CED 102

Intended for London Borough of Redbridge

Document type
Report

Date 18th December 2012

London Borough of Redbridge Decentralised Energy Masterplanning Study

LONDON BOROUGH OF REDBRIDGE DECENTRALISED ENERGY MASTERPLANNING STUDY

RAMBOLL

LONDON BOROUGH OF REDBRIDGE

Revision	**Final Version 6**
Date	**2012/12/18**
Made by	**Anthony Riddle/ Olof Jangsten**
Checked by	**Soren Vesterby Knudsen**
Approved by	**Crispin Matson**
Description	**London Borough of Redbridge Decentralised Energy Masterplanning Study**

Ref Report 12199430275-141-001

Ramboll
Hannemanns Allé 53
DK-2300 Copenhagen S
Denmark
T +45 5161 1000
F +45 5161 1001
www.ramboll.com

Ramboll Energy
60 Newman Street
London W1T 3DA
T +44 (0)20 7631 5291

CONTENTS

APPENDICES

APPENDIX 1 Summary of Business As Usual Case And Future Alternative Case For New Developments

APPENDIX 2 Heat Network Layouts / Concepts

APPENDIX 3 Investment and Carbon Appraisal Assumptions

APPENDIX 4 Summary of Heat Network Assets

APPENDIX 5 Cost Plans And Carbon Trajectories

APPENDIX 6 Summary of Heat Supply Contribution for Each Project

APPENDIX 7 Linear Heat Density Indicators for Each Project

TABLES

FIGURES

EXECUTIVE SUMMARY

Project Overview

The London Borough of Redbridge is participating in the Decentralised Energy Masterplanning (DeMAP) Programme, which was developed by the LDA / GLA to help meet the Mayor of London's target of providing 25% of London's energy supply from decentralised sources by 2025.

As part of this programme, Redbridge undertook a 'heat mapping' exercise in 2010 to identify areas in the borough of high heat demand which may be suitable for decentralised energy networks. The heat mapping exercise identified five decentralised energy opportunity areas within Redbridge, two of which London Borough of Redbridge subsequently shortlisted for further study on the basis that it felt they were the most suitable and deliverable for future decentralised energy networks.

As the next stage in the process, London Borough of Redbridge commissioned Ramboll Energy to develop a decentralised energy masterplan for the two preferred opportunity areas which are:

a) Decentralised Energy Opportunity Area 1 – Barkingside Investment Area
b) Decentralised Energy Opportunity Area 2 – Ilford Town Centre / Crossrail Corridor (including the Goodmayes 'Outlier').

The aims of this decentralised energy masterplanning study have been to:-

a) Establish to what extent the two nominated decentralised energy (DE) opportunity areas are suitable for a DE network (in all or part of the opportunity area).
b) Provide a DE evidence base which can be used in Redbridge's Local Development Framework (specifically for the upcoming Core Strategy review).

This study has considered four discrete decentralised energy network opportunities in the following geographical areas within the study boundaries:

a) Ilford Town Centre
b) Crossrail Corridor
c) Goodmayes Outlier
d) Barkingside Investment Area

Assessment methodology

The network opportunities have been assessed over 25 and 40 year periods. Establishing a decentralised energy network requires capital investment which can be repaid by revenues from sold heat and electricity. Projects can therefore be seen as business opportunities depending on the balance between investment and revenues. Viability has been assessed on the basis of minimum required Internal Rates of Return for fully private sector and fully public sector (ie London Borough of Redbridge) based procurement models. We have assumed minimum acceptable nominal internal rates of return of 10 % and 6 % respectively based on widely used industry benchmarks.

Project viability for each network opportunity has been tested on the basis of a fully built out network comprising identified suitable existing 'anchor heat loads' as well as identified suitable planned developments. The viability of 'initial cluster networks' has also been tested for each geographical area representing cases of connection of only existing buildings not relying on future planned developments.

The scale of projects depends on the size of heat demand. Heat demand projections for each of the identified existing and new developments within each of the Opportunity Areas are presented in Figure 1. This figure shows the cumulative annual heat demand for all of the indicated developments considered for connection to the project opportunities presented in this report[1,2].

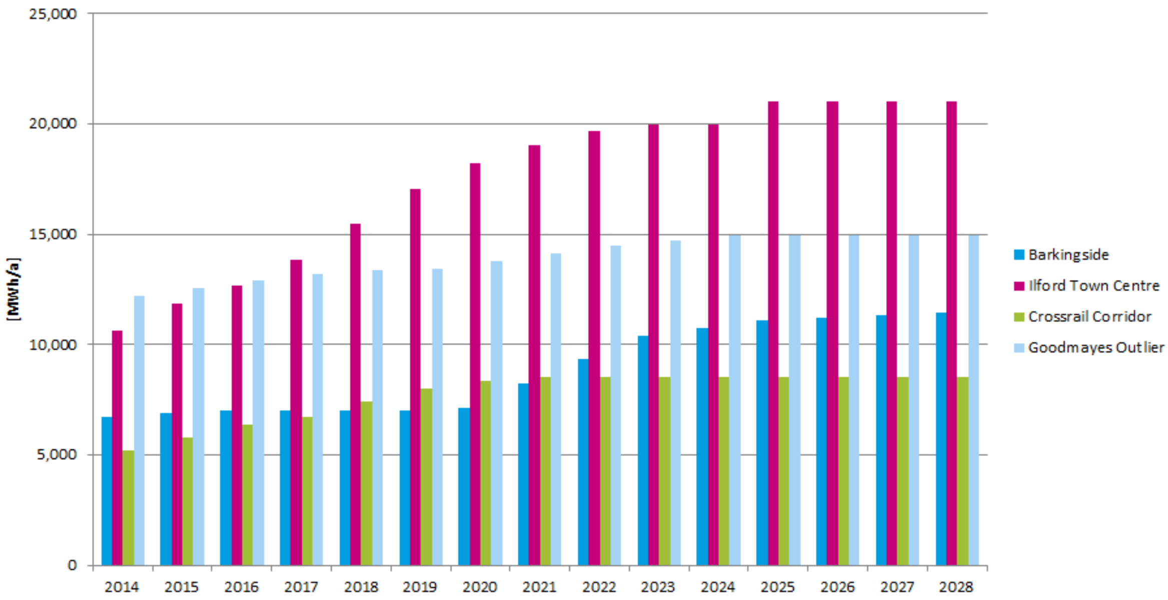


Figure 1: Heat Demand Projections for the Identified Developments for connection in the Opportunity Areas

<u>Key Findings</u>

The main conclusions in relation to the economic appraisal of the opportunities are presented below for each identified project, based on an assumption of required nominal internal rates of return of 10 % and 6 % respectively for private and public sector led projects.

The modelling on which these conclusions are based assumes a range of electricity selling arrangements appropriate to each project as described elsewhere in the report and are based on best estimates of electricity and heat selling prices and volumes sold, project running costs and capital investment requirements.

Ilford Town Centre

The cluster project at Ilford Town Centre is made up of a number of existing buildings, with the fully built out project expanding the cluster project and connecting future developments.

The fully built out project at Ilford Town centre is likely to be an economically attractive proposition to both the public and private sector.

However, the development timescales for the project are such that a fully built out project opportunity would not materialise until around 2025 and it is unlikely that the private sector will step in to develop a project in the interim period as the IRR for the initial cluster project is below 10% (7.1%). The IRR for the fully build out project is 11.3%.

---

[1] In this figure, the first year of operation represents the existing demand in each opportunity area, and the subsequent increases reflect the assumed demand growth projections as identified in the Housing Trajectory 2011-2028 [16]. Beyond, 2028 no further growth in demand is assumed to occur

[2] The figure includes the impact of energy efficiency measures for existing buildings and reflects expected standards of building fabric insulation under future building regulations and Zero carbon homes policy. The reduction in demand for the Goodmayes Outlier occurring in 2020 reflects the conversion to residential use of the existing King George hospital site.

On this basis, London Borough of Redbridge should consider establishing an initial cluster project to catalyse the opportunity and lay the foundation for any future involvement by the private sector.

In order for the initial cluster project to be economically attractive to London Borough of Redbridge, it is likely to require an Electricity Supply Licence Lite[3]. London Borough of Redbridge should therefore pursue developments in this area as part of any business planning undertakings, should it wish to take the opportunity forward.

IRR is seen to increase to 9.5% and 13% for a grant contribution of £1M for the cluster and fully built out projects respectively.

In the event that an Electricity Supply Licence Lite cannot be secured, the cluster project is unlikely to come forward, although the fully built out project may still be of interest at a later point in time, once a larger heat customer base has been established.

A public private sector partnering[4] approach may be of interest to certain ESCos and should therefore be considered by London Borough of Redbridge as a possible way forward for the cluster project. London Borough of Redbridge should however recognise that it will need to champion the development of such a project, since the private sector is unlikely to step in and do so.

If London Borough of Redbridge is prepared to take a long term view over the project term, the initial cluster project can also be considered as an economically attractive option.

If it chooses to develop the initial cluster project, London Borough of Redbridge could reasonably expect to attract interest from the private sector at a later stage, should it choose to sell the project once much of the development risk has diminished and additional investment into Ilford Town Centre is underway / completed.

There are relatively few Local Authority owned assets within the initial cluster project. London Borough of Redbridge should recognise that this will introduce complexity and risk in delivering the project since multiple, protracted stakeholder negotiations are likely to be required.

Crossrail corridor

There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Crossrail Corridor. The current characteristic of the area is one of relatively low heat density and any opportunity would primarily be related to future developments.

The calculated economic indicators for the Crossrail Corridor project would be of no interest to a private sector ESCo and equally would offer only a barely acceptable return to London Borough of Redbridge over 40 years, assuming an Electricity Licence Lite could be set up.

The recommendation is therefore for this opportunity not to be taken forward as a stand-alone project in isolation of other heat network opportunities.

The opportunity to develop Crossrail Corridor should be considered in conjunction with a project opportunity at Ilford Town Centre. Under this scenario, acceptable project returns can be made by avoiding the need to invest in an energy centre for the Crossrail Corridor project.

---

[3] A simplified electricity licence that would enable the licence holder to retail electricity to domestic and non-domestic customers.

[4] Partnership can de-risk the project for the ESCo with planning aspects and access to anchor heat loads

Ilford Town Centre and Crossrail corridor

In the event that the Ilford Town Centre heat network is taken forward, the case for interconnecting developments within the Crossrail Corridor to the Ilford Town Centre heat network at a future time appears to be reasonably strong, returning an IRR of 10.1% over 25 years.

However, it should be recognised that this is marginally lower than for the Ilford Town Centre only project and therefore is likely to require direct involvement from London Borough of Redbridge to bring about expansion into the Crossrail Corridor, since a commitment to do so from the private sector cannot be assumed. London Borough of Redbridge's interest in doing so would need to be predicated on the additional carbon reductions associated with the wider project opportunity.

In order to safeguard for future expansion into the Crossrail Corridor, the initial Cluster project in Ilford Town Centre would need to include additional investment in large diameter pipework and additional space within the energy centre. This will reduce the calculated IRR and London Borough of Redbridge will need to take a view on the acceptability of this safeguarding position in financial terms.

If London Borough of Redbridge is prepared to take a long term view over the investment proposition, the IRR for the safeguarded cluster project and the fully built out project can be expected to return IRRs that London Borough of Redbridge are likely to consider attractive.

The future of a possible Crossrail Corridor interconnection will rely on the presence of an initial cluster network in Ilford Town Centre. Therefore, the project opportunity will ultimately rely on London Borough of Redbridge to push forward the project at Ilford Town Centre in order to create the correct conditions to allow the Crossrail Corridor project to be taken forward.

Goodmayes Outlier

There appears to be a viable project opportunity for Goodmayes Outlier, based on the existing CHP assets at King George Hospital. It is recommended that the project opportunity is considered further by Barking Havering and Redbridge Hospitals NHS Trust.

The project benefits from an existing private wire arrangement[5]. Under this arrangement, the initial cluster project based around the existing buildings would deliver an IRR of around 11.0% over 25 years and the fully built out project would deliver an IRR of 11.6% over 25 years.

An initial cluster project is likely to be of interest to a private ESCo based on the calculated IRR over 25 years, the investment period over which the ESCo would typically consider the project. This could also be expected to interest Barking Havering and Redbridge Hospitals NHS Trust.

IRR is seen to increase to 19.0% and 18.4% for a grant contribution of £1M for the cluster and fully built out projects respectively.

Due to long development timescales of identified development opportunities, the IRR for the fully built out project viewed over 25 years are similar to that of the cluster project viewed over the same period. Whilst the Trust might find the calculated IRR of both scenarios acceptable over 25 years, it is difficult to see what incentive the Trust or an ESCo would have for extending the project beyond the initial cluster.

Viewed over 40 years, the IRR of the fully built out project exceeds that of the initial cluster network viewed over 25 years. This suggests that if the Trust were prepared to invest in the project and view its return over a long term, it could potentially sell the project to the private

[5] Electricity being sold directly to the customer through a private electricity network

sector at a later stage in its lifecycle, at which point the project would represent a low risk proposition that a private ESCo might be prepared to take on.

A comparison of the cases with and without inclusion of the low density housing elements (located mainly towards the west of the site) indicates that the low density housing elements reduces the economic case for the overall project. Although the indicated IRR's are still likely to be acceptable to Barking Havering and Redbridge Hospitals NHS Trust, it is difficult to see how connecting these developments could be an attractive proposition for the project. Our recommendation is therefore that these developments should not be required to safeguard to connect to the heat network.

London Borough of Redbridge are likely to have little interest or incentive to become involved in the project, since the scope for reducing local authority carbon emissions and future fuel costs would be limited due to its limited landholdings within the initial cluster area and the opportunity to extending the project beyond the immediate vicinity appear to be very low. London Borough of Redbridge's role in this project should be to act as a facilitator for the project bringing together key stakeholders and to require the new schools, polyclinic and high density developments to safeguard for connection to the project if it is taken forward.

Barkingside Investment Area

There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Barkingside Investment Area.

The calculated economic indicators for the future development opportunity in Barkingside Investment Area suggest that the project would be of no interest to a private sector ESCo or to London Borough of Redbridge.

The recommendation is therefore for this opportunity not to be taken forward.

<u>Barriers to Development</u>

Of the recommended projects opportunities, no insurmountable technical barriers have been identified. Further work will be required for projects taken forward in relation to more detailed network route planning. In relation to the Ilford Town Centre project, detailed technical feasibility of the energy centre proposals will also be required at the next stage.

<u>Recommended Next Steps</u>

The economic appraisal of the identified opportunities has shown that the Ilford Town Centre, Ilford Town Centre / Crossrail Corridor and Goodmayes Outlier projects could potentially be taken forward on the basis of reasonable economic propositions. The planned developments along the Crossrail Corridor can potentially be included in the Ilford Town Centre project, but will not stack up independently as a standalone project. The planned developments in Barkingside Investment Area are not considered to be viable to take forward and should not be pursued further in our opinion.

On this basis, the recommended next steps for London Borough of Redbridge are presented below.

Ilford Town Centre and Ilford Town Centre / Crossrail Corridor Projects

London Borough of Redbridge will need to consider the level of involvement it wishes to have in the identified project opportunities.

Under a do-nothing scenario, new developments within the opportunity areas are likely to come forward with individualised piecemeal solutions involving a range of low carbon technologies.

This approach risks failing to deliver significant carbon savings under the identified opportunity areas and also misses an opportunity to integrate existing buildings into any proposed network.

If London Borough of Redbridge chooses to pursue the do nothing route it should, as a minimum, ensure that its local planning framework requires that local heat networks with gas fired CHP are considered and implemented if feasible in line with GLA policy, and that new developments in indicated areas are designed with heating systems to be ready to connect to a future heat network.

London Borough of Redbridge may decide to use its planning powers to facilitate future development of the identified heat networks, but leave the actual development of the projects to the market to deliver. This approach risks failing to deliver the true project 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 projects too unattractive an investment proposition to take forward, and certainly are unlikely to do so until a considerable amount of development has taken place.

The alternative to this scenario would be for London Borough of Redbridge to take an active role in developing the identified project opportunities with the intention of securing a stake in the infrastructure assets and facilitating development to their full potential. There are considerable potential advantages to London Borough of Redbridge in adopting this approach including:-

- contributing towards Redbridge's CO_2 emissions reduction targets
- avoiding piecemeal approach to compliance for new developments
- developing a viable business with the opportunity to generate income for the Local Authority

If London Borough of Redbridge wishes to adopt this proactive approach, it should implement a range of measures to take the project opportunities forward including carrying out business planning and engaging with possible project partners and potential heat customers. These are detailed further in Section 10.

Goodmayes Outlier Project

The Goodmayes Outlier opportunity is considered to be of interest to Barking Havering and Redbridge Hospitals NHS Trust and / or a third party provider such as an ESCo, rather than to London Borough of Redbridge directly.

However, London Borough of Redbridge can play a role in the development of this opportunity by acting as a facilitator by bringing together the major stakeholders involved, guaranteeing the connection of the new schools, ensuring all new developments are safeguarded for future connection to the heat network through the planning process and considering how it might influence the massing design of the new residential developments to improve underlying project economics.

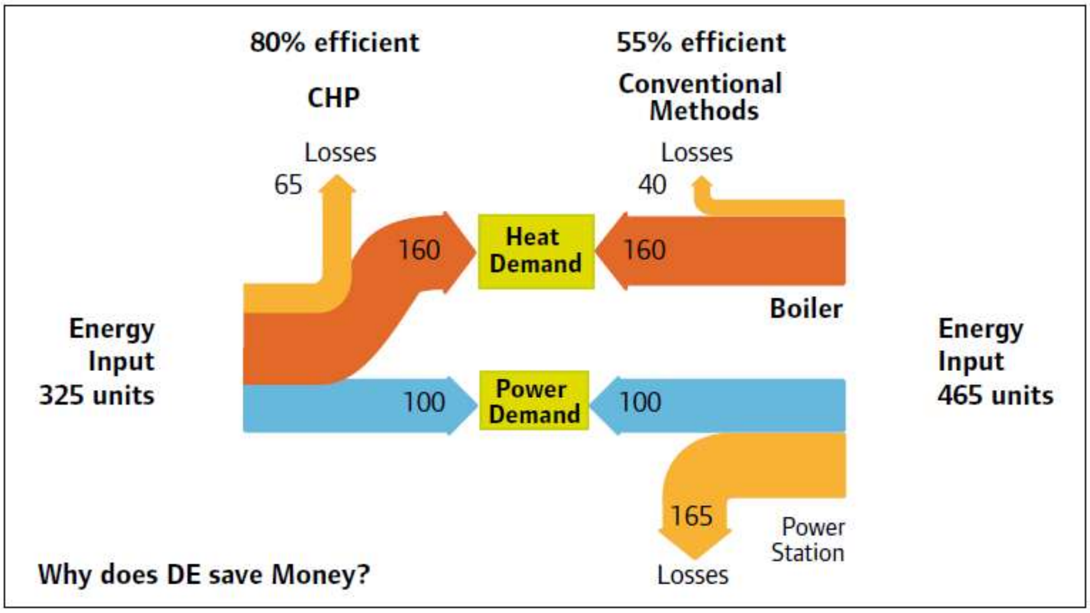
1. INTRODUCTION

1.1 Introduction to Decentralised Energy

Decentralised Energy is a term used to describe the supply of electricity and/or heat to end users from local sources, as opposed to via the national gas and electricity grids. In the context of this report, decentralised energy refers to the use of district heating networks to distribute heat to a number of buildings from energy centres hosting combined heat and power (CHP) plants together with boilers and thermal accumulators.

Heat generated within these energy centres is distributed to local buildings through a network of pre-insulated buried underground pipes. This heat is transferred to the buildings through Hydraulic Interface Units (HIU) located within each building, beyond which the heat is distributed for the purposes of space heating and domestic hot water provision. Where larger developments are concerned, the interface with the heat network can also take place at local community level, through one or more small energy centres located within the development.

District heating serves as an alternative to the use of gas or electricity to provide heating at each building. Hydraulic Interface Units can be thought of as the equivalent of the domestic or commercial boilers that would otherwise be used to provide heat to secondary circuits, domestic hot water and heating circuits within the buildings.



The generation of heat in district heating systems is typically carried out using combined heat and power systems. Combined heat and power describes the simultaneous generation of heat and electricity in a more efficient way than if the two forms of energy were to be produced separately. There are many technologies available to produce combined heat and power, involving many scales of application and many options in relation to fuel source including energy from waste, biomass and fossil fuels. In the context of this report, the focus is on the use of internal combustion engine technology using natural gas as the primary fuel. Such applications typically involve generation capacities in the range from 500 kW_e to 5 MW_e and generate heat at temperatures in the region of 90 °C to 95 °C.

District heating systems offer many advantages over conventional alternative supply options and have a significant role to play in contributing towards the UK's CO_2 reduction targets. It is also a highly flexible and adaptable medium for capturing, transporting and storing heat energy and so has a central role to play in integrating energy from multiple sources, and thereby provide the flexibility required to deliver low cost, low carbon energy to our society in the future.

District heating also brings many potential benefits to local communities and Local Authorities. For local authorities these include the opportunity to:-

1. contribute towards Local Authority CO_2 reduction targets,
2. bring about reductions in fuel costs and Carbon Reduction Commitment (CRC) payments that can result in financial savings to the council and savings to fuel poor tenants as applicable,
3. deliver increased security of supply to the council and local tenants,
4. support inward investment and job creation,
5. generate a long term, relatively secure income for the Local Authority that can help to support its other functions financially.

In general, a high linear density of heat demand is usually helpful in justifying the installation and economics of a district heating scheme. Linear heat density is a measure of the annual heat demand per unit length of heat network installed. The selection and sizing of district heating pipework is also critical to the economic success of a district heating scheme and, depending on the scale of the heat network, is usually the most expensive element of the scheme. Factors such as temperature difference, design and operating pressures and operating strategy all have a strong influence on scheme economics.

1.2 Background and Policy Context

The National Planning Policy Framework (NPPF) published in March 2012 at paragraphs 96 and 97 supports the greater use of decentralised energy. It says that new development should comply with Local Plan policies on the use of such energy, subject to considerations of feasibility and viability.

The London Plan as published in July 2011 contains strong support for decentralised energy. Policy 5.5 Decentralised Energy Networks states that the Mayor's expects 25% of the heat and power used in London by 2025 to come from "localised decentralised energy systems". It goes on to say that when preparing their Local Development Frameworks (which the NPPF – see above – now simply calls "Local Plans"), boroughs should develop policies and proposals to identify and establish decentralised energy network opportunities and as a minimum:

a) Identify and safeguard existing heating and cooling networks.
b) Identify opportunities for expanding existing networks and establishing new networks. Boroughs should use the London Heat Map tool and consider any new developments, planned major infrastructure works and energy supply opportunities which may arise.
c) Develop energy master plans for specific decentralised energy opportunities which identify:
    - major heat loads (including anchor heat loads, with particular reference to sites such as universities, hospitals and social housing)
    - major heat supply plant
    - possible opportunities to utilise energy from waste
    - possible heating and cooling network routes
    - implementation options for delivering feasible projects, considering issues of procurement, funding and risk and the role of the public sector
d) Require developers to prioritise connection to existing or planned decentralised energy networks where feasible.

The Redbridge Local Development Framework (or "Local Plan") consists of a Core Strategy adopted in 2008 and a number of other plans adopted over the intervening years. These include Area Action Plans for:

a) Ilford Metropolitan Centre
b) Gants Hill District Centre
c) The Crossrail Corridor which includes the town centres of Seven Kings, Goodmayes and Chadwell Heath. It also includes an "outlier" area embracing the sites of the King George and Goodmayes Hospitals and surrounding land.

The adopted Core Strategy seeks to address climate change by among other things reducing the borough's contribution to CO_2 emissions, but due to the (relatively early) timing of its adoption, it does not specifically mention decentralised energy.

Currently, the London Borough of Redbridge is participating in the Decentralised Energy Masterplanning (DeMAP) Programme, which was developed by the LDA/GLA to help meet the Mayor or London's target of providing 25% of London's energy supply from decentralised sources by 2025.

As part of this programme, Redbridge undertook a 'heat mapping' exercise in 2010 to identify areas in the borough of high heat demand which may be suitable for decentralised energy networks. The outcomes of this study helped inform production of the Crossrail Corridor Area Action Plan which was adopted in September 2011. Policy CC5 of this plan Energy Efficiency and Sustainable Development provides general support for decentralised and renewable energy and where there are "firm proposals" for area-wide combined heat and powers systems, makes it mandatory for new developments to provide for future connection to such systems.

In all, the heat mapping exercise identified five decentralised energy opportunity areas within Redbridge, two of which London Borough of Redbridge subsequently shortlisted for further study on the basis that it felt they were the most suitable and deliverable for future decentralised energy networks.

As the next stage in the process, London Borough of Redbridge commissioned Ramboll Energy to develop a decentralised energy masterplan for the two preferred opportunity areas which are:

a) Decentralised Energy Opportunity Area 1 – Barkingside Investment Area
b) Decentralised Energy Opportunity Area 2 – Ilford Town Centre / Crossrail Corridor (including the Goodmayes 'Outlier').

The Council is currently reviewing its Core Strategy. The initial "Preferred Options Report" was agreed by Cabinet in November 2012; the report proposes 5 discrete "Investment Areas" as locations for sustainable development of new homes and community facilities in response to the borough's fast growing population.

The identified Decentralised Energy Opportunity Areas coincide with three of these Investment Areas, namely Ilford Town Centre and Ilford Lane Investment Area, Barkingside Investment Area and Crossrail Corridor Investment Area (including the Goodmayes "outlier"). This decentralised energy masterplan will inform the drafting of detailed policies on decentralised energy which will occur following consultation on the Preferred Options Report and will help ensure the Council's policy on decentralised energy is consistent with both the NPPF and the London Plan. The final revised Core Strategy will be prepared during the course of 2013 and then subjected to independent examination. Adoption is expected in mid 2014.

1.3 Report Aims

The aims of this decentralised energy masterplanning study have been to:-

a) Establish to what extent the two nominated decentralised energy (DE) opportunity areas are suitable for a DE network (in all or part of the opportunity area).
b) Provide a DE evidence base which can be used in Redbridge's Local Development Framework (specifically for the upcoming Core Strategy review).

The specific requirements of the study have been to:-

a) Determine the energy demand arising from existing and potential development within the opportunity area, having regard to measures which might be introduced to reduce demand.

b) Advise London Borough of Redbridge on how the anticipated energy demand could be met through a decentralised energy system within the opportunity areas.

c) Establish whether and how a viable DE network can be developed in the opportunity areas and the extent to which these would contribute towards low carbon energy supply.

d) Determine and map a viable overarching DE network which connects as many existing and future properties as possible to a decentralised, low / zero carbon heat source.

e) Provide design information about the heat network and determine any constraints / barriers / opportunities.

f) Determine the environmental benefits in terms of carbon dioxide savings of the DE network compared with 'business as usual.'

g) Carry out an indicative economic investment appraisal having regard to the development costs, future income stream, payback periods, profitability etc.

h) Establish a DE delivery plan, taking into account phasing of heat load development and potential for phasing / clustering of the DE network.

i) If a viable network in the opportunity areas cannot be identified, advise what support would be necessary to establish a suitable and viable network.

1.4 Outline Methodology

This report has considered options for developing decentralised heat networks within each of the opportunity areas to supply space heating and domestic hot water to existing and future planned developments within the Opportunity Areas.

The study has considered four discrete network opportunities around the following geographical areas identified within the study boundaries:-

a) Ilford Town Centre
b) Crossrail Corridor
c) Goodmayes Outlier
d) Barkingside Investment Area

Project opportunities have been developed on the basis of information contained within a range of data sources, which are referenced from [1] through [10] in Section 11 of this report.

For existing buildings heat demand data have generally been collected from the following sources:-

a) London Heat Map
b) Display Energy Certificates
c) National Indicator NI 185 data, calculated carbon emission data from local authority buildings and services ~ provided by London Borough of Redbridge.
d) Reference to recent energy statements for known development applications in the planning process
e) Consultation with stakeholders for existing buildings that have not been mapped or identified through the above methods.

For new buildings heat demand projections have been calculated using development growth projections identified within the Housing Trajectory 2011-2028 as provided by London Borough of Redbridge [16]. These projections span a development timeframe to 2028, beyond which no further development has currently been identified as Central Government / Redbridge adopt a 15 year planning timeframe. The study is therefore limited to the known development opportunities contained within this trajectory[6].

[6] It is noted that the Housing Trajectory only provides an indication of when development may come forward, based on whether or not planning permission has been granted, if the site is currently vacant, planning constraints and so on.

For each identified geographical area, network opportunities have been analysed in terms of their economic viability and carbon reduction potential using Internal Rate of Return (IRR)[7], Net Present Value (NPV)[8] and CO_2 abatement[9] indicators. The basis of the economic evaluation is presented in Appendix 3.

The network opportunities have been assessed over 25 and 40 year periods. Viability has been assessed on the basis of minimum required Internal Rates of Return for fully private sector and fully public sector (ie London Borough of Redbridge) based procurement models. We have assumed minimum acceptable nominal internal rates of return of 10 % and 6 % respectively based on widely used industry benchmarks.

Our modelling includes inflation and we have therefore used real IRR hurdle rates of 7.5% and 3.5% respectively for fully private sector and fully public sector based procurement models (based on inflation at 2.5%). These hurdle rates do not necessarily reflect the current market or indeed London Borough of Redbridge's own required rates of return on investment and also reflect what would need to be 'risk free' projects to attract investment at those rates.

Our understanding of the current market is that nominal hurdle rates in the range 13-17 % for the private sector and above 8 % minimum for public sector are nearer reality in the current economic conditions.

Project viability for each network opportunity has been tested on the basis of a fully built out network comprising identified suitable existing 'anchor heat loads' as well as identified suitable planned developments as reported in the Housing Trajectory 2011-2028 [16]. We have tested a range of options in each case to identify suitable connections and establish which outlying buildings are not considered worth connecting for economic reasons. This has been done by comparing linear heat density indicators for the project with and without outlying buildings to identify which outliers will improve internal rates of return and which will not.

The viability of 'initial cluster networks' has also been tested for each geographical area. These initial clusters have been assumed to comprise identified suitable existing 'anchor heat loads' and known developments under construction. For these modelling scenarios, internal rates of return have been assessed over 25 and 40 years year periods, assuming that no future developments come forward, in order to reflect the worst case scenario to the project. It has been assumed that initial cluster projects would need to be viable in themselves (ie could be operated profitably regardless of any future developments connecting to the network in order to attract investment).

1.5 Layout of Report

The identified heat network opportunity for each opportunity area is presented in sections 2, 3, 4, 5 and 6 of this report, along with associated whole life costing evaluations, carbon reduction trajectories and route identification considerations. Where relevant, both initial cluster networks and fully built out networks are presented.

Each of these sections is structured in a common way that firstly introduces the opportunity and discusses the identified network and energy supply opportunities. Included in these sections are summaries of connected buildings and heat demand projections for the identified developments in the opportunity areas and heat maps showing these buildings along with the proposed networks and energy centre proposals.

Phasing strategy and implementation plans are then discussed briefly, with reference to the cost plans in Appendix 5, where year by year cashflow forecasts are given, from which details of the investment phasing can be determined.

---

[7] IRR is the discount rate at which the present value of all project cashflows are zero

[8] NPV is the difference of the present value of cash in and cash out throughout the project lifetime

[9] CO_2 abatement indicator is a measure of the CO_2 emission reductions attributed to the scheme compared to the business as usual alternative case for the buildings connecting to the scheme.

There then follows an economic appraisal of the identified opportunities, showing the key economic indicators for the projects including identified project Internal Rate of Return (IRR) and Net Present Value (NPV) assuming a 6% discount factor. The annual saving to London Borough of Redbridge associated with reduction in CRC payments under the project is also presented. These are presented over a 25 year project term for different types of electricity selling arrangements. Results for both cluster networks and fully built out networks where such cluster networks have been found to be economically viable are presented. Descriptions of relevant electricity selling arrangements are presented in Appendix 3. Discounted cashflow forecasts for the cluster and fully built out project are also presented.

A sensitivity analysis around the economic appraisals for the cluster and fully built out networks is then presented for the most economically favourable electricity selling arrangement. This identifies the impact of variations in a number of key variables on project Internal Rate of Return. A detailed description of the methodology applied is provided in Appendix 3.

The results of the economic appraisal are then interpreted in relation to their implications for project procurement. A further more general discussion on project procurement is provided in Section 7.

Details of the heat supply contribution from the CHP, boilers and thermal stores are then introduced, with the details for each project opportunity delegated to Appendix 6.

Similarly, the results of a carbon appraisal for each project opportunity is then presented, with the carbon reduction trajectories graphs for each project opportunity delegated to Appendix 5 and reference to the calculation methodology provided in Appendix 3. The carbon results are presented for two cases; that the Grid Carbon Factor remains unchanged over the life of the project; and that the DECC Grid Decarbonisation Trajectory is assumed to apply.

For identified viable opportunities, a high level route identification and risk appraisal is then presented. This is based on visual inspection of the identified routes and does not include reference to utility information.

In Section 7, procurement issues are discussed for each of the project opportunities whilst in Section 8, an overview of the main barriers, risks and opportunities to development are considered.

Each of the identified project opportunities is based around gas fired CHP. Section 9 therefore deals with future supply opportunities for each of the identified projects opportunities on the basis that alternative fuel sources will need to be considered in the longer term as and when grid decarbonisation begins to displace the benefit of gas fired CHP.

Project Conclusions, Recommendations and Next Steps are presented in Section 10. This includes recommendations about London Borough of Redbridge's options for developing the projects along with planning policy recommendations that should be considered within London Borough of Redbridge's Core Strategy and Local Development Framework documents.

Detailed results and sets of generic information and assumptions relating to all identified opportunities have been relegated to Appendices 1 through 7 as detailed below.

1. Summary of Business as Usual Case and future alternative case for new developments
2. Heat Network Layouts / Concepts for each of the identified project opportunities
3. Investment and Carbon Appraisal Assumptions used in the analysis
4. Summary of Heat Network Assets for the identified project opportunities
5. Cost and Carbon Plans for each of the identified project opportunities
6. Summary of Heat Supply Contribution for each of the identified project opportunities
7. Summary of Linear Heat Density Indicators for each of the identified project opportunities

2. ILFORD TOWN CENTRE HEAT NETWORK OPPORTUNITY

2.1 Summary of Opportunity

Ilford Town Centre is a priority area in terms of future growth and intensification of development in London. It is one of two Metropolitan Centres in the East London sub-region and emphasis is given within the London Plan to its long-term and sustainable growth. In pursuit of this, the London Plan encourages Ilford to build on its strategic role as a retail and leisure destination, realise opportunities for mixed-use intensification (including a substantial proportion of housing) and improve its public realm.

The Council has identified a number of development sites that it considers have the potential for mixed-use redevelopment within the lifetime of the Local Development Framework. These sites are in a variety of public/private sector ownerships and include:-

a) Sites within the town centre that have been allocated by the Development Sites with Housing Capacity Development Plan Document.
b) Sites within and around the town centre that have been allocated by the Development Opportunity Sites Development Plan Document.
c) Other Opportunity Sites that were identified during the preparation of Ilford Town Centre Area Action Plan, as having the potential to contribute to the delivery of the Council’s objectives for the future development of Ilford Town Centre. These sites were identified after consideration of their location and ownership, and the age, use and design of buildings on and around the sites.

The scale and density of the consented and planned developments coming forward over the coming decade presents an opportunity to bring forward a strategic district heating network within Ilford town centre.

The identified opportunity includes an initial cluster network focused around a number of existing anchor heat loads within the town centre as well as a longer term fully built out network opportunity that includes existing heat loads as well as identified suitable planned developments as reported in the Housing Trajectory 2011-2028 [16].

A network schematic showing of the proposed heat network opportunity is shown in Figure 2 and Figure 3. This identifies the proposed construction phasing of the heat network (by colour type) and identifies the initial cluster project (shown in green) as well as the extent of the fully built out project.

2.1.1 Initial Cluster Project

The anchor heat loads forming the initial cluster network[10] are shown in Table 1. The green coloured network in Figure 2 and Figure 3 is the initial cluster network part of the whole network.

[10] It is noted that for ITCOS21 we have assumed that planning application 2579/09 is CW11 and is planned for 101 flats instead of the 68 flats in the CW11 housing projection, but that it will keep the same construction phasing 2013 and 2014 with 50 and 51 respectively.

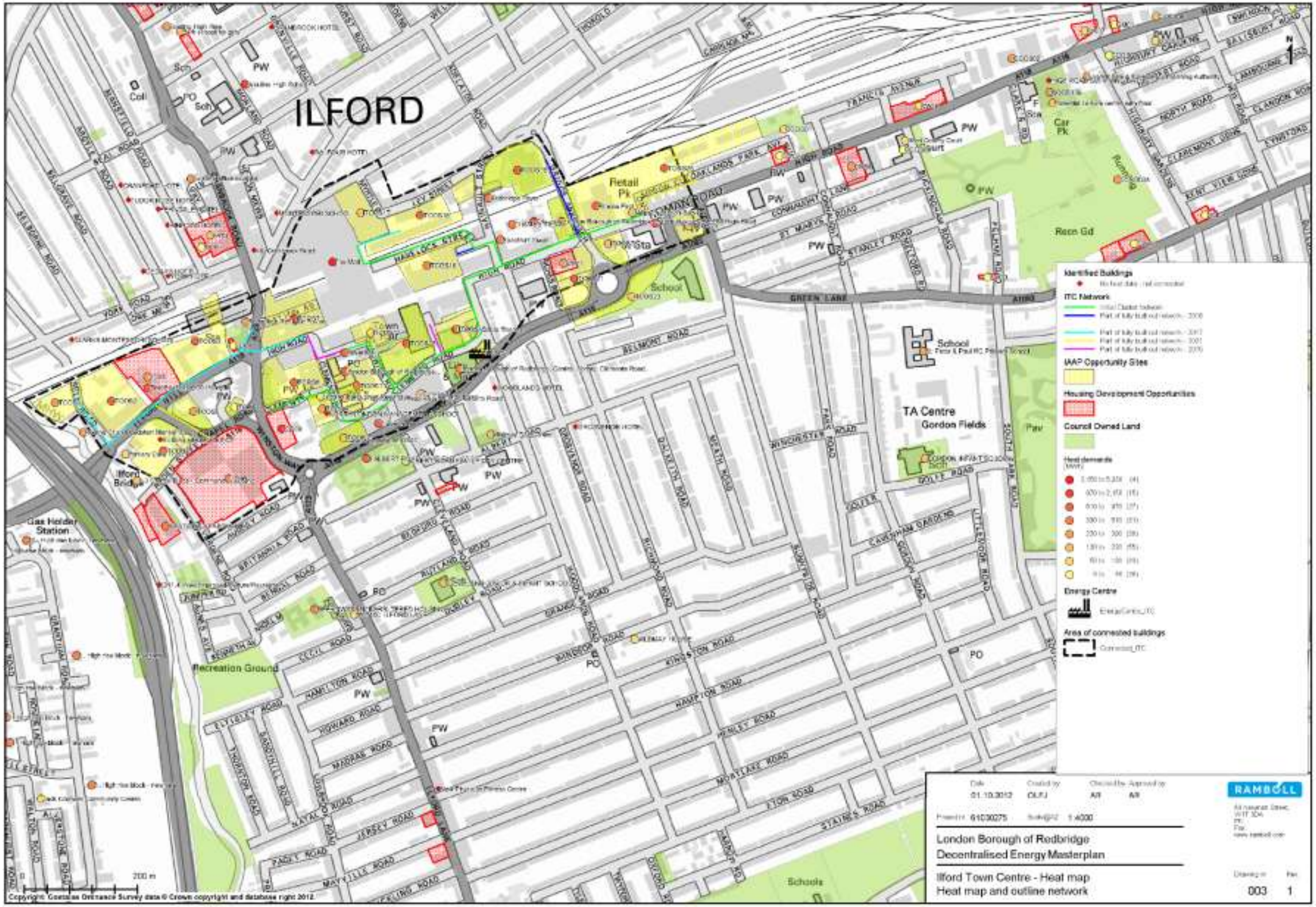


Figure 2: Heat map and network outline - Ilford Town Centre Project

Contains Ordnance Survey data © Crown copyright and database right 2012.

Figure 3: Heat Map and network outline - Ilford Town Centre Project

Load name	Address	Customer Type	Heat	Construction	Connection	Demand based on
			[MWh/a]			
The Mall	High Road, Ilford	Existing Commercial	1,208	Existing	2015	Benchmark
Travel Lodge	Clements Road, Ilford	Existing Commercial	928	Existing	2015	Benchmark
London Borough of Redbridge, 17-23 Clements Road	London Borough of Redbridge, 17-23 Clements Road	London Borough Redbridge	195	Existing	2015	DEC
London Borough of Redbridge, 22-26 Clements Road	London Borough of Redbridge, 22-26 Clements Road	London Borough Redbridge	99	Existing	2015	DEC
Kenneth More Theatre	Kenneth More Theatre, Oakfield Road	London Borough Redbridge	253	Existing	2015	DEC
Royal Mail	Royal Mail, Ilford Delivery Office, 4-24 Chadwick Road,	Existing Commercial	889	Existing	2015	DEC
London Borough of Redbridge	Town Hall	London Borough Redbridge	719	Existing	2015	DEC
London Borough of Redbridge, Central Library, Clements Road	London Borough of Redbridge, Central Library, Clements Road	London Borough Redbridge	473	Existing	2015	DEC
Metropolitan Police	Metropolitan Police, 270-294 High Road	Other Public	1,065	Existing	2015	DEC
London Borough of Redbridge, Lynton House, 255-259 High Road	London Borough of Redbridge, Lynton House, 255-259 High Road	London Borough Redbridge	609	Existing	2015	DEC
Nelps Probation Service	Nelps Probation Service, Nelps Probation Centre 277-289, High Road	London Borough Redbridge	138	Existing	2015	DEC
CW09	Pioneer Point, Winston Way, Ilford	Residential customers - new	1,492	Existing	2015	Benchmark
ITCOS21	246-250 High road, Ilford	Residential customers - new	668	2012	2015	Planning Application
Fitness First	261-275, High road, Ilford	Existing Commercial	574	Existing	2015	Benchmark
Total before energy efficiency measures			**9,308**			

Table 1: Summary of Connected Buildings - Ilford Town Centre Project – Cluster Project

The diversified[11] peak heat demand growth profile and annual consumption for the cluster project is shown in Figure 4 below. The shaded, coloured areas of the graph show the annual consumption as a function of customer type and year of operation of the network. The dotted blue line shows the diversified peak demand seen by the network for all of the customer types.

The reduction in diversified peak demand and annual consumption in 2020 reflects the assumption that all energy efficiency measures on existing buildings are implemented at this time. The impacts of energy efficiency measures are assumed to be 25% for LBR buildings and 12.5% for Existing Commercial and NHS buildings. This has been applied to all identified buildings within the scheme and for the purpose of modelling is assumed to occur at the same time for all buildings.

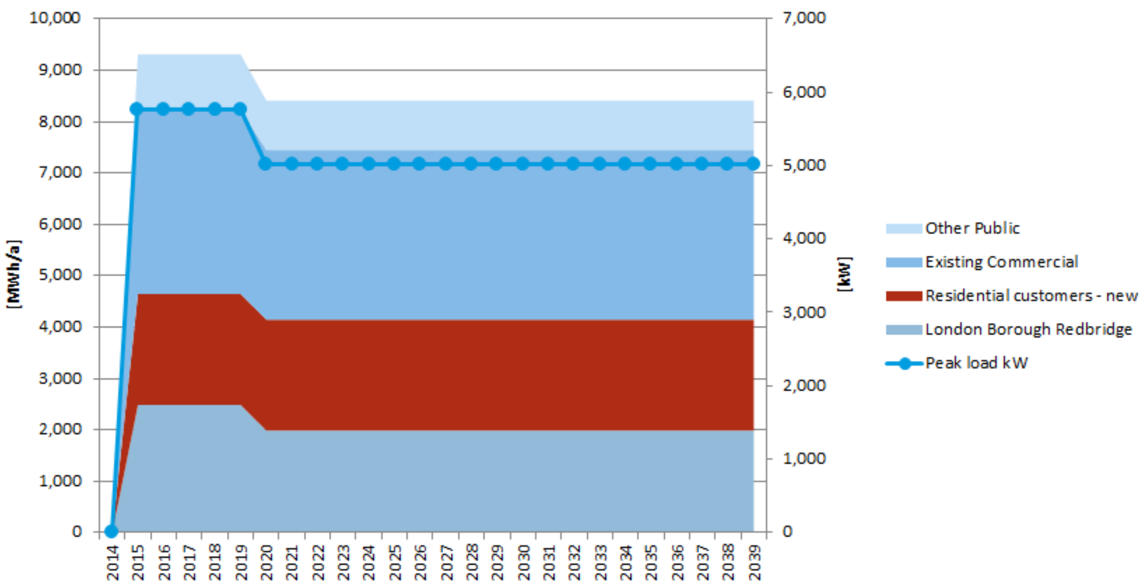


Figure 4: Diversified Peak Heat Demand Profile – Ilford Town Centre – Cluster Project

The associated annual consumption as a function of customer type for the initial cluster is shown in Table 2 below[12],[13].

Customer type	Heat [MWh]
London Borough Redbridge	1,988
Residential customers - new	2,160
Existing Commercial	3,303
Other Public	958
Total after energy efficiency measures	**8,409**

Table 2: Heat Demand by Customer Type – Ilford Town Centre – Cluster Project

[11] Because not all peaks will occur at the same time the loads are not entirely superimposed. The diversified peak is therefore smaller than the sum of all buildings' individual peak loads.

[12] In this table, large and medium commercial are split according to predicted gas consumption, with the threshold gas consumption between the two being as defined in [14],[15]. This is done for the purpose of identifying the alternative cost of heat for these customers.

[13] Refer to the subheading "Revenues from heat sales" within Appendix 3 for a full breakdown on customer types

There is a degree of uncertainty around the feasibility and future timescales of some of the connection opportunities. Initial enquiries with stakeholders have returned some information, as have assessments of energy statements for recently developed opportunities.

Ramboll Energy has used a combination of stakeholder engagements, reviews of recent planning applications for recent developments and internet based mapping services to identify buildings within the opportunity area that have incompatible heating systems (eg gas fired AHUs[14], individual gas boilers in apartment blocks).

Known buildings with incompatible heating systems have been excluded from the analysis and the remaining buildings have been assumed to be compatible on the basis that they contain wet heat systems[15] fed through gas boilers. This is considered to be a realistic assumption at this stage, although further assessment is clearly required at the next stage, particularly where direct engagement has not been possible with larger consumers such as Ilford Mall, Metropolitan Police, Travel Lodge.

Of the developments listed in Table 1, the presumption has therefore been made that connection would be feasible at the point of development of the heat network. The technical viability and cost implications of connecting these buildings has not been carried out at this stage and individual plantroom surveys have not been undertaken. This is normally carried out at feasibility stage. However, in our experience neither physical space or design compatibility of existing wet heating systems are unlikely to present insurmountable barriers to connection and are therefore not considered to be critical factors at this stage. The following buildings within the town centre have been excluded on the basis of the above discussion:-

- Cineworld[16],
- Sainsbury[17],
- Residential housing (Oakwood Lodge) to the south of Winston Way,
- Roding Court and Redstart Mansions[18],
- Westside Apartments[19], 1- 3 Caxton Place[20],
- City View, Thames View and Spectrum Tower Apartments [21]

The Exchange Mall presents a significant opportunity in view of its size and location. At the time of carrying out the analysis we were unable to establish contact with Exchange Mall. Therefore based on our experience of similar shopping centre developments we identified that as a minimum there is likely be an opportunity to supply the communal spaces being fed through AHU's[22]. In the absence of information from the Mall, we therefore applied a benchmarking approach to estimate the scale of this opportunity. Subsequently information was provided to

---

[14] Air Handling Units normally contains a blower, heating element and or cooling element. The conditioned air is then normally distributed through ductwork within the building.

[15] typically operating at 82 degree C/71 degree C

[16] Cineworld operates using rooftop mounted packaged gas fired AHU's with DX chilling. These are incompatible with future connection to a heat network as currently configured and would be expensive to convert. Such a conversion may be economically viable in the future at such time as the Heating, Ventilation and Air-Conditioning (HVAC) systems are overhauled / refurbished. However, we are not aware of any plans to do so at this stage and the opportunity has therefore been omitted for the present study.

[17] Sainsbury has expressed an interest in possible connection to a heat network and for buying electricity through green Power Purchase Agreement. Heat network could potentially supply AHU's (currently gas fired). The viability of doing so would rest on integrating the retrofitting works with planned refurbishment, of the HVAC systems. The timescale for this has not been established at this stage. Sainsbury has confirmed that it would have no interest in purchasing heat to operate local absorption chillers to serve its cooling demands. The commercial risk is too great from loss of supply risk and the level of backup needed would make such a project non-viable.

[18] Redstart mansions has individual gas boilers, Roding Ct (constructed in 2008) also assumed to have individual gas boilers.

[19] L018 Known to have individual gas boilers, L008 assumed to have gas boilers – insufficient information held in planning application.

[20] Known to have individual gas boilers.

[21] Thames View, City View known to have individual gas boilers, Spectrum Tower assumed to have individual gas boilers.

[22] either by displacing heating coils currently being supplied through gas boilers or by retrofitting heating coils if these are currently directly gas fired. It is noted that cost associated with this has not been factored into the analysis at this stage.

enable us to estimate the load more accurately and on this basis we have concluded that connecting the Ilford Mall will marginally reduce the economic viability over the alternative case of not connecting it.

The opportunity to connect a significant social housing development south west of Ilford Town Centre just inside the boundary of Newham has also been investigated. However, consultation with London Borough of Newham has confirmed that there are no communal or district heating systems on the estates at present and that the vast majority of the housing stock have gas fired wall mounted boilers. Whilst a future opportunity might exist (for example under future refurbishment plans for the blocks), these blocks are not considered to be suitable for connection to a heat network until any such refurbishment has taken place.

2.1.2 Fully Built Out Project

A summary of the proposed connected buildings to the heat network opportunity under the fully built out project is presented in Table 3 below. This includes all buildings within the initial cluster project and the relevant identified developments within [16].

The diversified peak heat demand growth profile and annual consumption for the fully built out project is shown in Figure 5 below. The shaded, coloured areas of the graph show the annual consumption as a function of customer type and year of operation of the network. The dotted blue line shows the diversified peak demand seen by the network for all of the customer types.

The associated annual consumption as a function of customer type at full build out is shown in Table 4 below[23]. Refer to Appendix 3 for more information on customer types.

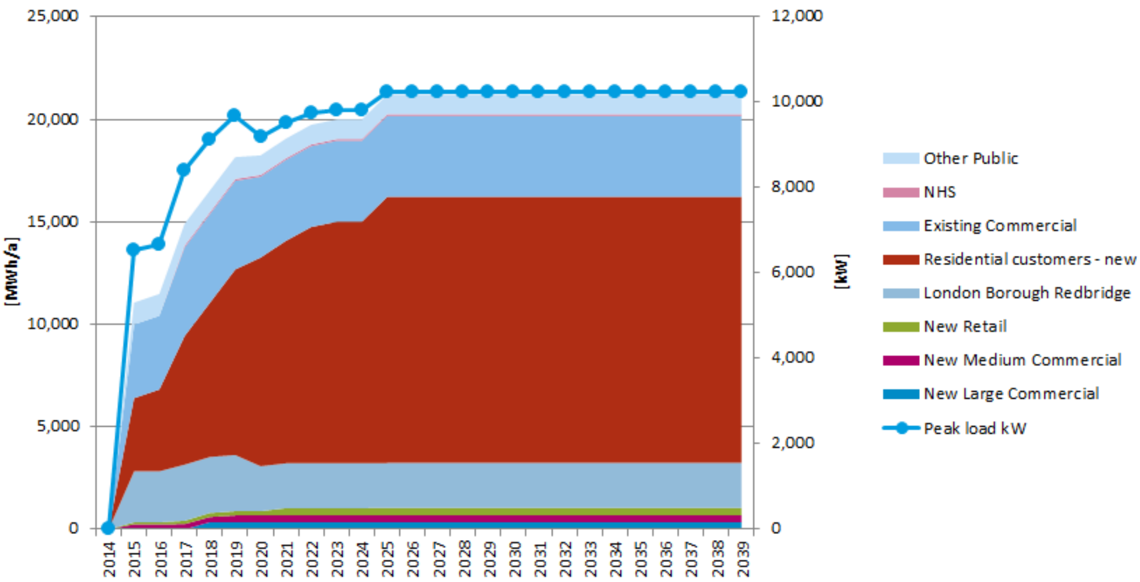


Figure 5: Diversified Peak Heat Demand Profile – Ilford Town Centre – Fully Built Out Project

[23] In this table, large and medium commercial are split according to predicted gas consumption, with the threshold gas consumption between the two being as defined in [14],[15]. This is done for the purpose of identifying the alternative cost of heat for these customers.

Load name	Address	Customer Type	Heat	Construction	Connection	Demand based on
			[MWh/a]	Year	Year	
Primary Care Trust		NHS	82	Existing	2017	Benchmark
Peachy House, 39 Ilford Hill		Existing Commercial	644	Existing	2017	Benchmark
Redbridge Refugee Forum	Redbridge Refugee Forum, Broadway Chambers, 1 Cranbrook Road,	London Borough Redbridge	203	Existing	2017	DEC
CW11	226-244 High Road, Ilford	Residential customers - new	625	2013	2015	Benchmark
LO05	Peachy House, 39 Ilford Hill, Ilford	Residential customers - new	319	2013	2017	Benchmark
ITCOS12	112-114 High Road, Ilford	Residential customers - new	109	2013	2015	Benchmark
ITCOS13	Town Hall Car Park	Residential customers - new	668	2014	2015	Benchmark
ITCOS14	Central Library Service Yard	Residential customers - new	91	2014	2015	Benchmark
ITCOS7	Land adjacent to Cranbrook Road, High Road and the railway, incorporating Station Road	Residential customers - new	1,260	2015	2015	Benchmark
ITCOS01	Land between Mill Road & the Railway Line, Ilford	Residential customers - new	274	2015	2017	Benchmark
ITCOS4	60-70 Roden Street and land between Chapel Road and Roden Street, Ilford	Residential customers - new	915	2015	2017	Benchmark
ITCOS5	40 Ilford Hill, Ilford	Residential customers - new	259	2015	2017	Benchmark
ITCOS10	Britannia Car Park, Clements Road	Residential customers - new	123	2016	2016	Benchmark
ITCOS15	Kenneth More Theatre	Residential customers - new	607	2016	2016	Benchmark
ITCOS6	22-32 Chapel Road, Ilford	Residential customers - new	49	2017	2017	Benchmark
ITCOS8	Site bounded by Chapel Road, High Road and Clements Lane	Residential customers - new	702	2017	2017	Benchmark
LO09	73-77 Ilford Hill, Ilford	Residential customers - new	40	2017	2017	Benchmark
ITCOS24	300 – 318 High Road, Ilford	Residential customers - new	165	2017	2025	Benchmark
ITCOS3	51-85 Ilford Hill and 1-27 Cranbrook Road	Residential customers - new	722	2017	2017	Benchmark
ITCOS19	Ley Street car park and bus depot, Ilford	Residential customers - new	669	2018	2018	Benchmark
ITCOS2	Mill House, Ilford Hill	Residential customers - new	617	2018	2018	Benchmark
ITCOS16	187-207 High Road, Ilford	Residential customers - new	472	2018	2018	Benchmark
ITCOS9	Land adjacent to Clements Lane and	Residential customers - new	248	2019	2019	Benchmark

	Clements Road						
ITCOS18	69-126 Ley Street and Opal Mews, Ilford	Residential customers - new	643	2019	2019	Benchmark
ITCOS11	Land bounded by Clements Road, Chadwick Road and Postway Mews	Residential customers - new	432	2020	2020	Benchmark
ITCOS22	262 – 268 High Road, Ilford	Residential customers - new	214	2019	2019	Benchmark
LO06	Sainsbury's, Roden Street, Ilford	Residential customers - new	587	2021	2021	Benchmark
ITCOS17	Ilford Exchange Shopping Centre Car Park	Residential customers - new	191	2025	2025	Benchmark
ITCOS25	Redbridge Enterprise and Ilford Retail Park	Residential customers - new	862	2025	2025	Benchmark
NORTH LONDON MANAGEMENT SCHOOL	NORTH LONDON MANAGEMENT SCHOOL	London Borough Redbridge	0	Existing	2015	No data
Subtotal added buildings			**12,792**	(after energy efficiency measures)		
Initial Cluster		**9,308** (before energy efficiency measures), **8,409** (after energy efficiency measures)				
Total		**22,240** (before energy efficiency measures), **21,200** (after energy efficiency measures)				

Table 3: Summary of Connected Buildings – Ilford Town Centre Project - Fully Built Out Project

Customer type	Heat [MWh]
New Large Commercial	346
New Medium Commercial	326
New Retail	371
London Borough Redbridge	2,191
Residential customers - new	12,978
Existing Commercial	3,947
NHS	82
Other Public	958
Total after energy efficiency measures	**21,200**

Table 4: Heat Demand by Customer Type – Ilford Town Centre - Fully Built Out Project

New developments within the opportunity areas that are considered to be unlikely to connect to the heat network opportunity are:

- 51-71 Cranbrook Road (VA13 as identified in the Ilford Town Centre Area Action Plan)
- Mansfield (VA14 as identified in the Ilford Town Centre Area Action Plan)

The basis for not connecting these buildings is that they are too small in heat demand terms and they are located too far away from the main heat demands and that the cost of connection outweighs the value to the project in income from heat sales. Appendix 1 summarises the likely alternative solutions for these developments, based on our experience of current buildings of this type coming forward in London and factoring the expected impact of Zero Carbon Homes policy and future changes to the building regulations.

2.2 Energy Supply Opportunity

2.2.1 Proposed Fuel Source and Heat Production Mix

Gas fired CHP in conjunction with gas boilers has been identified as the preferred heat production equipment for the project opportunity. Gas CHP has been widely applied in district heating projects across the UK and continues to be adopted by ESCo and public sector based projects alike. The technology is bankable[24] and presents a low investment risk (providing the project is economically attractive).

There is an opportunity to supplement this technology mix with biomass heating, although the economics of this option have not been considered at this stage due to the uncertainty around London Borough of Redbridge's position around adoption of biomass heating within Ilford Town Centre and the associated air quality, transportation and fuel storage implications[25].

