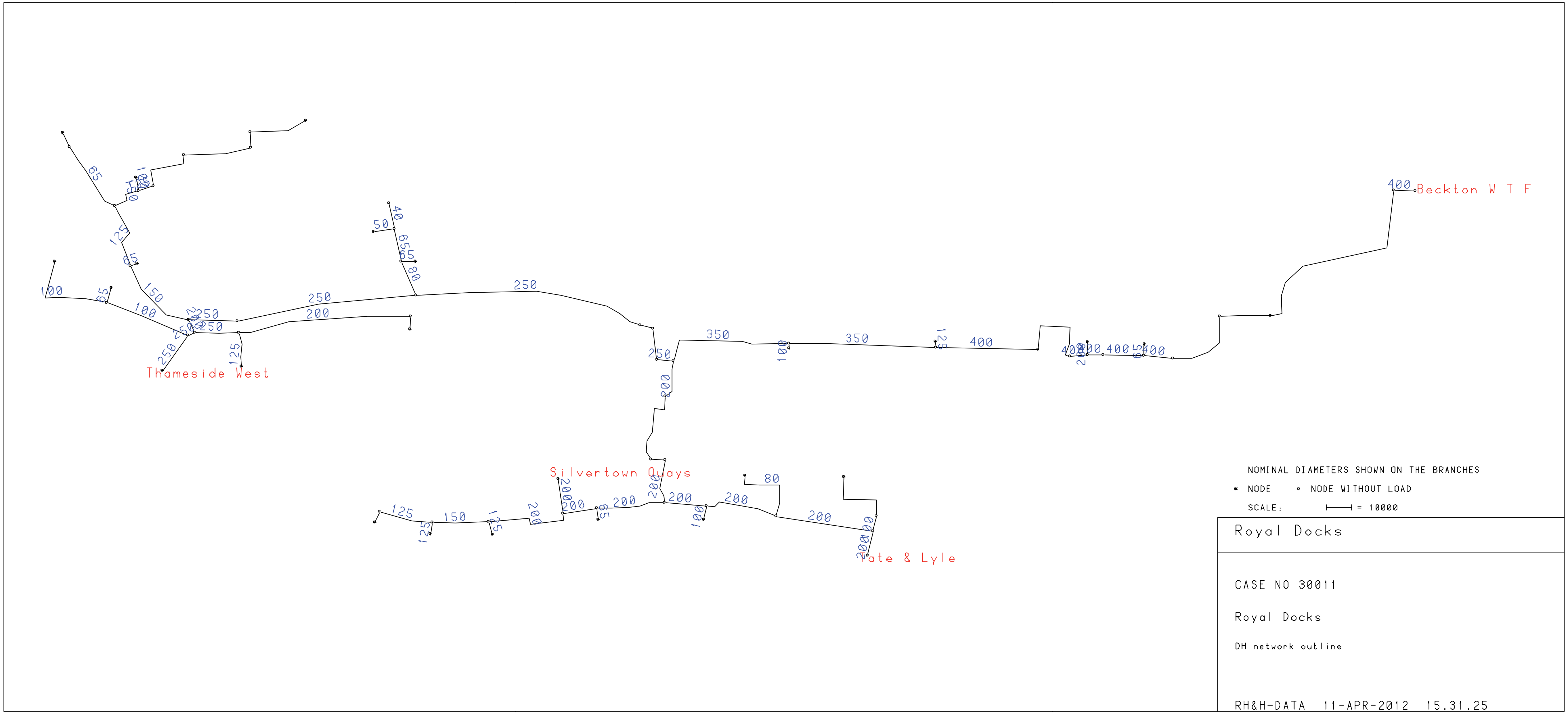

Figure 20: Heat Network Concept

3.2.1 Beckton Waste Treatment Facility

The total investment costs in the scheme to the period to 2050 will be £33.0M in today's prices. This includes investment in the heat network noted above, along with an investment of £9.8M in peaking plant, heat exchanger connections costs to all indicated developments, accumulators at Silvertown Keys and Thameside West and connection to Beckton Waste Treatment Facility with back up and top up capacity to supply Royal Albert.

Assuming construction and heat on to customers by 2017, the heat prices that the Project Company owning the strategic heat network assets could pay for baseload heat to deliver IRRs of 10%, 6% and 3.5 over 25 years and 40 years respectively are shown below.

Required IRR	Cost of heat [p/kWh] Calculation Period 25 years	Cost of heat [p/kWh] Calculation Period 40 Years
3.5%	2.80	3.70
6%	1.90	2.70
10%	0.20	0.70

Table 9: Calculated Cost of Heat for Scheme Options - Beckton Waste Treatment facility

If the Project Company could source heat at a price equal to 1.5 p/kWh (calculated rounded cost of purchasing heat from Beckton Waste Treatment Facility), the scheme would deliver IRRs of 6.88 % and 8.45 % over 25 years and 40 years respectively. Based on this, at full build out of the scheme (at 25 years) annual revenues from the scheme would be expected to amount to £7.2M per annum, with an operating margin of £4.20M.

The cumulative discounted cashflow forecast for the scheme is shown below, based on 6% discount factor.

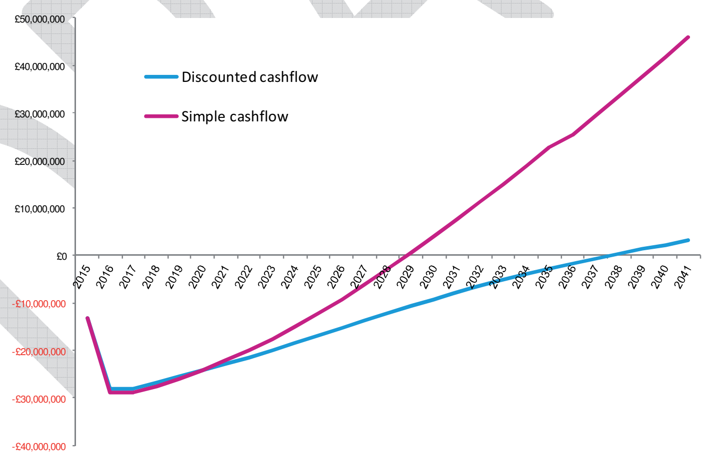

Figure 21: Cumulative Discounted Cashflow Forecast– Beckton Waste Treatment Facility

The NPV for the scheme assuming a 6% discount factor would be £3.2 M.

The NPV for the scheme assuming a 3.5% discount factor would be £15.5M.

3.2.2 Thames Water SPG

The total investment costs in the scheme to the period to 2050 will be £34.4M in today's prices. This includes investment in the heat network noted above, along with an investment of £11.1M in peaking plant, heat exchanger connections costs to all indicated developments, accumulators at

Silvertown Keys and Thameside West and connection to Thames Water SPG with back up and top up capacity to supply Royal Albert.

Assuming construction and heat on to customers by 2017, the heat prices that the Project could pay for baseload heat to deliver IRRs of 10%, 6% and 3.5% over 25 years and 40 years respectively are shown below.

Required IRR	Cost of heat [p/kWh]	
	Calculation Period 25 years	Calculation Period 40 Years
3.5%	2.68	3.47
6%	1.93	2.64
10%	0.51	0.98

Table 10: Calculated Cost of Heat for Scheme Options – Thames Water SPG

If the Project Company is able to source heat at a price equal to 2 p/kWh (calculated rounded cost of purchasing heat from Thames Water SPG), the scheme would deliver IRRs of 5.77 % and 7.57 % over 25 and 40 operational years respectively [assuming 2 year construction]. Based on this, at full build out of the scheme (at 25 years) annual revenues from the scheme would be expected to amount to £7.2M per annum, with an operating margin of £4.1M.

The cumulative discounted cashflow forecast for the scheme is shown below, based on 6% discount factor.

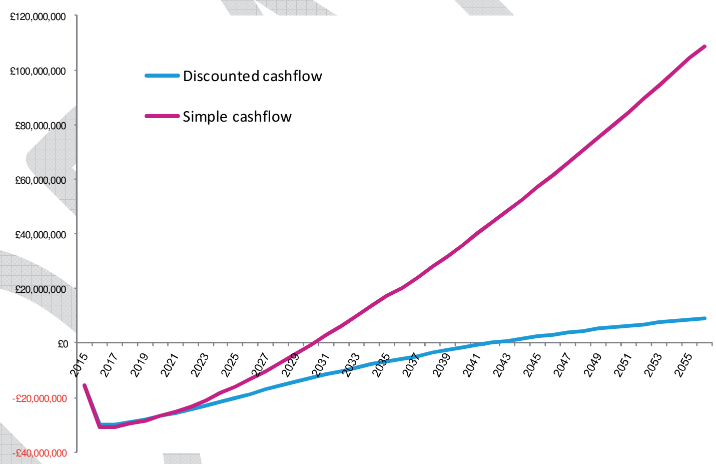

Figure 22: Cumulative Discounted Cashflow Forecast– Thames Water SPG Facility

The NPV for the scheme assuming a 6% discount factor would be £-0.9M.

The NPV for the scheme assuming a 3.5% discount factor would be £10.9M.

3.3 Energy Production and Carbon Appraisal

The heat supply contribution from each heat production asset is identified below under each scenario.

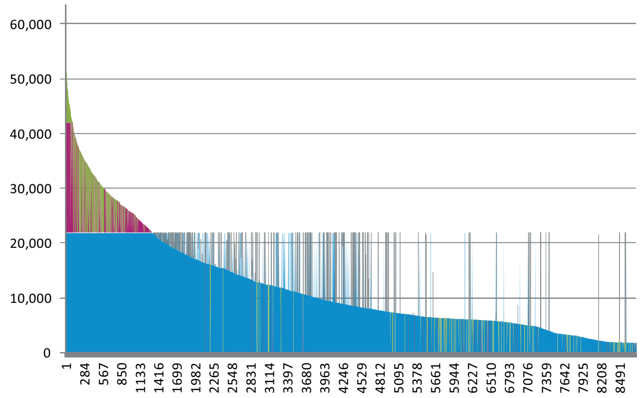

Figure 23: Supply Contribution from heat production assets – Thames Water SPG Facility as load duration curve

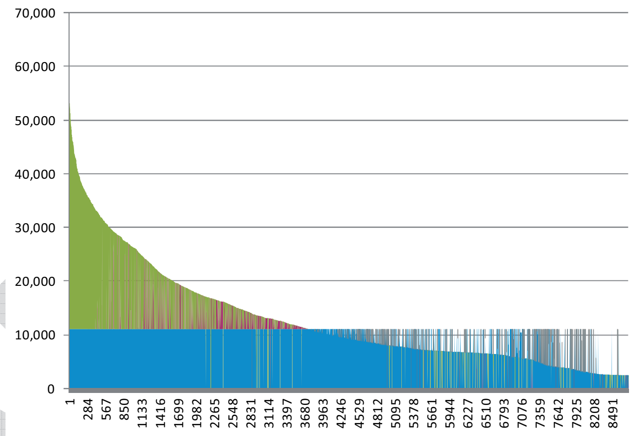

Figure 24: Supply Contribution from heat production assets – Beckton Waste Treatment Facility

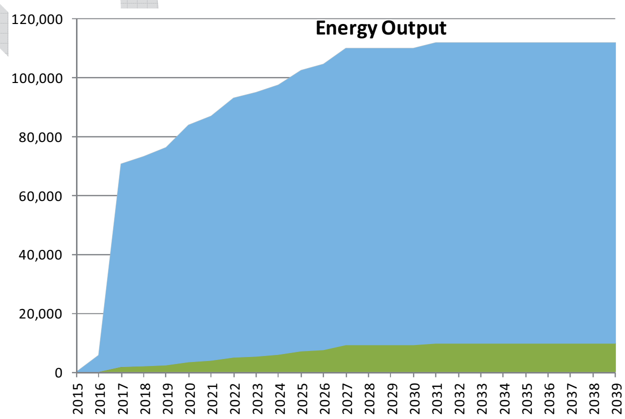

Figure 25: Supply Contribution from heat production assets – Thames Water SPG Facility

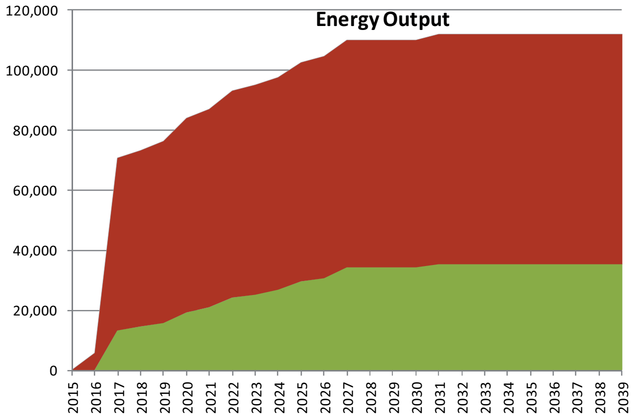

Figure 26: Supply Contribution from heat production assets – Beckton Waste Treatment Facility

The resulting carbon reductions against business as usual for year 2030 are presented in the Table below.

	Carbon Emissions due to Space Heating and Domestic Hot Water Provision [kt pa].	
	Thames Water SPG	Beckton Waste Treatment Facility
Business As Usual	18.8	
Scenario Modelled	4.3	13.1

Table 11: Carbon Emission at Full scheme build out (2031)

The calculated carbon trajectories to 2050 for the scenarios modelled are shown in Appendix 8.

In calculating these factors, carbon emission factors for grid electricity and natural gas have taken from 2011 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting [26]. Carbon emission calculations assume grid average and marginal grid production forecasts as reported in [27].

Calculated Carbon Intensity factors for heat production assets are shown in Appendix 3.

Based on the modelling carried out, the heat network would generate carbon reductions of 33% on heat supplied relative to the business as usual case over the 40 year period.

3.4 Cost Appraisal of Safeguarding Future Connection to Wider Area Networks

A safeguarding scenario for future interconnection to OPDES and LTGHN has been considered. The purpose of this approach has been to identify the cost uplift to the Project associated with safeguarding for this future interconnection.

Safeguarding for future interconnection of LTGHN and OPDES could be based on a number of design conditions. Around 110 MJ/s of heat low carbon heat could potentially be available from LTGHN in the future[26].The heat network could potentially be safeguarded to transfer this heat into

[26] Refer to Appendix 4 for further information.

OPDES, However, this is not recommended for the project at the present time due to the high investment costs and the high off-take risk.

Instead the approach taken has been to safeguard the heat network to meet a proportion of the projected future demand in the Southern Olympic Fringe under the baseload condition assuming that this would be supplied from within the Royal Docks network. Based on safeguarding for around 20% - 40% of the demand at Southern Olympic fringe, this would allow trading of upto 20MW of heat between the two schemes. In Ramboll Energy's view this represents a likely commercial basis on which heat might ultimately be traded between LTGHN, the Royal Docks and OPDES.

Safeguarding to supply heat into the Olympic Park, Stratford, Northern Olympic Fringe and beyond is not recommended due to the existing and planning supply capacity within OPDES, the long development timescales and uncertainty attached to bringing forward LTGHN and the commercial risk to the Project of this not happening. Any future bulk transfer of heat from LTGHN into OPDES could be accommodated through a parallel connection running for example along the northern sewage outfall to the north of the Royal Docks.

Based on safeguarding the heat network to deliver 20MW of heat to OPDES, the additional investment costs would be £3.4 M.

The safeguarding concept is illustrated in Appendix 4.

3.5 Impact of Scheme Proposals on Energy Prices

A high level sensitivity analysis of scheme IRR against achievable customer selling price has been carried out based on heat being supplied from the Thames Water SPG facility and assuming 2.0 p/kWh for heat supplied from the facility.

Three cases have been considered as follows:-

A 20% reduction in achievable heat selling price for all new residential customers would reduce the IRR over 25 years from 5.77% to 3.84%.

A 10% reduction in achievable heat selling price for all customers, would reduce the IRR over 25 years from 5.77% to 4.10%.

A strategy of delivering savings in heat to fuel poor tenants within the scheme would reduce the IRR over 25 years from 5.77% to 5.32% based on a 25% subsidy in their heating costs and assuming 20% of the new residential customers being supported.

3.6 Alternative Centrally Located Peak Boilers (SPG Facility)

The alternative to the proposed setup using distributed peak boilers is to focus all heat supply plant where the base load plant is located. To this end we have investigated what the impact would be in terms of cost and IRR of the scheme. Network cost would increase to £28.2M. Total CAPEX will be £43M. Setting the SPG heat cost at 2 p/kWh results in an IRR of 4.10% over 25 years or 6.23% over 40 years.

3.7 Business Case Appraisal for Developing Heat Network

3.7.1 Overview

The scale and density of consented and planned development coming forward in the Royal Docks and Canning Town over the coming decades presents an opportunity to bring forward a strategic heat network extending across the Royal Docks and into Canning Town on the basis that heat captured from one or more major low carbon heat sources located within the Royal Docks. The major heat supply opportunities that have been identified are Tate & Lyle, Thames Water SPG in

Beckton and a waste to energy facility that could potentially come forward at the Beckton Waste Treatment Facility. Other longer term heat supply opportunities involving industrial heat pumps could also potentially come forward at Wood Wharf, Beckton Sewage treatment works or Tate & Lyle.

The strategic heat network forms the critical link between the existing Olympic Park scheme (OPDES) and future opportunities to the east of the Royal Docks including developments that may emerge in the Sustainable Industries Park, a new EfW facility in Dagenham and any future additional supply capacity that may come forward at Barking Power Station.

Based on the work carried out in this report there appears be a reasonable business case around developing and operating a strategic heat network for the Royal Docks and Canning Town. This rests on the ability to integrate large scale generation facilities capable of delivering low cost, low carbon heat.

The required investment in a strategic heat network would be between £33.0M and £34.4M in today's prices, based around heat off-take from a waste to energy plant at the Beckton Waste Treatment Facility or Thames Water SPG. This assumes a 25 year project life[27] and investment in heat off-take equipment at the energy production facilities being met by the project. Alternative commercial models exist for financing the heat off-take equipment, which can be explored at the next stage.

Based on the analysis undertaken, the strategic heat network could ultimately deliver 106 GWh of heat per year, supplying the equivalent of around 29,250 Code Level 4 apartment dwellings[28].

Based around heat off-take from Thames Water SPG, the scheme could save 14.5 kt of CO_2 per year at full build out and create a business that would yield IRRs of 5.77 % and 7.57 % over 25 and 40 operational years respectively based on achieving a heat purchase price of 2 p/kWh. Based around heat off-take from a 100,000 tpa waste to energy plant the Beckton Waste Treatment Facility the scheme could save 5.7 kt of CO_2 per year at full build out and create a business that would yield IRRs of 6.88 % and 8.45 % over 25 years and 40 years respectively based on achieving a heat purchase price of to 1.5 p/kWh.

The business case for the existing and future major heat supply facilities capable of supplying the heat network should not rest on their ability to deliver heat into the heat network. The cost of heat purchased from these assets will need to reflect their opportunity costs in relation to forfeited electricity generation and the marginal increase in operating overhead associated with heat off-take.

In view of phasing of the project developments and uncertainty around the location, timescales and number of major low carbon heat sources in the study area, development of the heat network should proceed according to the implementation phasing identified in Section 4 of this report.

If London Borough of Newham wishes to take a proactive role in developing the project with the intention of securing a stake in the infrastructure assets, it should consider the following measures:-

- go to the market for potential waste to energy providers for the Beckton Waste Treatment Facility site.
- use its planning powers to require potential waste to energy providers to implement CHP and place a requirement on them to commit to connecting to the heat network as part of their planning approval
- conduct feasibility work to establish the appetite amongst major stakeholders such as Thames Water, Tate & Lyle to engage in the project and establish the commercial basis on which this could be achieved

[27] with one reinvestment cycle

[28] Based on average modelled energy usage for a Code 4 development comprising a mix of 1,2 and 3 bed apartments

- Conduct further feasibility work to establish a customer base for the heat network, including engaging with the projects identified in this scheme as well as identifying further opportunities for connecting existing head loads not assessed so far under this study
- examine its role in business planning for a heat network, developing a project steering group and engaging with heat customers to develop a business case on which to take the project forward
- use its planning powers to require individual developments constructed ahead of the heat network safeguarded for future connection into the heat network.
- consider using Community Infrastructure Levy, S106 and Allowable Solutions mechanisms to raise contributions towards funding the heat network
- safeguarding the energy centres at Silvertown Quays and Thameside West to operate as future peaking plants at the time when the heat network comes forward.
- pursuing the case for interconnecting the heat network to OPDES

London Borough of Newham potentially has a crucial role to play in bringing forward a heat network in the Royal Docks and Canning Town and needs to consider how it wishes to proceed in bringing forward this opportunity.

The high investment costs and long payback periods are likely to deter the private sector from investment in the early years. London Borough of Newham needs to consider owning a stake in the project to facilitate its development and to attract investment. This stake could be divested at a later stage, when the scheme has repaid its investment.

Alternatively London Borough of Newham may decide to adopt a limited role, leaving the market to bring forward the strategic opportunity. However, this approach risks failing to deliver the true scheme potential because of long term nature of the investment, the long payback time scales and the complex stakeholder engagement process that will be required.

If London Borough of Newham chooses not to progress the development of a strategic heat network now or in the future, then decentralised energy opportunities should continue on a site specific basis. London Borough of Newham should use its planning powers to ensure that this take place.

3.7.2 Business Case Model

The high level business case assessment presented in this study assumes that a Project Company would own and operate the strategic heat network assets contracting with one or more major heat suppliers to purchase heat and selling this heat to a range of consumers within the Royal Docks and Canning Town.

The Project Company would invest in connections to the heat production assets[29], accumulators embedded in the network and connections to customers at development level. Ownership of the peaking plant could remain with individual developments, with the Project Company operating them and paying for fuel and running costs only.

In order to minimise exposure to price and supply risk the Project SPV would need to attract multiple generators to the scheme or retain a stake in its own generation assets (ie be vertically integrated with the Project Company). This would promote competition, provide redundancy and avoid dependency on any single supplier. There will be a trade-off for the Project Company between the number of assets it intends to connect to the scheme and scheme payback. Further work is required to establish the optimal trade-off. The Project Company could also consider operating as a Distribution Company (DISCo) in order to retain a greater proportion of the economic value of the scheme.

[29] It is unlikely that generators would take on the risk of financing the cost of connection without strong commercial agreements to ensure recovery of investments over reasonable timeframes.

The Project Company should expect to invest in ongoing managing the operation of the scheme to ensure flexibility to source the heat on the basis of minimum cost of generation at any time.

The Project Company could potentially operate the heat network in such a way to allow future trading of heat between suppliers and heat customers through bi lateral contracts. It could expect to charge Use of System Charges for supplying heat on this basis. Further work is required to establish the uplift that could be applied.

A range of commercial ownership models could potentially be adopted to take the scheme forward. London Borough of Newham's stake within the scheme could take one of a number of forms as described below.

1) fully owned by public sector
2) Public / private sector JV
3) fully owned by private sector by London Borough of Newham

It is beyond the scope of this study to identify a preferred procurement route and London Borough of Newham will need to evaluate the advantages and disadvantages of each approach as part of further study work, should it decide to take the scheme forward.

3.8 Funding Options

Funding options potentially available to the project are presented in Appendix 7 [24]. A combination of funding streams will be required due to the limitation of each singular funding stream in relation to the scale of investment required by the project and the timescales over which investment will be required.

London Borough of Newham should use borough-specific structures such as Community Infrastructure Levy (CIL) and S106 to support funding the project, both for establishing the Project Company and to help fund construction of the heat network.

CIL/S106 payments from plot developers can be expected to contribute only a limited amount towards the costs of the infrastructure. Consideration should be given to using CIL funds both from within the Royal Docks and Canning Town and from elsewhere across Newham in order to maximise funding opportunity.

