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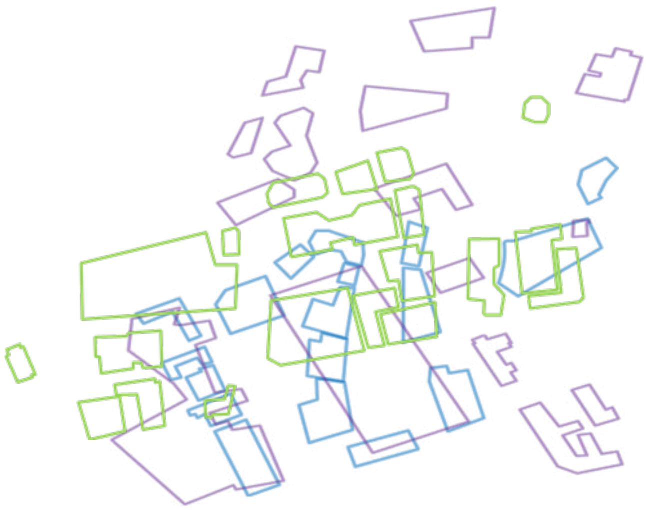
Building Engineering

The London Borough of Croydon

17 December 2009

Croydon Decentralised Energy Study



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Croydon District Energy Study

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1	Interim Study- issued for comment	RB	PSW	15/10/09
2	Final Study- issued for comment	RB	PSW	17/12/09

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Energy
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Executive Summary

The global challenge to reduce CO_2 emissions to limit the impact of global warming is being addressed at an international, national and local level. One of the responsibilities of local government is to consider how low carbon energy solutions can be introduced into their area following the Planning Policy Statement 1 Supplement on Climate Change. The CO_2 emissions of Croydon (excluding transport) are estimated from DECC statistics at 1.3 million tonnes p.a.

The centre of Croydon comprises a large number of commercial offices and public sector buildings including Croydon College, Fairfield Halls, the Home Office and the public Library. In addition, there are a number of major new developments planned for the area, including the new Council offices and Ruskin Square. The heat supply to Croydon is currently supplied mainly by gas-fired boilers and electricity is supplied from remote power stations. An alternative system would be to generate electricity within the town centre and to capture the heat released as a result of electricity production, a technology known as Combined Heat and Power (CHP). This heat would be piped to the buildings via a district heating network and connected to the buildings' heating systems by means of a heat exchanger. This study investigates the technical commercial and environmental implications of a CHP/DH scheme.

The high density of development in the centre of Croydon with many high-rise buildings is an advantage in that heat distribution costs will be relatively low. A further advantage is that there are a number of underground car parks which could be used to install the distribution pipework again reducing costs compared to routes involving pipework buried under roads. In addition, the scale of the project is relatively large which means that CHP plant will be the optimum size for energy efficiency and have relatively low capital and maintenance costs.

The disadvantage of the opportunity is that many of the buildings are offices and so there is limited heat demand in summer and at weekends. This means that the operating hours of the CHP are not as great as for a system supplying a larger proportion of residential buildings. As a result of this disadvantage we have also considered operating the CHP system to generate heat for use in absorption chillers during the summer. The market value of the heat supplied for this purpose is however limited compared to the heat sold to displace boilers.

Identification of heat customers and District Heating Zones

Within the study area we have identified potential existing customers and in collaboration with the masterplan process identified potential future customers. The levels of these customers' energy demands and demand profiles have then been assessed using various techniques including heat mapping, census data, Valuation Office data, accessing the LCCA data base for Croydon, information on individual buildings, and by meeting with the various developers and architects involved.

The brief identified four study areas and the masterplan identifies development areas. From this data three District Heating zones were identified, in part defined by the tram routes which would create a potential barrier to laying buried district heating. Broadly these zones can be defined as:

Zone 1 – southern part of mid-Croydon, Wellesley Rd and College Green

Zone 2 – East Croydon including Ruskin Square

Zone 3 – northern part of mid-Croydon, West Croydon and northern part of Wellesley Rd

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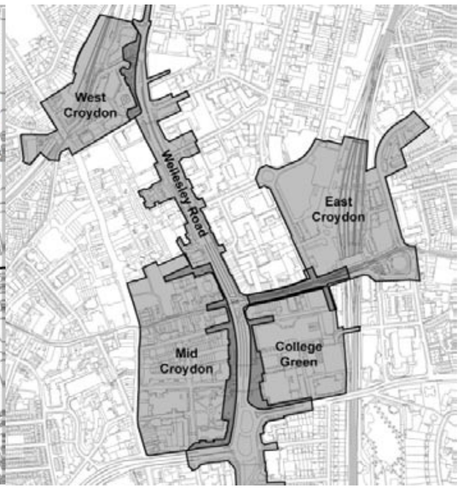
Study Areas



Masterplan Areas

In order to provide energy for these potential customers we defined the profile types of these customers, including estimating when they would require connection and what the likelihood of their commitment to the establishment of this connection would be. This influenced the choice of energy zoning and also the preferred locations of the energy centres to produce the energy. Indentifying the location for energy centres has proved very difficult due to the availability of appropriate public land and the expected reluctance of developers to include space for an Energy Centre that supplies adjacent areas, as this would lead to a loss of income from the site.

Heat supply options

Three options were evaluated:

- A separate CHP system for each of three zones identified
- A single CHP system supplying all three zones
- Heat supplied by the existing Rolls Royce power station

The second option was found to be the least favourable as there were limited efficiency benefits from the larger CHP plant, higher costs for interconnecting of pipework, potential difficulties in connecting to gas and electricity networks at this scale, and uncertainty over finding a suitable site for the larger plant.

The third option is the use of the existing Rolls Royce power plant on Factory Rd to the west of the town centre as a potential source of heat energy. As this heat is essentially a by-product of electrical power generation its production would be low cost and carbon free. The disadvantage is that the source is some distance away and requires the construction of a DH transmission main into the centre of Croydon. The other disadvantage is that the RR power station is only operated for about 5 hours per day through the winter period between 3pm and 8pm. As a result, the amount of heat is limited and a proportion of the heat available will need to be stored for use the following day to meet the early morning peak. Although it would be possible to extend the period of operation, this would involve additional costs for RR and hence increase the cost of heat supply. Evaluation of the extended operating hours and provision of additional heat would require more detailed discussions with RR to see how their costs would rise.

District Heating Network

From the three energy centres and/or the Rolls Royce power plant we then examined the pipework distribution required to transport the heat energy from the energy centres to the customers. Various routes were considered and due to infrastructure installation costs and maintenance practicalities the routes favoured were those integrated within existing and proposed structures such as in underground car parks, across bridges, through culverts or under-slung below elevated road sections, as opposed to routes in roads and pavements where digging and diversions for installation and maintenance would be difficult.

Business Case

In order to provide the evidence base to satisfy inclusion in the Council's Local Development Framework (LDF), we have looked at the business case for a decentralised energy network. In simple terms the costs of setting up the network, with the capital cost of the energy centres and energy distribution infrastructure has to be offset by the income generated, after operational costs have been accounted for, by customers connecting onto, consuming and ultimately paying for the use of the energy.

The results of comparing Options 1 and 3 with the base case of existing arrangements is indicated in Table 1.

Table 1 – Comparison of Options

		Zone 1 gas-engine CHP	**Zone 2 gas-engine CHP**	**Zone 3 gas-engine CHP**	**Option 1 - three gas-engine CHP**	**Option 3 - RR power station CHP conversion**
Heat supplied	MWh p.a.	54,286	29,372	45,479	129,137	n/a
CHP heat capacity	MW	9.5	4.8	8.9	23	35
Proportion of CHP heat	%	70%	70%	70%	70%	20%
Capital cost	£m	17.8	8.2	15.7	41.7	2.5 (extra over for pipeline and boiler only)
Grant assumed	£m	5.0	2.5	5.0	12.5	n/a
IRR	%	7.2	4.0	7.0	7.8	n/a
CO_2 savings	Tonnes p.a.	14,963	7,684	14,346	36,993	5,837

The rates of return without any grant funding were below the levels that attract private investment. LBC may wish to invest themselves using their own capital programme and prudential borrowing. We have discussed in the report the potential risks and opportunities for such investment. It may be preferable to form a joint venture company where the risks can be shared with the private sector. To improve the rate of return so that the JV company can raise sufficient capital can be achieved by the provision of equity or grant funding by the public sector. This equity could be obtained from:

- LB Croydon capital programme
- Prudential borrowing
- The LDA through their support to decentralised energy and the JESSICA fund

The above results assume a grant level of about 30% of the capital cost of the projects.

Air quality

We have also compared the projects with respect to air quality. It can be seen that each of the proposed schemes are predicted to lead to a net reduction in emissions of NO_x and PM_{10} when considered in terms of total regional emissions including that associated with electricity generated during their operation, which would otherwise have been generated regionally.

It is assumed that the reduction associated with the CHP plants reflects the greater efficiencies associated with larger and more modern power plants and the fact that it is easier and more cost effective to control emissions from larger combustion sources than for smaller, more spatially aggregated sources.

Emissions from the Rolls-Royce centre in Do Something Scenario 2, is lower in particulates but higher in levels of NOx than would occur from boilers. However, the use of tall stacks to disperse the emissions and the fact that emissions from boilers are displaced at lower levels means that predicted concentrations at the modelled height of 1.5m across the study area are lower.

Recommendations

As a result of this study we recommend that:

- LBC discuss with internal financial officers and with the LDA the prospects for finding sufficient grant finance or long-term equity participation in a JV district energy company.
- If the outcome is positive commence to select a suitable partner to deliver the scheme.
- Continue to develop the planning policies taking account of the results of this study
- Encourage the developers to plan their developments so that they can be connected to a low carbon district energy scheme in preference to local provision of low carbon systems to meet planning and Building Regulations requirements.
- Establish suitable planning policies that enable connection to the scheme to be seen as the first choice for developers who would have to justify why a connection cannot be made and to demonstrate that equivalent CO_2 savings can be achieved with an on-site solution.
- Hold further discussions with Rolls Royce to explore the potential for operating the plant for a longer period in the winter and some further hours in the summer and to

establish the net costs and benefits to establish the commercial viability of this approach.

- Should the Rolls Royce option continue to be positive a hybrid system would be a possible way forward with the first phase of Zone 1 being taken forward with a gas-engine CHP and when this has been established install the transmission main to the Rolls Royce plant. The gas-engine CHP would then operate in winter to meet peak demands and in summer when the Rolls Royce plant is not likely to be operated.

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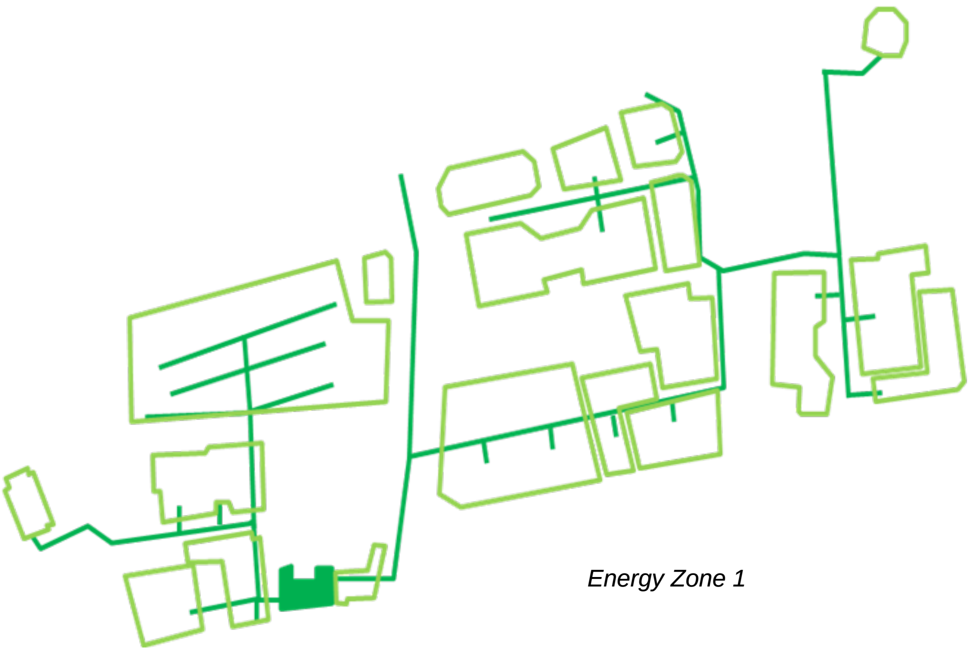
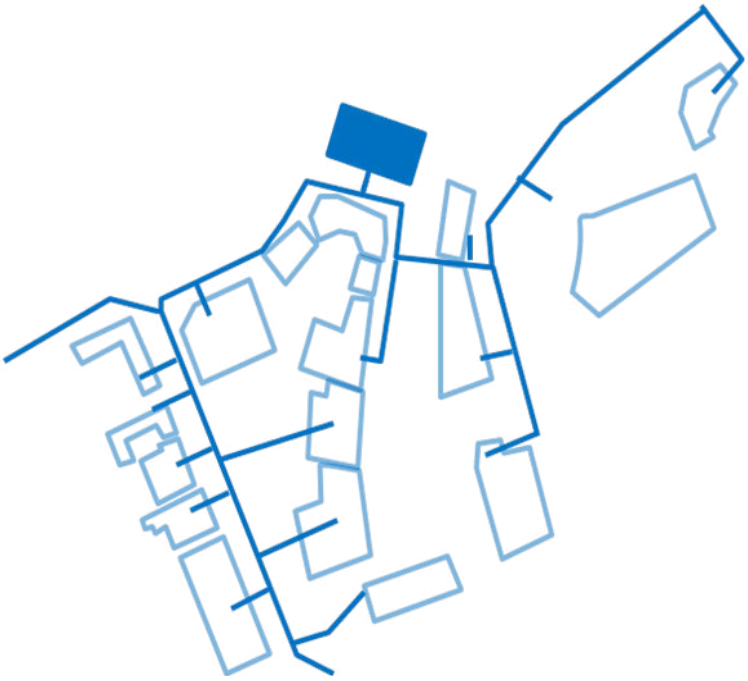
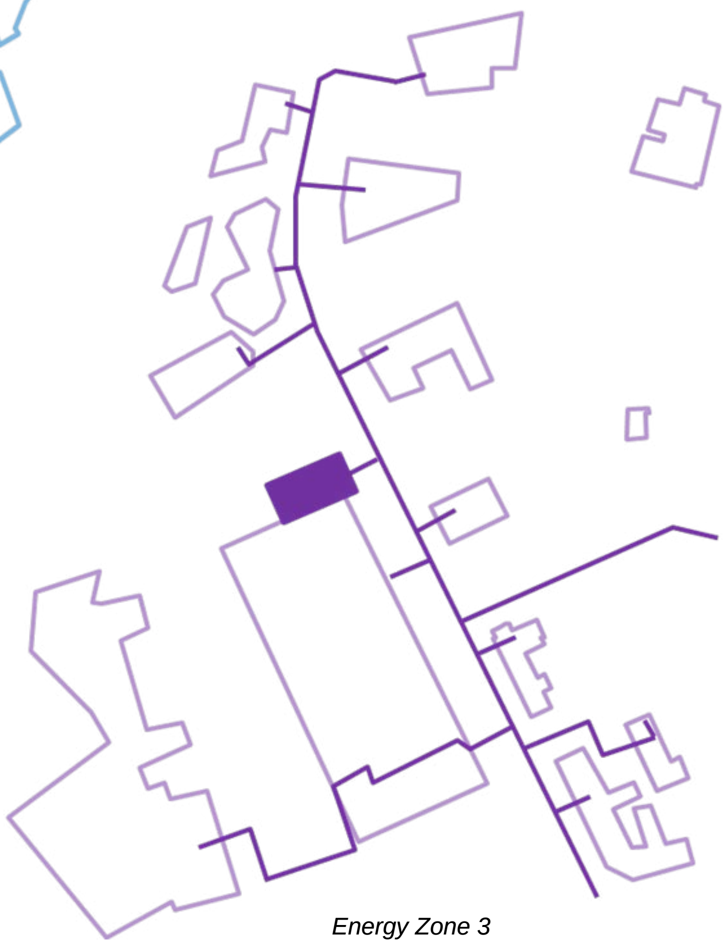