A summary of other fuel supply options considered for the project is presented in Section 9.

---

[24] Project or proposal that has sufficient collateral, future cashflow, and high probability of success, to be acceptable to institutional lenders for financing.

[25] It is noted that mitigation measures to maintain acceptable air quality impact should be possible using existing technologies, subject to local air quality and economic viability at the proposed scale. A fuller air quality impact assessment would be required to assess the requirements which should be carried out at the feasibility stage.

2.2.2 Energy Centre Capacity

An energy centre of approximate size 500 m^2 will be required. Based on an options appraisal around various modular arrangement a single gas CHP engine of capacity of 1.2 MWe is proposed (Appendix 6 has further information on the likely contribution of CHP and gas boilers at different points during the final year and also the varying contribution from year to year). This approach will serve the initial cluster project sub-optimally, but will ultimately improve the overall IRR for the fully built out project over the alternative proposal of installing CHP capacity in two phases. It is recognised that there is a possible risk to the project with this approach, if the fully built out project is never taken forward. This risk should be further assessed at the next stage if the project is taken forward.

2.2.3 Energy Centre Location

.

Three options for locating the energy centre within Ilford Town centre have been identified. The basis for selecting these sites has included consideration of a number of factors discussed in Appendix 4 as well as the development timescales for the Ilford Town Centre project, land ownership and land asset value considerations. The sites are:-

1) Rear of site ITCOS 05: a disused car park (former police station) off Chapel Road which is currently council owned land and intended for redevelopment as mixed use residential over the next 5 years.

2) ITCOS 25: Ilford Retail Park, privately owned land, currently containing a mixture of retail units, employment units and residential units and intended for redevelopment over the next 5 years as new employment, ground floor mixed use and residential.

3) ITCOS 14: the existing library service yard, intended for redevelopment over the next 5 years as residential.

In principle any of these sites could be used for location of the energy centre. A summary of the advantages and disadvantages of each site opportunity is presented in the table below. Grid connection and gas supply connection issues have not been considered, since utility route information has not been provided by London Borough of Redbridge.

Advantages	**Disadvantages**
ITCOS 05 (Disused car park off Chapel Road)	
Ample space for energy centre development. Energy centre location reasonably close to centre of gravity of anchor heat demands. Reduces cost of network and development risk if stakeholder uptake is dispersed. Location away from town centre implies lower land value and less nuisance to local business and general public during construction and during operation if biomass adopted. Land is owned by London Borough of Redbridge, therefore reduces development risk.	Very high stack heights likely to be required (based on future proposed building heights as indicated in Map 9 in Ilford Town Centre AAP and on existing development CW09). Site is located off major junction. Access for construction and maintenance is likely to cause significant traffic disruption. Less suited to biomass, since ongoing fuel deliveries will also cause traffic disruption. Highest pipework cost associated with safeguarding for future expansion into Crossrail Corridor implies increased development risk and reduced IRR relative to other options.

ITCOS 25 (Ilford retail park)	
Lower stack height likely to be required than for ITCOS 05 assuming construction to the east of the site as indicated by the Map 9 in the Ilford Town Centre AAP. Ample space for energy centre development. Site is adjacent to railway. Suggests that noise and air quality impact will be lower impact than for other options. Energy centre can be located to the east of the site, adjacent to the recycling centre. Opportunity for shared access thereby reducing traffic impact during construction and operation (for example if biomass deliveries are proposed). Biomass option easier to adopt (for reasons identified above). Lower pipework costs associated with safeguarding for future expansion into Crossrail Corridor implies lower development risk than for other options. Location away from city centre implies lower land value and less nuisance to local business and general public during construction and during operation if biomass adopted.	Land is not owned by London Borough of Redbridge. This will require negotiation with the landowner and presents an additional development risk to the project. Energy centre location is remote from centre of gravity of anchor heat demands. Adds to cost of network and increases development risk if stakeholder uptake is dispersed.
ITCOS 14 (Library service yard)	
Lower stack height requirements than ITCOS 05 are likely to be required as indicated by Map 9 in the Ilford Town Centre AAP. Energy centre location is close to centre of gravity of anchor heat demands. Reduces cost of network and minimised development risk if stakeholder uptake is dispersed. Land owned by London Borough of Redbridge. Reduces development risk. Access off Clements Rd reduces disruption and traffic management issues. Central location improves this financial case.	Higher pipework cost associated with safeguarding for future expansion into CC. Increased development risk, reduced IRR. Space is very limited. Likely to require two storey energy centre, increasing cost and visual impact. Biomass option less likely to be viable, taking into account access requirements and fuel storage requirements. Likely to be harder to implement due to local air quality concentrations. Location within town centre. Greater impact to local business and general public during construction and during operation if biomass adopted. Land value relatively high implies higher project costs. Visual impact likely to be an issue in relation to the required stack height.

Table 5: Energy Centre location Options - Ilford Town Centre

Modelling of the various options has identified that the configuration involving an energy centre at ITCOS 14 (library service yard) provides the highest IRR of the three options. ITCOS 14 is therefore taken forward as the basis of the heat network opportunity for the remainder of this report and all identified costs and economic indicators presented in this report reflect this assumption Based on our initial assessment, this location is considered to be feasible for an energy centre. However, it is recognised that the available space is tight and may require a two storey energy centre to be constructed with an elevation of up to 10 m from ground level (excluding stack height) or a buried basement which may increase construction costs. Further work will also be necessary to further establish the feasibility of the opportunity in relation to air quality impact[26], noise and visual impact.

2.3 Phasing Strategy and Implementation Plan

The identified phasing strategy for the heat network is shown graphically in Figure 2.

A single gas engine is proposed at the start of the project. The network should be installed in a modular fashion in order to minimise capital outlay and under-utilisation in the early years and allow capital expenditure to be matched more closely to revenues from heat and electricity sales. The proposed timescales for construction are identified in Appendix 5.

2.4 Economic Appraisal

Economic modelling has been carried out for both the initial cluster project and the fully built out project. The key economic indicators for the project are presented in Table 6 below, both for the initial cluster project and the fully built out project as a function of electricity selling arrangements and assuming a project term of 25 years.

For this project, an Electricity Licence Lite[27] and an Electricity Sell and Buy Back[28] arrangements have been considered, since a private wire network is unlikely to be a cost effective, unless one or two large scale users (such as Ilford Mall) could be connected[29]. Refer to Appendix 3 for definitions of electricity selling arrangement opportunities.

		Fully built out 25 years	Cluster project over 25 years
Total Investment CAPEX	[£ K]	9,802	6,111
Energy Centre CAPEX	[£ K]	3,708	3,575
Length of Heat Network	[m]	4,313	1,763
Cost of Heat Network	[£ K]	3,156	1,426
Connection CAPEX	[£ K]	1,811	407
Project Development Costs	[£ K]	1,128	703
Annual Operating Costs	[£ K]	1,614	828
Annual Revenues from Heat Sales	[£ K]	1,873	584
Annual Saving per year to LBR due to CRC savings [30]	[£ K]	0.9	1.3

[26] ie the required stack heights for flue dispersion purposes and any costs associated with achieving required NO_x emission levels which will also be dependent on existing NO_x levels at the proposed energy centre location.

[27] A simplified electricity licence that would enable the licence holder to retail electricity to domestic and non-domestic customers

[28] The electricity producer can arrange with a local electricity license holder to net off, for a fee, consumption against production.

[29] The possibility of this arrangement could be explored at the next stage if the project is taken forward, although it is noted that this approach would also carry significant risk to the project, since the customer(s) would not enter into long term agreements for this electricity and would be free to change supplier at any time under current electricity supply laws.

[30] The carbon dioxide intensity of heat delivered and therefore CRC savings changes with the proportional mix of gas boiler and CHP heat. The proportion of heat from CHP is larger in the cluster case.

Licence Lite			
Weighted Average Electricity Sales Value from Project	[£ /MWh]	86.9 in 2015 and 120.1 in 2039	87 in 2015 and 121.4 in 2039
Annual Operating Margin at full build out	[£ K]	1,507	613
Annual Revenues from Electricity Sales, LEC and CRC values	[£ K]	1,248	857
IRR % over 25 years	[%]	11.3%	7.1%
NPV at 6% discount factor	[£ K]	5,034	602
Sell and Buy Back			
Weighted Average Electricity Sales Value from Project	[£ /MWh]	67.3 in 2015 and 93.0 in 2039	67.3 in 2015 and 93.9 in 2039
Annual Operating Margin at full build out	[£ K]	1,237	428
Annual Revenues from Electricity Sales, LEC and CRC values	[£ K]	978	672
IRR % over 25 years	[%]	8.5%	3.3%
NPV at 6% discount factor	[£ K]	2,314	-1,367

Table 6: Key Economic Indicators - Ilford Town Centre Project

The required capital investment for the initial cluster and fully built out projects would be around £6.1M and £9.8M respectively.

The calculated IRRs for the cluster and fully built out project would be around 7.1% and 11.3% over 25 years, based on an Electricity Licence Lite arrangement. The corresponding NPV would be £0.6M and £5.0M at a 6% discount factor. The NPV describes today's value of the project due to expected future cash flow[31].

Under a sell and buy back arrangement, the calculated IRRs for the cluster and fully built out project would be around 3.3% and 8.5% over 25 years. The corresponding NPV would be £-1,4M and £2.3M at a 6% discount factor.

One of the most important variables (i.e. high impact) for the financial performance is the initial realised value of the electricity produced. As another benchmark for projects the electricity selling price required to deliver a 10% IRR[32] for the fully built out project over 25 years[33] would be 7.84 p/kWh. This benchmark is provided for all projects.

The annual saving to London Borough of Redbridge associated with reduction in CRC payments under the project would be £0.9K and £1.3K under the initial cluster and fully built out projects[34].

Fuel savings would remain unchanged under the current modelling assumptions. This assumes that the project would charge London Borough of Redbridge its current heat price, which has been calculated to be 4.12 p/kWh excluding annualised reinvestment costs and 4.27 p/kWh including annualised reinvestment costs. The cost of electricity to London Borough of Redbridge is assumed to be reduced by 10% of its current value under any proposed Licence Lite arrangement since, like other (private) customers purchasing electricity under the scheme, it is assumed that a 10% incentive would be offered to attract and retain customers over the long term.

---

[31] A positive NPV indicates a positive project value in present terms, whilst a negative NPV indicates an overall cost in present terms.
[32] 10% being the notional viability threshold for interest from the private sector as described elsewhere in the report.
[33] assuming all other variables remaining constant
[34] The CRC benefit shown in the table reflects the benefit seen by the connected buildings rather than the benefit taken by the project. Refer to Appendix 3 for details of the assumed benefit sharing arrangement.

Discounted cashflow forecasts for the initial cluster project and the fully built out project are presented in Figure 6 and
Figure 7 respectively. These are based on an Electricity Licence Lite arrangement. The presented cash flows shown illustrate the cumulative cash flows at various discount rates. The resulting value after 25 years indicates the NPV for the corresponding discount rate. Where the graph crosses the x-axis is the corresponding year when break-even occurs.

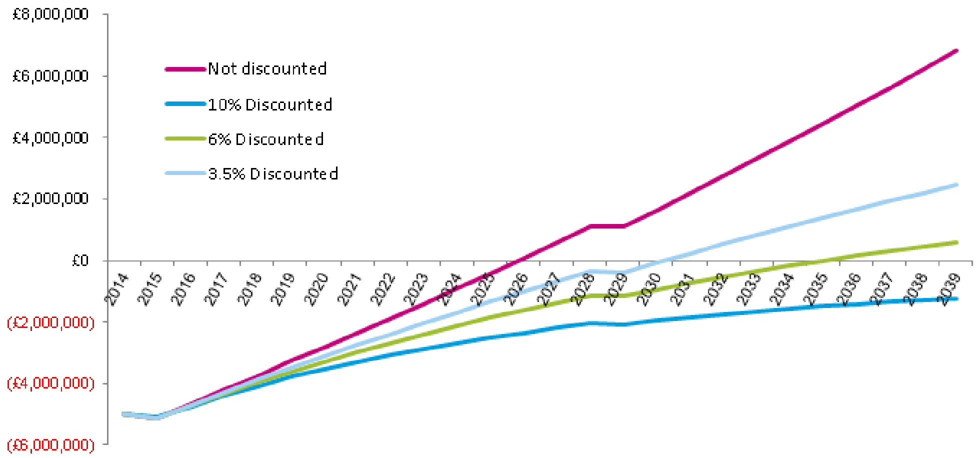


Figure 6: Cumulative Discounted Cashflow Forecast - Ilford Town Centre – Cluster Project – Electricity Licence Lite

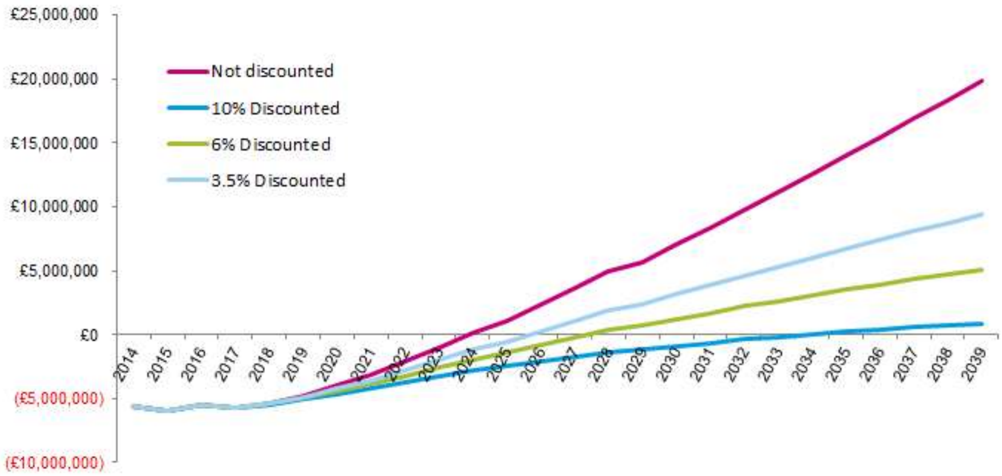


Figure 7: Cumulative Discounted Cashflow Forecast – Ilford Town Centre – Fully Built Out Project - Electricity Licence Lite

The impact of a range of capital contributions from 500K to £2M has been tested for the project. The results are shown in Figure 8. IRR is seen to increase to 9.5% and 13% for a grant contribution of £1M for the cluster and fully built out projects respectively.

Potential sources of grant funding could be Allowable Solutions, Section 106 funding, Community Infrastructure Levy, Housing Revenue Account, New Homes Bonus (for the fully built out project), Homes and Communities Agency and the London European Regional Development Fund. London Borough of Redbridge needs to explore these sources of funding and identify possible contribution levels.

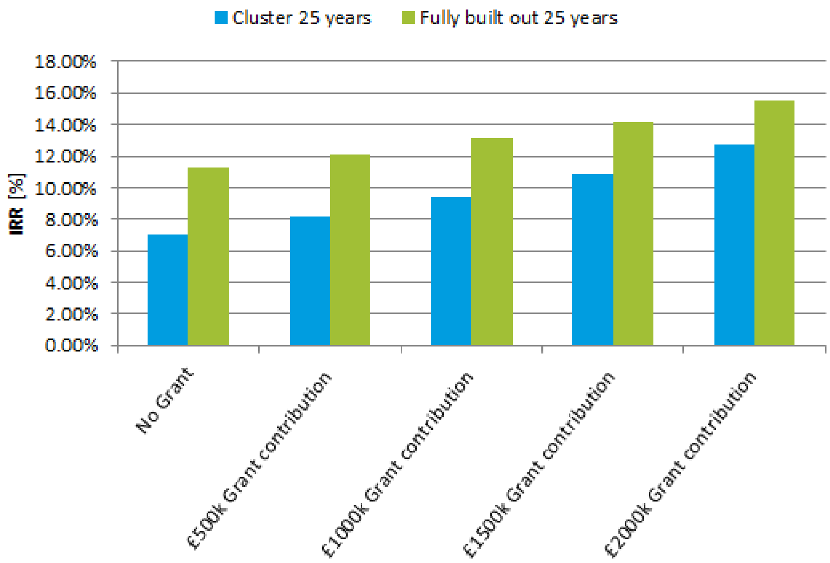


Figure 8: Impact of Grant Contribution to Project IRR for the Cluster and Fully Built Out Projects

2.5 Sensitivity Analysis

A sensitivity analysis has been carried out around the key variables that influence the IRR for the project. The results of the sensitivity analysis are presented in Figure 9 and Figure 10 below for the cluster project and fully built out project for the Electricity Licence Lite scenario.

The blue line shown in the graph represents the central estimate of the project IRR, based on the central estimates for the listed variable along the x-axis which were used to produce the economic indicators presented in Table 6 .

The bars in the graphs show the change in project IRR due to a change in the relevant variable, with all other variables being held constant. Red bars denote a 10% increase in the listed variable whilst green bars denote a 10% reduction in the listed variable. Exceptions to this are variables such as the 'Carbon Price Support for CHP' and the last columns of connection costs, which are modelled as being present (reference case), 50% or removed from the project. Further information on the methodology, the interpretation of the graphs and the values attributed to each variable is presented in Appendix 3.

The key conclusions drawn for the cluster project are that:-

1. Electricity selling price, gas purchase price, project capital cost, and heat selling price are the major drivers in uncertainty around IRR.
2. A favourable variation of 10% in any of the indicated variables will increase the IRR to over 8%.
3. An unfavourable variation of 10% in any of the indicated variables will reduce the IRR to under 6.0 %, which is considered to be unattractive to London Borough of Redbridge.

For the fully built out project an unfavourable variation of 10% in any of the indicated variables will still deliver an IRR of around 9 %, which is still considered to be attractive to London Borough of Redbridge.

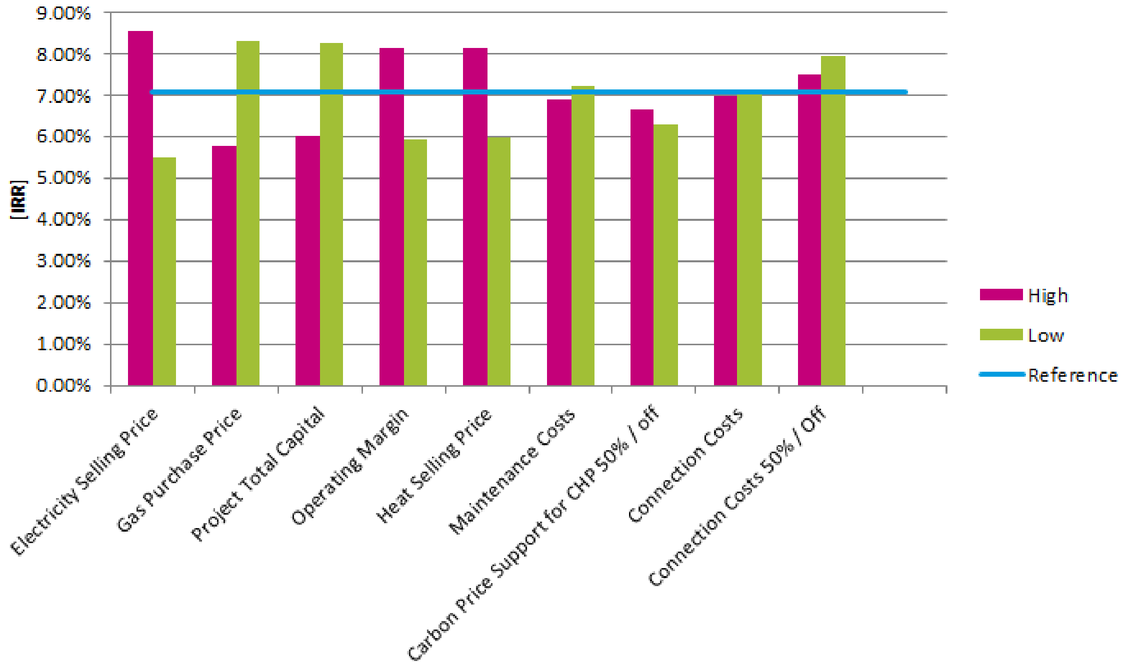


Figure 9: Economic Sensitivity Analysis – Ilford Town Centre – Cluster Project - Electricity Licence Lite

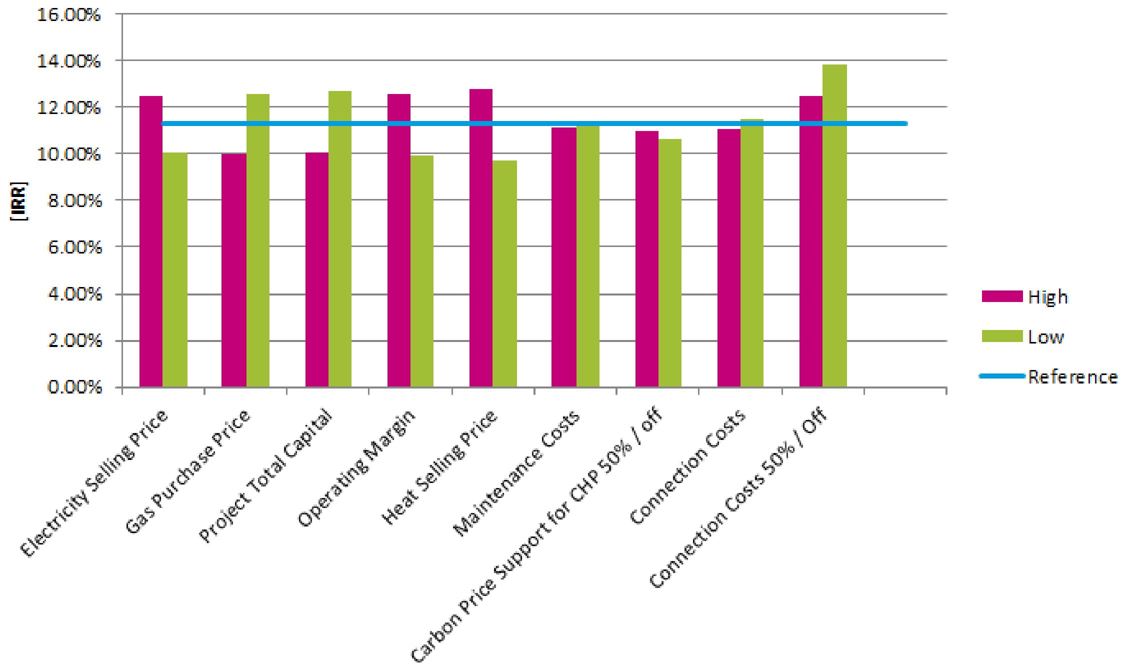


Figure 10: Economic Sensitivity Analysis – Ilford Town Centre – Fully Built Out Project - Electricity Licence Lite

2.6 Implication for Project Procurement

The fully built out project is likely to be attractive to London Borough of Redbridge if an Electricity Supply Licence Lite selling arrangement can be established. In the event that this cannot be secured, the fully built out project may still be of interest to London Borough of Redbridge since it would return an IRR of around 8.5% over 25 years (assuming that the council could 'net off'[35] electricity generation from the project under a sell and buy back arrangement with an electricity supplier).

The development timescales for Ilford Town centre are such that a fully built out project opportunity would not materialise until around 2025. On this basis, London Borough of Redbridge should consider establishing an initial cluster project in the interim period. However, in order for the initial cluster project to be economically attractive to London Borough of Redbridge, it is likely to require an Electricity Supply Licence Lite to be established. Even then, the project would only return an IRR of around 7.1% over 25 years.

Without an Electricity Supply Licence Lite the project would probably need to trade under a sell and buy back arrangement[36]. This would yield an IRR over 25 years of 3.3% which is clearly insufficient to be of interest to London Borough of Redbridge.

The fully built out project is likely to interest an ESCo, returning IRRs above 10%. However, the initial cluster project is unlikely to favour a wholly private sector approach, even if the project is able to realise electricity prices comparable to the value assumed under an Electricity Licence Lite arrangement. A public private sector partnering approach may be of interest to certain ESCos and should therefore be considered by London Borough of Redbridge as a possible way forward. London Borough of Redbridge should however recognise that it will need to champion the development of such a project, since the private sector is unlikely to step in and do so.

The viability of the cluster project therefore appears to be predicated on the need to be led by London Borough of Redbridge (as opposed to being offered to the market to deliver) and the need to establish an Electricity Licence Lite selling arrangement.

[35] i.e. The electricity producer (LBR) could arrange with the local electricity license holder to net off, for a fee, consumption against production

[36] Electricity supply via a private wire arrangement could also potentially be an attractive proposition for new developments connected to the scheme. Further consideration should also be given to this if the project is taken forward to business planning. The economics of a possible private wire arrangement have not been investigated here. This could potentially become a viable economic proposition, although it should be recognised that this would incur additional investment costs and would introduce considerable risk, given that it would need to supply the bulk of this electricity to a third party and would be unable to secure long term contracts to do so. Nevertheless, the opportunity could be further explored with key stakeholders such as the Ilford Mall, who are likely to represent the single most appropriate consumer under the cluster project.

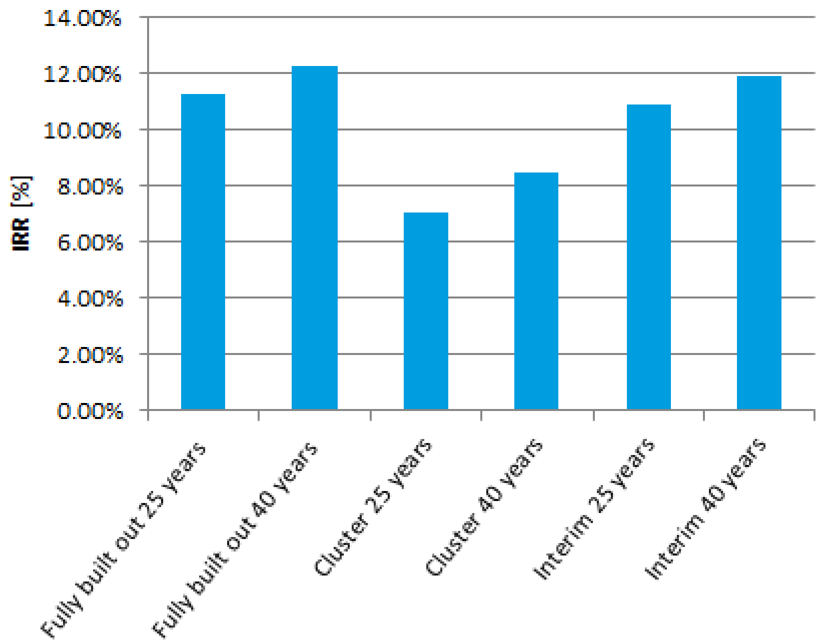


Figure 11: Modelling outcomes as a function of Project Term and Project Scale – Ilford Town Centre – Electricity Licence Lite

The impact of project term on IRR is shown in Figure 11. This presents the various modeling cases described in Appendix 3 based on an Electricity Licence Lite arrangement, which is considered to be the most economically favorable option for the project. The interim case is one where buildings planned for connection over the first 6 years of the project connect as planned and then no more buildings are connected beyond then. In other words it is like the fully built out project but stops connecting new buildings after 2021.

The IRR for the fully built out project viewed over 25 years are considerably more favorable than for the cluster project viewed over the same period. This suggests that the case for extending the network in the future will be strong.

Viewed over 40 years, the IRR of the cluster project and fully built out projects exceed 8% and 12% respectively. In both cases, this is considered to be an attractive proposition to London Borough of Redbridge, if it is prepared to take a long term view over the project return. It also suggests that London Borough of Redbridge could reasonably expect to attract interest from the private sector if it chose to sell the cluster project at a later stage, at which point the project would represent a low risk proposition that a private ESCo might be prepared to take on.

The IRR's of the interim project are higher than for the initial cluster and lower than for the fully built out project. This reflects an increasing linear heat density in going from the cluster to the interim project and a significant up-front investment in the network in going from the cluster to the fully built out project, which ultimately pays off later once additional customers connect to the project at incrementally low additional connection costs. When viewed in this way, this suggests that the project has a good potential for future expansion and a low risk of not realising it full potential.

It is noted that there are relatively few Local Authority owned assets within the initial cluster project. London Borough of Redbridge should recognise that this will introduce complexity and risk in delivering the project since multiple, protracted stakeholder negotiations are likely to be required.

2.7 Heat Supply Contribution

The heat supply contribution from each heat production asset for the initial cluster project and the fully built out project are shown in Appendix 6. These are shown as load duration curves, monthly supply profiles at full build out and cumulative supply contributions from each heat production asset as modeled for the initial cluster and fully built out projects.

2.8 Carbon Appraisal

Projected carbon savings for the initial cluster and fully built out projects over 25 years are presented in Table 7. Reference to the calculation methodology is provided in Appendix 3. Calculated carbon trajectories over the project lifecycle are presented in Appendix 5.

		Grid Carbon Factor Unchanged	DECC Grid Decarbonisation Trajectory
Business as Usual CO_2 over over 25 years - Cluster Project	[TCO_2]	54,298	47,806
CO_2 Savings over over 25 years – Cluster Project	[TCO_2]	16,767	-5,113
% reduction in CO_2 Savings over 25 years – Cluster Project	[%]	30.9%	-10.7%
Business as Usual CO_2 over 25 years - Fully built out project	[TCO_2]	136,759	82,258
CO_2 Savings over 25 years – Fully built Out Project	[TCO_2]	35,112	-42,353
% reduction in CO_2 Savings over 25 years – Fully built Out Project	[%]	25.70%	-51.50%

Table 7: Carbon Emission Projections - Ilford Town Centre Project

The table identifies a positive saving in CO_2 over the life of the project based on projections using current grid emission factors but a negative saving if the DECC decarbonisation trajectory is assumed, highlighting the limited on-going role that gas CHP will be able to play in carbon reduction in the future if DECC's grid decarbonisation trajectory is realized in practice. If so, the annual CO_2 savings are positive up to 2021 for the fully built out scenario and 2028 for the initial cluster scenario. See Appendix 5.

2.9 Route Identification and Risk Appraisal

A proposed network route is shown in Figure 2.

Specific constraints identified for this section of the route, in Figure 2, are:-

2.9.1 Railway Crossing

Routing of the pipework across the railway line will require approvals from Network Rail.

Two main options for crossing the railway have been identified as Griggs Approach and the access ramp to the multi-story car park at the Exchange Mall[37]. Both options appear to be technically feasible based on an initial review. Use of the multi storey car park will require permissions and wayleaves from the Exchange Mall. This is likely to be considerably simplified if the Exchange Mall is included in the project[38].

Both options are likely to present difficulties in terms of construction and access for on-going maintenance, due to the working arrangements required by the railway authorities. A cost benefit analysis will be required to compare the cost uplift associated with permissions and special engineering requirements for crossing the railway in two places and the savings in additional network length arising. If one crossing point is ultimately preferred, this is likely to be the Exchange Mall option providing that wayleaves and permissions can be arranged, since this will result in a lower overall network length.

Figure 12: indicates how pipework could potentially be supported along the crossing route.

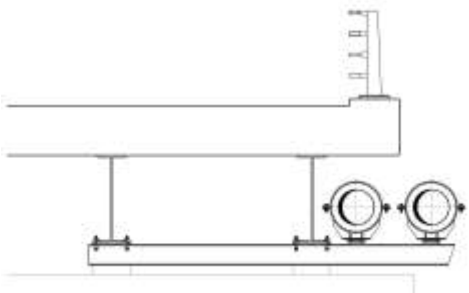


Figure 12: Example Bridge Crossing Detail

In each case, a number of technical issues would also have to be dealt with at design stage, such as the weight and thermal expansion of the pipes, structural integrity of the bridge, pipe routing 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 design work.

Alternative methods for crossing the railway would be for the pipework to be buried under the railway tracks using a directional drilling technique (known as 'mole-ing' or pipe jacking). This would be expensive (as working hours are usually very restricted) and is unlikely to be necessary. 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 Crossrail and Network Rail.

Tunnelling beneath the railway line 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.

Construction of a new structure to cross the railway at high level is likely to be prohibitively expensive due to the specification to which it would need to be designed in order to get approval from the relevant rail authorities.

---

[37] The route across Hainault St appears be very tight and is not recommended. (However, it is acknowledged that Hainault Street has recently received funding to expand, which may make this route more viable). Access across A123 crossing adjacent to railway station may be feasible, although there appears to be little additional load in this area and so would not be particularly beneficial

[38] Connection to the Exchange Mall is expected to take place at level 5 where the existing heating and cooling equipment are presently located towards the back of the car park. We have made an allowance to route this at high level across the car park to the centre of the site, based on a network connection along Havelock Street, traversing into Myrtle Rd, crossing the railway at high level.

2.9.2 Ilford Hill, Chapel Road and Winston Way

Routing of pipework around Ilford Hill, Chapel Road and Winston Way is likely to cause issues in relation to traffic management. In addition the route is a major bus route. Access for construction will require permissions with TfL and Council Highways Department.

The gyratory system is dual carriageway with a bus lane and therefore will not require complete closure of the road during construction. This will simplify and reduce cost. Utility congestion is likely to be an issue, and early de–risking through a utility search is recommended.

2.9.3 Pedestrian Precinct Area

The pedestrian area within either end of the High Rd represents an opportunity to reduce installation costs and minimise disruption to traffic.

However, construction in the area would cause major disruption to pedestrians, requiring enhanced health and safety provision and risking protestations from local businesses, both of which will increase costs and extend construction programme. Furthermore, since plantrooms will generally be located to the rear of the precinct, there will be an advantage in routing pipework behind these buildings through the streets enclosed between the High Road and Winston Way.

2.9.4 Archaeology

Ilford is an archaeology priority area and this will therefore have to be taken into account if this opportunity is taken forward.

2.10 Summary

A summary of the key project parameters is shown in the table below.

		Fully built out 25 years	Cluster project over 25 years
Total Investment CAPEX	[£ K]	9,802	6,111
IRR % over 25 years based on Electricity Licence Lite	[%]	11.3%	7.1%
NPV at 6% discount factor based on Electricity Licence Lite	[£ K]	5,034	602
CO_2 Savings over 25 years life of project relative to Business As Usual – Grid Factor unchanged	[TCO_2]	35,112	16,767
CO_2 Savings over 25 years life of project relative to Business As Usual – Grid Factor unchanged	[%]	25.7%	30.9%
Energy Centre footprint	[m^2]	500	500
Energy Centre CHP Capacity	[MW_e]	1.2	1.2
Length of Heat Network	[m]	4,313	1,763

Key Risks

The long development timescales present a significant development risk to the project. Future expansion of the project will depend on whether the future development proposals materialise.

The large number of stakeholders involved in the initial cluster phase of the project presents a risk in relation to developing a secure bankable customer base for the project.

The costs and differing timescales associated with refurbishment of existing internal heating

systems in the numerous existing buildings making up the cluster project makes the availability and phasing of future revenues from these buildings difficult to predict. There remains uncertainty about the technical suitability of many of the identified commercial and private existing buildings. Future developments in government policy around building regulations, zero carbon homes policy, financial and policy support mechanisms to gas CHP and alternative competing measures affect viability. Similarly uncertainty around future grid decarbonisation will have an impact on the future role for gas CHP. <u>Overall recommendation</u> The fully built out project at Ilford Town centre is likely to be an economically attractive proposition to both the public and private sector. However, the development timescales for the project are such that a fully built out project opportunity would not materialise until around 2025 and it is unlikely that the private sector will step in to develop a project in the interim period. On this basis, London Borough of Redbridge should consider establishing an initial cluster project based on existing buildings to catalyse the opportunity and lay the foundation for any future involvement by the private sector. In order for the initial cluster project to be economically attractive to London Borough of Redbridge, it is likely to require an Electricity Supply Licence Lite. It is recommended that London Borough of Redbridge should carry forward this project opportunity.

Table 8: Key Project Parameters - Ilford Town Centre Project

3. CROSSRAIL CORRIDOR

3.1 Summary of Opportunity

The Crossrail Corridor Area Action Plan [1] allocates several Opportunity Sites for future development. The Plan identifies five Character Areas, known as: East of Ilford, Seven Kings Local Centre, Goodmayes Local Centre, Grove and Chadwell Heath.

The Crossrail Corridor contains several large, former industrial and commercial sites that have remained vacant or underused for the last few decades, as low land values, heavy traffic congestion, noise from rail and industrial operations and the poor quality local environment have together limited the appeal of the area for investment and development.

The Council aims to transform the Crossrail Corridor and the surrounding area, with high quality, innovative developments that have environmental sustainability at their heart, whilst respecting and retaining the core elements of the remaining positive townscape and individual buildings of historic and/or architectural interest. The investment into and development of these underused and vacant sites will be driven by anticipation of the confirmed arrival of Crossrail in 2019, housing need and requirements, the changing demographics of the area, its strategic location, and will be key to the success of the Area Action Plan.

As a result the Area Action Plan identifies several Opportunity Sites along the Corridor which are deemed to be important for the regeneration of the Corridor through the provision of supporting infrastructure.

Many of the Opportunity Sites are located within Seven Kings and Goodmayes Local Centres and Chadwell Heath District Centre and will improve their economic vitality and viability and provide wider community benefits. The Opportunity Sites have been allocated for a mix of uses, including residential, retail, employment (Use Class B1), leisure, education, community use and healthcare.

3.2 Identified Network Opportunity

The opportunity to bring forward a heat network within the Crossrail Corridor has been assessed. This has focused on a network centred around Goodmayes that would extend eastwards towards Grove and westwards towards Ilford Town Centre up to the area called East of Ilford.

The opportunity comprises mainly new build mixed used and residential only developments, with a small number of existing buildings also connecting to the network.

Three sub options have been assessed for this opportunity; Crossrail Corridor East ~ a network extending eastwards from SK06, where the identified energy centre opportunity is situated; Crossrail Corridor West ~ a network extending westwards from SK06, where the identified energy centre opportunity is situated and; a combined option that encompasses both Crossrail Corridor East and Crossrail Corridor West. The analysis has shown that the combined project shows marginally favourable economics over the alternative options considered and this case is presented in the results taken forward.

The case for a cluster network centred around existing anchor heat loads has also been assessed. This has concluded that there are insufficient anchor heat loads in the area to warrant a cluster network, and this opportunity has not therefore been considered further.

A network schematic of the project opportunity is shown in Figure 13 and a summary of the buildings identified for potential connection to the heat network opportunity is presented Table 9.

Note that the numbers have been rounded in the tables which mean the totals differ slightly in Table 9 and Table 10.

There is degree of uncertainty around the feasibility and future timescales of some of the connection opportunities for the existing buildings considered within the project. Of those identified in Table 9 the assumption has been made that the connections would be feasible at the point of development of the heat network. Stakeholder consultations have not been carried out for these sites at this stage.

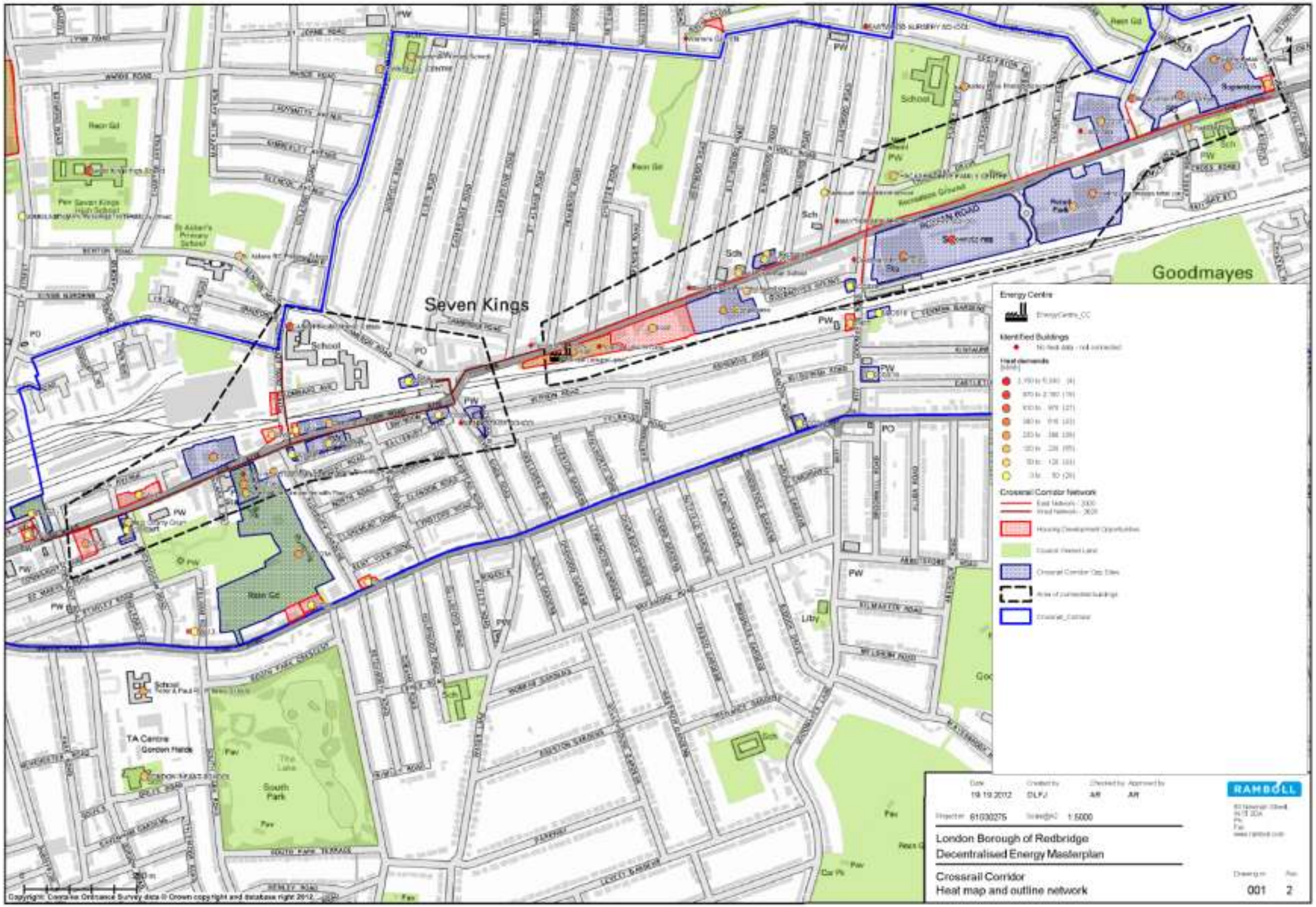


Figure 13: Heat Map and Network Outline Crossrail Corridor Project

Load name	Address	Customer Type	Area	Heat	Construction	Connection	Demand based on
				[MWh/a]	Year	Year	
BT Exchange	Off A118 High Road, Ilford	Existing Commercial	Goodmayes	98	Existing	2020	Benchmark
Ilford Grammar School	Off A118 High Road, Ilford	Existing Commercial	Seven Kings	66	Existing	2020	Benchmark
Gurdwara	Off A118 High Road, Ilford	Existing Commercial	Seven Kings	175	Existing	2020	Benchmark
Homebase	Off A118 High Road, Ilford	Existing Commercial	Seven Kings	170	Existing	2020	Benchmark
Tesco	Off A118 High Road, Ilford	Existing Commercial	Goodmayes	536	Existing	2020	Benchmark
Existing Goodmayes retail park	Off A118 High Road, Ilford	Existing Commercial	Goodmayes	352	Existing	2020	Benchmark
Existing Retail - Halfords	Off A118 High Road, Ilford	Existing Commercial	Grove	221	Existing	2020	Benchmark
Ilford Prep School - not found on map	Off A118 High Road, Ilford	Existing Commercial	Seven Kings	0	Existing	2020	Not found
Potential Health Clinic	Off A118 High Road, Ilford	NHS	Seven Kings	0	Existing	2020	0
Potential Leisure centre with Pool	Off A118 High Road, Ilford	London Borough Redbridge	East of Ilford	163	Existing	2020	Benchmark
Ilford County Court	Ilford County Court, Buckingham Road,	London Borough Redbridge	East of Ilford	57	Existing	2020	DEC
London Fire & Emergency Planning Authority	London Fire & Emergency Planning Authority, Fire Station, 460 High Road,	London Borough Redbridge	East of Ilford	238	Existing	2020	DEC
Metropolitan Police - Grove	Metropolitan Police, 3 Area NE Operational Headquarters, 11 Grove Road,	Other Public	Grove	629	Existing	2020	DEC
Chadwell Primary School	Chadwell Primary School, High Road, Chadwell Heath	London Borough Redbridge	Grove	158	Existing	2020	DEC
CH01	Chadwell Heath Service Station 1023 High Road, Chadwell Heath	Residential customers - new	Grove	117	2012	2020	Benchmark
CW07	561A High Road, Ilford	Residential customers - new	East of Ilford	61	2012	2020	Benchmark
GM01	569 High Road, Seven Kings	Residential	East of	25	2014	2020	Benchmark

		customers - new	Ilford				
CW16	461 High Road, Ilford	Residential customers - new	East of Ilford	81	2014	2020	Benchmark
SK02	674-700 High Road, Seven Kings	Residential customers - new	Seven Kings	159	2018	2020	Benchmark
SK06	Seven Kings Car Park & Lorry Park, High Road, Seven Kings	Residential customers - new	Seven Kings	315	2015	2020	Benchmark
CCOS15	Chadwell Heath Retail Park, High Road, Chadwell Heath	Residential customers - new	Grove	235	2015	2020	Benchmark
CCOS14	Chadwell Heath Business Area (Grove Farm,)rear of 951 - 1009 High Road, Chadwell Heath	Residential customers - new	Grove	460	2012	2020	Benchmark
CCOS12	Goodmayes Retail Park, High Road, Goodmayes	Residential customers - new	Goodmayes	126	2016	2020	Benchmark
CCOS11	822 (Tesco) High Road, Goodmayes	Residential customers - new	Goodmayes	1,332	2016	2020	Benchmark
CCOS10	706 - 720 (Homebase) High Road, Seven Kings	Residential customers - new	Seven Kings	227	2018	2020	Benchmark
CCOS07	The Joker Public House, Cameron Road, Seven Kings	Residential customers - new	East of Ilford	29	2013	2020	Benchmark
CCOS09	Seven Kings Methodist Church and Hall, Balmoral Gardens, Seven Kings	Residential customers - new	Seven Kings	56	2015	2020	Benchmark
CCOS08	Seven Kings Health Centre, 1 Salisbury Road, Seven Kings	Residential customers - new	East of Ilford	48	2014	2020	Benchmark
CCOS04	514-518 High Road, Ilford	Residential customers - new	East of Ilford	15	2013	2020	Benchmark
CCOS05	530-562 High Road, Ilford	Residential customers - new	East of Ilford	83	2018	2020	Benchmark
CCOS06	573-603 High Road, Ilford	Residential customers - new	East of Ilford	138	2018	2020	Benchmark
CCOS02	531-549 High Road, Ilford	Residential customers - new	East of Ilford	307	2018	2020	Benchmark
CCOS13	Metropolitan Police, 919 - 925 High Road, Chadwell Heath	Residential customers - new	Grove	149	2015	2020	Benchmark
CCOS20	Telephone Exchange, Corner of Kingswood Road and High Road, Goodmayes	Residential customers - new	Goodmayes	63	2014	2020	Benchmark
CCOS29	36-48 Goodmayes Road, Goodmayes	Residential customers - new	Goodmayes	37	2014	2020	Benchmark

CCOS30	Ilford County Court, High Road, Ilford	Residential customers - new	East of Ilford	47	2018	2020	Benchmark
CCOS03b	Former Ilford Swimming Pool, 468 High Road, Ilford	Residential customers - new	East of Ilford	310	2014	2020	Benchmark
CANON PALMER R.C. HIGH	ALDBOROUGH ROAD SOUTH,ILFORD,ESSEX,IG3 8EU	London Borough Redbridge	East of Ilford	799	Existing	2020	NI185
THACKARY DRIVE FAMILY CENTRE	THACKARY DRIVE,CHADWELL HEATH,ROMFORD,RM6 4RE	London Borough Redbridge	Goodmaye s	144	Existing	2020	NI185
CW06		Residential customers - new	East of Ilford	233	Existing	2020	Benchmark
Goodmans Health Club	16, Goodmayes Road, Ilford	Existing Commercial	Goodmaye s	0	Existing	2020	Benchmark
Lions Den	891, High Road, Romford, Essex	Existing Commercial	Grove	0	Existing	2020	Benchmark
HIGH ROAD SWIMMING BATHS	468, 468, HIGH ROAD, ILFORD	Existing Commercial	East of Ilford	0	Existing	2020	Benchmark
WENN STAGE SCHOOL	WENN STAGE SCHOOL	London Borough Redbridge	East of Ilford	0	Existing	2020	Benchmark
MAYTIME MONTESORRI NURSERY SCHOOL	MAYTIME MONTESORRI NURSERY SCHOOL	London Borough Redbridge	Goodmaye s	0	Existing	2020	Benchmark
Eastcourt independent school	1-5 Eastwood Road, Ilford, Essex	London Borough Redbridge	Goodmaye s	86	Existing	2020	Benchmark
Total				**8,545**			

Table 9: Summary of Connected Buildings - Crossrail Corridor Project

The diversified peak heat demand growth profile for the fully built out project opportunity is shown in Figure 14 below. This indicates the peak demand seen by the proposed network opportunity as a function of customer type and year of operation of the network[39]. The dotted blue line shows the undiversified peak demand for all of the customer types. This has been calculated by summing the non-diversified demands for each customer type. The shaded, coloured areas of the graph show the contributions towards the cumulative diversified peak demand seen by the network due to each of the customer types. The figure identifies a project start date of 2019, the first year at which a network development could conceivably come forward, based on the growth projections for the Crossrail Corridor project.

The associated annual consumption as a function of customer type at full build out is shown in Table 10 below[40]. Refer to Appendix 3 for more information on customer types.

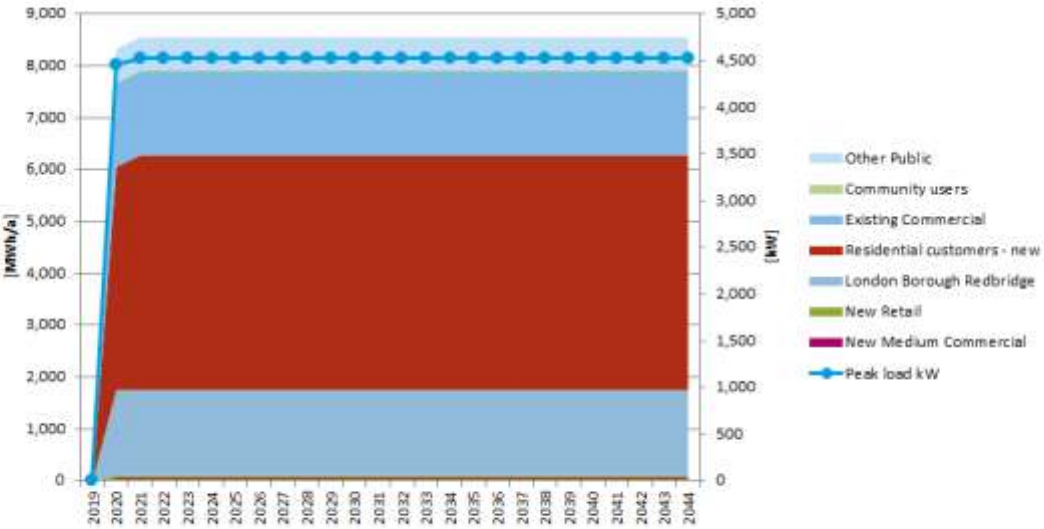


Figure 14: Diversified Peak Heat Demand Profile – Crossrail Corridor – Fully Built Out Project

Heat sold per customer type	[MWh/a]
New Medium Commercial	47
New Retail	58
London Borough Redbridge	1,645
Residential customers - new	4,521
Existing Commercial	1,619
Community users	28
Other Public	629
Total	**8,547**

Table 10: Heat Demand by Customer Type– Crossrail Corridor – Fully Built Out Project

All developments south of the Crossrail Corridor to the east of Seven Kings have been excluded from the potential project on the basis that the cost of crossing the Crossrail Corridor outweighs the value to the project in income from heat sales.

[39] The graph shows the date at which the buildings would connect to the network rather than the date at which the buildings are constructed.

[40] In this table, large and medium commercial are split according to predicted gas consumption, with the threshold gas consumption between the two being as defined in [14],[15]. This is done for the purpose of identifying the alternative cost of heat for these customers. The figure shows the 'connected loads' in each year as opposed to the demands associated with all identified buildings within the opportunity area.

All developments in Chadwell Heath have been excluded from the potential project on the basis that these are located too far away from the main heat demands in Grove and Goodmayes and that the cost of connection outweighs the value to the project in income from heat sales.

3.3 Energy Supply Opportunity

3.3.1 Proposed Fuel Source and Heat Production Mix

As for the Ilford Town Centre Project, gas fired CHP in conjunction with gas boilers has been identified as the preferred heat production equipment for the project opportunity.

A summary of other fuel supply options considered for the project is presented in Section 9.

3.3.2 Energy Centre Capacity

Based on a technical only evaluation, the project would support gas fired CHP engine with a capacity of 1.165 MW_e. (Appendix 6 has further information on the likely contribution of CHP and gas boilers at different points during the year)

3.3.3 Energy Centre Location

Based on discussions with London Borough of Redbridge site SK06 has been identified as the preferred location for the energy centre under this project. This land is owned by London Borough of Redbridge and is earmarked for development as a mix of retail and community / leisure / education uses on the ground and first floors with residential development above [13].

The BT Exchange site was considered initially as a possible site in an effort to reduce CAPEX investment and therefore improve IRR for the project. However, based on discussions with BT the available space appears to be too small and the opportunity has therefore been discarded[41]. No other existing sites have been identified at this stage.

Other future development opportunities generally present little scope for locating an energy centre on the basis that land ownership is mostly private and the heat demand associated with the majority of these developments would be unlikely to warrant a site based CHP projects in the absence of a district heat network.

The new development at SK02 appears to offer the best opportunity, due to its location and scale and since the land is currently owned by London Borough of Redbridge. A requirement could potentially be placed on the developer of this site (as a condition of its sale) to install a communal heating project with associated energy centre and to provide space for expansion to accommodate any future heat network opportunity.

The only other realistic opportunity appears to be the site of the existing TESCO superstore, (CCOS 11) where up to 522 residential units are being planned. However, even this would only be likely to support a CHP plant in the range 300 to 500 kW_e and it may therefore prove difficult to require a developer to allow for a significantly larger energy centre installation to support a heat network.

The recreation ground opposite CCOS11 which is owned by London Borough of Redbridge is assumed not to be a viable for location of an energy centre, given its recreational value and its

[41] BT are known to be interested in opportunities for housing CHP energy centres in disused spaces within exchange sites in order to align with their carbon saving opportunities. Whilst there are understood to be no immediate plans for downsizing or relocating this particular BT exchange, it is understood that the main block is full of equipment which would be too expensive to move whilst the annexe block contains rooms on the 1st floor that are vacant and measure only 14m x 5m.

current site designation. The land adjacent to site CCOS18, also owned by London Borough of Redbridge, could conceivably locate an energy centre, although this site currently appears to contain existing housing and is not particularly well placed due to railway crossing.

3.4 Phasing Strategy and Implementation Plan

Refer to Section 4.4.

3.5 Economic Appraisal

Economic modelling has been carried out for the fully built out project. The key economic indicators for the project are presented in Table 11 below based an Electricity Licence Lite arrangement and assuming a project term of 25 years[42].

		Fully built out Project Over 25 Years
Total Investment CAPEX	[£ K]	9,854
Energy Centre CAPEX	[£ K]	3,815
Length of Heat Network	[m]	4,888
Cost of Heat Network	[£ K]	3,792
Connection CAPEX	[£ K]	1,114
Project Development Costs	[£ K]	1,134
Annual Operating Costs	[£ K]	938
Annual Revenues from Heat Sales	[£ K]	717
Annual Revenues from Electricity Sales	[£ K]	940
Annual Saving per year to LBR due to CRC savings	[£ K]	0.52
Weighted Average Electricity Sales Value from Project	[£ /MWh]	87 in 2020 and 121.2 in 2044
Annual Operating Margin at full build out	[£ K]	760
Annual Revenues from Electricity Sales, LEC and CRC values	[£ K]	981
IRR % over 25 years	[%]	4.1%
NPV at 6% discount factor	[£ K]	-1,665

Table 11: Key Economic Indicators – Crossrail Corridor Project

The required capital investment for the project would be around £9.9M.

The IRR for the fully built out project based on an Electricity Supply Licence Lite selling arrangement would be around 4.1% over 25 years. The corresponding NPV would be £-1,7M at a 6% discount factor.

[42] IRR's based on an Electricity Sell and Buy Back arrangement have been calculated but are not presented here, since they indicate an even lower IRR.

Under a Sell and Buy Back arrangement this would reduce to around 1.1% over 25 years. Considered over 40 years, the equivalent IRR's would be 6.1% and 3.8% respectively.

The electricity selling price required to deliver a 10% IRR for the fully built out project over 25 years[43] would be 13.77 p/kWh.

The annual saving to London Borough of Redbridge associated with reduction in CRC payments under the project would £0.5K under the fully built out project[44].

Fuel savings would remain unchanged under the current modelling assumptions. This assumes that the project would charge London Borough of Redbridge its current heat price, which has been calculated to be 4.12 p/kWh excluding annualised reinvestment costs and 4.27 p/kWh including annualised reinvestment costs. The cost of electricity to London Borough of Redbridge is assumed to be reduced by 10% of its current value under any proposed Licence Lite arrangement.

A discounted cashflow forecast for the fully built out project is presented under the Electricity Licence Lite arrangement in Figure 15.