The basis of charging CIL payments will need to be established. For developments connecting to the heat network, this could reasonably be levied on the basis of avoided costs of meeting compliance under the London Plan, London Borough of Newham policy and Zero Carbon Homes policy from alternative methods.

CIL/S106 could also be collected from other developments in the area, including potential waste to energy providers, whose contributions could be used to help establish a Project Company and funding construction of the heat network.

Funding through the London Green Fund is considered to be unlikely, due to the limited fund remaining. In principle the waste Urban Development Funds (UDF) could potentially support the development of a waste to energy plant.

Access to funding through the Green Investment Bank is likely to require aggregation of the project with other projects due to the minimum size of loans it offers and its preference for larger projects. Whilst the GIB has a pool of around £750m to lend in the next financial year, the terms surrounding the loan are not yet guaranteed and the GIB's appetite for investment in this type of project remains unclear.

The government's proposed Allowable Solutions framework will require developers of zero carbon homes to meet on-site requirements for Carbon Compliance whilst also accounting for the carbon emissions that are not achievable on site through Allowable Solutions. Where approved Local authority policies are in place, developers will be able to pay into a local Community Energy Fund accordingly. In the absence of an established policy, developers will pay into Private Energy Fund without any geographical constraint over where the carbon-savings are realised. London Borough of Newham should therefore develop Allowable Solutions policies within its local plan in time for adoption by 2016 in order to be able to offer developers a local Community Energy Fund delivery route and thereby capture the benefit of Allowable solutions

London Borough of Newham should also explore opportunities for funding through the Public Works Loan Board. Under the Local Government Act 2003, local authorities are empowered to use unsupported prudential borrowing for capital investment projects. The Act allows councils to exercise flexibility in deciding their own levels of borrowing based upon their own assessments of affordability. The framework requires Local Authorities to identify appropriate borrowing levels according to what they judge to be prudent, sustainable and affordable. The key principle involved is that the borrowing needs to be repaid from a revenue stream created by the development scheme or from other local authority funds such as the sale of assets. Local authority borrowing is mostly accessed via the Public Works Loan Board, whose interest rates are determined by HM Treasury in accordance with the National Loans Act. Local authorities can usually access borrowing easily and quickly using this approach and cost of borrowing has typically been less than 5% using this approach in the past. Although it can be arranged at highly competitive rates, Prudential Borrowing nevertheless remains 'on-balance sheet'. Bond financing offers an alternative off-balance sheet approach which not have recourse to the local authority in the event of default, but this would be more expensive to the Local Authority.

3.9 Risk Appraisal

A risk appraisal from the perspective of the project is shown below.

Description	Risk Owner	Suggested Mitigation Measures
Project unable to attract investment	Project	De risk project by:- • Securing HOD agreements with potential generators and major heat customers • using planning process to minimize remaining heat off-take risk, • Securing funding and low cost borrowing opportunities • Carrying out market testing and engage with potential project partners and investors early. • Creating conditions to attract waste to energy providers • De risking heat network construction and future expansion through detailed route planning, route safeguarding and implementation of Local Development Order • Working with GLA to safeguard land for location of peaking plant, accumulators • Secure funding through CIL/S106 and Allowable solutions to bring to the project • Consider owning a stake in the heat network, which could be divested later once the project is fully operational and generating positive incomes. • Consider providing a concession agreement under which a specific energy company has a monopoly for the supply of heat, or the installation and operation of the heat network
Project unable to secure long term commitment from generators to provide heat.	Project	Heat generators may not view this as core business therefore lack of management attention / low priority. Uncertainty in long term viability of core business for some generators. Electricity market requires short term approach to trading which may make generators unwilling to commit to providing heat. Even though return on investment may be possible risk averse heat generators may not be willing to engage Negotiate mutually acceptable commercial terms that compensate generators for lost revenues. Target generators with greater certainty around long term presence in Royal Docks Create conditions to attract waste to energy providers, preferably with long term contracts in place.
Project unable to secure adequate heat customer base	Project	Require new developments above a certain heat demand to safeguard to connect to heat network through the planning process. Engage with major stakeholders including Excel, UEL, London City Airport to secure them as customers for the scheme Require existing local authority buildings above a certain heat demand and within appropriate locations to conduct feasibility assessments and connect to heat network (or safeguard for future connection) as appropriate at time of refurbishment of heating system assets. Ensure all relevant stakeholders within LA (housing, education, health, waste etc) are engaged in process.

		Ensure new developments designed to a common standard to ensure compatibility for future interconnection to heat network. Disseminate information to developers through planning process. Manage heat pricing risk
Unacceptable project operating margin (heat production costs too high, operating overheads too high)	Project	Heat supply agreements with generators to cover fixed overheads and compensate for lost revenue from electricity production in return for commitment to supply under appropriate terms. Agreements to allow transparent pricing structure to compensate for changing market conditions. Project to retain operation of peaking plant and accumulators to reduce exposure to pricing risk and to optimize operating margins Network to be designed to maximize operational flexibility and accommodate future heat generators from beyond the Royal Docks. Plan for and engage with multiple generators to produce market competition for heat. Target generators with lowest cost heat and greatest certainty around future presence in Royal Docks. Consider role of Electricity Licence Lite to increase operating margins Consider appropriate commercial operating models including outsourcing operational responsibility for the heat network to specialist organisations. Engage with potential providers early and ensure scheme design philosophy reflects operational requirements. Ensure that commercial terms of any agreement adequately reflect provider's obligation to maximise operating profitability with appropriate reporting structures and penalty clauses in place.
Heat network construction and extension inhibited due to unforeseen physical / technical , commercial constraints Physical route for heat network unachievable or will cause major disruption to existing infrastructure corridors. Physical routing of heat network becomes more difficult in time due to developments in the interim period. Cost of routing network is higher than forecasted.	Project	Carry out heat network route feasibility assessment and verification, engage with landowners, Crossrail, DLR to de-risk, safeguard identified heat network route. Engage with market to identify construction costs (in particular for constrained locations such as Dock Crossing, DLR tunnel crossing. Develop interconnection requirements to OPDES and LTGHN Phase 1 to concept design stage. Safeguard booster stations / heat exchanger stations requirements (sizing and locations). Ensure heat network is designed to standards defined in GLA district heating manual, to ensure compatibility with OPDES and LTGHN Phase 1. Explore commercial basis on which safeguarding for future connection to LTGHN and OPDES can be funded if additional investment cannot be borne by the project.

Table 12: Risk Assessment

4. DELIVERY PROGRAMME

4.1 Heat Network Construction Phasing

The earliest heat on date for buildings connecting to the heat network could be 2017, based on construction of the heat network starting in 2015.

However, the earliest supply date for heat from Thames Water SPG is expected to be 2017, based on planned refurbishment of the asset under its 5 year plan. Similarly, the earliest supply date for any future facility at Beckton Waste Treatment Facility is also 2017, based on planning and procurement timescales and this could easily extend to 2020.

Based on the phasing of new developments identified in this study and the development timescales associated with establishing heat off-takes from Beckton SPG or a future waste to energy plant the Beckton Waste Management, a heat network constructed from Beckton to West Silvertown and Canning Town in a continuous phase is considered to be the most appropriate way forward.

The total construction timescale for the heat network is expected to be between 1 and 2 years and 2017 is considered to be the earliest date at which heat on could be provided to customers.

The development timescale for the heat network will ultimately depend on the phasing and volume of heat customers available to connect to the heat network. The timescales identified in Section 4.3 assumes that the developments would be available according to the development construction timescales identified in Appendix 1.

In the event that developments constructed in advance of the heat network are required to install gas CHP (which will depend on the provisions under the future building regulations), the phasing of the heat network may be set back by individual developments preferring to continue to operate existing CHP assets to the end of their useful life. The decision will be made on a case by case basis and will depend on the price of heat from the network relative to the cost of heat from existing energy centres on gas CHP. Based on the modelling carried out in this report, it is expected that the cost of heat from the network will be at least comparable and potentially lower than from existing operating energy centres.

4.2 Initial Clustering Opportunities

4.2.1 West Silvertown

There appears to be a financial case for an initial cluster heat network linking City Airport and the Tate & Lyle facility into the existing and new developments in West Silvertown, in advance of a heat network connection from Beckton. The investment required would be £6.6M, and the scheme would achieve an IRR of 7.2% over 25 years assuming a heat purchase price of 2.7 p/kWh from Tate & Lyle (which reflects the cost of heat generation from this facility) and selling heat to customers at the market price for heat. The NPV of the scheme would be £0.9M based on a 6% discount factor.

The project should not be constructed until the long term future of the facility has been secured. In view of the uncertainty around the long term future of Tate & Lyle, this project also is unlikely to come forward before 2016. The case for developing the project at this time would also depend on the opportunities coming forward at Beckton.

The investment proposition would also need to be determined in the context of the other opportunities and the heat sales that the connection could reasonably expect to generate over the longer term. Economic viability is more likely under the scenario that Beckton Waste Treatment Facility comes forward since this would deliver only around 68% of the total heat required into the heat network (leaving a larger proportion for Tate & Lyle to pick up a use as revenue to repay the investment). In the case that Thames Water SPG comes forward this would deliver around 91% of the total heat requirement for heat network.

Extension of a heat network eastwards from Tate & Lyle does not appear to be viable based on the initial assessment carried out. Further feasibility assessment should be carried out once heat mapping results have been obtained.

4.2.2 Canning Town and Custom House

There appears to be no case for developing a cluster network in Canning Town ahead of 2017, which is the date by which connection to Thames Water SPG or a waste to energy facility is considered to be possible. Individual developments coming forward before this time should install local community heat networks and safeguard to connect to the future heat network.

4.2.3 Royal Victoria.

The existing CHP at Excel is underutilised and could potentially become a catalyst for a local heat network in Royal Victoria. Initial modelling suggests that this could be a viable proposition, based on construction of a local heat network westwards towards Silvertown Way, picking up existing and new developments in the area including Siemens. The network would need to be dimensioned for future backfeeding to Excel according to the scenarios modelling elsewhere in this study.

There does not appear to be an opportunity to connect developments in Custom House in advance of 2017 due to the development timescales for Custom House.

The IRR for the investment would be 25% over 25 years based on a heat purchase price of 4.04[30] p/kWh. The NPV for the scheme would be £4.1M, based on a discount factor of 6% over 25 years. This includes an investment of 250K in the energy centre for distribution pumps, control upgrade and some M&E works but excludes reinvestment in the CHP plant, which we understand might also be required.

4.2.4 Royal Albert and Royal Albert Basin

There appears to be no case for developing a cluster network in Royal Albert or Royal Albert Basin ahead of 2017, which is the date by which connection to Thames Water SPG or a waste to energy facility is assumed to be possible. Individual developments coming forward before this time should install local community heat networks and safeguard to connect to the future heat network.

[30] Based on new medium sized commercial customers with 10% discount.

4.3 System Outline Phasing Plan

Based on the assumptions set out in Section 4.1, an outline phasing plan is presented.

Date	Programme
2012 ~ 2014	Set up steering group, conduct stakeholder engagements, develop business case, establish key heat suppler(s) and heat customers and enter into MOUs, identify preferred procurement and governance models. Further feasibility work undertaken around major heat supply assets, heat network route proving, additional existing buildings that could connect. Finalise business case for heat network, obtain business case sign off, set up contracts, establish Project Company, source funding and finance, procure scheme, conduct design of heat network and associated heat production connection arrangements.
2012 ~2017	Individual developments constructed with temporary energy centres as and when they are built out and safeguarded for future connection into heat network. Silvertown Quays and Thameside West temporary energy centres constructed (by developer) as future peaking plants and fitted out with sufficient capacity to meet demand for each development until full build out. Construction of initial cluster heat network linking Excel to developments to the west of Excel in Royal Victoria (if taken forward by Excel)
2015 – 2016	Heat network construction commences, Build out starts from Beckton and extends westwards to pick up indicated developments in Royal Albert Basin, Royal Albert and Newham Dockside. At this time local heat network within Royal Albert Basin also constructed. (Prior to this, new developments being fed by temporary boilers). As network is constructed, additional developments along route (not currently identified) prepare to connect where technically and economically feasible. No heat on at this time.
2016 - 2017	Heat network extended westwards into Royal Victoria, West Silvertown, Custom House and Canning Town picking up all indicated developments along route. If already constructed, initial cluster heat network at Excel is connected to heat network when development reaches vicinity Silvertown Way. As network is constructed, additional developments along route (not currently identified) prepare to connect where technically and economically feasible. No heat on at this time.
2017 ~ 2020	Heat production asset(s) connected to the heat network.

	Heat network Accumulator(s) installed. Heat network commissioned and heat supplied to all indicated developments. Peaking plants at Silvertown Quays and Thameside West adopted by Project Company, who operates them and may/may not elect to own them. Additional boiler capacity and network distribution pumps installed at this time. Initial cluster heat network at Excel is supplied from heat network at this time, with existing assets taken off line or retained as back up. If constructed, Tate & Lyle cluster network integrated into wider heat network, with Tate & Lyle continuing to supply heat into network, assuming commercial case remains. If temporary energy centres at Silvertown Quays and Thameside West equipped with gas CHP prior to this time, gas CHP plant scrapped or adopted as part of the scheme. Viability of this likely to depend on opportunity to retail electricity under Licence Lite, with associated income accruing to the scheme.
2020 ~ 2050	Ongoing reinvestment in heat network and major heat production assets, typically across a 15 to 20 year lifecycle. Additional opportunities to integrate heat from industrial heat pumps may come forward. Interconnection to OPDES and LTGHN dependent on timescales of developments and subject to acceptable commercial arrangements in place.

Table 13: Outline Phasing Plan

4.4 Progressing Opportunities to Secure Major Low Carbon Heat Sources

4.4.1 Thames Water

1. There appears to be significant potential for heat recovery from the Thames Water facility using the various heat production assets discussed in this report. In particular, heat from the existing SPG facility and the planned Enhanced Digestion Facility represent opportunities that should be pursued further.

2. The long term operation of the SPG facility is dependent on approval and funding from OFWAT under the upcoming AMP6 investment programme for 2015 to 2020. This will be determined in 2014/2015 and would take place during the period from 2015 and 2020. Providing that the ongoing commercial viability of the operation can be assured, the facility is expected to receive such approval and funding.

3. If Thames Water SPG facility is taken forward as a heat production asset in the network, the timescale for developing the heat network will be driven by the availability of Thames Water SPG facility, which is expected to be around 2017. At this time, there may also be a case for extracting heat from the consented enhanced digestion facility.

4. Further feasibility work should be carried out to determine the technical and economic viability for heat recovery at the Thames Water SPG facility. The various options for heat recovery through extraction and through waste heat recovery from the

condenser should all be explored, recognising that for large periods of the year heat at temperatures below 100 ^{0}C could be acceptable in the heat network.

5. Based on discussions with Thames Water, it is understood that heat recovery from the exhaust systems of the biogas engines may not be available, since this will be recycled into the AD process. However the requirement for this heat may be intermittent rather than continuous and further work should be undertaken to establish whether there would be an opportunity to capture and export this when not required by the facility.

6. Heat off-take from the existing desalination facility might be appropriate in the medium term if the future of the biofuel generators can be secured. However, it is recognised that the biofuel generators may ultimately be taken out of service if the fuel remains non-Rocable and if Thames Water is able to source comparable low carbon electricity from alternative local sources.

7. Thames Water has indicated an appetite for working with London Borough of Newham to further develop these opportunities. The project Steering group should engage with Thames Water to identify possible commercial arrangements and development timeframes and to identify technical, commercial and planning related risks and opportunities. As a regulated utility, Thames Water faces potential barriers to selling heat on a commercial basis under its regulated operations. These will need to addressed as part of the process. Based on discussions with Thames Water these are not expected to be insurmountable.

8. The longer term strategic opportunity of heat recovery from treated sewage effluent using large industrial heat pumps is potentially very promising given the volumes of heat that could potentially be recovered. Further work should be carried out to establish the technical and commercial viability and understand the associated costs in more detail.

4.4.2 Tate & Lyle

9. There appears to be continuing appetite at Tate & Lyle for developing opportunities to extract heat and supply it into the proposed heat network. However, there is uncertainty around the future operation of Tate & Lyle due to emerging EU policies surrounding sugar production. The future commercial viability of the plant remains uncertain and will not become clear until around 2014, when new EU legislation becomes determined.

10. Depending on the outcome of the impending EU Legislation, there may be a case for implementing heat recovery from process steam at the site. Due to present uncertainties in this respect, the business case for investment at this time is weak. A decision to take forward a local heat network based around the Tate & Lyle facility should therefore be deferred until 2014.

11. The Tate & Lyle facility continues to represent an attractive option for bringing forward a heat network in the Royal Docks, particularly if heat off-take opportunities with Thames Water or waste to energy opportunities do not materialise. The heat network proposed in this report has been safeguarded to back-feed from Tate & Lyle in the event that its long term future can be guaranteed.

12. London Borough of Newham should engage further with Tate & Lyle and work to secure the option of connecting the facility to the heat network in the event that the outcome of the impending EU Legislation is positive.

13. The carbon content and cost of the heat from the facility using natural gas for supplementary firing is only marginally better than gas boilers. A local heat network based around the Tate & Lyle facility should therefore ideally adopt biomass boilers to reduce the carbon content of the heat. The economic viability of this needs to be tested.

14. Heat recovery from heat pumps may be feasible as a longer term strategy if the longer term commercial viability of the site can be secured. It is not considered to be a commercially viable option at the present time.

4.4.3 Waste to Energy Opportunities

15. Waste to energy technology offers the potential to deliver significant quantities of low cost, low carbon heat. London Borough of Newham should aim to encourage and attract waste to energy providers to the Royal Docks. This would support London Borough of Newham's aspirations for delivering low carbon, affordable heat to the Royal Docks and Canning Town in the event that heat off-take opportunities with Thames Water or Tate & Lyle cannot be secured,

16. London Borough of Newham should go to the market for potential providers of waste to energy facilities and work to de-risk opportunities for potential providers to allow opportunities to come forward.

17. In the event that a suitable opportunity does not come forward at the Beckton Waste Management Facility, London Borough of Newham should aim to attract other energy from waste opportunities to the Royal Docks, for example at the safeguarded Thames Wharf site or at the former site of the planned Covanta facility. London Borough of Newham should identify and safeguard additional land to maximise opportunities for bringing forward waste to energy facilities in the short to medium term. The safeguarded Thames Wharf should be considered as a potential opportunity in this respect, as should the Tate & Lyle site, where the Covanta plant was formerly due to be sited.

4.5 Secondary Opportunities involving Other Heat Production Assets

4.5.1 Excel

18. The existing CHP at Excel is underutilised and could potentially become a catalyst for a local heat network in Royal Victoria. Initial modelling suggests that this could be a viable proposition, based on construction of a local heat network westwards towards Silvertown Way, picking up existing and new developments in the area including Siemens. The network would be dimensions for future back-feeding to Excel according to the scenarios modelling elsewhere in this study.

4.5.2 Other Gas Fired CHP Plants Embedded in the Network

19. The construction of new gas fired CHP plant is not recommended as part of the longer term strategic ambition for the heat network.

20. There is not likely to be a commercial case for connecting the gas fired CHP plants identified in Section **Error! Reference source not found.** into the heat network. The developments served by these gas fired CHP plants could be connected to the heat network at a time that coincides with the replacement of the CHP and associated energy centre assets, subject to the heat network being in place at the time and suitable commercial terms being agreed.

21. Individual developments coming forward are likely to adopt gas fired CHP locally, depending on development timescales in relation to the heat network and on whether provisions exist for deferral of CHP in lieu of connection to a future heat under future revisions to the building regulations.

4.5.3 20C facility

22. The 20C facility will have a continuous 1 MJ/s of surplus heat available from 2014. However, due to its location, there doesn't appear to be a case for connecting 20C to supply Royal Albert Basin or UEL in advance of other low carbon sources at Beckton

coming forward. The heat network would need to be sized for the future supply of far greater volumes of heat than the facility can supply and the payback from heat sales from 2OC would not support the construction of such a heat network in the event that the other opportunities failed to come forward in the future. The 1 MJ/s of available heat from the facility cannot support the construction of a heat network that would be sized for delivering heat from other low carbon sources at Beckton in the future.

23. Connection of the plant when a heat network has been constructed may be viable, particularly since the heat price would be very low. Further work is required to establish this once the development plans in relation to Beckton become clearer.

24. 20C could potentially supply heat to local customers beyond the study area. Further feasibility work would be required to establish the technical and commercial viability of doing so. Physical barriers to doing so could be significant however, give the DLR routing in the local vicinity.

4.6 Longer Term Supply Opportunities

25. As grid decarbonisation occurs over the coming decades, industrial heat pumps can be expected to play an increasing role in delivering low carbon heat into the area. The technology has been successfully applied in Scandanavia and can be expected to do so in the Royal Docks.

26. Applications in the context of the Royal Docks could include heat recovery from sewage effluent at Thames Water Beckton and heat recovery from industrial processes including data centres and hotels coming forward in the area of Wood Wharf to the west of the Royal Docks.

27. Whilst the present study has not included for heat recovery from this facility under the business case, the long opportunity for heat recovery from this technique is recognised and it is recommended that a strategic long term ambition to integrate the technology when the grid is sufficiently decarbonised is adopted. The opportunities are likely to be particularly interesting post 2025, when the grid has decarbonised to such an extent that they deliver sufficient carbon savings.

28. In the longer term, additional low carbon heat is potentially also available from
    - Recovery of flash steam at the Tate & Lyle facility using heat pumps
    - Connection of the heat network to OPDES and to LTGHN

29. Further feasibility work should be carried out to establish the technical and commercial viability of these opportunities.

5. DELIVERY STRATEGY

5.1 Next Steps for London Borough of Newham

1. London Borough of Newham needs to decide the role it wishes to play in bringing forward the heat network proposals identified in this report. London Borough of Newham may decide to adopt a planning role and leave construction of the heat network to the market to deliver. This approach risks failing to deliver the true scheme potential because of long term nature of the investment, the time scales for payback and the multiple stakeholder engagements required to drive the project forward. It is likely that, given the investment costs and payback periods involved, the market may consider the scheme too unattractive an investment proposition.

2. Alternatively London Borough of Newham may decide to take a proactive role in developing the project in order to secure a controlling stake in the project and facilitate development to its full potential. Through access to public funding and with control over heat off-take, it will be able to de risk leverage funds through CIL and other developer contributions and charging mechanisms (refer to Section 3.8).

3. In this scenario London Borough of Newham should:-

   - Work with GLA as well as other potential stakeholders to establish Steering Group and a project delivery group to take forward the recommendations of this report. The Steering Group should include the major heat suppliers identified in this report and the major developers within Royal Docks and Canning Town.

   - Build political support and commitment, oversee the development of strategies and policies to develop the scheme opportunities and to obtain budget commitment to take forward the schemes through feasibility, planning, design and procurement.

   - Conduct further feasibility work to establish the appetite amongst major stakeholders such as Thames Water, Tate & Lyle, potential energy from waste providers and Excel to engage in the project and establish the commercial basis on which this could be achieved. The steering group should work with stakeholders to commission feasibility studies to identify and de-risk technical, commercial and planning related barriers to implementation and establish a route to delivery for the potential heat supply opportunities.

   - Conduct further feasibility work to establish a customer base for the heat network, including engaging with the projects identified in this scheme as well as identifying further opportunities for connecting existing head loads not assessed so far under this study. This should draw on heat mapping work currently being carried out by GLA.

   - Implement the technical safeguarding measures identified in 5.4 of this report, including in particular safeguarding for the heat network route.

4. If London Borough of Newham decides to take the project forward, ownership, procurement and governance options will need to be appraised. London Borough of Newham should evaluate its ambitions for ownership in the infrastructure and engage with the market to identify potential strategic opportunities for partnering. A business and financial plan will then need to be developed. This will need to establish the preferred delivery structure, identify funding streams and develop a detailed business case in order to attract investment. Business planning support can be provided through the Decentralised Energy Project Delivery Unit (DEPDU) programme being operated by GLA.