Energy Zone 1



Energy Zone 2



Energy Zone 3

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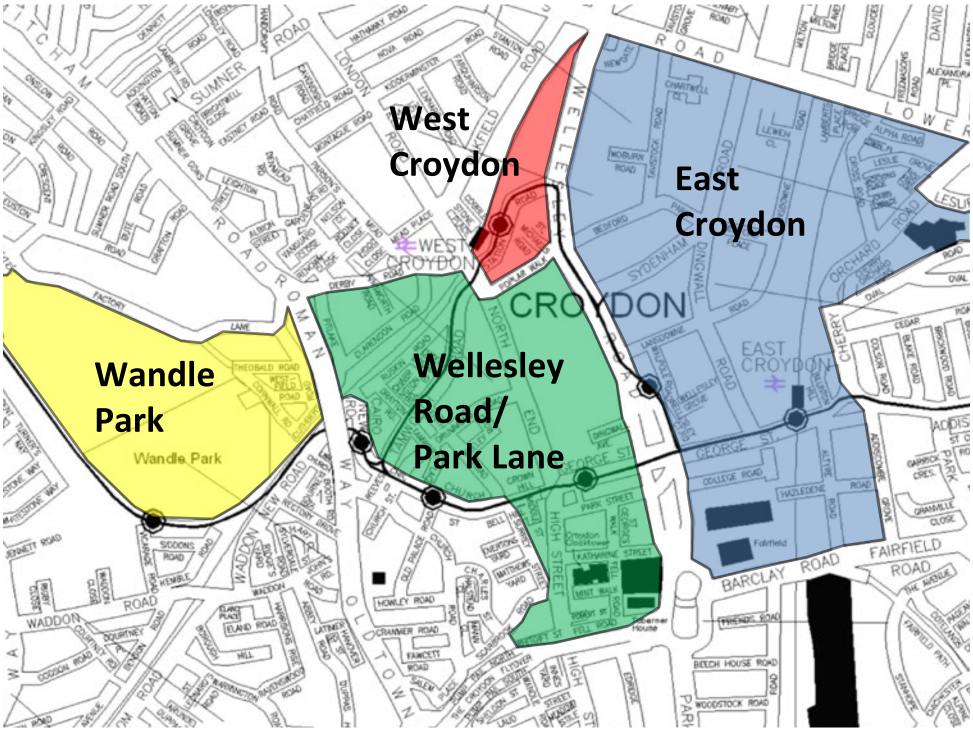
Capabilities on project:

1 Introduction

The purpose of this final study is to provide our detailed findings for the decentralised energy evaluation study for Croydon town centre. The results of the study will provide an evidence base to inform the development of the Core Strategy of the Local Development Framework (LDF) which is currently being prepared by the London Borough of Croydon (LBC).

The main area of the study is defined by four zones as highlighted in the diagram below. These zones are:

- Wellesley Road / Park Lane
- Wandle Park
- East Croydon
- West Croydon



Geographical Site Boundary of Works (town centre area)

Capabilities on project:

2 Programme

Due to the need to feed into the Council's Local Development Framework (LDF), this study consists of two parts, the interim report due on 15 October 2009 and the final report due on 17 December 2009.

Capabilities on project:

3 Scope of Detailed Study

Following the demonstration of the high level case for each scenario within the interim study the scope of the detailed study comprises:

A. Identifies the mechanisms for directing or persuading building owners and operators to utilise a piped energy network.

B. Identifies and locates potential customers who could be provided with thermal (heating and cooling) and electrical energy within the town centre and nearby surrounding areas.

C. Estimates the level of energy demands of potential customers now and in the future.

D. Examines the feasibility of conversion and utilisation of the existing Rolls Royce power plant in Factory Lane

E. Identifies other potential locations for energy centres from which thermal and electrical energy could be produced and distributed to the town centre and any possible outlying residential areas.

F. Estimates the spatial requirements for the energy centres and their energy outputs.

G. Based on these potential demands, reviews the construction and routing of the required pipe distribution system considering:

   a. The interconnection of new and existing energy loads
   b. The obstacles faced and how these might be overcome.

H. Examines the potential impact of a district wide tri-generation system on the existing infrastructure i.e. considers the impact of increased loading on infrastructure where energy centres are located and reduced local demand for gas and electrical energy where buildings are supplied with heat and cooling from a district wide energy scheme.

I. Considers the impacts on local air quality that arise from elimination of local combustion of gas and biofuels and the concentration of combustion at district energy centres.

J. Identifies opportunities and implications for the pipe distribution networks to accommodate gas/liquid biofuels and hydrogen in the future.

K. Considers the long term maintenance and replacement of existing and provision of new services within the pipe distribution network.

L. Estimates costings together with potential income streams for each scenario.

M. Estimates potential carbon savings achieved by the envisaged decentralised energy scenario(s) compared to conventional systems.

To provide the study as a written report showing all the findings from the Council's requirements shown in sections 3 and 4 with supplementary diagrams, maps, graphs and calculations.

Section A

Identifies the Mechanisms for directing or persuading building owners and operators to utilise a piped energy network (ESCO)

The type of mechanism to employ to promote ESCO (District Heating and Cooling) network take-up depends upon the characteristics of the building customer and the stakeholders involved in the process.

The Stakeholders

There are numerous stakeholders in this process including Developers, Customers, Investors, Local Authorities, Land Owners, LDA and the supply Chain. The supply chain is either direct as part of the ESCo vehicle/concessionaire or as an interested third party external. Each stakeholder has their own particular interests and drivers involved in the ESCO network take-up. Some of these stakeholders and their drivers are highlighted below:

- **Developer Drivers**
  Capital Saving, Revenue Opportunity, Price Assurance of Services, the order of priority changes according to developer nuances – the developer may not necessarily be owner of the land/asset but may take a commercial interest in return off the ESCo.

- **Customer Occupiers Drivers**
  Customers drivers are a price, standard and quality of service which is better than or equivalent to alternative services provision.

- **Investor Drivers and Funding Institutions**
  Assurance on Investment Return with the faster and higher the return the better or stability of return over defined period. It is affected by number of customers and period over which they are connecting. If the return is insufficient then the ESCo and/or employer will have to supplement the finances. Planning policy can help here by requiring new developments to connect thereby improving the business case.

- **Croydon Planning Authorities**
  The various stakeholders from the Croydon planning authorities include from the corporate level through to planners, environmental, energy and regeneration teams.

- **LDA**
  The London Development Agency (LDA) have identified that the implementation of decentralised energy in London has the potential to make significant reductions in CO_2. The LDA can offer support in a number of forms from funding to an LDA sink fund.

- **HCA**
  The improved availability of housing grants from HCA can be linked to ESCO. Within the developers financial resources the HCA investment in the various schemes will have impact on the housing energy mix and phasing. The HCA can act as a delivery vehicle if requested by the LA.

- **Land Owner**
  Improved return on leasing arrangement as landowners may or may choose not be integral to ESCo energy centre and/or infrastructure.

- **Public Sector**
  The public sector can offer support to the business case. Croydon may have access to preferential grant funding and offer public sector commitment to take an energy load from the ESCo. Depending on the route to ESCo taken, the Councils access to prudential borrowing could play a significant part in the formation of the business case. It will heavily influence the access to capital and therefore the choice of ownership of the energy centre and infrastructure network.

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- **Others**
  Other stakeholders include:

Residents of Croydon	**Tramlink**
Businesses of Croydon	**LTA**
Building Operators	**TFL**
CCURV Joint venture Company	

The extent of involvement of the stakeholders will vary depending on the scope of ESCo provision. The ESCo services provided needs to be well defined, the form of contract can be complex and tends to be bespoke. The complexity reflects the number of parties involved, the build-out programme, the price control mechanisms and most importantly revenue recovery and split. Other issues include asset ownership and transferral and tax and funding incentives and grants.

Mechanisms

Push Directing Mechanisms
Push mechanisms involve directing the potential ESCo network customer through processes such as planning, building regulations and compliance methodologies.

Pull Persuading Mechanisms
Pull mechanisms involve the persuasion of uptake by the ESCo network customer through strategies such as providing highly competitive energy consumption rates, offering easier procurement routes and highlighting the ESCO green credentials

Building Customer Categories

The main building customer categories within the Croydon Town Centre area are defined as follows:

1. **New Developments** on currently unoccupied sites
   a. Mixed use (e.g. Ruskin Square)
   b. Office (e.g. Croma, 100 George Street)
   c. Residential (e.g. Berkley Homes developments in West Croydon)
2. **Redevelopments** on currently occupied sites
   a. Mixed use (e.g. Cherry Orchard Road)
   b. Office (e.g. Cherry Orchard Road)
   c. Residential (e.g. West Croydon residential developments)
   d. Retail
3. **Refurbishments**
   a. Office (e.g. Dingwall Road)
   b. Residential
   c. Retail (e.g. Whitgift Centre)
4. **Existing Developments**
   a. Office
   b. Residential
5. **Public Sector Buildings**
   a. Office
   b. Residential
   c. Other (e.g. Town Hall, Library, Law Courts)
6. **Semi-Public Sector Buildings**
   a. College Green

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ESCo Connection Date

Understanding the timing of the following is crucial to the feasibility of the ESCo network. The date required are:

- Connection: contractual commitment date (definition of what is connected)
- Commitment to a Daily/ monthly and annual energy draw from the network
- An agreed peak energy draw and approximate energy demand profile

The understanding of the above is crucial to ensuring the following:

- The ESCO business model works
- The development is 'ESCO ready'
- The connection is made
- A reasonable energy profile is consumed
- The site is included on the piped energy network

Push Mechanisms Overview

The appropriateness of the mechanism depends on the characteristics of the building customer. For example some planning mandates to connect to an ESCO may not be enforceable on existing buildings that have not plans to change their systems or put in a planning application.

The Role of Planning: 'Planned' Developments

European

A number of European Directives support the development of low carbon energy supply, including the Energy Performance of Buildings Directive, the Cogeneration Directive and the recent Renewable Energy Agreement. These are being implemented through UK legislation in various ways, partly through Part L of the Building Regulations.

National

The Supplement to PPS1 on Planning and Climate Change defines a clear role for planning that goes beyond the promotion of carbon reduction measures. Croydon Council's Local Development Framework (LDF) should be seeking to create a strategic framework for CO_2 reduction including planning obligations and requirements.

The Role of LDA

Local Government's statutory planning powers are pivotal in establishing the spatial framework for the location, form and specification of new property developments as well as utility infrastructure and low carbon energy generation. Local authorities and other public authority departments have the opportunity, through the planning system, to request that developers consider community heating as part of the planning and design of their construction projects.

South London

The region London boroughs has collaborated on the Joint South London Waste plan initiatives like this may be utilised in the promotion of a decentralised energy scheme.

London Borough of Croydon

The role of planning is to look at the spatially mapping of the decentralised energy network opportunity areas, to support developers in meeting building regulations and identifying delivery mechanisms including designating local development orders.

Local Authorities have renewed powers under the Local Government Act 2000, the London Plan and draft new London Plan and numerous energy policies in support of district energy, such as the community infrastructure levy.

Croydon is part of the GLA family and Government guidance expressly includes participation in special purpose vehicles established to deliver low carbon energy services, but their remit extends much wider than this – encompassing their strategic role in coordinating investment in the regeneration of neighbourhoods and, increasingly, the establishment of public-private property investment portfolios.

Strategic heat planning will be required to facilitate the development of district heating networks, with district heating treated as essential utility infrastructure. In order for heat plans to have any status, they should be incorporated into Development Plan Documents and Area Action Plans.

Adoptable policies, with targets and requirements, supported by technical guidance that can be used when considering planning applications. The Supplement to PPS1 on Planning and Climate Change sets out the policy framework,

Planning alone is not enough to ensure connection. Complementary enabling mechanisms will need to support implementation. This section describes the key enabling mechanisms that can be brought into play in order to support the development of community energy.

London Plan Decentralised Energy Policies include:

Policy 4A.5 Provision of heating and cooling networks:
'Boroughs should ensure that all DPDs identify and safeguard existing heat and cooling networks and maximise the opportunities for providing new networks that are supplied by decentralised energy.'

'The Mayor will and boroughs should work in partnership to identify and establish network opportunities, to ensure the delivery of these networks and to maximise the potential for existing developments to connect to them.' (Policy 4A.5 Provision of heating and cooling networks)

Planning Policy Statement (PPS): Planning & Climate Change issued as a supplement to PPS1: Delivering Sustainable Development.
'It also expects councils to think about the potential for local low carbon energy generation and cutting carbon emissions when identifying the best sites for development. Croydon will be expected to look at the potential for connecting developments to neighbouring community heating and power schemes that can serve an entire local community. The PPS builds on the Merton rule which requires all new non-residential developments above a certain size to generate at least 10 per cent of their energy on-site from renewable sources. The Mayor of London also plans to double renewable electricity supply from the 2010 target of 10 per cent to 20 per cent by 2020'.

The Role of Building Regulations

Part L of the Building Regulations plays a role in the decision as to whether to connect to a District Heating network. The decentralised energy network can offer many benefits including, CO_2 credits, assisting with Part L2A compliance and contributing to consequential improvements.

Pull Mechanisms Overview

The appropriateness of the mechanisms to employ to promote ESCO network take-up depends on the characteristics of the customer and their understanding of the product.

The product: Hot Water

Before discussing sales, it is important to clarify the actual product that is being sold. The current proposal is to produce and sell hot water at 95^{o}C at a point of connection at the customer's site boundary. Customers will then consume a quantum of energy from that hot water and return the same water at a lower temperature 65^{o}C back to the same point of connection. Flow and return pipework will transport the hot water, which will be pumped from energy centres around a mainly subterranean insulated pipework network.