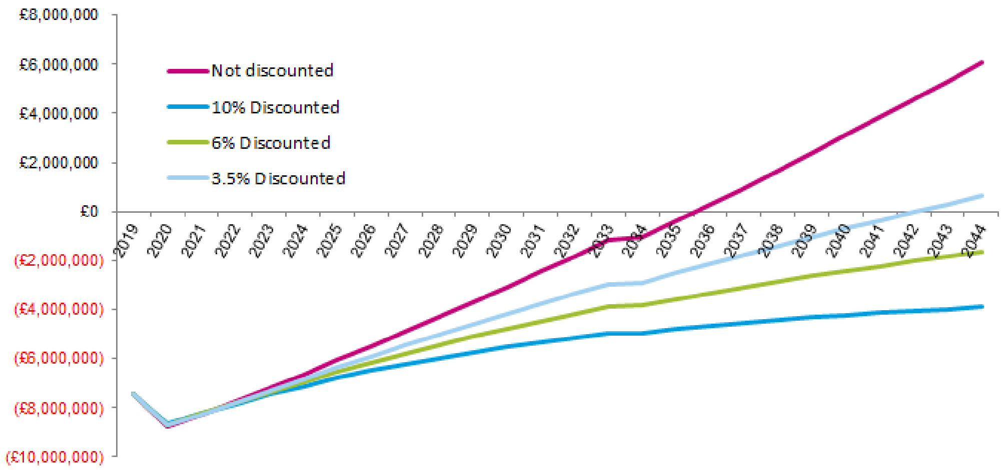


Figure 15: Cumulative Discounted Cashflow Forecast - Crossrail Corridor - Fully Built Out Project – Electricity Licence Lite

3.6 Sensitivity Analysis

A sensitivity analysis has been carried out around the key variables that influence the IRR for the project. The results presented in Figure 16 below for the fully built out project under the Electricity Licence Lite scenario. Refer to Section 2.5 and Appendix 3 for interpretation of this figure.

The key conclusions drawn from the analysis are:-

1. Electricity selling price, gas purchase price, project capital cost, and heat selling price are the major drivers in uncertainty around IRR.
2. A favourable variation of 10% in any of the indicated variables will still only deliver and IRR of under 5.5%, which is still considered to be unattractive to London Borough of Redbridge.
3. An unfavourable variation of 10% in any of the indicated variables will reduce the IRR to around 3.0%

[43] assuming all other variables remaining constant

[44] The CRC benefit shown in the table reflects the benefit seen by the connected buildings rather than the benefit taken by the project. Refer to Appendix 3 for details of the assumed benefit sharing arrangement.

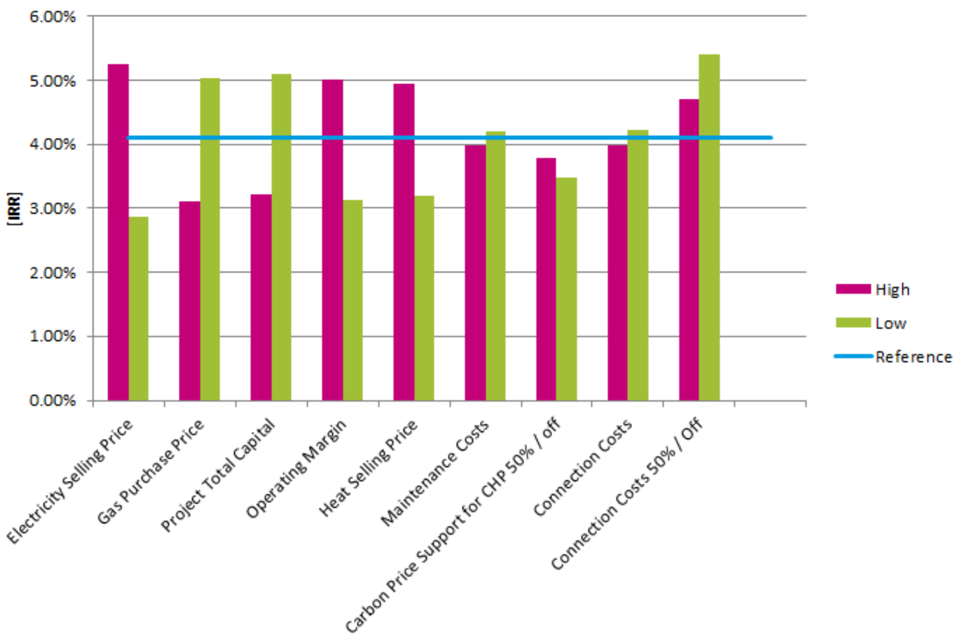


Figure 16: Economic Sensitivity Analysis – Crossrail Corridor – Fully Built Out Project - Electricity Licence Lite

3.7 Implication for Project Procurement

There are no anchor heat loads of any scale to support an initial cluster heat network along the Crossrail Corridor.

The calculated IRRs for the fully built out project suggest that the Crossrail Corridor project are not considered to be economically viable. The project would be of no interest to a private sector ESCo and equally would offer only a barely acceptable return to London Borough of Redbridge over 40 years, assuming an Electricity Licence Lite could be set up.

The recommendation is therefore for this opportunity not to be taken up as a stand-alone project in isolation of other heat network opportunities.

An opportunity involving the interconnection of the Crossrail Corridor project with the Ilford Town Centre Project is presented in Section 4 of this report.

3.8 Heat Supply Contribution

The theoretical heat supply contributions from each heat production asset for the project opportunity are shown in Appendix 6. These are shown as load duration curves, monthly supply profiles at full build out and cumulative supply contributions from each heat production asset.

3.9 Carbon Appraisal

Projected carbon savings for the fully built out project over 25 years are presented in Table 12. Reference to the calculation methodology is provided in Appendix 3. Calculated carbon trajectories over the project lifecycle are presented in Appendix 5.

		DECC Grid Carbon Factor Unchanged	DECC Grid Decarbonisation Trajectory
Business as Usual CO_2 over 25 years	[TCO_2]	57,957	44,974
CO_2 Savings over 25 years – Fully built Out Project	[TCO_2]	16,711	-27,099
% reduction in CO_2 Savings over 25 years – Fully built Out Project	[%]	28.8%	-60.3%

Table 12: Carbon Emission Projections – Crossrail Corridor

The table identifies a positive saving in CO_2 over the life of the project based on projections using current grid emission factors but a negative saving if the DECC decarbonisation trajectory is assumed, highlighting the limited role that gas CHP will be able to play in carbon reduction in the future if DECC's grid decarbonisation trajectory is realized in practice. If so, the annual CO_2 savings are positive until 2027. See Appendix 5.

3.10 Route Identification and Risk Appraisal

The network route proposal is shown in
Figure 13 and Appendix 2. A risk appraisal of the route is presented in Section 4 of this report.

3.11 Summary

A summary of the key project parameters is shown in the table below.

		Fully built out 25 years	Cluster project over 25 years
Total Investment CAPEX	[£ K]	9,854	n/a
IRR % over 25 years based on Electricity Licence Lite	[%]	4.1%	n/a
NPV at 6% discount factor based on Electricity Licence Lite	[£ K]	-1,665	n/a
CO_2 Savings over 25 years life of project relative to Business As Usual – Grid Factor unchanged	[TCO_2]	16,711	n/a
CO_2 Savings over 25 years life of project relative to Business As Usual – Grid Factor unchanged	[%]	28.8%	n/a
Energy Centre footprint	[m^2]	500	n/a
Energy Centre CHP Capacity	[MW_e]	1.2	n/a
Length of Heat Network	[m]	4,888	n/a

Overall recommendation

There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Crossrail Corridor.

The calculated economic indicators for the Crossrail Corridor project would be of no interest to a private sector ESCo and equally would offer only a barely acceptable return to London Borough of Redbridge over 40 years, assuming an Electricity Licence Lite could be set up.
The recommendation is therefore for this opportunity not to be taken forward as a stand-alone project in isolation of other heat network opportunities.

The opportunity to develop Crossrail Corridor should be considered in conjunction with a project opportunity at Ilford Town Centre. Under this scenario, acceptable project returns can be made by avoiding the need to invest in an energy centre for the Crossrail Corridor project.

Table 13: Key Project Parameters – Crossrail Corridor Project

4. ILFORD TOWN CENTRE AND CROSSRAIL CORRIDOR OPPORTUNITY

4.1 Summary of Opportunity

Refer to section 2.1 (Ilford Town Centre) and 3.1 (Crossrail Corridor).

4.2 Identified Network Opportunity

The opportunity to interconnect the identified opportunities at Crossrail Corridor and Ilford Town Centre projects has been investigated.

A network schematic showing the proposed interconnection under the fully built out project is shown in Figure 17 below. This composite project would comprise the heat demands identified in Section 2 for Ilford Town Centre, the heat demands identified in Section 3 for Crossrail Corridor and the additional buildings within East of Ilford, along the route section shown in dark green in Figure 17.

As for the Ilford Town Centre project, an initial cluster project has been identified. This would be identical to the cluster project identified for Ilford Town Centre in Section 2 of this report.

The connected buildings for this project at full build out are identified in Table 14.

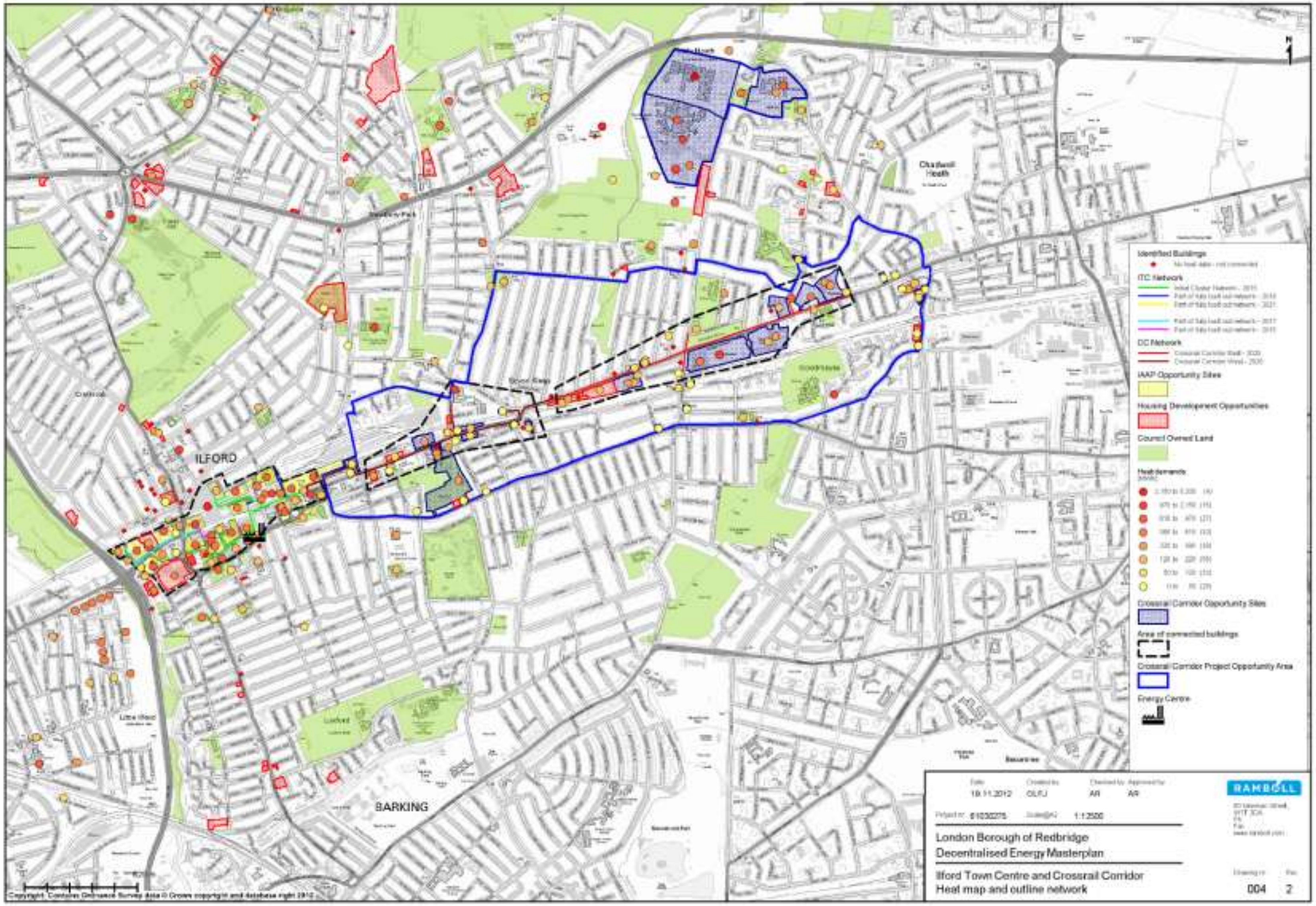


Figure 17: Heat map and Network Outline - Ilford Town Centre and Crossrail Corridor Project

Load name	Address	Customer Type	Area	Heat	Construction	Connection	Demand based on
				[MWh/a]	Year	Year	
Primary Care Trust	Ilford Hill, Ilford	NHS	ITC	82	Existing	2017	Benchmark
The Mall	Off A118 High Road, Ilford	Existing Commercial	ITC	1,095	Existing	2015	Benchmark
TravelLodge	Clements Rd	Existing Commercial	ITC	870	Existing	2015	Benchmark
BT Exchange	Off A118 High Road, Ilford	Existing Commercial	Goodmayes	98	Existing	2020	Benchmark
Ilford Grammar School	Off A118 High Road, Ilford	Existing Commercial	Seven Kings	66	Existing	2020	Benchmark
Gurdwara	Off A118 High Road, Ilford	Existing Commercial	Seven Kings	175	Existing	2020	Benchmark
Homebase	Off A118 High Road, Ilford	Existing Commercial	Seven Kings	170	Existing	2020	Benchmark
Tesco	Off A118 High Road, Ilford	Existing Commercial	Goodmayes	536	Existing	2020	Benchmark
Existing Goodmayes retail park	Off A118 High Road, Ilford	Existing Commercial	Goodmayes	352	Existing	2020	Benchmark
Existing Retail - Halfords	Off A118 High Road, Ilford	Existing Commercial	Grove	221	Existing	2020	Benchmark
Potential Leisure centre with Pool	Off A118 High Road, Ilford	London Borough Redbridge	East of Ilford	163	Existing	2020	Benchmark
Peachy House	39 Ilford Hill, Ilford	Existing Commercial	ITC	644	Existing	2017	Benchmark
London Borough of Redbridge, 17-23 Clements Road	London Borough of Redbridge, 17-23 Clements Road,	London Borough Redbridge	ITC	156	Existing	2015	DEC
London Borough of Redbridge, 22-26 Clements Road,	London Borough of Redbridge, 22-26 Clements Road,	London Borough Redbridge	ITC	79	Existing	2015	DEC
Kenneth More Theatre	Kenneth More Theatre, Oakfield Road,	London Borough Redbridge	ITC	202	Existing	2015	DEC
Royal Mail	Royal Mail, Ilford Delivery Office, 4-24 Chadwick Road,	London Borough Redbridge	ITC	712	Existing	2015	DEC

London Borough of Redbridge, ,	Town Hall	London Borough Redbridge	ITC	576	Existing	2015	DEC
London Borough of Redbridge, Central Library, Clements Road,	London Borough of Redbridge, Central Library, Clements Road,	London Borough Redbridge	ITC	378	Existing	2015	DEC
Metropolitan Police	Metropolitan Police, 270-294 High Road,	London Borough Redbridge	ITC	852	Existing	2015	DEC
London Borough of Redbridge, Lynton House, 255-259 High Road,	London Borough of Redbridge, Lynton House, 255-259 High Road,	London Borough Redbridge	ITC	487	Existing	2015	DEC
Nelps Probation Service	Nelps Probation Service, Nelps Probation Centre 277-289, High Road,	London Borough Redbridge	ITC	110	Existing	2015	DEC
Ilford County Court	Ilford County Court, Buckingham Road,	London Borough Redbridge	East of Ilford	57	Existing	2020	DEC
London Fire & Emergency Planning Authority	London Fire & Emergency Planning Authority, Fire Station, 460 High Road,	London Borough Redbridge	East of Ilford	238	Existing	2020	DEC
Redbridge Refugee Forum	Redbridge Refugee Forum, Broadway Chambers, 1 Cranbrook Road,	London Borough Redbridge	ITC	203	Existing	2017	DEC
Metropolitan Police - Grove	Metropolitan Police, 3 Area NE Operational Headquarters, 11 Grove Road,	Other Public	Grove	629	Existing	2020	DEC
Chadwell Primary School	Chadwell Primary School, High Road, Chadwell Heath	London Borough Redbridge	Grove	158	Existing	2020	DEC
CH01	Chadwell Heath Service Station 1023 High Road, Chadwell Heath	Residential customers - new	Grove	117	2012	2020	Benchmark
CW07	561A High Road, Ilford	Residential customers - new	East of Ilford	61	2012	2020	Benchmark
GM01	569 High Road, Seven Kings	Residential customers - new	East of Ilford	25	2014	2020	Benchmark
CW11	226-244 High Road, Ilford	Residential customers - new	ITC	625	2013	2015	Benchmark

CW09	Pioneer Point, Winston Way, Ilford	Residential customers - new	ITC	1,492	Existing	2015	Benchmark
LO09	73-77 Ilford Hill, Ilford	Residential customers - new	ITC	40	2017	2017	Benchmark
LO06	Sainsbury's, Roden Street, Ilford	Residential customers - new	ITC	587	2021	2021	Benchmark
CW16	461 High Road, Ilford	Residential customers - new	East of Ilford	81	2014	2020	Benchmark
SK02	674-700 High Road, Seven Kings	Residential customers - new	Seven Kings	159	2018	2020	Benchmark
SK06	Seven Kings Car Park & Lorry Park, High Road, Seven Kings	Residential customers - new	Seven Kings	315	2015	2020	Benchmark
LO05	Peachy House, 39 Ilford Hill, Ilford	Residential customers - new	ITC	319	2013	2017	Benchmark
ITCOS01	Land between Mill Road & the Railway Line, Ilford	Residential customers - new	ITC	274	2015	2017	Benchmark
ITCOS2	Mill House, Ilford Hill	Residential customers - new	ITC	617	2018	2018	Benchmark
ITCOS4	60-70 Roden Street and land between Chapel Road and Roden Street, Ilford	Residential customers - new	ITC	915	2015	2017	Benchmark
ITCOS5	40 Ilford Hill, Ilford	Residential customers - new	ITC	259	2015	2017	Benchmark
ITCOS6	22-32 Chapel Road, Ilford	Residential customers - new	ITC	49	2017	2017	Benchmark
ITCOS8	Site bounded by Chapel Road, High Road and Clements Lane	Residential customers - new	ITC	702	2017	2017	Benchmark
ITCOS9	Land adjacent to Clements Lane and Clements Road	Residential customers - new	ITC	248	2019	2019	Benchmark
ITCOS10	Britannia Car Park, Clements Road	Residential customers - new	ITC	123	2016	2016	Benchmark
ITCOS13	Town Hall Car Park	Residential customers - new	ITC	668	2014	2015	Benchmark
ITCOS12	112-114 High Road, Ilford	Residential customers - new	ITC	109	2013	2015	Benchmark
ITCOS14	Central Library Service Yard	Residential	ITC	91	2014	2015	Benchmark

		customers - new					
ITCOS18	69-126 Ley Street and Opal Mews, Ilford	Residential customers - new	ITC	643	2019	2019	Benchmark
ITCOS24	300 – 318 High Road, Ilford	Residential customers - new	ITC	165	2017	2020	Benchmark
ITCOS11	Land bounded by Clements Road, Chadwick Road and Postway Mews	Residential customers - new	ITC	432	2020	2020	Benchmark
ITCOS15	Kenneth More Theatre	Residential customers - new	ITC	607	2016	2016	Benchmark
ITCOS19	Ley Street car park and bus depot, Ilford	Residential customers - new	ITC	669	2018	2018	Benchmark
ITCOS7	Land adjacent to Cranbrook Road, High Road and the railway, incorporating Station Road	Residential customers - new	ITC	1,260	2015	2015	Benchmark
ITCOS16	187-207 High Road, Ilford	Residential customers - new	ITC	472	2018	2018	Benchmark
ITCOS22	262 – 268 High Road, Ilford	Residential customers - new	ITC	214	2019	2019	Benchmark
ITCOS3	51-85 Ilford Hill and 1-27 Cranbrook Road	Residential customers - new	ITC	722	2017	2017	Benchmark
CCOS15	Chadwell Heath Retail Park, High Road, Chadwell Heath	Residential customers - new	Grove	235	2015	2020	Benchmark
CCOS14	Chadwell Heath Business Area (Grove Farm,)rear of 951 - 1009 High Road, Chadwell Heath	Residential customers - new	Grove	460	2012	2020	Benchmark
CCOS12	Goodmayes Retail Park, High Road, Goodmayes	Residential customers - new	Goodmaye s	126	2016	2020	Benchmark
CCOS11	822 (Tesco) High Road, Goodmayes	Residential customers - new	Goodmaye s	1,332	2016	2020	Benchmark
CCOS10	706 - 720 (Homebase) High Road, Seven Kings	Residential customers - new	Seven Kings	227	2018	2020	Benchmark
CCOS07	The Joker Public House, Cameron Road, Seven Kings	Residential customers - new	East of Ilford	29	2013	2020	Benchmark

CCOS09	Seven Kings Methodist Church and Hall, Balmoral Gardens, Seven Kings	Residential customers - new	Seven Kings	56	2015	2020	Benchmark
CCOS08	Seven Kings Health Centre, 1 Salisbury Road, Seven Kings	Residential customers - new	East of Ilford	48	2014	2020	Benchmark
CCOS04	514-518 High Road, Ilford	Residential customers - new	East of Ilford	15	2013	2020	Benchmark
CCOS05	530-562 High Road, Ilford	Residential customers - new	East of Ilford	83	2018	2020	Benchmark
CCOS06	573-603 High Road, Ilford	Residential customers - new	East of Ilford	138	2018	2020	Benchmark
CCOS02	531-549 High Road, Ilford	Residential customers - new	East of Ilford	307	2018	2020	Benchmark
CCOS13	Metropolitan Police, 919 - 925 High Road, Chadwell Heath	Residential customers - new	Grove	149	2015	2020	Benchmark
CCOS20	Telephone Exchange, Corner of Kingswood Road and High Road, Goodmayes	Residential customers - new	Goodmaye s	63	2014	2020	Benchmark
CCOS29	36-48 Goodmayes Road, Goodmayes	Residential customers - new	Goodmaye s	37	2014	2020	Benchmark
CCOS30	Ilford County Court, High Road, Ilford	Residential customers - new	East of Ilford	47	2018	2020	Benchmark
CCOS03b	Former Ilford Swimming Pool, 468 High Road, Ilford	Residential customers - new	East of Ilford	310	2014	2020	Benchmark
CANON PALMER R.C. HIGH	ALDBOROUGH ROAD SOUTH,ILFORD,ESSEX,IG3 8EU	London Borough Redbridge	East of Ilford	799	Existing	2020	NI185
THACKARY DRIVE FAMILY CENTRE	THACKARY DRIVE,CHADWELL HEATH,ROMFORD,RM6 4RE	London Borough Redbridge	Goodmaye s	144	Existing	2020	NI185
CW06	At crossing of High Road and Connaught Road	Residential customers - new	East of Ilford	233	Existing	2020	Benchmark
ITCOS21	246-250 High road, Ilford	Residential customers - new	ITC	668	2012	2015	Planning Application
ITCOS17	Myrtle Rd	Residential customers - new	ITC	191	2025	2025	Benchmark
ITCOS25	Oakland Park Ave	Residential	ITC	862	2025	2025	Benchmark

		customers - new					
Goodmans Health Club	16, Goodmayes Road, Ilford	Existing Commercial	Goodmaye s	0	Existing	2020	Benchmark
Lions Den	891, High Road, Romford, Essex	Existing Commercial	Grove	0	Existing	2020	Benchmark
HIGH ROAD SWIMMING BATHS	468, 468, HIGH ROAD, ILFORD	Existing Commercial	East of Ilford	0	Existing	2020	Benchmark
WENN STAGE SCHOOL	WENN STAGE SCHOOL	London Borough Redbridge	East of Ilford	0	Existing	2020	Benchmark
MAYTIME MONTESORRI NURSERY SCHOOL	MAYTIME MONTESORRI NURSERY SCHOOL	London Borough Redbridge	Goodmaye s	0	Existing	2020	Benchmark
Eastcourt independent school	1-5 Eastwood Road, Ilford, Essex	London Borough Redbridge	Goodmaye s	86	Existing	2020	Benchmark
Fitness First	261-275, High road, Ilford,	Existing Commercial	ITC	538	Existing	2015	Benchmark
Total				**29,552**			

Table 14: Summary of Connected Buildings – Ilford Town Centre and Crossrail Corridor Project

The diversified peak heat demand growth profile and annual consumption for the fully built out project are shown in Figure 18 below. The associated annual consumption as a function of customer type at full build out is shown in Table 15 below[45]. Refer to Appendix 3 for more information on customer types.

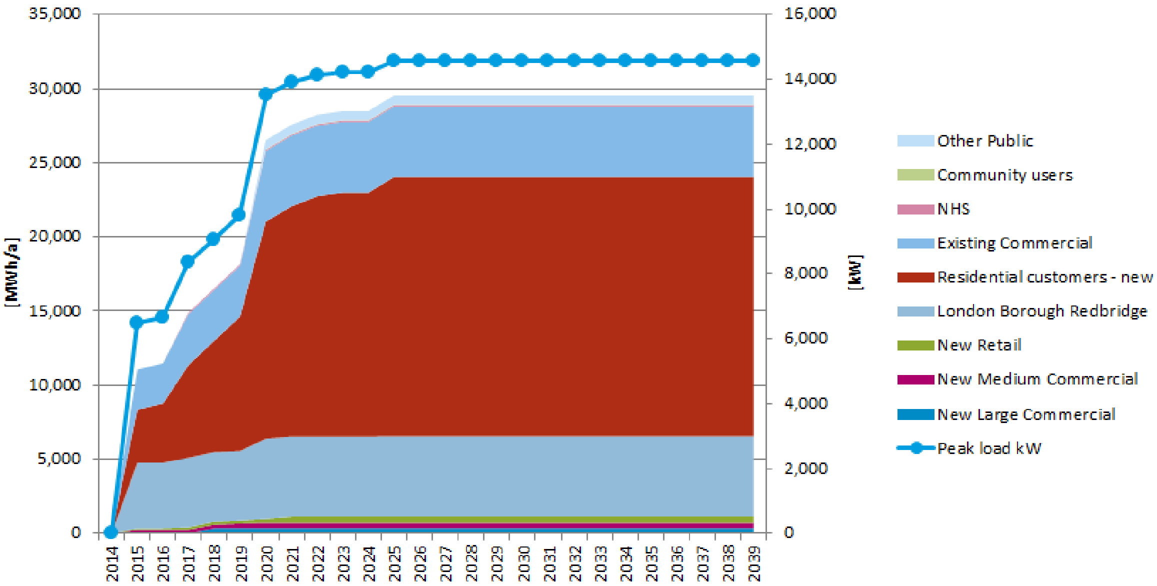


Figure 18: Diversified Peak and Heat Demand Profile – Ilford Town Centre and Crossrail Corridor – Fully Built Out Project

Customer Type	Heat [MWh]
New Large Commercial	346
New Medium Commercial	373
New Retail	429
London Borough Redbridge	5,400
Residential customers - existing	0
Residential customers - new	17,500
Existing Commercial	4,766
NHS	82
Community users	28
Other Public	629
Total	**29,552**

Table 15: Summary of Connected Buildings – Ilford Town Centre and Crossrail Corridor – Fully Built Out Project

[45] In this table, large and medium commercial are split according to predicted gas consumption, with the threshold gas consumption between the two being as defined in [14],[15]. This is done for the purpose of identifying the alternative cost of heat for these customers.

4.3 Energy Supply Opportunity

4.3.1 Proposed Fuel Source and Heat Production Mix

The preferred heat production equipment for the project opportunity would be as per the Ilford Town Centre project opportunity.

4.3.2 Energy Centre Capacity

The impact of interconnecting the Crossrail Corridor opportunity to the Ilford Town Centre Opportunity has been identified. This would require an increase in the net area requirement for the energy centre from circa 500 m^2 to circa 650 m^2 and to increase the ultimate CHP capacity required at full build out from 1.2 MW_e (under the Ilford Town Centre project) to 2.3 MW_e. This would be carried out by installing two identical engines over a phased build out as described below.

The additional capacity requirement comprises the heat demands identified in Section 3 for Crossrail Corridor and the additional buildings within East of Ilford, along the route .

4.3.3 Energy Centre Location

The proposed location of the energy centre would be as per the Ilford Town Centre project opportunity.

4.4 Phasing Strategy and Implementation Plan

The proposed phasing strategy for the heat network is shown in Figure 17. The initial cluster project is shown in light green, with subsequent construction phases in Ilford Town centre taking place in 2017, 2018 and 2021 (as shown in light blue, dark blue and yellow respectively).

Construction of Crossrail Corridor West (shown in maroon) and Crossrail Corridor East (shown in red) would take place from 2019 with heat on in 2020. An additional 4.5 km of pipework would be associated with the project extension to connect all indicated buildings East of Ilford and within the Crossrail Corridor. The project would make use of the energy centre proposed for the Ilford Town Centre project. The additional gas CHP engine also would be installed in 2019.

The proposed timescales for construction are identified in Appendix 5.

4.5 Economic Appraisal

Economic modelling has been carried out for the initial cluster project and the fully built out project. The key economic indicators for the project are presented in Table 16 below as a function of electricity selling arrangements and assuming a project term of 25 years. Refer to Appendix 3 for descriptions of electricity selling arrangement opportunities.

The required capital investment for the initial cluster and fully built out projects would be around £6.5M and £17.4M respectively[46].

The calculated IRRs for the cluster and fully built out project would be around 6.3 % and 10.1% over 25 years, based on an Electricity Licence Lite arrangement. The corresponding NPVs would be £0.17M and £5.9M at a 6% discount factor.

---

[46] The investment CAPEX for the initial cluster project is similar that for the Ilford Town Centre project, with the exception that the building envelope for the energy centre and the diameters of the sections of network to the east of the scheme (ie feeding East of Ilford in the future) are increased under the combined scheme.

Under a sell and buy back arrangement, the calculated IRRs for the cluster and fully built out project would be around 2.7% and 7.1% over 25 years. The corresponding NPV would be -£1.8M and £1.5M at a 6% discount factor.

The electricity selling price required to deliver a 10% IRR for the fully built out project over 25 years[47] would be 8.8 p/kWh.

		Fully built out 25 years	Cluster project over 25 years
Total Investment CAPEX	[£ K]	17,373	6,532
Energy Centre CAPEX	[£ K]	5,167	3,815
Length of Heat Network	[m]	9,320	1,763
Cost of Heat Network	[£ K]	7,284	1,580
Connection CAPEX	[£ K]	2,924	386
Project Development Costs	[£ K]	1,999	752
Annual Operating Costs	[£ K]	2,494	828
Annual Revenues from Heat Sales	[£ K]	2,589	584
Annual Saving per year to LBR due to CRC savings	[£ K]	1.4	1.3
Licence Lite			
Weighted Average Electricity Sales Value from Project	[£ /MWh]	87 in 2015 and 120.9 in 2039	87 in 2015 and 121.4 in 2039
Annual Operating Margin at full build out	[£ K]	2,399	428
Annual Revenues from Electricity Sales, LEC and CRC values	[£ K]	2,304	671
IRR % over 25 years	[%]	10.1%	6.3%
NPV at 6% discount factor	[£ K]	5,915	168
Sell and Buy Back			
Weighted Average Electricity Sales Value from Project	[£ /MWh]	67.4 in 2015 and 93.6 in 2039	67.3 in 2015 and 93.9 in 2039
Annual Operating Margin at full build out	[£ K]	1,901	428
Annual Revenues from Electricity Sales, LEC and CRC values	[£ K]	1,806	672
IRR % over 25 years	[%]	7.1%	2.7%
NPV at 6% discount factor	[£ K]	1,521	-1,800

Table 16: Key Economic Indicators - Ilford Town Centre and Crossrail Corridor Project

The annual saving to London Borough of Redbridge associated with reduction in CRC payments under the project would be £1.3K and £1.4K under the initial cluster and fully built out projects[48].

Fuel savings would remain unchanged under the current modelling assumptions. This assumes that the project would charge London Borough of Redbridge its current heat price, which has been calculated to be 4.12 p/kWh excluding annualised reinvestment costs and 4.27 p/kWh including annualised reinvestment costs. The cost of electricity to London Borough of Redbridge

[47] assuming all other variables remaining constant

[48] The CRC benefit shown in the table reflects the benefit seen by the connected buildings rather than the benefit taken by the project. Refer to Appendix 3 for details of the assumed benefit sharing arrangement.

is assumed to be reduced by 10% of its current value under any proposed Licence Lite arrangement.

The discounted cashflow forecast for the initial cluster project is similar to the Ilford Town Centre project shown in Figure 6 and not repeated here. The discounted cashflow forecast for the fully built out project are presented in Figure 19 under the Electricity Licence Lite arrangement.

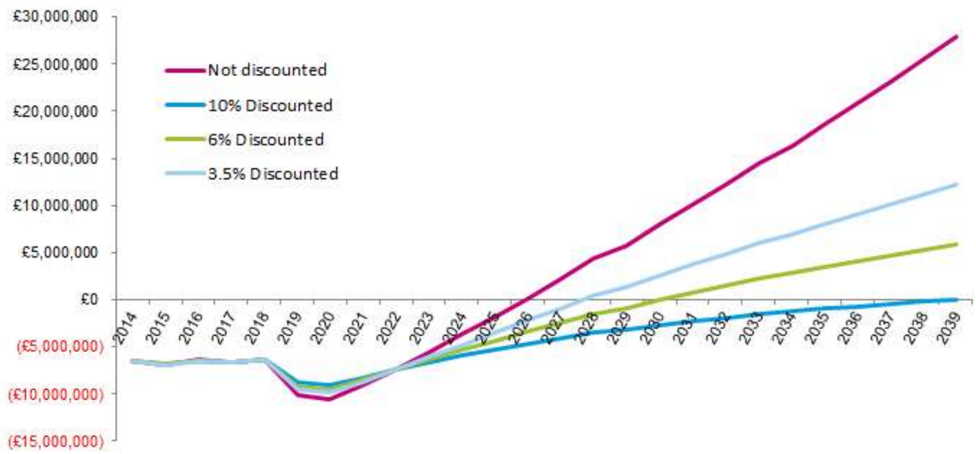


Figure 19: Cumulative Discounted Cashflow Forecast – Ilford Town Centre and Crossrail Corridor - Fully Built Out Project – Electricity Licence Lite

4.6 Sensitivity Analysis

A sensitivity analysis has been carried out around the key variables that influence the IRR for the project. The results of the sensitivity analysis are presented in Figure 20 below[49] for the fully built out project under the Electricity Licence Lite scenario. Please refer to Section 2.5 and Appendix 3 for interpretation of this figure.

The key conclusions drawn from the analysis are:-

1. Electricity selling price, gas purchase price, project capital cost, and heat selling price are the major drivers in uncertainty around IRR.
2. A favourable variation of 10% in any of the indicated variables will increase the IRR to over 11%.
3. An unfavourable variation of 10% in any of the indicated variables will still maintain an IRR of over 8.0%, which is still considered to be attractive to London Borough of Redbridge.

[49] Further information on the interpretation of the graphs and the values attributed to each variable is presented in Appendix 3.

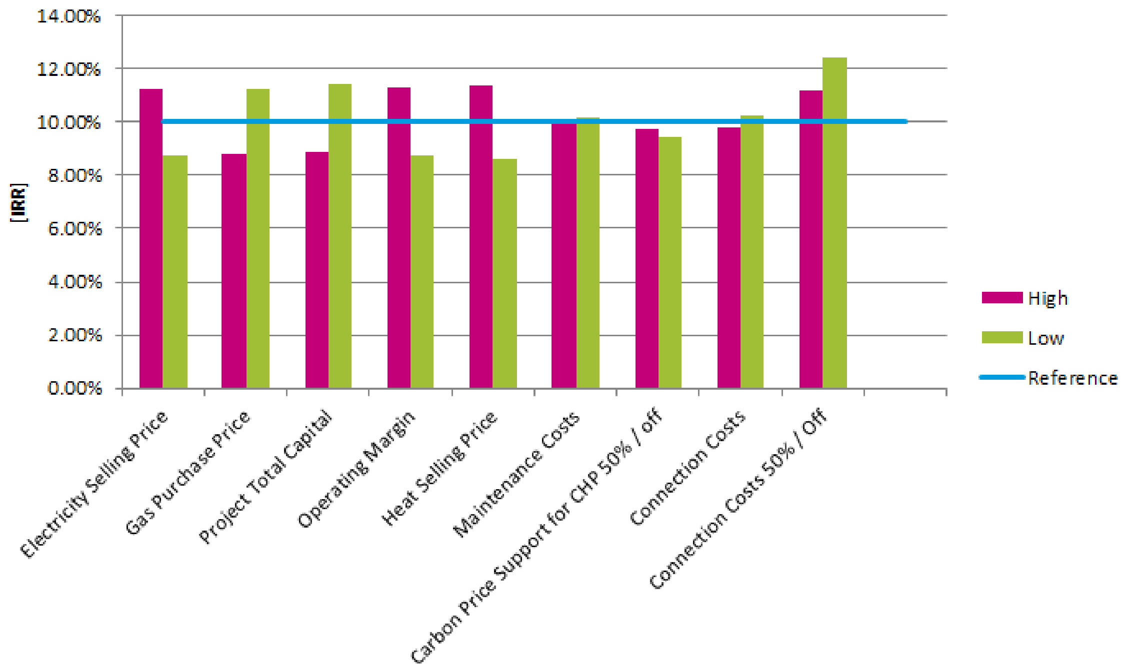


Figure 20: Economic Sensitivity Analysis – Ilford Town Centre and Crossrail Corridor – Fully Built Out Project - Electricity Licence Lite

4.7 Implication for Project Procurement

In the event that the Ilford Town Centre heat network is taken forward, the case for interconnecting developments within the Crossrail Corridor to the Ilford Town Centre heat network at a future time appears to be reasonably strong, returning an IRR of 10.1% over 25 years.

However, it should be recognised that this is marginally lower than for the Ilford Town Centre only project and therefore is likely to require direct involvement from London Borough of Redbridge to bring about expansion into the Crossrail Corridor, since a commitment to do so from the private sector cannot be assumed. London Borough of Redbridge's interest in doing so would need to be predicated on the additional carbon reductions associated with the wider project opportunity.

In order to safeguard for future expansion into the Crossrail Corridor, the initial Cluster project in Ilford Town Centre would need to include additional investment in large diameter pipework and additional space within the energy centre. This will reduce the calculated IRR from 7.1% to 6.3% over 25 year, based on a Licence Lite arrangement. Again, London Borough of Redbridge will need to take a view on the acceptability of this safeguarding position in economic terms.

The impact of project term on IRR is shown in Figure 21. This presents the various modeling cases described in Appendix 3 based on an Electricity Licence Lite arrangement, which is considered to be the most economically favorable option for the project.

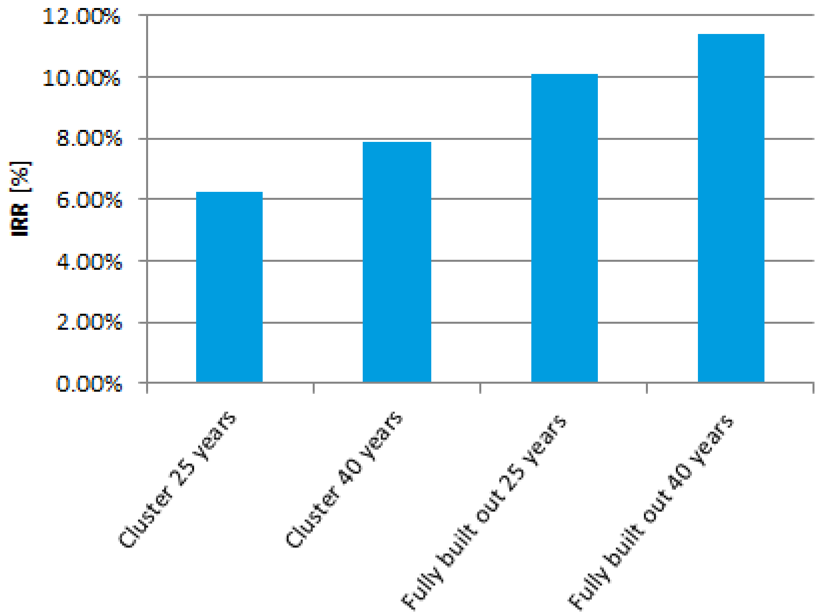


Figure 21: Modelling outcomes as a function of Project Term and Project Scale – Ilford Town Centre and Cross Rail Corridor – Electricity Licence Lite

If London Borough of Redbridge are prepared to take a long term view, 40 years, over the investment proposition, the IRR for the safeguarded cluster project can be expected to exceed around 7.8%.

Similarly, viewed over 40 years, the fully built out project can be expected to return and IRR of around 11.4% rather than the 10.1% achievable over 25 years.

4.8 Heat Supply Contribution

The heat supply contribution from each heat production asset for the initial cluster project and the fully built out project are shown in Appendix 6. These are shown as load duration curves, monthly supply profiles at full build out and cumulative supply contributions from each heat production asset as modeled for the initial cluster and fully built out projects.

4.9 Carbon Appraisal

Projected carbon savings for the initial cluster and fully built out projects over 25 years are presented in Table 17. Reference to the calculation methodology is provided in Appendix 3. Calculated carbon trajectories over the project lifecycle are presented in Appendix 5.

		Grid Carbon Factor Unchanged	DECC Grid Decarbonisation Trajectory
Business as Usual CO_2 over life of project for the Cluster Project	[TCO_2]	54,298	47,806
CO_2 Savings over life of project – Cluster Project	[TCO_2]	16,767	-5,113

% reduction in CO_2 Savings over life of project – Cluster Project	[%]	30.9%	-10.7%
Business as Usual CO_2 over life of project for the fully built out project	[TCO_2]	186,354	121,384
CO_2 Savings over life of project – Fully built Out Project	[TCO_2]	50,502	-56,981
% reduction in CO_2 Savings over life of project – Fully built Out Project	[%]	27.1%	-46.9%

Table 17: Carbon Emission Projections - Ilford Town Centre and Crossrail Corridor Project

The table identifies a positive saving in CO_2 over the life of the project based on projections using current grid emission factors but a negative saving if the DECC decarbonisation trajectory is assumed, highlighting the limited role that gas CHP will be able to play in carbon reduction in the future if DECC's grid decarbonisation trajectory is realized in practice. If so, the annual CO_2 savings are mostly positive until 2024. See Appendix 5.

4.10 Route Identification and Risk Appraisal

The network route proposal is shown in Figure 17 and Appendix 2. The indicated route is considered to be reasonably straightforward with no insurmountable barriers identified. Relevant aspects of the route are discussed below for the sections from East of Ilford into Goodmayes, since the remainder of the route for Ilford Town Centre has already been discussed in Section 2.9.

1) Routing of pipework along Ilford High Road into the vicinity of Seven Kings appears to present no major difficulties. Similarly, beyond Seven Kings towards Goodmayes, no major barriers have been identified and the road is reasonably wide along the majority of the route, making construction easier and allowing traffic diversions to be avoided.

2) However, the route is single carriageway along most of its length from Ilford into Goodmayes. Access for construction is therefore likely to cause significant traffic management issues. Permissions with TfL and the Council Highways Department will be necessary. Bus diversions are not likely to be necessary although traffic contraflows and parking suspensions are likely to be required, both of which will add cost to the development of the network. Cycle routes run along large sections of the route and cycle lane closures are likely to be necessary, introducing a safety issue and the need to consult with bodies and relevant interest groups.

3) Utility congestion may also be an issue, although this hasn't been assessed at this stage. Early de–risking through a utility search is recommended. The route narrows along extended sections (for example on the approach to Goodmayes from Seven Kings) and utility congestion can be expected to be more sever in these areas.

4) Routing of the pipework across the railway line will require approvals from Network Rail and may cause major disruption to local traffic, given that it is a fairly major junction. Possible design solutions discussed under Section 2 of this report can be expected to apply for this crossing point also.

5) The section of route along the High Road between Barley Lane and Eccleston Crescent has access to green space to the north of the High Road (i.e. the recreation ground). This is also understood to be land that falls under the ownership of London Borough of Redbridge. Access to this green space would allow soft digging, which would reduce

construction cost along that section. However, in overall terms this section of route is reasonably short and the savings in construction cost may not be worth the disruption to the recreational value of the space.

6) There is also the option to access soft verge to the south of the High Road, bordering the site of the existing TESCO store, where the new development CCOS10 is due to come forward. However this would require permissions, wayleaves from landowners which would add cost and would also need to provide for future access requirements for ongoing maintenance. Similarly, access across other development sites along the route could be pursued on the same basis, if this were found to be less costly or complicated than using the main highway.

Issues highlighted in relation to the Ilford Town Centre network are presented in Section 2.9 of this report.

4.11 Summary

A summary of the key project parameters is shown in the table below.

		Fully built out 25 years	**Cluster project over 25 years**
Total Investment CAPEX	[£ K]	17,373	6,532
IRR % over 25 years based on Electricity Licence Lite	[%]	10.1%	6.3%
NPV at 6% discount factor based on Electricity Licence Lite	[£ K]	5,915	168
CO_2 Savings over 25 years life of project relative to Business As Usual	[TCO_2]	50,502	16,767
CO_2 Savings over 25 years life of project relative to Business As Usual	[%]	27.1%	30.9%
Energy Centre footprint	[m^2]	650	650
Energy Centre CHP Capacity	[MW_e]	2.3	1.2
Length of Heat Network	[m]	9,320	1,763

Key Risks

The future of a possible Crossrail Corridor interconnection will rely on the presence of an initial cluster network in Ilford Town Centre. Therefore, the project opportunity will ultimately rely on London Borough of Redbridge to push forward the project at Ilford Town Centre in order to create the correct conditions to allow the Crossrail Corridor project to be taken forward

The IRR for the combined project is marginally lower than for the Ilford Town Centre only project and therefore is likely to require direct involvement from London Borough of Redbridge to bring about expansion into the Crossrail Corridor, since a commitment to do so from the private sector cannot be assumed.

In order to safeguard for future expansion into the Crossrail Corridor, the initial Cluster project in Ilford Town Centre would need to include additional investment in large diameter pipework and additional space within the energy centre. London Borough of Redbridge needs to take a view on the acceptability of this safeguarding position in financial terms.

Overall recommendation

In the event that the Ilford Town Centre heat network is taken forward, the case for interconnecting developments within the Crossrail Corridor to the Ilford Town Centre heat network at a future time appears to be reasonably strong.

It is recommended that this option is taken forward for further appraisal if Ilford Town Centre heat network is taken forward.

Table 18: Key Project Parameters - Ilford Town Centre and Crossrail Corridor Project

5. GOODMAYES OUTLIER

5.1 Summary of Opportunity

The Goodmayes Outlier site has been identified as a site that no longer meets the criteria for inclusion within Green Belt and where alternative uses may be appropriate over the coming decade. A range of community facilities have been proposed, whereby the former administration hospital building could form a new community hub facility at the heart of the site. Other proposed facilities include a primary school, a secondary school and a new polyclinic.

The development proposals are not complete and a future masterplanning exercise for this area will consider all of the Green Belt area including King George Hospital, Goodmayes Hospital, the Ford Sports Site and Seven Kings Park. The outcome will form part of the evidence base for the submission version of the Core Strategy review, although the site is already identified as being potentially suitable for decentralised energy under the Crossrail Corridor Area Action Plan.

The housing element suggested in the Green Belt study has been identified at around 1,500 units, although London Borough of Redbridge believes that it is likely to be less than this in order to retain the open and historic character of the site.

Goodmayes Hospital has been identified as having the potential to be developed as a residential urban quarter, with part of the existing building being converted into residences and an additional amount constructed as new infill development.

Additional housing opportunities have been proposed along the central western boundary and south east corner of the site and north of King George Hospital.

The development proposals are in the very early stages. Based on discussions with London Borough of Redbridge planning department, the following assumptions have been developed around the phasing of the residential development. These are reflected in the demand projections identified in this report. The key points of note in relation to the heat network opportunity are summarised below.

1) The new residences will be predominantly family housing in a garden suburb setting. Of the one thousand units proposed, only around 10% will be flats which will be located to the north of the site. The remainder will be terraced houses with an average dwelling density of around 50 dw/ha.

2) Construction phasing will take place between 2020 to 2028 with around 125 units per year, most likely starting at the Goodmayes site with conversion of the existing locally listed building into 120 dwellings, followed thereafter by new infill development at that site.

3) Development phasing along the central western boundary, the south east corner and the northern part of the site follow thereafter, with the central western boundary being developed last.

Two new schools are proposed on the site; a primary school of one hectare (GFA 4140m^2) and a Secondary school of one hectare (GFA 7340 m^2). These are expected to come forward over the next decade. Construction is assumed to take place in 2024 for the purpose of this report.

Development opportunities for Redbridge College include the possible relocation of the facility to the Crossrail Corridor / Ilford Town Centre (with redevelopment of the site as another secondary school with new residential housing) and extension of the existing college (again with new residential housing). For the purpose of this report, it has been assumed that 60 residential units would come forward and that the college would stay on-site and expand its provision (GFA 2,500 m^2). It is noted that if the college stays on site, it is likely to be in a new building that would be more energy efficient.

Finally a new polyclinic is proposed in the King George's Hospital area (GFA 3500 m^2).

The existing buildings within the opportunity area include both existing hospital sites and Redbridge College. Goodmayes Hospital has constructed a new mental health facility as an extension to Chapters House in the south of the main building complex, where part of the existing hospital functions will decant in order to permit the new residential development at that site.

Due to the development plans at Goodmayes Hospital, a significant proportion of the existing medium temperature hot water (MTHW) demand is likely to disappear as hospital functions are moved to other facilities. Based on consultation with King George Hospital, we have estimated a reduction of current demand at Goodmayes Hospital of 75% during the cluster phase of the project, which subsequently reduces to zero when replaced by infill residential development.

5.2 Identified Network Opportunity

5.2.1 Existing Heat Network Opportunity at King George Hospital

The heat network opportunity has been developed around the existing MTHW heat network at King George Hospital.

The existing heat network is shown in Figure 22 and consists of direct buried heat mains supplying heat to each of the buildings as shown in the figure.

The network is currently supplied from three Medium temperature Hot Water (MTHW) boilers each rated at 4,750KW, although the heat production assets on the site consist also of a CHP plant, two steam boilers and a heat recovery boiler recovering heat from the exhaust gas of the CHP in separate, adjoining buildings (shown in the bottom left of the figure).

Chilled water is also supplied to the hospital from centralised chillers located in the King George Plant room, located at the centre of the figure.

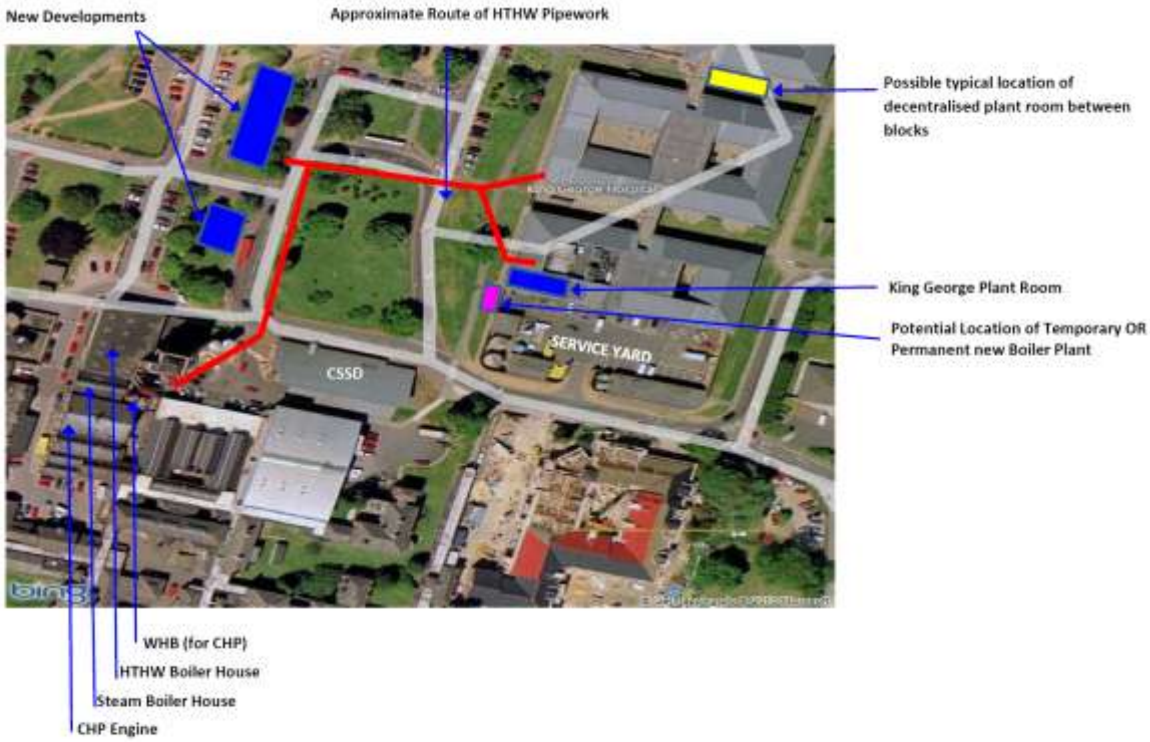


Figure 22: Summary of Existing MTHW Heat Network at King Georges Hospital

The existing CHP plant which is rated at 1,070 kWe was installed in 2005. This incorporated a waste heat steam boiler which recovered high grade heat energy from the CHP exhaust gases in order to meet the loads of the on-site laundry and Sterile Services (or Decontamination Units). The existing steam boilers were also operated to take the additional load, not met by the CHP plant. The CHP was taken out of operation in 2009, when the laundry was shut down, and remains non-operational at present. Laundry services are now contracted off site and the Sterile Services (Decontamination Units) are supplied through the two steam boilers, since there is insufficient demand to justify economic operation of the CHP. However, the Trust continues to pay the supplier under a 15 year lease agreement for a service contract, from which it is not benefiting. The Trust in conjunction with the CHP supplier is understood to be looking at options for returning the CHP into operation.

The existing medium temperature heat network shown in Figure 22 also extends south to Goodmayes hospital through an additional main running south from the south of the energy centre (not shown in the figure). Heat is delivered to 10 plantrooms within Goodmayes Hospital via this main. However, this section of the network, which runs predominantly elevated across the existing Goodmayes hospital buildings, will be decommissioned and removed when the Goodmayes hospital site is redeveloped and is therefore not considered to be part of the opportunity carried forward for this project.

Barking Havering and Redbridge Hospitals NHS Trust is understood to be considering options for removal for the CHP plant and decentralisation of the existing energy supply (with possible relocation of the main heat production assets as shown in Figure 22).

5.2.2 Network Opportunity Taken Forward

The proposed heat network opportunity is shown in Figure 23.

The existing heat network delivers heat at 120 °C which is well above the temperature required to supply new buildings connecting to the project.

Based on discussions with Barking Havering and Redbridge Hospitals NHS Trust's the preferred approach for developing any wider opportunity would be to retain the existing medium temperature hot water service to King George Hospital as opposed to reconfiguring the network to allow it to operate at lower temperatures.

Discussions with Barking Havering and Redbridge Hospitals NHS Trust, indicates that the limiting factor in this decision are the hot water calorifiers[50] serving the existing buildings which we assume have been sized on the basis of heat delivered at 120 °C, (i.e. based on the existing MTHW network).

However, there could be a case for de rating the supply temperature in the network to around 95 °C to 100°C to improve the heat recovery efficiency of the CHP and it is considered likely that the existing calorifiers would have sufficient excess capacity to continue to meet the hospital demands at the lower operating temperatures.

For the purpose of this report, we have therefore modelled the project on this basis, without including any investment in upgrading the calorifier capacity. It is noted however, that this assumption needs to be tested at the next stage.

A range of possible network configurations exist based on the retaining the existing MTHW network. For the purpose of the study we have assumed a concept that would supply the newly connected buildings from the return of the existing MTWH network. This concept would maximise capacity in the existing MTHW network by increasing its overall temperature drop (delta T), thereby maximising heat capacity and minimising the likelihood of having to replace or extend the existing network.

Under this arrangement, water from the return of the existing MTHW heat network would be delivered through a hydraulic interface unit located within a new energy centre as shown in Figure 23 (i.e. the site earmarked for a potential new boiler house as shown in pink in Figure 22). This building would also house booster pumps to distribute heat to the newly connected buildings and a further boiler to provide back-up and topping up capability to ensure sufficient supply capacity at all times. This would allow the newly connected buildings to be supplied at temperatures of up to 110 °C in the peak condition, with the capability of lowering supply temperatures at part load through recirculation of the return water from the newly connected buildings.

It has also been assumed that the existing heat production assets (CHP and MTHW boilers) would be retained in situ. This decision would clearly need to form part of the Barking Havering and Redbridge Hospitals NHS Trust's wider strategic development plans, but it is considered to be the most cost effective approach from the perspective of developing a wider heat network opportunity and on balance is considered likely to be the scenario that would be taken forward.

On this basis, it is assumed that:-

1. the existing CHP would be re-configured to recover heat from the engine jacket (not currently being done as we understand) and deliver at MTHW rather than as steam (as is currently the case through the existing heat recovery steam generator).

2. two new network branch connections would be installed as follows:-

    - A new network branch connection supplying the new schools, the new residential developments to the south and west of the site, the new and existing wings at Goodmayes Hospital and the new Polyclinic to the south of the site.

[50] The calorifiers generate hot water from the MTHW supply and store and distribute this water to the various hospital wings. There are understood to be no plans to upgrade these in the near or mid-term future.

- A new network branch connection supplying Redbridge College, Newbridge school and the residential sites to the north of King Georges Hospital.

The technical feasibility of achieving this will need to be addressed further through feasibility stage, but for the purposes of this study it has been assumed that this could be achieved with an investment of £1.2M. This fee is assumed to cover:-

1. reconfiguring the gas CHP to recover heat from the jacket and deliver at MTHW rather than as steam[51]

2. a new thermal store located in the near vicinity of the CHP plant

3. a new energy centre building located at the site earmarked for a potential new boiler house (shown in pink in Figure 22) containing a hydraulic interface , distribution pumps, a LTHW boiler rated at around 4.5MW and associated M&E controls etc.

It is recognised that, if this opportunity is taken forward, a value engineering exercise will ultimately need to be carried out to assess the benefits in overall investment terms associated with de-rating the existing MTHW heat network by replacing or modifying the calorifiers serving existing building heating systems.

A network schematic showing of the proposed heat network opportunity is shown in Figure 23. This identifies the proposed construction phasing of the heat network and identifies the initial cluster project (shown in red) as well as the extent of the fully built out project.

There could also be a further opportunity to install an absorption chiller at King George's hospital to displace load from the existing central chiller station. This opportunity has been evaluated separately in Section 5.11.

[51] At the request of Barking Havering and Redbridge Hospitals NHS Trust' we have not approached the CHP supplier at this stage to discuss costs and possible technical configurations.