5. In the longer term, the legal framework around the setting up a Project Company and buying and selling heat across the heat network will need to be established. This will need to include preparing and signing MoU's with potential joint venture partners and other major stakeholders involved in the scheme, formulating and signing-off legal contracts for these partners (including Development Agreements, Heat Supply Agreements, MoUs, etc),

5.2 Planning Related Recommendations

5.2.1 Policy and Strategy Documents

6. London Borough of Newham's strategy documents should be updated to reflect and safeguard for the proposals set out in this energy masterplan. The information should be disseminated to relevant departments within Newham Council and to external stakeholders, including local developers.

5.2.2 Safeguarding Connection of New Developments

7. London Borough of Newham should, through its planning powers, require developers to safeguard for future connection into the heat network.

8. Under current building regulations, developments can achieve compliance using gas only boilers. However, future updates of the building regulations are set to adopt the compliance targets set out under the government's zero carbon homes policy. This will require developments to install compliant technologies in order to meet the building regulations and may not include provision to defer installation of such technologies in lieu of connecting to a heat network in the future.

9. Dependent on the provisions of future updates to the building regulations, London Borough of Newham should consider allowing developers to defer installation of gas CHP and/or placing a requirement on developments to retrofit gas CHP within a fixed period, in the event that a heat network is not taken forward. If the strategy is adopted spatial planning of the energy centre should allow for this.

10. Subject to acceptable provisions under future updates to the building regulations, for developments being planned with a horizon of 5 years from the point at which the heat network is intended to be constructed in the vicinity of the development:
    - The development should be designed on the basis of their own CHP with standby boilers etc, and 'future-proofed' to connect into the heat network in the future.
    - Allowance should be made to defer investment (installation) in the CHP plant for five years to allow time for the heat network to be constructed and connected to the network. Once the network connection is made, the requirement to install CHP should fall away.
    - If the heat network connection is not made within five years and there is no reasonable prospect of doing so, then the development should be required to install a CHP plant. A section 106 obligation could be employed from the outset to ensure the CHP installation is carried out.
    - During the five year period, the development will be supplied with heat from its own heat-only boilers, noting that the environmental benefits will not accrue until either the heat network connection is made or CHP installed.
    - The developer could be given a planning condition o allow any 'freed-up' plant space resulting from the heat network connection to be used for more profitable purposes.

11. Subject to acceptable provisions under future updates to the building regulations, for developments being planned with a horizon of 10 years from the point at which the heat network is intended to be constructed in the vicinity of the development, the development should be required to install CHP and safeguard to connect to the heat network at the end of the economic life of the CHP plant

12. For developments being planned to come forward in the longer term (beyond 10 years) and at locations where they could connect into the heat network, the

developments should design for a district heating connection from the outset. This would entail a smaller plant room to accommodate the interfacing district heating heat exchanger and displace the requirement for heat-only boiler and CHP plant.

13. Future-proofing, where required, assumes a single plant room producing hot water for space heating and domestic hot water. Future-proofing involves providing 'tees' and isolation valves in the hot water headers to facilitate the connection of an interfacing heat exchanger at a later date. A space reservation should be provided for the heat exchanger, or it could be planned that the heat exchanger replaces a heat-only boiler at time of making the connection to the DE network. Provision should also be made in the building fabric to facilitate the installation of district heating pipework at a later time. External buried pipework routes should be safeguarded to a nearby road way or similar where connection to the main DE network would be made.

5.2.3 Aligning Waste and Energy Policy and Safeguarding for Waste to Energy Opportunities

14. From the perspective of developing low carbon energy infrastructure in the Royal Docks and Canning Town, London Borough of Newham should aim to encourage and attract waste to energy providers to the Royal Docks. This would support London Borough of Newham's aspirations for delivering low carbon, affordable heat to the Royal Docks and Canning Town

15. London Borough of Newham should seek to coordinate its energy and waste policies in order to create appropriate conditions to attract waste to energy facility providers in the Royal Docks.

16. London Borough of Newham should go to the market for potential providers of waste to energy facilities and work to de-risk opportunities for potential providers to allow opportunities to come forward.

17. London Borough of Newham should identify and safeguard additional land to maximise opportunities for bringing forward waste to energy facilities in the short to medium term. The safeguarded Thames Wharf should be considered as a potential opportunity in this respect, as should the Tate & Lyle site, where the Covanta plant was formerly due to be sited.

18. London Borough of Newham should use its planning powers to require potential waste to energy providers to implement CHP and place a requirement on them to commit to connecting to the heat network as part of their planning approval.

19. In relation to the Beckton Waste Management Facility, London Borough of Newham should ensure that bidders under the waste services procurement process consider the technical and economic impact of delivering heat into the heat network as part of their tenders

5.2.4 Adoption of Local Development Order

20. London borough of Newham should consider adopting a Local Development Order (LDOs) to facilitate deployment of the heat network. This will allow the London Borough of Newham to create a blanket planning permission to a future Project Company for constructing the heat network without the need for specific planning applications at each stage. This will remove some of the risk associated with planning consents, thereby facilitating expansion of the network and enabling any potential Project Company to roll out the network in response to market opportunity and without the delay and uncertainty which the planning process creates. In addition, the LDO would encourage local developers to adopt standards of materials and methods which comply with the terms of the LDO. This would assist in ensuring compatibility of local operators' systems with the wider heat network. Without an LDO in place, expansion of the proposed heat network could require many planning permissions to cover the works associated with the buried heat mains. This could generate a considerable number and cycle of planning applications for each extension of the network or any change to the approved network. The LDO could therefore potentially create considerable resource and cost savings in determining such

applications and in the longer term potentially realize additional savings in the form of avoided planning fees to developers.

21. It is our understanding that London Borough of Newham has been involved in discussions with London Development Agency (LDA), the London Thames Gateway Development Corporation (LTGDC) and the London Boroughs of Havering and Barking & Dagenham around the proposed LDO for the LTGHN. London Borough of Newham should pursue this with the intention of adopting the LDO through the relevant members' approval process.

5.2.5 Ensuring Correct Design Standards are adopted

22. The design of customer connections and internal heating systems for new developments will have a significant impact on the operational capacity and efficiency of the heat network.

23. Developers should be required to implement appropriate internal heating system designs to ensure flow and return temperatures are compatible with the heat network. London Borough of Newham, through its planning department should ensure that systems are being designed, installed and commissioned appropriately.

24. Recommendations contained in the final version of the technical standards for district heating being developed by GLA (draft [31]) should be adopted and disseminated to developers within the Royal Docks and Canning Town to ensure that heating systems are designed to a common standard, capable of future integration into the proposed heat network.

25. London Borough of Newham should require new developments to examine, and consider as part of any viability assessment, opportunities for district energy balancing, where new office and retail developments are planned close to residential heating demands.

5.3 Electricity Supply Arrangements

26. Electricity Licence Lite offers an opportunity for locally generated electricity to be retailed to local consumers at higher prices than generators could attract through wholesaling. The additional value realised through retailing could potentially be recycled into the scheme in the form of lower heat prices.

27. The project steering group should engage with potential future generators to explore appetite and opportunities for establishing a Licence Lite and possible commercial arrangements for securing any benefits arising for the scheme. The project steering group should also engage with GLA and leading local authorities in the field to explore a role that London Borough of Newham might play in such an arrangement.

28. The impact of electricity retailing on scheme economics should be tested once a commercial model has been developed and once the scale of potential electricity supply becomes clearer.

29. Local generators that could potentially benefit from trading under a Licence Lite would include potential future waste to energy providers and Tate & Lyle.

5.4 Technical Safeguarding Measures

5.4.1 Anchor heat loads

1. London Borough of Newham, through its housing stock, schools and other municipally owned buildings has a considerable quantity of heat demand within and beyond that study area that could further increase the viability of the heat network. The viability of connecting these has not been assessed as part of the present study.

2. There are also a number of private non-municipally owned buildings within the study area that could also connect to the proposed heat network. The viability of connecting these has not been assessed as part of the present study.

3. London Borough of Newham should adopt a safeguarding position of connecting its buildings into the heat network at the time that their heating assets are due for refurbishment. Feasibility assessments should be carried out on a case by case basis to establish technical and economic viability.

4. London Borough of Newham should safeguard for the connection of non municipally owned buildings into the heat network at the time that their heating assets are due for refurbishment through the planning process, subject to the technical and commercial viability of connecting them.

5.4.2 Safeguarding for Physical Infrastructure Assets

5. The project phasing strategy requires new mixed use residential developments to be designed with local temporary energy centres feeding community heating networks. These should be safeguarded to connect into the heat network in the future and to retrofit gas CHP in the event that the heat network does not come forward.

6. Energy centres should be designed to run on dual fuel boilers and should be fitted out with in a modular fashion in line with the construction phasing of the developments.

7. Boilers should be sized to supply the individual developments only until the point of future interconnection with the heat network (with provision for redundancy etc). Space provision for additional boilers in the event that the heat network is never built out should also be provided (along with space provision for retrofitting CHP as discussed above). The developments will be required to connect to the heat network or retrofit gas CHP once around 60% of the development has come forward in order to comply under CSH policy.

8. The energy centres at Silvertown Quays and Thameside West should be retained for use as peaking plant at the time that the heat network is constructed. These locations have been selected on the basis that they are located on land owned by LDA, which should considerably facilitate the safeguarding process. These should also be safeguarded to connect into the heat network and to retrofit gas CHP in the event that the heat network does not come forward. The boiler plant for these should be specified for future operation as peaking plant within heat network. Pressure and temperature ratings should be specified accordingly.

9. The satellite energy centres and associated communal heat networks should be developed and funded by the developers taking forward each scheme. There should be provision within the terms of the planning agreement to allow any Project Company the opportunity to adopt (or take on the operation of) the satellite energy centre assets (subject to appropriate commercial terms being agreed) at the time that the heat network comes forward.

10. London Borough of Newham, in collaboration with GLA, should safeguard for the installation of accumulators adjacent to the energy centres/peaking plant at Silvertown Quays and Thameside West. These should be installed at the time of connection into the heat network.

5.4.3 Future Interconnection to OPDES and LTGHN

11. The business case for safeguarding for a wider area heat network needs to be explored to better understand the basis of the wider strategic opportunity that this might provide.

12. London Borough of Newham should safeguard for connecting the heat network to OPDES and LTGHN at a future date, with appropriate land allocation for interfacing connections / booster pumping stations at each end of the Royal Docks heat network.

Further hydraulic analysis will be required to verify the size and physical location of these interface stations, once clearer commercial proposals are in place. London Borough of Newham should engage with relevant stakeholders (GLA, Cofely, ATO Power, Biossence) to pursue these opportunities.

5.4.4 Heat network Route Planning

13. The choice of routes options identified in Section 2.4 of this study are not supported by utility surveys. When the project is taken to the next level of detail, a utility survey will be required. In the first instance this should include the main utilities as follows: Electricity, water, sewage, drainage, major telecoms, gas. Leading up to the design phase it is important that a more detailed survey covering all services, including main telephone and data transmission cables should be included. The initial survey should focus on verifying the proposals identified with a detailed investigation of the constraints along the route posed by the main utilities. An important part of the survey will be to establish the depths in which services are buried. It is information which is often underestimated but is crucial to both costs and construction programme.

14. When considering a crossing between the strategic heat network pipes and e.g. sewers or gas mains a cross section of the pipe route is needed to assess the options. In cases where information is limited or thought to be misleading or the relocation of other services will be difficult and time consuming, it is recommended that an observation hole is dug to identify and precisely locate these services. This must take place as early as possible during the design phase.

15. This more detailed survey should result in a map with cross sections showing both the strategic heat network pipe line and other services along the route. The map will be an important tool because it will assist the design engineer and the contractor in taking the right decisions, not only during the design phase but also during construction.

16. Construction of the heat network will need approvals and wayleaves from the major stakeholders and landowners within in the area. A number of other issues such as nature conservation, archaeological inheritance, etc. may cause concern in relation to the route. Consultation with the appropriate bodies will be required.

17. Based on a visual survey of ordnance survey maps and the Parameters for Development [8], the heat main is likely to pass through the following land ownership types:

Public land: The public land (both public highways and local authority owned land) would fall under the jurisdiction of the local planning authority (i.e. the Borough). The Highways Agency's jurisdiction it not expected to extend into the area under investigation.

Local authority and LDA owned: Given that London Borough of Newham and LDA are broadly in support of the heat main and their continual involvement in the implementation of this heat main, the applications for installation of the heat main should be un-impeded if the LA's are in agreement.

Private commercial In order to run the main across privately owned land (both commercial and residential) landowners would have to give permission and this would have to be formalised within a wayleave agreement. Negotiation could be a lengthy process and would potentially involve some form of reimbursement for the landowner.

However, the current route predominantly only enters private land where the heat main crosses to enter for connection of customer's (i.e. to access a local energy centre on a new development), and it is anticipated that it will be possible to negotiate a wayleave as part of the heat supply agreement.

DLR/Network Rail owned land: Any work within a 6.5 m exclusion zone of any DLR/crossrail asset or land will require a design study to be undertaken to demonstrate that the proposed activities would have no impact on the rail systems. Approval by DLR and/or Crossrail could potentially be a lengthy and expensive procedure. It is recommended that DLR and/or Crossrail are involved early in the design process to minimise possible delays and costs.

18. Depending on the route option taken forward, Crossrail development timescales offer a potential opportunity to safeguard pipework routes and thereby reduce longer term construction cost and levels of disruption. Engagement with Crossrail is recommended to test the viability for doing this.

19. The project will need to be procured through OJEU, with appropriate legal, commercial and technical Tender packages being prepared.

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APPENDIX 1 ENERGY DEMAND FORECASTS

Load name	Demand	Elec	Heat	Area	Node
		[MWh]	[MWh]		
Silvertown Quays 4,930/5 residential units	2015	2,720	2,859	West Silvertown & LCY	s21
Silvertown Quays 4,930/5 residential units	2019	2,806	1,946	West Silvertown & LCY	s21
Silvertown Quays 4,930/5 residential units	2023	2,806	1,946	West Silvertown & LCY	s21
Silvertown Quays 4,930/5 residential units	2027	2,806	1,946	West Silvertown & LCY	s21
Silvertown Quays 4,930/5 residential units	2031	2,806	1,946	West Silvertown & LCY	s21
Silvertown Quays 4,320/2 m2 retail (A1)	2015	0	50	West Silvertown & LCY	s21
Silvertown Quays 5,570/2 m2 restaurants (A3/A4/A5)	2015	1,279	561	West Silvertown & LCY	s21
Silvertown Quays 7,800/2 m2 office and employment (A2 + B1)	2015	258	130	West Silvertown & LCY	s21
Silvertown Quays 7,600/2 m2 flexible commercial (A1 – A5/B1)	2015	330	103	West Silvertown & LCY	s21
Silvertown Quays 18,925 m2 leisure incl 11,000 m2 aquarium	2015	1,145	2,352	West Silvertown & LCY	s21
Silvertown Quays 8,000 m2 hotel (300 bedrooms)	2015	430	1,005	West Silvertown & LCY	s21
Silvertown Quays 8,000/2 m2 community (incl library, school health centre)	2015	62	263	West Silvertown & LCY	s21
Silvertown Quays 4,320/2 m2 retail (A1)	2022	188	58	West Silvertown & LCY	s21
Silvertown Quays 5,570/2 m2 restaurants (A3/A4/A5)	2022	1,279	561	West Silvertown & LCY	s21
Silvertown Quays 7,800/2 m2 office and employment (A2 + B1)	2022	258	130	West Silvertown & LCY	s21
Silvertown Quays 7,600/2 m2 flexible commercial (A1 – A5/B1)	2022	330	103	West Silvertown & LCY	s21
Silvertown Quays 8,000/2 m2 community (incl library, school health centre)	2022	62	263	West Silvertown & LCY	s21
Buhler Sortex - completed industrial development of about 100,000 sqft	2015	469	1,359	RAB & UEL	s19
Royal Quay - completed residential development of about 450 units	2015	1,552	1,631	RAB & UEL	s19
Gallions Quarter - Residential part - the LDA is finalising a development agreement with Notting Hill for a residential/mixed use scheme including about 700 units and retail/employment space. Subject to planning should be on site 2013.	2015	2,414	2,537	RAB & UEL	s19
Gallions 3A - One Housing Group has recently been refused planning permission for a 150-unit residential scheme	2015	517	544	RAB & UEL	s19
Gallions 3B - 3-acre residential development plot.	2020	648	449	RAB & UEL	s19
Armada 2 - 7-acre industrial development plot.	2020	148	308	RAB & UEL	s19
Great Eastern Quay (formerly Ivax Pharmaceuticals) - proposed residential/mixed use scheme of (I think) about 1000 units being worked up by Notting Hill Housing Trust. Subject to planning should be on site 2013	2015	1,724	1,812	RAB & UEL	s19
Great Eastern Quay (formerly Ivax Pharmaceuticals) - proposed residential/mixed use scheme of (I think) about 1000 units being worked up by Notting Hill Housing Trust. Subject to planning should be on site 2013	2022	1,778	1,234	RAB & UEL	s19
Gallions 1	2015	2,009	0	RAB & UEL	s19
Excel	1900	28,238	16,037	Excel & Royal Victoria	Excel
London City Airport	1900	3,279	1,862	West Silvertown & LCY	London City Airport
Newham Dockside - Building 1000	1900	6,432	3,653	Royal Business Park	s31
Existing Residential East - west	1900	990	2,345	West Silvertown & LCY	Existing Residential East - west
University of East London	1900	10,375	5,892	RAB & UEL	UEL
University of East London Extension	2027	955	958	RAB & UEL	UEL
Thames Barrier Park East	2013	1,843	1,278	West Silvertown & LCY	Thames Barrier Park East
Thames Barrier Park East	2020	879	609	West Silvertown & LCY	Thames

					Barrier Park East
Minoco Wharf (Ballymore)	2015	1,848	1,282	West Silvertown & LCY	s22
Minoco Wharf (Ballymore)	2018	1,848	1,282	West Silvertown & LCY	s22
Minoco Wharf (Ballymore)	2021	1,848	1,282	West Silvertown & LCY	s22
Minoco Wharf (Ballymore)	2024	1,848	1,282	West Silvertown & LCY	s22
Minoco Wharf (Ballymore)	2027	1,848	1,282	West Silvertown & LCY	s22
Royal Business Park -Retail	2015	0	268	Royal Business Park	s31
Royal Business Park - Office	2015	2,560	1,319	Royal Business Park	s31
Royal Business Park - Office	2018	2,480	1,247	Royal Business Park	s31
Royal Business Park - Office	2021	2,480	1,247	Royal Business Park	s31
Royal Business Park - Office	2024	2,480	1,247	Royal Business Park	s31
Royal Business Park - Office	2027	2,480	1,247	Royal Business Park	s31
Thames side West - Residential	2015	3,664	3,851	South Canning Town & S08	s08
Thames side West - Commercial	2015	1,845	575	South Canning Town & S08	s08
Thames side West - Residential	2020	3,779	2,621	South Canning Town & S08	s08
Thames side West - Commercial	2020	1,845	575	South Canning Town & S08	s08
Thames side West - Residential	2025	3,779	2,621	South Canning Town & S08	s08
Thames side West - Commercial	2025	1,845	575	South Canning Town & S08	s08
Royal Victoria West - Siemens	2015	208	286	Excel & Royal Victoria	s30
Royal Victoria West - Cable car	2015	1,577	0	South Canning Town & S08	s30
S16: Silvertown Way East (Canning Town Area 12)	2020	320	222	South Canning Town & S08	s16
S17: Silvertown Way West (Canning Town Area 8)	2020	1,778	1,234	South Canning Town & S08	s17
S18: Limmo site (C12) Canning Town Area 9 (Custom House & Canning Town).	2020	640	444	South Canning Town & S08	s18
S18: Limmo site (C12) Canning Town Area 9 (Custom House & Canning Town).	2025	711	493	South Canning Town & S08	s18
Kier Hardie Primary School, (Fife Road) Edwin Street (Canning Town Area 3)	2016	1,421	1,493	North Canning Town	s15
S13: Manor Road Park (Formely Canning Town Regeneration Site 20	2022	356	247	North Canning Town	s13
S13: Manor Road Park (Formely Canning Town Regeneration Site 20	2026	889	617	North Canning Town	s13
S14: Canning Town Central, (Canning town areas 1a, 1c and 7)	2017	1,003	696	North Canning Town	s14
S14: Canning Town Central, (Canning town areas 1a, 1c and 7)	2022	1,341	930	North Canning Town	s14
S15: Canning Town East (Formerly Canning Town Areas 11, 2, 3 and 1b)	2019	1,601	1,110	North Canning Town	s15
S15: Canning Town East (Formerly Canning Town Areas 11, 2, 3 and 1b)	2022	1,601	1,110	North Canning Town	s15
S15: Canning Town East (Formerly Canning Town Areas 11, 2, 3 and 1b)	2026	2,134	1,480	North Canning Town	s15
ExCeL Park Inn Hotel	2015	695	1,624	Excel & Royal Victoria	Excel
Excel phase 2a	2015	873	2,039	Excel & Royal Victoria	Excel
26 - 34 Tidal Basin Road	2015	935	2,185	Excel & Royal Victoria	s30
26 - 34 Tidal Basin Road	2015	605	419	Excel & Royal Victoria	s30
Site Wc8 (The Pumping Station)	2015	605	419	Excel & Royal Victoria	s30
Rathbone Market (site 1a)	2015	934	982	North Canning Town	s14
Rathbone Market (site 1a)	2017	1,071	743	North Canning Town	s14
S28: Custom House (Formerly Canning Town Regeneration Sites 6 & 19.	2017	356	247	Custom House	s28
S28: Custom House (Formerly Canning Town Regeneration Sites 6 & 19.	2022	1,060	735	Custom House	s28
Canning Town Regeneration Site 4	2021	679	471	Custom House	SPD4
Canning Town Regeneration Site 5	2022	1,138	790	Custom House	SPD5
Lea Mouth Peninsula	2020	1,778	1,234	South Canning Town & S08	P
Lea Mouth Peninsula	2025	1,778	1,234	South Canning Town & S08	P

Table 14: List of Existing Sites and Developments Opportunities Analysed in the Study

Year	Domestic Hot Water	Space Heating
	[kWh]	[kWh]
2015	20,780,124	40,741,929
2016	21,705,959	41,309,376
2017	23,205,720	41,494,740
2018	24,471,373	42,757,992
2019	27,191,584	43,094,198
2020	33,343,934	44,638,173
2021	35,028,993	45,953,262
2022	39,795,772	47,346,866
2023	41,527,853	47,560,943
2024	42,793,506	48,824,195
2025	46,721,170	49,819,935
2026	48,587,637	50,050,622
2027	51,776,891	52,294,032
2028	51,776,891	52,294,032
2029	51,776,891	52,294,032
2030	51,776,891	52,294,032
2031	53,508,973	52,508,110

Table 15: Space Heating and Domestic Hot Water Consumption Growth Projections

Year	Diversified peak
	[kW]
2015	36,446
2016	37,243
2017	37,972
2018	39,608
2019	40,929
2020	44,641
2021	46,481
2022	49,177
2023	50,019
2024	51,655
2025	54,034
2026	54,941
2027	58,114
2028	58,114
2029	58,114
2030	58,114
2031	58,955

Table 16: Space Heating and Domestic Hot Water Diversified Demand Growth Projections

Year	Electricity demand
	[kWh]
2015	82,413,050
2016	83,833,626
2017	86,263,023
2018	90,591,524
2019	94,997,874
2020	106,812,971
2021	111,820,850
2022	121,210,602
2023	124,016,324
2024	128,344,825
2025	136,458,583
2026	139,481,990
2027	147,571,214
2028	147,571,214
2029	147,571,214
2030	147,571,214
2031	150,376,936

Table 17: Electricity Consumption Growth Projections

Notes

1) Where development quantums have been provided, demand and consumption profiles have been calculated from relevant benchmarks.
2) Where development quantums have not been available, demand and consumption profiles have been taken from previous work carried out [2] and from information obtained through engaging with stakeholders.