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Uses of Hot water Energy

The customer can use this primary high temperature hot water at 95^{o}C for the following uses:

1. Heating: once passed through a heat exchanger the customer can produce medium or low temperature hot water for the developments heating circuits
2. Domestic hot water: once passed through a calorifier the customer can produce hot water for the developments domestic hot water circuits
3. Chilled Water: once passed through an absorption chiller the customer can produce chilled water for the developments chilled water cooling circuits (note the use of this primary hot water to produce cooling does not exclude the need for onsite heat rejection)

The use of local chilled water production facilities nodes serving groupings of energy clusters is addressed later in this section.

Customer: New Developments Building Owners

For a developer customer planning a new development within Croydon Town Centre there are a number of incentives to connecting onto the Croydon Decentralised energy network. It is assumed that the new development is to be on a sterile site which does contain existing buildings and doesn't have existing infrastructure within its boundary.

Customer: Redevelopments Building Owners

For a developer customer planning a redevelopment within Croydon Town Centre there are a number of incentives to connecting onto the Croydon Decentralised energy network.

Customer: Refurbishments Building Owners & Operators

For a developer customer planning to refurbish an existing development within Croydon Town Centre there are a number of incentives to connecting onto the Croydon Decentralised energy network.

New Developments/Redevelopments/Refurbishments: Positive Mechanism Table	
Persuasive Mechanisms	**Description**
Promote reduction in capital expenditure	Remove boiler CAPEX. Boilers are no longer required, replaced by cheaper smaller heat exchangers.
Promote floor area saving	A boiler plantroom is no longer required with its associated plant and access space. With biomass boilers the additional area savings are realised on storage and delivery space
Highlight boiler flue removal	With no boilers there is no need for unsightly boiler flues and their associated air quality issues
Offer resilience to fluctuation in energy prices	Offer resilience to fluctuation in energy prices
Highlight fuel feed benefits	A gas connection is no longer required for the boilers and compared to a biomass boilers no deliveries are required
Remove air quality issues	Air quality leverage over developments! Remove all their planning air quality issues in one go! Pollution Nox reduction
Show improvements in DEC & EPC ratings	An improved Energy Performance in Buildings Directive rating
Deliver low & Zero carbon technologies contribution	The ESCo should deliver the 20% renewables contribution for LZC technologies.
Enhance code for sustainable homes rating	Improved Code for Sustainable Homes scoring
Offer competitive utilities cost to site occupants	Offer competitive utilities cost to site occupants
Reduce ongoing risk of asset maintenance	Reduced risk to the developer as operation and maintenance is now the responsibility of ESCo
Access preferential energy deals with utilities	Get preferential bulk buying deals
Lead negotiations with energy suppliers	Have a lot better understanding and bargaining position with utility companies
Offer to manage billing process	Manage the process of billing the occupants
Absorb cost of plant replacement	Plant now responsibility of ESCo
Promote increased marketability	Increased marketability of the site to potential tenants
Reduced fuel poverty	Offer the option of discounted energy to help reduced fuel poverty
Offer reliable supply	With the reliability of infrastructure and interlinked energy centres supply is very reliable
Price assurance of services	The ESCo can offer a consistent financial spread
Offer revenue opportunity	Potential revenue could be generated from useless land for housing the energy centre or accommodating infrastructure.
Offer ESCo partner opportunity	Opportunities to partner in an ESCo team and to be part of the revenue stream.

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Customer: Existing Developments Building Owners & Operators

For a building owner customer planning a redevelopment within Croydon Town Centre there are a number of incentives to connecting onto the Croydon Decentralised energy network.

Existing Developments: Positive Mechanism Table	
Persuasive Mechanisms	**Description**
Promote reduction in capital expenditure	This is dependent on remaining life on existing plant. May be difficult to justify, on capital cost, the replacement of boilers with life remaining with heat exchangers
Promote floor area saving	The boiler plantroom is no longer required with its associated plant and access space.
Highlight boiler flue removal	Removal of unsightly boiler flues and their associated air quality issues + stack riser area gained on each floor.
Offer resilience to fluctuation in energy prices	Offer resilience to fluctuation in energy prices
Highlight fuel feed benefits	A gas connection is no longer required for the boilers.
Remove air quality issues	Air quality leverage over developments. Remove all their planning air quality issues in one go. Pollution Nox reduction
Show improvements in DEC rating	An improved Energy Performance in Buildings Directive rating (energy performance certificate and display energy certificate for public buildings)
Contribution to CRC Energy Efficiency Scheme	This low carbon connection will make significant contribution to reducing CO_2 emissions to generate income from this scheme.
Deliver low & Zero carbon technologies contribution	The ESCo should deliver a renewables contribution for LZC technologies.
Enhance code for sustainable homes rating	Improved Code for Sustainable Homes scoring
Offer competitive utilities cost to site occupants	Offer competitive utilities cost to site occupants
Reduce ongoing risk of asset maintenance	Reduced risk to the developer as operation and maintenance is now the responsibility of ESCo
Access preferential energy deals with utilities	Get preferential bulk buying deals
Lead negotiations with energy suppliers	Have a lot better understanding and bargaining position with utility companies
Offer to manage billing process	Manage the process of billing the occupants
Absorb cost of plant replacement	Rather than replacing old boilers, the energy network would offer a lower cost solution using heat exchangers
Promote increased marketability	Increased marketability of the site to potential tenants
Reduced fuel poverty	Offer the option of discounted energy to help reduced fuel poverty
Offer reliable supply	With the reliability of infrastructure and interlinked energy centres supply is very reliable
Price assurance of services	The ESCo can offer a consistent financial spread
Offer revenue opportunity	Potential revenue could be generated from useless land for housing the energy centre or accommodating infrastructure.
Offer ESCo partner opportunity	Opportunities to partner in an ESCo team and to be part of the revenue stream.

Refurbishments: Barriers Table	
Barriers	**Description**
Existing Energy Ties	Occupier already has corporate rates agreed with energy providers
Commitment to energy consumption	Building owners may have to sign-up to buy energy from anything from a 15 to 40 year period
Connection Charge	Building owners may have to contribute to the capital cost of the energy centre and the infrastructure
Phased connection commitment	The building owner will have to provide a prediction of the phased connection of the development (kW & kWh)
Energy profile commitment	Over the life of the development a demand profile need to be agreed. Unoccupied properties, not consuming energy, will effect this prediction
Fuel price exposure	Tied in to wholesale energy prices through the ESCo purchasing agreements. Can't go out to get other tariffs from alternative utility companies

Complementary Product: Electricity

With the use of combined heat and power units in the ESCO business model, electricity is produced as well as heating hot water in the energy centres. It is our understanding that existing power distribution network in Croydon town centre is reaching capacity. With new developments coming online network reinforcement is required in the town centre to support those developments.

The host distribution network operator (DNO) is obligated under the terms of its license to provide the developers with a network connection agreement to supply additional load. The distribution licence holder for the Croydon town centre area has suggested that any significant network capacity increase will require an additional primary sub-station in the area. One proposed location for a potential primary sub-station is under Queen's Gardens. The cost of this substation would be apportioned across any new developments demanding the load increase. Within a definitive timeframe the ESCO centre could help offset or remove this burden by supplying that additional load or by providing a stronger negotiating position with the host network provider.

Complementary Product: Chilled Water

This strategy proposes the production and distribution of high temperature hot water to points of connection of the energy clusters. In the summer this can be used for heating. In the winter, there is obviously less demand for heating. The hot water can be fed into absorption chillers to produce cooling. The use of hot water for the purposes of converting into chilled water is not as effective as displacing boiler heat and therefore the business case for chilled water production in summer is less viable.

Capabilities on project:
Energy
Environment

Other Issues to consider

Point of Connection Definition

When connecting to a customer, where does the ESCO owned energy network infrastructure stop and the site internal infrastructure start? Where does responsibility for the infrastructure asset end? Does the ESCo manage the infrastructure up to the heat meter on the individual residential units, or stop at a 'capped off' point of connection at the site boundary?

Preferential Rates

Can customers be penalised for either not connecting or connecting late to the energy network? Can preferential rates be offered for early sign up encouraging customers to sign up now with discounted connection costs and consumption charges, on a first come first serve basis? Do regulations prevent this kind of penalty clauses or preferential treatment?

Subsidised Pricing

Could subsidised pricing be introduced to help address issues such as fuel poverty?

Phased Pricing

With the network infrastructure distributed over a considerable distance, the first customer may be at the far end of the proposed infrastructure. This would mean that the whole cost of the infrastructure would need to be put in at the beginning to serve just this one development. The phased connection onto this network over time would be very difficult to justify financially. Should this first development be charged more?

Unoccupied property

Landowners will have to consider residential apartments where owners are not necessarily occupiers and buy the property as investment or second home and only spend one month a year there in the summer. The landowner may have signed up to consume energy against an energy profile for that unit which has no energy demand for heating.

Pneumatic Waste Distribution System

A pneumatic waste distribution system should be considered for areas of high density. An interesting idea is the use of the green spine along Wellesley Road to collect waste to feed down into a collection centre housed within the current location of the Wellesley Road/ Park Lane underpass

IT

There is a great opportunity as pipework infrastructure is being installed to lay data and fibre optics in the roads, trench, along structures etc. at the same time. The green spine along Wellesley Road could also form the Croydon data connectivity spine.

Legal Issues

Legal issues of ownership and energy consumption and load commitment and will have to be resolved.

Connection Charges

On day one of the customer connection a connection charge will have to be paid to contribute to the capital cost of energy centres, infrastructure etc.

Reliability of Heating

What about heating/ power resilience? Who are the users? Data centres, dealer floors, doubling up? Fail safe connections?

Existing offices

What is my incentive to connect? Equipment connection costs? Stepdown heat exchangers, connection charge, controls etc., but freed up space in basement where boilers, chillers were and potential roof space freed from heat rejection equipment. Remove all the external split units on the façade and rooftop to improve visual amenity. Zero carbon, green roof gardens.

Capabilities on project:
Energy
Environment

Existing old boilers that need replacing, free life cycle analysis for potential customers. Part L2B, Encouragement, the spirit of the ESCO, incremental expansion, CAPEX in ground heat sales over time.

Load Matching
Offer Croydon strategic design advice to get their loads down and profiles matching the Croydon delivery profiles. Can we affect the building mix through energy policy to match the optimum output profiles? Can it start to influence where we put housing and when?

Who Owns the Network
Does Croydon own the network infrastructure with 25-30 years life on it? Do developers trust Croydon more than an ESCO company?

Catalyst Connections
When does the network reach critical mass? If we can get commitment from the large public sector groupings and/or from some of the high density large developments proposed, then with these on board, and with the scheme successfully operation, then the others will follow suit.

Exit strategy/ Exit Mechanism
Does Croydon Council require an exit strategy? When to exit and what does Croydon Council want to come away from the deal with?

Operational Risk
Is this low carbon energy solution economically viable? What is the worst case scenario?

Reputational risk
Croydon Council may suffer if the ESCO fails to deliver projects of sufficient impact.

ESCo's
There are a number of companies offering ESCo capability these are listed below:

- Dalkia PLC
- LondonESCo
- Scottish and Southern Energy (SSE)
- E.On Sustainable Energy Solutions
- Ener-g Combined Power
- RWE Energy
- ABB
- Inexus/ Metropolitan
- Morgan EST
- Thameswey Energy
- United Utilities
- Utilicom
- Thames Energy (Less Energy)
- Elyo
- Ecocentrogen
- Cogenco
- EnviroEnergy
- Centrax
- Vital Energi

Capabilities on project:
Energy
Environment

Section B

Indentifies and locates potential customers who could be provided with thermal (heating cooling) and electrical energy within the town centre and nearby surrounding areas.

Within the scope of this study we have identified approximately 50 potential energy customers. Some customers are existing Croydon Town centre energy consumers with existing relationships with energy providers, some potential customers are in the process of or considering developing in Croydon Town centre and, unless they already have corporate deals with energy providers, will be looking to obtain, easy and cheap access routes to reliable energy, some potential customers, like Croydon Council are looking not only to purchase energy, but also to play a role in the production of, and revenue streams from, that energy.

All these customers have various thermal and electric demand characteristics for their existing buildings or future buildings. This study has looked to identify those potential customers, predict the scale of their energy demand loads and energy profile characteristics. Using customer parameters such as information of location, peak demands and load profiles we have offered an example energy connection solution for Croydon Decentralised energy.

We have taken a number of practical opportunities and constraints of delivering energy around an energy distribution network around Croydon. We have looked at the potential energy centre locations and estimated when the potential 50# customers could in practice connect onto and start drawing energy from the network.

This approach has led to the identification of three clear energy network zones. These zones are:

1. Zone 1: South Croydon
2. Zone 2: East Croydon
3. Zone 3: West Croydon

Each of these zones has very different and very specific energy characteristics. These zones are then broken down into energy clusters. An energy cluster is single or group of buildings in the same geographical location, which are owned by the same customer or have very similar demand characteristics. The potential customer is therefore a sub-set of the energy clusters and for this study would be the address where a ‘point of connection’ is made onto the decentralised energy network.

The energy pathway would therefore be as follows:

1. Thermal and electrical energy is produced at the energy centre
2. Thermal and electrical energy is then passed through pipes and cables
3. The customer receives the energy at their site boundary at the point of connection (POC)

South Croydon Energy Zone (Zone 1)

Potential Energy Centre Location

The proposed location for Zone 1 energy centre is in the basement of Taberner House. The specifics of this energy centre will be addressed in a later section of this report. In order to identify the potential customers in Zone 1 is good to understand the precise location of the energy source. The main land owner within this zone is Croydon Council and can therefore exert influence over the potential customers within this zone.

CCURV Energy Cluster
The potential customers in existing or proposed buildings, which make up the CCURV energy cluster, are:

- Taberner House
- CCURV PSDH (Croydon Council Urban Regeneration Vehicle, Public Service Delivery Hub)
- Davis House
- Town Hall
- Library

Taberner House
The current proposal is for Taberner House to be demolished and replaced by an 18 storey stepped residential development on the site. The proposal would be to retain the current hole in ground of Taberner House's existing basement, to house the Zone 1 energy centre

CCURV PSDV
The Croydon Register office building and Crosfield House (the L-shaped building along Fell Road and Mint Walk) is being demolished to make way for CCURV PSDH. The proposal is or Croydon Council offices to be decanted from the current Taberner House into the new CCURV PSDH building.

Davis House
It is our understanding that Davis House will be refurbished.

Town Hall and Library
The Town Hall and Library fronting onto Katharine Street are currently supplied from the energy plant under Taberner House.

Customer Likelihood
As these buildings fall under the Croydon Council's or CCURV authority it is thought highly likely that these customers would be able to justify signing up to the Croydon Decentralised energy scheme.

Bridge House Energy Cluster
Bridge House-The Exchange sits to the west side of the C-CURV Energy Cluster. We have been asked to consider this building as part of this study.

Mid-Croydon Energy Cluster
With regards to the progression of the Masterplan for Mid-Croydon we have been informed that 'the brief is in development'. The potential customers in existing or proposed buildings, which make up the Mid-Croydon energy cluster, are:

- St George's House (Nestle Tower)
- Park Place

The masterplan for Mid-Croydon is in its infancy and very little is known about the proposals for Mid-Croydon apart from Croydon Councils current preference for a mix use consisting of approximately 50% residential.