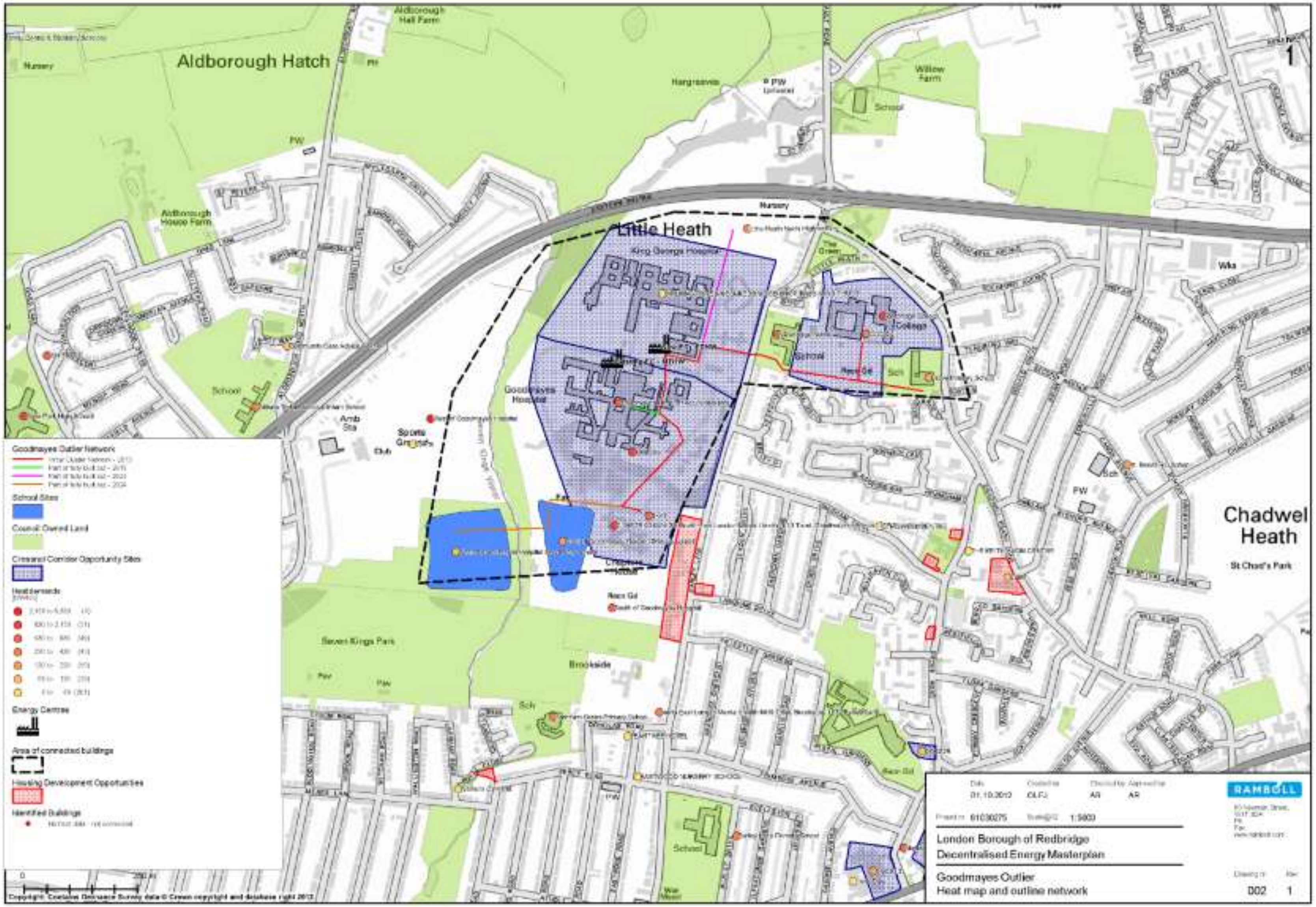


Figure 23: Heat map and Network Outline – Goodmayes Outlier

5.2.3 Initial Cluster Project

The anchor heat loads forming the initial cluster network (that would serve existing buildings only) are shown in Table 19 below:-

Load name	Address	Customer Type	Heat	Construction	Connection	Demand based on
			[MWh/a]	Year	Year	
CHAPTERS HOUSE, North-East London Mental Health NHS Trust, Goodmayes Hospital, 157 Barley Lane,	CHAPTERS HOUSE, North-East London Mental Health NHS Trust, Goodmayes Hospital, 157 Barley Lane,	NHS	1,380	Existing	2015	DEC
Newbridge School	Newbridge School, 258 Barley Lane,	London Borough Redbridge	475	Existing	2015	DEC
Barking, Havering and Redbridge Hospitals NHS Trust	Barking, Havering and Redbridge Hospitals NHS Trust, King George Hospital, Barley Lane	NHS	8,860	Existing	2015	Stakeholder
Grove Primary School	Grove Primary School, Chadwell Heath Lane,	London Borough Redbridge	163	Existing	2015	DEC
Redbridge College	Redbridge College, Little Heath,	Separate entity	715	Existing	2015	DEC
SK01	NHS extension at Chapters House	NHS	583	Existing	2015	Planning Application
Goodmayes Hospital		NHS	791	Existing	2015	Estimate based on actual
Total			**12,966**			

Table 19: Summary of Connected Buildings – Goodmayes Outlier – Cluster Project

Existing buildings connecting to the project are assumed to be connected through plate heat exchanger stations located in existing plantrooms. Building surveys have not been carried out at this stage. For the purpose of this study it has been assumed that:-

1. physical space could be made available, with replacement of an existing standby boiler under the worst case scenario if necessary

2. the existing heating systems would typically operate at 82°C / 71°C or similar and could therefore be supplied from a primary network temperature varying between 110 °C in the peak condition and around 87 °C in the summer condition (or lower if temperature compensation is in place).

Refer to Appendix 4 for further information.

The diversified peak heat demand growth profile for the cluster project is shown in Figure 24 below. The shaded, coloured areas of the graph show the annual consumption as a function of customer type and year of operation of the network. The dotted blue line shows the diversified peak demand seen by the network for all of the customer types.

The associated annual consumption as a function of customer type at cluster project is shown in Table 20 below.

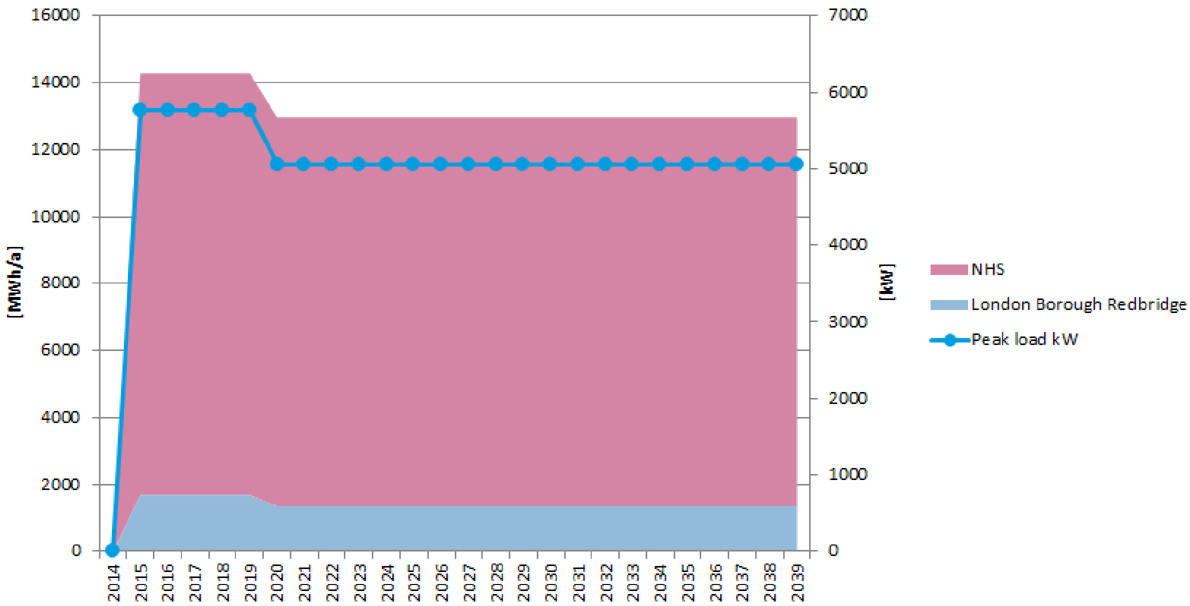


Figure 24: Heat Demand Growth Profile – Goodmayes Outlier - Cluster Project

Customer Type	Heat [MWh/a]
London Borough Redbridge	638
NHS	11,613
College	715
Total	**12,966**

Table 20: Heat Demand by Customer Type – Goodmayes Outlier – Cluster Project

5.2.4 Fully Built Out Project

A summary of the proposed connected buildings under the fully build out project is presented in Table 21.

Load name	Address	Customer Type	Heat	Construction	Connection	Demand based on
CCOS28	Redbridge College, Little Heath, Goodmayes	Residential customers - new	241	2018	2018	Benchmark
CCOS26	Goodmayes Hospital, Barley Lane, Goodmayes	Residential customers - new	1,041	2015	2015	Benchmark
Little Heath North High density		Residential customers - new	247	2023	2023	Benchmark
Goodmayes Hospital Residential Infill		Residential customers - new	691	2021	2021	Benchmark
West of Goodmayes Hospital Secondary school		London Borough Redbridge	207	2024	2024	Benchmark
West of Goodmayes Hospital Primary school		London Borough Redbridge	153	2024	2024	Benchmark
CCOS27	King George Hospital - new polyclinic	NHS	315	2020	2020	Benchmark
Subtotal			**2,896**			
Cluster Project			**12,966**			
Goodmayes Hospital Decommissioned (estimated 2019)			**-791**			
Total			**15,071**			

Table 21: Summary of Connected Buildings – Goodmayes Outlier - Fully Built Out Project

It is noted that Goodmayes Hospital has been excluded from the fully built out scenario even though 25% of the demand was included in the cluster project. The reason for doing this is that we assume that it won't be decommissioned in the near term and therefore has an impact on the initial cluster. On the other hand it would be unwise to include it together with all infill flats as this could potentially lead to an overestimation of heat sales. Adding it would result in a very small increase of IRR (less than 0.5% change).

The diversified peak heat demand growth profile and annual consumption for the fully built out project is shown in Figure 25 below. The shaded, coloured areas of the graph show the annual consumption as a function of customer type and year of operation of the network. The dotted blue line shows the diversified peak demand seen by the network for all of the customer types.

The associated annual consumption as a function of customer type at full build out is shown in Table 22 below.

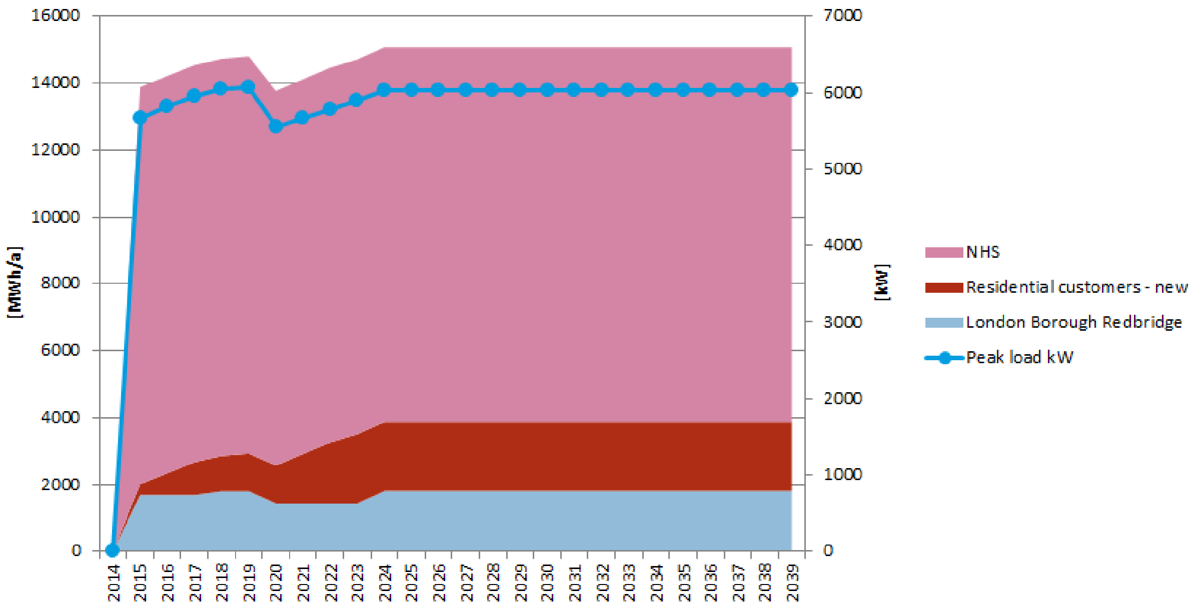


Figure 25: Diversified Peak Heat Demand Profile – Goodmayes Outlier - Fully Built Out Project

Customer type	Heat demand [MWh/a]
London Borough Redbridge	1,807
Residential customers - new	2,065
NHS	11,199
Total	**15,071**

Table 22: Heat Demand by Customer Type – Goodmayes Outlier - Fully Built Out Project

New buildings connecting to the project are assumed to be connected through plate heat exchanger stations located in newly constructed plantrooms at basement or ground level in the buildings. Refer to Appendix 4 for further information.

Ramboll Energy has investigated the viability of connecting the North East London Mental Health NHS Trust, Brookside to the south of Goodmayes hospital and the low density residential developments to the south and west of Goodmayes Hospital from 2025 onwards.

These have been excluded from the network opportunity on the basis of insufficient linear heat density[52]

5.3 Energy Supply Opportunity

5.3.1 Proposed Fuel Source and Heat Production Mix

Gas fired CHP in conjunction with gas boilers has been identified as the proposed heat production equipment, based on the existing assets at King Georges hospital. There could be an opportunity to replace the existing MTWH boilers with biomass or biofuel heating only boilers and/or to install the proposed new MTHW boiler as a biomass or biofuel fired alternative. The economics of these options have not been considered at this stage[53]

5.3.2 Energy Centre Capacity

Based on the scale of the proposed heat network at full build out, a new energy centre of approximate size 200 m^2 will be required to house the new heat exchanger station, distribution pumps and MTHW boiler.

The existing CHP and MTHW boiler assets would be retained and an additional thermal store of capacity 235 m^3 would be required. The modelling indicates that there is no case for installing additional CHP capacity for this project under the fully built out scenario.

5.3.3 Energy Centre Location

The proposed location of the new energy centre is shown in Figure 23. This is the site already earmarked by the Hospitals Trust for a potential new boiler house as shown in pink in Figure 22.

5.4 Phasing Strategy and Implementation Plan

The identified phasing strategy for the heat network is shown graphically in Figure 23.

The initial cluster shown in Figure 23 is assumed to be constructed in 2014 and operational from 2015 and would comprise King George's Hospital, reduced Goodmayes Hospital, Redbridge College, Newbridge School, Chapters House and SK01.

The proposed timescales for connecting these additional new development opportunities shown in Figure 23 are as follows:-

- Polyclinic ~2018
- Goodmayes Hospital Residential Infill ~ 2021
- Little Heath North High Density development ~ 2023
- Primary and secondary schools ~ 2024

The new energy centre would be constructed in 2014, at the same time that the heat network is installed. The proposed timescales for construction are identified in Appendix 5.

5.5 Economic Appraisal

Economic modelling has been carried out for both the initial cluster project and the fully built out project. The key economic indicators for the project are presented in Table 23, both for the initial

---

[52] ie the cost of connection is deemed to be too high for the amount of heat sold over the life of the scheme.

[53] It is noted that mitigation measures to maintain acceptable air quality impact should be possible using existing technologies, subject to local air quality and economic viability at the proposed scale. A fuller air quality impact assessment would be required to assess the requirements which should be carried out at the feasibility stage.

cluster project and the fully built out project[54]. The results are presented as a function of electricity selling arrangements for a Private Wire arrangement and a project term of 25 years.

Refer to Appendix 3 for definitions of electricity selling arrangement opportunities.

		Initial Cluster	Fully Built Out
Total Investment CAPEX	[£ K]	3,244	4,235
Energy Centre CAPEX	[£ K]	1,759	1,759
Length of Heat Network	[m]	1,354	2,325
Cost of Heat Network	[£ K]	965	1,588
Connection CAPEX	[£ K]	148	402
Project Development Costs	[£ K]	373	487
Annual Operating Costs	[£ K]	1,068	1,209
Annual Revenues from Heat Sales	[£ K]	694	921
Annual Revenues from Electricity Sales	[£ K]	754	819
Annual Saving per year to LBR due to CRC savings	[£]	0.3	0.3
Weighted Average Electricity Sales Value from Project	[£ /MWh]	78.9 in 2015 and 110 in 2039	78.9 in 2015 and 110.1 in 2039
Annual Operating Margin at full build out	[£ K]	422	573
Annual Revenues from Electricity Sales, LEC and CRC values	[£ K]	796	861
IRR % over 25 years	[%]	11.0%	11.6%
NPV at 6% discount factor	[£ K]	1,412	1,898

Table 23: Key Economic Indicators - Goodmayes Outlier Project – Private Wire Arrangement

The required initial capital investment for the project would be around £3.2M and £4.2M under the initial cluster and the fully built out projects.

The project benefits from an existing private wire arrangement (refer to Appendix 3). Under this arrangement, the initial cluster project based around the existing buildings would deliver an IRR of around 11.0% over 25 years[55] and the fully built out project would deliver an IRR of 11.6% over 25 years. The corresponding NPVs would be £1.4M and £1.9M respectively at a 6% discount factor. The annual saving to London Borough of Redbridge associated with reduction in CRC

[54] Under the Private Wire arrangements, is has been assumed that no investment in a private wire would be necessary, since this is already in place for the site.

[55] This assumes £250k capital expenditure in the CHP at the start of the project, a 50% (of a new CHP installation cost) replacement cost in year 2029, no connection cost for King Georges hospital and a nominal investment in additional gas boilers.

payments under the project would be £0.3K under both the initial cluster and fully built out projects[56].

Fuel savings would remain unchanged under the current modelling assumptions. This assumes that the project would charge London Borough of Redbridge its current heat price, which has been calculated to be 4.12 p/kWh excluding annualised reinvestment costs and 4.27 p/kWh including annualised reinvestment costs.

Discounted cashflow forecasts for the initial cluster project and the fully built out project are presented in Figure 26 and Figure 27 respectively. These are based on a private wire selling arrangement.

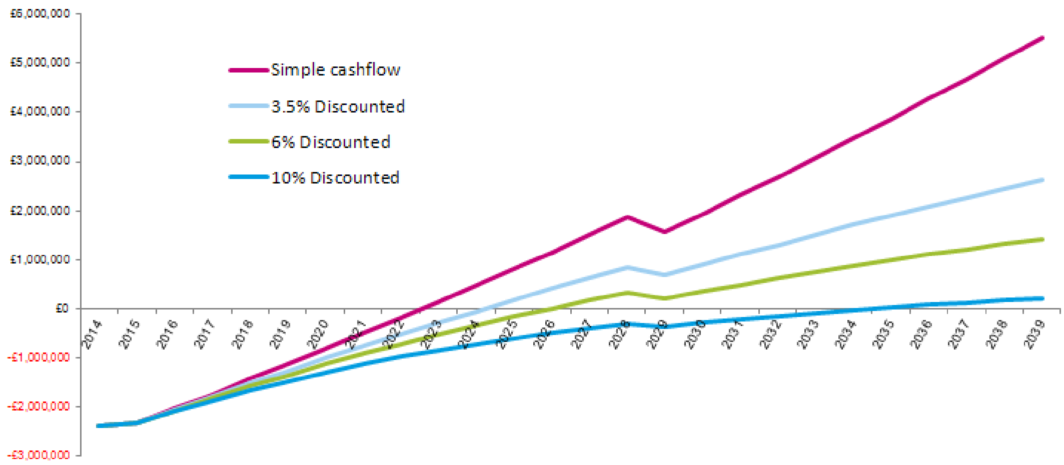


Figure 26: Cumulative Discounted Cashflow Forecast - Goodmayes Outlier – Cluster Project – Private Wire Arrangement

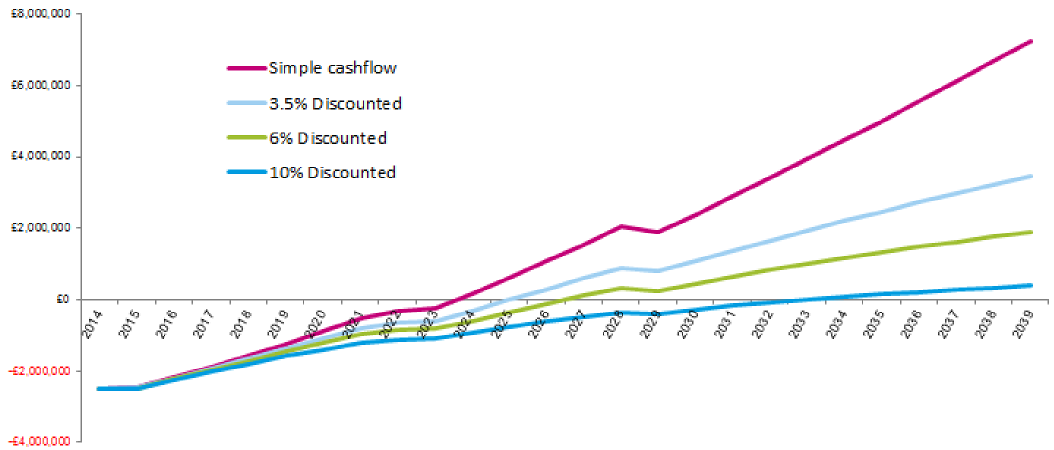


Figure 27: Cumulative Discounted Cashflow Forecast – Goodmayes Outlier - Fully Built Out Project– Private Wire Arrangement

[56] The CRC benefit shown in the table reflects the benefit seen by the connected buildings rather than the benefit taken by the project. Refer to Appendix 3 for details of the assumed benefit sharing arrangement.

The impact of a range of capital contributions from £500K to £2M has been tested for the project. The results are shown in Figure 28. IRR is seen to increase to 19.0% and 18.4% for a grant contribution of £1M for the cluster and fully built out projects respectively.

Potential sources of grant funding could be Allowable Solutions, Section 106 funding, Community Infrastructure Levy, Housing Revenue Account, New Homes Bonus (for the fully built out project), Homes and Communities Agency and the London European Regional Development Fund. London Borough of Redbridge needs to explore these sources of funding and identify possible contribution levels.

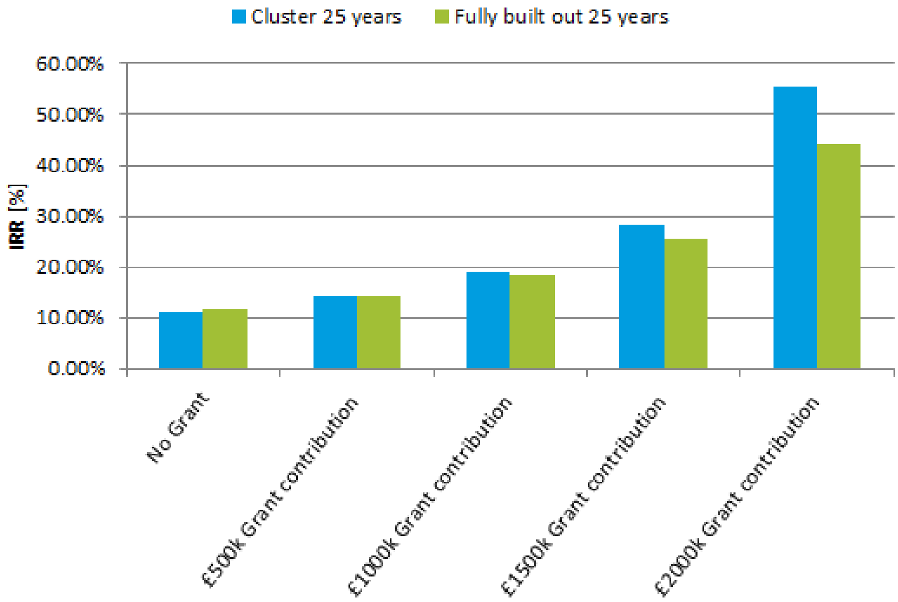


Figure 28: Impact of Grant Contribution to Project IRR for the Cluster and Fully Built Out Projects

5.6 Sensitivity Analysis

A sensitivity analysis has been carried out around the key variables that influence the IRR for the project. The results of the sensitivity analysis are presented in Figure 29 and Figure 30 for the cluster project and fully built out project for the Private Wire scenario. Please refer to Section 2.5 and Appendix 3 for interpretation of this figure.

The key conclusions drawn for the cluster project are that:-

1. Electricity selling price, gas purchase price, project capital cost, and heat selling price are the major drivers in uncertainty around IRR.
2. A favourable variation of 10% in any of the indicated variables will increase the IRR to over 12%.
3. An unfavourable variation of 10% in any of the indicated variables will still maintain an IRR of over 8.0%, which is still considered to be attractive.

For the fully built out project similar conclusions apply with IRRs of over 12.5% and 9% respectively.

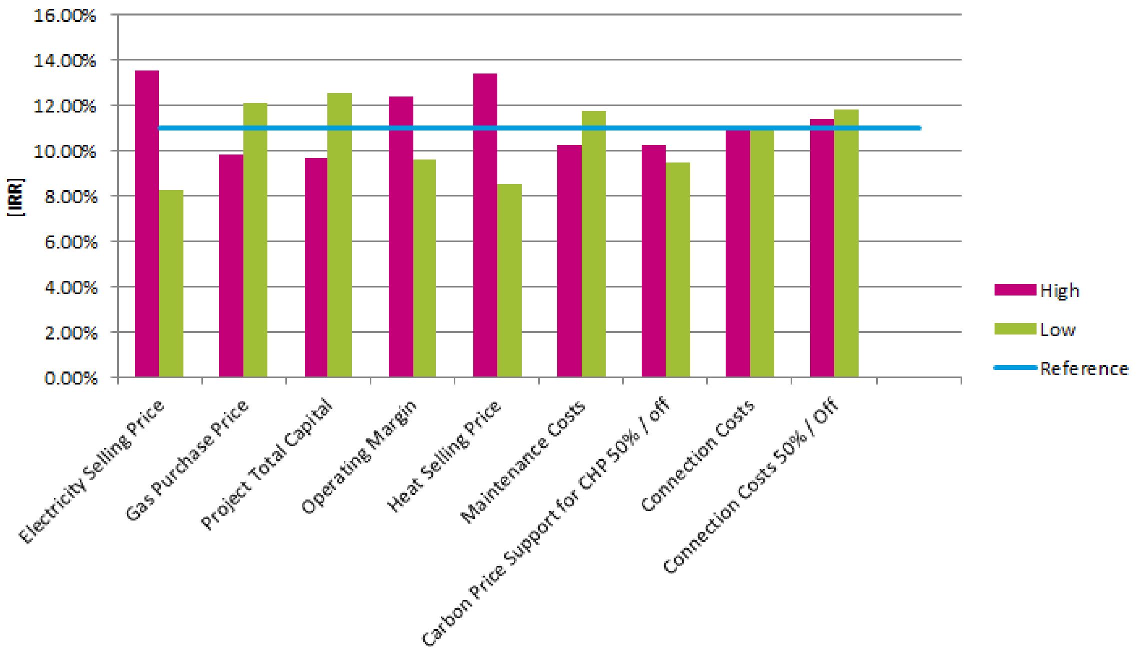


Figure 29: Economic Sensitivity Analysis – Goodmayes Outlier - Cluster Project

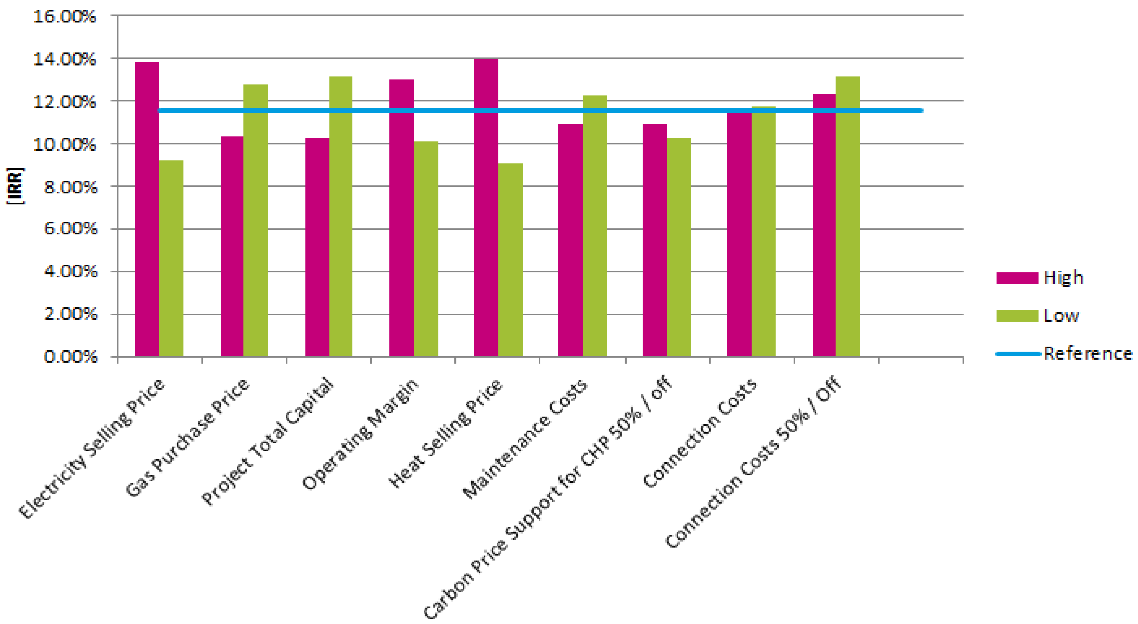


Figure 30: Economic Sensitivity Analysis – Goodmayes Outlier - Fully Built Out Project

5.7 Implications for Project Procurement

The Goodmayes project appears to represent a viable business opportunity and it is recommended that the project opportunity is considered further by Barking Havering and Redbridge Hospitals NHS Trust.

Two main procurement options could be considered for taking forward this project opportunity.

Firstly the hospital could develop and own the network and sell heat to the various customers identified under the opportunity. This would generate an income for Barking Havering and Redbridge Hospitals NHS Trust, which could be used to fund its core activities but would require the Trust to inject capital or borrow to finance construction of the network. The Trust's appetite for adopting this approach would need to be explored further since this would represent a departure from its core business and would introduce operational risk.

Secondly, a third party provider such as an ESCo could step in and operate the energy centre under an energy services contract, selling heat to both the Trust and the new developments in the area. This could be of interest to the Trust, particularly if the ESCo were to take on the Trust's additional carbon reduction commitments under that contract. The existing assets could remain under the ownership of the Trust or could be transferred to the ESCo provider, whilst investment in the new infrastructure could be made by the ESCo. The ESCo would operate and maintain the project under a concession period, with a commitment to supply energy to the Trust throughout the period. By injecting finance into the project, the ESCo would free up the capital for the Trust allowing it to divert this money to other services.

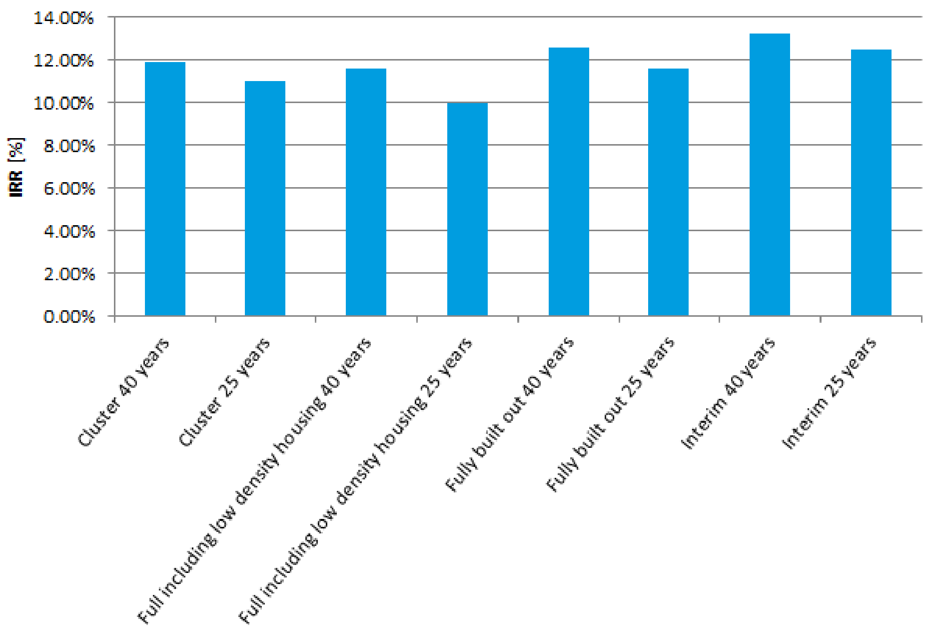


Figure 31: Modelling outcomes as a function of Project Term and Project Scale – Goodmayes Outlier – Private Wire Arrangement

Figure 31 presents the various modeling cases described in Appendix 3 based on a private wire arrangement, which is considered to be the most economically favorable option given the existing electrical connection arrangements at the site. The interim project provides another investment perspective which represents a scenario between the pessimistic initial cluster scenario and the fully built out, where only the first 6 years' additional connections are realised.

Using this figure the following conclusions have been drawn in terms of procurement options.

Due to long development timescales, the IRR for the fully built out project viewed over 25 years are similar to that of the cluster project viewed over the same period. Whilst the Trust might find the calculated IRR of both scenarios acceptable over 25 years, it is difficult to see what incentive the Trust or an ESCo would have for extending the project beyond the initial cluster.

Viewed over 40 years, the IRR of the fully built out project exceeds that of the initial cluster network viewed over 25 years. This suggests that if the Trust were prepared to invest in the project and view its return over a long term, it could potentially sell the project to the private sector at a later stage in its lifecycle, at which point the project would represent a low risk proposition that a private ESCo might be prepared to take on.

A comparison of the cases with and without inclusion of the low density housing elements indicates that the low density housing elements reduces the economic case for the overall project. Although the indicated IRR's are likely to be acceptable to Barking Havering and Redbridge Hospitals NHS Trust, it is difficult to see how connecting these low density housing developments could be an attractive proposition for the project. Our recommendation is therefore that these developments should not be required to safeguard to connect to the heat network. These are identified as points named as 'West of Goodmayes Hospital' and 'South of Goodmayes Hospital' in Figure 23.

The interim project includes the first set of investments (first six years in this case) and subsequently only the necessary re-investments and running costs. This effectively means not extending the network or connecting more buildings after this cut-off period. Economically this is the most attractive of the options considered and is likely to be the view that an ESCo would take. In theory, every next 'optional' investment such as connection and extension of network would be judged on its merits and hence independent of the interim project business case. This case is in principle very similar to an initial cluster scenario but carries more risk as it is dependent on future buildings and the inherent risk of such.

London Borough of Redbridge are likely to have little interest or incentive to become involved in the project since the scope for reducing local authority carbon emissions and future fuel costs would be limited and the opportunity to extending the project beyond the immediate vicinity appear to be very low. London Borough of Redbridge's role in this project should be to act as a facilitator for the project bringing together key stakeholders and to require the new schools, polyclinic and high density developments to safeguard for connection to the project if it is taken forward.

5.8 Heat Supply Contribution

The heat supply contribution from each heat production asset for the initial cluster project and the fully built out project are shown in Appendix 6. These are shown as load duration curves, monthly supply profiles at full build out and cumulative supply contributions from each heat production asset as modeled for the initial cluster and fully built out projects.

5.9 Carbon Appraisal

Projected carbon savings for the initial cluster and fully built out projects over 25 years are presented in Table 24. Reference to the calculation methodology is provided in Appendix 3. Calculated carbon trajectories over the project lifecycle are presented in Appendix 5.

		Grid Carbon Factor Unchanged	DECC Grid Decarbonisation Trajectory
Business as Usual CO_2 over life of Fully built out Project	[TCO_2]	95,064	87,072
CO_2 Savings over life of Fully built out Project	[TCO_2]	17,952	-6,922
% reduction in CO_2 savings over life of Fully built out Project	[%]	18.9%	-7.9%
Business as Usual CO_2 over life of Cluster Project	[TCO_2]	91,451	90,510
CO_2 Savings over life of Cluster Project	[TCO_2]	23,899	7,500
% reduction in CO_2 Savings over life of Cluster Project	[%]	26.1%	8.3%

Table 24: Carbon Emission Projections - Goodmayes Outlier Project

The table identifies a positive saving in CO_2 over the life of the project based on projections using current grid emission factors but a negative saving for the fully built out project if the DECC decarbonisation trajectory is assumed, highlighting the limited role that gas CHP will be able to play in carbon reduction in the future if DECC's grid decarbonisation trajectory is realised in practice. If so, the annual CO_2 savings are positive up to 2028 for the fully built out project. See Appendix 5.

5.10 Route Identification and Risk Appraisal

There are no major barriers identified for the pipework routing across the site. The site has significant proportion of green field, making construction relatively cheap and quick. Permissions and wayleaves requirements will be minimal, since the majority of the network could be routed across the Trust's private land and London Borough of Redbridge's land. However, there is a river running north-south direction just west of the hospitals which would need to be crossed to access the proposed secondary school and low density housing area towards the west of the site.

Access through brownfield areas can be carried out during development of the site, with potential for sharing trenches with other services, thereby significantly reducing costs.

Access across King George's Hospital would require road and car park closures with associated disruption. There may be opportunities for using green field parts of the site and for extending the network from its existing route across the site. However, the technical case for doing this would need to be established through a design study.

5.10.1 Archaeology / SSSI

Based on the GIS data provided by London Borough of Redbridge, there is no indication of an SSSI or any archaeological interest that would present a risk to the project.

5.10.2 Access across river

Access across the river is not expected to cause a problem since it not very wide. There is an existing crossing point in the vicinity of the Bowling Green which could potentially be used to route pipework across the river.

Additional access across the river will be provided under any future development of the site and this will need to incorporate other utilities. The district heating mains can be incorporated along with these utilities.

If necessary, it would be possible to consider submerging the pipework and routing it across the bed of the river. Effective anchoring of the pipework to the bed of the river will be required if this approach is taken to prevent damage due to static loading variations arising from changing water levels. The ground stability in the river is likely to be poor, potentially complicating anchoring arrangements. Alternatively the pipework could be installed beneath bed level but this is considered to be unnecessary for this project.

5.10.3 Access to Redbridge College

Access to Redbridge College could take place across London Borough of Redbridge owned land (Newbridge School grounds). This would avoid routing the network along a section of the public highway, B177.

Access across the road would be required. The road is single carriage and is a bus route, causing potential traffic management problems. Approvals from TfL and Highways department will be required. The length of this section would be very short, and the associated disruption would be short in duration. Grove Primary School could also be supplied via the college.

5.11 Absorption Chiller Option

King George hospital currently operates two existing vapour compression chillers located within a centralised chilling station at the centre of the hospital site. Each chiller is rated at 595 kW_{CHW}.

The chillers operate in a duty, standby arrangement. Each is sized approximately for the summer peak and operates reasonably constantly at full load during working/operating hours over the summer months from June to August, with a reduced load at weekends. During non-summer months, the chillers are understood to operate at around 35% capacity for the majority of the year.

The opportunity to supply the hospital from an absorption chiller has been investigated on the basis that it would operate using LTHW heat from the gas CHP distributed through the existing MTHW mains (operating at a de-rated temperature as discussed earlier in this chapter).

Figure 32 below shows the calculated hourly heat consumption requirement for one year from the MTHW network to supply the proposed absorption chiller. The calculation is based on information provided by Barking Havering and Redbridge Hospitals NHS Trust. Chilled water consumption is not metered at the site. In the absence of any detailed chilled water demand information from Barking Havering and Redbridge Hospitals NHS Trust, Ramboll Energy has therefore estimated the chilled water demand profile for the King George’s hospital and used this to calculate the contribution from an absorption chiller that would be sized to take up the baseload demand for the site. On this basis, it has been concluded that an absorption chiller of 500 kW could potentially be installed with an estimated LTHW requirement of 1,593 MWh per year.

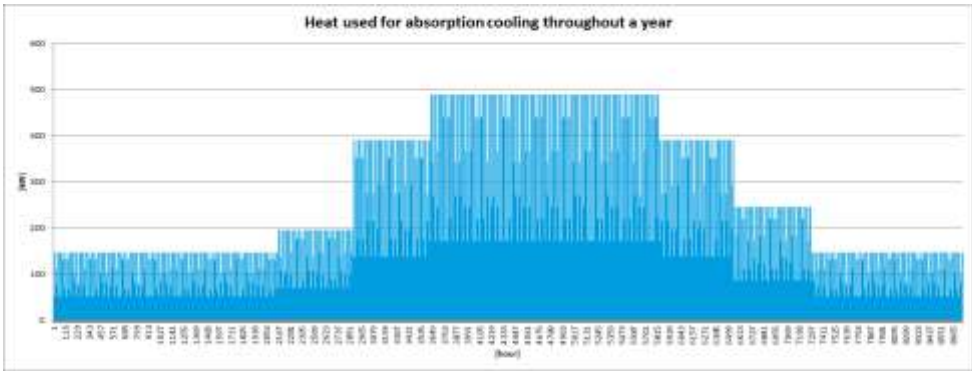


Figure 32: Assumed Heat used for Chilled Water Production Profile for King Georges Hospital

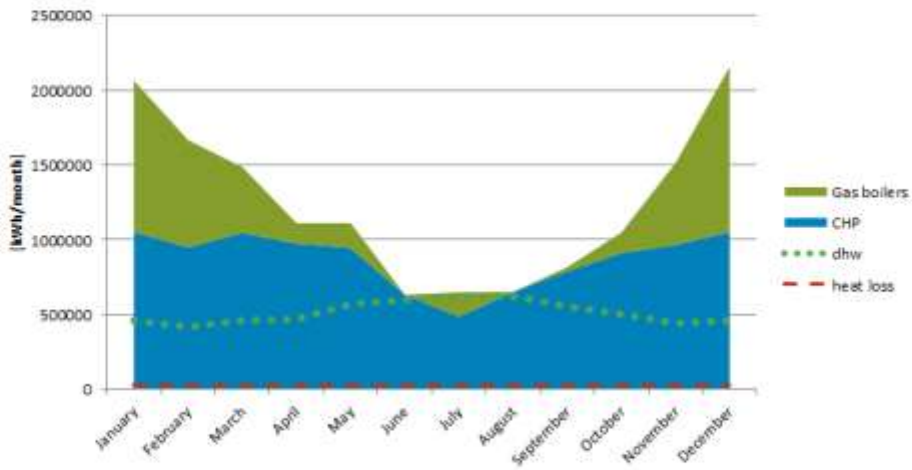


Figure 33: Annual demand profile showing the absorption chiller impact on heat demand – the heat for cooling is included in the DHW legend green dotted curve

Based on this analysis, the inclusion an absorption chiller sized to supply the baseload chilled water demand for the hospital would cost around £300K (with associated heat rejection and balance of plant included) and would not have a significant impact on project IRR. Based on our calculations, it would reduce the IRR from 11.0% to 10.9% over 25 years, which is within an error of margin and too small to draw a clear conclusion as to whether it would be beneficial to take forward. Similarly, the change in carbon dioxide emissions savings impact is also only 0.1%. This assumes a single effect chiller could be installed[57] and that sufficient capacity would exist in the MTHW network to deliver this additional requirement.

The initial recommendation is therefore to review the option for an absorption chiller through a more detailed study if the opportunity for extending the heat network is taken forward by the Trust. It is noted that any decision to proceed with the absorption chiller option would need to take into account proposals for reducing the operating temperatures of the existing MTHW network, which could impact on the assumptions that Ramboll Energy has made regarding chiller COPs and therefore project IRR.

[57] operating at around 95 °C

5.12 Summary

A summary of the key project parameters is shown in the table below.

		Fully built out 25 years	Cluster project over 25 years
Total Investment CAPEX	[£ K]	4,235	3,244
IRR % over 25 years based on Private Wire Arrangement	[%]	11.6	11.0
NPV at 6% discount factor based on Electricity Licence Lite	[£ K]	1,898	1,412
CO_2 Savings over 25 years life of project relative to Business As Usual – Grid Factor unchanged	[TCO_2]	17,952	23,899
CO_2 Savings over 25 years life of project relative to Business As Usual – Grid Factor unchanged	[%]	18.9%	26.1%
Energy Centre footprint (heat transfer station)	[m^2]	200	200
Energy Centre CHP Capacity	[MW_e]	1.0	1.0
Length of Heat Network	[m]	2,325	1,354

<u>Key Risks</u>

Many of the risks identified for the Ilford Town Centre project also apply to this project.

A key barrier to this project opportunity is the timescales for the development proposals. The Trust has a short to medium term objective to address around the future of its existing CHP asset but the wider development opportunities will not come forward for many years. The proposed network opportunity may not be in the Trust's best economic interests.

Future expansion of the project will depend on whether the future development proposals materialise and indeed whether the site gets released for alternative uses from its current Green Belt status.

There is uncertainty around the cost and technical viability of retrofitting heating systems to the proposed flats in Goodmayes, since this is a listed building.

There is uncertainty around the future plans for Redbridge College.

There is uncertainty around the viability and costs to the Trust associated with modifying its existing systems to operate at lower temperatures.

<u>Overall recommendation</u>

There appears to be a viable project opportunity for Goodmayes Outlier, based on the existing CHP assets at King George Hospital. It is recommended that the project opportunity is considered further by Barking Havering and Redbridge Hospitals NHS Trust.

London Borough of Redbridge are likely to have little interest or incentive to become involved in the project, since the scope for reducing local authority carbon emissions and future fuel costs would be limited and the opportunity to extending the project beyond the immediate vicinity appear to be very low. London Borough of Redbridge's role in this project should be to act as a facilitator for the project bringing together key stakeholders and to require the new schools, polyclinic and high density developments to safeguard for connection to the project if it is taken forward.

The low density housing element proposed for the opportunity area significantly reduces the economic case for the overall project and it is difficult to see how connecting these developments could be an attractive proposition for the project. Our recommendation is therefore that these developments should not be required to safeguard to connect to any future heat network opportunity.

Table 25: Key Project Parameters – Goodmayes Outlier Project

6. BARKINGSIDE INVESTMENT AREA

6.1 Summary of Opportunity

Barkingside Investment Area is located towards the northern part of Redbridge.

Specific opportunities within the Barkingside Investment Area for a decentralised energy network have been identified under previous work as presented in [2].

<u>Oakfields Playing Fields and Redbridge Sports and Leisure Centre</u>

The Green Belt Study carried out in Sept 2010 identified Oakfields Playing Fields and Redbridge Sports and Leisure Centre site as a site for potential release from the Green Belt designation under the NPPF as it is considered to no longer meet the criteria for Green Belt.

The site is 25ha in area and is presently used for sporting purposes and represents the largest sporting centre in the borough. London Borough of Redbridge owns (or leases) the majority of the site, making it potentially a very interesting opportunity from the perspective of developing a heat network. The Green Belt Study proposed two conceptual development options for this site incorporating a mix of residential development (between 690– 1150 dwellings), a school and / or a polyclinic.

<u>King Solomon and Ilford Jewish Primary School Playing Fields</u>

The Green Belt Study carried out in Sept 2010 identified King Solomon and Ilford Jewish Primary School Playing Fields as a site which may be suitable for release from the Green Belt.

The site is 12ha in area and currently accommodates two schools – one to the north of the site and one to the south. London Borough of Redbridge owns the whole of the site, making it potentially a very interesting opportunity from the perspective of developing a heat network.

The Green Belt Study suggested this site could potentially accommodate between 150-250 residential dwellings in the area between the two schools as well as the possibility of extending the capacity of the existing schools.

<u>Barkingside and Fullwell Cross</u>

Barkingside is designated as a District Centre. It is a typical London suburb with a population of 27,000 people. The town centre includes a range of shops and services concentrated along the 700 metre long High Street.

The Barkingside Town Centre Improvement Plan [5] proposes a broad range of social, economic and physical improvements in the town centre. One suggestion in the plan identifies an area for a new town square (near Fullwell Cross roundabout), which primarily involves lighting, street furniture etc. The Council has recently received funding from the Mayor of London for improvements to Barkingside Town Centre. In addition, the Craven Gardens car park (next to Fullwell Cross round-a-bout) is identified as a possible location for a new NHS Health Care facility and has a range of other potential uses if a health care facility does not materialise.

There is an existing Sports Centre (to the northern end of the High Street) (Fullwell Cross) which houses an existing 70 kWe CHP which provides heat to the centre (including pool) and the adjacent Fullwell Cross library.

In addition, there are a number of significant existing buildings to the southern end of the High Street and a number of development opportunity sites identified in [8], also predominantly to the southern end of the High Street.

6.2 Identified Network Opportunity

6.2.1 Initial Cluster Network

The opportunity to bring forward a heat network within the Barkingside Investment Area has been assessed.

This has focused on options for an initial cluster project centred around a number of existing heat loads; Redbridge Sports and Leisure Centre, King Solomon High School and the Bingo Club, and consideration of the possibility of using the existing CHP at Fullwell Leisure Centre to supply the network opportunity.

The modelling carried out has indicated that the existing 70 kWe gas CHP engine at Fullwell Cross Leisure Centre is too small to contribute effectively towards the proposed cluster network and that CHP capacity of 185 kW_e would be required to deliver a reasonable contribution. The existing energy centre housing the 70 kWe gas CHP engine located at the Fulwell Cross Leisure Centre is considered to be too small to accommodate the future CHP capacity and a new location would therefore be required to take this project forward. The modelling has shown that the additional cost associated with construction of the new energy centre would render the future network opportunity non-viable in economic terms (see below) and on this basis, the value to London Borough of Redbridge of an initial cluster network based around the identified demands is questionable.

6.2.2 Fully Built Out Network

Further development opportunities around the identified new developments in Fullwell Cross[58] have also been explored. Six network configurations representing various combinations and extents of heat network build out have been tested. The smallest network considered was connecting the leisure centre with King Solomon, Ilford Jewish Primary School and the new developments in between the two schools. Other options were to include or exclude the part of the network south of Ilford Jewish Primary School and also to include or exclude the part of the network north of King Solomon School. Of these, the most favourable option in economic terms is a project comprising all identified developments as presented in Figure 34.

The new developments in the Oakfield area are considered too low heat density to prove financially attractive taking into account the anticipated low rise nature of these, coupled with the geographical spread and low heat demand.

However, this option returns an IRR of around 4.1% over 25 years, based on an electricity Licence Lite arrangement and a delayed project start until 2023, when most of the new developments are complete.

The Electricity Licence Lite arrangement is considered to be the most economically attractive basis on which to take forward the proposed opportunity, and yet the indicated IRR under this arrangement falls considerably short of what is considered to be economically viable.

On this basis it has been concluded that a project at Barkingside should not be pursued on the basis of the current development opportunities identified for the site.

[58] as indicated in [16]

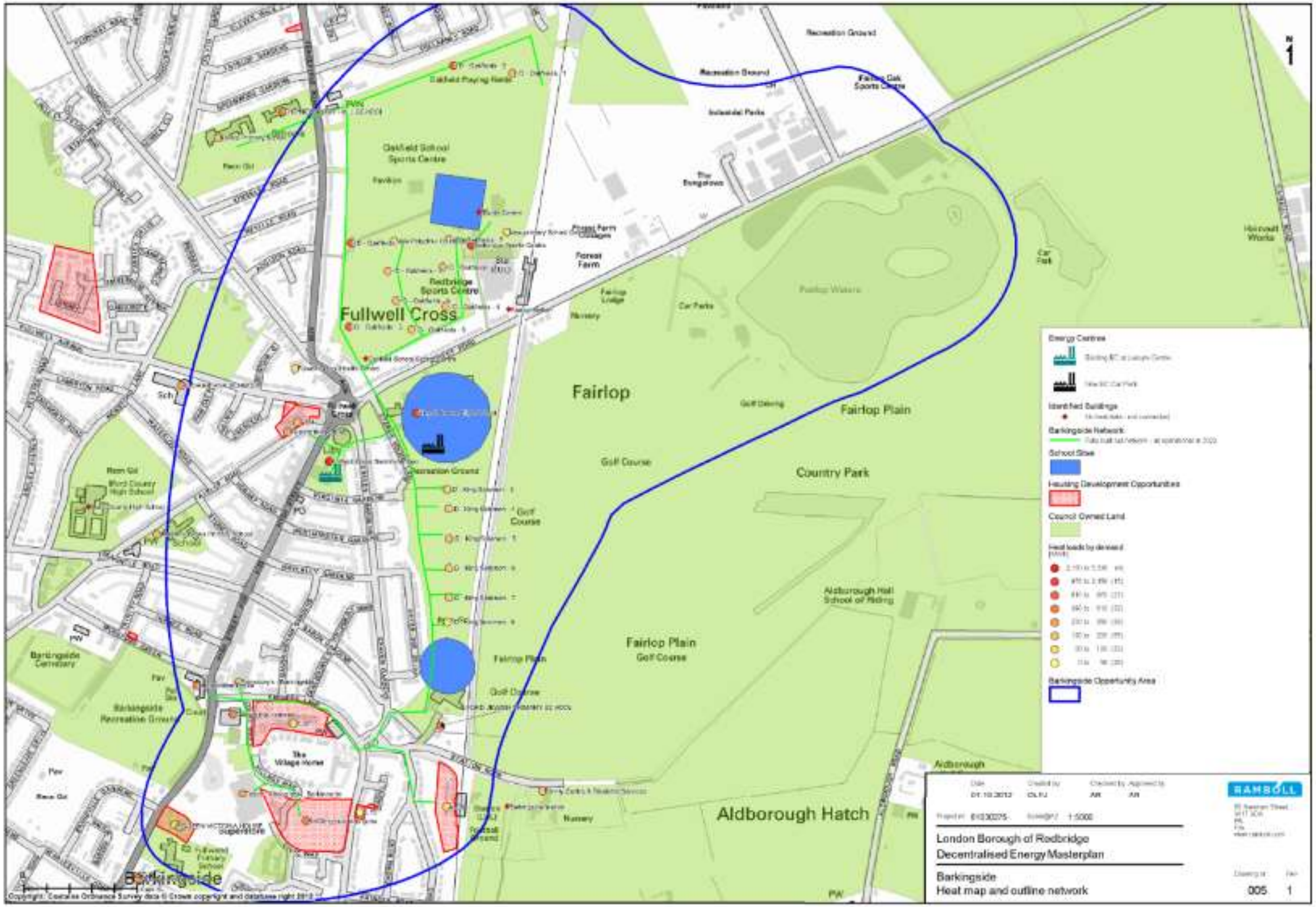


Figure 34: Heat map and network outline Barkingside Project

A summary of the buildings considered for the heat network opportunity is presented in Table 26 below.

Load name	Address	Customer Type	Heat	Construction	Connection	Demand based on
			[MWh/a]	Year	Year	
Sainsbury's - Barkingside	Tanners Lane, Barkingside	Existing Commercial	168	Existing	2023	Benchmark
Redbridge Sports Centre	Forest Rd, Barkingside	Existing Commercial	1,221	Existing	2023	Benchmark
Existing Bingo Club	Fullwell Avenue, Barkingside	Existing Commercial	309	Existing	2023	Benchmark
Tesco - Village Way, Barkingside	Village Way, Barkingside	Existing Commercial	267	Existing	2023	Benchmark
THE NEW RUSH HALL SCHOOL	Fencepiece Road, Barkingside	London Borough Redbridge	319	Existing	2023	Actual data
Clerk to the Justices	Clerk to the Justices, 850 Cranbrook Road,	London Borough Redbridge	369	Existing	2023	DEC
Metropolitan Police	Metropolitan Police, 1 High Street, Barkingside	London Borough Redbridge	435	Existing	2023	DEC
Fullwell Cross Swimming Pool	London Borough of Redbridge, Fullwell Cross Library, 140 High Street, Barkingside	London Borough Redbridge	1,720	Existing	2023	DEC
Fairlop Primary School	Fairlop Primary School, Colvin Gardens,	London Borough Redbridge	168	Existing	2023	DEC
King Solomon High School	King Solomon High School, Forest Road,	London Borough Redbridge	871	Existing	2023	NI185
AL10	366-380 Horns Road, Barkingside	Residential customers - new	37	2016	2023	Benchmark
AL08	Station Approach/Carlton Drive, Barkingside	Residential customers - new	74	2016	2023	Benchmark
FL04	Coral Bingo Club, 2a Fairlop Road, Barkingside	Residential customers - new	127	2015	2023	Benchmark
AL03	New Mossford Site, part of Barnardos Village	Residential customers - new	406	2013	2023	Benchmark
HD - Oakfields - 1	n/a	Residential customers - new	141	2021	2023	Benchmark
HD - Oakfields - 2	n/a	Residential customers - new	141	2022	2023	Benchmark
HD - Oakfields - 3	n/a	Residential customers - new	141	2023	2023	Benchmark

HD - Oakfields - 4	n/a	Residential customers - new	141	2024	2024	Benchmark
HD - Oakfields - 5	n/a	Residential customers - new	141	2025	2025	Benchmark
HD - Oakfields - 6	n/a	Residential customers - new	141	2026	2026	Benchmark
HD - Oakfields - 7	n/a	Residential customers - new	141	2027	2027	Benchmark
HD - King Solomon - 8	n/a	Residential customers - new	74	2028	2028	Benchmark
LD - Oakfields - 1	n/a	Residential customers - new	775	2021	2023	Benchmark
LD - Oakfields - 2	n/a	Residential customers - new	775	2022	2023	Benchmark
LD - Oakfields - 3	n/a	Residential customers - new	775	2023	2023	Benchmark
LD - King Solomon - 3	n/a	Residential customers - new	186	2021	2023	Benchmark
LD - King Solomon - 4	n/a	Residential customers - new	186	2022	2023	Benchmark
LD - King Solomon - 5	n/a	Residential customers - new	186	2023	2023	Benchmark
LD - King Solomon - 6	n/a	Residential customers - new	186	2024	2024	Benchmark
LD - King Solomon - 7	n/a	Residential customers - new	186	2025	2025	Benchmark
New Polyclinic Oakfields	n/a	London Borough Redbridge	74	2020	2023	Benchmark
New primary School Oakfields	n/a	London Borough Redbridge	56	2020	2023	Benchmark
ILFORD JEWISH PRIMARY SCHOOL	CARLTON DRIVE, Barkingside	London Borough Redbridge	412	Existing	2023	NI185
AL07	Tanners Lane, Barkingside	New Medium Commercial	80	Existing	2023	Planning Application
Total			**11,426**[59]			

Table 26: Summary of Connected Buildings - Barkingside Investment Area

[59] Rounding means the sum of the individual buildings (11,429) does not match this total.