APPENDIX 2 ROUTE OPTIONS APPRAISAL

Route Section	Route Option	Key Constraints
Section 1 East of Tate & Lyle	Three route options have been identified. None has been identified as a preferred option. Complexity along this route is expected to be high. For further information refer to [21].	The key constraints identified for this section of the route are:- • utility congestion • proximity to existing/proposed Crossrail railway corridor • traffic management issues • narrow carriageways and footpaths
Section 2 Tate & Lyle to LCA	A single route has been identified in this area. Complexity along this route is expected to be medium. For further information refer to [21].	No major constraints expected other than traffic management during construction.
Section 3 Tate & Lyle to Connaught Bridge	Three route options have been identified. Option 3a is considered to be most feasible. Complexity along this route is expected to be medium. For further information refer to [21].	There are potential ecology issues as a result of removal of trees and shrubs during construction. Traffic management issues may be significant due to the narrow road and the significant volume of large vehicles.
Section 4 Connaught Bridge to Silvertown	Three route options have been identified. Option 4a has been identified as the preferred option. Complexity along this route is expected to be medium/low. For further information refer to [21].	Detailed co-ordination around the Pontoon Dock structure will be required. Coordination works within the protection zone and under the raised section of the DLR would need to be agreed with DLR. Crossing of the North Woolwich Roundabout may be difficult due to traffic management issues.
Section 5 Connaught Bridge to dock crossing	Two route options have been identified[21]. Option 5b has been identified as the preferred route. Complexity along this route is expected to be low. For further information refer to [21].	The key constraints identified for this section of the route are:- Utility constraints at Connaught Bridge Road embankment or the path between LCA and the road bridge. Traffic management issues are expected at the Airport Roundabout crossing. Works are close to, or within highway structures, which will require consultation with the Highway Authority. Low headroom below the underpass may present construction and maintenance related issues.

Section 6 Dock crossing	Two options have been identified. Neither option has been identified as a preferred option. This area is considered to have a high level of complexity. Both options propose laying pipework on the dock bed. For further information refer to [21].	The dock wall structures will affect the location of the crossing and the form of the proposed shaft and tunnel construction. The existing Connaught tunnel and the existing service tunnel forms a vertical barrier along the dock bed. The existing bridge mechanisms for both the road and the foot bridge will affect the location of the crossing. There is a high risk of encountering unknown obstructions as a result of its historic industrial past in this area. Existing utilities may cross the docks in this location and will complicate the crossing if so. Restricted headroom working under the bridge is likely to increase cost and may require non standard installation practices.
Section 7: Dock Crossing to ExCeL	A single route has been identified in this area. Complexity along this route is expected to be Low-Medium. For further information refer to [21].	There are likely to be moderate traffic management and utility constraint issues along this section of the route.
Section 8 Dock crossing to Galleons Reach	Three options have been identified, with varying levels of complexity. Option 8a is considered to have the lowest complexity and has been identified as a preferred option. For further information refer to [21].	The viability of route through Royals Business Park and UEL campus has not been tested. Existing utilities may present an issue.

Table 18: Royal Docks Route Options Appraisal

Route Section	Route Option	Key Constraints
Transmission Branch to Silvertown Way from Connaught Bridge	<u>Option 1</u> Under Option 1 the route would run along Festoon Way and Sandstone Lane along the southern boundary of the DLR, picking up Excel and the hotel planned along Festoon Way. It appears that there is significant available space between the ExCeL building and the DLR tracks and it is likely that a feasible route could be found in this area. Such a route could either run adjacent to Seagull Lane itself or could potentially run to the north Seagull Lane along the land adjacent to the DLR. A 5m protection zone extends beyond the outer extents of the DLR structures. Consultation with DLR indicates that in principle they could accept pipework running in this zone, subject to approving the pipe specification and construction details. Landowner approval would also be required. The route would then continue in the vicinity of Seagull Lane and extend westwards beyond Excel picking up additional existing and planned demands including Site Wc8 (The existing Pumping Station for which an application has been submitted for the development of a 24-storey residential tower and commercial space). The existing apartments (Alaska, Atlantic, Oceanis) and Crowne Plaza Hotel could also be connected at this point. The route into Canning Town would then follow DLR westwards, crossing the DLR at high level or beneath the railway at a suitable crossing point to access the eastern boundary of the DLR route prior to the heavily congested DLR junction. Above ground sections of pipework would be installed as a steel-in-steel pipe system. The route would then continue north into Canning Town to the west of Peto St before joining Silvertown Way.	The key constraints identified for this section of the route are:- . Routing of pipework across the DLR tracks in the vicinity of Silvertown Way. Discussions with DLR indicate that crossing the DLR at high level is likely to be acceptable, subject to obtaining approvals from DLR and permissions from landowners within the exclusion zone. Three options exist for crossing at high level. All options would present difficulties in construction and in terms of access for ongoing maintenance, Permissions would be required from DLR to access and work in the area as would approval and wayleaves from landowners. The preferred option is to use the Silvertown Way road bridge crossing running above Victoria Dock Rd. Construction of a new structure is likely to be prohibitively expensive due to the specification to which it would need to be designed, whilst an alternative crossing point at a footbridge to the east of Silvertown Way is considered to be too lightweight a structure to carry the strategic heat network pipework. Figure 29: indicates how pipework could potentially be supported on the Silvertown Way bridge crossing. A number of issues would have to be dealt with in the technical design, such as the weight and the thermal expansion of the pipes, structural integrity of the bridge, the pipe run to and from the bridge itself, the anchoring of supports and the requirement for future access to inspect both the bridge construction and the pipes. This will need to be verified through detailed study and design work. It is not clear whether the bridge is already used to support cables and whether there would be space to carry the pipes. To cross the rail lines, pipework could be buried under the railway tracks using a directional drilling technique (also known as 'mole-ing' or pipe jacking) under the tracks. This would be expensive as working hours are usually very restricted. The decision to install the heat main under or over the railway line would be the result of value engineering and a detailed design process including consultation with DLR, Crossrail and Network Rail.

		Tunnelling beneath DLR and Crossrail could also be considered. However, there are a number of issues associated with tunnelling works which generate additional risk to cost, construction programme and overall route feasibility. Again, these would need to be assessed in greater detail at the next stage.
Transmission Branch to Silvertown Way from Connaught Bridge	<u>Option 2</u> Option 2 would involve routing the pipework northwards across the dock crossing to the west of Connaught bridge, crossing Lynx Way and Royal Albert Way before joining Victoria Dock Rd. At this point it would be routed across Victoria Dock Rd and would run westwards along Victoria Dock Road towards Custom House. Beyond Custom House, the route would continue to Royal Victoria station and cross beneath Silvertown Way, picking up the route to Silvertown Way along Peto St or Caxton St North as per Option 1. Adopting route option 2 would allow routing of the strategic heat network line to pick up new developments proposed on land adjacent to Ashburton Grove Woods and Freemasons Road, land to north of Coolfin Road and Boreham Avenue and land at Custom House and East of Freemasons Road. This option would require routing the pipework southwards across the Silvertown Bridge to access developments to the south of DLR tracks, including Excel, Limmo and Lea Mouth Peninsula.	The entrance of the crossrail tunnel in the vicinity of Royal Albert Way presents a potential barrier. Vertical tunnel clearances would need to be established to verify this. Refer to Figure 28 Routing the network along Royal Albert Way and access through Royal Albert Way in the vicinity of Custom House station and Royal Victoria stations may presents challenge in terms of access for construction, utility congestion and traffic management. A further option of routing the pipework through back streets adjoining Freemasons Rd into Canning Town (via Radland Rd or Appleby Rd) in order to avoid traffic management issues along Royal Albert Way may also be possible. However this may cause unacceptable disruption to local residents in relation to parking restrictions and utility congestion.
Transmission Branch to Silvertown Way from Connaught Bridge	<u>Option 3</u> Option 3 would involve routing the pipework north across the dock crossing to the west of Connaught bridge, crossing Lynx Way and Royal Albert Way. At this point it would be routed adjacent to the southern side of Victoria Dock Rd, to the north of the proposed Crossrail route towards Custom House. Beyond Custom House, the route would continue to Royal Victoria station crossing Royal Albert Way in the vicinity of Tidal Basin roundabout, thereafter picking up Royal Albert Way and crossing beneath Silvertown Way, to pick up the route along Silvertown Way from Peto St as per Options 1 and 2.	Custom House station presents a potential obstacle, due to the number of existing structures that would need to be avoided. It might be possible to route the pipework along Royal Albert Way, bypassing the station, to avoid this. The option would present difficulties in construction and for ongoing maintenance, requiring permissions from Crossrail, DLR to access and work in the area. Approval and wayleaves would also be required from landowners within the exclusion zone. Any route running through Crossrail's exclusion zone would potentially cause disruption to Crossrail services in relation to ongoing maintenance requirements of the heat network. This route would avoid many of the traffic management issues associated with Option 2 and, if constructed prior to 2018, could be carried out with little disruption to crossrail. However, even if the strategic heat network line is constructed earlier than the Crossrail project, there are likely to be uncertainties about the Crossrail project that could have a significant impact on the design of the pipe line, making it more expensive. There are likely to be utility constraints along this route.

		Crossing Royal Albert Way is likely to cause traffic management issues. Horizontal directional drilling could be considered to avoid disturbances to traffic and at the same time giving the pipes a higher level of protection at the road crossing.
Silvertown Way to Canning Town	The route into Canning Town and Custom House from Victoria Dock Rd would run between the eastern boundary of the northbound DLR and Peto St North, following a route behind the proposed Silvertown Way West development. This would avoid disruption along the majority of Silvertown Way. A short section of the route would need to travel along Silvertown Way (unless private development land could be crossed) but it could then divert westwards again behind the bus terminal at Canning Town before heading north towards Newham Way. The new developments to the east of Silvertown Way (connections and Rathbone St , the land between A13 and Tant Avenue 2, Keir Hardie School and Land to the East, Silvertown Way and Rathbone St, East of Rathbone Street) would be picked up from a branch connection running across Silvertown Way (eg in the vicinity of Hallsville Rd) with relatively minor disruption. Access north to the developments north of Barking Way A13 at Wharfside Road and the land between Bidder St and Stephenson St would require crossing a major roundabout beneath Newham Way. This appears to rest on a raised deck, the depth of which is unclear. Further work is required to establish the viability of routing pipework through this area. The simplest route appears to be to route the pipework to the west of the roundabout, beneath the raised section of the Barking Way flyover to pick up connections to Manor Rd and Barding Road disruption route, since this would minimise traffic disruption.	The bridge crossing beneath Silvertown Way may have congested buried services. Routing pipework along Silvertown Way and crossing Silvertown Way to access the east under the Peto St option is likely to cause traffic management issues. Horizontal directional drilling could be considered to avoid disturbances to traffic and at the same time giving the pipes a higher level of protection at the road crossing. There are likely to be utility constraints along the route from Silvertown Way into Canning Town Routing piepwork across the roundabout beneath Barking Way is likely to present significant traffic management issues. The section appears to be on a raised deck, which may present vertical clearance issues. Access across the DLR into Wharfside Road would require suspending pipework from the bridge along the B164 Barking Road. This would present difficulties in construction and for ongoing maintenance, requiring permissions from DLR to access and work in the area.
Silvertown Way to Limmo and Lea Mouth Peninsula, Thameside West, S30 and Excel	Routing pipework to the major opportunity zones at Limmo and Lea Mouth Peninsula would require a branch connection from the main strategic heat network line in the vicinity of Silvertown Way. Under Option 1 of the Transmission Branch to Silvertown Way from Connaught Bridge, this would require connection prior to routing the strategic heat network line north across the DLR tracks (in the vicinity of the roundabout adjoining Tidal Basin Road beneath Silvertown Way). For options 2 and 3 of the Transmission Branch to Silvertown Way from Connaught Bridge, this would require routing a branch	The Silvertown Bridge crossing and the Lower Lea bridge crossing would present similar issues to those pertaining for option 1. However, due the reduced diameters required for the branch sections, this is less likely to present a significant obstacle, particularly since twin pipe could be adopted along restricted sections if necessary. Construction of a new structure to cross the DLR at high level is likely to be prohibitively expensive due to the specification to which it would need to be designed. An alternative crossing point could potentially be the signalling structure across the DLR tracks but this appears to be too lightweight a structure to carry the pipework. Permission/wayleaves would be required from DLR in either case.

	connection south across the Silvertown bridge crossing from the junction of Silvertown Way and Victoria Dock Rd. Access to Limmo and Lea Mouth Peninsula could then take one of two options: • Use the Low Lea Crossing road bridge to support the pipes to gain access to both Limmo and Lea Mouth Peninsula. • Access Limmo by crossing above or beneath the DLR and access Lea Mouth Peninsula by crossing Bow Creek with submerged steel in steel pipework. Under options 2 and 3, access to Thameside West, S30 and Excel would follow a route eastwards, from the branch connection to Limmo and Lea Mouth Peninsula. Under option 1 of the Transmission Branch to Silvertown Way from Connaught Bridge, these sites would be supplied from the Connaught Bbridge Crossing. An alternative sub option could be to connect Excel from the Transmission Branch to Silvertown Way from Connaught Bridge (Option 1) by tunneling beneath DLR at suitable point between Custom House and Royal Victoria DLR stations.	As per Option 1, cross the DLR would present difficulties in construction and for ongoing maintenance, requiring permissions from DLR to access and work in the area. Approval and wayleaves would be required from landowners within the exclusion zone. To cross the rail lines at low level (for all options described), the same issues would pertain as per option 1. However, due the reduced diameter of required the branch sections, this is less likely to present a significant obstacle in terms of cost or in technical terms. Access to Lea Mouth Peninsula across Bow creek would require submerging the pipework and routing it along the bed of the creek. Shafts may need to be constructed on both sides of the creek so that the pipework can be installed down to creek bed level. Effective anchoring of the pipework to the bed of the creek would be required to prevent damage due to static loading variations arising from changing water levels. The ground stability across the creek is likely to be poor, further complicating anchoring arrangements.

Table 19: Royal Docks to Canning Town Route Options Appraisal

Route Option	Route Option	Key Constraints
University of East London to Thames Water	Option 1 The route would run along University Way parallel to and beneath the raised section of the DLR crossing Woolwich Manor Way and routing north before branching east to Alantis Avenue to supply Royal Albert Basin. The route would continue north along undeveloped land between Royal Docks Rd and the raised section of the DLR, ultimately connecting into the heat production units at 20C, and Thames Water and forming the route for the future connection to LTGHN.	Crossing the DLR as it enters a tunnel to route beneath Royal Docks Rd could be a problem in relation to vertical clearances.
	Option 2 The route would run along University Way parallel to and beneath the raised section of the DLR crossing Woolwich Manor Way and routing north before branching east to Alantis Avenue to supply Royal Albert Basin. Instead of routing north, the route would continue along Atlantis Avenue and divert north along Amada Way, past the DLR depot and into Hornet Way, where it would cross into the Thames Water site.	This route would avoid potential constraints of crossing the DLR. Wayleaves and permissions would be required from Thames Water and National Grid who are understood to currently own the land [8].

Table 20: Royal Docks to Royal Albert Basin Route Options Appraisal

Figure 27: Silvertown Crossing

Figure 28: Location of Crossrail tunnel

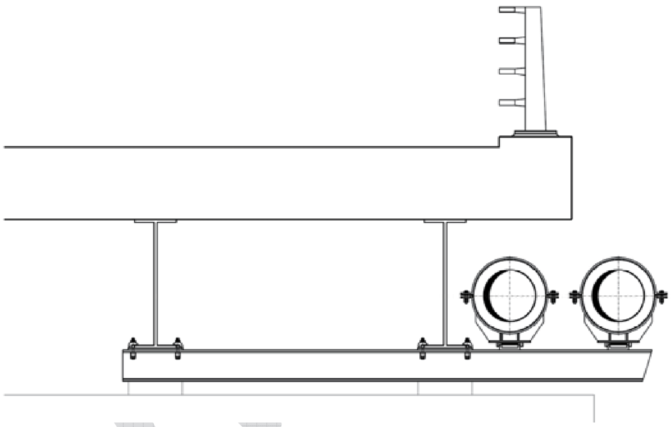
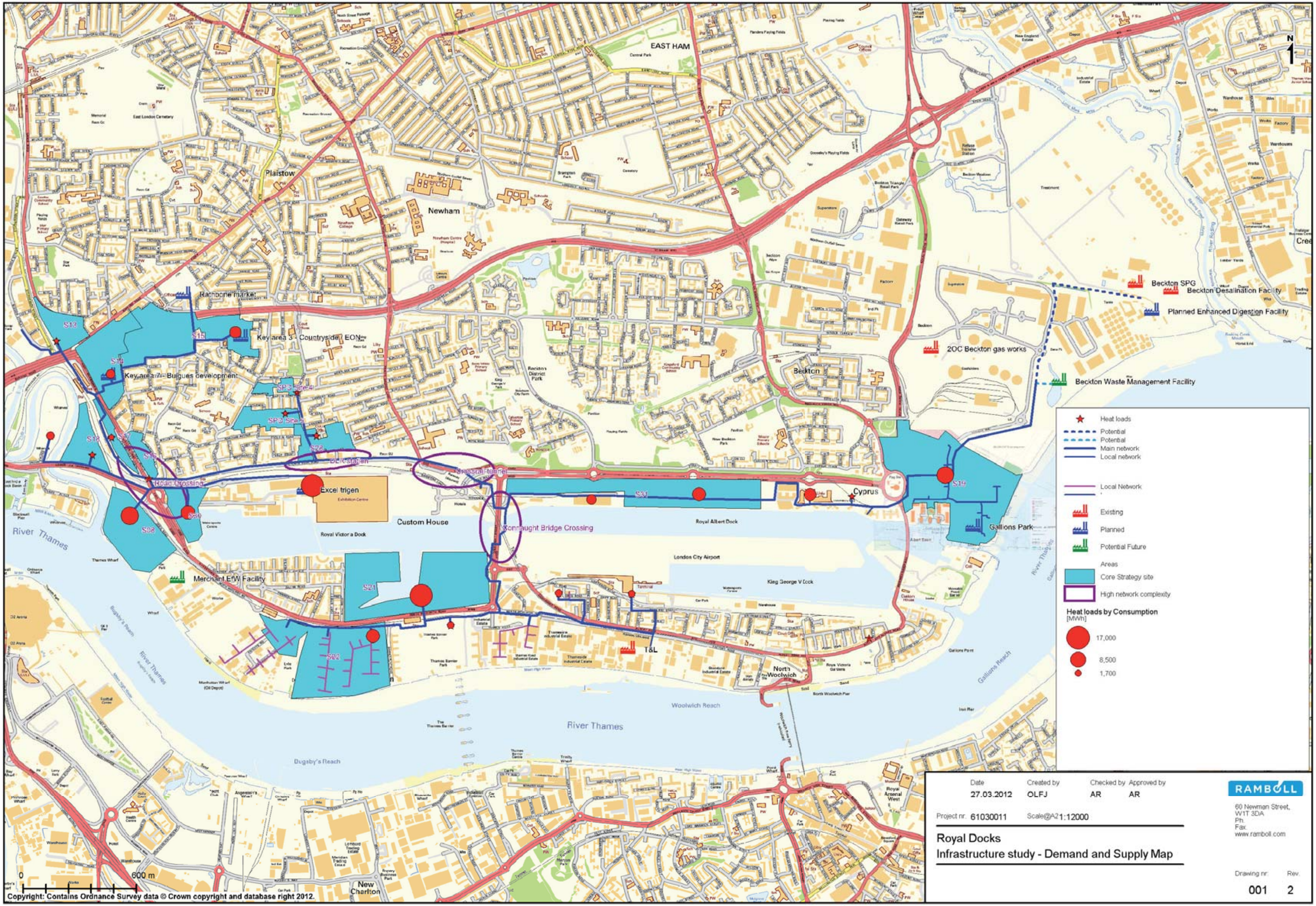


Figure 29: Example Bridge Crossing Detail

APPENDIX 3

APPENDIX 3A: DEN AND SUPPLY MAP



Date	Created by	Checked by	Approved by
27.03.2012	OLFJ	AR	AR

Project nr. 61030011 Scale@A2 1:12000

Royal Docks

Infrastructure study - Demand and Supply Map

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APPENDIX 3B: VISION MAP

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Royal Docks
Infrastructure Study - Vision Map

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APPENDIX 3C: INITIAL CLUSTERS MAP

Hest Supply Plants

- Initial Cluster base load
- Peak plant
- Local gas CHP base load
- Local
- SPV network

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APPENDIX 4 SUMMARY OF MAIN HEAT PRODUCTION ASSETS

Summary of Supply Opportunities	Thermal Capacity [MJ/s]	Supply Capability [MWh/a] @ 10% Offtake	Maximum Supply Capability [MWh/a]	Date of Heat Availability	Forfeited ROCS	Cost of Heat [p/kWh] in today's prices	Carbon Burden of Heat kg/kWh
Tate & Lyle	10.0	7884	78,840	2015 (1)	[-]	2.72	0.208
Thames Water SPG	30.4	25094	250,940	2017	1.50	1.98	0.018
Thames Water Desalination Facility	3.9	2167	21,666	current	[-]	0.15	0.000
Thames Water Enhanced Digestion Facility	2.4	2035	20,352	2014	[-]	0.15	0.000
20C Plant	1.0	832	8,322	early 2014	[-]	0.15	0.000
Beckton Waste Treatment Facility	11.0	9154	91,542	unknown	0.50	1.36	0.056
Merchant W2E facility	48.9	40695	406,946	unknown	0.50	1.42	0.056
Excel	1.593	1326	13,257	current	[-]	4.70 0.14	0.129 in 2012, 0.385 in 2040

Table 21: Summary of Heat Production Assets

Notes.

1. Maximum Supply Capacity assumes 95% availability. Also shown is the heat output assuming 10% of the available heat is taken.
2. RHI is not currently available on the heat recovered from the Thames Water Desalination Facility, the Thames Water Enhanced Digestion Facility or the Thames Water SPG. However, a review of the technology bandings under RHI is due to take place in 2013 and it is noted that the position could potentially change in the future.
3. 1.5 ROCs assumed to apply for Thames Water SPG. The UK Renewables Obligation Banding Review has recently undergone consultation and the Government's response to the consultation is due in Spring 2012 with legislation following in Summer 2012. The regulations setting the new bands in law will take effect on 1 April 2013. It is assumed that future support will be grandfathered. Accreditation was submitted in March 2008. Based on Ofgem guidance documents, ROCs will not be issued in respect of generation beyond 31 March 2027.
4. It is assumed that energy from waste plants would achieve 0.5 ROCs plus RHI. RHI benefit is not included in the model since the value of this is assumed to accrue to the operator.
5. Forfeited electricity price taken from wholesale prices for 2012 as identified in [5] and based on Low Carbon Transition Plan policy measures and central growth projection.
6. Maintenance costs taken to be 0.15 p/kWh
7. Carbon burden from Tate & Lyle assumes heat led operation with supplementary firing of the HRSG. In the event that firing of biomass boilers were to be used, the carbon burden would drop to around 0.03 to 0.04 kg/kWh[31].
8. Thames Water SPG: Thames water are in the process of modifying the design of the facility to reduce co firing requirement, which is expected to be virtually zero by the time the facility could supply heat to the network. Currently the process uses 10% supplementary firing using natural gas. The calculated carbon burden reflects this. Carbon burden of heat apportioned in ratio of Z factor.
9. Beckton EfW Plant and Merchant W2E facility are assumed to achieve Mayor's carbon intensity floor level of 400 grams of CO_2 per kWh [16]. Carbon burden of heat for these energy from waste facilities apportioned in ratio of Z factor
10. Carbon burden associated with increase/decrease in marginal plant on grid not attributed to scheme
11. For Excel CHP, heat cost is calculated with and without net income from electricity generation. Carbon burden is quoted in today's figures and for 2040 to reflect reducing grid intensity.