Customer Likelihood
Little is known about the proposals for this area. Although, given the close proximity to the energy centre potential identified, by this study, at Taberner House and the extensive underground car park, and therefore relative ease of local energy distribution below the cluster, the opportunities for connection are very favourable.

College Green Energy Cluster

The potential customers in existing or proposed buildings, which make up the College Green energy cluster, are:

- Fairfield Halls & Ashcroft Theatre
- Croydon College
- Fairfield Halls West New Residential
- College Tower
- College Green North Refurb Offices
- Croma (100 George Street)
- Law Courts

Customer Likelihood

- Given the relationship between the Council and the College, the close proximity to the energy centre potential identified, by this study, at Taberner House and the extensive underground car park, and therefore relative ease of local energy distribution below the cluster, the opportunities for connection are very favourable.

Law Courts Energy Cluster

The potential customers in existing or proposed buildings, which make up the Law Courts energy cluster, are:

- The Law Courts
- Croydon Park Hotel
- Altitude 25
- No. 1 Croydon

Customer Likelihood

- Given the public nature of these building and their relationship to Croydon Council the potential for their connection is very favourable. The main issue to address will be the crossing of the rail tracks from College Green in the West to the Law Courts energy cluster to the east and the feasibility of using the rail bridge along Hazledean Road as the structure to support this pipework crossing connection.

East Croydon Energy Zone (Zone 2)

Potential Energy Centre Location

The proposed location for Zone 2 energy centre has been given a rough location to the East of Landsdowne Road at its North end. As there is no clear energy centre site this approximate area has been designated in order to address the feasibility of pipework distribution and to measure the pipe distances from source to POC for the costing exercise. Also, in order to identify the potential customers in Zone 2 is good to understand the approximate location of the energy source.

Ruskin Square Energy Cluster

The potential customers in existing or proposed buildings, which make up the Ruskin Square energy cluster, are:

- Phase 1 (West)
- Phase 2 (North)
- Phase 3 (Mid)
- Phase 4 (South)

Based on discussion with Stanhope, the developer for this site, for all four phases, we are currently making an allowance of 12 MVA for power (3MVA per phase) and 12 MW for heating/ hot water (3MW per phase). Our energy profiling is based upon a typology split, for all phases of 50% commercial office and 50% residential.

Customer Likelihood

- There are many issues to be presented and discussed with potential new developers in relation to connection to an energy network. Given the size, nature and location of Ruskin Square there are significant mutual benefits for Stanhope and the ESCo provider. If an early collaborative approach is taken then there are some major win-win opportunities.

Cherry Orchard Energy Cluster

The potential customers in existing or proposed buildings, which make up the Cherry Orchard Road energy cluster, are:

- Phase 1 (Mid)
- Phase 2 (North)
- Phase 3 (Post Office)

Menta are the developer of the Cherry Orchard Road site. With regards to the split of of energy loads and use typologies please refer to the relevant energy data sheets.

- Oval Primary School

Customer Likelihood

- There are many issues to be presented and discussed with potential new developers in relation to connection to an energy network. Given the size, nature and location of Cherry Orchard Road development there are significant mutual benefits for Menta and the ESCo provider. If an early collaborative approach is taken then there are some major win-win opportunities.

East Croydon Station Energy Cluster

Some provision has been made to allow additional capacity on the network to support the energy loads of the current railway station and the potential expansion of this facility.

Dingwall Road Energy Cluster

The potential customers in existing or proposed buildings, which make up the Dingwall Road energy cluster, are:

- 29-30 Dingwall Road
- 14-17 Dingwall Road
- Other existing office buildings along Dingwall Road

Existing private office buildings and office refurbishments offer a different customers profile and characteristic to developer new build and public office buildings.

Customer Likelihood

- There are many issues to be presented and discussed with potential customers along Dingwall Road. The customer likelihood connection depends a lot on the timing. Potential customers will not be looking to buy energy from an outside source that would mean leaving their existing new boiler plant redundant whereas if they have old boilers reaching the end of their life the offer of replacing that energy source with a potentially cheaper, more sustainable one which also frees up net lettable space where boilers are removed could be very attractive.

West Croydon Energy Zone (Zone 3)

Potential Energy Centre Location

The proposed location for Zone 3 energy centre has been given a rough location in the loading bay area in the lowest level basement at the North end of the Whitgift Centre. As there is no clear energy centre site this approximate area has been designated in order to address the feasibility of pipework distribution and to measure the pipe distances from source to POC for the costing exercise. Also, in order to identify the potential customers in Zone 3 is good to understand the approximate location of the energy source.

Whitgift Centre Energy Cluster
With the current proposed location for the energy centre in its lower levels the Whitgift Centre would be an essential part of the West Croydon energy cluster. Given the huge demand for energy and the potential to balance its retail energy profiles with surrounding residential and office profiles having the Whitgift Centre as a customer would add significant strength to the decentralised energy scheme for Croydon.

Customer Likelihood
- Given the land ownership by the Whitgift Foundation, an educational trust and the leaseholder for the Whitgift Centre Howard Holdings. There are both significant opportunities offered as well as barriers to overcome before a customer deal could be struck.

Centrale Centre Energy Cluster
With the huge demand for energy and the potential to balance its retail energy profiles with surrounding residential and office profiles having the Centrale Centre as a customer would add considerable strength to the decentralised energy scheme for Croydon.

Wellesley Road Energy Cluster
The potential customers identified in existing or proposed buildings, which make up the Wellesley Road energy cluster, are:
- Lansdowne Road Hotel
- Southern House
- Lunar House & Apollo House (Home Office)
- Wellesley Square
- Delta Point
- Prospect First

Existing private office buildings and office refurbishments offer a different customers profile and characteristic to developer new build and public office buildings. Given the very public role of the Home Office the Lunar House & Apollo House buildings could offer substantial support to any proposed energy network along Wellesley Road.

Customer Likelihood
- There are many issues to be presented and discussed with potential customers along Wellesley Road. The customer likelihood connection depends a lot on the timing. Potential customers will not be looking to buy energy from an outside source that would mean leaving their existing new boiler plant redundant whereas if they have old boilers reaching the end of their life the offer of replacing that energy source with a potentially cheaper, more sustainable one which also frees up net lettable space where boilers are removed could be very attractive.

West Croydon Energy Cluster
The potential customers in existing or proposed buildings, which make up the West Croydon energy cluster, are:
- Berkeley Homes 250-units new residential development
- Other 250-units new residential development
- Existing Bus Station facilities

The West Croydon Masterplan is in the early stages. Provision has been made for the above customers.

Capabilities on project:
Energy
Environment

Handcroft Road Estate Energy Cluster

Handcroft Road Estate energy cluster is based upon an existing residential district heating scheme. Given its proximity to Factory Lane, there is potential to connect this mini district network onto the Croydon decentralised network if the Roll Royce power plant and its pipework connection to the town centre forms part of the network. It will be important to retain and upgrade this estate including installing local small-scale CHP if connection to the wider scheme is unfeasible. This is one of the few examples in the Borough of a significant district heating project and its reputation will influence the development of further District heating schemes.

Capabilities on project:
Energy
Environment

Section C

Estimates the level of energy demands of potential customers now and in the future

From the interim study, the Croydon town centre boundary has been agreed, which defined the scope of the decentralised energy study. This boundary embodies 4 main quadrants, as shown in Figure 1, which corresponds to key development areas:

- Wellesley Road/Park Lane
- Wandle Park
- East Croydon
- West Croydon

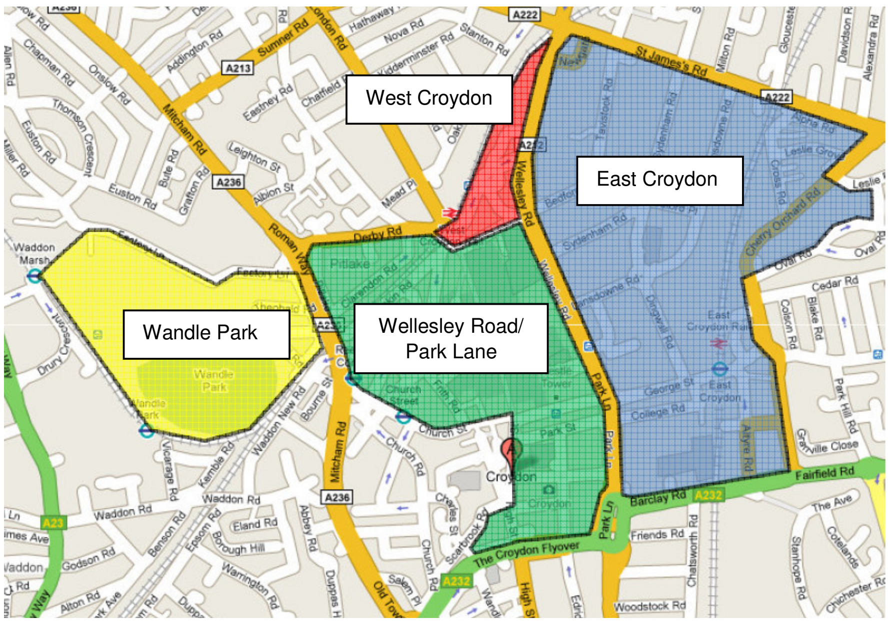


Figure 1 Town centre quadrants as defined by the council

These quadrants contain the majority of the earmarked developments to take place over the next 10 years in-line with the Urban Regeneration Vehicle and Croydon's aspiration to be 'London's Third City'.

For the final report, a total of 30 Energy Clusters have been established to provide spatial indication of the heating, cooling and electrical annual peak and energy demands in the town centre zone. These Energy Clusters are as shown in Figure 2.

Capabilities on project:
Energy
Environment

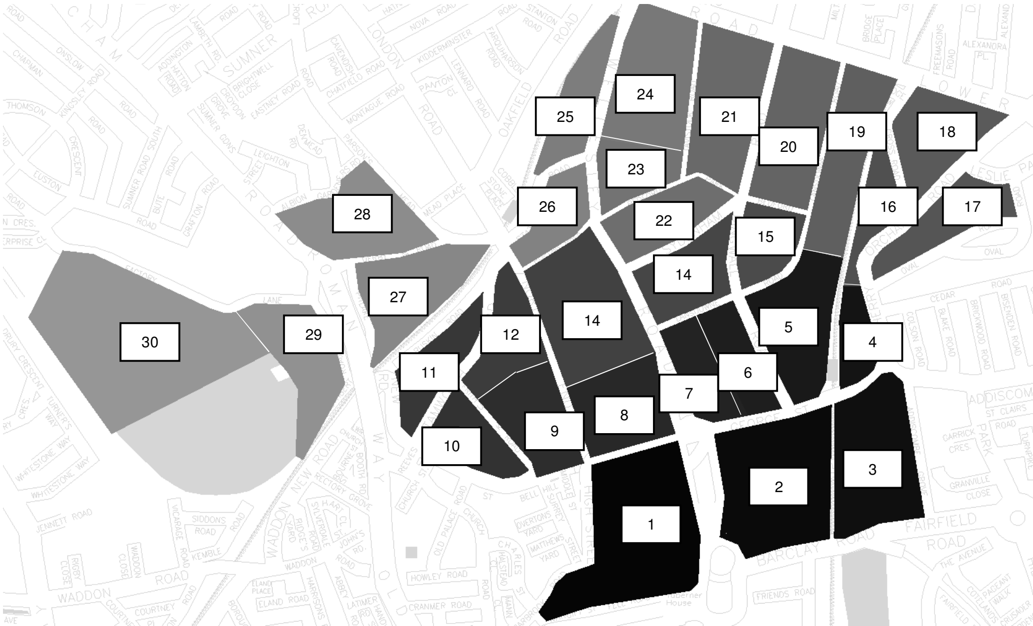


Figure 2 Map showing Energy Clusters (1 to 30) defined for the town centre area

Each Energy Clusters will indicate the sum of energy and peak demand in MWh and MW respectively of buildings identified within them as being relevant within the scope of the study. More details are available in Section B.

For the Decentralised Energy (DE) scheme to be economically viable and for it to work successfully, customers along with their respective estimate of energy demands will need to be identified. This enables the planning of the DE network routing and the prediction of the energy centre capacity to be carried out. For the purposes of this study, potential customers identified are assumed will connect to the DE scheme, to ensure that ceiling demands are at least catered for in the DE scheme capacity prediction.

The Council has listed several existing major buildings in the town centre zone, amongst which are also several major public buildings. Figure 3 highlights the location of major existing buildings and approved and pending development sites around the town centre of Croydon.

Capabilities on project:
Energy
Environment

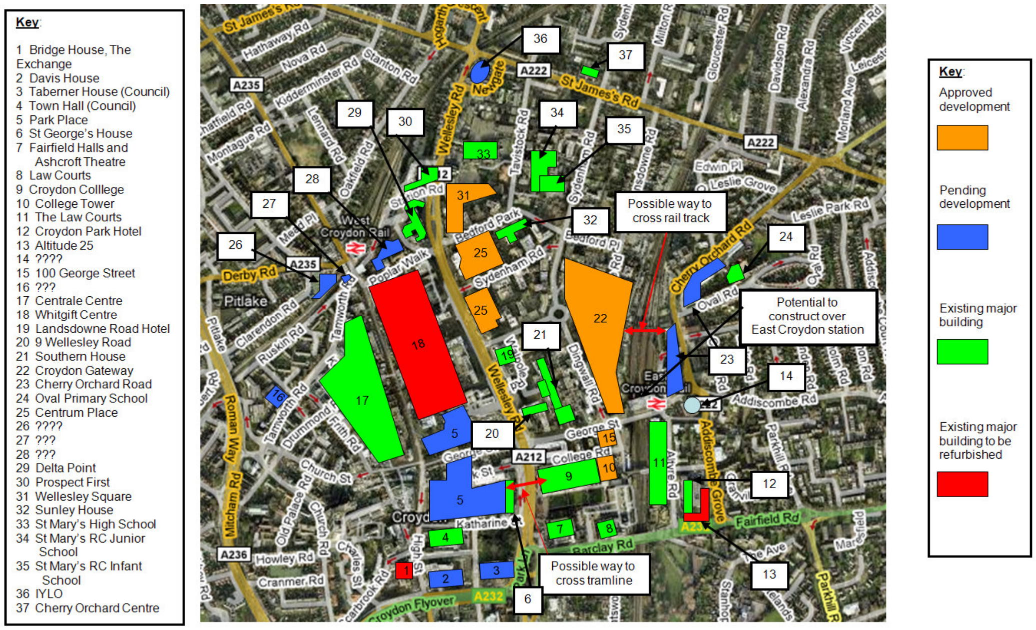


Figure 3 Map from the Council indicating the location of major existing buildings and approved and pending development sites

There are a large number of new developments to come online at different times in the Croydon town centre zone and it is crucial within the council's sustainability remit to commit these new developments to the energy scheme as well. Table 1 summarises the potential customers the study has identified to connect to the DE scheme.