The diversified peak heat demand growth profile for the fully built out project opportunity is shown in Figure 35 below. As for other cases in this report, this indicates the diversified peak demand and annual consumption for the proposed network opportunity as a function of customer type and year of operation of the network[60].

The figure identifies a project start date of 2023, which is considered to be the most economically favourable time at which a network development could come forward, based on the identified development projections for the opportunity area.

The associated annual consumption as a function of customer type at full build out is shown in Table 27[61].

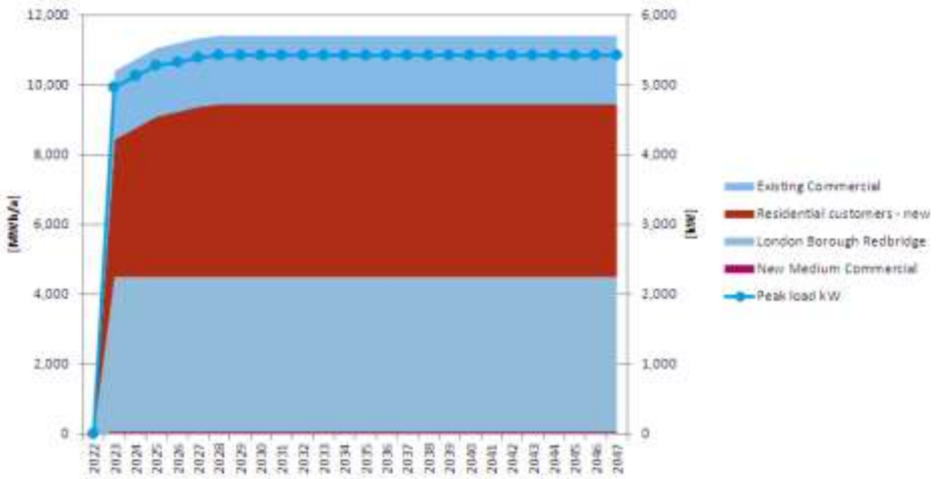


Figure 35: Diversified Network Peak Load and Heat Demand Profile by Customer Type – Barkingside Investment Area – Fully Built Out Project

Customer type	Heat demand [MWh/a]
New Medium Commercial	80
London Borough of Redbridge	4,426
Residential Customers – new	4,956
Existing Commercial	1,964
Total	**11,426**

Table 27: Heat Demand by Customer Type – Barkingside Investment Area – Fully Built Out Project

6.3 Energy Supply Opportunity

6.3.1 Proposed Fuel Source and Heat Production Mix

Gas fired CHP in conjunction with gas boilers has been identified as the preferred heat production equipment for the project opportunity. As for other identified opportunities this could potentially

[60] The dotted blue line shows the undiversified peak demand for all of the customer types. This has been calculated by summing the non-diversified demands for each customer type. The shaded, coloured areas of the graph show the contributions towards the cumulative diversified peak demand seen by the network due to each of the customer types.

[61] In this table, large and medium commercial are split according to predicted gas consumption, with the threshold gas consumption between the two being as defined in [14],[15]. This is done for the purpose of identifying the alternative cost of heat for these customers. The figure shows the 'connected loads' in each year as opposed to the demands associated with all identified buildings within the opportunity area. Refer to Appendix 3 for more information on customer types.

be supplemented with biomass or biofuel boilers, although the economics of this option have not been considered at this stage.

Based on the scale of the identified heat network opportunity, an energy centre of approximate size 600 m^2 would be required, accommodating a CHP with installed capacity of 1.5 MWe.

6.3.2 Energy Centre Location

As noted in Section 6.2 above, the energy centre housing the existing 70 kWe gas CHP engine located at the Fulwell Cross Leisure Centre is considered to be too small to accommodate the additional CHP capacity for the identified network opportunity.

On this basis, a new energy centre is proposed in the vicinity of King Solomon High School as identified in Figure 34.

6.4 Economic Appraisal

The results of the economic appraisal for the project opportunity identified in Figure 34 are shown in Table 28 and Figure 36 below for the fully built out project assuming an Electricity Licence Lite selling arrangement and a project term of 25 years.

		Fully Built out project
Total Investment CAPEX	[£ K]	10,502
Energy Centre CAPEX	[£ K]	4,069
Length of Heat Network	[m]	7,110
Cost of Heat Network	[£ K]	4,474
Connection CAPEX	[£ K]	750
Project Development Costs	[£ K]	1,208
Annual Operating Costs	[£ K]	1,132
Annual Revenues from Heat Sales	[£ K]	904
Annual Saving per year to LBR due to CRC savings	[£ K]	0.9
Weighted Average Electricity Sales Value from Project	[£ /MWh]	89.3 in 2023 and 124.5 in 2047
Annual Operating Margin at full build out	[£ K]	821
Annual Revenues from Electricity Sales, LEC and CRC values	[£ K]	1,049
IRR % over 25 years	[%]	4.1%
NPV at 6% discount factor	[£ K]	-1,830

Table 28: Key Economic Indicators - Barkingside Investment Area Project

The required capital investment for the fully built out project would be £10.5M.

The calculated IRRs for the fully built out project would be around 4.1% over 25 years, based on an Electricity Licence Lite arrangement. The corresponding NPV would be -£1.8M at a 6% discount factor.

The project will require a delayed project start in 2023, by which time most of the new developments would be complete, in order to optimise cashflow.

The electricity selling price required to deliver a 10% IRR for the fully built out project over 25 years[62] would be 13.9 p/kWh.

The annual saving to London Borough of Redbridge associated with reduction in CRC payments under the project would be £0.9K under the fully built out project[63].

Fuel savings would remain unchanged under the current modelling assumptions. This assumes that the project would charge London Borough of Redbridge its current heat price, which has been calculated to be 4.12 p/kWh excluding annualised reinvestment costs and 4.27 p/kWh including annualised reinvestment costs. The cost of electricity to London Borough of Redbridge is assumed to be reduced by 10% of its current value under any proposed Licence Lite arrangement.

A discounted cashflow forecast for fully built out project is presented in Figure 36. This is based on an Electricity Licence Lite arrangement.

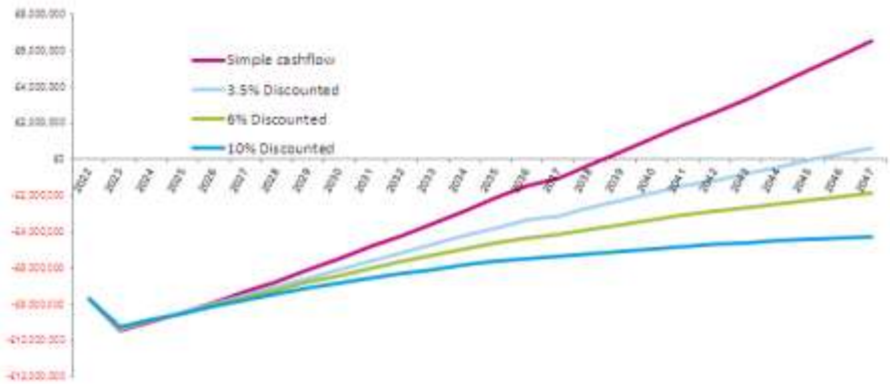


Figure 36: Cumulative Discounted Cashflow Forecast – Barkingside Investment Area – Fully Built Out Project – Electricity Licence Lite

6.5 Sensitivity Analysis

A sensitivity analysis has been carried out around the key variables that influence the IRR for the project. The results presented in Figure 37 are for the fully built out project under the Electricity Licence Lite scenario. Please refer to Section 2.5 and Appendix 3 for interpretation of this figure.

---

62 assuming all other variables remaining constant

63 The CRC benefit shown in the table reflects the benefit seen by the connected buildings rather than the benefit taken by the project. Refer to Appendix 3 for details of the assumed benefit sharing arrangement.

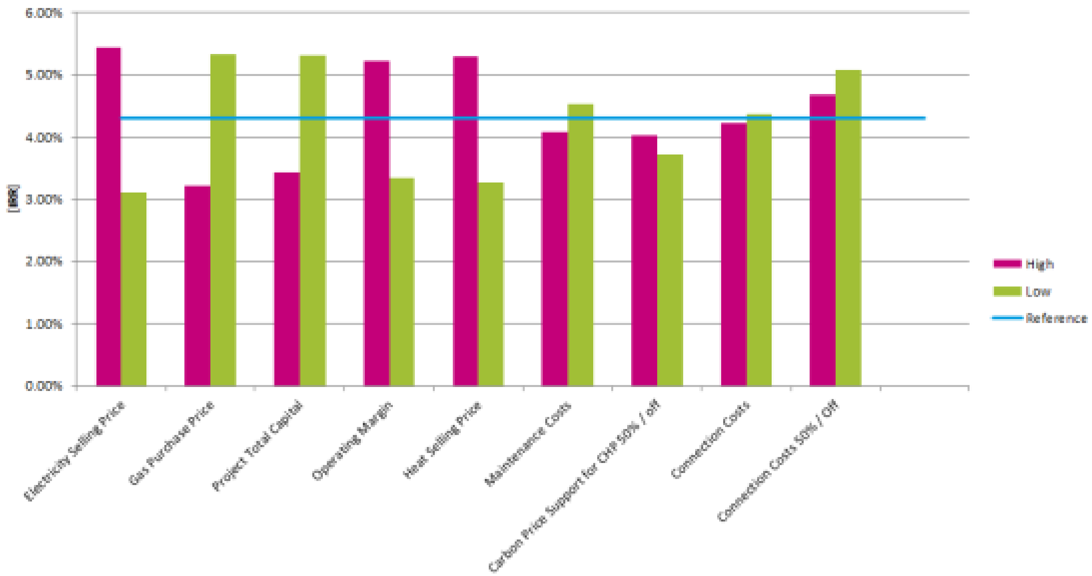


Figure 37: Economic Sensitivity Analysis – Barkingside Investment Area – Fully Built Out Project – Electricty Licence Lite

Key conclusions to be drawn from the sensitivity analysis are that:-

1) the project's economic performance (IRR) is highly sensitive to electricity selling price, gas purchase price, project capital cost, and heat selling price.
2) A 10% improvement in any of these indicated variables will not improve the project IRR to a point where it would become of any interest to a private ESCo or London Borough of Redbridge.

6.6 Implication for Project Procurement

There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Barkingside Investment Area.

The economic indicators for the project suggest that the Barkingside Investment Area project will not be economically viable and would be of no interest to a private sector ESCo or to London Borough of Redbridge.

The recommendation is therefore for this opportunity not to be taken up as a stand-alone project in isolation of other heat network opportunities.

6.7 Heat Supply Contribution

The heat supply contributions from each heat production asset under the identified network opportunity are shown in Appendix 6. These are shown as load duration curves, monthly supply profiles at full build out and cumulative supply contributions from each heat production asset as modeled for the fully built out project.

6.8 Carbon Appraisal

Projected carbon savings for the fully built out project over 25 years is presented in Table 29. Reference to the calculation methodology is provided in Appendix 3. Calculated carbon trajectories over the project lifecycle are presented in Appendix 5.

		DECC Grid Carbon Factor Unchanged	DECC Grid Decarbonisation Trajectory
Business as Usual CO_2 over 25 years	[TCO_2]	76,745	49,243
CO_2 Savings over 25 years – Fully built Out Project	[TCO_2]	14,617	-53,252
% reduction in CO_2 Savings over 25 years – Fully built Out Project	[%]	19.0%	-108.1%

Table 29: Carbon Emission Projections Barkingside Project

The table identifies a positive saving in CO_2 over the life of the project based on projections using current grid emission factors but a negative saving if the DECC decarbonisation trajectory is assumed, highlighting the limited role that gas CHP will be able to play in carbon reduction in the future if DECC's grid decarbonisation trajectory is realized in practice. If so, the annual CO_2 savings are positive up to 2024. See Appendix 5.

6.9 Route Identification and Risk Appraisal

A risk appraisal of the route has not been carried out since this project is not considered to be viable and is not recommended to be taken forward.

6.10 Summary

A summary of the key project parameters is shown in the table below.

		Fully built out 25 years	Cluster project over 25 years
Total Investment CAPEX	[£ K]	10,502	n/a
IRR % over 25 years based on Private Wire Arrangement	[%]	4.1	n/a
NPV at 6% discount factor based on Electricity Licence Lite	[£ K]	-1,830	n/a
CO_2 Savings over 25 years life of project relative to Business As Usual – Grid Factor unchanged	[TCO_2]	14,617	n/a
CO_2 Savings over 25 years life of project relative to Business As Usual – Grid Factor unchanged	[%]	19	n/a
Energy Centre footprint	[m^2]	600	n/a
Energy Centre CHP Capacity	[MW_e]	1.5	n/a
Length of Heat Network	[m]	7,110	n/a
Overall recommendation There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Barkingside Investement Area. The calculated economic indicators for the future development opportunity in Barkingside Investment Area suggest that the project would be of no interest to a private sector ESCo or to London Borough of Redbridge. The recommendation is therefore for this opportunity not to be taken forward.			

Table 30: Key Project Parameters – Barkingside Investment Area Project

7. PROCUREMENT ISSUES

The main procurement considerations around developing heat networks of the type identified in this report are discussed below. These should be read mainly in the context of the Ilford Town Centre and Ilford Town Centre and Crossrail Corridor projects which, based on the findings of this report, represents the most viable opportunity in which London Borough of Redbridge would be likely to play a proactive project development role.

7.1 Considerations for London Borough of Redbridge

There are a range of options for procuring district heating projects ranging from a fully private ESCo[64] based approach to a fully public sector based approach.

The appropriate procurement model for the projects identified in this report will depend first and foremost on the achievable IRR and London Borough of Redbridge's attitude to risk. If the project has an IRR of 10% or higher, the private sector is likely be attracted, subject to the level of risk involved, and the project could potentially be delivered without any direct involvement of London Borough of Redbridge. Equally London Borough of Redbridge may want to consider investing in the project in order to generate revenue for the Council to deliver on its underlying aims of carbon reduction, fuel poverty alleviation and realise savings in the form of reduced energy bills.

If the IRR of the project is below 10%, it is unlikely that the project will come about without involvement from London Borough of Redbridge. In this case, a fully public sector based approach or a partnering approach may be suitable. Minimum returns of 5-6% are likely to be required for the project to work, even under the public sector model to cover the cost of borrowing associated with the project (including any risk priced into the cost of borrowing).

Whichever model is adopted, the project will typically need to be financed through a combination of Debt and Equity. Debt is usually cheaper, and is likely to be in the order of 70- 80% of the total financing depending on project risk profile. Equity will normally be provided by the shareholders in the project in proportion to their shareholding.

7.1.1 Private sector ESCo Approach

Private sector based procurement models tend to involve ESCo's who will typically design, build, own and operate the heat network for a period of 25 years or longer. There are a number of private ESCo's operating in the energy market, that may have an appetite for investing in the project identified for Ilford Town Centre, Crossrail Corridor and Goodmayes outlier.

Ultimately the interest amongst these ESCos will be determined by the project IRR, which will need to be above 10% to incentivise the ESCo to borrow or invest against their higher cost of capital and their shorter payback requirements than the public sector could accept.

A private ESCo would arrange its own external funding, through capital reserves or through financing arrangements with banks or investors. This would be attractive to London Borough of Redbridge since it would not need to invest in the project and its capital reserves could be spent elsewhere.

Under this approach, London Borough of Redbridge would become a customer in the project and would potentially benefit from lower fuel bills within its connected buildings and reductions in CRC payments. However, it would not be able to realise any wider benefits and would not receive an income from the project.

---

[64] Energy Services Company – an entity who's core business is to provide heat and or cooling and or electricity to its customers.

Private ESCos tend not to invest at risk based on a future speculative opportunity that has not materialised and for which a heat sales contract has not been agreed. Therefore, any private ESCo's interest in the projects identified here may not materialise for several years until sufficient heat demand becomes available. London Borough of Redbridge has a role to play here in terms of helping to secure these future heat demands through local planning policy. This is discussed further in Section 10.4 of this report.

The scope for extending the project beyond the initial cluster identified may also be limited, since the ESCo would have little incentive to grow the project, unless higher IRRs could be achieved.

7.1.2 Public Sector ESCo Approach

Under the public sector model, London Borough of Redbridge could set up an arm's length trading company that operates as a discrete business but is able to return dividends from the project to London Borough of Redbridge, who would act as a shareholder in the company.

The company would create its own business plan and manage the project independently of other London Borough of Redbridge department functions. This would allow the company to borrow against its assets and revenue streams and, since debts are likely to be consolidated into the Council's accounts, the financial risk could be contained within the project company.

The company could access its equity requirement through reserves, prudential borrowing at close to public sector rates, grants and should also be eligible for low cost borrowing from the Green Investment bank. It may also be able to attract capital contributions through Community Infrastructure Levy / S106 agreements and income through Allowable Solutions if London Borough of Redbridge is set up as a provider to allow it to do so.

Because of State Aid rules, London Borough of Redbridge would not be able to offer lower heat prices to private customers within the project as a result of its lower cost of borrowing, since this would constitute unfair competition against private energy companies. The heat selling price would therefore need to factor in the impact of grants and assume private sector interest rates.

However, public sector consumers and council tenants within the project could benefit in this way, which is where additional value would arise for London Borough of Redbridge and where the opportunity to alleviate fuel poverty within the borough could be realised if applicable.

The project could be procured as design, build and operate, contracted out to the private sector in order to pass through technical and financial risk. Elements of the assets carrying the highest risk could also be held by the private sector under manufacturer financing arrangements or forward revenue purchase deals from banks.

As an equity investor London Borough of Redbridge would be in a position to retain control over the strategic direction of the project. This would allow London Borough of Redbridge to extend the project over a number of years in order to realise greater carbon benefits and potentially achieve greater savings in energy costs. It might also realise its wider socio economic goals of alleviating fuel poverty, creating jobs and attracting investment to the area.

7.1.3 Public Private Partnership Approach

Under a Public Private partnership based approach risk could be shared between the public and private sectors, placing it where it can best be managed. The project vehicle could be structured as a joint venture or as special purpose vehicle in which each party holds a shareholding. London Borough of Redbridge could guarantee the anchor heat loads within its control as a way of reducing off-take risk to the private company and could de risk (although not guarantee) new connections though the planning process (i.e. strongly encourage developers to connect to the project). In addition, London Borough of Redbridge could access its share of the external capital required at the lower rates than the private sector, making the overall required hurdle rate of the project lower than the fully private sector based approach. The private sector would bring additional finance and would use its expertise to minimise design, construction and operational risk. London Borough of Redbridge would not be required to underwrite or guarantee revenues or interest payments to the private sector under this approach.

7.1.4 Summary of Advantages of Each Approach

A summary of the advantages and disadvantages of each approach is presented in the tables below.

Private ESCo Model	
Opportunity	**Risk**
The private company will bring substantial technical expertise and project management skills, ensuring a low risk solution is delivered enabling the ESCo to carry the technical risk. The ESCo can invest and maintain ownership and operation over the long term, carrying the financial risk and leaving London Borough of Redbridge free of risk. It represents the lowest risk approach for London Borough of Redbridge. If London Borough of Redbridge secures long term Power or Heat Purchase Agreements (PPA/HPA) these can mitigate some of the risks that they assume through the provision of power price guarantees.	The project timescales and development uncertainty will deter the private sector, particularly given the identified rates of return for the project(s). The private ESCo will not invest at risk and the scope for growth of the project may therefore be extremely limited. Energy charges to the Council as a customer to the project(s) will be higher than for a Council owned project(s), since the private ESCo will require higher rates of return than the Council would. London Borough of Redbridge will have very little influence, control over the project(s) and their future development other than through the initial contract. Performance requirements could be written into the contract, to require the ESCo to understand the vision and anticipate future requirements. London Borough of Redbridge will miss the opportunity to raise an income from the project(s) and meet the needs of its fuel poor tenants in the borough. London Borough of Redbridge may need to consider providing heat price, heat demand or power price guarantees, if financial performance of the project without guarantees does not meet private sector return requirements. This will enhance the credit quality of the revenues of the project, enabling the private sector partner to secure project finance debt, achieving lower cost of investment overall than investing by themselves.

Table 31: Opportunities and Risks - Private Sector ESCo Model

London Borough Of Redbridge Project	
Opportunity	**Risk**
Council ownership and control would ensure London Borough of Redbridge is able to align the project with its social and environmental policy objectives. Council ownership facilitates the process of obtaining finance, and at a lower cost compared to private sector borrowing. The project(s) can be used to support the delivery of other services, e.g. pooling facilities management (FM) activities, within the London Borough of Redbridge's remit. Future expansion of the project(s) can be co-ordinated and controlled by the London Borough of Redbridge. By putting the operations of the project into a Special Purpose Vehicle[65] (SPV), the ability to vary the future capital structure of the project is enhanced, i.e. London Borough of Redbridge could divest its interests more easily. Using different SPV's to retain operations of the network and to run the energy centres would allow London Borough of Redbridge the future option of involving the private sector funding for part of project, whilst being able to retain control over the future extension of network.	The project company is reliant on the financial strength of the London Borough of Redbridge and it will remain on the London Borough of Redbridge's balance sheet. London Borough of Redbridge therefore carries financial risk, which it might not have the appetite for. London Borough of Redbridge is unlikely to be technically competent to operate the project(s) without expertise from the private sector A large amount of capital investment is likely to be required, which could otherwise be spent on other services. The Council will inherit an asset that it will need to maintain in the future. Capital will be locked into the project(s). If there is changing political control within London Borough of Redbridge (eg changes to budget allocations) the future of the project(s) may become uncertain. London Borough of Redbridge will need to manage and maintain the assets to avoid deterioration and becoming a financial burden on London Borough of Redbridge. Loans may need to be secured against London Borough of Redbridge's total revenues, not just the Project revenues. State Aid rules yet to be properly verified.

Table 32: Opportunities and Risks - Local Authority Model

[65] An entity created to facilitate the delivery a specific project.

Public/private sector partnership (special purpose vehicle)	
Opportunity	**Risk**
Risks are allocated to those most able to deal with them. The London Borough of Redbridge can remain involved as a major stakeholder, allowing it to maintain close alignment with the socio-environmental aims of the public sector and draw on the benefits identified above under the public sector based model. The approach offers a greater flexibility than either wholly public or private project(s). The project(s) can access capital at lower cost than purely private sector project(s) thereby allowing lower IRRs to be achieved. By putting the operations of the project into a Special Purpose Vehicle, the ability to vary the future capital structure of the project is enhanced, i.e. London Borough of Redbridge could divest its interests more easily.	A degree of risk remains with London Borough of Redbridge and liabilities would remain on the Council's books. Public sector procurement procedures apply, making procurement more complex and expensive than for a purely private sector based approach. Loans may need to be secured against London Borough of Redbridge's total revenues, not just the Project revenues. State Aid rules yet to be properly verified. London Borough of Redbridge's control of the project limited to the rights attached to its equity investment in the partnership. Apportioning risks/rewards to each party in the joint venture is complex and requires lengthy negotiations.

Table 33: Opportunities and Risks - Public/Private Sector Partnership Model

8. BARRIERS, RISKS AND OPPORTUNITIES

The main barriers and risks around developing heat network opportunities are discussed below. These should be read mainly in the context of the Ilford Town Centre Project which, based on the findings of this report, represents the most viable opportunity in which London Borough of Redbridge could/would play a proactive project development role.

These risks generally lie with the project company, which may or may not include the London Borough of Redbridge, depending on the future structuring of the project opportunities, as discussed elsewhere in this report. Suggested risk mitigation measures are identified in this chapter where appropriate.

The overall investment proposition will be determined around the risk factors discussed. The cost of borrowing for the project will reflect the degree of risk perception that the project has. In order to maximise financial performance it will be important to minimise risks and thereby attract a low cost of borrowing for the project. This will reduce the level of interest paid on any loans associated with the project, allowing greater profits to be retained from the operating revenues.

8.1 Project Development Risk

8.1.1 Risks

The main risks associated with the project development phase are:-

a. Financing risk ~ whether the project can attract finance, whether investors are willing to invest based on the perceived levels of risk due to other factors.
b. Design risk ~ whether the project is fit for purpose, performs as expected, is correctly dimensioned (i.e. not over or undersized) and is able to meet the demand under all operating conditions.
c. Technology risk ~ whether the technology is bankable.
d. Planning risk ~ whether the project will achieve planning due to visual impact, noise, air quality impact, transportation impact during construction and operation, land designation issues.
e. Heat Offtake risk – whether the customer base on which the project relies for its payback can be secured.
f. Procurement and Governance Risk ~ exposing London Borough of Redbridge to excessive construction risk (i.e. whether the project overruns and incurs delay, and whether there is capital overspend), forgoing ability to influence future control and development of project due to inadequate share of project ownership.

8.1.2 Mitigation Measures

Mitigation measures that London Borough of Redbridge can implement to reduce the level of risk at the next stage are to:-

<u>Financing risk</u>

a. Undergo business and financial planning. Establish the preferred delivery structure, for the project, identify funding streams and develop a detailed financial model and business case to present to investors.
b. Establish funding sources and mechanisms to raise revenue to support the project and minimise the need for external financing, or financing through London Borough of Redbridge's capital reserves (for example use of developer connection charges, CIL /S106, allowable solutions).
c. Establish Heat Purchase Agreements with anchor heat loads.

d. Engage early with potential project partners to establish appetite for involvement.
e. Consider owning a stake in the network, which could be divested later once the project is fully operational and generating positive incomes.
f. Conduct further technical feasibility work to minimise design risk, technology risk, planning risk etc. before engaging with the market and before seeking to raise finance.
g. Establish commercial arrangements for netting off. Maintain a watching brief on developments under Electricity Licence Lite and consider adoption of a Electricity Licence Lite once the project concept has been tested and implemented successfully.

Design risk

h. Carry out initial route proving and verification to minimise the amount of risk passed to the private sector. Carry out detailed route planning and safeguard identified routes.
i. Place design risk with private partner or outsource design to specialist organisation.
j. Safeguard land for the location of a future energy centre.
k. Conduct further feasibility work to assess technical suitability of key anchor loads to connect
l. Ensure new developments are designed with the ability to connect.
m. Ensure early involvement of future operators in the design of the project to ensure best practice design is adopted.
n. Minimise exposure to operational losses through a phased approach to development, with the network and heat production units installed as and when new developments are able to connect.
o. Ensure network and energy are sized for capacity at full build out.

Technology risk

p. Minimise technology risk through adoption of bankable technology.

Planning risk

q. Carry out further feasibility work around the impact of identified energy centre options in relation to planning.
r. Safeguard the proposed network route and energy centre locations within the planning framework.
s. Consider implementing a Local Development Order to facilitate the process of installing the heat network[66]. Without an LDO in place, expansion of any 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 can 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.

Heat Offtake risk

t. Guarantee anchor heat loads within London Borough of Redbridge’s control as heat customers for the initial project

[66] Local Development Orders (LDO) can be used to facilitate deployment of heat networks. Such orders allow Local Authorities to create a blanket planning permission for constructing heat networks without the need for specific planning applications at each stage. This can 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, an LDO can 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.

u. Conduct feasibility assessments to ensure technical ability to connect these buildings to the project.
v. Secure future heat customers within London Borough of Redbridge's control at the time that their heating assets are due for refurbishment
w. Require new developments to be designed to connect to the heat network through the planning process[67].
x. Ensure that new developments are designed to a common standard to ensure their internal heating systems are compatible with the future heat network. Developer guidelines should be disseminated to developers through planning process to support this.
y. Engage early with external stakeholders to secure them as potential customers (for example Ilford Mall).

<u>Procurement and Governance Risk</u>

z. Seek expert advice on how to structure a public private partnership including risks/reward sharing, governance arrangements, contract structure, voting powers, liability etc.
aa. Structure procurement so that exposure to construction risk is minimised[68].

8.2 Project Performance risk

8.2.1 Risks

The main risks associated with how the project performs financially in the operational phase are:-

a. Supply and Operational Risk ~ maintaining an agreed level of heat supply to customers, exposure to high operation and maintenance costs, high plant replacement costs, unforeseen deterioration of plant due to poor maintenance.
b. Customer Credit Risk ~ exposure to payment defaults and bad debt.
c. Price risk ~ risk of shortfall in commodity supplies, fuel price escalation, exposure to falling energy prices from competing sources.
d. Revenue Risk ~ exposure to uncertain electricity prices, exposure to heat offtake risk, exposure to uncertainty around future policy support for project (or for business as usual alternative that would compromise ability of project to sign up new customers in the future).
e. Policy Risk ~ uncertainty around future government policy in relation to support for district heating and gas CHP and for alternative fuel sources that would compete with the proposed heat network for new developments[69].

8.2.2 Mitigation Measures

Partnering with the private sector will reduce exposure to most forms of performance risk since the partnering organisation will bring technical and commercial expertise including standard heat supply contracts, billing structures and capital and resources to the project. Mitigation measures that London Borough of Redbridge could consider include:-

---

[67] i.e. be DH ready and to design block level heating systems around a single plant room with facility to connect to the heat network. Refer to Appendix 4 for more detail.

[68] Examples of typical procurement models operating in the market include Design, Build, Finance, Own, Operate and Design, Build, Operate

[69] A project planned on the basis of achieving a heat price comparable to the alternative counterfactual scenario involving heat pumps for example may not stack up if RHI support is extended to heat pumps, or if future support to fuel cells, micro chp etc. makes the heat network unable to compete. Similarly uncertainty over projected grid decarbonisation (as a result of unclear policy around electricity mix after 2031) creates uncertainty over the carbon savings that the project will achieve and therefore the value of the heat to developers as a method of complying under the allowable solutions framework. Continuing uncertainty around future government policy in relation support for gas CHP under the Electricity Market Reform proposals as well as the future for Electricity Licence Lite creates uncertainty in achievable income from electricity sales and therefore operating margins from the project.

Supply and Operational Risk

a. Outsourcing operational risk to the private sector, which is best placed and most experienced to be able to deal with it.
b. Considering risk sharing based approach with the operations provider to incentivise them to maximise operational efficiency and minimise operating costs.
c. Ensuring performance guarantees and penalties are included within the contracts with the operations provider. Ensuring warranties and product guarantees are provided by sub suppliers. Adopting fixed price performance penalty linked contracts.
d. Minimising exposure to heat supply risk through design. This can be addressed through redundancy in plant and equipment, provision of temporary emergency plant, use of pipe surveillance systems, securing maintenance contracts with appropriate performance guarantees etc.
e. Establishing a sinking fund to cover the plant reinvestment costs.
f. Incentivising customers to reduce return temperatures by offering lower cost heat as a way of improving overall system efficiency and reducing overall cost of heat to customers.
g. Avoiding external factors that influence the ability to maintain the contracted level of performance such as secondary side water quality fouling etc., poorly operating controls etc. by designing for indirect connections to buildings[70].

Customer Credit Risk

h. Billing and bad debt risk is not likely to be a significant issue for the identified projects. The risk is considered most likely to arise in the residential new build sector. The most effective way to manage risk for these customers would be for the project company to enter into heat supply contracts with freeholders/landlords as opposed to with individual dwellings within the developments.

Price risk

i. Managing exposure to changes in fuel prices by linking heat selling price within contracts to a basket of alternative fuel prices available on the market.
j. Minimise exposure to fuel price volatility through long term supply contracts for volume and price.
k. Consolidating the purchasing of fuel with other council functions or with other local authorities.
l. Using multiple fuel sources to reduce exposure by allowing switching of fuel source according to price factor variations.
m. Using thermal storage to minimise heat production costs

Revenue Risk

n. Incentivising customers to connect to the project and to remain connected through lower heat prices than their alternative case.
o. Maximising value of electricity through Electricity Licence Lite
p. Using thermal storage to maximise revenues from electricity generation
q. Minimising exposure to future uncertainty in revenues by phasing project expansion according to future development.
r. Ensuring low carbon alternative fuel supply in place for project over medium to long term.

---

[70] It is common for the network operator to own and maintain the heat exchanger stations and be responsible for delivery of the commodity (i.e. heat) at a defined temperature and flow rate on the secondary side of the heat exchanger.

Policy Risk

s. Policy risks need to be tracked by continually monitoring developments in Government policy and reviewing project proposals in the context of these policy updates. In particular, government policy developments in relation to building regulations, renewable heat incentive, Zero Carbon Homes and Allowable Solutions, support to gas CHP under Electricity market reform, Electricity Licence Lite could all directly influence the project proposals. Green Deal and Eco are considered to be less significant, since the projects do not involve existing residential housing stock, although the Green Deal is not limited to just residential buildings.

8.3 Risks specific to Ilford Town Centre and Ilford Town Centre and Crossrail Corridor Projects

The long development timescales present a significant development risk to the project. It is unlikely that the private sector would be willing to invest speculatively on the basis of unknown future heat demands and any financial institution lending to the project would reflect any such risk in the cost of capital, which would be passed back to the project making it more expensive to implement.

It is vital that any initial cluster project developed by London Borough of Redbridge is financially viable without being reliant on income from future heat sales that may never materialise.
Even if the fully built out project is not developed until all developments are in place, the need to safeguard for future expansion will require additional funding at construction of the cluster project.

Future expansion of the project will depend on whether the future development proposals materialise. Commercial market factors may delay or even deter private developers from building according to the development projections on which the project has been planned.

Although London Borough of Redbridge can require developers to be ready to connect to the network, it cannot force connection upon new developments. Therefore the future growth and ultimate scale of the project will be highly dependent on the future housing markets and the broader economic climate. Since there is no requirement for future customers to connect, the business case for doing so will need to be continually evaluated as potential new customers become available.

The large number of stakeholders involved in the initial cluster phase of the project presents a risk in relation to developing a secure bankable customer base for the project.

The costs and differing timescales associated with refurbishment of existing internal heating systems in the numerous existing buildings making up the cluster project makes the availability and phasing of future revenues from these buildings difficult to predict and depend upon in any business case proposition. There remains uncertainty about the technical suitability of many of the identified commercial and private existing buildings since stakeholder responses have not been forthcoming. The modelling has assumed that these buildings would be willing to connect from 2014/15. In practice, recent heating system upgrades to some buildings and lack of internal funding to carry out any necessary modifications may prevent this from happening as quickly as assumed or at all.

Risks to the project around future developments in government policy will affect decisions that developers and existing building owners make. For example factors such as building regulations, zero carbon homes policy, financial and policy support mechanisms to gas CHP and alternative technologies with which it will need to compete will affect project viability. Similarly uncertainty around future grid decarbonisation will have an impact on the future role for gas and the choice of alternative building scale technologies taken forward by developers.

8.4 Risks specific to Goodmayes Outlier Project

Several of the risks identified for the Ilford Town Centre and Ilford Town Centre and Crossrail Corridor Projects also apply to the Goodmayes outlier project. In addition the following considerations apply.

A key barrier to this project opportunity is the timescales for the development proposals. The Trust has a short to medium term objective to address in terms of resurrecting the existing CHP engine or adopting an alternative heat supply solution that would involve decentralising the existing energy centre.

On the other hand, any business case around a wider heat network would require certainty around the future heat demands which are not expected to come forward until the early 2020's at the earliest.

The case for a heat network based around the existing CHP and connecting existing buildings only appears to be viable, based on a private wire electricity selling arrangement and utilization of the existing heat production assets at King George's hospital. Therefore a cluster project could be established on this basis until such a time that the new developments come forward and a business case can be established around connecting these developments.

This could potentially include the involvement of an ESCo who would own and operate the project under a concession agreement or could involve the Trust retaining ownership of the project and selling heat to third party customers in much the way it has done to date with Goodmayes hospital.

There is uncertainty around the cost and technical viability of retrofitting heating systems to the proposed flats in Goodmayes, since this is a listed building. Indeed its listed building status may prohibit this altogether. Equally, there is uncertainty around the future plans for Redbridge College and the extent to which it will decant to another location.

The opportunity to reduce the operating temperatures of the existing MTHW heat network at King Georges hospital may require investment which has not been accounted for in this study, and the Trust's alternative proposals for the site may be more attractive to them both in economic and non-economic terms and from a wider development perspective.

Future expansion of the project will depend on whether the future development proposals materialise and indeed whether the site's Green Belt status is reviewed and becomes available for alternative uses. Equally the commercial drivers and changes in government policy discussed in the previous section will also affect when and how much of the development coming forward is likely to connect to the project. As noted above, although London Borough of Redbridge can require developers to be ready to connect to the network, it cannot force connection upon new developments.

London Borough of Redbridge can influence the level of risk around the development opportunity by requiring developments to be designed to connect to a district heating network, bringing forward the development timescales for the proposed new schools, minimising the number of developers to whom the residential sites are sold and influencing the development massing, all of which ultimately affect risk and economic payback.

8.5 Risks Specific to Barkingside Project

These have not been addressed since the project is not considered viable. Refer to Section 6.

8.6 Generic Factors Associated with Heat Network Routing and Route Identification.

8.6.1 Permissions and Wayleaves

Wherever possible, public land under London Borough of Redbridge's control should be used for routing the network. Based on discussions with the Highways department in London Borough of Redbridge, the Highways Agency's jurisdiction is understood not to extend into any of the areas included in the study.

In order to route the network across privately owned land (both commercial and residential) landowners will have to give permission. This will have to be formalised within a wayleave agreement. Negotiation could be a lengthy process and will involve some form of reimbursement for the landowner.

Any routing of the network within the exclusion zones of Crossrail, Network Rail or TfL owned assets or land will also require relevant approvals which could potentially be a lengthy and expensive procedure. This will be a potential issue for the Ilford Town Centre project in particular. Design studies will need to be undertaken to demonstrate that the proposed activities would have no impact on the rail systems and significant restrictions can be expected during construction where this takes place. Network Rail, TFL and Crossrail should be consulted early to determine and plan for mitigating the risk.

The identified routes have sought to minimise the need to use private land and TfL owned land for routing the network. However detailed consideration of land ownership issues will be required at the next stage of the project.

8.6.2 Utilities

Existing utilities will introduce physical barriers to installing the heat network. Usually these can be overcome without undue difficulty, but it is important to realise that the uncertainties around the presence of existing utilities present a significant construction risk to the projects in relation to delay, and cost of delivery. If this risk is passed to the private sector it is likely to be handed all the way down to the contractor and the project will ultimately incur a higher development cost, since the risk borne by the contractor will be priced in to their fee.

Initial network route proving can and should therefore be carried out by London Borough of Redbridge and/or the Project Company in order to de-risk as far as possible the impact of utilities prior to going to procurement. In general, a best value approach should be sought whereby the risk is placed where it can best be managed, so that the overall price risk is minimised for the project.

Consultation will be required with the relevant authorities at the feasibility stage. Initial enquiries with the Highways department in London Borough of Redbridge has identified that no information is held at the local authority and it has not therefore been possible to consider the impact of utility congestion on the identified route proposals at this stage. Based on the GIS information provided by London Borough of Redbridge, there are no concerns associated with the 275kV gas transmission network routes in relation to the proposed network routes.

8.6.3 Traffic Management

Routing of the heat network will create traffic management issues such as the need to suspend parking bays, divert bus routes and introduce contraflows and diversions.

The identified routes have sought to minimise the impact on traffic management issues. However detailed consideration of traffic management will be required at the next stage in liaison with the Council's Highways team.

8.6.4 Other

A number of other issues such as nature conservation, archaeology, sites of special scientific interest may cause concern in relation to the route. Consultation with the appropriate bodies will be required. An indication of the extent of archaeological activity in the area has been established through the GIS data provided by London Borough of Redbridge. Based on the high level review carried out using this data a section of the Ilford Town Centre network and the Crossrail Corridor are within an archaeology priority zone and could therefore add risk to these projects. The Oakfields area is also within an archaeology priority zone but, since the site is being developed anyway, the additional risk associated with a decentralised energy project is not deemed to be highly significant, particularly since utility infrastructure would need to be laid in any case.

9. EXISTING AND FUTURE SUPPLY OPTIONS APPRAISAL

9.1 Overview

This section of the report discusses the existing and future supply options for each of the identified network opportunities.

The Crossrail Corridor opportunity is considered as part of the Ilford Town Centre opportunity, since Sections 3 and 4 of this report have concluded that no viable opportunity appears to exist for Crossrail Corridor unless this is developed as part of the Ilford Town Centre project.

Although Section 6 of this report concludes that the Barkingside Investment Area opportunity appears to be non-viable from an investment perspective, a summary of possible alternative / future energy supply options for the opportunity area has been considered in the context of a heat network that could come forward in the future.

This basis for adopting this approach is that future changes to the existing development plans presented in [8] or indeed additional development plans beyond those considered in [8] may alter the conclusions of the present report.

9.2 Ilford Town Centre and Crossrail Corridor Project

There is no indication from the ELWA Joint Waste Development Plan Document (adopted February 2012) of any future opportunity sites in Redbridge for thermal treatment of waste or any Anaerobic Digestion based opportunities. The existing sites identified under Schedule 1 of the ELWA Joint Waste Development Plan Document include the existing household waste amenity site and materials recycling treatment facility in Ilford Town Centre (Ilford Recycling Centre), but this is not indicated development opportunity and it is understood that this will be retained as a recycling facility for the foreseeable future.

There are no significant industrial heat users in the immediate vicinity of the opportunity area that could supply heat into a heat network. There are no identified sewage treatment works within the vicinity of the opportunity area that could potentially give rise to opportunities for heat recovery through heat pumps or biogas generation.

The potential for harnessing industrial waste heat is considered to be negligible based on existing industrial users in the vicinity and known future development proposals for the area. There are no known proposals for new data centres either consented or in planning within the opportunity area that could give rise to the opportunity to recover low grade heat from associated cooling systems. Although an existing data centre is known to exist, it is considered to be highly unlikely that an opportunity exists to exploit the use of this heat.

The potential for electricity generation from biomass is considered to be negligible, due to a combination of reasons including commercial viability at the required scale of deployment, space constraints for establishing a plant, air quality impact, and traffic management issues associated with fuel transportation.

The current proposal for the energy centre relies on gas fired CHP with gas fired back up boilers. In the future, one or both of these heat supply technologies could be replaced or supplemented with bioliquid fuelled alternatives, Biofuel CHP and heat only boilers are both currently established technologies with proven operating track records.

However, the availability, price, transportation costs and sustainability credentials of biofuels are currently such that the technology is not widely deployed at the present time. Biofuel remains an option for the future, subject to suitable access to a sustainable fuel source being available at the right price and one that can also attract Renewable Obligation Certificates to make the marginal cost of heat and electricity production acceptable. However, it should be recognised that competition with the transportation sectors is always likely to make the fuel commercially unattractive for the generation sector at the scale appropriate to the Ilford Town Centre Project. Nevertheless, safeguarding for future adoption of this technology is relatively straightforward and it is recommended that this is carried out if the project is taken forward.

Similarly the existing proposal for gas CHP could be replaced or retrofitted to operate on biogas in the future. Since there is no realistic opportunity to generate biogas locally and since transportation of biogas is expensive, such an option would, in our view, be subject to fuel availability through bio methane injection into the national gas grid. The extent to which and timescale over which a bio methane grid becomes available will determine the viability of this option. Safeguarding for future adoption of this technology is relatively straightforward and it is recommended that this is carried out if the project is taken forward. This can be achieved by specifying a dual fuel unit from the outset, adjusting the engine operating parameters at a future time or by installing a new engine in the future. The key is to safeguard space in the energy centre for doing this.

The proposed gas fired boilers could be fitted with duel fuel burners (biofuel) to allow them to be switched to bio-fuel in the future if this becomes economically viable and sustainable fuels can be sourced.

Biomass heating is a currently employed technology that could be integrated into the heat network now or in the future and with or without gas CHP. Biomass heating in conjunction with heat networks is currently deployed in many projects across Europe, UK and elsewhere. The technology is simple, commercially proven, low risk and commercially viable on the basis of support under Renewable Heat Incentive (RHI) and current fuel prices. Biomass heating is often deployed in conjunction with gas CHP, operating as second tier supply and typically contributing around 10% of the energy supply to a project. Barriers to adopting this technology include mainly fuel storage and transportation requirements and air source emissions, both of which would require planning approval from London Borough of Redbridge.

Fuel cell CHP could potentially be installed at the proposed energy centre in the future, subject to commercial viability. Safeguarding for future adoption of this technology is relatively straightforward and it is recommended that this is carried out if the project is taken forward.

Solar thermal is a currently available technology that could be integrated into the heat network now or in the future and with or without gas CHP. There are several examples of projects emerging in Denmark where ground based solar arrays are being used to capture energy for use in district heating projects. When integrated with inter seasonal storage, these systems can increase solar fraction from around ten to twenty per cent to fifty or sixty per cent, significantly improving project economics. Inter seasonal heat stores in this context typically involve borehole, aquifer, cavern or buried tank based thermal stores that can be charged and discharged on a seasonal basis in order to capture surplus heat from solar arrays in summer and use this heat in winter to displace fossil fuels when there is sufficient demand for the heat.

Collection of heat from the systems can take a number of forms. Most commonly these include ground collector pipe networks embedded within car parks or solar panels. The particular application determines the achievable temperatures and the associated network configuration[71]. For example, heat can be injected into the return of the network or used in conjunction with extra low temperature heat networks supplying simultaneous heating and cooling to new

[71] Temperatures of up to 90 degree C have been achieved in Denmark using flat place solar panels

developments (typically involving a mix of buildings) and using aquifer, borehole or cavern thermal storage concepts. Building mounted collectors can also be used at building level, but these tend to offset the requirement from the heat network rather than supplement the supply from the network. From the perspective of the Project Company operating the heat network, building mounted solar thermal therefore detracts from the business case rather than adding to it.

Space availability for integrating solar thermal into the heat network is likely to be limited however due to the density of development and the limited access to space for constructing a centralised array. Rooftop solar thermal could be used to displace heat demands at the building interface, although contributions will generally be very small (due to building heights) and would arguably be better served by solar PV (in order not to displace CHP heat and since greater CO2 savings per m2 of roof space can be realised in this way).

Opportunities for capturing waste heat from cooling systems within both new and existing developments may exist and may present a case for inter seasonal heat storage. The economics of such a proposition would need to be tested in greater detail at feasibility stage.

9.3 Goodmayes Outlier

The future supply options presented for Ilford Town Centre are largely applicable also to the Goodmayes Outlier project. The proposed safeguarding and retrofitting measures could be applied equally to both projects.

In addition, an extra low temperature heat network based around an aquifer seasonal storage concept is an interesting possibility that should be considered further at the next stage. The site appears to offer several opportunities that make this concept worth exploring in more detail. These include large space availability for incorporating solar collectors, a scale and mix of developments that offer both heating and cooling requirements, the presence of an aquifer at around 70m depth [ref British Geological Survey] and the opportunity to recover waste heat from the existing chillers at King George's hospital. Such a system could supply elements of the new development (for example the schools and the new terraced housing) and could integrate solar thermal through central ground or roof mounted solar arrays and potentially heat from a gas fired CHP as well. A reasonable balance between heating and cooling would be required however and the application would rely on the use of new build only (with appropriately designed heating and cooling systems). The carbon and economic benefits of such a project would also need to be assessed carefully and may not achieve significant savings in CO2 until the electricity grid has decarbonised sufficiently.

Provision for the future uptake of an extra low temperature heat network would impact on the current heat network design and might add development costs that might compromise project economics in the early years. The economics of such a proposition would therefore need to be tested further at feasibility stage if the project is taken forward and once firmer development proposals are available.

Schedule 1 of the ELWA joint Waste Development Plan Document identifies an existing clinical waste incinerator at Goodmayes Hospital with a permitted annual Tonnage of 7000 tonnes (operated by Clinical Waste Ltd). Such an asset could potentially be of interest in terms of supplier into a heat network. However, North East London NHS Foundation Trust, Goodmayes Hospital has indicated that this incinerator is no longer operational and that there are no future plans for introducing new incineration capacity at the site. This is not therefore considered to be an opportunity to pursue further.

9.4 Barkingside Investment Area

The future supply options presented for Ilford Town Centre would be largely applicable to a future heat network opportunity in Barkingside Investment Area.

Unlike for Goodmayes Outlier, an opportunity does not appear to exist around an extra low temperature heat network in conjunction with inter seasonal storage. The scale and density of the demand, along with the limited cooling requirements across the site suggest that building scale heat pump solutions involving inter seasonal storage are likely to be preferable to a centralised concept based on a community heat network.

It is recommended of this report that developers in the Barkingside Investment Area are therefore required to consider such options given that a community heat network is not considered viable for the site.

There is a significant amount of green space available in the vicinity of Fairlop which could potentially yield opportunities for other future low carbon heat sources. The key options are summarised below. Any development would clearly require release of land from the green belt and would need to be considered in the planning context as well as in the context of the alternative opportunity cases (e.g. development of homes, commercial space etc.), which is beyond the scope of this report.

In principle a waste to energy facility or biomass CHP could come forward in the area. This would require a minimum scale of deployment to achieve commercial viability and would rest on the ability to secure a use for the waste heat from the process. Based on current known development projections within the vicinity of the site, these opportunities will simply not materialise over the coming years, unless they do so on the basis of not being required to implement CHP, which is considered to be highly unlikely given current GLA policy. The scale of the opportunity at Barkingside is far too small to support these CHP technology options[72] and any development of this type would therefore rest on a wider strategic heat network opportunity coming forward.

Viable waste streams for a waste to energy facility could include commercial food waste, source segregated residential food waste (i.e. collected separately from households under local Council recycling projects) and commercial and industrial waste, including Solid Recovered Fuel (SRF). The commercial development of any such an opportunity would rely on either:-

1) a waste provider securing a long term waste contract to handle waste from ELWA or another Waste Authority in London (it is noted that renegotiation of the ELWA contract is due in 15 years' time) or

2) a merchant facility setting up and sourcing waste through private contracts (commercial and industrial waste, animal waste from local farms etc.).

Local biomass sources for use in biomass CHP could potentially include straw (collected from outside the M25 area), pellet, wood chips derived from construction waste and virgin biomass in the form of pellets imported from further afield. The main technologies that could be conceived in this context are steam cycle CHP based on moving grate technology, gasification / pyrolysis[73]

---

[72] Requiring significant land allocation for construction and operation of the plant, waste handling, fuel storage etc.

[73] The future viability of this technology remains to be proven, although it is reasonable to suppose the technology may be proven when considered over a 15 year timescale into the future. The technology is currently unbankable at this scale, suffering from on-going problems with reliability in relation to tar formation from the gasification process.

coupled to gas engines and organic rankine cycle CHP. It is worth noting that each technology only stacks up commercially at the correct scale and that technologies such as gasification / pyrolysis are yet widely considered to be bankable at scales relevant to the projects.

There are a number of historical landfill sites in the vicinity of the project. The most interesting of these lie immediately to the east of the site. The former Fairlop Airfield site was closed in 1984 (having operated since 1958) and comprises inert, commercial and household waste. Adjacent to this, Aldborough Hatch Farm, which closed in 1988, also comprises inert, commercial and household waste.

Both opportunities might potentially be suitable for implementing biogas CHP from landfill and it is noted that control measures are in place at the Aldborough Hatch Farm, suggesting ongoing activity at the site. Further investigation is recommended, at the next stage, although the sites are likely to require exploitation in the short to medium term since they are approaching the end of the window of opportunity for extracting useful methane (around 30 years from closure).

Bordering the above mentioned sites is Fairlop Quarry, a licenced site currently operated by Brett Lafarge Ltd. Dealing in inert waste only (A05), this site is not a viable opportunity for biogas CHP fuelled from landfill.

10. CONCLUSIONS, RECOMMENDATIONS AND NEXT STEPS

10.1 Summary of Findings for Project Opportunities

Summary of Opportunities
Ilford Town Centre Project <u>Overall recommendation</u> It is recommended that London Borough of Redbridge should carry forward this project opportunity. The development timescales for the project are such that a fully built out project opportunity would not materialise until around 2025 and it is unlikely that the private sector will step in to develop a Project in the interim period. On this basis, London Borough of Redbridge should consider establishing an initial cluster project to catalyse the opportunity and lay the foundation for any future involvement by the private sector. In order for the initial cluster project to be economically attractive to London Borough of Redbridge, it is likely to require an Electricity Supply Licence Lite. <u>Key Considerations Going Forward</u> The long development timescales present a significant development risk to the project. Future expansion of the project will depend on whether the future development proposals materialise. The large number of stakeholders involved in the initial cluster phase of the project presents a risk in relation to developing a secure bankable customer base for the project. The costs and differing timescales associated with refurbishment of existing internal heating systems in the numerous existing buildings making up the cluster project makes the availability and phasing of future revenues from these buildings difficult to predict. There remains uncertainty about the technical suitability of many of the identified commercial and private existing buildings. Future developments in government policy around building regulations, zero carbon homes policy, financial and policy support mechanisms to gas CHP and alternative technologies that might be adopted in lieu of CHP with a heat network affect viability. Similarly uncertainty around future grid decarbonisation will have an impact on the future role for gas CHP.

Crossrail Corridor Project

<u>Overall recommendation</u>

There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Crossrail Corridor.

The calculated economic indicators for the Crossrail Corridor project would be of no interest to a private sector ESCo and equally would offer only a barely acceptable return to London Borough of Redbridge over 40 years, assuming an Electricity Licence Lite could be set up.

The recommendation is therefore for this opportunity not to be taken forward as a stand-alone project in isolation of other heat network opportunities.

Ilford Town Centre and Crossrail Corridor Project

<u>Overall recommendation</u>

In the event that the Ilford Town Centre heat network is taken forward, the case for interconnecting developments within the Crossrail Corridor to the Ilford Town Centre heat network at a future time appears to be reasonably strong.

It is recommended that this option is taken forward for further appraisal if Ilford Town Centre heat network is taken forward.

<u>Key Considerations Going Forward</u>

The future of a possible Crossrail Corridor interconnection will rely on the presence of an initial cluster network in Ilford Town Centre. Therefore, the project opportunity will ultimately rely on London Borough of Redbridge to push forward the project at Ilford Town Centre in order to create the correct conditions to allow the Crossrail Corridor project to be taken forward.

The IRR for the combined project is marginally lower than for the Ilford Town Centre only project and therefore is likely to require direct involvement from London Borough of Redbridge to bring about expansion into the Crossrail Corridor, since a commitment to do so from the private sector cannot be assumed.

In order to safeguard for future expansion into the Crossrail Corridor, the initial Cluster project in Ilford Town Centre would need to include additional investment in large diameter pipework and additional space within the energy centre. London Borough of Redbridge needs to take a view on the acceptability of this safeguarding position in financial terms.

Goodmayes Outlier Project

Overall recommendation

There appears to be a viable project opportunity for Goodmayes Outlier, based on the existing CHP assets at King George Hospital. It is recommended that the project opportunity is considered further by Barking Havering and Redbridge Hospitals NHS Trust.

London Borough of Redbridge are likely to have little interest or incentive to become directly involved in the project, since the scope for reducing local authority carbon emissions and future fuel costs would be limited and the opportunity to extend the project beyond the immediate vicinity appear to be very low. London Borough of Redbridge's role in this project should be to act as a facilitator for the project bringing together key stakeholders and to require the new schools, polyclinic and high density developments to safeguard for connection to the project if it is taken forward.

The low density housing element proposed for the opportunity area significantly reduces the economic case for the overall project and it is difficult to see how connecting these developments could be an attractive proposition for the project. Our recommendation is therefore that these developments should not be required to safeguard to connect to any future heat network opportunity.

Key Considerations Going Forward

A key barrier to this project opportunity is the timescales for the development proposals. The Trust has a short to medium term objective to address around the future of its existing CHP asset but the wider development opportunities will not come forward for many years. The proposed network opportunity may not be in the Trust's best economic interests.

Future expansion of the project will depend on whether the future development proposals materialise and whether the site gets released for alternative use from its current Green Belt status.

There is uncertainty around the cost and technical viability of retrofitting heating systems to the proposed flats in Goodmayes Hospital, given its listed building status.

There is uncertainty around the future plans for Redbridge College.

There is uncertainty around the viability and costs to the Trust associated with modifying its existing systems to operate at lower temperatures.

Barkingside Project <u>Overall recommendation</u> There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Barkingside Investment Area. The calculated economic indicators for the future development opportunity in Barkingside Investment Area suggest that the project would be of no interest to a private sector ESCo or to London Borough of Redbridge. The recommendation is therefore for this opportunity not to be taken forward.

Table 34: Summary of Findings for Project Opportunities

10.2 Economic Appraisal of the Project Opportunities

The main conclusions in relation to the economic appraisal of the opportunities are presented below, based on an assumption of required nominal internal rates of return of 10 % and 6 % respectively for private and public sector led projects.

<u>Ilford Town Centre</u>

The fully built out project at Ilford Town centre is likely to be an economically attractive proposition to both the public and private sector.

However, the development timescales for the project are such that a fully built out project opportunity would not materialise until around 2025 and it is unlikely that the private sector will step in to develop a project in the interim period since the IRR for the initial cluster project is below 10% (7.1%). The IRR for the fully build out project is 11.3%.

On this basis, London Borough of Redbridge should consider establishing an initial cluster project to catalyse the opportunity and lay the foundation for any future involvement by the private sector.

In order for the initial cluster project to be economically attractive to London Borough of Redbridge, it is likely to require an Electricity Supply Licence Lite. London Borough of Redbridge should therefore pursue developments in this area as part of any business planning undertaking, should it wish to take the opportunity forward.

IRR is seen to increase to 9.5% and 13% for a grant contribution of £1M for the cluster and fully built out projects respectively.

In the event that an Electricity Supply Licence Lite cannot be secured, the cluster project is unlikely to come forward, although the fully built out project may still be of interest at a later point in time, once a larger heat customer base has been established.

A public private sector partnering approach may be of interest to certain ESCos and should therefore be considered by London Borough of Redbridge as a possible way forward for the cluster project. London Borough of Redbridge should however recognise that it will need to champion the development of such a project, since the private sector is unlikely to step in and do so.

If London Borough of Redbridge is prepared to take a long term view over the project term, the initial cluster project can also be considered as an economically attractive option.

If it chooses to develop the initial cluster project, London Borough of Redbridge could reasonably expect to attract interest from the private sector at a later stage, should it choose to sell the project once much of the development risk has diminished and additional investment into the Crossrail Corridor area is required.