[31] http://archive.defra.gov.uk/environment/business/reporting/pdf/110819-guidelines-ghg-conversion-factors.pdf
http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,163182&_dad=portal&_schema=PORTAL

APPENDIX 5 WIDER AREA HEAT NETWORK INTERFACING OPPORTUNITIES

Opportunities to the East of Royal Docks

A future heat network to the east of the Royal Docks could potentially deliver surplus heat from a range of heat sources including a new EfW facility in Dagenham and any future additional supply capacity that may come forward in the Sustainable Industries Park and/or Barking Power Station.

Of these, the major known opportunities at the time of writing are Barking Power station and the planned Biossence Facility in Havering.

Barking Power station

Barking Power station is a 400 MWe combined cycle gas turbine CCGT based plant.
There is currently no CHP heat recovery capability at the plant and, although previous work carried out by Ramboll for LDA [25] identified the opportunity to extract up to 170 MJ/s of heat from the plant, the commercial future of the existing plant is uncertain due to current market conditions. The facility has moved down the merit order in recent years due to rising gas prices and has seen significantly reduced operating hours. Whilst the situation may improve in the future, the outlook suggests operation as a peaking station at best. This, together with a number of major technical barriers associated with extracting heat from the facility, suggest that it is unlikely to come forward as a source of heat for LTGHN.

Ramboll's report also identified the opportunity to extract a further 140 MJ/s of heat from the proposed new generating block at the facility. Discussions with ATCO Power indicate that any decision to go ahead would be market driven and the plant would need to operate more or less as baseload to justify construction costs. Possible development timescales would see the plant operational in 2017 with an option to install heat recovery as recommended in the Ramboll report [25].

Biossence Facility

Biossence have planning permission to construct a facility to gasify the energy fuel from the Shanks MBT process in order to create electricity and heat. The site lies within London Borough of Havering on land adjacent to the Fairview Industrial Estate on the River Thames frontage, and was previously used by the Ford Motor Company as part of its vehicle holding centre. The site lies within a strategic industrial location (SIL) and sustainable industrial park (SIP) and adjacent to the Ford Motor Company car compound. The energy facility will provide for the conversion of solid recovered fuel (made from waste left after recycling and composting) into a synthetic gas (or syngas), which is then used to generate electricity. Electricity generated would then be supplied to Ford Motor Company or the national grid. As part of this scheme, the process of electricity generation is based on the combustion of the synthetic gas in a boiler plant to generate steam, which, in turn, would be used in a condensing steam turbine to produce electrical power.

The current plan is to develop a facility with a waste processing capacity of 130,000 tonnes per annum which would have a gross electrical output of 25MWe (with no heat export currently planned). This would be equivalent to a single line of the two-line plant that Metso has recently delivered for Lahti Energia, a local Finnish utility in the City of Lahti, Finland. A total of 40MJ/s[32] could potentially be available from the plant subject to the commercial terms of any heat supply agreement and Metso is targeting 7,800 hrs of operation per annum for the facility.
A summary of relevant heat production capacity from LTGHN is presented in Table 22.

[32] Based on scaling the output of the Finnish project which will process 250,000 tonnes of processed waste a year and generate 50MWe or electricity as well as 90MWth of heat for the existing heat network.

Summary of Supply Capacity	Quantity of Heat [MJ/s]	Grade [°C]
Baseload Capacity from Barking Power Station	140	>105
Baseload Capacity from Biossence W2E facility, London Riverside	40	~ 80 – 100

Table 22: Summary of Relevant Heat Production Capacity from LTGHN

Anticipated future growth of Phase 1 - Barking and Dagenham

Any heat available from Barking Power station and the planned Biossence Facility in Havering would be net of the demands for heat to the east of the Royal Docks. Based on maximum heat load and heat demand estimates presented in [18], the long term baseload heat demand has been estimated to be 69 MJ/s by 2030.

Olympic Park District Energy Scheme (OPDES)

The Olympic Park District Energy Scheme (OPDES) supplies heating and cooling to the Olympic Park and Westfield's development at Stratford City. The scheme is owned, operated and maintained by COFELY under a 40 year Concession Agreement with the Olympic Delivery Authority (ODA) and Stratford City Developments Ltd. OPDES provides low carbon heat and cooling from a number of sources including natural gas-fired Combined Heat & Power (CHP), biomass and biofuel boilers as well as conventional back-up heating and cooling plant.

The OPDES is expected to expand substantially over the coming years, supported by the existing and emerging planning policies of the Boroughs of Hackney, Tower Hamlets, Newham and Waltham Forest in which the scheme is located along with the Mayor of London's policies as set out the London Plan. An estimated total of nearly 3.7 million m^2 of new development is anticipated in the Olympic Legacy area, with around 29,200 housing units and 1.36 million m2 of commercial space over the period considered in the present study. The predicted long term heating consumption and diversified peak heating demands in the Olympic Park Legacy Area are shown below [13].

	Heating consumption	Diversified Heating & DHW demand
	MWh /a	MW
Hackney Wick Fish Island	32,784	29.3
Northern Olympic Fringe	17,509	17
Olympic Park	15,106	14.1
Southern Olympic Fringe	54,247	49.8
Stratford	76,222	60.7
Total	195,868	170.9

Table 23: OPDES future Heat Demands in Legacy Mode

The energy centres at Kings Yard and Stratford City have been sized and constructed with the legacy build over the 40 year concession agreement period out in mind. The proposed timescale for future expansion is understood to be 2012 to 2021. A summary of the heat production assets at OPDES in the future fully built out legacy mode is presented below[33].

			Kings Yard	Stratford City
Electricity				
CHP Engines			16.7 MWe	13.3 MWe
Heating				
CHP Engines			15.8 MJ/s	12.6 MJ/s
Biomass boilers			6.0 MJ/s	0.0 MJ/s
Gas boilers			100.0 MJ/s	60.0 MJ/s
Total thermal output			121.8 MJ/s	72.6 MJ/s

Table 24: Future Total Heat Production Capacity OPDES- Legacy Mode

[33] information provided by COFELY

APPENDIX 6 INVESTMENT AND CARBON APPRAISAL MODEL ASSUMPTIONS

6.1.1 Economic Modelling Assumptions

Scheme economics have been calculated around required Internal Rates of Return of 10 %, 6 % and 3.5 % to reflect a private sector led scheme, a scheme funded by London Borough of Newham using PWLB money and investment according to HM Treasury Green Book guidelines.

6.1.2 Project Term

The financial value of the project and the calculation period for Internal Rate of Return (IRR) and Net Present Value calculation (NPV) is taken to be 25 years. For the final scheme, a calculation period period of 40 years has also been tested. This represents the economic life of the heat network, the single most expensive asset in the scheme. Ongoing re-investment in infrastructure has been included in the financial model as an annual sinking fund.

6.1.2.1 Project Investment Costs

Where available, cost estimates for installing heat recovery equipment at heat production facilities has been based on information provided by others. A detailed evaluation and verification of these costs has not been carried out. In the absence of any information, investment costs have been modelled based on Ramboll's experience of similar projects carried out in Denmark.

Heat network construction costs have been taken from [17], with corrections for 2012 prices based on inflation under the Retail Price Index.

The economic modelling has assumed that a Project Company would finance the costs of investment in the strategic heat network and associated infrastructure assets, including connections to the major developments considered in the study.

The costs of developing local heat networks within the major developments are assumed to be borne by the developers, under their planning obligations. The value associated with these networks is assumed to be realised by the developers through the selling and letting of the developments and is not therefore included in the project model.

Project design, development and commissioning costs have been taken to be 13% of construction costs (5% development, 5% design and 3% commissioning).

Reinvestment costs in the strategic heat network and in all other associated infrastructure assets have been annualised based on assumed reinvestment rates and replacement cycles, in line with experience on other projects in Denmark and UK.

The cost of financing these scheme has not been modelled.

6.1.3 Operating Revenues

6.1.3.1 Assumed revenues from heat sales under the scheme

The operator's connection model is likely to involve the following elements:

- A connection charge ~ one off payment for connection to the network for new connections, dependent on cost of connection assets.
- Annual Capacity Charge, payable monthly and dependent on capacity of connection – intended to cover fixed operating costs of the scheme (lifecycle replacement costs and fixed maintenance costs of the primary plant and heat network).
- Consumption Charge, payable monthly for metered heat as supplied to the customer and based on monthly meter readings ~ possibly linked to return temperature to incentivise customer to return water at low temperatures

Costs of connection to the heat network are modelled by assuming that these are borne by the Project Company, who would recover the costs through annual capacity charges and consumption charges.

Annual equivalent heat charges to consumers have been calculated on the basis of their avoided heat generation costs under the business as usual case. The avoided cost of heat generation is taken to comprise avoided fuel costs, avoided operations and maintenance costs and avoided plant reinvestment costs assuming a 15 year replacement cycle.

The business as usual case for new mixed use residential developments in the absence of a heat network to connect into assumes that they would implement gas fired CHP community based heating system with thermal storage and top up using gas boilers[34]. The contribution from gas CHP in this scenario is assumed to be 55% of the heat delivered to individual schemes. The cost of heat for these developments has been calculated to be 7.2 p/kWh. The investment model for the Project Company assumes that the Project Company would not adopt the local heat networks on each development site, which would instead be owned by third party private sector organisations and operated by facilities management company or similar entity. On this basis, the cost of heat that could be levied to residents has been calculated to be 5.65 p/kWh. This assumes that the cost of recovery of investment in the local network would be borne by tenants and leaseholders.

The business as usual case for new commercial, office, retail developments assumes that they would implement VRF air source or ground source heat pump systems with top up heating and cooling, from gas boilers and dry air coolers (or electric chillers as required). The fuel cost to these developments is assumed to comprise a 50% split between DHW (which is supplied from gas boilers) and space heating (which is assumed to be supplied 90% through heat pumps and 10% through top up gas.

Seasonal COPs of 2.5 are assumed based on air source heat pump technology. Although higher COPs would be achievable for ground and water source schemes, higher installation costs would also be incurred. A detailed cost appraisal of the options has not been carried out as part of the present study. Further work would be required to establish this.

The business as usual case for existing developments assumes that they would continue to operate using gas boilers, with upgrading of boilers to higher efficiency plant at the time of refurbishment.

The avoided costs to new mixed use residential developments associated with increased saleable area in lieu of installing boilers and CHP plant has been taken to be zero, since temporary boiler plant would be adopted in almost all cases until the heat network is constructed and available to connect into. Similarly the avoided costs to new commercial developments has also been taken to be zero, since plantroom space would still be required for distributing heating and cooling within the buildings.

[34] in line with London Borough of Newham's LDF.

Customer heat prices for each customer type in the business as usual scenario are presented in Table 25 (today's prices). Also shown is the heat price to customers under the scheme. This includes the variable tariff that would be paid to reflect avoided fuel costs along with a capacity charge to reflect avoided O&M costs and avoided annualised replacement/refurbishment costs.

Customer Type	Alternative Heat Price p/kWh	Heat demand MWh	Heat demand %	Capacity charge £	Total cost per heat demand p/kWh
New Large Commercial	3.53	17,643	17%	23,524	3.66
New Medium Commercial	4.46	2,274	2%	4,330	4.65
New Retail	4.41	1,499	1%	2,064	4.55
London Borough Newham	3.41	3,916	4%	5,221	3.54
Residential customers - existing	3.91	3,976	4%	5,301	4.04
Residential customers - new	5.65	51,961	50%	69,282	5.78
Excel centre	3.41	16,037	15%	21,383	3.54
University of East London	3.62	6,850	7%	9,133	3.75

Table 25: Heat Tariff Assumptions

The impact of incentivising existing customers to connect to the scheme has not been modelled in these figures. It is noted that a reduction in heat prices might be required in reality.

It is assumed that a proportion of the benefit of avoided CRC payments for existing customers (City Airport, Excel, Newham Dockside, UEL) would accrued to the scheme. A rate of £8 / Tonne has been assumed.

6.1.4 Operating Costs

6.1.4.1 Cost of Purchasing Heat from Heat Generators

The cost of purchasing heat from heat generators are presented in Appendix 3 for each heat production unit. These include the marginal operations and maintenance costs associated with heat extraction and the forfeited electricity generation costs as appropriate, depending on technology.

6.1.4.2 Fuel Price Assumptions

Energy prices for the Project Company, for the generators and for customers are taken from [5] and [6]. Energy price increases for gas and electricity under the scheme and under the business as usual case are based on the central forecasts presented in [27]. Revenues from heat and electricity sales are also assumed to accrue on this basis. Prices increases have been linearized over a 30 year period and used to extrapolate prices beyond to 2050.

Energy price increases from energy from waste plants as assumed to scale with electricity prices factors by the plant Z factor.

6.1.5 Scheme Operation and Maintenance Overheads

Operation and maintenance costs are modelled as variable running costs accruing on per kWh basis and as fixed administration costs associated with operational and staff overheads. Staffing overheads assume a small operating team consisting of a Plant Manager, Administration Assistant and two FTE maintenance technicians in the early years. This rises to four FTE maintenance technicians over the longer term at the point when the wider heat network is constructed.

Variable costs include operation and maintenance of specific heat production units as well those associated with general energy centre operating overheads (eg water treatment, general repair, consumables etc).

Heat network pumping and heat loss costs are modelled based on results of hydraulic calculations using System Rornet assuming variable volume, variable temperature operation. Heat losses are modelled in kW per unit length of network. Pumping losses assume a cubic relationship with demand.

Operation and maintenance costs for generators associated with supplying heat are covered under the heat selling prices calculated in Section 6.1.4.1.

6.1.6 Heat Network Sizing Methodology

The heat network has be designed in accordance with the design parameters set out the draft District Heating Manual for London being prepared by GLA[31] (due to be published in Final Version in March 2012).

Accordingly, the design parameters assumed in this report are as follows:-

Design Parameter	
Maximum design pressure	16 bar
Design flow temperature	110 °C
Design return temperature	50°C

Table 26: Heat Network Design Parameter

The necessary pipe dimensions are estimated using the software package SR developed by Ramboll Energy. SR is a simulation program for hydraulic and thermal analysis of district heating networks. SR calculates the optimum diameters of the pipes based on knowledge of temperature difference between flow and return, pressure levels, costs for piping and the maximum velocity in the pipes.

APPENDIX 7 FUNDING OPTIONS

Greater London Authority

Decentralised Energy Programme Development Unit

Funding Options Analysis

218060-02

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Contents

Glossary of Abbreviations

CERT	Carbon Emissions Reduction Target
CESP	Community Energy Saving Programme
CHP	Combined Heat and Power
CIL	Community Infrastructure Levy
DE	Decentralised Energy
DEPDU	Decentralised Energy Programme Delivery Unit
ECA	Enhanced Capital Allowances
ECO	Energy Company Obligation
EEE-F	European Energy Efficiency Fund
EIB	European Investment Bank
ELENA	European Local Energy Assistance
ERDF	European Regional Development Fund
ESCO	Energy Service Company
FIT	Feed in Tariff
GIB	Green Investment Bank
GLA	Greater London Authority
HRA	Housing Revenue Account
IRR	Internal Rate of Return
JESSICA	Joint European Support for Sustainable Investment in City Areas
LA	Local Authorities
LEEF	London Energy Efficiency Fund
LIBOR	London Interbank Offered Rate
LGF	London Green Fund
PWLB	Public Works Loan Board
RHI	Renewable Heat Incentive
ROC	Renewables Obligation Certificate
S106	Section 106
SRI	Socially Responsible Investing
TIF	Tax Increment Financing
UDF	Urban Development Fund

Executive Summary

The objective of this high-level report is to outline the range of possible public and private sector funding options for decentralised energy (DE) projects in London both in terms of the options for financing upfront capital costs, and sources of revenue financing that can improve project returns.

A long list of funding options for DE projects, covering sources of financing from the perspective of local authorities (LAs) and the private sector, has been gathered from desktop analysis, stakeholder consultation and internal Arup expertise.

Table 1 details the long list of funding options considered.

These have been divided into three categories in relation to their suitability as a funding option for DE projects:

1. Those that should always be considered
2. Those that are possible options, depending on the specific characteristics of individual projects
3. Those that are unlikely to be well suited to DE projects

Section 2 provides more detail and analysis on each funding option. In addition, a separate Appendix is available with the main characteristics of each option.

Table 1 Long List of Funding Options

Funding Option	Funding Source	Financial Instrument	Description	Suitability
Local Authority Internal Reserves	Public sector	Equity	The lowest cost option with easiest access. However availability will be a problem for some LAs.	1
Prudential Borrowing from Public Works Loan Board (PWLB)[1]	Public Sector	Debt	Low cost of capital (approx 4% for 20 year project). Availability could be an issue and will depend on LA's appetite for debt.	1
Developer contributions (Community Infrastructure Levy (CIL)[2] **or Section 106 Agreements)**	Public Sector	Subsidy	LAs will be able to implement a charging schedule for developers to raise revenues for infrastructure. CIL is flexible, and no right of repayment to developers but won't begin until April 2014. Section 106 remains an option until April 2014. Neither likely to fund all capital expenditure requirements for a given DE opportunity.	1
Feed in Tariffs (FITs)[3] **/Renewable Heat Incentive (RHI)**[4]	Public Sector	Subsidy	FITs and RHI are potentially a source of revenue for DE projects which involve renewable energy. Cannot be used concurrently. FIT might not be appropriate for DE projects (focus on microCHP), RHI more suitable but will not be applied until 2012.	1

[1] See: http://www.dmo.gov.uk/index.aspx?page=PWLB/Introduction
[2] See: http://www.communities.gov.uk/planningandbuilding/planningsystem/communityinfrastructurelevy/
[3] See: http://www.fitariffs.co.uk/
[4] See: http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx

Funding Option	Funding Source	Financial Instrument	Description	Suitability
Renewables Obligation[5]	Public Sector	Subsidy	Renewables Obligation Certifications (ROCs) are a source of revenue for DE projects that involve renewable energy. Should be evaluated in individual project appraisals.	1
Enterprise Zones[6]	Public Sector	Subsidy	To stimulate economic growth and generate jobs the Government has created new Enterprise Zones. New businesses that locate within a zone will benefit from reduced business rates for five years. Importantly, business rates collected locally will be retained for the next 25 years. Collected monies can then be reinvested into promoting economic growth or set against borrowing for investment.	2
Allowable Solutions[7]	Public Sector	Subsidy	The Government has for some time recognised that achieving zero carbon in new development is unlikely to be viable in most cases. A new system of *'allowable solutions'* has been proposed to help offset residual carbon emissions. This includes low carbon measures away from developments, such as renewable energy installations, DE network or building retrofit. It is expected that these offset solutions will be agreed in advance with developers, to deliver themselves or pay a third party to deliver. The model is similar to the way Section 106 and CIL collects revenue contributions. Primary legislation is still required before full implementation can take place. Our judgement is that no money will be collected through this system before 2016.	2

[5] See: http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx
[6] See: http://www.london.gov.uk/media/press_releases_mayoral/london%E2%80%99s-royal-docks-become-one-country%E2%80%99s-largest-enterprise-zones
[7] See: http://www.zerocarbonhub.org/definition.aspx?page=9

Funding Option	Funding Source	Financial Instrument	Description	Suitability
London Carbon Offset fund	Public Sector	Subsidy	The GLA's Climate Change Mitigation and Energy Strategy provides information on proposals for a carbon offsetting fund. It is expected to operate in a similar manner to the proposed Allowable Solutions framework. Where new developments cannot achieve their carbon reduction target in an economically viable way, the shortfall in carbon savings can be offset. This will enable new developments to maximise emissions reductions. It will be delivered at the borough level, where financial contributions will be made directly into a dedicated carbon reduction fund, established by each borough. Funds will then be used to contribute to support carbon savings within the boroughs.	2
Carbon Emissions Reduction Target (CERT)[8]	Public Sector	Grant	Possible funding source for small scale DE projects with installed thermal capacity (solely from biomass) not exceeding 3MWth. CERT support can be given to private and public sectors. Ends December 2012. Application needs to be made to utility company. From 2013 CERT (and CESP) will be replaced by the new Energy Company Obligation[9] (ECO) from 2013. Legislation is yet to be finalised so the full extent of the obligation is unclear.	2
Housing Revenue Account (HRA)[10]	Public Sector	Subsidy	HRA could be a useful facility for LA considered DE projects. New powers being introduced in April 2012 will give LAs full control over housing income and expenditure. Surplus revenue could be used in energy efficiency and generation projects.	2

[8] See: http://www.decc.gov.uk/en/content/cms/funding/funding_ops/cert/cert.aspx
[9] See: http://www.decc.gov.uk/en/content/cms/consultations/green_deal/green_deal.aspx
[10] See: www.communities.gov.uk/documents/housing/pdf/138964.pdf

Funding Option	Funding Source	Financial Instrument	Description	Suitability
New Homes Bonus[11]	Public Sector	Subsidy	If a particular scheme involves building new housing the LA will receive a New Homes Bonus from central government for each new home. This could be used to partially fund a DE scheme but unlikely to be sufficient to fund entire capital cost.	2
Homes and Communities Agency (HCA)[12]	Public Sector	Grant	HCA has a long term commitment to provide support to local DE networks. One project which is being supported is the Greenwich Peninsula DE network. Given current constraints it is unlikely that support in the short-term will be available. However, in the long-term the HCA could be a viable source providing significant contributions.	2
Enhanced Capital Allowances (ECA)[13]	Public Sector	Subsidy	ECAs can make DE projects more financially viable where assets in a DE scheme are owned by the private sector. Opportunity to claim 100% of first year capital allowances on qualifying plant and machinery. This means that a business can write off the whole of the capital cost of an investment against taxable profits.	2
London European Regional Development Fund (ERDF)[14]	Public Sector	Grant	ERDF is grant financing from the EU. It may be possible to secure some ERDF financing for marginal DE projects. However, this ERDF will have to be matched/co-financed by public or private sources. Investments will need to be made before 31st December 2015.	2

[11] See: http://www.communities.gov.uk/housing/housingsupply/newhomesbonus/
[12] See: http://www.homesandcommunities.co.uk/
[13] See: http://etl.decc.gov.uk/
[14] See: http://www.london.gov.uk/priorities/championing-london/london-and-european-structural-funds/erdf

Funding Option	Funding Source	Financial Instrument	Description	Suitability
European Union (FP7) Framework Programme for Research and Technical Development[15]	Public Sector	Grant	The FP7 programme was launched in 2007 and scheduled to complete by 2013 with a budget of EUR 2.35 billion. It provides grants to fund research and innovative technology projects. Grants are allocated upon on a call for proposals and a peer review process. There is a possibility that FP7 could support the delivery of new generation technology; however the possibility of financing a standard DE scheme is highly unlikely.	2
Green Investment Bank (GIB)[16]	Public Sector	Debt	The GIB has been set up by Department for Business, Innovation and Skills (BIS) to fund a range of energy efficiency and renewable energy projects. It has an initial capital allocation of £3 billion. Possibility to arrange finance for DE through GIB. Pooling projects to achieve sufficient scale and sound business cases is likely to be crucial.	2
European Investment Bank (EIB)[17]	Public Sector	Debt	The EIB can offer project finance to projects over EUR 25 million or intermediate loans to projects under EUR 25 million. DE projects would be suitable for these loans, and can be provided on medium to long term (up to 20 years). In both cases the EIB loan will finance up to 50% of total project cost. In rare cases the EIB will finance 100% of project cost through an intermediary loan.	2

[15] See: http://cordis.europa.eu/fp7/energy/
[16] See: http://www.bis.gov.uk/greeninvestmentbank
[17] See: http://www.eib.org/projects/cycle/applying_loan/index.htm