	Existing Buildings				Buildings to come online by 2015		
	Council/Public Buildings	**Cluster**	**Details**		**Council/Public Buildings**	**Cluster**	**Details**
1	Civic centre	C001	Council	23	CURV PSDH	C001	Government
2	Davis House	C001	Council				
3	Suffolk House	C002	Office, part council rented		**Private Buildings**	**Cluster**	**Details**
4	Law courts	C003	Public building	24	100 George Street (Chroma)	C002	Private office
5	East croydon station	C004	Public building	25	Essex House	C002	Private office
6	Head post office	C004	Public building	26	College Tower	C002	Private residential
7	Southern House	C007	Government	27	Croydon learning and cultural quarter	C002	Private education
8	Tamworth Rd Resource Centre	C011	Council: Corporate services	28	Fairfield Halls & Ashcroft Theatre	C002	Public building (refurbished)
9	Oval Primary & Nursery School	C017	School	29	Croydon Gateway (Ruskin Sq)	C005	Private office & residential
10	Lunar house & Apollo house(home office)	C022	Government	30	14-17 Dingwall Rd	C006	Private
11	St Mary's High School	C024	School	31	Park place	C008	Retail
				32	Wellesey Square	C023	Private residential &retail
	Private Buildings	**Cluster**	**Details**	33	Berkeley Homes	C024	Private residential
12	St George's House (also Nestle Tower)	C001	Private				
13	Bridge house, the exchange	C001	Residential		**Buildings to come online beyond 2015**		
14	Croydon College	C002	Private education		**Private Buildings**	**Cluster**	**Details**
15	Croydon park Hotel	C003	Private	34	Taberner House (residential)	C001	Private residential
16	Altitude 25	C003	Residential	35	Croydon learning and cultural quarter - Phase 2, 3 & 4	C002	Private education
17	No. 1 Croydon	C003	Residential	36	Croydon Gateway (Ruskin Sq) - Phase 2, 3 & 4	C005	Private office & residential
18	Landsdowne Road Hotel	C007	Private	37	Cherry Orchard Road	C017	Private office & residential
19	Centrale	C009	Private retail				
20	Whitgift Centre (refurb)	C013	Private retail		**Potential future buildings**		
21	Prospect First	C025	Private	38	IYLO	C002	Residential
22	Delta Point	C026	Private	39	Hancroft Road	C028	Residential
				40	29-30 Dingwall Rd	C014	Private

Table 1 List of buildings of potential customers to connect to the DE network

Capabilities on project:
Energy
Environment

Figure 4 shows the location of these buildings in the Croydon town centre area in their corresponding index numbers. They have been colour coded to represent the timeframe in which they could possibly connect to the DE scheme.

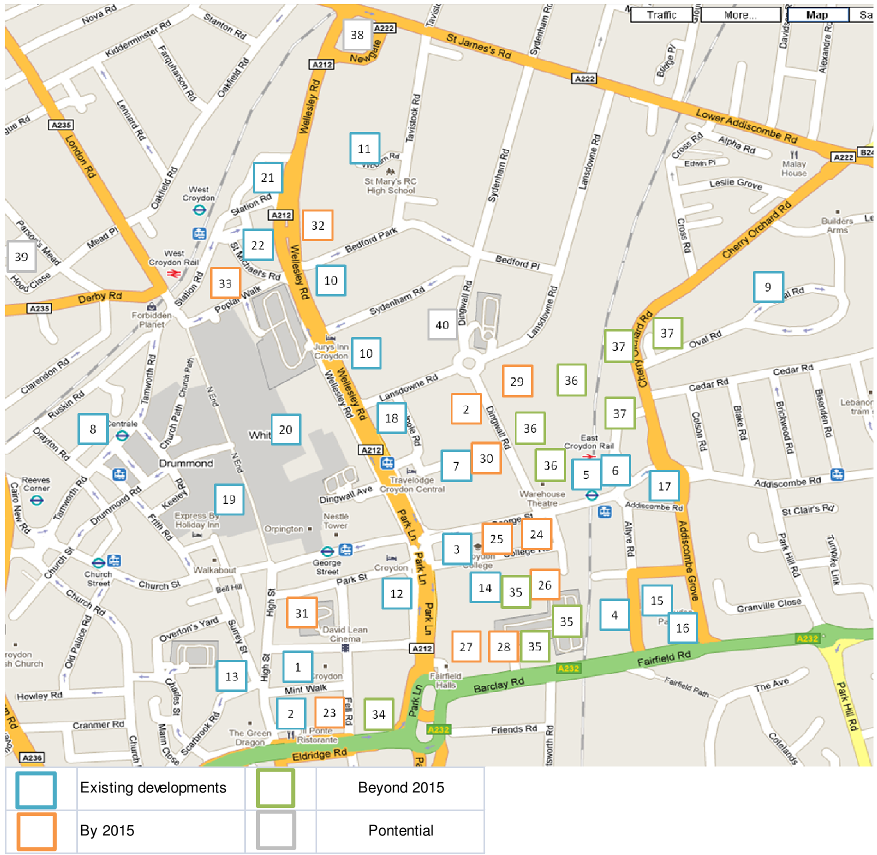


Figure 4 Locations of potential DE network customers

Having identified the potential customers that could connect to the DE scheme, the possible locations for the Energy Centres could be proposed. In the interim study, Option 3 proposed Zonal type Energy Centres as shown below in Figure 5.

Capabilities on project:
Energy
Environment

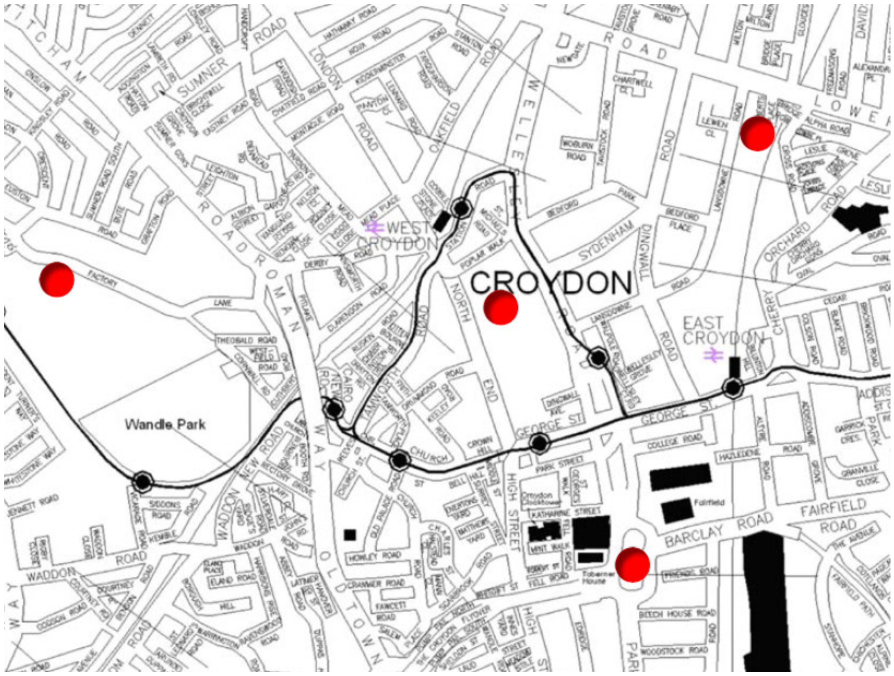


Figure 5 Zonal district Energy Centres option

This corresponds to locating the Energy Centres in the following Energy Clusters as an indicative suggestion:

1) Energy Centre 1 to be located in the basement of the new ‘Taberner House’ in Energy Cluster 1
2) Energy Centre 2 to be located somewhere along Lansdowne Road in Energy Cluster 5 or 19
3) Energy Centre 3 to be located somewhere in the basement car park/storage space of the Whitgift Centre in Energy Cluster 13

Each Energy Centre is designed to cater for the energy demands of several Energy Clusters as listed in Table 2 and illustrated in Figure 6. The buildings listed as potential customers are located within one of these Energy Clusters, as already listed in Table 1 and illustrated in Figure 4.

Energy Centre 1	Energy Centre 2	Energy Centre 3
Energy Cluster 1	Energy Cluster 4	Energy Cluster 7
Energy Cluster 2	Energy Cluster 5	Energy Cluster 8
Energy Cluster 3	Energy Cluster 6	Energy Cluster 9
	Energy Cluster 16	Energy Cluster 13
	Energy Cluster 17	Energy Cluster 14
		Energy Cluster 22
		Energy Cluster 23
		Energy Cluster 24
		Energy Cluster 25
		Energy Cluster 26

Table 2 List of Energy Clusters serviced by the respective Zonal Energy Centres

Capabilities on project:
Energy
Environment

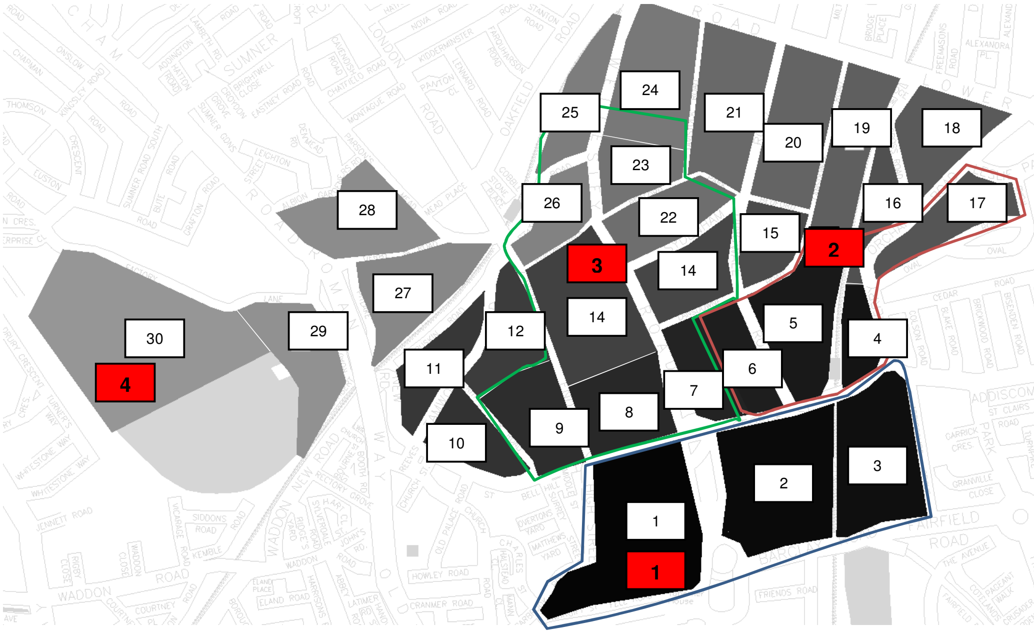


Figure 6 Proposed locations of the Zonal Energy Centres and an indication of the Energy Clusters they will serve respectively

To serve these buildings, a pipe network to deliver the energy demand to the location of the buildings is needed. Figure 7 shows the primary level pipe network for each Energy Centre. These network starts from the respective Energy Centres and ends just off the site of the identified buildings. The secondary pipeline is only indicative in this study and is illustrated in Figure 7 for discussion purposes.

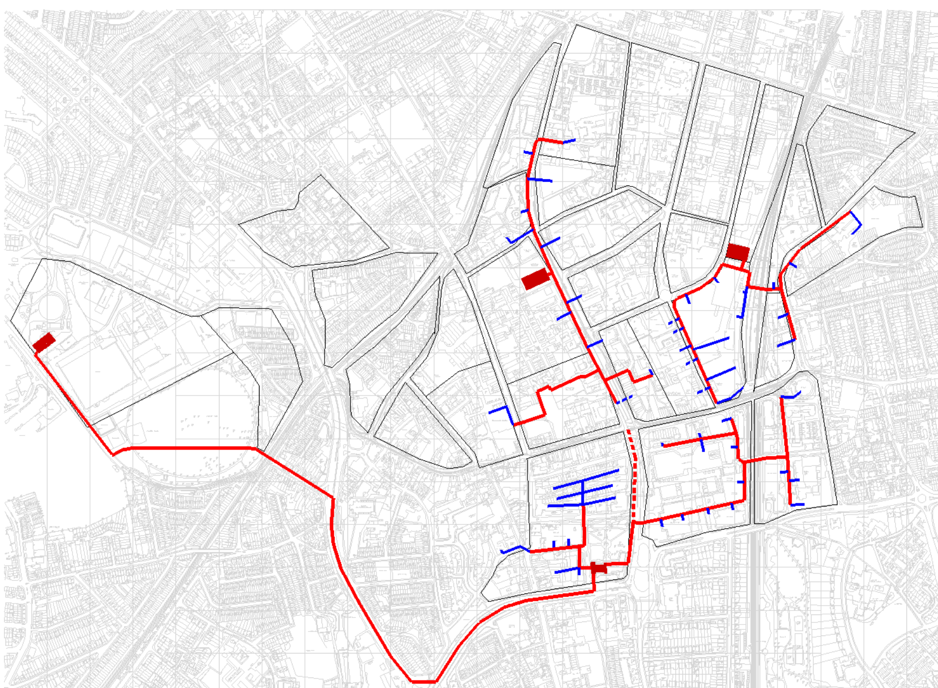


Figure 7 The routing of the primary pipelines of the DE network branching out of the respective Energy Centres. The secondary pipeline connecting the primary pipeline to the respective buildings are indicative only. The Energy Clusters are also highlighted

Capabilities on project:
Energy
Environment

Principles and Methodology

The Croydon town centre consists of a mix of building types ranging from domestic and non-domestic buildings. It was previously identified in the interim study that, in general, the town centre consists of mainly commercial buildings (shown in green) with generally residential (shown in blue) areas surrounding its fringes. Figure 8 shows an indication of the dominant building type around the town centre.

Commercial		Education	
Domestic		Industrial	

Figure 8 Map showing dominant building type clusters

In order to tailor the energy demand prediction to fit within the scope of study, the energy demand of the domestic sectors has been disregarded. The rationale behind this simplification is that it is conceded in this study that it is economically and practically not viable to connect the general existing dwellings onto the proposed DE scheme due to marketing uncertainty and risk. Generally, larger developments are considered would benefit from connecting to the DE scheme and could help make the investment into a DE scheme financially sensible.

Several sources of data have been used to estimate the heating, cooling and electrical annual energy and peak demands. These are:

- Data from the Valuation Office Agency
- Information on existing major buildings
- Information on public buildings
- Information on buildings controlled by the Council

The Valuation Office Agency (VOA) data for the Borough of Croydon has been used to help establish the present day/base case annual energy demand (in MWh) for the town centre due to commercial buildings. The VOA data contain information on the building types, locations and floor area for all existing commercial buildings in the borough. There were minute amount of inconsistencies in the VOA data, however the overall effect is considered insignificant in this study.