There are relatively few Local Authority owned assets within the initial cluster project. London Borough of Redbridge should recognise that this will introduce complexity and risk in delivering the project since multiple, protracted stakeholder negotiations are likely to be required.

<u>Crossrail corridor</u>

There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Crossrail Corridor.

The calculated economic indicators for the Crossrail Corridor project would be of no interest to a private sector ESCo and equally would offer only a barely acceptable return to London Borough of Redbridge over 40 years, assuming an Electricity Licence Lite could be set up.

The recommendation is therefore for this opportunity not to be taken forward as a stand-alone project in isolation of other heat network opportunities.

<u>Ilford Town Centre and Crossrail Corridor</u>

In the event that the Ilford Town Centre heat network is taken forward, the case for interconnecting developments within the Crossrail Corridor to the Ilford Town Centre heat network at a future time appears to be reasonably strong, returning an IRR of 10.1% over 25 years.

However, it should be recognised that this is marginally lower than for the Ilford Town Centre only project and therefore is likely to require direct involvement from London Borough of Redbridge to bring about expansion into the Crossrail Corridor, since a commitment to do so from the private sector cannot be assumed. London Borough of Redbridge’s interest in doing so would need to be predicated on the additional carbon reductions associated with the wider project opportunity.

In order to safeguard for future expansion into the Crossrail Corridor, the initial Cluster project in Ilford Town Centre would need to include additional investment in large diameter pipework and additional space within the energy centre. This will reduce the calculated IRR from 7.1% to 6.3% over 25 years, based on a Licence Lite arrangement. Again, London Borough of Redbridge will need to take a view on the acceptability of this safeguarding position in financial terms.
If London Borough of Redbridge is prepared to take a long term view, 40 years, over the investment proposition, the IRR for the safeguarded cluster project can be expected to exceed around 7.8%.

Similarly, viewed over 40 years, the fully built out project can be expected to return an IRR of around 11.4% which is considered to be an attractive proposition to London Borough of Redbridge.

The future of a possible Crossrail Corridor interconnection will rely on the presence of an initial cluster network in Ilford Town Centre. Therefore, the project opportunity will ultimately rely on London Borough of Redbridge to push forward the project at Ilford Town Centre in order to create the correct conditions to allow the Crossrail Corridor project to be taken forward.

<u>Goodmayes Outlier</u>

There appears to be a viable project opportunity for Goodmayes Outlier, based on the existing CHP assets at King George Hospital. It is recommended that the project opportunity is considered further by Barking Havering and Redbridge Hospitals NHS Trust.

The project benefits from an existing private wire arrangement. Under this arrangement, the initial cluster project based around the existing buildings would deliver an IRR of around 11.0% over 25 years and the fully built out project would deliver an IRR of 11.6% over 25 years.

An initial cluster project is likely to be interest to a private ESCo based on the calculated IRR over 25 years, the investment period over which the ESCo would typically consider the project. This could also be expected to interest Barking Havering and Redbridge Hospitals NHS Trust.

IRR is seen to increase to 19.0% and 18.4% for a grant contribution of £1M for the cluster and fully built out projects respectively.

Due to long development timescales, the IRR for the fully built out project viewed over 25 years are similar to that of the cluster project viewed over the same period. Whilst the Trust might find the calculated IRR of both scenarios acceptable over 25 years, it is difficult to see why there would be a strong incentive for the Trust or an ESCo to extend the project beyond the initial cluster.

Viewed over 40 years, the IRR of the fully built out project exceeds that of the initial cluster network viewed over 25 years. This suggests that if the Trust were prepared to invest in the project and view its return over a long term, it could potentially sell the project to the private sector at a later stage in its lifecycle, at which point the project would represent a low risk proposition that a private ESCo might be prepared to take on.

A comparison of the cases with and without inclusion of the low density housing elements indicates that the low density housing elements reduces the economic case for the overall project. Although the indicated IRR's are likely to be acceptable to Barking Havering and Redbridge Hospitals NHS Trust, it is difficult to see how connecting these low density housing developments could be an attractive proposition for the project. Our recommendation is therefore that these developments should not be required to safeguard to connect to the heat network.

London Borough of Redbridge are likely to have little interest or incentive to become involved in the project since the scope for reducing local authority carbon emissions and future fuel costs would be limited and the opportunity to extending the project beyond the immediate vicinity appear to be very low. London Borough of Redbridge's role in this project should be to act as a facilitator for the project bringing together key stakeholders and to require the new schools, polyclinic and high density developments to safeguard for connection to the project if it is taken forward.

<u>Barkingside</u>

There is insufficient anchor heat load to support an economically viable initial cluster heat network in the Barkingside Investment Area.

The calculated economic indicators for the future development opportunity in Barkingside Investment Area suggest that the project would be of no interest to a private sector ESCo or to London Borough of Redbridge.

The recommendation is therefore for this opportunity not to be taken forward.

Comparison of Economic Options

As a useful comparator between projects, Table 35 below shows the required electricity selling price (i.e. value to project) to achieve a 10% IRR over 25 years for each of the fully built out project opportunities[74].

This indicates that the Ilford Town Centre and Ilford Town Centre / Crossrail Corridor projects are both likely to be attractive propositions under an Electricity Licence Lite arrangement and that the Goodmayes Outlier project is likely to be an attractive proposition under the private wire arrangement, since in each case the required selling price can be exceeded by the project. For reference London Borough of Redbridge's weighted electricity prices are 9.8 p/kWh for day tariff and 6.2 p/kWh for the night tariff. Residential electricity retail prices are currently estimated to be around 13.8p/kWh (including standing charge).

Opportunity project	Electricity value
Ilford Town Centre	7.84 p/kWh
Ilford Town Centre and Crossrail Corridor	8.80 p/kWh
Goodmayes Outlier	7.52 p/kWh
Barkingside	13.88 p/kWh
Crossrail Corridor	13.77 p/kWh

Table 35: Required Electricity Prices to Achieve 10% IRR over 25 years

10.3 Technical Viability and Barriers to Development

Of the recommended projects opportunities, no insurmountable technical barriers have been identified. Further work will be required for projects taken forward in relation to more detailed network route planning. In relation to the Ilford Town Centre project, detailed technical feasibility of the energy centre proposals will also be required at the next stage.

10.4 Recommended Next Steps to take the Opportunities Forward

10.4.1 Ilford Town Centre or Ilford Town Centre / Crossrail Corridor projects

London Borough of Redbridge will need to play a proactive role in bringing forward the identified opportunities. This will require investment of both time and local authority funds in order to develop the projects to the point at which investors, and potential project partners could be interested in taking on the project.

Under the do-nothing scenario, new developments within the opportunity areas are likely to come forward with individualised piecemeal solutions involving a range of low carbon technologies[75].

[74] It is noted that in the cases of Goodmayes Outlier, Ilford Town Centre and Ilford Town Centre and Crossrail Corridor this represents a reduction in the electricity selling achieved for that project , since the IRR is already above 10% for those projects.

[75] These will generally install building scale technologies which collectively may fail to deliver the carbon savings to 2030 that can be achieved via the identified heat network opportunities.

This approach also risks missing an opportunity to integrate existing buildings into a future network (that are unable or unlikely to connect to a network now but who in future might do so at the time of asset refurbishment).

The alternative to the do nothing scenario is for London Borough of Redbridge to take an active role in developing the identified project opportunities with the intention of securing a stake in the infrastructure assets and facilitate development to its full potential.

There are significant potential advantages to London Borough of Redbridge in adopting this approach including:-

- contributing towards Redbridge's CO2 emissions reduction targets
- avoiding piecemeal approach to compliance for new developments
- developing a viable business with the opportunity to generate income for the Local Authority

Alternatively London Borough of Redbridge 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 project 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 projects too unattractive an investment proposition to take forward, and certainly are unlikely to do so until a considerable amount of development has taken place.

If London Borough of Redbridge wishes to adopt a proactive route, it should consider the following measures:-

a. Working with potential stakeholders to establish a Steering Group and a project delivery group to take forward the recommendations of this report.

b. Engage with the potential customer base for the heat networks, including engaging with the projects identified in this project as well as identifying further opportunities for connecting existing head loads not assessed so far under this report.

c. Engaging with the market around possible joint development opportunities for a heat network in Ilford Town Centre. A local delivery vehicle could potentially be established being led by the private sector but with London Borough of Redbridge having a stake in the project company. This will bring the advantages of opportunities for funding and low cost borrowing through PWLB, CIL/S106, allowable solutions and the London Energy Efficiency Fund, which has recently opened to DE projects and is likely to be very interested in investing in publicly backed opportunities of this nature. It will also enable London Borough of Redbridge to establish a project vehicle on which to gain experience and form a platform for the delivery of other low carbon project opportunities over the longer term. Such an approach is also likely to be favourable to larger scale developers investing in the area, who will thereby avoid the need to procure an ESCo separately to deliver on their commitments.

d. Building internal political support and commitment, oversee the development of strategies and policies to develop the project opportunities and to obtain budget commitment to take forward the project through feasibility, planning, design and procurement.

e. Carry out business planning, drawing on support from GLA through the Decentralised Energy Programme Delivery Unit (DEPDU), to establish the London Borough of Redbridge's role in the identified project opportunities and the commercial basis on which the future strategic opportunities could be delivered.

f. Maintain a watching brief around developments under Electricity Licence Lite and establish a vehicle for setting up such an arrangement when the opportunity arises and/or for collaborating with other bodies such as GLA to pool operating costs and thereby reduce overheads.

g. Guarantee existing buildings within its control to connect to any heat network that comes forward and require new developments to safeguard for future connection through the planning process.

h. If London Borough of Redbridge decides to take the project forward, ownership, procurement and governance options will need to be appraised. London Borough of Redbridge 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. London borough of Redbridge will need to take a view as to how much risk it will be willing or able to own. Key risks that need to be assigned as part of any procurement process are discussed in Section 8. Developing the risk profile that London Borough of Redbridge is willing to bear will take detailed negotiation with many departments. The overall process should not be underestimated. In the longer term, the legal framework around the setting up a Project Company 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 project, formulating and signing-off legal contracts for these partners (including Development Agreements, Heat Supply Agreements, MoUs, etc),

i. Secure funding to minimise the need to inject capital reserves into the identified development opportunity.

j. Further evaluate the technical options identified for energy centre locations and safeguard the most appropriate site(s) for future energy centre developments.

k. Conduct further feasibility work to establish the appetite and technical viability amongst major stakeholders 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 and commercial barriers to implementation and establish a route to delivery.

l. Conduct route de risking and implement technical safeguarding for the heat network routes.

If London Borough of Redbridge chooses to pursue the do nothing route it should, as a minimum, ensure that its local planning framework requires that local heat networks with gas fired CHP are considered and implemented if feasible in line with GLA policy, and that new developments in indicated areas are designed with heating systems to be ready to connect to a future heat network.

10.4.2 Goodmayes Outlier

The opportunity at Goodmayes is considered to be of interest to Barking Havering and Redbridge Hospitals NHS Trust or a third party provider such as an ESCo, rather than for London Borough of Redbridge directly.

If Barking Havering and Redbridge Hospitals NHS Trust wishes to act on this opportunity, it should consider:

a. Forming a steering group to take the project forward internally.

b. Engaging with the private sector to establish options for taking forward the project opportunity. Addressing issues similar to those identified in Section 10.4.1 for London Borough of Redbridge in relation to procurement, governance, risk etc.

c. Working with the supplier of the existing CHP to establish the technical feasibility of reconfiguring the existing project to supply new developments with lower grade heat and assessing the viability of including absorption cooling at the site.

d. Identifying its appetite for involvement in wider project opportunity, carry out business planning and consider alternative commercial models to deliver the project (e.g. Energy Performance Contracting model involving ESCo, Trust led project, public private partnership).

London Borough of Redbridge can play a role in the development of this opportunity in the following ways:-

e. Engaging with Barking Havering and Redbridge Hospitals NHS Trust around possible development opportunities for a heat network in the King Georges Outlier Opportunity Area.

f. Acting as a facilitator by bringing together the major stakeholders in the opportunity area (including Redbridge College, King George and Goodmayes hospitals, housing developers and education providers) to ensure that a strategic opportunity is planned for and delivered in an efficient manner.

g. Guaranteeing the connection of the new schools to the heat network provider.

h. Considering influencing the massing design of the new residential developments to improve underlying project economics.

i. Ensuring all new developments are designed for future connection to the heat network through the planning process.

10.5 Planning Policy Recommendations

10.5.1 Policy and Strategy Documents

a. London Borough of Redbridge's Core Strategy document should be updated to reflect the heat network opportunities identified in this report.

b. The proposals should be disseminated to relevant departments within the Council to raise awareness of the planned infrastructure proposals.

10.5.2 Safeguarding Connection of New Developments

c. London Borough of Redbridge should use its planning powers to require identified developments to safeguard for future connection into a heat network by implementing a series of future proofing measures where feasible. The indicated developments relate to Ilford Town Centre, Crossrail Corridor and Goodmayes Outlier as identified on the vision maps in Appendix 2.

d. In the case of Barkingside Investment area, where a viable opportunity has not been identified, planning policy should not, in our view, require safeguarding for a heat network at this stage.

e. Future proofing measures that should be included in planning policy where appropriate and/or planning conditions, where identified to be feasible, are:

i. Requiring ‘wet’ heating systems to be installed and prohibiting electrical heating systems.
ii. Requiring the incorporation of communal heating systems instead of individual boilers. Communal heating systems should be fed from plant rooms producing low temperature hot water for space heating and domestic hot water. Future proofing should include for providing 'tees' and isolation valves to facilitate future connection of heat exchangers. Space should be reserved for heat exchangers, or it should be planned for heat exchangers to replace heat-only boilers at time of connecting to the heat network.
iii. Ensuring internal heating systems are designed so that they can be connected to supply a DE network with minimum retrofit. This should be achieved through measures such as built-in penetrations allowing pipes to be pushed through into plantrooms without structural alterations or significant works, designing heating systems to minimise return water temperatures, allowing provision in the building fabric to facilitate the installation of district heating pipework at a later time.
iv. External buried pipework routes should be safeguarded to the boundary of the plot where connection to the heat network will be made.

f. There may be an opportunity for London Borough of Redbridge to allow developers to defer installation of alternative compliant technologies in lieu of making a provision to connect to a heat network. This will depend on provisions under future updates to the building regulations, which London Borough of Redbridge will need to be mindful of in policy setting terms. In such circumstances London Borough of Redbridge could place a requirement on developments to retrofit compliant technologies within a fixed period, in the event that a heat network is not taken forward.

g. Developments of a relevant scale where CHP would be considered that are 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:

i. The development should be designed on the basis of their own CHP with standby boilers and 'future-proofed' to connect into the heat network in the future.
ii. 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.
iii. 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 retrospectively.
iv. 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.
v. The developer could be given a planning condition to allow any 'freed-up' plant space resulting from the heat network connection to be used for more profitable purposes.

These recommendations are subject to acceptable provisions under future updates to the building regulations.

h. The timescales for the known developments under each project are such that no developments are likely to come forward over a horizon of beyond 5 years from the date of construction of a heat network opportunity. Nevertheless, provisions should be made for developments beyond a 5 year timeframe as follows:-

i. For developments of a relevant scale where CHP would be considered that are 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 safeguard to connect to the heat network at the end of the economic life of the CHP plant.

ii. For developments of a relevant scale where CHP would be considered that may in future be planned to come forward beyond 10 years and at locations where they could connect into the heat network, these developments should be designed 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.

10.6 Adoption of Local Development Order

a. London Borough of Redbridge should consider adopting a Local Development Order (LDO) to facilitate deployment of the heat network. This would allow the Council to create a blanket planning permission to a future Project Company for constructing heat networks without the need for specific planning applications at each stage of development of the heat network.

10.7 Ensuring Correct Design Standards are adopted

a. 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.

b. 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 Redbridge, through its planning department should ensure that systems are being designed, installed and commissioned appropriately.

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

d. London Borough of Redbridge should also require new developments involving office, retail and residential to examine and consider as part of any viability assessment, opportunities for district energy balancing at development scale.

10.8 Route De Risking

a. The identified heat network routes in this report are not supported by utility surveys. When the projects are taken to the next level of detail, utility surveys will be required. In the first instance these should include the main utilities as follows: Electricity, water, sewage, drainage, major telecoms, gas.

b. 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. 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. 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.

10.9 Future technology options

a. A number of potential future low carbon supply opportunities have been identified in this report. Further feasibility work should be carried out to assess the economic and technical potential for these opportunities. The results of this exercise should inform future design iterations of the heat network to ensure that the network is future proofed to accept these future supply technologies.

11. REFERENCES

[1] Crossrail Corridor Area Action Plan – September 2011. London Borough of Redbridge
[2] Redbridge Site Studies – Stage 5 – Masterplanning and Sustainability Appraisal. Colin Buchannan, Sept 2010
[3] Ilford Town Centre Area Action Plan. Development Plan Document May 2008.
[4] London Borough of Redbridge LDF Core Strategy. Development Plan Document March 2008.
[5] Barkingside Town Centre Improvement Plan Final Report, MVA, March 2010
[6] London Borough of Redbridge LDF, Development Sites with Housing Capacity May 2008
[7] London Borough of Redbridge NI185 Database
[8] London Borough of Redbridge Housing Trajectory 2011-2028
[9] Display Energy Certificates were accessed from Centre for Sustainable Energy, http://www.cse.org.uk/
[10] Summary of Planning Applications for Housing Development Opportunity Sites – Excel File from LBR, 2012.
[11] ENERGY CONSUMPTION GUIDE 19 Energy Use in Offices – Energy Efficiency Best Practice Programme, December 2000
[12] Building fabric, Energy saving techniques to improve the efficiency of building structures, Carbon Trust
[13] Seven Kings Car & Lorry Park Planning Brief May 2012
[14] DECC industrial price statistics Average prices of fuels purchased by manufacturing industry in Great Britain http://www.decc.gov.uk
[15] DECC quarterly price statistics http://www.decc.gov.uk
[16] London Borough of Redbridge Housing Trajectory 2011-2028
[17] DECC "Estimated impacts of energy and climate change policies on energy prices and bills", July 2010
[18] Greater London Authority, Decentralised Energy Programme Development Unit Funding Options Analysis , 20 January 2012
[19] Energy Planning Monitoring the Impact of London Plan Energy policies in 2010, GLA 2011
[20] 2011 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting
[21] DECC (2010) IAG Toolkit, Table 1: http://www.decc.gov.uk/en/content/cms/about/ec_social_res/iag_guidance/iag_guidance.aspx
[22] Delivering London's Energy Future. The Mayor's Climate Change Mitigation and Energy Strategy" October 2011, GLA
[23] Allowable Solutions for Tomorrows New Homes – Towards and Workable Framework – Zero Carbon Hub - July 2011
[24] Decentralised Energy for London: Towards a District Energy Manual for London: seeking your opinion, GLA, February 2011
[25] http://www.decc.gov.uk/en/content/cms/emissions/crc_efficiency/crc_efficiency.aspx
[26] Community Energy: Planning, Development and Delivery. International District Energy Association – Mike King, 2012.
[27] Financing the Roll Out of District Heating – Ernst & Young – Presentation to Heat and the City 2012

APPENDIX 1 SUMMARY OF BUSINESS AS USUAL CASE AND FUTURE ALTERNATIVE CASE FOR NEW DEVELOPMENTS

The anticipated business as usual case for heating and cooling of new developments is summarised in the sections below for the range of new development mix proposed within the opportunity areas.

The proposed scenarios reflect Ramboll's view of the current market and how developments are likely to meet requirements of future building regulations as well as zero carbon homes policy.

There remains uncertainty around government policy including future changes to the building regulations, adoption of zero carbon homes policy and tariff support for micro renewables under the FIT[76] and RHI[77]. Therefore the condensing gas boilers may continue to play a significant role or the market in micro technologies may evolve, displacing both gas boilers and heat pumps (as described below). This in turn may either converge on a single solution or multiple technologies may come forward.

Mixed Use Developments (Residential, Commercial, Office, Retail)

The business as usual case for residential mixed use developments and residential only developments is taken to be Air Source Heat Pumps, dual mode heat pumps or ground source heat pumps in conjunction with underfloor heating and with immersion coil top up for domestic hot water requirements. This reflects the most likely scenario in our opinion.

Ground source heat pumps are not considered likely in town centre locations (because of the space limitations) in but they may find applications in the town houses in Barkingside and King George’s projects.

ASHP are likely to be installed in conjunction with solar thermal and/or direct electric top up (through immersion coils) in conjunction with hot water cylinders. Smaller residential applications are likely to have single ASHP’s for each apartment (approximately 5kW unit for a 1 or 2 bed apartment) or potentially heat pumps supplying pairs of flats.

Seasonal Energy Efficiency Ratios (SEER’s) for space heating are likely to be in the region of 3.0 to 3.5 (based on underfloor heating). Seasonal Energy Efficiency Ratios (SEER’s) for domestic hot water provision are likely to be in the region of 2 to 2.5.

Larger residential applications adopting ASHP use communal heating systems, with banks of ASHPs located in a central plantroom alongside a central domestic hot water cylinder.

Where cooling is also required (i.e. for commercial, office, leisure applications within the development), air source heat pumps are likely to be used to provide both heating and cooling (in conjunction with Variable Refrigerant Volume (VRV) systems). Condenser water loops may also be applied in such circumstances. Ground floor retail will typically be let as shell and core, fitted out with electricity (and potentially gas) supplies, depending on use.

Communal biomass heating solutions from suitably exempt appliances may also play a role, with pellet firing being the most likely solution in urban areas. Wood chip or other waste materials may be suitable in Barkingside and King Georges green belt areas. Experience from ([19] indicates that air quality considerations have stifled the widespread uptake and this can be expected to continue within urban settings, unless air quality issues can be overcome.

There is precedent for this approach in Ilford Town Centre (ITCOS21), which suggests that this may be a solution for other developments in the area.

Larger mixed use developments (typically in the range 300 to 500 apartments of which there are only a few in the area) are likely to be required by GLA to investigate the use of gas fired CHP. Those with resulting CHP capacities in the range 100 kWe to 500 kWe are likely to implement this technology ([19]) in conjunction with solar PV. Active cooling to commercial spaces and offices within these developments would typically be provided through air source heat pumps, As for

---

[76] Feed in tariff

[77] Renewable Heat Incentive

smaller mixed use developments, retail would typically be let as shell and core, fitted out with electricity (and potentially) gas supplies.

New Schools

In Ramboll Energy's view, new schools are likely to adopt heat pumps in conjunction with solar thermal, condensing gas boilers, underfloor heating and VRV systems to provide space heating, domestic hot water and cooling where required. Ground source heat pumps are likely to be adopted in most cases, although some projects are understood to be considering the optional addition of air source heat pumps to operate in tandem with ground source heat pumps, taking up operation during periods when acceptable COPs can be achieved (i.e. when extremes of ambient air temperatures are not present).

Biomass heating may come forward as an alternative option, subject to local planning and air quality issues, particularly since the new schools are located in the green belt area, where air quality concerns are likely to be lower. However, experience on previous projects suggests that there may be risks with this technology around ongoing fuel and maintenance costs that may limit the tendency to continue to operate such systems.

Adoption of CHP is considered unlikely for the new schools within the opportunity areas due to the seasonal nature of the demand and the relatively low domestic hot water base load.

New Community, Leisure and Healthcare

Community, leisure and healthcare facilities integrated into mixed use developments will adopt the solutions as described above, dependent on scale of application.

In larger leisure facilities (particularly involving swimming pools, showering etc. where there is a sizeable domestic hot water baseload demand) and hotels, gas fired CHP is unlikely to be adopted.

Inter seasonal Heat Storage at building and multi development scale

Inter seasonal storage in conjunction with heat pumps and solar thermal is an emerging building scale technology aimed at improving both the utilisation of solar energy and the seasonal energy efficiency ratio of heat pumps. The concept has been quite widely applied in countries such as Sweden and Holland and is now starting to appear in the UK as well.

Such systems typically use underground storage tanks or boreholes to store heat energy captured throughout the year and to discharge this energy at various points throughout the year according to when the heat is required. Because the temperature of the store is higher than average ground temperature during the heating seasons, enhanced seasonal energy efficiency ratios can be achieved. In some cases, air source heat pumps are also integrated into the design to recover heat during the shoulder seasons, when the seasonal store is depleted and the seasonal energy efficiency ratio from air source heat pumps is favourable.

On a wider scale, a similar concept can be adopted to serve a collection of buildings. The system relies on the fact that different types of buildings (retail, residential, offices) 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.

In such projects, heat can be collected from a number of sources including solar thermal collectors, ground collector pipe networks embedded within car parks, asphalt, gas CHP, heat rejected from chiller condensing circuits, industrial waste heat etc. Examples of projects emerging in Denmark suggest that ground based solar arrays integrated into heat networks of this type with seasonal storage can increase solar fraction from a few per cent to tens of per cent.

The scale and nature of the development, the local geology and the nature of available heat source(s) all determine the achievable temperatures and network configuration[78]. Borehole systems are typically adopted for smaller scale applications, where high temperature heat is collected. Open loop aquifer based systems tend to be employed at larger scale, where developments have reasonably balanced heating and cooling demands (for example mixed use with significant cooling requirements). Open loop aquifer based systems require the use of lower grade heat due to environmental permitting restrictions on temperature rises within aquifers and require reasonably balanced heating and cooling demands over the long term, again for environmental permitting reasons. This drives the concept towards a larger pipe concept, which increases cost and requires individual heat pumps at each building which either reject or extract heat to, or from, the network, depending on their need for cooling or heating. Closed loop borehole systems can use centralised heat pumps to collect heat and raise its temperature centrally to feed a higher temperature network, reducing both cost and design complexity of the heat network.

There are relatively few examples of these types of system in the UK at present, although developments elsewhere in Europe (Sweden, Netherlands, Denmark in particular) suggest a significant potential for such projects in the coming years. However, investment costs in such systems are understood to be high and the complexities associated with delivering these systems in multi developer scenarios are likely to act as a barrier to implementation. With the exception of Ilford Town Centre and King George's hospital site, the mix of buildings (both new and existing) does not lend itself particularly well to balanced heating and cooling projects on a district scale, with a predominance of residential demand providing a significantly greater heating demand in overall terms. Nevertheless, applications involving interseasonal heat storage and ground based solar thermal collectors may be suitable as highlighted elsewhere in this report, and further consideration should be given to these technology options at feasibility / design stage.

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[79] 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.

The prevalence of such systems in the UK is low at the present time. Adopting such a design may deter appetite amongst ESCos and investors in the project.

Longer Term Perspective - Building Scale Technologies

Micro technologies such as micro CHP based on Stirling engine and fuel cell CHP are expected to increase their share of the market in the coming years. Such technologies generate electricity and heat simultaneously on site, with very high total conversion efficiencies[80]. These technologies are currently available on the market and have so far been deployed in the UK in the 100's rather than 1000's. Although they have demonstrable operating track records they remain expensive and offer inadequate payback under current levels of RHI, FIT support. Depending on government financial support proposals under residential RHI, proposed support levels may increase which would have the effect of stimulating the market.

If such technologies emerge, they can be expected to have applications at building scale within the majority of building types proposed under the opportunity areas.
The development timescales for opportunity areas suggest that these technologies may appear in certain applications, but in Ramboll Energy's view they are unlikely to become deployed at scale within the timescales to 2020 by which time the projects will have come forward.

---

[78] For example heat from solar thermal collectors can be injected into the return of the network or heat rejected from cooling towers can be captured and used in extra low temperature heat networks to supply under floor heating via building level heat pumps. Building mounted solar collectors can also be used to displace the requirement from the heat network. Temperatures of up to 90 degree C have been achieved in Denmark using flat place solar panels

[79] When the bulk of the cooling demand is present

[80] Up to 85% as reported by a leading example of such technologies BlueGen.

APPENDIX 2 HEAT NETWORK LAYOUTS / CONCEPTS

APPENDIX 3 INVESTMENT AND CARBON APPRAISAL ASSUMPTIONS

Required Returns on Investment

The network opportunities have been assessed over 25 and 40 year periods. Project viability has been assessed on the basis of minimum required Internal Rates of Return for fully private sector and fully public sector (i.e. London Borough of Redbridge) based procurement models. We have assumed minimum acceptable nominal internal rates of return of 10 % and 6 % respectively reflecting what are considered to be the requirements of a private sector led project and a project funded by London Borough of Redbridge.

Our modelling includes inflation and we have therefore used real IRR hurdle rates of 7.5% and 3.5% respectively for fully private sector and fully public sector based procurement models (based on inflation at 2.5%). These hurdle rates do not necessarily reflect the current market or indeed London Borough of Redbridge's own required rates of return on investment and also reflect what would need to be 'risk free' projects to attract investment at those rates.

Our understanding of the current market is that nominal hurdle rates in the range 13-17 % for the private sector and above 8 % minimum for public sector are nearer reality in the current economic conditions.

Project Term

The project terms over which IRR's are evaluated and the extent and phasing of future extensions to the network will influence the view that private sector ESCos and London Borough of Redbridge are likely to take on the project value in economic terms. All project opportunities have therefore been evaluated over 25 years and 40 years as follows to explore a range of scenarios as viewed by private and public sector led projects.

<u>Cluster Projects</u>

The IRR calculation over 25 year project term tests the view that the private sector could be expected to take for the project. It also presents the case for the London Borough of Redbridge (or NHS Trust project in the case of Goodmayes Outlier) led project, both of whom would arguably also look for returns over the same period.

The IRR calculation over a 40 year project term tests the rate of return that could be achieved by the London Borough of Redbridge (or NHS Trust project in the case of Goodmayes Outlier) if it were prepared to view the investment over a longer term. Reinvestment cycles are included in this longer term assessment.

<u>Fully Built Out Project</u>

Whilst the IRR calculation over 25 year project term tests the value of the fully built out project from day one, it potentially misrepresents the project's true value since future investments in extensions to the cluster network would arguably be viewed over a 25 year cycle starting from the point of investment.

Calculation of a rolling IRR would be extremely time consuming and has not been carried out at this stage. A project term of 40 years has therefore been used to estimate the value of the fully built out project seen from the point of initial investment in the cluster project.

This aims to represent the value of the project seen by a private ESCo who might choose to acquire the cluster project from London Borough of Redbridge at some point in the future and continue to develop it into the fully built out project.

From the perspective of London Borough of Redbridge this also represents the value of the fully built out project if it were prepared to take a long term perspective on the investment

Interim Project

A third case has also been tested. This presents the IRR over 25 years and 40 years for an interim project involving the initial cluster project and development opportunities occurring within 5 years of initial construction of the cluster project.

The project term of 25 years aims to capture the value of the fully built out project as seen by a private ESCo who would not be inclined to invest speculatively beyond the initial 5 year timeframe. It also represents the view that London Borough of Redbridge may take if they are not prepared to view the project over the longer timeframe.

The project term of 40 years aims to capture the value of the fully built out project as seen by London Borough of Redbridge if they would be prepared to view the project over a longer timeframe and if the future developments beyond the initial 5 year timeframe did not materialise for whatever reason.

Hybrid Scenario

In practice, there could be a scenario in which a public sector led (or joint venture based) cluster project (developed by London Borough of Redbridge or NHS Trust project in the case of Goodmayes Outlier) may be sold to the private sector at a future time. For example, London Borough of Redbridge may prefer to divest its share in any cluster project it develops rather than commit additional investment to extend the project at a future time. The private sector ESCo purchasing the project at the time would typically formulate a business case around the value of the assets being sold and the future revenues and costs associated with taking on an expanding the cluster project into the fully built out project.

Project Capital Investment Costs

Investment costs have been modelled based on Ramboll Energy's experience of similar projects carried out in UK and Denmark with corrections for inflation to 2012 prices.

Land value associated with energy centres has been estimated based on information provided by London Borough of Redbridge's Property Services department.

Project Development Costs

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

Developer Contributions

The economic modelling has assumed that the Project Company would finance the costs of investment in the heat network and associated infrastructure assets, including branch connections to the developments at block level and installation of heat exchanger stations.

For larger developments, where developers might reasonably be required to install a community heating network with CHP[81], it has been assumed that the community networks within the development would be funded by the developer. Where such developments occur in advance of the heat network being available to connect into, it has also been assumed that a temporary boiler plant would be installed in lieu of installing a CHP and the developer would make a contribution to the project equal to the net saving on investment as a result of not having to install the CHP plant. The relevant sites where this could apply are considered to be ITCOS 07 and CCOS 11.

[81] We have taken the threshold to be above 1250 MWh /pa) [17]assuming 100kWe unit supplying around 60% of heat demand

For smaller developments, where developers could not reasonably be required to install a community heating network, developer contributions have been taken to be zero, since it is unclear at this stage what the basis for levying these contributions might be, given their freedom to adopt alternative solutions to achieve carbon compliance.

Grants, Funds, Other Contributions

Investments in the project from EU grants, funds other contributions (such as CIL, Allowable Solutions, S106) have not been considered in this study[82]. However, for the Ilford Town Centre scheme and the Goodmayes outlier scheme the possible impact of a range of levels of grant funding has been assessed. Potential sources of grant funding could be Allowable Solutions, Section 106 funding, Community Infrastructure Levy, Housing Revenue Account, New Homes Bonus (for the fully built out project), Homes and Communities Agency and the London European Regional Development Fund.

Revenues from heat sales

Revenues from heat sales to customers are modelled as a function of customer type as shown in Table 36. This has allowed us to model varying gas prices paid by customer type according to predicted gas consumption and whether customers are commercial, residential, local authority or industrial in nature. The threshold gas consumption used to define user types are presented in [14][15].

The project company's heat selling price model is likely to include some or all of 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 project (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

For the purpose of this report, the costs of connection to the heat network have been modelled by assuming that these would be borne by the Project, which would recover the investment costs through annual capacity charges and consumption charges. These costs cover the heat exchanger stations and the branched connections from the main spine of the heat network to the heat exchanger stations. For large developments it is assumed that the cost of installing community heat networks within the developments would be funded by local developers as a requirement under planning.

Heat prices to consumers have been calculated on the basis of their avoided heat generation costs under their business as usual cases. The avoided cost of heat 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 developments is described in Appendix 1. The business as usual case for existing developments assumes that they would continue to operate using gas boilers, with upgrading to higher efficiency replacement boilers plant at the end of their useful operating lives.

[82] with the exception of developer contributions paid by ITCOS 07 and CCOS 11 due to avoided need to install CHP.

The avoided costs to new mixed use residential developments associated with increased lettable floor space in lieu of installing alternative heating systems is considered to be negligible and is taken to be zero.

RHI assumed not to apply to heat generated from air source heat pumps, since it is unclear at the present time whether Phase 2 of the RHI will consider this to be an eligible technology.[83]

Customer heat prices in the business as usual scenario are presented in Table 36 (at today's prices). This figure excludes annualised replacement costs for the heating plant installed under the alternative case.

Also shown are the heat price paid by customers under the project, both with and without the impact of avoided annualised replacement costs for the heating plant installed under the alternative case. All existing customers, with the exception of London Borough of Redbridge, are assumed to have a 10% reduction incentive applied to encourage connection to the project. This is not applied to new customers. Finally, future heat prices based on DECC fuel projections after 25 years are shown in today's terms for information. These exclude avoided annualised replacement costs for the heating plant installed under the alternative case.

	Alternative Heat Price excluding replacement cost	Heat Price excluding replacement cost	Heat Price including replacement cost	Future prices using DECC fuel projections after 25 years excluding replacement cost
Customer Type	p/kWh	p/kWh	p/kWh	p/kWh
New Medium Commercial	5.18	5.18	5.71	5.36
New Retail	5.13	5.13	6.01	5.31
London Borough Redbridge	4.12	4.12	4.27	4.26
Residential customers - new	8.18	7.36	7.52	7.62
Existing Commercial	4.09	3.68	3.84	3.81
NHS	3.58	3.23	3.70	4.21
Community users	3.85	3.46	3.97	3.59
Other Public	3.85	3.46	3.58	3.59

Table 36: Heat Tariff Assumptions

[83] The RHI project does not apply to domestic systems until 2013. Following the delay to the non-domestic project, DECC re-evaluated the timing for the domestic phase (originally projected April 2012). The intention was that there would be a consultation by the end of 2011, with implementation October 2012 alongside the Green Deal. However the timetable was delayed again in March 2012, where three further consultation stages were proposed before the domestic phase of the RHI could start – now proposed for summer 2013

Carbon Reduction Commitment (CRC)

CRC is assumed to apply for all London Borough of Redbridge buildings, NHS buildings and existing commercial buildings connected to the project.

The value of savings under CRC is taken to be £12/Tonne CO_2 saved, based on the CRC Energy Efficiency Scheme (Allocation of Allowances for Payment) Regulations 2012 [25].

It is assumed that only a proportion of the benefit of avoided CRC payments for eligible non London Borough of Redbridge customers would accrue to the project, reflecting a benefit sharing arrangement that would act to incentivise the customer to connect. A rate of £8 / tonne has been assumed on this basis.

For London Borough of Redbridge owned buildings connecting to the project, a value of £8 / Tonne has also been assumed. This reflects the same benefit sharing approach on the basis that not all of the saving would be attributed to the project company.

Fuel Price Assumptions

Gas and electric prices for customers are taken from [14] and [15]. Price increases are based on central forecast estimates as presented in [21]. Revenues from heat and electricity sales are assumed to accrue on the basis of a linearized increase over a 30 year period.

For the Ilford Town Centre Project and the Barkingside project, the cost of gas for the project (which is assumed to be purchased by London Borough of Redbridge through is existing contract under the Laser consortium) is taken to be between 2.7 p/kWh (the lowest price currently paid under the contract) and 2.0 p/kWh (prediction based on quarterly fuel price statistics at the applicable volumes of gas purchased).

For the Goodmayes Outlier, gas prices reflect current costs paid by King George hospital who, it is assumed, would purchase gas for the project. The Trust currently purchases gas under contract to Corona at a price of 2.5 p/ kWh (excluding other charges). There is uncertainty around future gas prices, since the Trust has recently switched over to new contract with EDF under the Government Procurement Framework. In the absence of any further information, these numbers have been used in this report.

Project Operation and Maintenance Overheads

Operations 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.

Variable costs include operation and maintenance of specific heat production units as well those associated with general energy centre operating overheads (e.g. 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 as fixed losses over the length of the network. Pumping losses assume a cubic relationship with demand.

Ongoing re-investment in the network and energy centre has been modelled assuming an annual sinking fund.

Electricity selling arrangements

Four models for selling CHP electricity have been considered for the projects:-

1) Selling electricity directly into the wholesale market as spill[84] electricity
2) Entering into a Sell and Buy Back Arrangement with a Supplier (netting off)
3) Supplying local customers under a private wire network
4) Retailing electricity under Electricity Licence Lite

Electricity supply into the wholesale market

The simplest arrangement for the project would be to sell electricity directly to the wholesale market. However, due to its intermittent nature and the small volumes involved, the value of the electricity generated would be low to the Suppliers with whom the project would need to enter into contract.

For this reason, the wholesaling arrangement represents the least favourable option to the projects and is not considered to be a viable arrangement under which any of the projects could operate.

In the modelling carried out, the value of electricity sold by the projects into the wholesale market is based on 2011 wholesale prices at transmission level as reported through the Balancing Mechanism Reporting Data published by Elexon with 10% uplift to reflect increased value to the Supplier as a result of avoided transmission use of system charges associated with the generated electricity.

Private Wire

Under a private wire arrangement, the projects would supply electricity to local customers through a dedicated cable installed specifically for the purpose. The private wire network would also be connected to the public distribution system, thereby permitting not only the sale of excess generation to third parties, but also providing a technical back-up source to cover periods when generation within the private network is insufficient to meet concurrent demand (e.g. generator outage). The flexibility offered by this arrangement removes the need to balance generation and demand at all times and significantly reduces the cost of providing high quality electricity supply over an isolated system.

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. Private wire networks are generally most suited to a small number of large consumers connected locally and operating at the same voltage at the generator. In this way connection cost are minimised and the payback on the investment is quicker. Private wire networks, especially when applied as a retrofit, do not normally prove economic unless consumer demand is particularly concentrated.

Establishing contracts with existing stakeholders can be complex to negotiate and time consuming, particularly for private customers who may have little to benefit from the arrangement. There is also the on-going risk that these customers would switch to alternative Suppliers under the Citiworks ruling[85], which requires the private wire supplier to make provision for this eventuality. Under the Citiworks ruling, it would not be possible to bind customers legally

[84] Spill electricity is a term normally used for CHP electricity surplus to local demand and therefore 'spilled' to grid at low value.

[85] Following the 'Citiworks' judgement, determined under European law, all consumers connected to private networks have the right to obtain an electricity supply from third party suppliers (i.e.. not the ESCo to whose network they are connected) such that they can no longer be regarded as 'captive' customers. This judgement is being implemented in the UK.

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 networks also present an on-going risk of creating a stranded asset over time in the event that the customers choose to change supplier or cease to exist for whatever reason.

Where public sector customers are involved, greater incentives are likely to exist and the local authority is likely to have greater influence and control over the connected buildings.

The connection of new developments to private wire networks carries risk and prevents a project from going ahead prior to these developments coming on line.

In the case of Ilford Town Centre, a private wire connection could potentially be established around a customer base including one or more of the existing anchor heat loads within and/or without the control of London Borough of Redbridge. Equally, one or more new developments could also become party to such a network. The technical and economic feasibility of a private wire arrangement would need to be determined at the next stage and the option has not been modelled in the present report. With the exception of London Borough of Redbridge controlled buildings, it is unlikely that customers under this arrangement would be willing to tie themselves into private wire contracts for extended periods[86], preferring instead to retain their ability to purchase the cheapest power available amongst the top 5 Suppliers. The risk to the project would therefore be significant[87] unless London Borough of Redbridge could support the entire level of generation from the project, which is considered unlikely.

In the case of Goodmayes Outlier, the existing CHP project is understood to operate under a private wire arrangement, with both Goodmayes Hospital and King George hospital being party to the arrangement. It is assumed that this arrangement would continue into the future for the purpose of the present report and that the resulting electrical demand from the two hospitals would continue to absorb the entire generation capacity from the project. This assumption needs to be tested if the project is taken forward and the spill value of the exported electricity or the connection costs associated with any additional private wire arrangement to avoid this would need to be taken into account in the economic modelling of this opportunity.

The value to the project of the electricity generated is based on the electricity costs paid by the Trust, which average 9.45 p/kWh (including settlement and agent charges, supply and distribution charges and CCL) based on existing prices. We have assumed a net value of 8.08 p/kWh, subtracting an element of the fixed charges payable by the Trust to the electricity supply company that would continue to be payable under a private wire arrangement, which we have assumed to be 50%.

If necessary (i.e. if the assumptions regarding existing electrical demand on the site are incorrect), a private wire connection could potentially be extended to one or more existing or new customers in the vicinity of the plant. At under $1.5MW_e$ and without domestic premises involved, the arrangement could be implemented under The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001; SI3270. This exemption means that the project would not require any of a generation, distribution, or supply licence.

In practical terms, since any existing consumer site involved in this arrangement will currently be connected to the local public distribution network, such an arrangement would require the consumer to find a supplier willing to offer a supply contract via the private network. The project would have to obtain or provide central registration services in order for the consumer's metering

[86] Contracts with such customers would typically need to be between three and five years in duration and the project would therefore need to expect to renegotiate the supply contract many times during the lifetime of the plant.

[87] and unlikely to be acceptable to financers of the project

point to participate in the regular market and offer a use of system tariff. As an existing half hourly metered site, the existing consumer will have commercial contracts for electricity supply which may have been placed directly or via an agency or centralised purchasing function. Embedded within these supply contracts will be a connection agreement for physical connection to the distribution network which would need to be replaced by similar contracts with the project. A further contract for the provision and maintenance of the metering equipment would also be required. Within the half hourly metered market, the consumers may own the metering, may have a direct contract with the meter operator or may purchase the services within the supply contract. These contracts would need to be terminated or transferred as appropriate.

The project would contract with an electricity supplier for 'top-up and spill' or a similar risk management arrangement to enable any excess of generation over private network demand to be revenue earning and to facilitate net imports when demand exceeds generation. The commercial aspects of this may be passed through to the network consumers within their supply tariff. The pricing of such a product would be complex, but it should be envisaged that the 'top-up' element would carry a 10-15% premium over the day energy prices currently paid by the consumers, whilst the 'spill' of generation element, being most likely skewed to overnights, would be discounted to approximately 3-3.4p/kWh. The target counterparties would be licensed suppliers with a significant consumption in the area and aggregators offering generation/supply risk management services. Risk management services would have a different pricing basis and are likely to be commercially attractive to the project but would depend on the volume and pattern of the network imports and exports. The selection will be a matter of trading aspiration, timing and commercial value at the time of going to market.

In the case of Barkingside a private wire could potentially be established between the CHP and one or more of a number of local authority controlled buildings such as the library, King Solomon high School and Redbridge sports centre. In the modelling carried out, a private wire arrangement has not been modelled for the Barkingside project for the following reasons:-

- the project fails to stack up under a licence lite arrangement, which would offer a comparable or better rate of return as well as a significantly lower risk profile.
- There is uncertainty around the cost of connection and the volumes of electricity available at each site.

Further work would be required to assess the technical and economic viability of this option.

Electricity Sell and Buy Back

Some of the savings over a conventional electricity supply arrangement can be achieved without the need for a private network. This can achieved commercially under a 'sell and buy back' type of arrangement with a licensed electricity supplier. Under this arrangement the project would sell its generated electricity to a Supplier who would net-off his exposure to wholesale energy and transmission use of system charges by virtue of those charges being based on his deemed take at the grid supply point group (GSP Group) level. The agreement with the Supplier would be contingent on the consumers also buying their energy from the Supplier. This is essentially ring-fencing the value of the embedded generator and sharing the benefit with the supplier. Distribution Use of System (DUoS) charges under this arrangement would not be avoided.

Although less attractive in terms of costs savings than a private wire arrangement, this option would avoid the capital investment costs and ongoing maintenance costs associated with setting up and operating a private wire network[88] and would deliver benefit to the project even though the netted off consumers (i.e. London Borough of Redbridge's assets) are dispersed and remote from the generator.

[88] Under the sell and buy back arrangement, the investment in the electricity infrastructure is borne by the District Network Operator as opposed to the private network operator.

This type of arrangement is likely to be the most favourable option for the Ilford Town Centre and Barkingside projects, in the absence of a Licence Lite (see below). The arrangement would require agreement with the Supplier, who would also realise benefits from the arrangement and should therefore be receptive to the proposal. The benefits to the Supplier arise in the form of reduced DUoS charges as a result of the embedded generating capacity[89] and reduced settlement charges seen by the Supplier as a result of the supply company being able to aggregate the London Borough of Redbridge's multiple supply meters into a single aggregation point. Assessing the value of this benefit requires addressing the market directly as the value realisation is achieved through negotiation and can be assigned either at the generator or the consumer according to preference. These benefits are assumed to be zero for the purpose of this report.

In the modelling carried out, it is assumed that the projects would net off all generation from the project against electricity purchased elsewhere for London Borough of Redbridge's buildings within the distribution network and that the cumulative consumption of these buildings would match the generator's output over the year. This assumption needs to be tested at the next stage.

The value to the projects of a netting off arrangement in which London Borough of Redbridge nets off generation against its existing consumption is based on London Borough of Redbridge's weighted average electricity prices for two rate Half Hourly (HH) supply under its current procurement arrangements as part of the Laser consortium. These values are taken to be 9.8p/kWh (day rate) and 6.16p/kWh (night rate). DUoS charges payable by the project are taken to be 3 p/kWh during daytime operation and 1 p/kWh during night time operation.

<u>Electricity Licence Lite</u>

In 2009, Ofgem introduced its Electricity Supply Licence Lite proposals, intended to make it easier for embedded generators, including decentralised energy projects, to operate as licensed suppliers across the public electricity network.

Under the proposed 'Licence Lite', the project could enter into a 'supplier services agreement' with a licensed third party supplier and benefit from being able to retail electricity generated to residential, commercial, retail and public sector consumers within the local distribution network[90], whilst also avoiding the many of the cost overheads associated with setting up and operating a full electricity supply licence. The electricity supply customer base would not necessarily need to be the same customer base receiving heat from the project and the customer base could therefore be matched to the export capacity of the project.

The value of the retailed electricity could be expected to be comparable to concurrent prices paid by customers under the project, with an incentive or discount to attract and retain them over an ongoing period.

There are currently no Licence Lite projects in operation, although GLA and Ofgem are working together with selected London Boroughs to finalise project proposals and establish the first Licence Lite projects in London[91]. 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

---

[90] Retailing into the strategic network would probably be un-economic due to the Transmission Use of System (TUoS) charges arising

[91] 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 project. 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).

commercial organisations would be operating under such licences at that time in London and beyond.

London Borough of Redbridge could potentially set up and operate a single Licence Lite to cover multiple project opportunities. Equally, it could co-operate a Licence Lite with third parties such as other Local Authorities or the GLA, who is currently in the process of establishing the first Licence Lite in the UK.

The cost of administrating the Licence Lite is unclear at the present time, since there are no operational projects against which to benchmark (the economic modelling in this study does not take into account set-up costs for a Licence Lite, although it does include an estimation of on-going admin costs). The GLA is currently conducting work in this area and, whilst early adopters are likely to incur relatively high setting up and running costs, the intention would ultimately be to pool the administrative burden of setting up and operating a Licence Lite across a number of projects so that the operating margins would be acceptable to small generators.

In the modelling carried out, it is assumed that the net value to the projects would be 8.9 p/kWhr, reflecting a mix of residential and commercial customers connecting to the project, a 10% incentive on their alternative prices to attract and retain them and an operating overhead payable on a p/kWhr basis. This assumption needs to be tested at the next stage, if the project opportunities are taken forward.

Impact of Green Deal and ECO on Energy demands

In relation to the Green Deal, Eco, REFIT, RENEW and the Better Buildings Partnership other energy efficiency measures for existing buildings, the following considerations have been taken into account:-

- The impact of energy efficiency measures on the existing residential sector, where retrofitting and refurbishment under Green Deal is likely to take place over the coming decades has not been modelled, since connection of existing residential buildings are not included in the project proposals for the identified opportunities.

- The impact of energy efficiency measures on existing public and commercial buildings, where retrofitting and refurbishment under Eco, REFIT, RENEW and the Better Buildings Partnership is likely to take place over the coming decades has been modelled. Such buildings are likely to implement a range of measures to reduce energy demands for space heating and hot water, including improved control of existing internal heating systems (zone control, variable speed drives, plant upgrades, pipework insulation etc) and fabric improvements such as double glazing, insulation, installation of solar thermal panels. An estimation of the impact on these measures has been made with reference to Table B1 in ECON 19 [11] where reductions in space heating and domestic hot water demand are quoted for typical and good practice offices for a range of building types. The table shows savings of the order of 50% for all building types. For non-council buildings, it has been assumed that 50% of existing buildings connecting to the project represent typical practice and that of these, 50% would be upgraded to achieve a 50% saving in energy consumption. This results in a global 12.5% reduction in energy demand on existing buildings, which has been applied to all existing connected public buildings excluding Council buildings. For Council buildings, a global 25% reduction in energy demand has been applied on the basis that all buildings requiring refurbishment would be refurbished. We have not modelled energy efficiency improvements in any greater resolution at this stage, although we have applied an uncertainty of +/- 25% on this central estimate (refer below) to reflect the broad ranging nature of the assumption. It has been assumed that all energy efficiency improvements would be made by the point of connection to the project. Reference has also been made to [12].

Sensitivity Analysis

A sensitivity analysis has been carried out for each project opportunity around the key variables that influence the IRR for the project. The results of the sensitivity analysis are presented within the relevant sections of this report.

The blue lines in the graphs represent the central estimate of the project IRR, based on the central estimates for the listed variable along the x-axis which were used to produce the economic indicators for the project.

The bars in the graphs show the changes in project IRR due to changes in the relevant listed variable, with all other variables being held constant. Red bars generally denote a % increase in the listed variable whilst green bars generally denote a % reduction in the listed variable.

Exceptions to this are variables such as the Carbon Price Support for CHP and connection costs, which are treated as half / removed variables.

Further information on each variable is presented below.

Electricity Selling Price: Variation in electricity selling price have been modelled as +/- 10% on the central estimate under Sell and Buy Back, Electricity Licence Lite or Private Wire as appropriate.

Gas Purchase Price: Variations in gas purchase price have been modelled as +/- 10% on the centrally estimated purchase price for each project.

Project Total Capital: There is often a high degree of uncertainty around network construction costs due to both uncertainty in the route (e.g. impact of utilities, traffic management, parking suspensions, difficult crossings, soft dig/hard dig etc.) as well as external factors such as global price of steel and the level of competition in the market. Since network capex generally contributes around 60% to 70% of total project costs, uncertainty in this variable has a very significant effect on uncertainty in total project development costs. Energy centre construction costs are generally less difficult to predict. However, for the projects considered here, uncertainties remain around whether existing plantrooms can be used for the projects (Barkingside and Goodmayes Outlier) and around lease or sales value of the land (particularly for the Ilford Town Centre project). The uncertainty in project development costs has been modelled as +/- 10% around the central estimate. Uncertainties around development costs (design, panning, procurement), which are likely to be less significant than the CAPEX related costs, are included in this variation.

Operating Margin: The impact of uncertainty for the operating margin modelled as a +/-10% variation on the central estimate.

Heat Selling Price: The impact of heat selling price is modelled as a +/-10% variation on the central estimate of heat selling price for each individual customer type. Refer to Table 36.

Maintenance Costs: The uncertainty in project fixed and variable operating costs has been modelled as +/- 10% around the central estimate. This includes the variation in annual sinking funds for reinvestment in the heat network and energy centre.

Carbon Price Support for CHP: The 2011 Budget removed Climate Change Levy Exemption Certificate support[92] for new and existing CHP plants. This was subsequently confirmed in the 2012 Budget. There is uncertainty around what the impact of the government's Electricity Market Reform proposals will be on support for gas CHP (ie whether equivalent levels of support will be

---

[92] Climate Change Levy Exemption Certificates (LECs) are tradable certificates that enable electricity exported to the grid from combined heat and power (CHP) plants to be exempted from the Climate Change Levy.

provided to replace the Climate Change Levy Exemption Certificates). This uncertainty is modelled by assuming equivalent support as the base case by assuming a level of support equivalent to the current LEC value of £5.09/MWh forward in the 'government support' scenario. It has been modelled as half the current support and no support.

Connection Costs: The uncertainty around branch connection costs (connection distances) assuming that the project pays for connections has been modelled as +/- 10% around the central estimate.

Connection Costs 50% / Off : The impact of excluding connection costs for the project is modelled as a 50% reduction in connection costs. This models the scenario that new developers subsidise their connections through planning whilst connections to existing buildings are paid for by the project. This could represent allowable solution and/or CIL contributions towards new developments.

Carbon Emission Assumptions

Carbon savings are reported against DECCs forecasts for marginal and average grid intensity CO_2 factors as reported in [21]. Gas CHP is modelled as displacing the marginal plant on the grid taken from marginal grid production forecasts as reported in [21]. The business as usual alternative for each customer is based on average grid production forecasts as reported in [21].

On this basis, the carbon intensity of the heat generated from gas CHP increases over time and for new residential customers exceeds the alternative heat pump option beyond 2021.

The scenario that current grid average and grid marginal CO_2 factors prevail throughout the life of the project has also been modelled. Both scenarios are presented in the sets of results to provide upper and lower bounds on the likely CO_2 savings for the projects.

The CO_2 emission factor calculation is based on the SAP 2009 methodology.

APPENDIX 4 SUMMARY OF HEAT NETWORK ASSETS

Heat Network

Control Concept

The operating concept of the heat networks 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 [24].

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 typically be controlled between[93] 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.

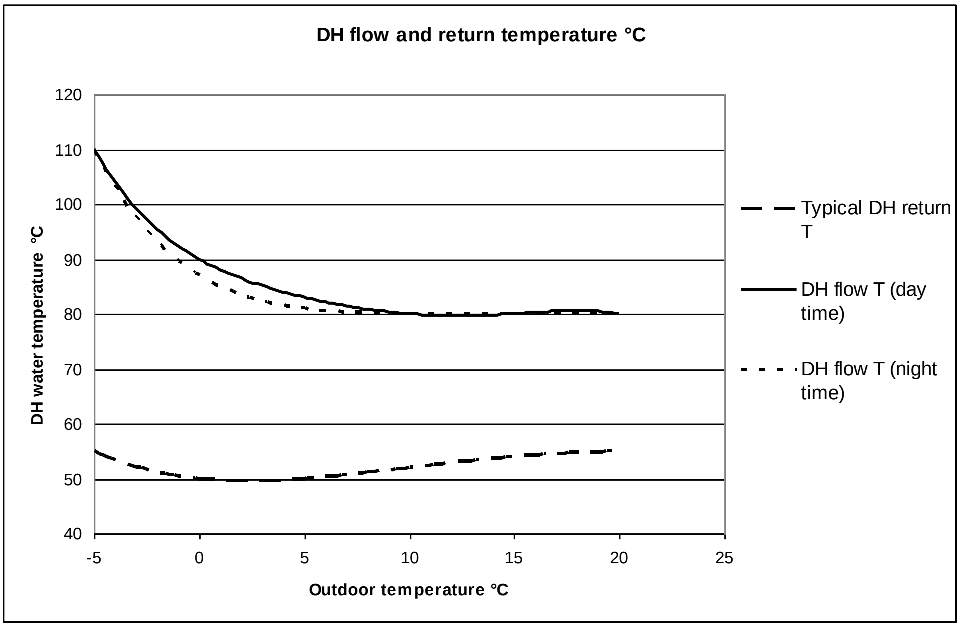


Figure 38: Typical Flow and Return Temperature Characteristics (image courtesy LDA/GLA)

The heat network will typically be pressurised at a single point. This should be located at the energy centre which will also house the primary distribution pumps, water treatment and pressurisation and expansion systems for the heat network.

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.

Pipework Selection

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. Pipe systems have

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

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 are also be used for special applications or in systems with special requirements along the route (for example the railway bridge crossing in Ilford Town Centre, which is likely to be installed as steel in steel pipe. Pre-insulated pipes consist 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.

Rigid steel pipes are generally envisaged as the medium pipe for the projects identified in this report. These employ standard steel pipe, in standard pipe sizes, e.g. DN100, DN125 and are manufactured in straight lengths of 6m, 12m and 16m for general purpose use.