Funding Option	Funding Source	Financial Instrument	Description	Suitability
London Green Fund (LGF)[18]	Public Sector	Debt/Equity	The LGF is London's JESSICA (Joint European Support for Sustainable Investment in City Areas) Holding Fund with a £100m capitalisation. Two Urban Development Funds (UDFs) have been set up to date – the London Energy Efficiency Fund (LEEF) and the London Waste Fund – the former with an allocation of £50m and the latter with £35m. It is possible that the remaining £15m could be allocated to DE projects. This will have to be allocated by end of December 2015.	2
European Energy Efficiency Fund (EEE-F)[19]	Public Sector	Debt/Equity	The EEE-F is a new European fund with an approximately EUR 265 million capitalisation. It will invest in all types of energy efficiency and renewable energy projects including DE. The Fund will offer a large range of financial products such as senior and junior loans, guarantees or equity participation. Investments need to be made before 31st March 2014.	2
Project and Municipal Bonds	Public Sector	Debt	Both LAs and the GLA can now raise project or municipal bonds to finance projects. The pooling of projects will be important to achieve project scale because transaction costs may be significant. However, if scale is achieved then bond finance could be a financially attractive way to fund DE projects because finance is secured using an LA's often high credit rating. The Local Government Association (LGA) is arranging a bond club to allow LAs to borrow jointly from financial markets. This may make bond finance more appealing to LAs.	2

18 See: http://www.london.gov.uk/erdf/jessica-london-green-fund
19 See: http://ec.europa.eu/energy/eepr/eeef/eeef_en.htm

Funding Option	Funding Source	Financial Instrument	Description	Suitability
Commercial bank	Private Sector	Debt/Mezzanine	An LA or a private sector contractor could secure debt from a commercial bank to pay for DE capital costs. However, it is unlikely to be as low cost as PWLB.	2
ESCO/Contractor	Private Sector	Debt	An ESCO/contractor could finance the capital cost of DE plants and networks themselves. This would depend on the availability of equity reserves and the projects overall rate of return.	2
Climate Change/Green Investment Funds	Private Sector	Debt/Equity	There are some investment funds such as Triodos[20], Climate Change Capital[21] and Earth Capital Partners[22] that have been established with a specific remit to invest in energy efficiency and renewable energy projects. However, they tend to be interested mainly in projects that have relatively high returns (10-20%) and with short investment periods (5-7 years). In addition, they will be looking for projects or project portfolios with a large scale investment potential. Should be investigated further for specific DE project portfolios.	2
Salix Finance[23]	Public Sector	Debt	Salix Finance had a £20m funding pot for energy efficiency projects however this will close on 31st March 2012. In addition, all projects must have payback period of 5 years or less which is likely to make DE projects unsuitable.	3

[20] See: See: http://www.triodos.co.uk/en/institutional_investors/
[21] See: http://www.climatechangecapital.com/home.aspx
[22] See: http://www.earthcp.com/
[23] See: http://www.salixfinance.co.uk/home.html

Funding Option	Funding Source	Financial Instrument	Description	Suitability
Business Rate Retention: Renewable Energy[24]	Public Sector	Tax subsidy	The Department of Communities and Local Government (DCLG) published on 18th July a consultation paper into business rate retention. One proposal is for communities that host renewable energy projects to retain the associated business rates. Statutory legislation and the definition of qualifying renewable energy and infrastructure are yet to be finalised.	3
Tax Increment Financing (TIF)[25]	Public Sector	Debt	TIF is due to be implemented in the UK in April 2013. It is based on ring-fencing or hypothecating future business rate increases as a result of infrastructure development to pay for the initial capital costs of the development. Borrowing can be secured against these future tax increases from either private or public sector sources such as PWLB. At present TIF is not suitable for DE projects because the ability to hypothecate tax revenues has not yet been granted to LAs. In addition, it is unlikely that the majority of DE projects would have significant impacts on business rates. TIF is likely to be a possibility only in the case of a particularly transformative development which would involve a major regeneration scheme in low value areas.	3

[24] See: http://www.communities.gov.uk/documents/localgovernment/pdf/1969601.pdf
[25] See: http://www.hm-treasury.gov.uk/press_47_10.htm

Funding Option	Funding Source	Financial Instrument	Description	Suitability
Community Energy Saving Programme (CESP)[26]	Public Sector	Grant	CESP is administered by Ofgem and is focused on delivering reductions in carbon in areas of low income and high deprivation. CESP is funded by energy suppliers and generators. It has been designed to deliver £350m of funding to improve energy efficiency and reduce fuel costs at the household level, with a focus on specific areas of deprivation. However, CESP closes at the end of December 2012 and only supports projects with payback periods of 5 years or less. It is therefore unlikely to be suitable for the majority of DE projects. From 2013 CESP (and CERT) will be replaced by the new Energy Company Obligation (ECO) from 2013. Legislation is yet to be finalised so the full extent of the obligation is unclear.	3
Pension Funds	Private Sector	Debt/Equity	Pension funds are beginning to be attracted to the infrastructure market to diversify their portfolios into more stable and tangible assets. Infrastructure assets are inflation-linked and therefore attractive to institutional investors. They also fit well into their remit for socially responsible investing (SRI). However, pension funds are traditionally uncomfortable accepting construction risk and may be more likely to invest once assets are operational although issues around sufficient IRRs will remain - pension funds tend to make investments at a high cost of capital 7% and above.	3

[26] See: http://www.decc.gov.uk/en/content/cms/funding/funding_ops/cesp/cesp.aspx

Funding Option	Funding Source	Financial Instrument	Description	Suitability
Private Equity/Venture Capital	Private Sector	Equity	Private Equity/Venture Capital firms tend to be interested in projects with IRRs of 15-20% and with short investment periods (1-10 years). They will also be attracted to large scale projects for attractive investment proposals. For these reasons they may not be appropriate for the majority of DE projects where returns are less certain and scale is small. If the GLA could create a viable business case for a large-scale network then this may be more attractive.	3
Sovereign Wealth Funds	Private Sector	Debt/Equity	Sovereign wealth funds tend to be attracted to investing in large scale, high profile projects with high IRRs, typically in the 15-20% range. Due to the uncertainty surrounding DE project returns, it is unlikely that a sovereign wealth fund would target DE as an investment.	3

1 Introduction and Approach

Appropriate funding is critical to the successful delivery of decentralised energy (DE) projects. Most DE projects need long-term finance for successful delivery due to typically longer payback periods than more standard energy efficient building retrofit projects. In addition, the often uncertain demand profiles of DE projects, and resultant high risk, mean that they may require a blend of financing such as subsidies, incentives, debt and equity to achieve the requisite funding amounts for delivery.

The objective of this high-level report is to outline the range of possible public and private sector funding options for DE projects in London both in terms of the options for financing upfront capital costs, and sources of revenue financing that can improve project returns.

A long list of funding options for DE projects, covering sources of financing from the perspective of local authorities (LAs) and the private sector, has been gathered from desktop analysis, stakeholder consultation and internal Arup expertise. These have been divided into three categories:

1. Those that should always be considered
2. Those that are possible options, depending on the specific characteristics of individual projects
3. Those that are unlikely to be well suited to DE projects

The characteristics of each funding option are described in a separate Appendix which includes: funding source, timescales, funding criteria, funding available, indicative costs of capital, and an overall consideration of the suitability of the option for funding DE projects.

The categorisation is intended as a guideline for typical DE projects, however the suitability of different funding options will depend on individual project characteristics.

Therefore, those in Category 3 that Arup have advised are unlikely to be suitable may be appropriate in cases where project timescales are sufficiently low, or returns are particularly high.

2 Funding Options for DE projects in London

2.1 Funding Options that should always be considered

The first types of funding options that should be considered are the ones to which LAs have relatively easy access, or access is within their control. This includes internal reserves and using prudential debt finance from the PWLB. In addition, there are a range of options for revenue support for DE projects including FITs, and the upcoming RHI and ROCs, which improve financial viability and should be considered for every project.

2.1.1 Funding options for Capital Expenditure

Local Authority Internal Reserves/Equity Financing

The most straightforward method is for an LA to invest equity into a project and build an energy centre and network. However, given present constraints in local authority budgets, this may not prove to be feasible. This option does however provide the greatest level of flexibility and control to a local authority.

Prudential Borrowing (Public Works Loan Board)

If the objective of a LA is to own or share part of the DE scheme then there is an option to fully or partially fund this investment through prudential borrowing from the PWLB.

The PWLB offers favourable costs of capital on fixed or variable rate loans to LAs which do not have to be project specific. LAs can borrow up to a “headroom” limit. This is the maximum amount of legal borrowing capacity an authority can make.

Loans are either fixed rate for between 2 to 50 years, or variable rate for between 2-10 years. Indicative fixed rate loans for a 20 year period have (approximately) a 4 per cent cost of capital.

Community Infrastructure Levy and Section 106

The Community Infrastructure Levy (CIL) provides LAs with the ability to implement a charging schedule to raise revenue for infrastructure, charging new developments on a rate per m^2 basis. Unlike Section 106 (S106) there is considerable flexibility on what the money can be spent on, and there is also no right of repayment to developers if the money is not completely spent.

New regulations provide a reform to the current system of planning obligations to enable both S106 and CIL to operate effectively alongside each other. S106 agreements require LAs to spend the money providing infrastructure that directly benefits the developments which make the contributions. The developer has a right of repayment if the money is not fully spent.

By 2014, regardless of whether a charging schedule has been adopted by an LA, they will not be able to pool contributions for infrastructure through S106 agreements that can be funded by CIL.

2.1.2 Funding options for revenue support

Renewable Energy Incentives

The RHI and FITs have been developed to support the delivery of renewable energy generation. Their purpose is to guarantee a price for a period of generation, currently set at 20 years from introduction. FITs and the RHI are designed to support the generation of electricity and heat respectively, within banded limits.

Under the FIT the technology most suited for DE is MicroCHP. DECC is currently reviewing the level at which FIT support is set with a final decision expected in early 2012. The current proposal is for a support price of 10.5p/kWh on installations of up to 2kWe of capacity. At this scale of generation it is highly unlikely that FIT will provide a significant source of revenue funding for DE[27].

DECC has set the initial RHI support levels for generators of renewable heat. The most appropriate technologies for DE supported under this initiative are CHP, using either solid biomass or solid biomass contained in municipal solid waste. The current RHI price is banded into different sizes and tiers. Suitable large biomass stations of greater than 1 MWth are supported with a price of 1p/kWh. This scheme favours only heat generated from renewable sources; therefore a LA will need to consider the size, scale and fuel source of the CHP. In addition, to claim RHI LAs will need to follow Ofgem's eligibility rules. In particular the rules indicate that no scheme can claim RHI if any other public sector subsidy has been provided i.e. a project cannot receive direct LA support. Analysis will therefore need to be carried out to determine the most favourable option.

Renewables Obligation

The RO is the main support mechanism for renewable energy projects in the UK. The RO places an obligation on UK electricity suppliers to source an increasing proportion of their electricity supply from renewable sources.

Operators can trade ROCs with other parties which are ultimately used by suppliers to demonstrate that they have met their renewable obligation target.

ROCs can be traded by DE project owners to source revenue financing for their schemes. This should be taken into consideration in financial appraisals for individual projects. Supported technologies which could form part of a DE development include: co-firing of biomass with CHP; co-firing of energy crops with CHP; dedicated biomass with CHP; dedicated energy crops with CHP; and energy from waste with CHP

The current regime dictates that a choice must be made when selecting support mechanisms. Only one option can be made between ROCs, RHIs and FITs.

[27] This tariff is available only for 30,000 micro-CHP installations, subject to a review when 12,000 units have been installed.

2.2 Funding Options with possibilities for specific projects

2.2.1 Grants, Incentives and Subsidies

Carbon Emissions Reduction Target

CERT is a legal obligation on the six largest utilities to achieve CO_2 reductions in domestic buildings. LAs and Registered Social Landlords (RSLs) can utilise the funding available from CERT to improve the energy efficiency of their housing stock.

Funding can support:

- improvements in energy efficiency;
- increases in electricity generated or heat produced by microgeneration;
- promotion of community heating powered by biomass (up to 3MWth); and
- measures to reduce consumption of supplied energy.

As such it is a possible match for small scale DE projects with generation (from biomass) not exceeding 3MWth. CERT support can be allocated to both the private and social housing sectors. However, the programme will close at the end of December 2012, and to date the majority of projects supported have been housing retrofit programmes.

To secure investment a DE project sponsor will need to prepare a project proposal with which to contact an energy supplier.

Housing Revenue Account

LAs are required by the Local Government and Housing Act 1989 to keep a HRA. This records all revenue expenditure and income relating to the provision of council dwellings and related services.

The use of the money collected in this HRA account is prescribed by statute and can only be used to fund expenditure for housing-related services.

From April 2012 LAs will have new devolved powers which will give them control over all their housing income and expenditure, allowing them to make investment decisions for their housing stock. Any surplus revenue could therefore be used for energy efficiency and DE projects. The extent to which this could be used for DE projects would be limited to surplus revenue and the opportunity cost of using this surplus on DE as opposed to building new homes.

Allowable Solutions

The UK Government has recognised that achieving actual zero carbon in new development is unlikely to be viable in most cases and indeed may not be technically achievable in many cases. It has therefore proposed to implement a system of “allowable solutions” to deliver carbon reductions to offset residual emissions in new development.

Allowable solutions would include low carbon measures away from a new development, for example, stand alone renewable energy installations, a district heating network or building retrofit. It is expected that the allowable solutions will be focused on the local area or region, to avoid concerns about verifiability.

The basic concept is for the carbon offset solutions to be defined in advance (either locally or nationally, or both), with developers able either to deliver a solution themselves which will offset their residual emissions or to pay a third party which will take responsibility for delivering a solution. The third party could be a local authority or it could be another organisation. The allowable solutions model bears some similarities to the way financial contributions are currently collected through the planning system (under Section 106 or CIL), but could offer greater flexibility and should result in more universal application of the regime.

The AS system will require primary legislation and would then follow local adoption processes similar to planning policy. Consequently our judgment is that no money will be collected through such a system before 2016. For the time being the most likely route for developer contributions to be available to fund DE schemes will be through Section 106 agreements or through CIL payments

London Carbon Offset Fund

The GLA's Climate Change Mitigation and Energy Strategy provides information on proposals for a carbon offset fund. It is expected to operate in a similar manner to the Government's proposed Allowable Solutions framework. Where new developments cannot achieve their carbon reduction target in an economically viable way, the shortfall in carbon savings can be offset. This will enable new developments to maximise carbon reduction. It will be delivered at the borough level, where financial contributions will be made directly into a dedicated carbon reduction fund, established by each borough. Funds will then be used to contribute toward supporting carbon savings within the boroughs. This could include low carbon generation such as DE development.

Enterprise Zone

The UK Government has announced the creation of new enterprise zones across the UK, to boost local growth and create new jobs. In London, an Enterprise Zone has been established at the Royal Docks. The key benefit for business is reduced rates over a five year period, which in London will be collected via the GLA's London Enterprise Partnership. The Partnership will contribute toward the delivery of the Mayor's Economic Development Strategy and will be supported by strong local partnership arrangements. Therefore, to obtain funding for a DE project, a sponsor will need to demonstrate to the Partnership how its project will contribute toward the Mayor's Economic Development Strategy.

Business Rate Retention for Renewable Energy Projects

The Department for Communities and Local Government has recently published a consultation paper on proposals for business rate retention from new renewable energy projects. This is with a review to introducing business rates retention from April 2013. One of the key proposals has been for communities that host renewable energy projects to retain the associated business rates from new installations. The statutory legislation and definition of qualifying renewable energy and infrastructure is yet to be finalised. However, the current consultation does outline generation technology which would normally be part of a DE development. This includes: biomass CHP; biomass conversion with CHP; and energy for waste with CHP. The key incentive is for communities and local authorities to promote the development of renewable energy plant.

New Homes Bonus

The New Homes Bonus was introduced in April 2011 to encourage LAs to develop and grant planning permission for new homes, in return for additional revenue. The programme works by matching additional council tax raised on each new home built across a six year period. In areas where new housing is central to the development of a DE network this could be a potentially significant source of additional revenue.

Homes and Communities Agency

The HCA has a long term commitment to providing support to local DE networks. One project which is being supported is the Greenwich Peninsula DE network. Given current constraints it is unlikely that support in the short-term will be available. However, in the long term the HCA could be a viable source providing significant contributions to DE projects.

Enhanced Capital Allowances

Tax incentives like ECAs are focused on providing incentives to the private sector to encourage the delivery of energy saving plants, low carbon generation and infrastructure. ECAs will enable a private sector organisation to write off the whole of the capital cost of an investment against taxable profits for the period in which they make the investment. Although LAs do not directly benefit from these types of incentives, they should be aware of the incentives available to the private sector when developing a marketable DE project.

London European Regional Development Fund

The London ERDF is a pot of grant financing from the EU which is dedicated to supporting regional development. London’s 2007-2013 ERDF Operational Programme sets out four main investment priorities of which the third “Sustainable places for business” is relevant for DE as it enables the creation of high quality environments for businesses that are serviced by renewable and co-generated decentralised energy.

Depending on the amounts of ERDF left in the funding pot it may be possible to secure some level of ERDF financing for DE projects that require grant financing. However, this will have to be matched by public or private sources.

European Union (FP7)

Launched in 2007 and scheduled to complete by 2013 the FP7 programme provides grants to fund research and innovative technology projects. The objective is to promote the creation of new cost effective technology, necessary to create a more sustainable environment.

FP7 is strict in its allocation of funding. Emphasis is given to nine technologies including: hydrogen fuel cells; renewable electricity production; renewable fuel production; renewables for heating and cooling; CO_2 capture and storage; clean coal technology; smart energy networks; energy efficiency; and knowledge creation for energy policy making.

Grants are allocated based upon a call for proposals and a peer review process. There is a possibility that FP7 could be used to support the delivery of a new and innovative heat generation project; however the possibility of financing a standard DE scheme is highly unlikely.

2.2.2 Debt finance

Debt finance could be obtained for DE projects from a range of public and private sector sources.

2.2.2.1 Public Sector Sources

Green Investment Bank

The GIB has been set up under the auspices of the Department for Business Innovation and Skills (BIS). It is intended to be a wholesale bank with an initial capital allocation of £3 billion that can invest in off-shore wind, waste recycling and waste to energy, and non-domestic energy efficiency projects. Currently the GIB is in the process of sourcing its project pipeline which could include DE projects.

Funding from the GIB could be in the form of debt or equity instruments however it is mostly likely to be debt. They are looking to provide finance in large tranches (over £20 million) therefore there could be scope for pooling a number of projects under DEPDU with which to approach the GIB. Indicative costs of capital are likely to be marginally lower than the market rate of 2 to 3 per cent above LIBOR.

European Investment Bank

The EIB grants medium to long term loans to energy efficiency and renewable energy projects. It can provide project finance to projects over EUR 25m in value or intermediate loans through credit lines to banks or other financial institutions if projects are less than EUR 25m in value.

Debt finance from the EIB could be suitable for DE projects because they can grant long term loans with up to 20 year maturities which include grace periods for repayment and provide the assurance needed for private sector lenders. The EIB can lend at rates lower than the commercial market: technically, they can lend at the country-specific reference rate to avoid State aid issues and this is currently approximately 1.75 per cent in the UK[28].

However, a major barrier will be whether projects can be scaled up to meet the funding criteria of the EIB – projects under EUR 25m are more likely to have shorter maturity periods. In addition it is unclear to date whether EIB finance will be cheaper than UK sources such as PWLB.

The last point to note is that the EIB will generally only finance 50 per cent of project costs. In rare cases the EIB will finance 100 per cent of a loan granted by an intermediary bank. Adequate security will be needed in all cases such as that provided by a bank or banking syndicate, a financial institution or a large diversified parent company with a good credit rating.

[28] Country-specific reference rates are published by the European Commission at: http://ec.europa.eu/competition/state_aid/legislation/reference_rates.html

London Green Fund

The LGF is the Holding Fund for the London JESSICA Programme (Joint European Support for Sustainable Investment in City Areas). It initially had a £100m allocation from the London ERDF programme and the London Development Agency (LDA) and the London Waste and Recycling Board (LWARB). However, £85m of this has now been allocated to two Urban Development Funds (UDFs): the London Energy Efficiency Fund (LEEF) managed by Amber Infrastructure and the London Waste Fund (Foresight Environmental Fund) managed by Foresight.

The remaining £15m has some potential for DE projects. It needs to be allocated to projects by the end of 2015 and therefore there are time constraints. It is possible that if feasible business cases are put to the LGF Investment Committee that they might consider allocating the remainder to DE in London. However, there is significant demand for this £15m and it is also possible that it could be allocated to one of the existing UDFs.

European Energy Efficiency Fund

The European Energy Efficiency Fund (EEE-F) is a new European fund with a EUR 265m capitalisation operated by Deutsche Bank. EEE-F will invest in energy saving, energy efficiency and renewable energy projects, particularly in urban areas. Projects could involve high efficiency CHP, micro-cogeneration and district heating networks.

The EEE-F is a potential funding option for DE projects. Its priorities are aligned with DE, and the fund will cover a large range of financial products such as senior and junior loans, guarantees and equity participation. In addition the EEE-F can provide technical assistance similar to ELENA at a project level.

Investments will need to be made before 31st March 2014.

Project and municipal bonds

Legislation passed in 2004 allows LAs to issue bonds for capital projects without permission from central government. However, to date there has been little issuance apart from a £215 million bond issued by Birmingham City Council to finance the refurbishment of the National Exhibition Centre, and a bond issued by the Greater London Authority (GLA) to finance Crossrail.

There has been increased interest in the possibilities of raising bond finance after the Treasury's decision to increase the cost of loans from the PWLB in 2010.

In addition, the Local Government Association (LGA) is looking into the possibilities for aggregating borrowing needs across many LAs to issue bonds. Before the end of 2011 the LGA is planning to announce a bond club arrangement that could allow councils to jointly borrow from financial markets. The GLA itself could also raise a bond to finance London-wide DE projects.

Bond finance generally has high transaction costs but the finance itself can be cheaper than other types of debt because it is secured on the typically high credit rating of the LA.[29] Therefore aggregating project portfolios and borrowing needs will be essential in making this type of finance viable for DE projects.

2.2.2.2 Private Sector Sources

Senior Debt secured against an organisation or project

The project sponsor could take out senior debt from a commercial bank secured on the organisation's or the project's assets. This is likely to be at LIBOR +3 per cent for a project with a 20 year timescale. In the latter case this tends to be non-recourse debt which means that the equity provider's liability is limited to the collateral.

Due to current uncertainty in the markets it may be difficult to secure this type of financing for DE projects which have a medium to high level risk profile. If the project has a low risk profile it may be more viable.

However, with the current rate of PWLB at 4 per cent for loans up to 20 years this does not seem to be a favourable funding option for DE projects.

Senior Debt provided by a contractor/ESCO

LAs could use finance from an ESCO or a contractor to fund a DE project. The security required by the ESCO or contractor is likely to be more flexible than that required by a bank.

The cost of capital will be dependent on the ESCO's own internal cost of capital.

Climate Change/Green Investment Funds

There are some investment funds such as Triodos[30], Climate Change Capital[31] and Earth Capital Partners[32] that have been established with a specific remit to invest in projects that contribute to climate change reduction such as energy efficiency and renewable energy projects. As such they attract fund raising from pension funds and other investors with a Social Responsible Investment (SRI) protocol. However, they tend to be interested only in projects that have relatively high returns (10-20 per cent) and with short investment periods (5-10 years). In addition, they will be looking for projects or project portfolios with a large scale investment potential rather than individual small-scale projects.

For these reasons they may not be appropriate for the majority of DE projects where returns are less certain and scale is small. If the GLA could create a viable business case for a large-scale network then this may be more attractive to one of these funds.