Capabilities on project:
Energy
Environment

The VOA data do not provide energy figures; therefore, in order to obtain an estimate of annual energy and peak demand, the VOA data would need to be linked with energy benchmark figures. For this, the CIBSE Technical Manual (TM 46): Energy Benchmarks and BSRIA Rules of Thumbs design guide have been used to formulate the energy (kWh/m²) and peak (W/m²) demand approximation for the different building types identified. The energy benchmark figures in CIBSE TM46 are derived from CIBSE Guide F: *Energy efficiency in buildings* and Energy Consumption Guide ECG19: *Energy efficiency in offices*, which are based on real energy data from samples of typical existing building stock. The TM46 energy benchmarks are provided for 29 different types of buildings as listed below in Table 3.

Building type	**Building type**
General office	Public buildings with light usage
High street agency	Schools and seasonal public buildings
General retail	University Campus
Large non-food shop	Clinic
Small food Store	Hospital - clinical and research
Large food store	Long term residential
Restaurant	General accommodation
Bar, pub or licensed club	Emergency services
Hotel	Laboratory or operating theatre
Cultural activities	Public waiting or circulation
Entertainment halls	Terminal
Swimming pool centre	Workshop
Fitness and health centre	Storage facility
Dry sports and leisure facility	Cold storage
Covered car park	

Table 3 List of building types covered in TM46

Typically, only electrical and fossil-thermal energy benchmarks could be obtained from the TM46. Therefore, for buildings with cooling demand, an informed approximation was made by considering the typical amount of internal and solar gains in these buildings type. Derivation of the cooling demand was also made based on the proportion of electricity consumed for lighting, equipment and fans/pumps of the cooling system. The remainder proportion will reflect the approximate electricity used by the chillers. By using nominal chiller Coefficient of Performance (CoPs) figures, the cooling energy demand could be approximated. Nominal boiler efficiencies were also assumed to obtain the heating demand from the fossil-thermal energy benchmark figures. The split between space heating and domestic hot water was based on building type and this detail could be found in Section F. The CIBSE Guide A was also used where required as reference for relevant information such as typical building internal gains. Domestic and industrial buildings have been assumed to not have any cooling demands.

The VOA data for the borough of Croydon shows that the majority proportion of the town centre consists of office and retail spaces. As other types of buildings, including domestic buildings are in small proportion, it was found that the VOA data could adequately represent the majority of the annual energy and peak demands in the town centre area. Typically in study like this, energy and peak demand figures are essentially estimations and predictions. Therefore, the figures published in the report should be viewed as an indicator of the qualitative significance of the study carried out.

Whilst some real energy data were available, they were not used in this study as some were found to be unreliable and incomplete at times. Also, some energy data were for a particular building space and not for the whole building. For the scope of the study, the prediction of energy demand for the purpose of DE scheme consideration required whole-building figures.

The Council has identified a list of existing major buildings, with potentially high energy demands. Their energy demands have been accounted for in the VOA data energy figures.

Croydon Town Centre annual energy and peak demand estimates and predictions

The estimate of annual energy and peak demand in the town centre has been broken down into the Energy Clusters level defined earlier. *Heat maps* are used to illustrate the annual energy demand in MWh and peak demand in MW for heating, cooling and electricity of the Energy Clusters in the town centre. They are shown for four scenarios:

1) Present day Croydon town centre
2) Future Croydon town centre beyond year 2015 with business as usual and no DE scheme is implemented
3) Future Croydon town centre by year 2015 with DE scheme in place and the listed potential customers connect to the scheme
4) Future Croydon town centre beyond year 2015 with DE scheme in place and the listed potential customers connect to the scheme

The objective is to identify the spatial profile of the town centre energy demands and the potential changes in the future. This would lead to a better strategic planning and the sizing of the energy centres and the optimisation of the district energy distribution network to be implemented.

Table 4 summarises the annual heating, cooling and electricity energy and peak demands for the listed potential customers of the DE scheme.

In the *heat maps* shown in Figures 9 to 23, there are shades of blue, which indicate relatively low energy demand. This indirectly inferred that these are generally existing masses of residential areas. These are Energy Clusters that are not considered in the DE scheme. In general, all the *heat maps* demonstrated high level of demand in the core of the town centre. This is where most of the major existing buildings are located.

Furthermore, this level of demand is shown to increase significantly over the years as new developments come online in the area. Specifically, Cluster 1, 2, 4 and 5 will witness large increases in demand due to the new large developments such as Ruskin Square, Croydon Learning and Cultural Quarters, Cherry Orchard Road, Park Place and developments to replace the current Taberner House with CURV PSDH and a new residential tower.

Potential customer	Energy Cluster	Energy Centre	Floor area	Energy (MWh) Htg	Energy (MWh) Clg	Energy (MWh) Electricity	Peak (MW) Htg	Peak (MW) Clg	Peak (MW) Electricity	Type	Note
			[m²]	[MWh]	[MWh]	[MWh]	[MW]	[MW]	[MW]		
Existing to connect to DE network											
Civic centre	1	1	20,440	1,395.03	-	408.80	1.84	2.04	1.23	Council	To connect to DE scheme
Davis House	1	1	1,178	106.02	95.71	111.91	0.08	0.15	0.07	Council	To connect to DE scheme
Law courts	3	1	7,884	538.08	-	157.68	0.71	0.79	0.47	Public building	To connect to DE scheme
Taberner House	1	NA	30,800	2,772.00	2,502.50	7,650.00	2.16	3.85	1.85	Council	To be demolished for new residential, excluded from DE scheme
St George's House (also Nestle Tower)	1	1	28,128	2,531.52	2,285.40	2,672.16	1.97	3.52	1.69	Private	To connect to DE scheme
Bridge house, the exchange	1	1	9,165	595.73	-	366.60	0.55	-	0.46	Residential	To connect to DE scheme
Fairfield Halls and Ashcroft Theatre	2	1	10,440	712.53	-	208.80	0.94	1.04	0.63	Public building (to be demolished)	Site to be replaced by croydon college development
The Law Courts	2	NA	11,750	801.94	-	235.00	1.06	1.18	0.71	Public	Site to be replaced by croydon college development
Croydon park Hotel	3	1	6,878	1,702.31	816.76	722.19	0.41	1.03	0.21	Private	To connect to DE scheme
Altitude 25	3	1	24,363	1,583.60	-	974.52	1.46	-	1.22	Residential	To connect to DE scheme
No. 1 Croydon	3	1	21,432	1,566.21	562.66	1,238.16	1.36	0.87	1.14	Residential	To connect to DE scheme
Centrale	9	3	76,180	9,712.95	3,809.00	5,332.60	7.62	12.19	3.81	Private Retail	To connect to DE scheme
Whitgift Centre (retail extension refurb)	13	3	116,129	14,806.45	5,806.45	8,129.03	11.61	18.58	5.81	Private Retail	To connect to DE scheme
Lunar house & Apollo house(home office)	22	3	81,000	5,040.00	4,550.00	5,320.00	3.92	7.00	3.36	Government	To connect to DE scheme
Landsdowne Road Hotel	7	3	10,188	2,521.53	1,209.83	1,069.74	0.61	1.53	0.31	Private	To connect to DE scheme
Southern House	7	3	25,245	2,272.05	2,051.16	2,398.28	1.77	3.16	1.51	Government	To connect to DE scheme
Prospect First	25	3	26,890	2,420.10	2,184.81	2,554.55	1.88	3.36	1.61	Private	To connect to DE scheme
Delta Point	26	3	25,104	2,259.36	2,039.70	2,384.88	1.76	3.14	1.51	Private	To connect to DE scheme
Hancroft Road (residential park)	28	NA	20,160	1,310.40	-	806.40	1.21	-	1.01	Residential	Out of range of DE scheme unless RR Energy centre is feasible
Oval Orimary & Nursery School	17	1	2,597	227.08	-	74.05	0.26	-	0.10	Council: School	To connect to DE scheme
St Mary's High School	24	3	1,467	48.83	-	4.33	0.15	-	0.06	Council: School	To connect to DE scheme
Tamworth Road Resource Centre	11	NA	2,072	339.84	-	195.08	0.15	0.26	0.12	Council: Corporate services	Out of range, exclude from DE scheme
Suffolk House	2	1	14,000	1,260.00	1,137.50	1,330.00	0.98	1.50	0.72	Office, part council rented	To connect to DE scheme
East croydon station	4	2	10,800	1,209.60	-	432.00	1.08	-	0.43	Public	To connect to DE scheme
Head post office	4	2	19,200	1,728.00	1,560.00	1,824.00	1.34	2.40	1.15	Public	To connect to DE scheme
Berkeley Homes (approx based on altitude 25)	26	3	24,000	1,583.60	-	974.52	1.46	-	1.22	Residential	To connect to DE scheme
by 2015 to connect to DE network											
Croydon College	2	1	32,695	5,885.10	2,247.78	2,615.60	3.27	3.27	1.96	Private Education	To connect to DE scheme
100 George Street (aka Chroma w EssexHouse)	2	1	24,155	2,264.53	1,887.11	2,234.34	1.76	3.10	1.43	Private Office	To connect to DE scheme
Park place	8	1	92,903	11,845.13	4,645.15	6,503.21	9.29	14.86	4.65	Pending development	Indicative, included in DE scheme
CURV PSDH	1	1	21,770	2,775.68	1,088.50	1,523.90	2.18	3.48	1.09	Government	To connect to DE scheme
College Tower	2	1	54,000	3,510.00	-	2,160.00	3.24	-	2.70	Private residential	To connect to DE scheme
Croydon learning and cultural quarter - phase 1	2	1	51,325	5,138.10	3,737.78	4,529.98	4.01	6.90	2.94	Private Education	To connect to DE scheme
14-17 Dingwall Rd	6	2	20,000	1,800.00	1,625.00	1,900.00	1.40	2.50	1.20	Private	To connect to DE scheme
29-30 Dingwall Rd	14	2	6,604	594.36	536.58	627.38	0.46	0.83	0.40	Private	Out of range, exclude from DE scheme
Croydon Gateway (Ruskin Sq) - phase 1	5	2	26,923	2,168.03	1,358.71	1,996.65	1.78	2.09	1.51	Private Office & residential	To connect to DE scheme
Wellesey Square	21	3	51,035	3,504.78	150.00	2,131.40	3.18	0.48	2.55	Private residential &retail	To connect to DE scheme
IYLO	2	NA	11,895	773.18	-	475.80	0.71	-	0.59	Residential	Out of range, exclude from DE scheme
beyond 2015 to connect to DE network											
Croydon learning and cultural quarter - phase 2, 3 &	2	1	113,199	8,774.60	3,889.83	7,143.13	10.70	9.64	8.07	Private Education	To connect to DE scheme
Taberner House (resi)	1	1	30,800	2,002.00	-	1,232.00	1.85	-	1.54	Private residential	To connect to DE scheme
Cherry Orchard Road	17	2	122,000	8,845.00	2,973.75	6,893.00	7.69	4.58	6.47	Private Office & residential	To connect to DE scheme
Croydon Gateway (Ruskin Sq) - phase 2, 3 & 4	5	2	114,340	10,229.10	5,857.35	8,483.59	7.78	9.73	6.51	Private Office & residential	To connect to DE scheme

Table 4 List of potential customer to DE scheme and their respective annual energy and peak demands

Capabilities on project:
Energy
Environment

1) Present day Croydon town centre

For present day Croydon scenario, Figures 9, 11 and 13 show the annual heating, cooling and electricity energy demand and Figure 10, 12 and 14 show the peak demands of the Energy Clusters in the town centre.

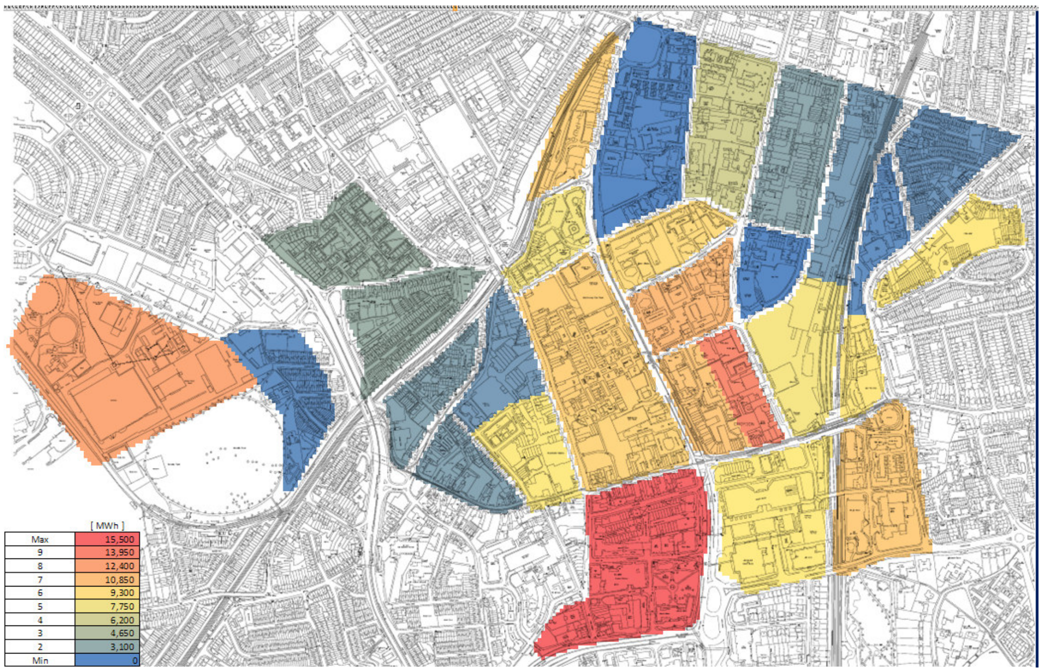


Figure 9 Present day Croydon – Heating energy demand (MWh)

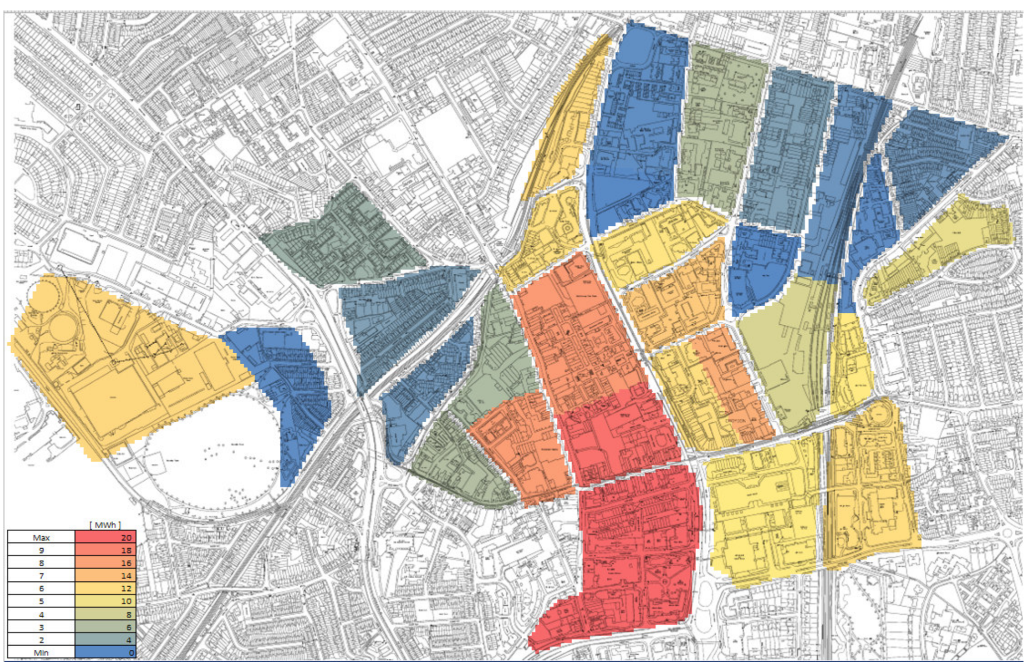


Figure 10 Present day Croydon – Heating peak demand (MW)