Different insulation options are available, providing varying levels of insulation thickness of the polyurethane foam. The increased foam thickness reduces the heat losses from the pipe system. The selection is usually made on the basis of a cost benefit analysis at the design stage, although Class 1 insulation is considered suitable for the projects identified in this report.

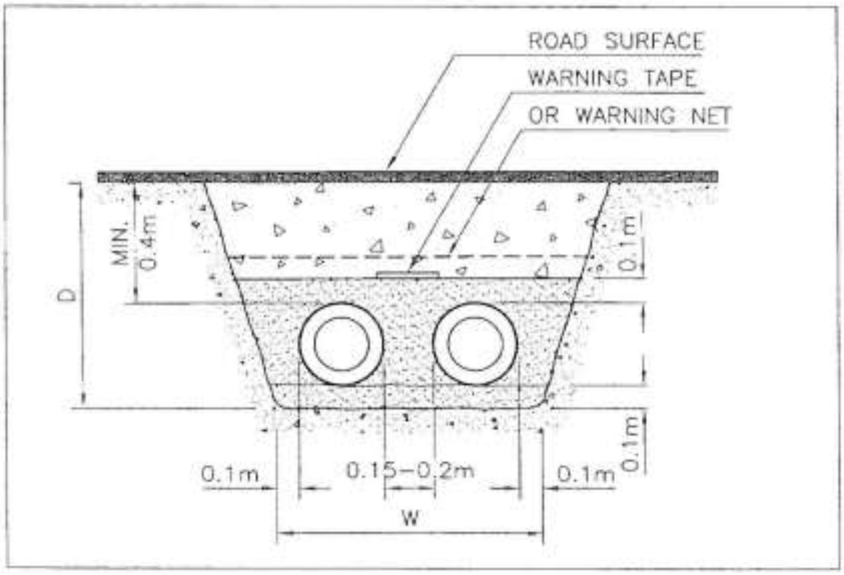
Figure 39: Rigid Steel pipes for District Heating (image courtesy of Ramboll)

Twin pipe options are available as an alternative to single pipe system. These 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 production technology limitations, twin pipes are presently limited to a maximum pipe size of DN200, which limits their use in larger networks.

Twin pipes are best suited to long runs, where branch connections are minimised, since the complexity involved in welding twin pipes can be significant and ultimately can offset the cost savings arising from manufacturing. Considerable skill and expertise is needed for welding twin pipe systems. This may also influence the decision to adopt this pipe system. The choice of pipe system will ultimately also be dictated by route constraints, which is the subject of detailed route appraisal at the design feasibility stage.

Figure 40: Twin Pipes for District Heating (image courtesy of Ramboll)

Typical pipework dimensional requirements are shown below for various pipework diameters based on 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 41: Pipework Trenching Details (image courtesy District Heating Handbook, EDHPMA)

Typical installation requirement details are shown in Figure 42.

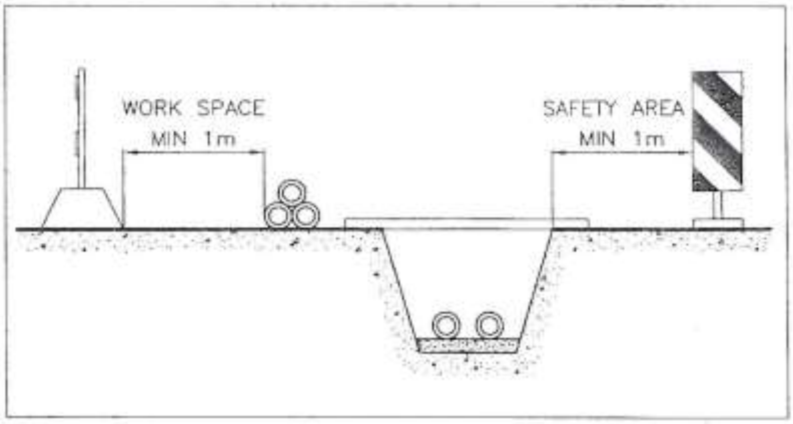


Figure 42: Pipework Installation Working Space (image courtesy image courtesy District Heating Handbook, EDHPMA)

Services pipes connecting buildings to the heat network 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. Depending on the final project design parameters they may or may not be unsuitable for use in the proposed heat network.

<u>Design Temperatures and Pressure Considerations</u>

The approach to designing the heat networks for the Ilford Town Centre, Crossrail Corridor and Barkingside Projects has been to assume that variable volume, variable temperature control would be implemented. Design delivery temperature on the primary side would be 105 °C with design return temperatures of 70 °C and 50 °C for existing and new developments respectively, giving design temperature differences of 55 °C and 35 °C for existing and new developments respectively.

Primary design return temperatures of 70 °C are expected to be the limiting value for existing buildings unless / until modifications to internal heating systems are carried out to permit lower return temperatures (e.g. through temperature compensation, increased thermal efficiency of building fabric insulation etc.). It is noted that return temperatures from existing buildings may be higher than this in many cases, particularly at off design temperatures.

Primary design return temperatures of 50 °C should be achievable for new buildings based on underfloor heating concepts, with a presumption that developers would be required to design their heating systems to achieve this (with a secondary returns in the region of 45 °C). Developers could be incentivised for designing to return heat at below these temperatures.

The approach for Goodmayes Outlier has been based on the same network parameters, on the basis that the delivery of heat to the Trust could be reduced by de-rating / modifications to their their existing DHW circuits. This would be necessary also to allow the gas CHP to deliver a greater proportion of heat into the existing MTHW network than would be possible if the MTHW continued to operate at 120 °C and would also reduce heat losses making operation more efficient.

In relation to pressure, there are two design 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. The 120°C; 16bar option will be suitable for the projects identified in this report. Based on the hydraulic modelling carried out it is envisaged that a 10 bar g or 16 bar g design pressure can be specified for the network fittings and auxiliary equipment, with pressurisation on the system return and indirect connection to customers.

The scope for increasing future capacity and operating the network at lower operating temperatures to allow supply from lower grade heat sources in the future relies on being able to reduce return temperatures from existing buildings. The cost, viability and timescales for this approach will require detailed assessment at the next stage.

Energy Centre Assets

<u>Gas CHP</u>

Gas CHP units are assumed to be based on internal combustion spark ignition engine technology.

These units will typically deliver LTHW to the network via a skid mounted plate heat exchanger. Heat recovery 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. Delivery temperatures into the network will typically be at up to 95 ºC on the flow side, although this can be lowered based on the choice of heat network configuration. Higher temperatures required in the peak condition will be provided through top up boilers (see below).

A typical arrangement detail of the heat recovery system including the heat exchanger station is shown below.

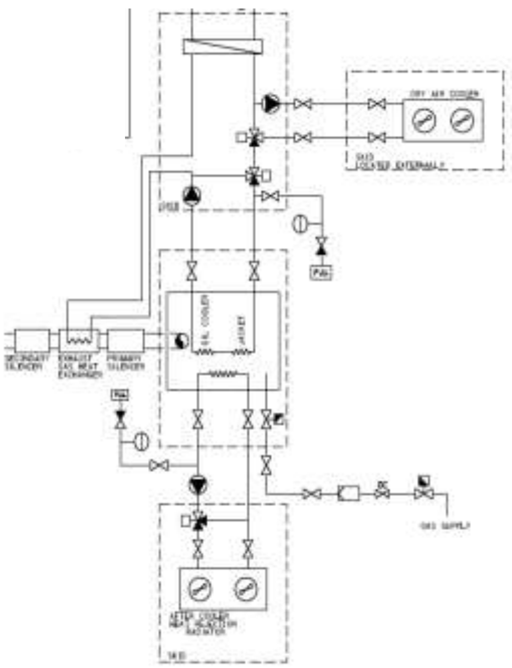


Figure 43: Typical Arrangement for Heat Recovery from Internal Combustion Engine CHP

Gas CHP units will typically be equipped with dry air cooler circuits to allow heat to be rejected under emergency conditions (i.e. if excess heat from the CHP cannot be removed in any other manner).

Gas CHP units will generally be sequenced as the lead heat production unit (when the sales price of electricity is favourable). Where multiple units are installed, each unit would have its own packaged control and safety systems. Sequencing control of the units will be carried out by a central SCADA system.

Gas CHP units will typically operate at constant electrical output under normal operation. They will also be capable of modulating to meet the heat demand, although it is likely to be economically unjustified to run the CHP's at part load with the consequent decrease in efficiency and production in relation to running costs.

Connection of new Gas CHP units to the electrical grid will typically take place at 11 kV grid via dedicated step up transformers from the generator operating at 400V.

Boilers

The boilers are likely to be supplied as packaged shell and tube boilers fitted with fully automatic, fully modulating low NOx burners. These will provide back up and top up to the gas CHP.

Biofuel can be specified as a back-up fuel, however the CO_2 benefit is likely to be marginal due to the low running hours to be expected on biofuel and the need to continuously heat the stored fuel throughout the year.

Heat Accumulators

Heat accumulators are likely to be required for the purpose of storing heat generated from the gas CHP at off peak times when heat production costs are low and discharging this heat during peak demand conditions and when heat production costs would otherwise be high.

Heat accumulators will be located at each proposed energy centre and will be owned, operated and maintained by the Project Company.

Sizing of the accumulator will depend on a trade-off between investment cost and operational cost savings. The modeling carried out at this stage has assumed storage capacity to provide up to three hours storage from the installed CHP capacity.

A typical heat accumulator arrangement is shown below.

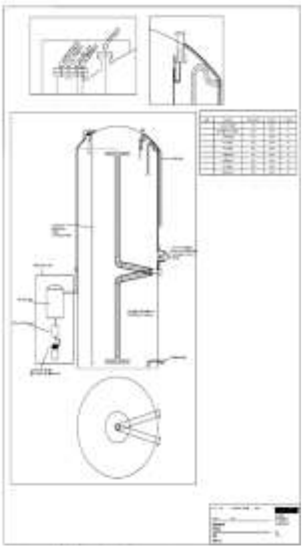


Figure 44: Typical Accumulator Configuration

Consumer Connections

Indirect connections between the primary heat network and the connected buildings through plate heat exchanger stations are the norm in modern heat networks since they provide a number of distinct advantages including:-

1) clear and suitable demarcation boundary between the Project Company and individual plot developers
2) opportunity for simplified billing arrangement for the project company, without the need to take on billing to individual residential customers
3) Avoidance of contamination between primary network and connected buildings (ie water quality issues)
4) Simplified design of primary network in relation to development phasing
5) Increase flexibility for developers to adopt their own individual building services solutions.

This method of connection is anticipated for the projects identified in this report.

Point of Connection to Heat Network

The point of connection to new buildings (residential, mixed use or other) will typically be at the mechanical services plantroom for the building. These are usually located to the rear of the building at basement or ground floor level within the building envelope.

The point of connection to existing buildings will also be at the mechanical services plantroom for the building. In some cases these may be located at roof level, depending on individual building design.

In larger new developments, where multiple blocks are involved, a community heating network should be established by the developer. This will be fed from a temporary energy centre within the boundary of the development until the heat network is available to connect to. The point of connection to these developments will be the temporary energy centre. Depending on the design of the community heat network, the point of connection to the heat network can be either direct or indirect. A direct connection will have advantages in terms of reduced heat losses and avoidance of temperature difference reductions seen by the network but will subject the primary heat network to the water quality regime of the community heat network and require the community heat network to be designed to the pressure requirements of the primary heat network. In such circumstances it is recommended that the project company adopts the community heat network at the point of connection of the project and takes on operational responsibility from thereon in.

Connection within Community Heat Networks

For individual buildings within community heat networks 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 maximises temperature difference in the system, reduces internal heat gains and makes use of the available pressure in the network thereby minimising additional circulation pumping at block level.

Alternatively, communal heat exchanger stations located at block level provide a hydraulic break and a clear commercial demarcation point between the network operator and the maintenance company responsible for the individual buildings.

Three connection arrangements are typically adopted.

1) Direct heating and direct hot water connection
2) Indirect heating and indirect hot water connection
3) Direct heating and indirect hot water connection

The direct approach involves connecting the community network to the consumer's internal heating system directly, without any physical separation of the two systems (i.e. without a heat interface unit).

The indirect approach involves introducing physical separation between the community network and the consumer's internal heating system in the form of a heat interface unit so that the two systems are hydraulically separated. For residential applications this interface can be located at each individual apartment or in the form of a communal interface located in the basement of the apartment block. A further variation is possible in the indirectly connected system in which an additional interface is provided between the community network and the consumer (i.e. at the building interface / basement). For non-residential, mixed use applications, the interface is provided at the building interface.

The decision about which connection method to choose will be based on a trade-off between investment costs, operating costs, operational risk (e.g. impact of leakages) and impact on operational and ownership model (i.e. interfacing arrangements between the network operator, the landlord and the apartment owners). Individual developers will have their own preferences and may choose to adopt either strategy. We would recommend further analysis of the options at the design stage of the project, with reference to the principles set out in the GLA's Design Manual for London which is currently in draft.

Residential Heat Interface Units

Customer interface connections can be delivered as pre-fabricated units also known as hydraulic interface units (HIU) or it can be built by the heating installer. The choice of unit reflects the type of connection i.e. direct / indirect heating and cylinder / instantaneous DHW connection.

Temperatures and pressure levels, also for the mains cold water supply and for the domestic hot water, are among the important parameters when specifying the units.

One important issue is the capacity of the unit in relation to the building's heat demand and the demand for domestic hot water. This will lead to requirements in terms of flow over the installation, combined with the obtainable supply and return temperature. The pre-fabricated units have to be designed for the special conditions in the UK. These conditions include water quality and pressure as well as the way in which the heating system is operated.

Generally, there will not be significant differences in layout and size of these units between different manufactures but there can be a difference in the quality of the components used. A cheaper brand may be compromising on the quality of for instance the heat exchanger and/or the control valves.

The customer interface is achieved through pre-fabricated off the shelf unit solutions as the one seen in the figure below, especially for smaller thermal load connections and single family homes. The units include all equipment such as circulating pump and a heat meter.

Figure 45 -Typical Heat Interface Unit for individual apartments

Commercial Heat Interface Units

The typical design connection for commercial and other non-residential 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 on next page.

Figure 46 – Heat Exchanger Substation for Non Residential Application

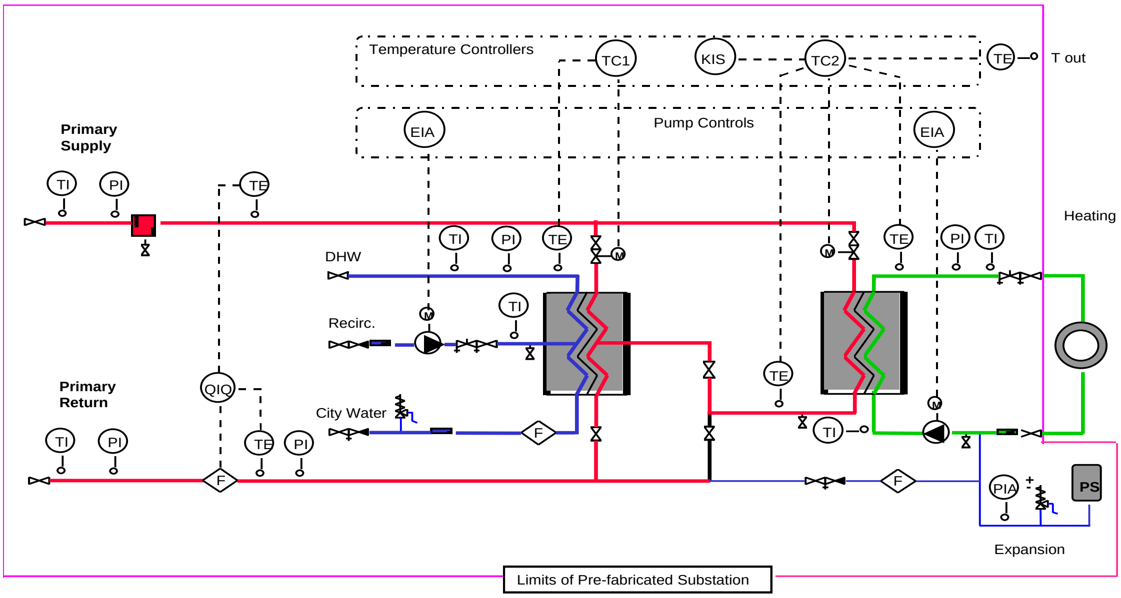


Figure 47: Typical Substation Connection Arrangement (image courtesy of LDA/GLA)

Size Considerations

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 37: 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.

Metering Control and Communication

Each building is expected to 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 project 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.

APPENDIX 5 COST PLANS AND CARBON TRAJECTORIES

Cost Plan Ilford Town Centre – Fully Built Out Project Over 25 Years – Electricity License Lite

Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CAPEX/REPEX																											
Energy Centre	[£]	-3,187,688	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-520,784	0	0	0	0	0	0	0	0	0	0
Network	[£]	-1,771,098	-172,380	-26,520	-561,421	-190,000	-86,190	-53,040	-116,556	-33,150	-13,260	0	-129,281	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	-594,628	-58,690	-373,421	-183,299	-201,417	-103,524	-94,483	-78,486	-38,436	0	-92,278	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project development costs	[£]	-644,564	-88,711	-11,077	-121,530	-48,919	-37,389	-20,353	-27,435	-14,513	-5,680	0	-28,803	0	0	0	-67,702	0	0	0	0	0	0	0	0	0	0
SUBTOTAL	[£]	-5,602,748	-866,719	-96,287	-1,056,372	-425,219	-324,996	-176,917	-238,474	-126,148	-49,377	0	-250,361	0	0	0	-588,486	0	0	0	0	0	0	0	0	0	0
OPEX																											
Fuel	[£]	0	-596,601	-617,339	-731,758	-866,785	-947,328	-964,288	-1,018,627	-1,061,887	-1,087,656	-1,124,214	-1,171,768	-1,189,077	-1,206,386	-1,223,694	-1,241,003	-1,258,311	-1,275,620	-1,292,929	-1,310,237	-1,327,546	-1,344,855	-1,362,163	-1,379,472	-1,396,781	-1,414,089
Overhead and Administration	[£]	0	-93,506	-94,026	-98,465	-106,537	-102,582	-102,485	-103,459	-104,272	-104,579	-104,579	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123	-106,123
Maintenance of plant	[£]	0	-65,872	-67,583	-76,069	-79,634	-82,148	-83,170	-85,061	-85,599	-85,591	-85,591	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148	-86,148
Network maintenance	[£]	0	-4,859	-4,925	-6,329	-6,811	-7,027	-7,159	-7,451	-7,533	-7,567	-7,567	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890	-7,890
SUBTOTAL	[£]	0	-750,840	-783,873	-962,620	-1,053,767	-1,138,998	-1,156,942	-1,214,598	-1,259,292	-1,285,391	-1,321,950	-1,371,929	-1,389,238	-1,406,546	-1,423,855	-1,441,164	-1,458,472	-1,475,781	-1,493,090	-1,510,398	-1,527,707	-1,545,015	-1,562,324	-1,579,633	-1,596,941	-1,614,250
REVENUES																											
Electricity sales	[£]	0	690,867	688,049	788,162	836,094	874,028	897,434	930,582	949,920	963,758	977,737	997,957	1,012,026	1,026,095	1,040,164	1,054,234	1,068,303	1,082,372	1,096,441	1,110,510	1,124,579	1,138,648	1,152,718	1,166,787	1,180,856	1,194,925
Heat sales	[£]	0	589,946	632,557	871,461	1,003,500	1,149,698	1,204,670	1,288,526	1,366,034	1,408,654	1,429,535	1,558,538	1,580,981	1,603,424	1,625,868	1,648,311	1,670,754	1,693,198	1,715,641	1,738,084	1,760,527	1,782,971	1,805,414	1,827,857	1,850,301	1,872,744
Avoided CRC	[£]	0	4,754	4,680	4,480	4,184	3,966	3,392	3,298	3,202	3,168	3,168	2,995	2,995	2,995	2,995	2,995	2,995	2,995	2,995	2,995	2,995	2,995	2,995	2,995	2,995	2,995
LEC	[£]	0	38,718	39,724	44,711	46,807	48,288	48,885	49,987	50,313	50,308	50,308	50,636	50,636	50,636	50,636	50,636	50,636	50,636	50,636	50,636	50,636	50,636	50,636	50,636	50,636	50,636
SUBTOTAL	[£]	0	1,294,285	1,365,009	1,708,814	1,890,585	2,075,971	2,154,381	2,272,371	2,369,469	2,425,888	2,460,749	2,610,125	2,646,638	2,683,150	2,719,663	2,756,175	2,792,687	2,829,200	2,865,712	2,902,225	2,938,737	2,975,250	3,011,762	3,048,275	3,084,787	3,121,300
TOTALS																											
Operating margin	[£]	0	543,445	581,937	744,194	836,818	936,982	997,439	1,057,773	1,110,176	1,140,495	1,158,799	1,238,196	1,257,400	1,276,604	1,295,808	1,315,011	1,334,215	1,353,419	1,372,623	1,391,827	1,411,030	1,430,234	1,449,438	1,468,642	1,487,846	1,507,049
Total cashflow	[£]	-5,602,748	-323,274	485,650	-312,178	411,600	611,986	820,522	819,299	984,028	1,091,118	1,158,799	987,835	1,257,400	1,276,604	1,295,808	726,525	1,334,215	1,353,419	1,372,623	1,391,827	1,411,030	1,430,234	1,449,438	1,468,042	1,487,846	1,507,949
Cumulative cashflow	[£]	-5,602,748	-5,926,022	-5,440,372	-5,752,551	-5,340,951	-4,728,965	-3,908,444	-3,089,145	-2,105,117	-1,013,999	144,800	1,132,635	2,390,035	3,666,639	4,962,446	5,688,972	7,023,187	8,376,606	9,749,229	11,141,855	12,552,886	13,982,320	15,431,758	16,900,400	18,388,246	19,896,295
CARBON DIOXIDE																											
Total Carbon dioxide emissions	[kg CO2]	0	1,999,731	2,098,958	2,918,649	3,312,332	3,697,290	3,868,211	3,869,834	4,038,887	4,152,375	4,152,375	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171	4,419,171
Network heat CO2 intensity	[kg CO2 / MWh]	0	175	176	187	190	194	193	195	196	197	197	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Alternative CO2 emissions (BAU)	[kg CO2]	847,514	3,145,650	3,419,239	4,072,525	4,566,932	5,085,619	5,126,983	5,376,247	5,598,435	5,679,206	5,679,206	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559	5,877,559
Temporary CO2 emissions	[kg CO2]	709,394	222,899	322,491	38,079	38,079	38,079	38,079	38,079	38,079	38,079	38,079	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 savings from network including temporary emissions	[kg CO2]	138,120	923,020	1,086,792	1,115,797	1,216,521	1,350,458	1,420,693	1,468,333	1,520,268	1,538,752	1,538,752	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387	1,458,387

Cost Plan Ilford Town Centre – Cluster Project Over 25 Years – Electricity License Lite

Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CAPEX/REPEX																											
Energy Centre	[£]	-3,084,769	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-490,089	0	0	0	0	0	0	0	0	0	0
Network	[£]	-1,326,239	-99,450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	-407,446	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project development costs	[£]	-573,431	-65,897	0	0	0	0	0	0	0	0	0	0	0	0	0	-63,712	0	0	0	0	0	0	0	0	0	0
SUBTOTAL	[£]	-4,984,438	-572,793	0	0	0	0	0	0	0	0	0	0	0	0	0	-553,801	0	0	0	0	0	0	0	0	0	0
OPEX																											
Fuel	[£]	0	-519,203	-528,235	-537,267	-546,298	-555,330	-516,084	-526,380	-534,677	-542,974	-551,271	-559,568	-567,864	-576,161	-584,458	-592,755	-601,052	-609,348	-617,645	-625,942	-634,239	-642,536	-650,832	-659,129	-667,426	-675,723
Overhead and Administration	[£]	0	-91,531	-91,531	-91,531	-91,531	-91,531	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239
Maintenance of plant	[£]	0	-60,651	-60,651	-60,651	-60,651	-60,651	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341
Network maintenance	[£]	0	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564	-3,564
SUBTOTAL	[£]	0	-674,949	-683,981	-693,013	-702,044	-711,076	-670,228	-678,525	-686,821	-695,118	-703,415	-711,712	-720,009	-728,305	-736,602	-744,899	-753,196	-761,493	-769,789	-778,086	-786,383	-794,680	-802,977	-811,273	-819,570	-827,867
REVENUES																											
Electricity sales	[£]	0	609,141	619,138	629,135	639,132	649,129	634,720	644,347	653,974	663,601	673,227	682,854	692,481	702,108	711,735	721,362	730,988	740,615	750,242	759,869	769,496	779,123	788,750	798,376	808,003	817,630
Heat sales	[£]	0	463,779	471,528	479,278	487,027	494,777	451,862	458,906	465,940	472,914	479,888	486,862	493,835	500,809	507,783	514,757	521,731	528,705	535,679	542,653	549,627	556,601	563,575	570,549	577,523	584,497
Avoided CRC	[£]	0	4,774	4,774	4,774	4,774	4,774	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302	4,302
LEC	[£]	0	35,649	35,649	35,649	35,649	35,649	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292
SUBTOTAL	[£]	0	1,113,344	1,131,090	1,148,837	1,166,583	1,184,329	1,125,305	1,141,906	1,158,507	1,175,108	1,191,709	1,208,309	1,224,910	1,241,511	1,258,112	1,274,713	1,291,313	1,307,914	1,324,515	1,341,116	1,357,717	1,374,318	1,390,918	1,407,519	1,424,120	1,440,721
TOTALS																											
Operating margin	[£]	0	438,395	447,110	455,824	464,539	473,253	455,078	463,382	471,686	479,990	488,294	496,598	504,902	513,206	521,510	529,814	538,118	546,422	554,726	563,030	571,334	579,638	587,942	596,246	604,550	612,854
Total cashflow	[£]	-4,984,438	-134,398	447,110	455,824	464,539	473,253	455,078	463,382	471,686	479,990	488,294	496,598	504,902	513,206	521,510	-23,987	538,118	546,422	554,726	563,030	571,334	579,638	587,942	596,246	604,550	612,854
Cumulative cashflow	[£]	-4,984,438	-5,118,836	-4,671,727	-4,215,903	-3,751,364	-3,278,111	-2,823,033	-2,359,652	-1,887,966	-1,407,976	-919,683	-423,085	81,818	595,022	1,116,532	1,092,544	1,630,662	2,177,084	2,731,810	3,294,839	3,866,173	4,445,811	5,033,753	5,629,998	6,234,548	6,847,402
CARBON DIOXIDE																											
Total Carbon dioxide emissions	[kg CO2]	0	1,680,389	1,680,389	1,680,389	1,680,389	1,680,389	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771
Network heat CO2 intensity	[kg CO2 / MWh]	0	172	172	172	172	172	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166
Alternative CO2 emissions (BAU)	[kg CO2]	426,803	2,386,122	2,386,122	2,386,122	2,386,122	2,386,122	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051	2,097,051
Temporary CO2 emissions	[kg CO2]	354,281	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 savings from network including temporary emissions	[kg CO2]	72,522	705,733	705,733	705,733	705,733	705,733	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280

Cost Plan Ilford Town Centre and Crossrail Corridor – Fully Built Out Project Over 25 Years – Electricity License Lite

Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
CAPEX/REPEX														
Energy Centre	[£]	-3,478,588	0	0	0	0	-768,081	0	0	0	0	0	0	0
Network	[£]	-2,320,428	-172,380	-26,520	-561,421	-190,000	-3,203,722	-609,960	-123,166	-33,150	-13,260	0	-26,520	0
Customer Substations	[£]	0	-594,628	-56,690	-373,421	-183,299	-201,417	-1,213,922	-115,094	-78,486	-39,436	0	-74,920	0
Project development costs	[£]	-753,869	-88,711	-11,077	-121,530	-48,919	-542,516	-237,185	-30,965	-14,513	-6,680	0	-13,187	0
SUBTOTAL	[£]	-6,552,885	-888,719	-96,287	-1,056,372	-425,219	-4,715,716	-2,060,888	-269,154	-126,148	-49,377	0	-114,627	0
OPEX														
Fuel	[£]	0	-576,644	-636,631	-765,217	-848,057	-989,378	-1,559,547	-1,631,582	-1,687,130	-1,723,216	-1,749,408	-1,823,175	-1,850,967
Overhead and Administration	[£]	0	-93,256	-93,765	-98,021	-100,030	-103,665	-114,859	-115,378	-116,192	-116,498	-116,498	-117,762	-117,762
Maintenance of plant	[£]	0	-64,912	-66,553	-74,804	-78,309	-84,396	-152,453	-154,391	-155,823	-155,995	-155,995	-157,925	-157,925
Network maintenance	[£]	0	-6,232	-6,298	-7,702	-8,184	-16,194	-17,719	-18,027	-18,109	-18,143	-18,143	-18,209	-18,209
SUBTOTAL	[£]	0	-741,044	-773,447	-945,744	-1,034,580	-1,193,632	-1,843,777	-1,919,378	-1,977,253	-2,013,851	-2,040,043	-2,117,071	-2,143,963
REVENUES														
Electricity sales	[£]	0	652,215	678,848	773,446	823,028	898,289	1,653,942	1,699,727	1,740,322	1,768,203	1,793,854	1,841,329	1,867,288
Heat sales	[£]	0	589,946	632,557	871,461	1,003,500	1,149,698	1,753,477	1,864,329	1,950,818	2,002,018	2,031,680	2,155,123	2,186,140
Avoided CRC	[£]	0	4,962	4,880	4,812	4,530	3,175	5,851	5,683	5,629	5,595	5,595	5,507	5,507
LEC	[£]	0	38,153	39,118	43,968	46,026	48,698	89,668	90,747	91,589	91,690	91,690	92,824	92,824
SUBTOTAL	[£]	0	1,285,276	1,355,401	1,693,688	1,877,086	2,098,768	3,502,876	3,660,487	3,788,157	3,867,506	3,922,819	4,094,784	4,151,759
TOTALS														
Operating margin	[£]	0	544,232	581,954	747,942	842,505	905,136	1,659,100	1,741,109	1,810,904	1,853,655	1,882,776	1,977,713	2,007,796
Total cashflow	[£]	-6,552,885	-322,468	485,666	-308,430	417,287	-3,810,580	-401,888	1,471,954	1,684,755	1,804,278	1,882,776	1,863,086	2,007,796
Cumulative cashflow	[£]	-6,552,885	-6,875,352	-6,389,686	-6,698,116	-6,280,829	-10,091,409	-10,493,295	-9,021,341	-7,336,586	-5,532,307	-3,649,530	-1,786,445	221,351
CARBON DIOXIDE														
Total Carbon dioxide emissions	[kg CO2]	0	1,959,667	2,050,764	2,843,497	3,225,399	3,915,593	5,234,765	5,492,866	5,644,418	5,706,426	5,706,426	5,947,039	5,947,039
Network heat CO2 intensity	[kg CO2 / MWh]	0	174	176	186	190	195	181	183	184	184	184	186	186
Alternative CO2 emissions (BAU)	[kg CO2]	1,152,495	3,621,384	4,038,570	4,782,436	5,480,023	6,156,993	7,361,756	7,653,385	7,873,573	7,956,345	7,956,345	8,154,697	8,154,697
Temporary CO2 emissions	[kg CO2]	964,199	620,408	848,220	651,098	823,533	960,032	0	0	0	0	0	0	0
CO2 savings from network including temporary emissions	[kg CO2]	188,298	1,041,309	1,139,580	1,287,841	1,431,091	1,201,366	2,126,993	2,161,319	2,229,155	2,249,919	2,249,919	2,207,658	2,207,658

Year		2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CAPEX/REPEX														
Energy Centre	[£]	0	0	-536,229	0	0	0	0	-384,831	0	0	0	0	0
Network	[£]	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	0	0	0	0	0	0	0	0	0	0	0	0
Project development costs	[£]	0	0	-69,710	0	0	0	0	-49,924	0	0	0	0	0
SUBTOTAL	[£]	0	0	-605,939	0	0	0	0	-433,954	0	0	0	0	0
OPEX														
Fuel	[£]	-1,876,959	-1,903,851	-1,930,743	-1,957,636	-1,984,528	-2,011,420	-2,038,312	-2,065,204	-2,092,096	-2,118,988	-2,145,880	-2,172,772	-2,199,664
Overhead and Administration	[£]	-117,762	-117,762	-117,762	-117,762	-117,762	-117,762	-117,762	-117,762	-117,762	-117,762	-117,762	-117,762	-117,762
Maintenance of plant	[£]	-157,925	-157,925	-157,925	-157,925	-157,925	-157,925	-157,925	-157,925	-157,925	-157,925	-157,925	-157,925	-157,925
Network maintenance	[£]	-18,209	-18,209	-18,209	-18,209	-18,209	-18,209	-18,209	-18,209	-18,209	-18,209	-18,209	-18,209	-18,209
SUBTOTAL	[£]	-2,170,855	-2,197,747	-2,224,639	-2,251,532	-2,278,424	-2,305,316	-2,332,208	-2,359,100	-2,385,992	-2,412,884	-2,439,776	-2,466,668	-2,493,560
REVENUES														
Electricity sales	[£]	1,893,247	1,919,206	1,945,165	1,971,124	1,997,083	2,023,042	2,049,001	2,074,960	2,100,919	2,126,878	2,152,837	2,178,796	2,204,755
Heat sales	[£]	2,217,156	2,248,173	2,279,189	2,310,206	2,341,222	2,372,239	2,403,255	2,434,272	2,465,288	2,496,305	2,527,321	2,558,338	2,589,354
Avoided CRC	[£]	5,507	5,507	5,507	5,507	5,507	5,507	5,507	5,507	5,507	5,507	5,507	5,507	5,507
LEC	[£]	92,824	92,824	92,824	92,824	92,824	92,824	92,824	92,824	92,824	92,824	92,824	92,824	92,824
SUBTOTAL	[£]	4,208,735	4,265,710	4,322,686	4,379,661	4,436,637	4,493,612	4,550,588	4,607,563	4,664,539	4,721,514	4,778,490	4,835,465	4,892,441
TOTALS														
Operating margin	[£]	2,037,879	2,067,963	2,098,046	2,128,130	2,158,213	2,188,296	2,218,380	2,248,463	2,278,547	2,308,630	2,338,713	2,368,797	2,398,880
Total cashflow	[£]	2,037,879	2,067,963	1,492,107	2,128,130	2,158,213	2,188,296	2,218,380	1,814,509	2,278,547	2,308,630	2,338,713	2,368,797	2,398,880
Cumulative cashflow	[£]	2,259,231	4,327,193	5,819,301	7,947,431	10,105,644	12,293,940	14,512,320	16,326,829	18,605,375	20,914,005	23,252,719	25,621,516	28,020,396
CARBON DIOXIDE														
Total Carbon dioxide emissions	[kg CO2]	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039	5,947,039
Network heat CO2 intensity	[kg CO2 / MWh]	186	186	186	186	186	186	186	186	186	186	186	186	186
Alternative CO2 emissions (BAU)	[kg CO2]	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697	8,154,697
Temporary CO2 emissions	[kg CO2]	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 savings from network including temporary emissions	[kg CO2]	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658	2,207,658

Cost Plan Ilford Town Centre and Crossrail Corridor – Cluster Project Over 25 Years – Electricity License Lite

Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
CAPEX/REPEX														
Energy Centre	[£]	-3,324,769	0	0	0	0	0	0	0	0	0	0	0	0
Network	[£]	-1,480,221	-99,458	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	-407,446	0	0	0	0	21,845	0	0	0	0	0	0
Project development costs	[£]	-624,649	-65,897	0	0	0	0	2,736	0	0	0	0	0	0
SUBTOTAL	[£]	-5,429,638	-572,793	0	0	0	0	23,781	0	0	0	0	0	0
OPEX														
Fuel	[£]	0	-519,203	-528,235	-537,267	-546,298	-555,330	-518,884	-526,380	-534,677	-542,974	-551,271	-559,568	-567,864
Overhead and Administration	[£]	0	-91,531	-91,531	-91,531	-91,531	-91,531	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239
Maintenance of plant	[£]	0	-60,651	-60,651	-60,651	-60,651	-60,651	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341
Network maintenance	[£]	0	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949
SUBTOTAL	[£]	0	-675,334	-684,366	-693,397	-702,429	-711,461	-670,613	-678,909	-687,206	-695,503	-703,800	-712,097	-720,394
REVENUES														
Electricity sales	[£]	0	471,515	479,253	486,991	494,730	502,468	491,314	498,766	506,218	513,670	521,122	528,573	536,025
Heat sales	[£]	0	463,779	471,529	479,278	487,027	494,777	451,992	458,966	465,940	472,914	479,888	486,862	493,835
Avoided CRC	[£]	0	4,774	4,774	4,774	4,774	4,774	4,382	4,382	4,382	4,382	4,382	4,382	4,382
LEC	[£]	0	35,649	35,649	35,649	35,649	35,649	34,292	34,292	34,292	34,292	34,292	34,292	34,292
SUBTOTAL	[£]	0	975,717	991,205	1,006,693	1,022,180	1,037,668	981,980	996,325	1,010,751	1,025,177	1,039,603	1,054,029	1,068,454
TOTALS														
Operating margin	[£]	0	300,383	306,839	313,295	319,751	326,207	311,287	317,416	323,545	329,674	335,803	341,932	348,061
Total cashflow	[£]	-5,429,638	-272,410	306,839	313,295	319,751	326,207	335,068	317,416	323,545	329,674	335,803	341,932	348,061
Cumulative cashflow	[£]	-5,429,638	-5,702,047	-5,395,208	-5,081,913	-4,762,161	-4,435,954	-4,100,886	-3,783,470	-3,459,925	-3,130,252	-2,794,449	-2,452,517	-2,104,456
CARBON DIOXIDE														
Total Carbon dioxide emissions	[kg CO2]	0	1,680,389	1,680,389	1,680,389	1,680,389	1,680,389	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771
Network heat CO2 intensity	[kg CO2 / MWh]	0	172	172	172	172	172	166	166	166	166	166	166	166
Alternative CO2 emissions (BAU)	[kg CO2]	426,803	2,386,122	2,386,122	2,386,122	2,386,122	2,386,122	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851
Temporary CO2 emissions	[kg CO2]	354,281	0	0	0	0	0	0	0	0	0	0	0	0
CO2 savings from network including temporary emissions	[kg CO2]	72,522	705,733	705,733	705,733	705,733	705,733	658,280	658,280	658,280	658,280	658,280	658,280	658,280

Year		2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CAPEX/REPEX														
Energy Centre	[£]	0	0	-490,089	0	0	0	0	0	0	0	0	0	0
Network	[£]	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	0	0	0	0	0	0	0	0	0	0	0	0
Project development costs	[£]	0	0	-63,712	0	0	0	0	0	0	0	0	0	0
SUBTOTAL	[£]	0	0	-553,801	0	0	0	0	0	0	0	0	0	0
OPEX														
Fuel	[£]	-576,161	-584,458	-592,755	-601,052	-609,348	-617,645	-625,942	-634,239	-642,536	-650,832	-659,129	-667,426	-675,723
Overhead and Administration	[£]	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239	-90,239
Maintenance of plant	[£]	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341	-58,341
Network maintenance	[£]	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949	-3,949
SUBTOTAL	[£]	-728,690	-736,987	-745,284	-753,581	-761,878	-770,174	-778,471	-786,768	-795,065	-803,362	-811,658	-819,955	-828,252
REVENUES														
Electricity sales	[£]	543,477	550,929	558,381	565,832	573,284	580,736	588,188	595,640	603,091	610,543	617,995	625,447	632,899
Heat sales	[£]	500,809	507,783	514,757	521,731	528,705	535,679	542,653	549,627	556,601	563,575	570,549	577,523	584,497
Avoided CRC	[£]	4,382	4,382	4,382	4,382	4,382	4,382	4,382	4,382	4,382	4,382	4,382	4,382	4,382
LEC	[£]	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292	34,292
SUBTOTAL	[£]	1,082,880	1,097,306	1,111,732	1,126,157	1,140,583	1,155,009	1,169,435	1,183,861	1,198,286	1,212,712	1,227,138	1,241,564	1,255,989
TOTALS														
Operating margin	[£]	354,190	360,319	366,448	372,577	378,706	384,835	390,964	397,093	403,222	409,350	415,479	421,608	427,737
Total cashflow	[£]	354,190	360,319	-187,353	372,577	378,706	384,835	390,964	397,093	403,222	409,350	415,479	421,608	427,737
Cumulative cashflow	[£]	-1,750,266	-1,389,948	-1,577,301	-1,204,724	-826,019	-441,184	-50,220	346,872	750,094	1,159,444	1,574,924	1,996,532	2,424,269
CARBON DIOXIDE														
Total Carbon dioxide emissions	[kg CO2]	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771	1,438,771
Network heat CO2 intensity	[kg CO2 / MWh]	166	166	166	166	166	166	166	166	166	166	166	166	166
Alternative CO2 emissions (BAU)	[kg CO2]	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851	2,097,851
Temporary CO2 emissions	[kg CO2]	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 savings from network including temporary emissions	[kg CO2]	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280	658,280

Cost Plan Goodmayes Outlier – Fully Built Out Project Over 25 Years – Private Wire

Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CAPEX/REPEX																											
Energy Centre	[£]	-1,190,812	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-567,724	0	0	0	0	0	0	0	0	0	0
Network	[£]	-1,818,064	-49,168	-6,145	-6,145	-12,290	-6,145	-6,145	-6,145	-154,721	-310,888	-12,290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	-191,782	-24,516	-24,516	-25,982	-11,752	-14,297	-25,888	-25,080	-21,694	-36,866	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project development costs	[£]	-287,154	-31,322	-3,986	-3,986	-4,975	-2,327	-2,657	-4,859	-23,374	-43,224	-6,390	0	0	0	0	-73,804	0	0	0	0	0	0	0	0	0	0
SUBTOTAL	[£]	-2,496,030	-272,264	-34,647	-34,647	-43,248	-20,223	-23,100	-35,284	-203,174	-375,718	-55,546	0	0	0	0	-641,528	0	0	0	0	0	0	0	0	0	0
OPEX																											
Fuel	[£]	0	-654,154	-680,557	-704,642	-724,264	-739,334	-715,516	-742,523	-774,397	-807,498	-836,301	-848,876	-861,452	-874,028	-886,603	-899,179	-911,754	-924,330	-936,906	-949,481	-962,057	-974,632	-987,208	-999,784	-1,012,359	-1,024,935
Overhead and Administration	[£]	0	-96,686	-97,074	-97,462	-97,692	-97,782	-96,576	-96,991	-97,524	-98,064	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505	-98,505
Maintenance of plant	[£]	0	-75,537	-76,128	-76,716	-77,164	-77,339	-77,154	-78,247	-79,607	-81,095	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983	-81,983
Network maintenance	[£]	0	-2,668	-2,683	-2,699	-2,730	-2,745	-2,760	-2,776	-3,162	-3,939	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970	-3,970
SUBTOTAL	[£]	0	-829,045	-856,443	-881,519	-901,850	-917,200	-892,006	-920,536	-954,690	-990,589	-1,020,759	-1,033,335	-1,045,910	-1,058,486	-1,071,061	-1,083,637	-1,096,213	-1,108,788	-1,121,364	-1,133,939	-1,146,515	-1,159,091	-1,171,666	-1,184,242	-1,196,817	-1,209,393
REVENUES																											
Electricity sales	[£]	0	540,783	554,144	567,431	579,749	590,279	597,788	616,028	636,384	657,370	674,495	684,140	693,785	703,430	713,075	722,719	732,364	742,009	751,654	761,299	770,944	780,589	790,234	799,879	809,524	819,169
Heat sales	[£]	0	544,382	578,687	613,917	634,079	651,825	617,224	655,735	695,139	726,965	755,552	766,571	777,590	788,610	799,629	810,649	821,668	832,687	843,707	854,726	865,746	876,765	887,784	898,804	909,823	920,842
Avoided CRC	[£]	0	6,028	5,724	5,638	5,455	5,424	4,987	4,983	4,661	4,381	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888
LEC	[£]	0	34,986	35,180	35,451	35,659	35,739	35,654	36,159	36,707	37,475	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885	37,885
SUBTOTAL	[£]	0	1,126,019	1,173,736	1,222,437	1,255,741	1,282,468	1,255,654	1,312,825	1,372,970	1,426,051	1,471,820	1,492,484	1,513,148	1,533,813	1,554,477	1,575,141	1,595,806	1,616,470	1,637,134	1,657,799	1,678,463	1,699,128	1,719,792	1,740,456	1,761,121	1,781,785
TOTALS																											
Operating margin	[£]	0	296,974	317,293	340,919	353,891	365,267	363,648	392,288	418,281	435,462	451,061	459,149	467,238	475,327	483,416	491,504	499,593	507,682	515,771	523,859	531,948	540,037	548,126	556,215	564,303	572,392
Total cashflow	[£]	-2,496,030	24,710	282,646	306,272	310,644	345,044	340,548	357,085	215,106	59,745	395,514	459,149	467,238	475,327	483,416	-150,023	499,593	507,682	515,771	523,859	531,948	540,037	548,126	556,215	564,303	572,392
Cumulative cashflow	[£]	-2,496,030	-2,471,320	-2,188,674	-1,882,403	-1,571,759	-1,226,715	-886,167	-529,163	-314,056	-254,312	141,203	600,352	1,067,590	1,542,917	2,026,333	1,876,309	2,375,902	2,883,584	3,399,355	3,923,215	4,455,163	4,995,200	5,543,326	6,099,540	6,663,844	7,236,236
CARBON DIOXIDE																											
Total Carbon dioxide emissions	[kg CO2]	0	2,816,652	2,915,152	2,991,079	3,035,094	3,052,367	2,801,103	2,877,848	2,976,983	3,076,327	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621	3,160,621
Network heat CO2 intensity	[kg CO2 / MWh]	0	199	201	202	202	203	199	200	200	201	202	202	202	202	202	202	202	202	202	202	202	202	202	202	202	202
Alternative CO2 emissions (BAU)	[kg CO2]	0	3,604,338	3,687,201	3,770,071	3,815,824	3,839,932	3,545,268	3,625,738	3,786,191	3,786,551	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208	3,855,208
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	0	0
CO2 savings from network including temporary emissions	[kg CO2]	0	787,678	772,048	778,992	788,730	787,565	744,165	747,882	729,207	710,224	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587	694,587

Cost Plan Goodmayes Outlier – Cluster Project Over 25 Years –Private Wire

Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CAPEX/REPEX																											
Energy Centre	[£]	-1,190,812	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-567,724	0	0	0	0	0	0	0	0	0	0
Network	[£]	-927,730	-36,670	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	-156,960	0	0	0	0	8,511	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project development costs	[£]	-275,411	-25,981	0	0	0	0	1,106	0	0	0	0	0	0	0	0	-73,804	0	0	0	0	0	0	0	0	0	0
SUBTOTAL	[£]	-2,393,953	-218,911	0	0	0	0	9,617	0	0	0	0	0	0	0	0	-641,528	0	0	0	0	0	0	0	0	0	0
OPEX																											
Fuel	[£]	0	-675,765	-687,528	-699,291	-711,053	-722,816	-685,044	-696,033	-707,822	-718,810	-729,799	-740,788	-751,777	-762,765	-773,754	-784,743	-795,732	-806,720	-817,709	-828,698	-839,687	-850,675	-861,664	-872,653	-883,642	-894,630
Overhead and Administration	[£]	0	-97,275	-97,275	-97,275	-97,275	-97,275	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720	-95,720
Maintenance of plant	[£]	0	-76,587	-76,587	-76,587	-76,587	-76,587	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479	-75,479
Network maintenance	[£]	0	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412	-2,412
SUBTOTAL	[£]	0	-852,038	-863,801	-875,564	-887,326	-899,089	-859,455	-870,443	-881,432	-892,421	-903,410	-914,398	-925,387	-936,376	-947,365	-958,353	-969,342	-980,331	-991,320	-1,002,308	-1,013,297	-1,024,286	-1,035,275	-1,046,263	-1,057,252	-1,068,241
REVENUES																											
Electricity sales	[£]	0	548,294	557,293	566,291	575,290	584,288	585,346	594,224	603,102	611,980	620,858	629,736	638,614	647,492	656,370	665,248	674,126	683,004	691,882	700,760	709,638	718,516	727,394	736,272	745,150	754,028
Heat sales	[£]	0	546,869	555,812	564,955	574,097	583,240	536,655	544,937	553,219	561,501	569,783	578,065	586,348	594,630	602,912	611,194	619,476	627,758	636,041	644,323	652,605	660,887	669,169	677,451	685,734	694,016
Avoided CRC	[£]	0	7,828	7,828	7,828	7,828	7,828	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602	7,602
LEC	[£]	0	35,392	35,392	35,392	35,392	35,392	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880	34,880
SUBTOTAL	[£]	0	1,138,183	1,156,324	1,174,466	1,192,607	1,210,748	1,164,483	1,181,643	1,198,803	1,215,964	1,233,124	1,250,284	1,267,444	1,284,604	1,301,764	1,318,925	1,336,085	1,353,245	1,370,405	1,387,565	1,404,725	1,421,885	1,439,046	1,456,206	1,473,366	1,490,526
TOTALS																											
Operating margin	[£]	0	286,145	292,523	298,902	305,280	311,659	305,029	311,200	317,371	323,543	329,714	335,886	342,057	348,228	354,400	360,571	366,743	372,914	379,085	385,257	391,428	397,600	403,771	409,942	416,114	422,285
Total cashflow	[£]	-2,393,953	68,134	292,523	298,902	305,280	311,659	314,646	311,200	317,371	323,543	329,714	335,886	342,057	348,228	354,400	-280,956	366,743	372,914	379,085	385,257	391,428	397,600	403,771	409,942	416,114	422,285
Cumulative cashflow	[£]	-2,393,953	-2,325,819	-2,033,295	-1,734,394	-1,429,113	-1,117,454	-802,809	-491,609	-174,237	149,306	479,020	814,905	1,156,962	1,505,191	1,859,590	1,578,634	1,945,377	2,318,290	2,697,376	3,082,633	3,474,061	3,871,660	4,275,431	4,685,374	5,101,487	5,523,772
CARBON DIOXIDE																											
Total Carbon dioxide emissions	[kg CO2]	0	2,954,763	2,954,763	2,954,763	2,954,763	2,954,763	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938	2,638,938
Network heat CO2 intensity	[kg CO2 / MWh]	0	202	202	202	202	202	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
Alternative CO2 emissions (BAU)	[kg CO2]	0	3,933,257	3,933,257	3,933,257	3,933,257	3,933,257	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240	3,589,240
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	0	0
CO2 savings from network including temporary emissions	[kg CO2]	0	978,495	978,495	978,495	978,495	978,495	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302	958,302

Cost Plan Crossrail Corridor – Fully Built Out Project Over 25 Years – Electricity License Lite

Year		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
CAPEX/REPEX																											
Energy Centre	[£]	-3,324,769	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-490,089	0	0	0	0	0	0	0	0	0	0
Network	[£]	-3,234,685	-558,290	-6,630	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	-1,893,039	-20,521	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project development costs	[£]	-852,719	-213,633	-3,530	0	0	0	0	0	0	0	0	0	0	0	0	-63,712	0	0	0	0	0	0	0	0	0	0
SUBTOTAL	[£]	-7,412,092	-1,856,962	-30,680	0	0	0	0	0	0	0	0	0	0	0	0	-553,801	0	0	0	0	0	0	0	0	0	0
OPEX																											
Fuel	[£]	0	-533,123	-552,778	-562,231	-571,684	-581,136	-590,589	-600,042	-609,495	-618,947	-628,400	-637,853	-647,305	-656,758	-666,211	-675,663	-685,116	-694,569	-704,021	-713,474	-722,927	-732,379	-741,832	-751,285	-760,737	-770,190
Overhead and Administration	[£]	0	-91,340	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602	-91,602
Maintenance of plant	[£]	0	-66,230	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160	-67,160
Network maintenance	[£]	0	-9,462	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479	-9,479
SUBTOTAL	[£]	0	-700,155	-721,020	-730,472	-739,925	-749,378	-758,830	-768,283	-777,736	-787,188	-796,641	-806,094	-815,546	-824,999	-834,452	-843,904	-853,357	-862,810	-872,263	-881,715	-891,168	-900,621	-910,073	-919,526	-928,979	-938,431
REVENUES																											
Electricity sales	[£]	0	665,607	685,412	696,479	707,546	718,613	729,681	740,748	751,815	762,882	773,949	785,016	796,083	807,150	818,218	829,285	840,352	851,419	862,486	873,553	884,620	895,687	906,755	917,822	928,889	939,956
Heat sales	[£]	0	494,056	519,427	528,000	536,573	545,146	553,719	562,292	570,866	579,439	588,012	596,585	605,159	613,732	622,305	630,878	639,451	648,025	656,598	665,171	673,744	682,317	690,891	699,464	708,037	716,610
Avoided CRC	[£]	0	2,391	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385	2,385
LEC	[£]	0	38,928	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475	39,475
SUBTOTAL	[£]	0	1,200,983	1,246,699	1,266,339	1,285,980	1,305,620	1,325,260	1,344,901	1,364,541	1,384,181	1,403,822	1,423,462	1,443,102	1,462,743	1,482,383	1,502,023	1,521,664	1,541,304	1,560,944	1,580,585	1,600,225	1,619,865	1,639,506	1,659,146	1,678,786	1,698,427
TOTALS																											
Operating margin	[£]	0	500,829	525,679	535,867	546,055	556,242	566,430	576,618	586,805	596,993	607,180	617,368	627,556	637,743	647,931	658,119	668,306	678,494	688,682	698,869	709,057	719,245	729,432	739,620	749,808	759,995
Total cashflow	[£]	-7,412,092	-1,356,134	494,999	535,867	546,055	556,242	566,430	576,618	586,805	596,993	607,180	617,368	627,556	637,743	647,931	104,318	668,306	678,494	688,682	698,869	709,057	719,245	729,432	739,620	749,808	759,995
Cumulative cashflow	[£]	-7,412,092	-8,768,226	-8,273,227	-7,737,360	-7,191,306	-6,635,063	-6,068,634	-5,492,016	-4,905,211	-4,308,218	-3,701,037	-3,083,669	-2,456,114	-1,818,370	-1,170,439	-1,066,121	-397,815	280,679	969,361	1,668,230	2,377,287	3,096,532	3,825,964	4,565,584	5,315,392	6,075,387
CARBON DIOXIDE																											
Total Carbon dioxide emissions	[kg CO2]	0	1,571,529	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685	1,614,685
Network heat CO2 intensity	[kg CO2 / MWh]	0	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164
Alternative CO2 emissions (BAU)	[kg CO2]	1,071,174	2,234,775	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138	2,277,138
Temporary CO2 emissions	[kg CO2]	1,695,512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 savings from network including temporary emissions	[kg CO2]	-624,339	663,246	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453	662,453

Cost Plan Barkingside Investment Area – Fully Built Out Project Over 25 Years – Electricity License Lite

Year		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
CAPEX/REPEX																											
Energy Centre	[£]	-3,685,706	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-266,920	0	0	0	0	-116,674	0	0	0	0	0
Network	[£]	-3,090,960	-1,339,970	-12,290	-12,290	-6,145	-6,145	-6,145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Substations	[£]	0	-636,751	-34,883	-34,883	-16,037	-16,037	-11,752	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project development costs	[£]	-880,967	-256,974	-6,133	-6,133	-2,884	-2,884	-2,327	0	0	0	0	0	0	0	0	-34,700	0	0	0	0	-15,168	0	0	0	0	0
SUBTOTAL	[£]	-7,657,632	-2,233,694	-53,306	-53,306	-25,065	-25,065	-20,223	0	0	0	0	0	0	0	0	-301,620	0	0	0	0	-131,841	0	0	0	0	0
OPEX																											
Fuel	[£]	0	-617,372	-642,918	-669,363	-686,956	-704,567	-719,864	-731,380	-742,896	-754,412	-765,929	-777,445	-788,961	-800,477	-811,993	-823,510	-835,026	-846,542	-858,058	-869,574	-881,091	-892,607	-904,123	-915,639	-927,156	-938,672
Overhead and Administration	[£]	0	-94,443	-94,844	-95,244	-95,418	-95,592	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687	-95,687
Maintenance of plant	[£]	0	-83,725	-84,518	-85,431	-85,929	-86,363	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723	-86,723
Network maintenance	[£]	0	-11,077	-11,108	-11,139	-11,154	-11,169	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185	-11,185
SUBTOTAL	[£]	0	-806,617	-833,387	-861,177	-879,458	-897,691	-913,458	-924,974	-936,491	-948,007	-959,523	-971,039	-982,555	-994,072	-1,005,588	-1,017,104	-1,028,620	-1,040,136	-1,051,653	-1,063,169	-1,074,685	-1,086,201	-1,097,717	-1,109,234	-1,120,750	-1,132,266
REVENUES																											
Electricity sales	[£]	0	696,504	714,636	734,016	750,034	765,605	780,637	792,477	804,317	816,156	827,996	839,836	851,676	863,516	875,356	887,196	899,036	910,876	922,716	934,556	946,396	958,236	970,076	981,916	993,756	1,005,596
Heat sales	[£]	0	566,809	601,649	637,333	658,992	681,014	697,900	708,771	719,642	730,512	741,383	752,254	763,125	773,995	784,866	795,737	806,608	817,478	828,349	839,220	850,091	860,961	871,832	882,703	893,573	904,444
Avoided CRC	[£]	0	2,784	2,682	2,592	2,586	2,577	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575	2,575
LEC	[£]	0	39,694	40,070	40,502	40,739	40,944	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115	41,115
SUBTOTAL	[£]	0	1,305,790	1,359,037	1,414,443	1,452,351	1,490,140	1,522,226	1,544,937	1,567,648	1,590,358	1,613,069	1,635,780	1,658,491	1,681,201	1,703,912	1,726,623	1,749,333	1,772,044	1,794,755	1,817,466	1,840,176	1,862,887	1,885,598	1,908,309	1,931,019	1,953,730
TOTALS																											
Operating margin	[£]	0	499,173	525,650	553,267	572,893	592,449	608,768	619,963	631,157	642,352	653,546	664,741	675,935	687,130	698,324	709,519	720,713	731,908	743,102	754,297	765,491	776,686	787,880	799,075	810,269	821,464
Total cashflow	[£]	-7,657,632	-1,734,521	472,344	499,961	547,828	567,384	588,545	619,963	631,157	642,352	653,546	664,741	675,935	687,130	698,324	407,899	720,713	731,908	743,102	754,297	633,650	776,686	787,880	799,075	810,269	821,464
Cumulative cashflow	[£]	-7,657,632	-9,392,153	-8,919,809	-8,419,849	-7,872,021	-7,304,637	-6,716,092	-6,096,129	-5,464,972	-4,822,620	-4,169,074	-3,504,333	-2,828,398	-2,141,268	-1,442,944	-1,035,045	-314,331	417,576	1,160,679	1,914,976	2,548,626	3,325,311	4,113,192	4,912,267	5,722,536	6,544,000
CARBON DIOXIDE																											
Total Carbon dioxide emissions	[kg CO2]	0	2,173,239	2,262,687	2,350,890	2,382,140	2,414,074	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280	2,430,280
Network heat CO2 intensity	[kg CO2 / MWh]	0	178	180	182	182	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183
Alternative CO2 emissions (BAU)	[kg CO2]	803,580	2,763,430	2,857,122	2,950,813	2,996,619	3,042,424	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532	3,066,532
Temporary CO2 emissions	[kg CO2]	1,939,178	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 savings from network including temporary emissions	[kg CO2]	-1,135,598	590,191	594,435	599,923	614,479	628,350	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252	636,252

The carbon Trajectories over the 25 year life of the project are shown below for the cases that the Grid Carbon Factor remains unchanged over the life of the project and for the case that the DECC Grid Decarbonisation Trajectory is assumed to apply. This demonstrates the adverse impact that grid decarbonisation would have on the carbon savings arising from each project, assuming the alternative case for the indicated developments as described in Appendix 3[94].