2.2.3 Equity sources

Mezzanine Finance

Mezzanine finance can be sought if the amount of debt the project can support is insufficient and acts as a risk buffer to debt. It therefore can be a cheaper way to

[29] Recently Kensington and Chelsea and Wandsworth councils both secured AAA ratings.
[30] See: http://www.triodos.co.uk/en/institutional_investors/
[31] See: http://www.climatechangecapital.com/home.aspx
[32] See: http://www.earthcp.com/

replace some of the additional equity that may otherwise be needed, thus improving the overall cost of finance.

Payments to mezzanine providers are made after that of senior debt. Therefore the provider takes on a higher level of risk which increases financing costs (as opposed to using debt only). Indicative costs of capital are LIBOR +7 per cent.

2.3 Funding Options that are unlikely to be well suited to DE projects

2.3.1.1 Public Sector Sources

Salix Financing

Salix provides funding to energy efficiency projects that generate energy and cost savings. The programme is set up and designed to provide public sector organisations with access to either loans or grants. There is currently £20 million of funding available via the SEELS 4 programme; the application process for this will end by 31st March 2012.

Each project is scrutinised and expected to payback within a maximum of five years, loans are paid back through savings on energy bills. Since most DE projects under review have roll-out and development beyond this time horizon, this option for DE networks does not appear to be feasible.

Tax Increment Financing

Tax Increment Financing (TIF) is due to be implemented in the UK in April 2013. It is based on ring-fencing or hypothecating future business rate increases as a result of a new development. Forecast increases can be used to secure borrowing against future revenues, which can be used to pay for the initial capital costs of infrastructure. The most important criterion to get TIF started in the UK is the ability to directly hypothecate a stream of tax revenue to repay debt finance.

TIF has been used widely across the US where it is a private finance tool and the TIF bond market is well developed. However, in the UK it is thought that initial debt financing will be from the PWLB.

TIF is a risky prospect for DE projects due to four main factors:

1. The primary legislation for TIF is yet to be developed to enable the hypothecation of future tax revenues
2. The linkage between DE projects to increases in business rates is not well established
3. There is not yet a sophisticated LA or GLA bond market by which to raise finance
4. The public sector has to take on the risk that occurs between the initial investment and when the private sector starts paying taxes to repay it – because of the lack of linkage between DE and increases in business rates this risk will be particularly high

It is recommended that LAs look at other funding options until TIF has been established properly in the UK and there is some precedent for financing energy infrastructure projects.

TIF is likely to be a possibility only in the case of a particularly transformative development which would involve a major regeneration scheme in low value areas. Such situations do exist in London, such as in the Upper Lea Valley and Thames Gateway. Were a DE network to be planned as part of a comprehensive infrastructure strategy, then it might benefit from the TIF which would be secured against the entire delivery programme. From the perspective of the DEPDU programme, the involvement of DE-specific interests in a TIF opportunity would be marginal.

Community Energy Saving Programme

The Community Energy Saving Programme (CESP) is administered by Ofgem and is focused on delivering CO_2 reductions in areas of low income and high deprivation.

In a similar way to CERT, CESP is funded via a statutory obligation on the utility suppliers to deliver energy saving measures to domestic consumers. It has been designed to deliver £350m of funding to improve energy efficiency and reduce fuel costs at the household level, with a focus on specific areas of deprivation. Opportunities are focused on and more suited to large scale housing retrofit. However, the programme is expected to stop by the end of December 2012.

2.3.1.2 Private Sector Sources

Pension Funds

Pension funds are attracted to the infrastructure market to diversify their portfolios into more stable and tangible assets. Infrastructure assets are inflation-linked and therefore attractive to institutional investors. In addition, investment in infrastructure is also considered to be SRI which is a priority of many pension funds. There has been much press coverage in recent months on how pension funds can play a greater role in infrastructure financing.

However, pension funds are traditionally uncomfortable accepting construction risk and may be more likely to invest once assets are operational and the projects cash flows have been demonstrated. Even then it is possible that typical DE project IRRs would be too low for pension funds which tend to make investments at high cost of capital 7 per cent and above.

Therefore, investment by pension funds in DE projects does not appear feasible for the majority of cases.

Private Equity/Venture Capital Funds

The Foresight Environment Fund (London Waste UDF) is a private equity model that will source investment from pension funds and venture capital funds to make investments in waste to energy and waste recycling facilities. The higher risks and related returns involved in these types of projects make them more suitable for equity investment than debt. In addition, they may also not be able to secure the amount of debt finance needed to fund capital expenditure for the facility.

It is yet to be seen whether there is any financing potential from private equity or venture capital funds for DE projects. The major barrier would be the typically uncertain returns and long payback periods of DE projects which may well require a mix of grant, subsidy, debt and equity finance to ensure viability.

Sovereign Wealth Funds

Sovereign wealth funds tend to focus on large scale projects which yield high IRRs in the 15 to 20% range, or alternatively in projects that have a high profile and commercial appeal that raise the exposure of the relevant country (e.g. football clubs). In the majority of cases returns from DE projects may struggle to reach sufficient levels of returns. In addition, the uncertainty of cash-flows, returns and long payback periods mean that DE projects are unlikely to be a target for sovereign wealth investment.

2.4 Conclusions and Recommendations

There are a wide range of funding options for DE projects, some more viable than others.

Realistically successful delivery of DE projects will involve a mix of funding sources. Subsidies and grants can be used to improve the project's internal rate of return and make them more attractive to funders and investors in addition to LAs and the PWLB.

It is recommended that LAs look first at the options to which they have direct access such as their internal reserves, the PWLB and the full range of subsidies available to DE projects. If these are not sufficient then they can explore a range of other options including grant and debt options from UK and EU public sector sources. If projects have particularly strong returns then private equity sources could also be explored.

In addition it is also recommended that LAs look at pooling project portfolios to provide more attractive investment proposals to funders such as the GIB, EIB, and EEE-F. Project scale and reducing transaction costs will be central to the successful delivery and financing of DE projects.

Finally, it has long been recognised that many of the potential funding sources, both public and private, do not regard DE as a suitable class of investment, given its typical scale, risk profile and normal rates of return. Whilst part of the solution to this issue is in the structuring of opportunities, another part is in the communication with funders to help them become more familiar with DE projects and by that means to become more comfortable with the typical risk profile. Therefore engagement on a non-project-specific basis with key funders could be part of a mix of actions for DEPDU to facilitate project access to funding.

3 Next Steps

It is important to note that the selection of funding sources for individual projects, and larger-scale project portfolios will be based around project characteristics including:

- Project risk (and importantly who bears this risk)
- Project returns
- Project timescales
- Commercial structures; and
- Appetite for Local Authority debt or equity financing.

Therefore integrating this initial high-level analysis with research on the indicative commercial structures and project characteristics on actual live projects will be an important next step. This will enable DEPDU and LAs to begin to investigate the most appropriate funding strategy for individual projects and project portfolios.

A further recommended action is to engage with funders and other stakeholders to help shape key decision makers' opinions on DE.

Appendix A

Long List of Funding Options for DE Projects

A1 Long List of Funding Options

Table 1 Characteristics of Funding Options

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
LA Internal Reserves	Equity	LA can fund DE projects using its own internal reserves	0%	Continuous	Dependent on LA	This is the simplest and cheapest form of finance for a LA however it is unlikely that most LAs will have sufficient reserves to finance large capital projects
Prudential Borrowing – Public Works Loan Board (PWLB)[1]	Debt	If LA intends to own all or part of DE assets this could be fully or partially funded through prudential borrowing from the PWLB	Approx. 4% for a 20 year loan	Continuous	Up to a "headroom" level for each LA	Suitable source of relatively low cost capital for projects that are wholly or jointly owned by a LA

[1] See: http://www.dmo.gov.uk/index.aspx?page=PWLB/Introduction

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Salix Finance[2]	Debt	Salix is an independent non-proft organisation that provides funding for projects that generate energy and cost savings	0%	Each project is subject to scrutiny against strict compliance requirements including: five year payback; cost of carbon under £100/te over project life; nine months to complete capital works Programme closes on 31st March 2012	Investment limit of £20m across programme	Unlikely to be suitable to fund DE projects because projects must pay for themselves from energy savings within a maximum of 5 years. In addition programme ends on 31st March 2012
European Union (FP7) Framework Programme for Research and Technical Development 10[3]	Grant	FP7 provides grants to fund research and technology development projects.	0%	Launched in 2007 and scheduled to complete by 2013. Grants are allocated upon on a call for proposals and a peer review process.	The total investment budget is EUR 2.35 billion	Funding is focused on developing new renewable technologies and innovative demonstration projects. It is unlikely to be a suitable source of funding for a standard DE project. It could potentially be a source of finance if a new renewable source of heat was being research and developed.

[2] See: http://www.salixfinance.co.uk/home.html
[3] See: http://cordis.europa.eu/fp7/energy/

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Green Investment Bank (GIB)[4]	Debt or equity	GIB has been set up under the auspices of the Department for Business Innovation and Skills It will be a wholesale bank with an initial capital allocation of £3 billion that can invest in off-shore wind, waste recycling and waste to energy, and non-domestic energy efficiency projects Currently the GIB is in the process of sourcing deal flow and may well look at DEPDU favourably as a source of projects	2% to 3% above LIBOR (marginally lower than commercial rate)	As the GIB's remit is being finalised, no date has been announced around an operational start date. Lack of clarity to date on availability No end date finalised	Up to £3 billion for a range of energy efficiency and renewable energy projects	A possible suitable source of sub-market rate financing for long term DE projects. Viability will depend upon the individual project Pooling projects into fundable portfolios will be important, as will detailed business cases

[4] See: http://www.bis.gov.uk/greeninvestmentbank

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Carbon Emissions Reduction Target (CERT)[5]	Grant	CERT is a legal obligation on the six largest utilities to achieve CO_2 reductions in domestic buildings	0%	Programme is expected to close by December 2012 Funding is aimed at non-profit community based organisations to deliver improvements in energy efficiency, electricity generation from microgeneration , and promote community heating powered by biomass (up to 3MWth)	Funding is available via the utility companies	A possible match for small scale DE projects, with generation (from biomass) not exceeding 3MWth CERT support can be allocated to both private and social sectors. However, this will stop at the end of December 2012 Unlikely to fund the entire capital cost of a DE scheme

[5] See: http://www.decc.gov.uk/en/content/cms/funding/funding_ops/cert/cert.aspx

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Community Energy Saving Programme (CESP)[6]	Grant	CESP is administered by Ofgem. It is focused on delivering reductions in carbon in areas of low income and high deprivation CESP requires gas and electricity suppliers to deliver energy savings measures to domestic consumers	0%	Funding is expected to be completed by December 2012 Funding is aimed at non-profit community based organisations, for installing micro-generation technologies and energy efficiency measures	Organisations can apply for up to £50,000 or 50 per cent of the project cost (whichever is lower). £8 million available and £1 million for project development grants	CESP runs out at the end of December 2012 and only supports projects with payback of 5 years. It is unlikely to be suitable for the majority, if not all, of DE projects It also will not cover the full capital cost of a DE scheme
Housing Revenue Account (HRA)[7]	Subsidy	LAs are required by the Local Government and Housing Act 1989 to keep a HRA. This records all revenue expenditure and income relating to the provision of council dwellings and related services	0%	Continuous Revised rules governing HRA are expected to be introduced by April 2012. The use of money collated in a HRA account is prescribed by statute. An LA is not allowed to fund any expenditure for non-housing related services from this account	Funding is dependent upon the number of social houses under local authority control	HRA is a useful facility for a local authority considering DE. New powers being introduced in April 2012 will give local authorities full control over housing income and expenditure. Surplus revenue could be used in energy efficiency and generation projects

[6] See: http://www.decc.gov.uk/en/content/cms/funding/funding_ops/cesp/cesp.aspx
[7] See: www.communities.gov.uk/documents/housing/pdf/138964.pdf

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Business Rate Retention: Renewable Energy	Subsidy	The Department of Communities and Local Government (DCLG) has published a consultation into business rate retention. One proposal is for communities hosting renewable projects to retain the associated business rates.	0%	Results and a final decision from the consultation are expected during 2012. The definition of qualifying renewable technologies is yet to be finalised.	Final results of the consultation are expected shortly	If the consultation proposals are implemented it will provide local authorities with incentives to develop renewable CHP, which could form part of a wider DE scheme for delivery.

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Community Infrastructure Levy (CIL)[8]	Levy/charges	A new levy introduced in 2010 LAs now have the ability to charge new developments a levy on a per m^2 basis	0%	CIL is expected to begin in April 2014. It is set to replace S106 as the primary source of revenue collection from new developments. Levies can be charged following guidelines in the Planning Act (2008)	All LAs are expected to implement the new CIL arrangements	CIL could be suitable for funding DE schemes where a LA wants a private sector developer to support a new DE scheme There is a significant amount of flexibility built into the levy on location, type of project, or repayment. However, it is unlikely to be able to support the full capital costs of a DE scheme so support from other funding sources would be required Lead in time is also an issue because CIL is expected to be implemented by April 2014

[8] See: http://www.communities.gov.uk/planningandbuilding/planningsystem/communityinfrastructurelevy/

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Section 106	Levy/charges	The new CIL Regulations provide a reform to the current system of planning obligations to enable both Section 106 contributions and the new CIL to operate effectively alongside each other	0%	Continuous. However the introduction of CIL has effectively removed the ability of S106 to fund any energy infrastructure projects	All LAs are still expected to implement S106 agreements	The introduction of CIL has meant that S106 is no longer able to directly fund DE projects
Enterprise Zone	Subsidy	To stimulate economic growth and generate jobs the government has created new enterprise zones. New businesses locating in a zone will receive reduced business rates for five years. The local authority hosting the zone will retain the rates for the next 25 years.	0%	An enterprise zone has been established at the Royal Docks, London. Business rate are expected to be collected over the next 25 years. The GLA has established the London Enterprise Partnership to collect business rates.	The London Enterprise Partnership will hold funds collected business rates.	Collected monies can then be reinvested into promoting economic growth or set against borrowing for investment. A DE project will need to demonstrate how it will contribute towards the delivery of the Mayor's Economic Development Strategy.

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Allowable Solutions	Subsidy	The Government has for sometime recognised that achieving zero carbon in new development is unlikely to be viable in most cases. A new system of *'allowable solutions'* has been proposed to help offset residual carbon emissions. This includes low carbon measures away from developments, such as renewable energy installations, DE network or building retrofit. It is expected that these offset solutions will be agreed in advance with developers, to be delivered by them or pay a third party.	0%	Our judgement is that no money will be collected through this system before 2016.	Funding from developers is already available via S106 and CIL. The offset fund would allow these sources to be unlocked and targeted at specific low carbon energy generation projects	Potentially a very suitable source of funding for DE projects. If Allowable Solutions is implemented it will create a framework for local authorities to deliver new low carbon infrastructure.

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Offsetting fund	Subsidy	The GLA's climate change mitigation and energy strategy provides information on proposals for a carbon offsetting fund. It is expected to operate in a similar manner to the proposed Allowable Solutions framework. Where new developments cannot achieve their carbon reduction target, in an economically viable way, the shortfall in carbon savings can be offset through the funding of other low carbon projects.	0%	The proposed scheme and how it will work in practice are still to be finalised. Because of its similarities with Allowable Solutions It would be our opinion that it will operate on a similar timescale.	Funding from developers is already available via S106 and CIL. The offset fund would allow these sources to be unlocked and targeted at specific low carbon energy generation projects	Potentially a very suitable source of funding for DE projects. If implemented it will create a framework for local authorities to deliver new low carbon infrastructure.

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Project and Municipal Bonds issued by Local Authority	Bonds	Legislation was passed in 2004 to enable LAs to issue bonds for capital projects without permission from government Little issuance apart from a £215m bond from Birmingham city council, to finance the refurbishment of the National Exhibition Centre	Dependant on credit rating of LA but can be lower than commercia l debt rates	Attractive credit rating required to reduce costs of capital to borrowers	Dependent on the level of debt a local authority is willing to take on and robustness of future returns	Project or municipal bonds could be suitable for DE projects The prospect of a bond club arrangement by the LGA, which could allow LAs to borrow jointly from capital markets could make bond finance more attractive to LAs Due to the high credit ratings of many LAs bond finance could prove cheaper than PWLB but higher initial transaction costs apply
Project and Municipal Bonds issued by GLA	Bonds	Bond issued by GLA. Most recent example is that for Crossrail	Dependant on credit rating of LA but can be lower than commercia l debt rates	Attractive credit rating required to reduce costs of capital to borrowers	Dependent on the level of debt GLA is willing to take on and robustness of future returns	A GLA raised bond could be suitable for DEPDU if it was intended to finance London-wide projects If PWLB becomes cheaper for DE schemes then bond finance may be less attractive

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Enhanced Capital Allowances (ECAs)[9]	Tax incentives	ECA enables a business to claim 100% of the first-year capital allowance on qualifying plant and machinery	0%	Continuous	Open to those entities promoting the delivery of new CHP	ECAs are suitable with a private sector asset owner It will enable a private sector organisation to claim 100% of first-year capital allowance. This should be taken into account in a financial appraisal for individual projects

[9] See: http://etl.decc.gov.uk/

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Tax Increment Financing (TIF)[10]	Tax incentives	TIF allows a hypothecation of future business rate increases as a result of infrastructure development to secure borrowing that will fund the initial capital costs of that development In the US finance is raised on the bond market however in the UK it is thought that PWLB will be the initial lender to TIF schemes	Cost of capital will vary between funding type (bond or PWLB for example)	TIF is expected to be implemented by April 2013 (announcement made in the Spending Review)	Will be implemented from April 2013	TIF does not appear suitable for most DE projects because they do not necessarily increase land values or business rates It is likely to be a long term option as no TIF projects have been implemented in the UK There could be some scope for TIF for transformative developments involving major regeneration in low value areas, and should be considered as part of a long term infrastructure financing strategy

[10] See: http://www.hm-treasury.gov.uk/press_47_10.htm

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Feed in Tariffs (FIT)[11]	Subsidy support	The FIT scheme is the main support mechanism to encourage deployment of additional small-scale (<5MW) low carbon electricity generation	0%	Funding expected to last until 2020/21 Generators with an installed capacity <5MW can receive FIT support DECC is currently reviewing FIT support levels and banding levels could change significantly	FIT is currently available	Appropriate level of FIT should be taken into consideration in financial appraisals for individual projects. It has a focus on microCHP <2kW which is likely to be too small for a DE project If banding levels are adjusted this could also change

[11] See: http://www.fitariffs.co.uk/

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Renewable Heat Incentive (RHI)[12]	Subsidy support	The RHI is a financial support scheme for renewable heat The scheme is being introduced over two phases. The first is for big-heat users - industrial, business and public sector organisations. The second phase will see expansion to other generation technologies	0%	Funding expected to last until 2020/21 The RHI scheme is currently undergoing final review	Funding for the RHI is available once accreditation has been completed	RHI forms a potential source of revenue financing for DE projects Appropriate level of RHI should be taken into consideration in financial appraisals for individual projects. No double subsidy is allowed (i.e. a project will not be eligible for RHI and FITs)

[12] See: http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Renewables Obligation (RO)[13]	Electricity market support mechanism	The RO is the main support mechanism for renewable energy projects in the UK The RO places an obligation on UK electricity suppliers to source an increasing proportion of electricity supplied to customers from renewable sources Operators can then trade RO Certificates (ROCs) with other parties, with the ROCs ultimately being used by suppliers to demonstrate that they have met their RO target	0%	RO support is currently under review The next round of support will be from April 2013 to April 2017 A CHP system will need to be installed and meet its generating capacity before a ROC can be issued RO programme is underway and will continue to run until 2017, when the programme is expected to be discontinued	Funding via RO is available once accreditation is complete DECC is currently consulting on the level of support for all types of renewable technology	ROCS can be traded by DE project owners to source revenue financing for their schemes ROCs should be taken into consideration in financial appraisals for individual projects

[13] See: http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
New Homes Bonus[14]	Incentive	A new scheme designed to encourage local authorities to grant planning permission for building new homes, in return for additional revenue	0%	Funding began April 2011 with an expected completion date of April 2014	Funding is dependent upon a LAs' success in promoting housing development	If a scheme involves the building of new housing the LA will receive a New Homes Bonus for each new home. This could be used to fund a DE scheme. However, it is unlikely to be enough to finance the entire capital cost

[14] See: http://www.communities.gov.uk/housing/housingsupply/newhomesbonus/

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
London European Regional Development Fund 2007 to 2013[15]	Grant	ERDF supports regional development through actions such as business innovation and support and regeneration. London's 2007-2013 ERDF Operational Programme sets out four main investment priorities. Priority 3, Sustainable places for business. is especially relevant for DE as it allows for creating high quality environments for businesses that are serviced by renewable and co-generated decentralised energy and innovative waste management and water resource support systems	0%	Grant allocation began in 2007, with expected completion date December 2015. The project will need to have a marginal economic return	This will depend on how much funding is left in the London Operational Programme ERDF will have to be matched by public or private sources	It may be possible to secure some level of ERDF financing for DE projects that are very marginal and require grant financing

[15] See: http://www.london.gov.uk/priorities/championing-london/london-and-european-structural-funds/erdf

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
European Investment Bank (EIB)[16]	Debt	The EIB tends to grant medium to long-term loans to RES and EE projects. It can provide project finance to projects >EUR £25m, or intermediate loans through credit lines to banks or other financial institutions to help them provide finance to SMEs or public sector projects	For projects < EUR 25 million costs of capital are determined by the respective EIB partner bank Maturities typically range between 5-12 years	Availability should be strong for DE projects with a strong business case	Relatively unlimited	EIB could be a good source of finance for long term DE projects. Loans will finance a maximum of 50% of the total cost of any project, if the project value is >EUR 25 million Adequate security will be needed such as that provided by a bank or banking syndicate, a financial institution or a large diversified parent company with a good credit rating In terms of intermediated loans (lines of credit or indirect loans designed to permit the financing of projects with total investment cost of less than EUR 25 million) an EIB credit line may finance up to 50% of the total cost of any project, or in certain cases, 100% of the loan granted by the intermediary bank

[16] See: http://www.eib.org/projects/cycle/applying_loan/index.htm

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
London Green Fund (LGF)[17]	Debt	The LGF is London's JESSICA Holding Fund There is £15m out of the total £100m funding pot that is currently unallocated This could be used either as a guarantee, debt or equity instrument to fund DE projects	Cost of capital is likely to be around 2% to 3% + LIBOR however no funding is available at present	Funding is expected to be allocated by December 2015 At present no funds are available for DE projects	At present no funds are available for DE projects	LGF could potentially be used to fund DE projects, however there is some risk that the unallocated £15 million will go to one of the existing UDFs or be used on another GLA programme.