Capabilities on project:
Energy
Environment

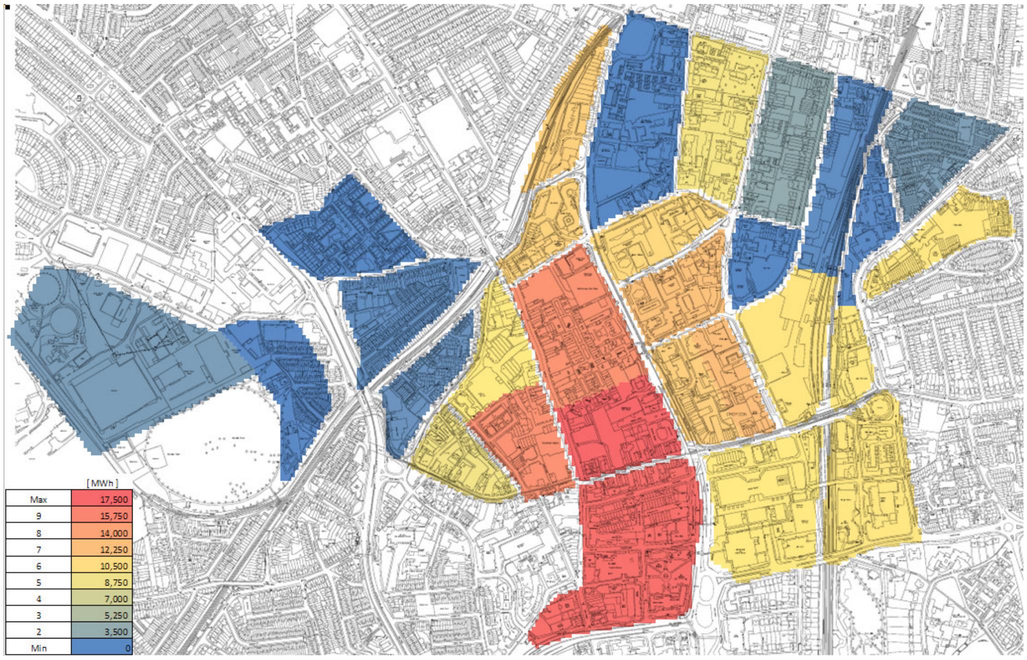


Figure 11 Present day Croydon – Cooling energy demand (MWh)

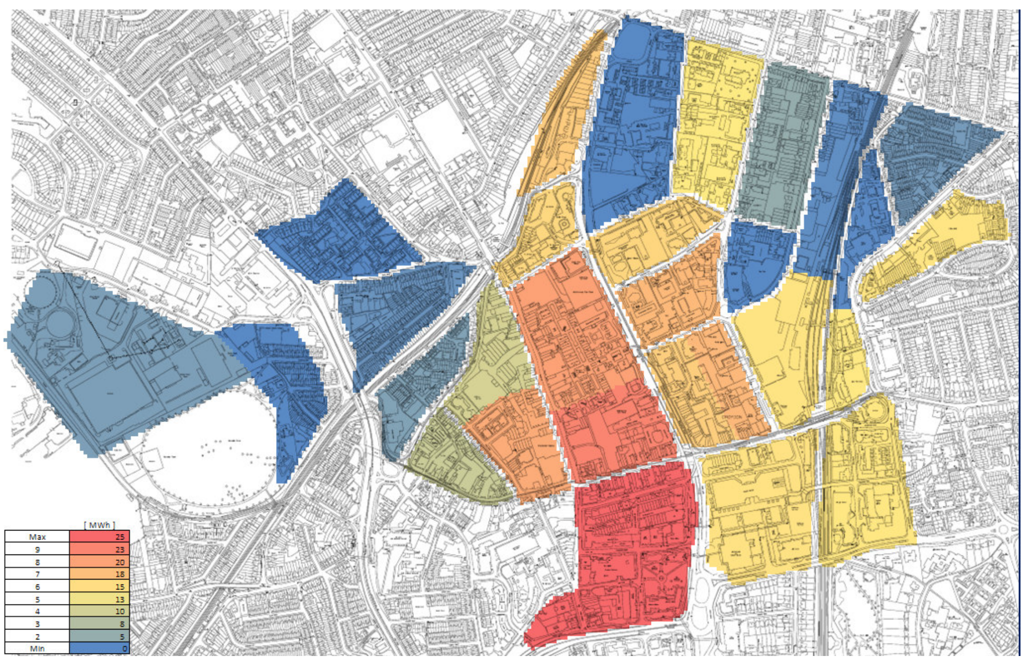


Figure 12 Present day Croydon – Cooling peak demand (MW)

Capabilities on project:
Energy
Environment

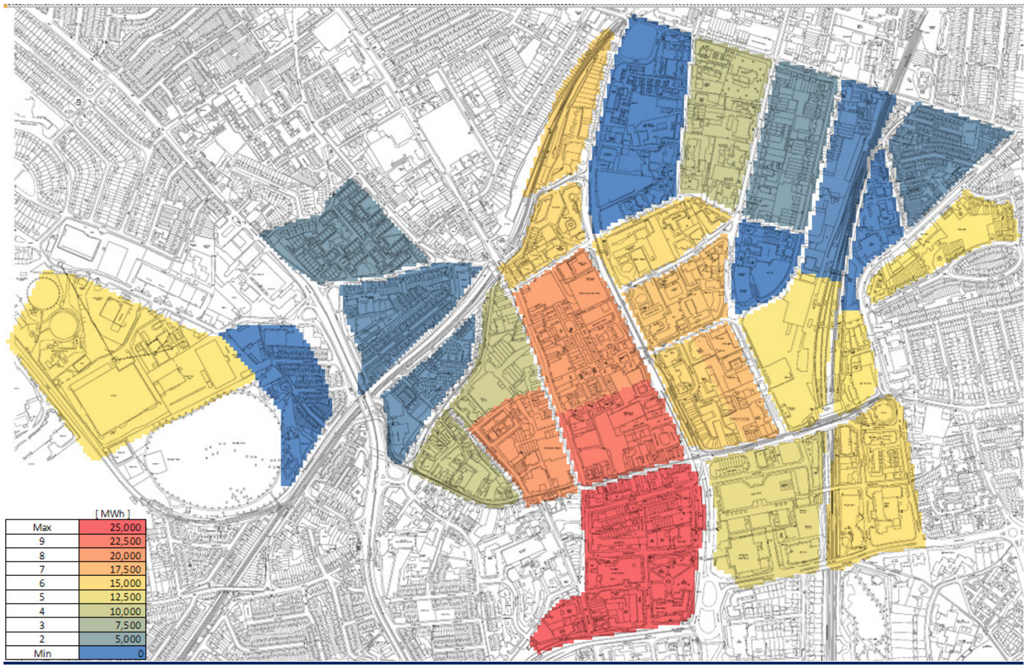


Figure 13 Present day Croydon – Electricity energy demand (MWh)

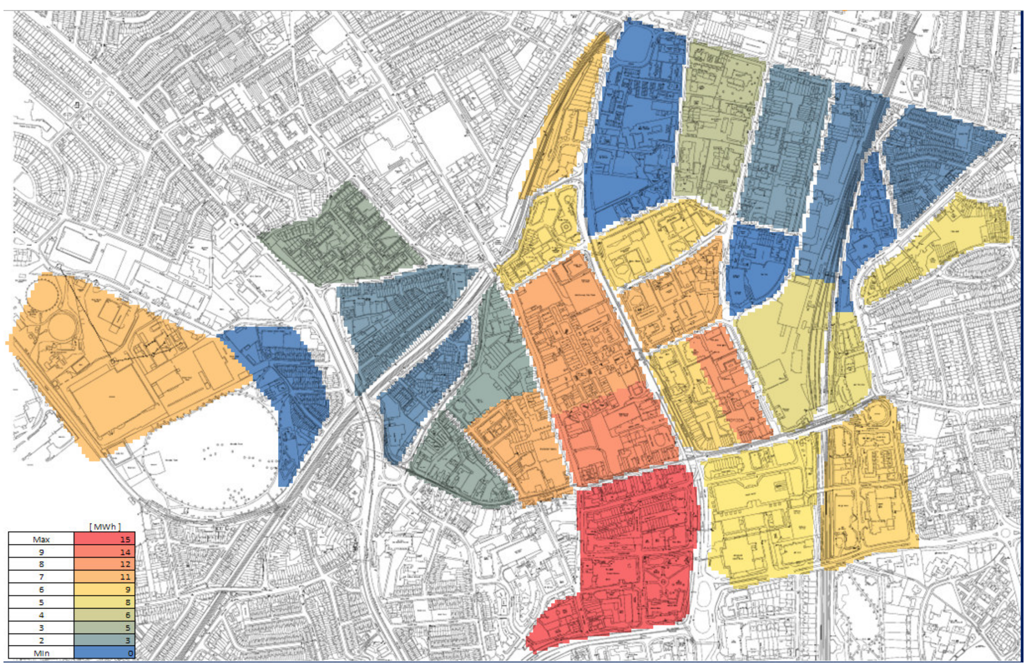


Figure 14 Present day Croydon – Electricity peak demand (MW)

Capabilities on project:
Energy
Environment

2) Future Croydon town centre beyond year 2015 with business as usual and no DE scheme is implemented

If business carries on as usual in the Croydon town centre and without the consideration of decentralising part of the town centre energy demands, new developments coming online in the coming years will lead to a significant increase in its energy demand. The *heat map* in Figure15 demonstrates how the heating energy demand changes in the affected Energy Clusters beyond year 2015.

Please note that the scale has changed in Figure 15 compared to the common scale used in Figure 9 to 14.

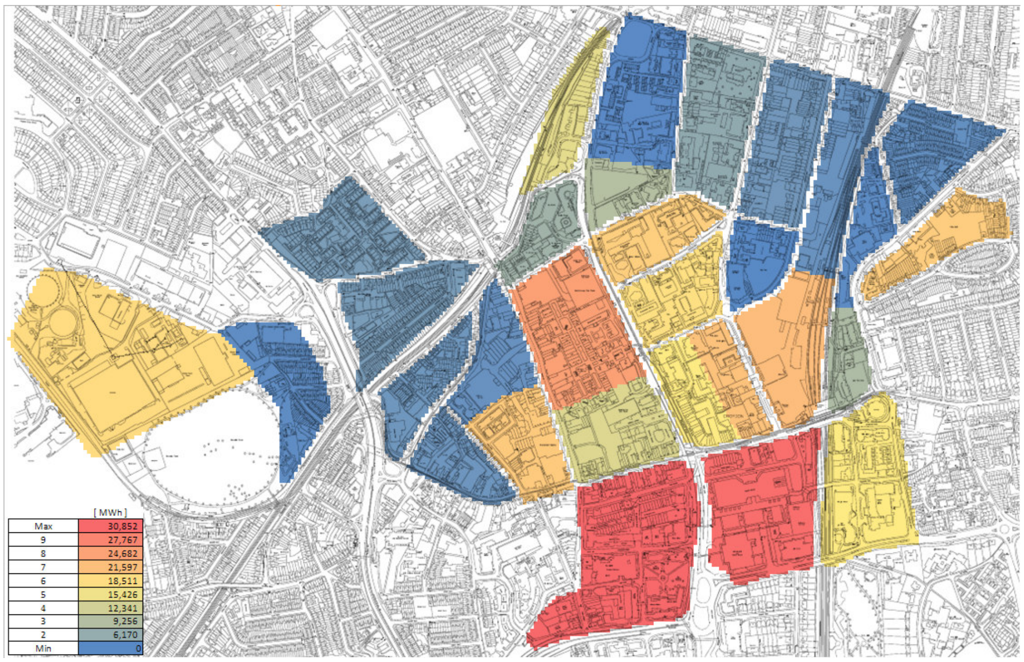


Figure 15 Business as usual beyond 2015 Croydon – Heating energy demand (MWh)

Capabilities on project:
Energy
Environment

3) Future Croydon town centre by year 2015 with DE scheme in place and the listed potential customers connect to the scheme

Figures 16 and 18 show the annual heating and cooling energy demand and Figure 17 and 19 show the peak demands of the Energy Clusters in the town centre. It can been seen that overall the town centre energy demand remains the same, although in reality, there will be some fluctuations due to minor developments and changes in the town centre not being capture in this scope of study.

What is also apparent on the *heat maps* is the immergence of concentrated energy levels where the proposed Energy Centres are located. This in effect is the energy capacity to be provided by the Energy Centre to the buildings that have connected to the DE scheme.