The graphs highlight a positive saving in CO_2 over the life of the project based on projections using current grid emission factors but a negative saving if the DECC decarbonisation trajectory is assumed, highlighting the limited role that natural gas CHP will be able to play in carbon reduction in the future if DECC's grid decarbonisation trajectory is realised in practice.

The actual carbon dioxide emissions from the scheme will not go up but because the electricity production is discounted against the use of fuel the more the grid electricity is decarbonised the less savings are achieved. There is a double effect in the case of the new developments connected to the network because the alternative to connecting these are assumed to be electric based systems. As the electricity grid is gradually decarbonised the alternative systems' theoretical emissions become smaller.

District heating systems are flexible and one can imagine that as and when the decarbonisation happen as necessary to be on track for carbon savings target in 2050 the fuel and technology mix can be updated. Potentially biomass/biofuel CHP systems could be available and/or using injected biomethane to reduce the carbon content of the fuel for gas engines.

It is worth pointing out that the alternative scheme represents an increase in emissions, compared to the modelled schemes, until such time that the grid is decarbonisation has caught up.

The negative numbers a year before operation is due to local temporary gas boiler systems for new developments until such time when they receive heat from the network.

[94] The reasons for the decreased savings are twofold; electricity is produced by CHP using fossil fuel so the benefit decrease and the alternative solution for new residential developments are modelled as heat pumps, so their carbon dioxide emissions would decrease with the decreasing electricity intensity over the period

Carbon Trajectories Ilford Town Centre – Fully Built Out Project Over 25 Years

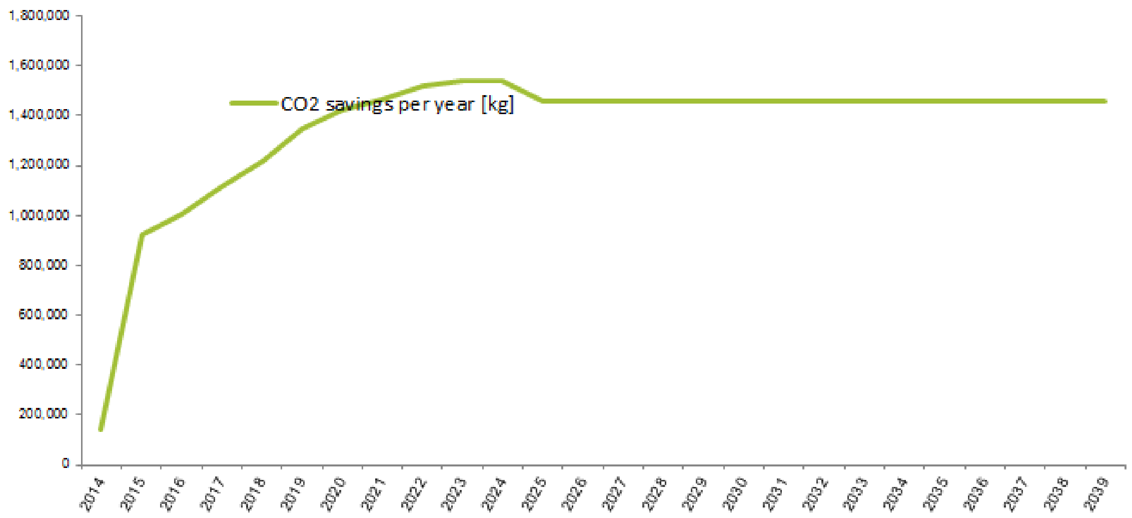


Figure 48: Carbon savings using current DECC Grid Carbon Intensity Factor over Life of Project

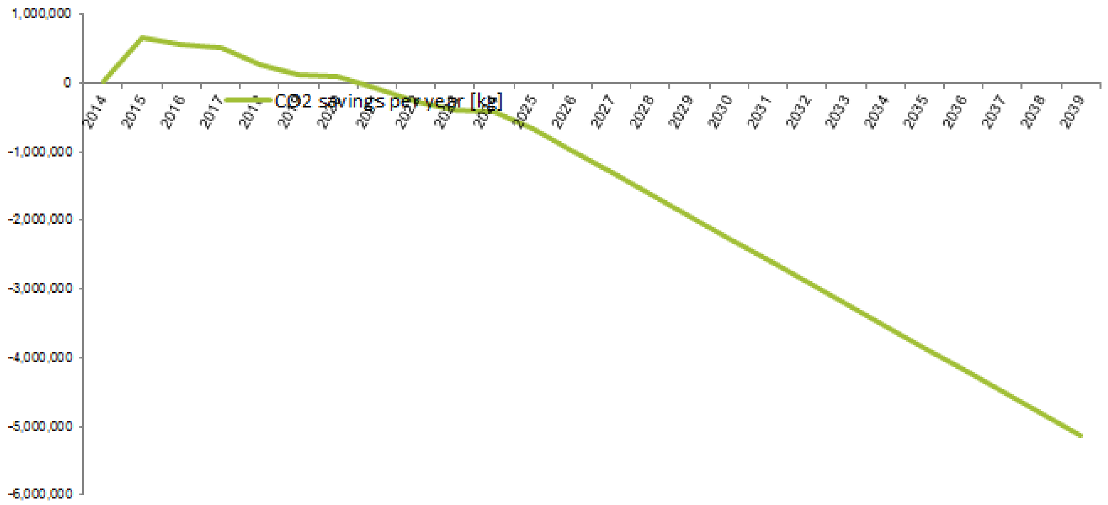


Figure 49: Carbon savings using DECC Grid Decarbonisation Trajectory

Carbon Trajectories Crossrail Corridor – Fully Built Out Project Over 25 Years

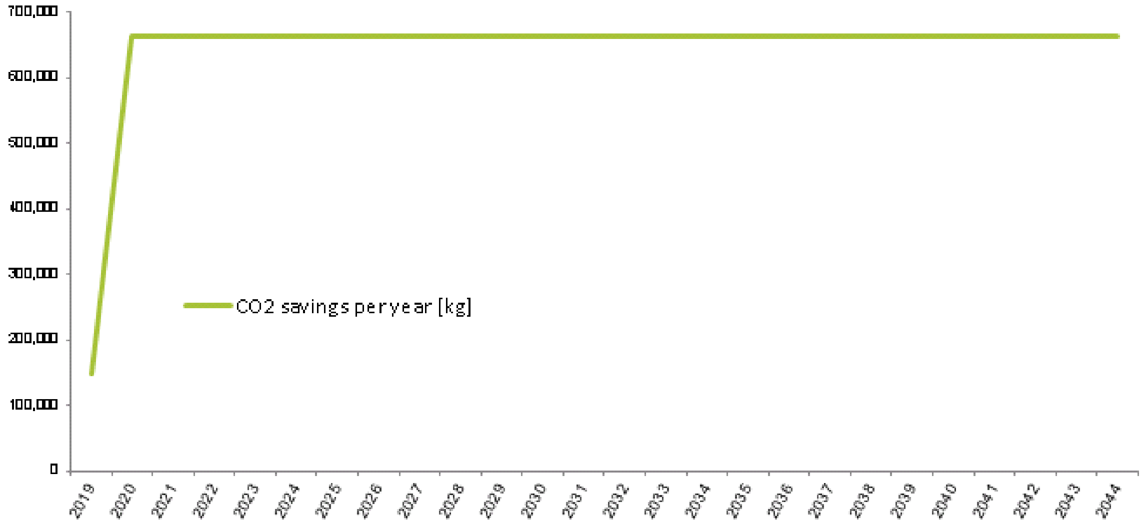


Figure 50: Carbon savings using current DECC Grid Carbon Intensity Factor over Life of Project

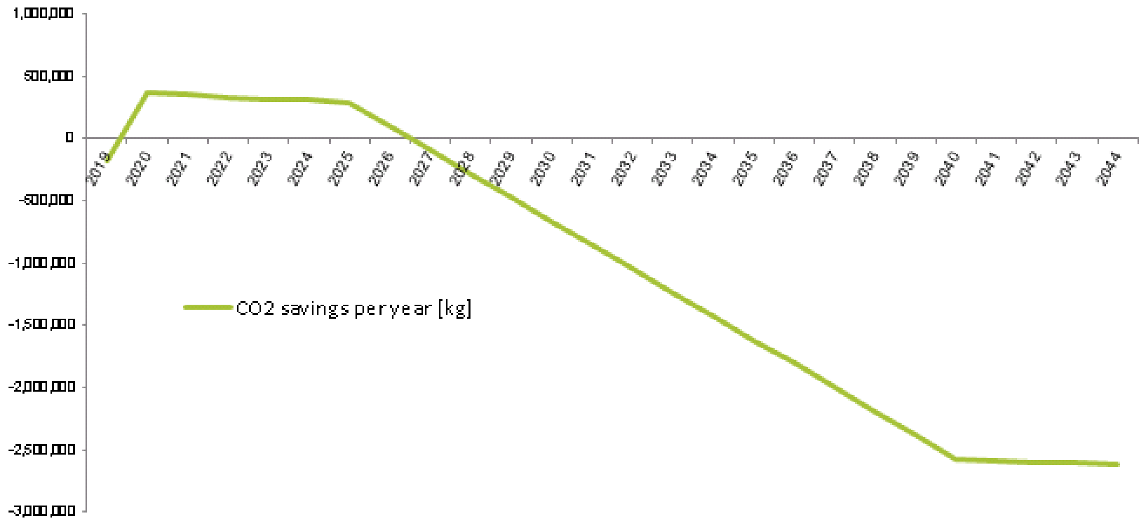


Figure 51: Carbon savings using DECC Grid Decarbonisation Trajectory

Carbon Trajectories Ilford Town Centre and Crossrail Corridor – Fully Built Out Project Over 25 Years

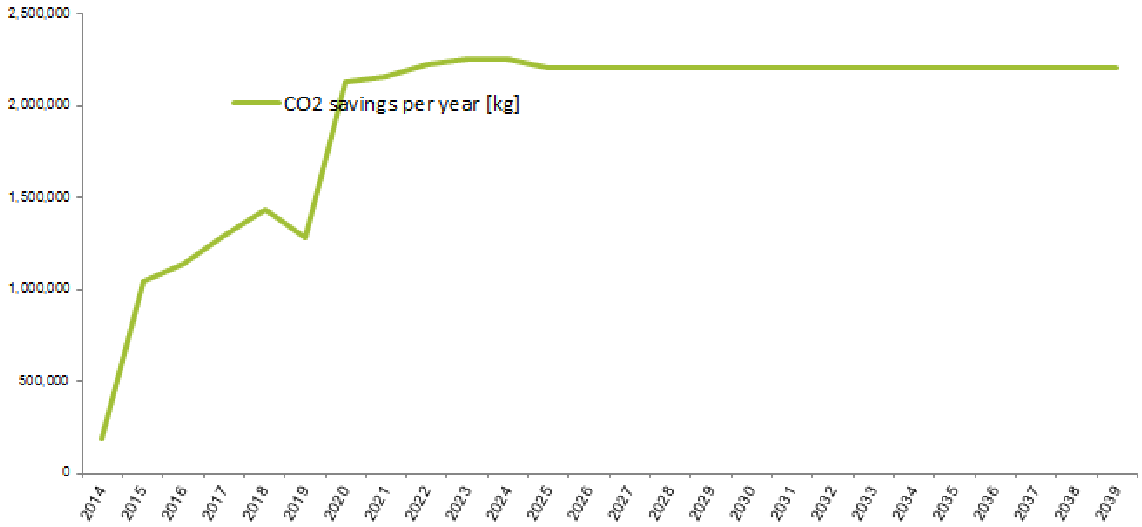


Figure 52: Carbon savings using current DECC Grid Carbon Intensity Factor over Life of Project

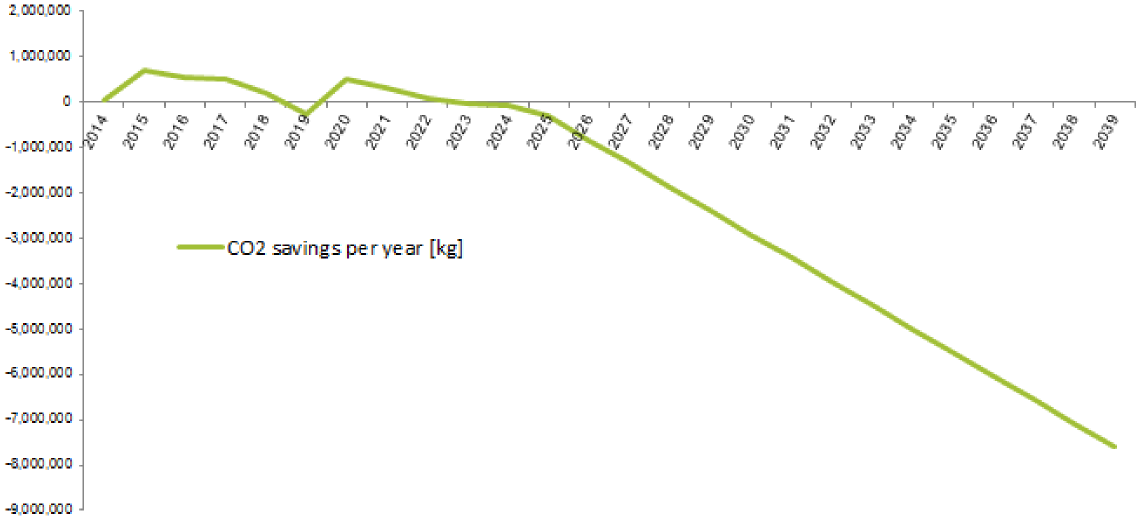


Figure 53: Carbon savings using DECC Grid Decarbonisation Trajectory

Carbon Trajectories Cost Plan Goodmayes Outlier – Fully Built Out Project Over 25 Years

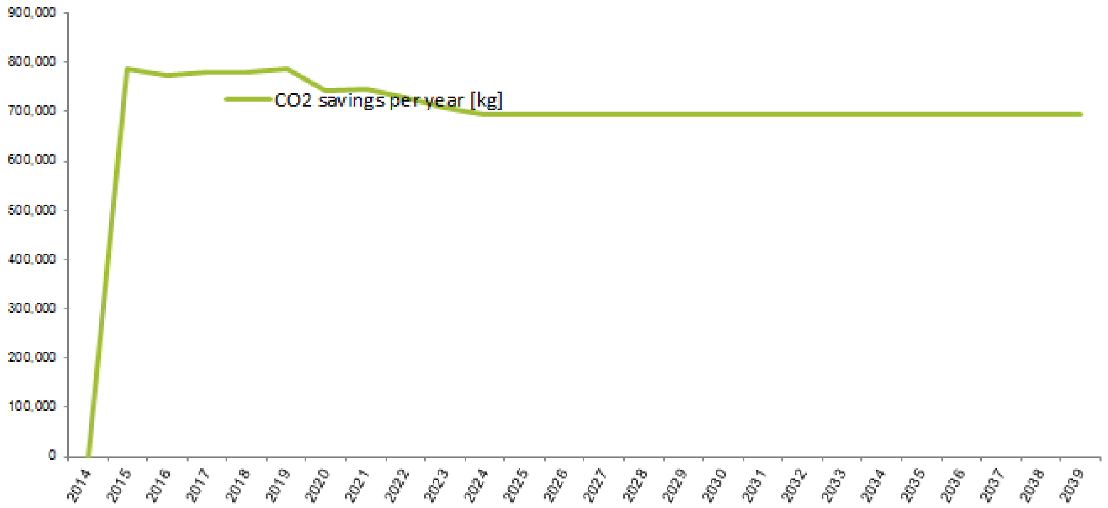


Figure 54: Carbon savings using current DECC Grid Carbon Intensity Factor over Life of Project

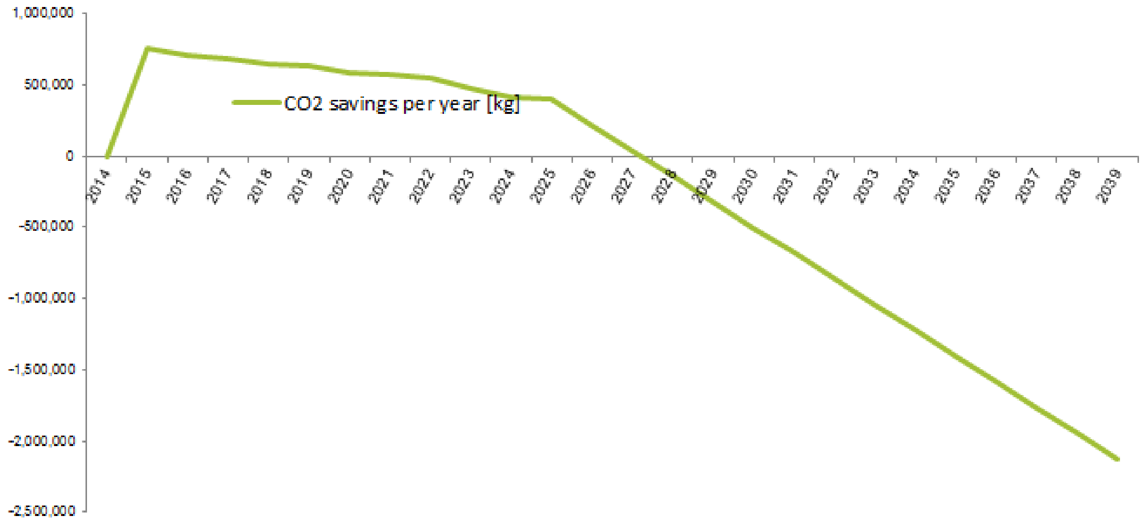


Figure 55: Carbon savings using DECC Grid Decarbonisation Trajectory.

Carbon Trajectories Barkingside – Fully Built Out Project Over 25 Years

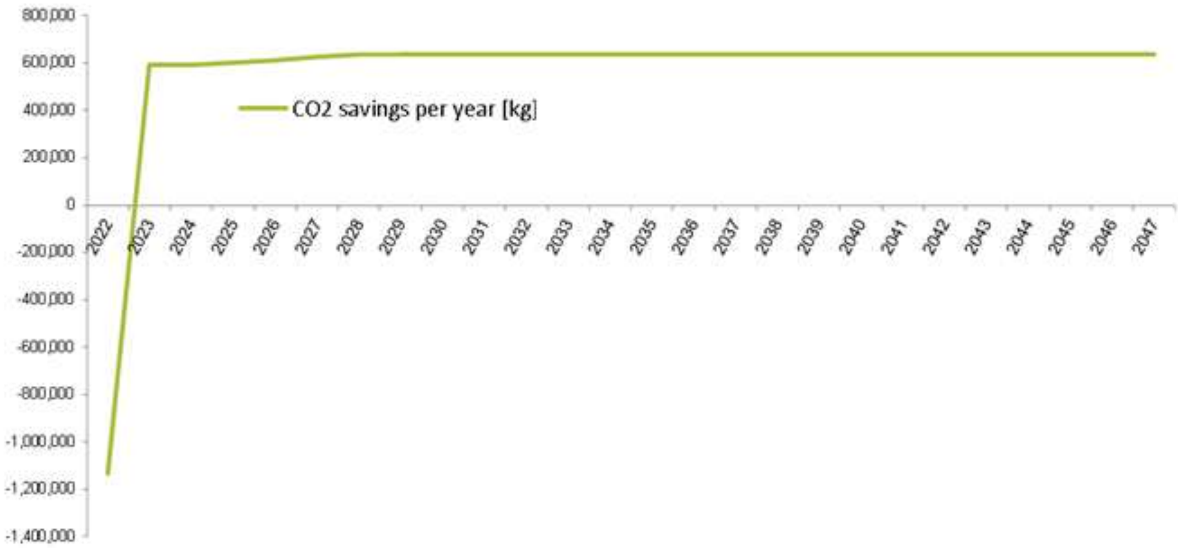


Figure 56: Carbon savings using current DECC Grid Carbon Intensity Factor over Life of Project

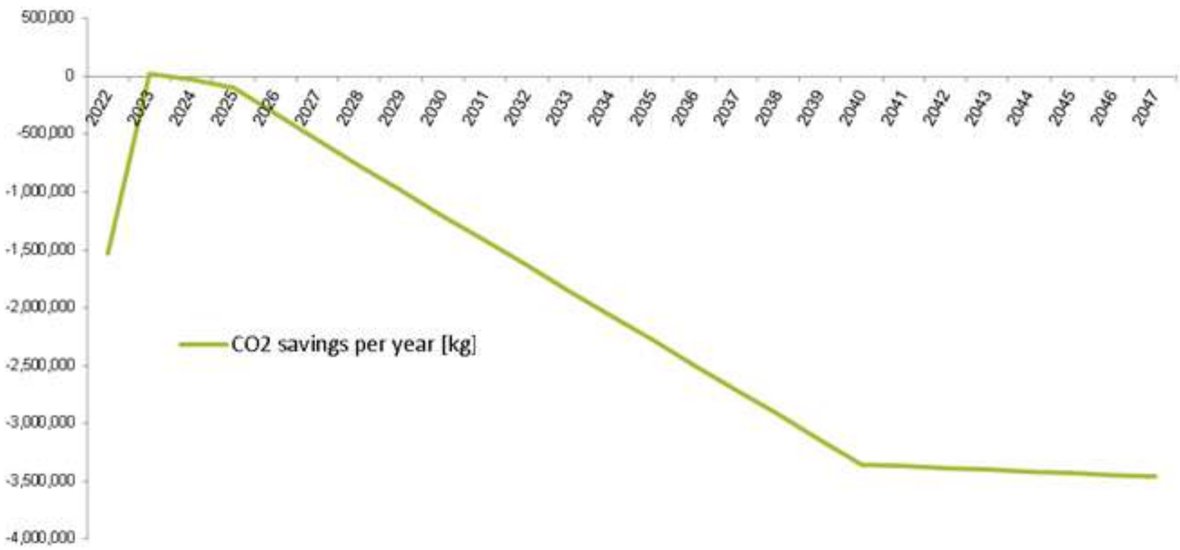


Figure 57: Carbon savings using DECC Grid Decarbonisation Trajectory.

APPENDIX 6 SUMMARY OF HEAT SUPPLY CONTRIBUTION FOR EACH PROJECT

The graphs presented in this Appendix identify various supply characteristics for the heat production assets in each of the schemes. A summary of the information presented in each of the graphs is presented below. It should be noted that the graphs present the same information for the project in different ways and or at different phases during the project's lifetime.

Duration curve: For the cluster and fully built out projects, the duration curves show the number of hours per year that each individual heat production asset spends at any given level of output. For the cluster project, this is representative of all years of operation. For the fully built our project, this is shown for the year by which all buildings have been connected to the project. Heat delivered to the system from the thermal store is derived through charging the thermal store through the CHP during the preceding hours of operation. Where more than one CHP is proposed for the scheme, the contribution from each CHP is shown individually.

Monthly supply profile: For the cluster and fully built out projects, the monthly supply profile provides a breakdown of contribution from each heat production asset toward total heat supplied in that month. For the cluster project, this is representative of all years of operation. For the fully built our project, this is shown for the year by which all buildings have been connected to the project. In these profiles, domestic hot water consumption profiles and heat losses are also shown across the year. The contribution from the thermal store is not shown in these curves since it is not a producer of heat. Where more than one CHP is proposed for the scheme, the contribution from each CHP is shown individually.

Annual Cumulative Supply Contribution: The annual cumulative supply contributions for the cluster and fully built out projects show the breakdown of contribution from each heat production asset toward total heat supplied for each year of operation of the scheme. The contribution from the thermal store is not shown in these curves since it is not a producer of heat. Where more than one CHP is proposed for the scheme, the contribution from each CHP is shown individually.

Ilford Town Centre Project

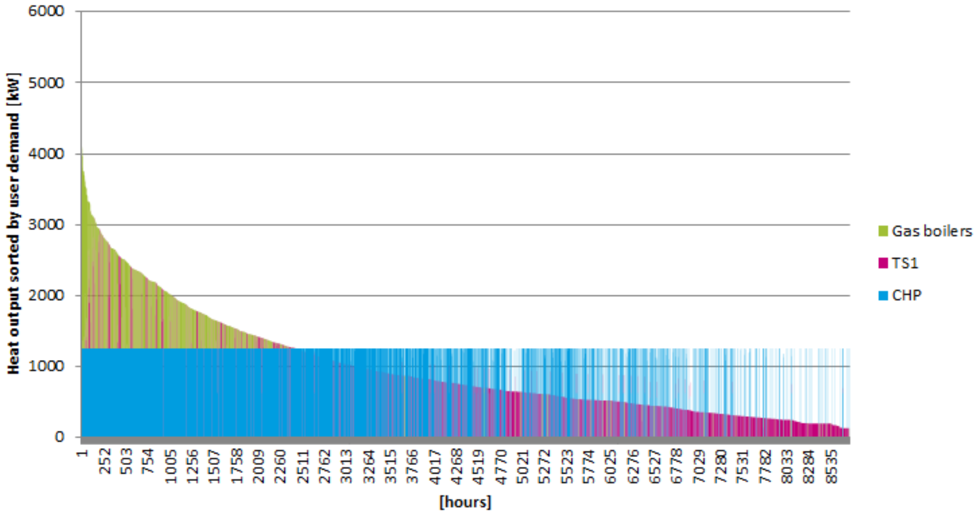


Figure 58: Duration curve - Ilford Town Centre – Cluster Project

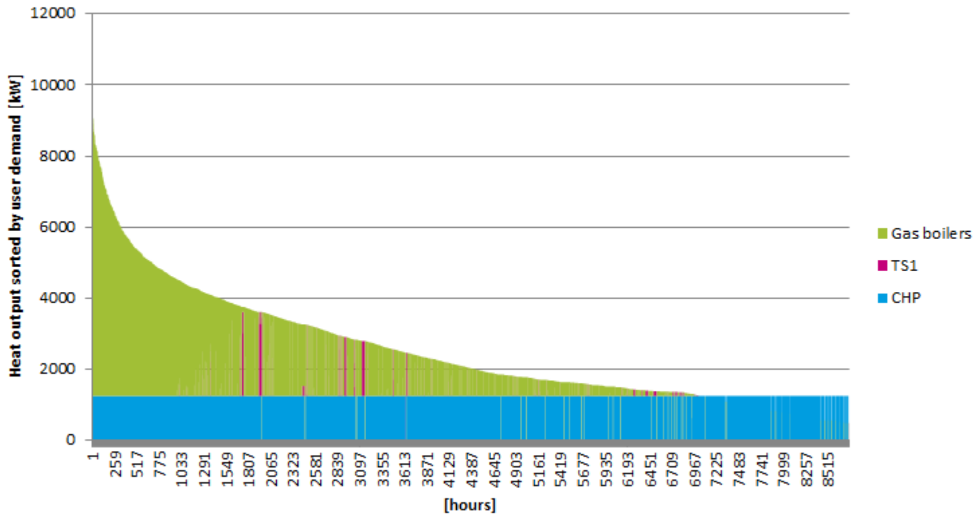


Figure 59: Duration curve - Ilford Town Centre - Fully Built Out Project

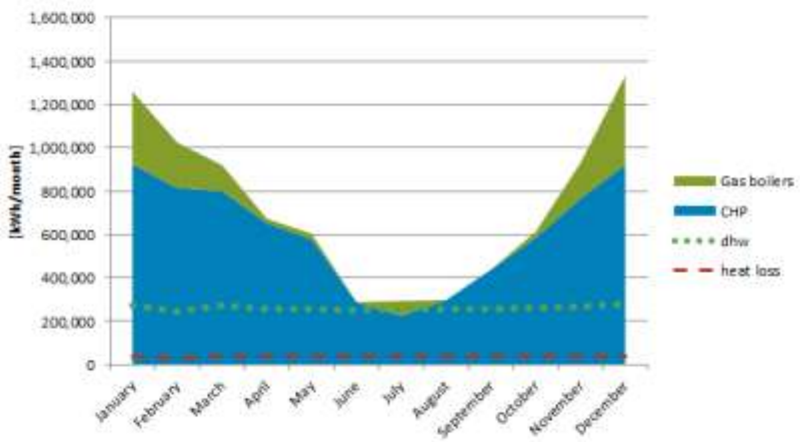


Figure 60: Monthly supply profile at Full Build Out - Ilford Town Centre - Cluster Project

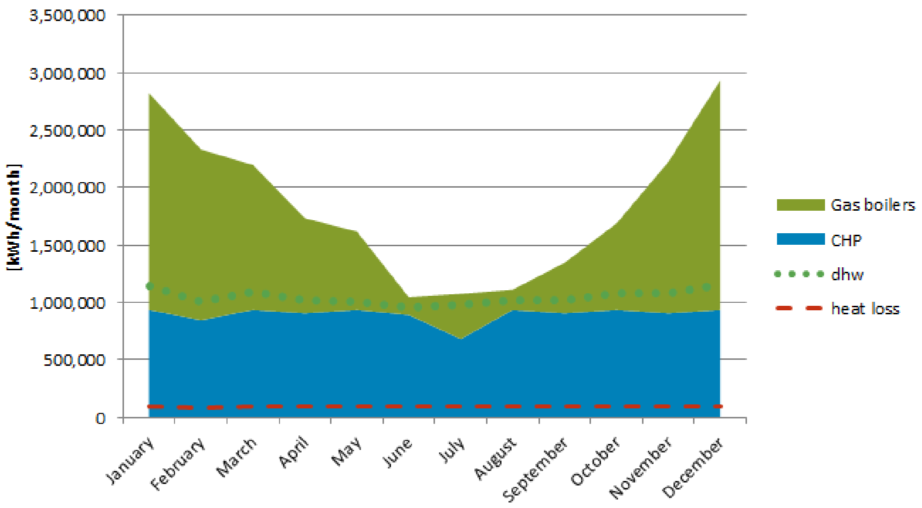


Figure 61: Monthly supply profile at Full Build Out - Ilford Town Centre - Fully Built Out Project

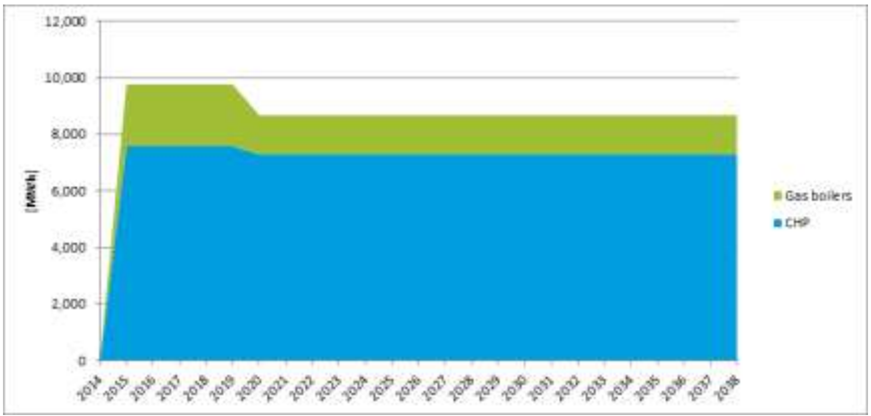


Figure 62: Annual Cumulative Supply Contribution – Ilford Town Centre - Initial Cluster Project

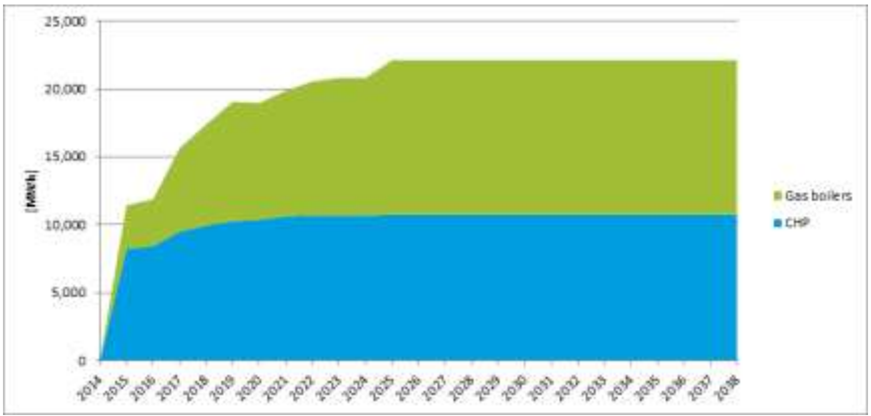


Figure 63: Annual Cumulative Supply Contribution– Ilford Town Centre - Fully Built Out Project

Crossrail Corridor Project

Note: No initial cluster project has been identified for this opportunity.

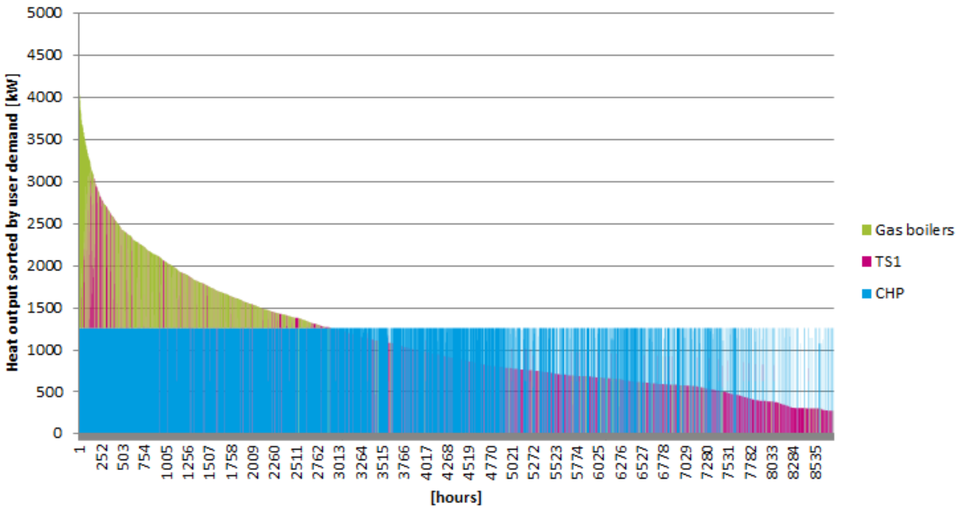


Figure 64: Duration curve for Crossrail Corridor - Fully Built Out Project

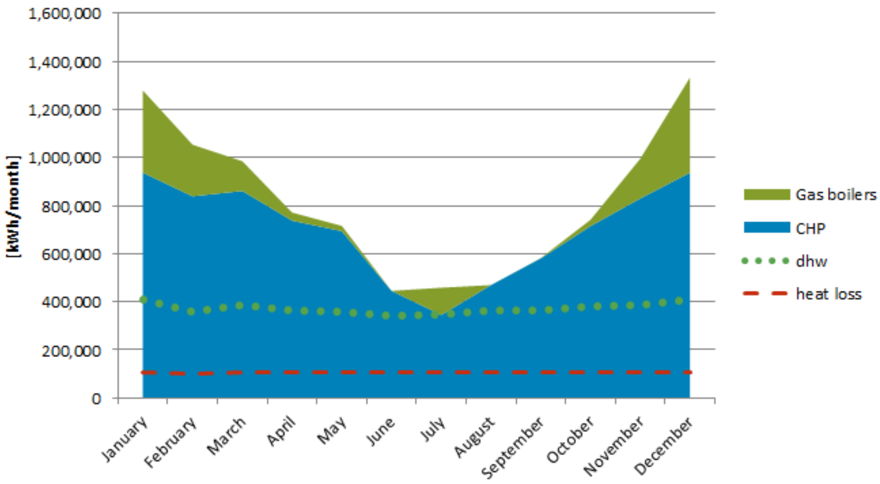


Figure 65: Monthly Supply Profile at Full Build Out - Crossrail Corridor - Fully Built Out Project

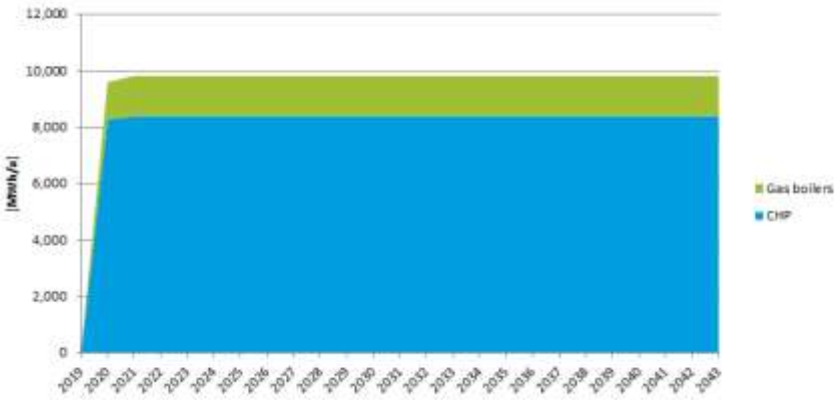


Figure 66: Annual Cumulative Supply Contribution – Crossrail Corridor - Fully Built Out Project

Ilford Town Centre and Crossrail Corridor Project

Note: The Initial Cluster Project for this opportunity is as per the Ilford Town Centre Project.

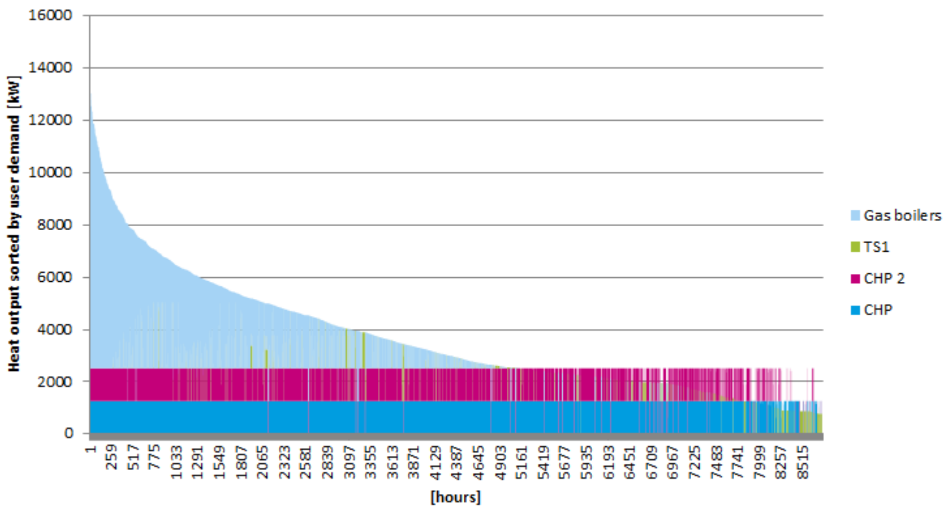


Figure 67: Duration Curve - Ilford Town Centre and Crossrail Corridor - Fully Built Out Project

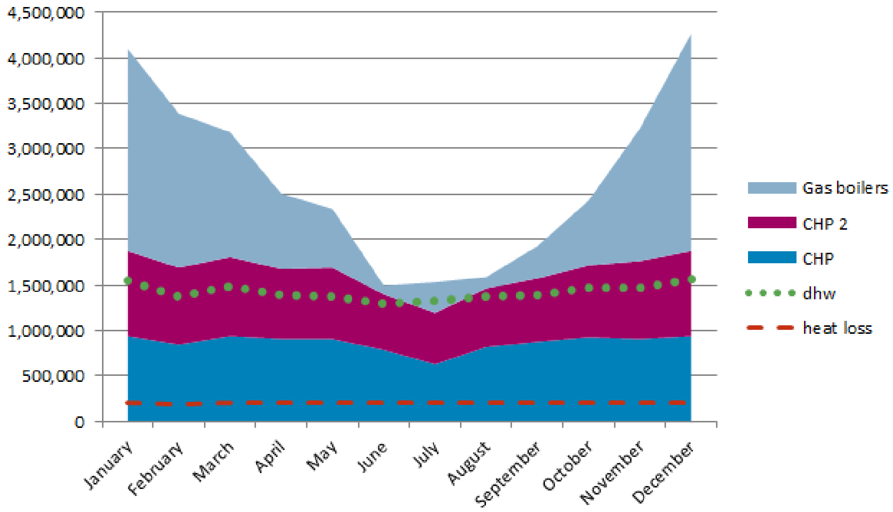


Figure 68: Monthly Supply Profile at Full Build Out - Ilford Town Centre and Crossrail Corridor - Fully Built Out Project

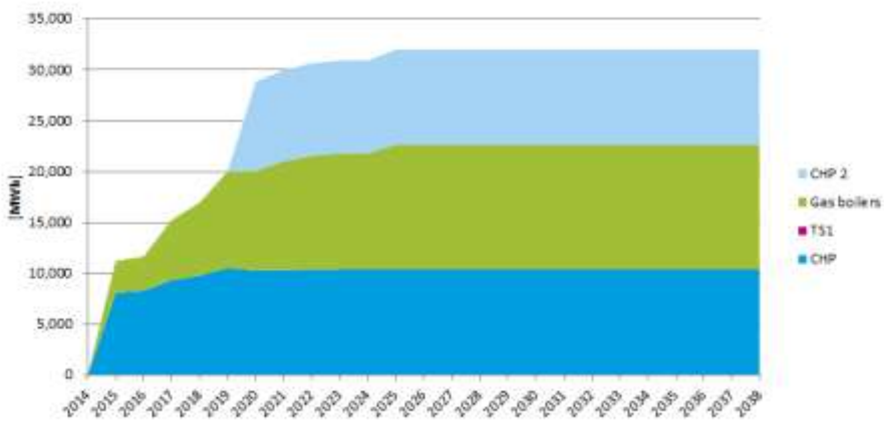


Figure 69: Annual Cumulative Supply Contribution – Ilford Town Centre and Crossrail Corridor - Fully Built Out Project

Goodmayes Outlier Project

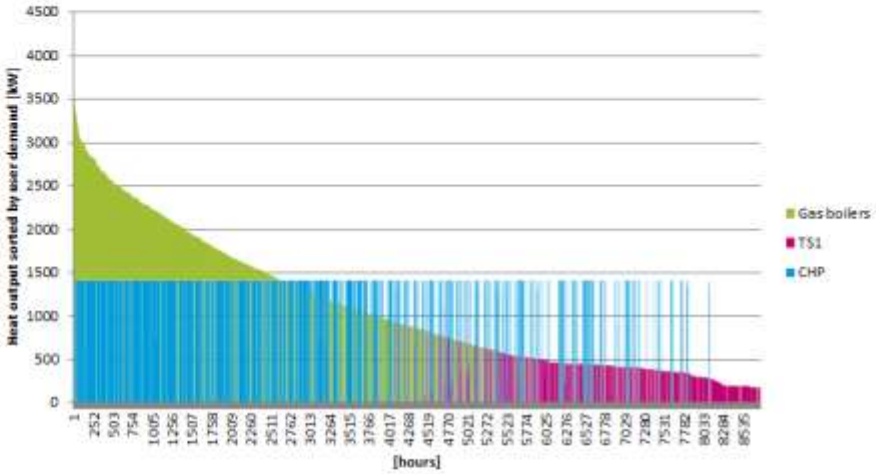


Figure 70: Duration curve - Goodmayes Outlier – Cluster Project

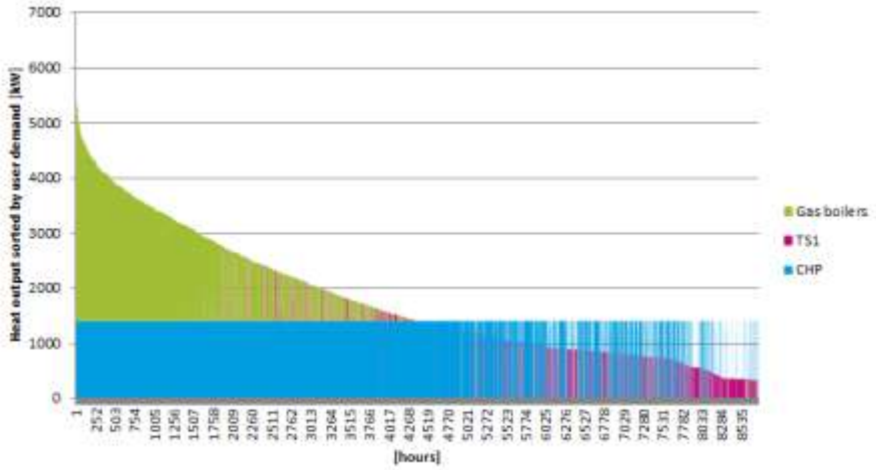


Figure 71: Duration curve - Goodmayes Outlier – Fully Built Out Project

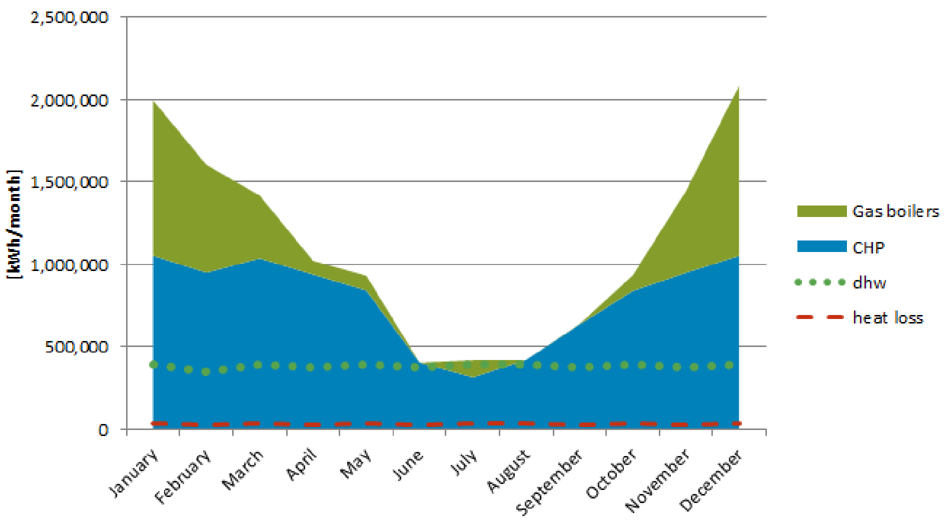


Figure 72: Monthly Supply Profile at Full Build Out - Goodmayes Outlier – Cluster Project

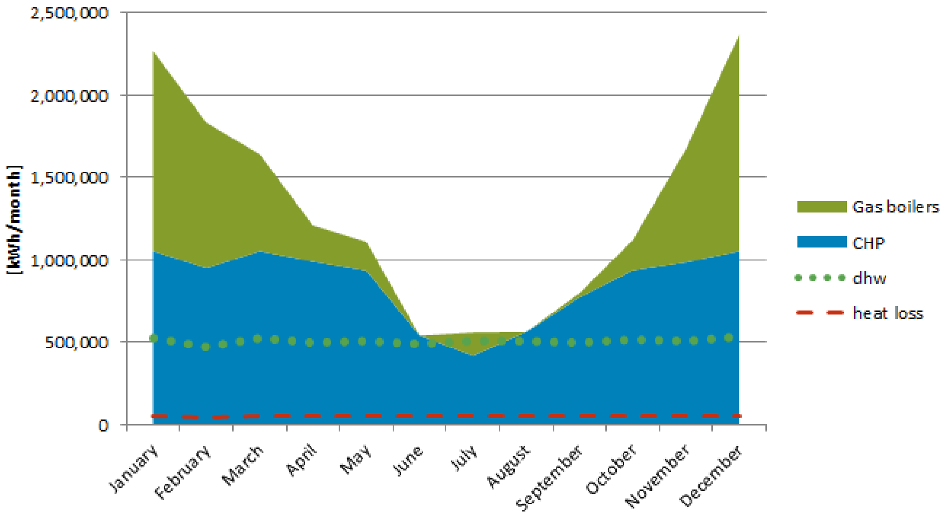


Figure 73: Monthly Supply Profile at Full Build Out - Goodmayes Outlier – Fully Built Out Project

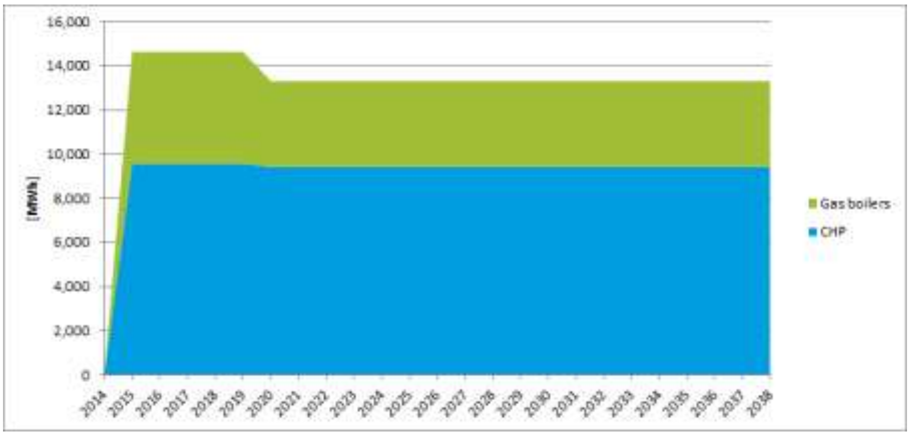


Figure 74: Annual Cumulative Supply Contribution – Goodmayes Outlier – Cluster Project

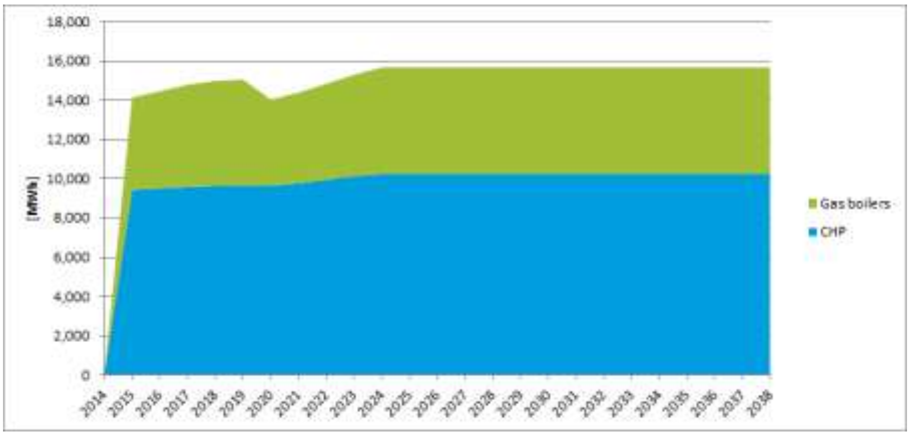


Figure 75: Annual Cumulative Supply Contribution – Goodmayes Outlier – Fully Built Out Project

Barkingside Investment Area Project

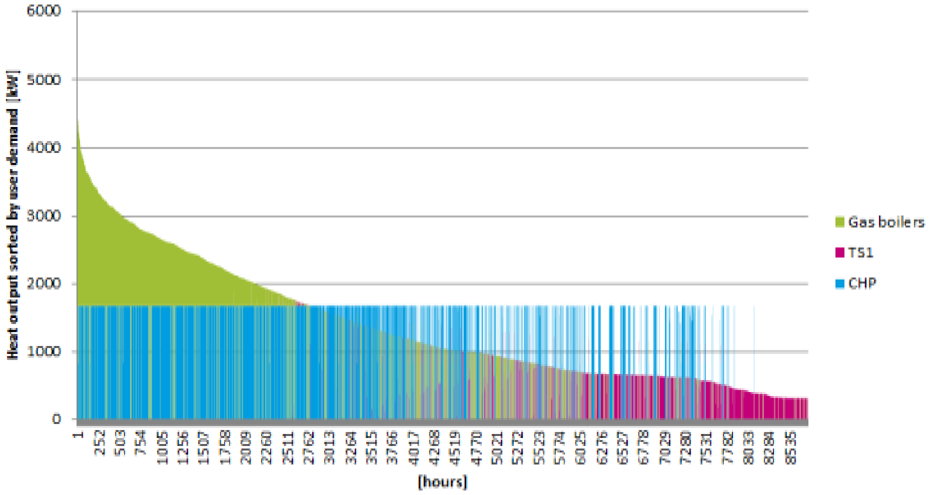


Figure 76: Duration Curve - Barkingside - Fully Built Out Project

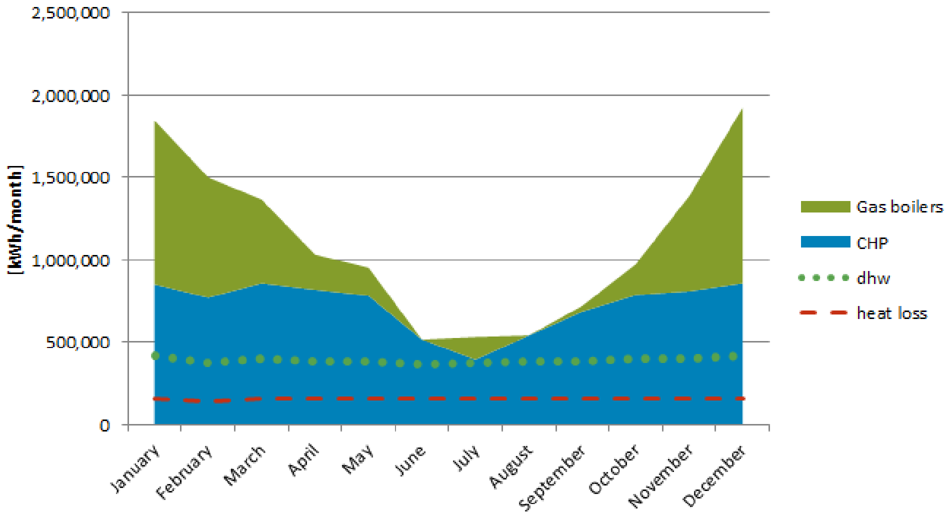


Figure 77: Monthly Supply Profile at Full Build Out - Barkingside - Fully Built Out Project

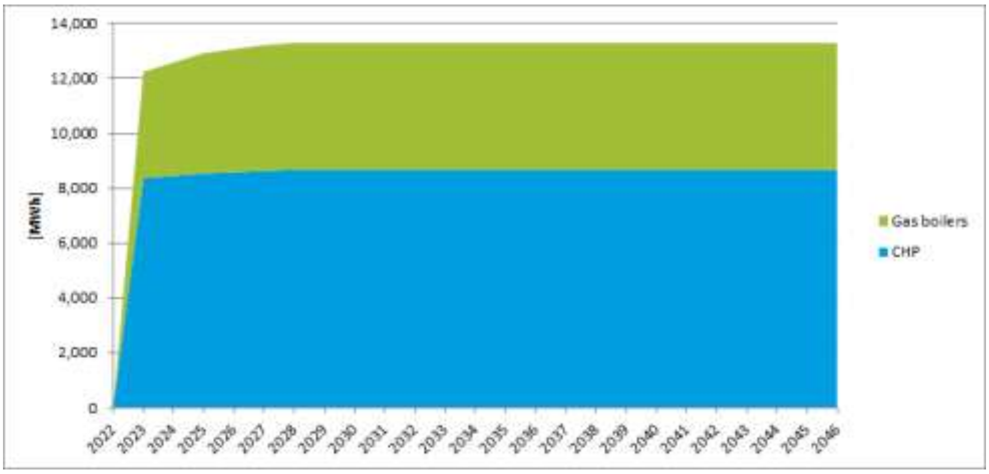


Figure 78: Annual Cumulative Supply Contribution – Barkingside - Fully Built Out Project

APPENDIX 7 LINEAR HEAT DENSITY INDICATORS FOR EACH PROJECT

Linear heat density indicators for various identified project opportunities are shown below. Linear heat density is a measure of the connected heat load per metre length of trench and provides an indication of the economic viability of the network under any particular set of economic conditions (e.g. heat selling price, electricity selling price etc.).

Where initial cluster projects have been identified, these are shown separately for the initial cluster projects and fully built out project.

A comparison of the linear heat densities with their associated IRRs provides an indication of how future development / network extension opportunities could be assessed. For example, where the incremental linear heat density of a new connection is broadly similar to the overall linear heat density for the existing network, the new connection can be considered likely to be a viable economic proposition. However, where the incremental linear heat density of a new connection is significantly lower than the overall linear heat density for the existing network, the new connection can be considered likely to be a non-viable economic proposition.

Linear heat density	Full build out	Cluster
MWh per metre trench	5.25	4.42
Project IRR over Project Term	12.29% over 40 years	7.1% over 25 years

Table 38: Linear Heat Density Indicators – Ilford Town Centre Project

Linear heat density	Full build out	Cluster
MWh per metre trench	1.75	n/a
Project IRR over Project Term	6.09% over 40 years	n/a

Table 39: Linear Heat Density Indicators – Crossrail Corridor Project

Linear heat density	Full build out	Cluster
MWh per metre trench	3.4	4.42
Project IRR over Project Term	11.37% over 40 years	6.3% over 25 years

Table 40: Linear Heat Density Indicators – Ilford Town Centre and Crossrail Corridor Project

Linear heat density	Full build out	Cluster
MWh per metre trench	4.3	5.61
IRR over Project Term	12.5% over 40 years	11.9% over 25 years

Table 41: Linear Heat Density Indicators – Goodmayes Outlier Project

Linear heat density	Full build out
MWh per metre trench	1.6
IRR over Project Term	4.1% over 40 years

Table 42: Linear Heat Density Indicators – Barkingside Project