[17] See: http://www.london.gov.uk/erdf/jessica-london-green-fund

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
European Energy Efficiency Fund (EEE-F)[18]	Debt / equity	New European fund with approximately EUR 265 million capitalisation operated by Deutsche Bank EEE-F will invest in energy saving, energy efficiency and renewable energy projects particularly in urban areas Projects could include high efficiency CHP, micro-cogeneration and district heating networks	TBC but EIB can potentially lend at country-specific reference rate	All funding is expected to be allocated by March 2014 Potential beneficiaries are public authorities, preferably at local and regional level, and public and private companies which are acting on behalf of those public authorities such as local energy utilities, ESCOs, district heating CHP companies or public transport providers	No maximum but currently EEE-F has capitalisation of EUR 265 million	EEE-F is very suitable for DE projects and could fund all potential beneficiaries involved in a commercial structure. Availability will be the main risk
Senior debt (secured against an organisation)	Debt	Debt backed by a public sector body	Interest rate at LIBOR + 3%	Current uncertainty in markets, however the demand for the returns provided by lower risk infrastructure projects remain attractive to investors	Limited by market capacity	Potentially suitable however unlikely to be more attractive than PWLB in cost terms

[18] See: http://ec.europa.eu/energy/eepr/eeef/eeef_en.htm

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Senior debt (secured against a project)	Debt	Project finance is provided solely on the basis of the project's cash flow for repayment with security held on project's assets, rights and interests Tends to be non-recourse which means that the equity provider's liability is limited to the collateral. First tranche of debt to get repaid.	Interest rate at LIBOR + 3%	General Lender requirements will be to minimise project risk by due diligence on all aspects of a project Issues will include security of revenues, project risk, fuel arrangements, timetable and delays, deliverability of project, financial standing of contractors etc Will need SPV to seperate cash flows from project from general LA cash flows	Limited by market capacity	Specific DE projects will need sufficient scale or returns to attract and secure project finance.
Senior debt (corporate)	Debt	Corporate debt includes debt provided by an ESCO/contractor to fund a project	Dependent on corporation 's internal cost of capital	Will depend on ESCO/contractor's willingness to finance project	Limited by organisations capacity	Potentially suitable however unlikely to be more attractive than PWLB

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Mezzanine debt	Debt	Mezzanine finance can be sought if the amount of debt the project can support is insufficient and it can act as a risk buffer but at an additional premium to debt. It can therefore be a cheaper way to replace some of the additional equity that may be otherwise needed, thus improving cost of overall finance Payments to mezzanine lenders are made after that of senior debt	LIBOR + 7%	Current uncertainty in markets, however the demand for the returns provided by lower risk infrastructure projects remain attractive to investors	Limited by market capacity	Potentially suitable however unlikely to be more attractive than PWLB

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Pension Funds	Equity	Pension funds attracted to the infrastructure market to diversify their portfolios into more stable and tangible assets Infrastructure assets are inflation-linked and therefore attractive to institutional investors. Also fit well into their remit for socially responsible investing (SRI)	7% and above	Pension funds are traditionally uncomfortable accepting construction risk and may be more likely to invest once assets are operational although even then it is possible that IRR would be too low for pension funds which tend to make investments at high cost of capital 7% and above	Potentially far greater than the scale of funding required for DE	Unlikely to be suitable until assets are operational
Private equity/Venture Capital	Equity	Private Equity/Venture Capital firms tend to be interested in projects with IRRs of 15-20% and with short investment periods (1-10 years)	15-20%	Likely to make short to medium term investments (1-10 years) Will require large scale projects/project portfolio for an attractive investment proposal	Unlikely to be suitable until assets are operational	May not be appropriate for the majority of DE projects where returns are less certain and scale is small. If the GLA could create a viable business case for a large-scale network then this may be more attractive

Funding Source	Financial Instrument	Description	Indicative Cost of Capital	Funding Timescales and Criteria	Funding Available	Suitability for DE projects
Climate change funds	Debt / equity	There are some investment funds such as Triodos[19], Climate Change Capital[20] and Earth Capital Partners[21] that have been established with a specific remit to invest in energy efficiency and renewable energy projects	10-20%	Short investment periods are preferable (5-7 years) Will require large scale projects/project portfolio for an attractive investment proposal	Unlikely to be suitable until assets are operational	May not be appropriate for the majority of DE projects where returns are less certain and scale is small. If the GLA could create a viable business case for a large-scale network then this may be more attractive Should be investigated further for specific DE project portfolios
Sovereign wealth funds	Debt / equity	Sovereign wealth funds tend to focus on large scale, high profile projects with yields of typically 15 - 20%	15-20%	Payback period are likely to be in the short to medium term range (1 – 10 years). Projects typically need to be large scale in nature to be attractive investment propositions.	Unlikely to be suitable	Unlikely to be suitable for the majority of DE projects. This is due to the uncertainty around cashflow, returns and payback.

[19] See: http://www.triodos.co.uk/en/institutional_investors/
[20] See: http://www.climatechangecapital.com/home.aspx
[21] See: http://www.earthcp.com/

APPENDIX 8 COST AND CARBON PLAN

Thames Water SPG

Sum	Sequence / Year	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
	Sequence		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
-35,241,622	Total Capital	[£]	-15,679,119	-14,978,862	-1,400,878	-84,951	-87,944	-321,980	-117,623	-336,027	-46,760	-84,951	-159,727	-79,389	-171,426	0	0	0	-46,760	0	0	0	0	-822,613	0	0
-104,433,576	Fuel subtotal	[£]	0	0	-1,452,716	-1,519,060	-1,597,783	-1,779,607	-1,862,352	-2,017,487	-2,079,242	-2,157,494	-2,293,019	-2,363,043	-2,520,020	-2,539,075	-2,558,130	-2,577,186	-2,645,492	-2,664,983	-2,684,474	-2,703,965	-2,723,456	-2,742,947	-2,762,438	-2,781,929
-11,529,227	O&M excl fuel subtotal	[£]	0	0	-246,792	-249,767	-253,363	-262,417	-265,947	-273,194	-275,484	-278,459	-284,252	-286,719	-293,110	-293,110	-293,110	-293,110	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400
259,857,892	Revenue subtotal	[£]	0	0	2,882,402	3,055,683	3,294,002	3,815,499	4,037,438	4,481,335	4,677,533	4,885,817	5,283,839	5,504,943	5,907,209	5,990,810	6,074,411	6,158,012	6,385,048	6,470,580	6,556,111	6,641,642	6,727,174	6,812,705	6,898,237	6,983,768
108,653,466	Total cashflow	[£]	-15,679,119	-14,978,862	-217,983	1,201,905	1,354,912	1,451,495	1,791,515	1,854,627	2,276,047	2,364,913	2,546,842	2,775,793	2,922,653	3,158,625	3,223,171	3,287,717	3,397,397	3,510,197	3,576,238	3,642,278	3,708,318	2,951,745	3,840,399	3,906,440
143,895,089	Operating margin	[£]	0	0	1,182,894	1,286,856	1,442,856	1,773,475	1,909,139	2,190,654	2,322,807	2,449,864	2,706,569	2,855,181	3,094,079	3,158,625	3,223,171	3,287,717	3,444,157	3,510,197	3,576,238	3,642,278	3,708,318	3,774,359	3,840,399	3,906,440
152,227,178	Total Carbon dioxide emissions	kg CO2	0	0	1,662,712	1,774,606	1,912,124	2,294,198	2,477,176	2,834,461	2,948,168	3,148,447	3,494,550	3,639,133	4,129,810	4,124,367	4,118,924	4,113,524	4,255,797	4,250,354	4,244,912	4,239,469	4,234,027	4,228,584	4,223,184	4,217,741
1,417	Network heat CO2 intensity	kg CO2 / MWh	0	0	23	24	25	27	28	30	31	32	34	35	37	37	37	37	38	38	38	38	38	38	38	38
722,185,079	Alternative CO2 emissions (BAU)	kg CO2	3,340,105	3,512,486	13,659,472	13,938,107	14,334,171	15,464,639	15,810,996	16,737,581	16,974,156	17,256,617	17,877,150	18,128,121	18,704,517	18,663,490	18,622,462	18,581,754	18,801,512	18,760,484	18,719,456	18,678,428	18,637,401	18,596,373	18,555,666	18,514,638
10,512,805	Temporary CO2 emissions	kg CO2	5,071,609	5,441,196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
559,445,096	CO2 savings from network including temporary emissions	kg CO2	-1,731,504	-1,928,710	11,996,759	12,163,501	12,422,047	13,170,441	13,333,820	13,903,120	14,025,988	14,108,171	14,382,600	14,488,988	14,574,708	14,539,123	14,503,537	14,468,230	14,545,715	14,510,130	14,474,545	14,438,959	14,403,374	14,367,789	14,332,482	14,296,896

Beckton Waste Treatment Facility

Sum	Sequence / Year	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
	Sequence		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
-34,148,580	Total Capital	[£]	-13,238,844	-15,652,479	-1,400,878	-84,951	-87,944	-321,980	-117,623	-336,027	-46,760	-84,951	-159,727	-79,389	-171,426	0	0	0	-46,760	0	0	0	0	-1,159,422	0	0
-99,123,228	Fuel subtotal	[£]	0	0	-1,230,521	-1,299,090	-1,375,768	-1,554,088	-1,642,013	-1,800,310	-1,865,660	-1,951,065	-2,092,121	-2,167,093	-2,333,778	-2,358,273	-2,382,767	-2,407,262	-2,481,336	-2,506,409	-2,531,482	-2,556,555	-2,581,627	-2,606,700	-2,631,773	-2,656,846
-11,313,274	O&M excl fuel subtotal	[£]	0	0	-241,393	-244,368	-247,964	-257,019	-260,548	-267,796	-270,085	-273,060	-278,853	-281,320	-287,711	-287,711	-287,711	-287,711	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001
259,857,892	Revenue subtotal	[£]	0	0	2,882,402	3,055,683	3,294,002	3,815,499	4,037,438	4,481,335	4,677,533	4,885,817	5,283,839	5,504,943	5,907,209	5,990,810	6,074,411	6,158,012	6,385,048	6,470,580	6,556,111	6,641,642	6,727,174	6,812,705	6,898,237	6,983,768
115,272,810	Total cashflow	[£]	-13,238,844	-15,652,479	9,611	1,427,273	1,582,325	1,682,413	2,017,254	2,077,203	2,495,028	2,576,741	2,753,139	2,977,141	3,114,293	3,344,826	3,403,932	3,463,039	3,566,952	3,674,170	3,734,629	3,795,087	3,855,546	2,756,583	3,976,463	4,036,921
149,421,391	Operating margin	[£]	0	0	1,410,489	1,512,224	1,670,270	2,004,393	2,134,877	2,413,230	2,541,787	2,661,691	2,912,866	3,056,530	3,285,719	3,344,826	3,403,932	3,463,039	3,613,711	3,674,170	3,734,629	3,795,087	3,855,546	3,916,004	3,976,463	4,036,921
483,369,705	Total Carbon dioxide emissions	kg CO2	0	0	6,529,256	6,931,534	7,338,906	8,443,688	8,959,224	9,923,323	10,224,176	10,691,657	11,497,284	11,832,693	12,820,114	12,814,671	12,809,229	12,803,828	13,109,456	13,104,014	13,098,571	13,093,129	13,087,686	13,082,243	13,076,843	13,071,401
4,529	Network heat CO2 intensity	kg CO2 / MWh	0	0	92	95	96	100	103	106	107	109	112	113	116	116	116	116	117	117	117	117	117	117	117	117
722,185,079	Alternative CO2 emissions (BAU)	kg CO2	3,340,105	3,512,486	13,659,472	13,938,107	14,334,171	15,464,639	15,810,996	16,737,581	16,974,156	17,256,617	17,877,150	18,128,121	18,704,517	18,663,490	18,622,462	18,581,754	18,801,512	18,760,484	18,719,456	18,678,428	18,637,401	18,596,373	18,555,666	18,514,638
10,512,805	Temporary CO2 emissions	kg CO2	5,071,609	5,441,196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
228,302,569	CO2 savings from network including temporary emissions	kg CO2	-1,731,504	-1,928,710	7,130,215	7,006,573	6,995,265	7,020,952	6,851,773	6,814,258	6,749,980	6,564,960	6,379,866	6,295,427	5,884,404	5,848,819	5,813,233	5,777,926	5,692,056	5,656,470	5,620,885	5,585,300	5,549,715	5,514,129	5,478,822	5,443,237

Excel CHP In Royal Victoria

Sum	Sequence / Year	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
	Sequence		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
-2,275,953	Total Capital	[£]	-2,113,545	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-141,250	0	0	0	0	-21,157	0	0	0
-12,578,513	Fuel subtotal	[£]	-415,542	-422,842	-430,142	-437,442	-444,742	-452,042	-459,341	-466,641	-473,941	-481,241	-488,541	-495,841	-503,141	-510,440	-517,740	-525,040	-532,340	-539,640	-546,940	-554,240	-561,539	-568,839	-576,139	-583,439
-1,636,317	O&M excl fuel subtotal	[£]	-61,922	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600	-65,600
26,346,884	Revenue subtotal	[£]	877,741	892,419	907,097	921,775	936,453	951,130	965,808	980,486	995,164	1,009,842	1,024,520	1,039,198	1,053,875	1,068,553	1,083,231	1,097,909	1,112,587	1,127,265	1,141,942	1,156,620	1,171,298	1,185,976	1,200,654	1,215,332
9,856,102	Total cashflow	[£]	-1,713,268	403,977	411,355	418,733	426,111	433,489	440,867	448,245	455,623	463,001	470,379	477,757	485,135	492,513	499,891	366,019	514,647	522,025	529,403	536,781	523,002	551,537	558,915	566,293
12,132,055	Operating margin	[£]	400,277	403,977	411,355	418,733	426,111	433,489	440,867	448,245	455,623	463,001	470,379	477,757	485,135	492,513	499,891	507,269	514,647	522,025	529,403	536,781	544,159	551,537	558,915	566,293
52,119,908	Total Carbon dioxide emissions	kg CO2	1,304,443	1,304,443	1,304,443	1,304,443	1,304,443	1,304,443	1,304,443	1,304,443	1,304,443	1,304,443	1,304,443	1,490,517	1,675,764	1,861,838	2,047,912	2,233,159	2,419,234	2,605,308	2,790,555	2,976,629	3,162,703	3,347,950	3,534,024	3,720,098
5,143	Network heat CO2 intensity	kg CO2 / MWh	129	129	129	129	129	129	129	129	129	129	129	147	165	184	202	220	239	257	275	294	312	330	349	367
60,596,504	Alternative CO2 emissions (BAU)	kg CO2 / MWh	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860	2,423,860
0	Temporary CO2 emissions (BAU)	kg CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8,476,596	CO2 savings from network including temporary emissions	kg CO2	1,119,417	1,119,417	1,119,417	1,119,417	1,119,417	1,119,417	1,119,417	1,119,417	1,119,417	1,119,417	1,119,417	933,343	748,096	562,022	375,948	190,701	4,627	-181,447	-366,695	-552,769	-738,843	-924,090	-1,110,164	-1,296,238

Silvertown / T&L

Sum	Sequence / Year	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
	Sequence		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
-6,588,289	Total Capital	[£]	-5,605,296	0	0	-42,613	-46,760	-35,226	-42,613	-112,050	-46,760	-42,613	0	0	-89,373	0	0	0	-46,760	0	0	0	-478,226	0	0	0
-18,417,295	Fuel subtotal	[£]	-414,574	-417,191	-420,226	-458,675	-516,045	-536,759	-576,628	-612,141	-671,832	-713,203	-718,106	-723,039	-822,142	-827,693	-833,273	-838,882	-902,625	-907,994	-913,362	-918,730	-924,099	-929,467	-934,835	-940,203
-2,207,164	O&M excl fuel subtotal	[£]	-68,021	-77,427	-77,427	-78,935	-81,225	-81,942	-83,450	-84,761	-87,051	-88,559	-88,559	-88,559	-92,357	-92,357	-92,357	-92,357	-94,647	-94,647	-94,647	-94,647	-94,647	-94,647	-94,647	-94,647
36,553,205	Revenue subtotal	[£]	642,757	653,707	664,657	753,562	886,057	938,474	1,035,000	1,105,728	1,250,578	1,354,948	1,375,006	1,395,064	1,640,234	1,663,493	1,686,753	1,710,012	1,876,706	1,901,896	1,927,085	1,952,275	1,977,464	2,002,654	2,027,843	2,053,033
9,340,457	Total cashflow	[£]	-5,445,134	159,089	167,004	173,339	242,028	284,547	332,309	296,775	444,935	510,573	568,340	583,465	636,362	743,443	761,123	778,773	832,674	899,255	919,076	938,898	480,493	978,540	998,361	1,018,183
15,928,746	Operating margin	[£]	160,162	159,089	167,004	215,952	288,788	319,774	374,922	408,825	491,695	553,186	568,340	583,465	725,734	743,443	761,123	778,773	879,434	899,255	919,076	938,898	958,719	978,540	998,361	1,018,183
78,782,547	Total Carbon dioxide emissions	kg CO2	2,200,711	2,145,874	2,129,320	2,250,983	2,503,332	2,602,622	2,747,845	2,861,682	3,097,459	3,259,441	3,227,222	3,202,707	3,592,344	3,564,249	3,535,988	3,507,792	3,721,165	3,689,547	3,657,929	3,626,311	3,594,693	3,563,075	3,531,704	3,500,086
3,206	Network heat CO2 intensity	kg CO2 / MWh	144	140	139	136	135	136	134	133	132	132	130	129	128	127	126	125	124	123	122	121	120	119	118	117
91,128,790	Alternative CO2 emissions (BAU)	kg CO2	2,365,377	2,365,377	2,365,377	2,537,162	2,797,947	2,879,608	3,051,393	3,200,787	3,461,572	3,633,357	3,633,357	3,633,357	4,065,927	4,065,927	4,065,927	4,065,927	4,326,712	4,326,712	4,326,712	4,326,712	4,326,712	4,326,712	4,326,712	4,326,712
0	Temporary CO2 emissions	kg CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,346,243	temporary emissions	kg CO2	164,666	219,503	236,057	286,179	294,616	276,986	303,548	339,104	364,113	373,916	406,135	430,650	473,583	501,678	529,939	558,135	605,548	637,166	668,784	700,402	732,020	763,638	795,009	826,627

Thames Water SPG

Sum	Sequence		24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
	Year		**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**
-35,241,622	Total Capital	[£]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-822,613
-104,433,576	Fuel subtotal	[£]	-2,801,420	-2,820,911	-2,840,402	-2,859,893	-2,879,384	-2,898,875	-2,918,366	-2,937,857	-2,957,348	-2,976,839	-2,996,330	-3,015,821	-3,035,312	-3,054,803	-3,074,294	-3,093,785	-3,113,276	-3,132,767
-11,529,227	O&M excl fuel subtotal	[£]	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400	-295,400
259,857,892	Revenue subtotal	[£]	7,069,299	7,154,831	7,240,362	7,325,894	7,411,425	7,496,956	7,582,488	7,668,019	7,753,551	7,839,082	7,924,613	8,010,145	8,095,676	8,181,208	8,266,739	8,352,270	8,437,802	8,523,333
108,653,466	Total cashflow	[£]	3,972,480	4,038,520	4,104,561	4,170,601	4,236,642	4,302,682	4,368,722	4,434,763	4,500,803	4,566,843	4,632,884	4,698,924	4,764,965	4,831,005	4,897,045	4,963,086	5,029,126	4,272,553
143,895,089	Operating margin	[£]	3,972,480	4,038,520	4,104,561	4,170,601	4,236,642	4,302,682	4,368,722	4,434,763	4,500,803	4,566,843	4,632,884	4,698,924	4,764,965	4,831,005	4,897,045	4,963,086	5,029,126	5,095,166
152,227,178	Total Carbon dioxide emissions	kg CO2	4,212,299	4,206,856	4,206,261	4,205,666	4,205,070	4,204,475	4,203,922	4,203,327	4,202,732	4,202,137	4,201,541	4,200,946	4,200,946	4,200,946	4,200,946	4,200,946	4,200,946	4,200,946
1,417	Network heat CO2 intensity	kg CO2 / MWh	38	38	38	38	38	37	37	37	37	37	37	37	37	37	37	37	37	37
722,185,079	Alternative CO2 emissions (BAU)	kg CO2	18,473,610	18,432,582	18,428,095	18,423,607	18,419,120	18,414,632	18,410,465	18,405,978	18,401,491	18,397,003	18,392,516	18,388,028	18,388,028	18,388,028	18,388,028	18,388,028	18,388,028	18,388,028
10,512,805	Temporary CO2 emissions	kg CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
559,445,096	CO2 savings from network including temporary emissions	kg CO2	14,261,311	14,225,726	14,221,834	14,217,941	14,214,049	14,210,157	14,206,543	14,202,651	14,198,759	14,194,867	14,190,975	14,187,082	14,187,082	14,187,082	14,187,082	14,187,082	14,187,082	14,187,082

Beckton Waste Treatment Facility

Sum	Sequence		24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
	Year		**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**
-34,148,580	Total Capital	[£]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,159,422
-99,123,228	Fuel subtotal	[£]	-2,681,919	-2,706,992	-2,732,065	-2,757,138	-2,782,210	-2,807,283	-2,832,356	-2,857,429	-2,882,502	-2,907,575	-2,932,648	-2,957,721	-2,982,794	-3,007,866	-3,032,939	-3,058,012	-3,083,085	-3,108,158
-11,313,274	O&M excl fuel subtotal	[£]	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001	-290,001
259,857,892	Revenue subtotal	[£]	7,069,299	7,154,831	7,240,362	7,325,894	7,411,425	7,496,956	7,582,488	7,668,019	7,753,551	7,839,082	7,924,613	8,010,145	8,095,676	8,181,208	8,266,739	8,352,270	8,437,802	8,523,333
115,272,810	Total cashflow	[£]	4,097,380	4,157,838	4,218,297	4,278,755	4,339,214	4,399,672	4,460,131	4,520,589	4,581,048	4,641,506	4,701,965	4,762,423	4,822,882	4,883,340	4,943,799	5,004,257	5,064,716	3,965,753
149,421,391	Operating margin	[£]	4,097,380	4,157,838	4,218,297	4,278,755	4,339,214	4,399,672	4,460,131	4,520,589	4,581,048	4,641,506	4,701,965	4,762,423	4,822,882	4,883,340	4,943,799	5,004,257	5,064,716	5,125,174
483,369,705	Total Carbon dioxide emissions	kg CO2	13,065,958	13,060,516	13,059,920	13,059,325	13,058,730	13,058,135	13,057,582	13,056,987	13,056,391	13,055,796	13,055,201	13,054,605	13,054,605	13,054,605	13,054,605	13,054,605	13,054,605	13,054,605
4,529	Network heat CO2 intensity	kg CO2 / MWh	117	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116
722,185,079	Alternative CO2 emissions (BAU)	kg CO2	18,473,610	18,432,582	18,428,095	18,423,607	18,419,120	18,414,632	18,410,465	18,405,978	18,401,491	18,397,003	18,392,516	18,388,028	18,388,028	18,388,028	18,388,028	18,388,028	18,388,028	18,388,028
10,512,805	Temporary CO2 emissions	kg CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
228,302,569	CO2 savings from network including temporary emissions	kg CO2	5,407,652	5,372,066	5,368,174	5,364,282	5,360,390	5,356,498	5,352,884	5,348,992	5,345,099	5,341,207	5,337,315	5,333,423	5,333,423	5,333,423	5,333,423	5,333,423	5,333,423	5,333,423

Excel CHP In Royal Victoria

Sum	Sequence		24
	Year		**2039**
-2,275,953	Total Capital	[£]	0
-12,578,513	Fuel subtotal	[£]	-590,739
-1,636,317	O&M excl fuel subtotal	[£]	-65,600
26,346,884	Revenue subtotal	[£]	1,230,009
9,856,102	Total cashflow	[£]	573,671
12,132,055	Operating margin	[£]	573,671
52,119,908	Total Carbon dioxide emissions	kg CO2	3,905,345
5,143	Network heat CO2 intensity	kg CO2 / MWh	385
60,596,504	Alternative CO2 emissions (BAU)	kg CO2 / MWh	2,423,860
0	Temporary CO2 emissions (BAU)	kg CO2	0
8,476,596	CO2 savings from network including temporary emissions	kg CO2	-1,481,485

Silvertown / T&L

Sum	Sequence		24
	Year		**2039**
-6,588,289	Total Capital	[£]	0
-18,417,295	Fuel subtotal	[£]	-945,572
-2,207,164	O&M excl fuel subtotal	[£]	-94,647
36,553,205	Revenue subtotal	[£]	2,078,222
9,340,457	Total cashflow	[£]	1,038,004
15,928,746	Operating margin	[£]	1,038,004
78,782,547	Total Carbon dioxide emissions	kg CO2	3,468,468
3,206	Network heat CO2 intensity	kg CO2 / MWh	116
91,128,790	Alternative CO2 emissions (BAU)	kg CO2	4,326,712
0	Temporary CO2 emissions	kg CO2	0
12,346,243	temporary emissions	kg CO2	858,245