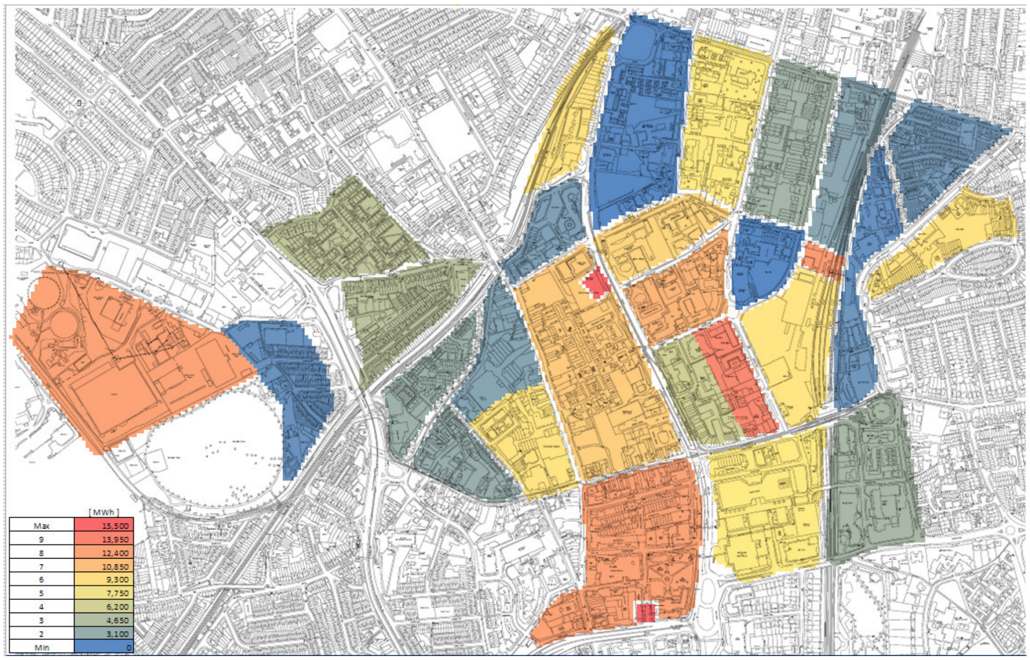


Figure 16 By 2015 Croydon – Heating energy demand (MWh) and capacity of heat energy to be supplied by Energy Centres in MWh

Capabilities on project:
Energy
Environment

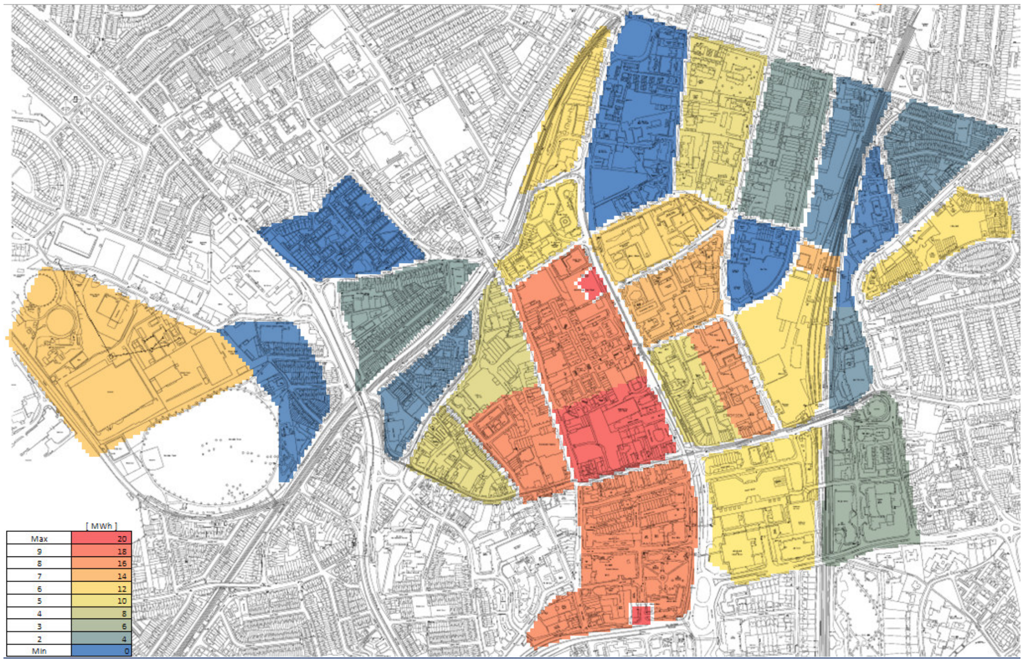


Figure 17 By 2015 Croydon – Heating peak demand (MW) and peak capacity of heat to be supplied by Energy Centres in MW

Capabilities on project:
Energy
Environment

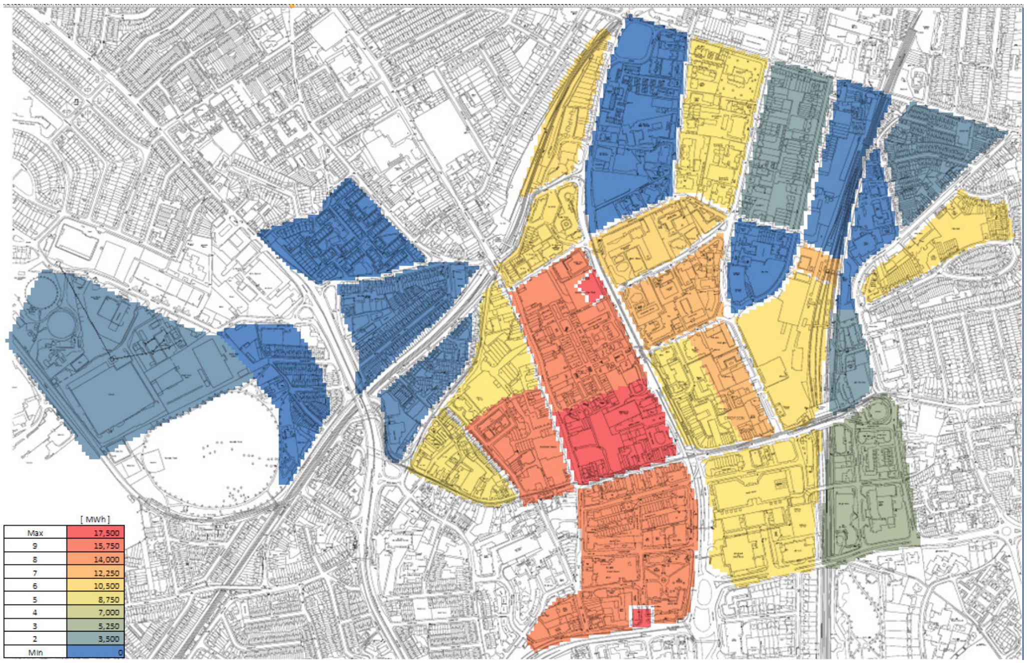


Figure 18 By 2015 Croydon – Cooling energy demand (MWh) and capacity of cooling energy to be supplied by Energy Centres in MWh

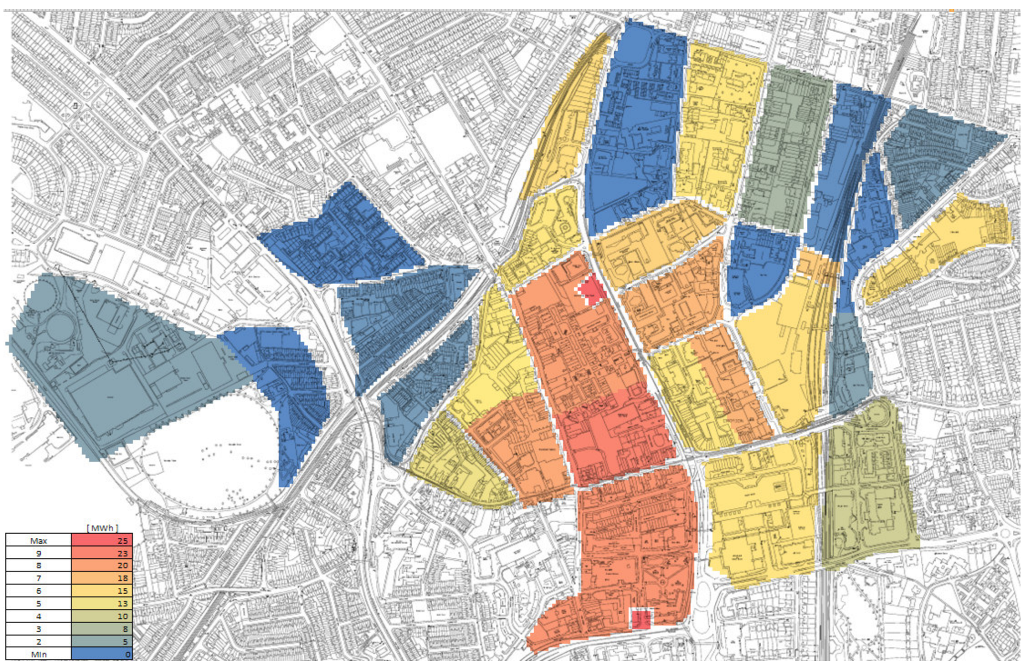


Figure 19 By 2015 Croydon – Cooling peak demand (MW) and peak capacity of cooling to be supplied by Energy Centres in MW

Capabilities on project:
Energy
Environment

4) Future Croydon town centre beyond year 2015 with DE scheme in place and the listed potential customers connect to the scheme

Beyond year 2015, more new developments come online and their energy demand are continuously offset and provided by their respective Energy Centre. This alters the landscape of the *heat maps*, however, only locally at the Energy Centres. Again, in reality, there will be some fluctuations in the energy demand in the other areas due to minor developments but this is not captured in this scope of study.

Figures 20 and 22 show the annual heating and cooling energy demand and Figure 21 and 23 show the peak demands of the Energy Clusters in the town centre.

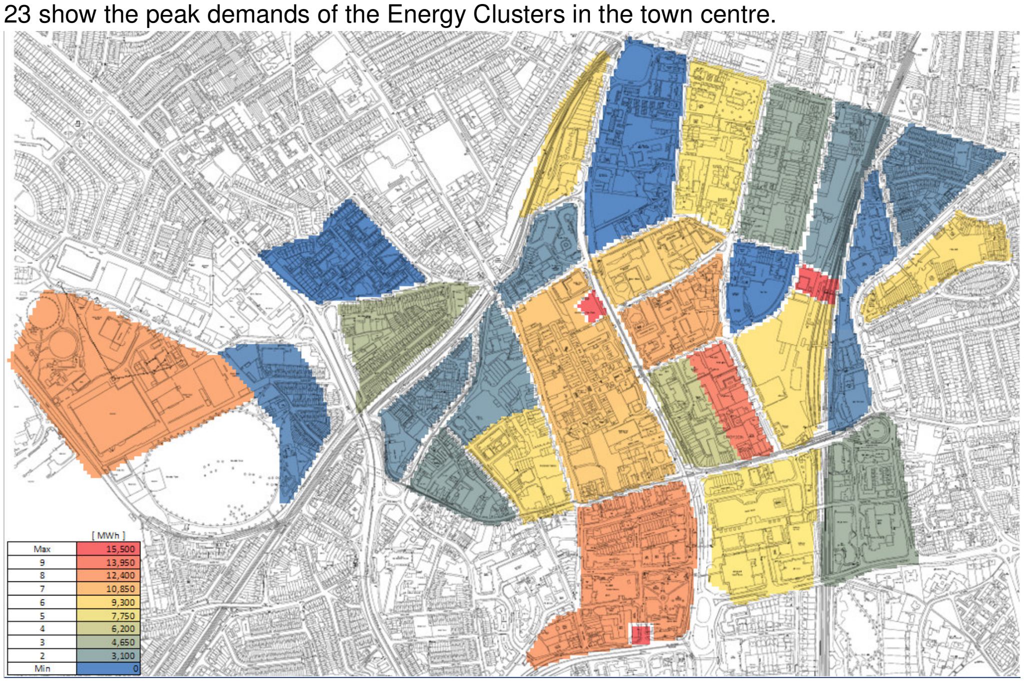


Figure 20 Beyond 2015 Croydon – Heating energy demand (MWh) and capacity of heat energy to be supplied by Energy Centres in MWh

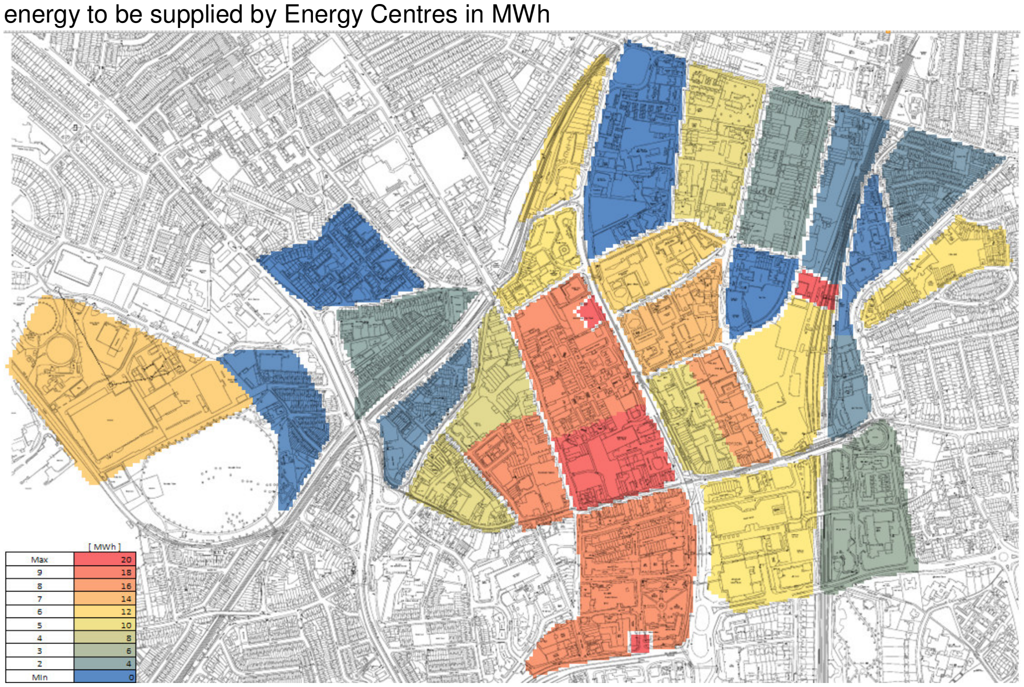


Figure 21 Beyond 2015 Croydon – Heating peak demand (MW) and peak capacity of heat to be supplied by Energy Centres in MW

Capabilities on project:
Energy
Environment

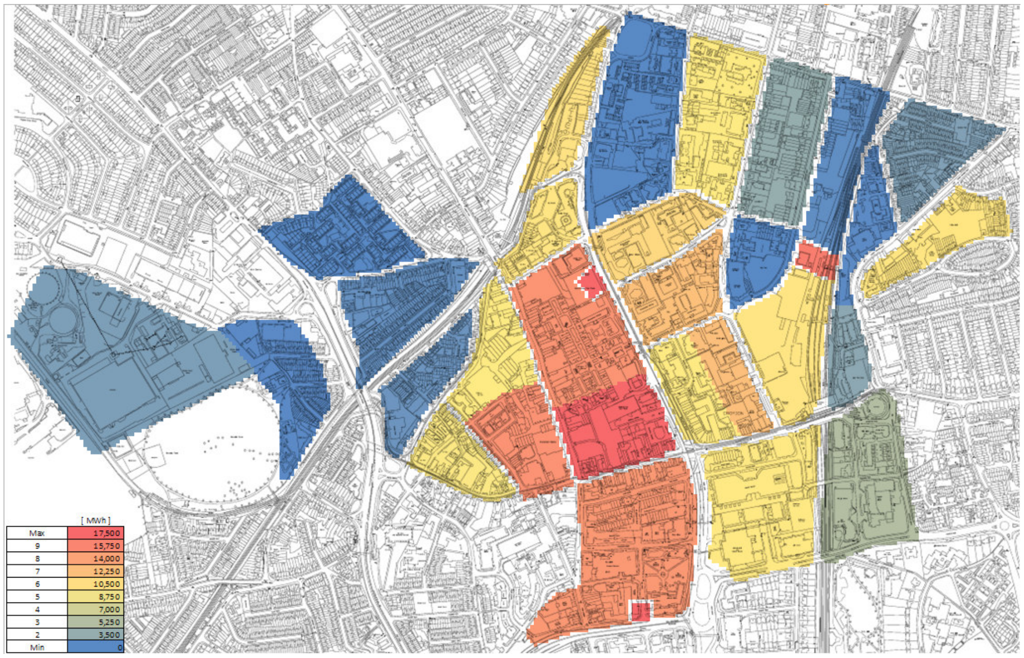


Figure 22 Beyond 2015 Croydon – Cooling energy demand (MWh) and capacity of cooling energy to be supplied by Energy Centres in MWh

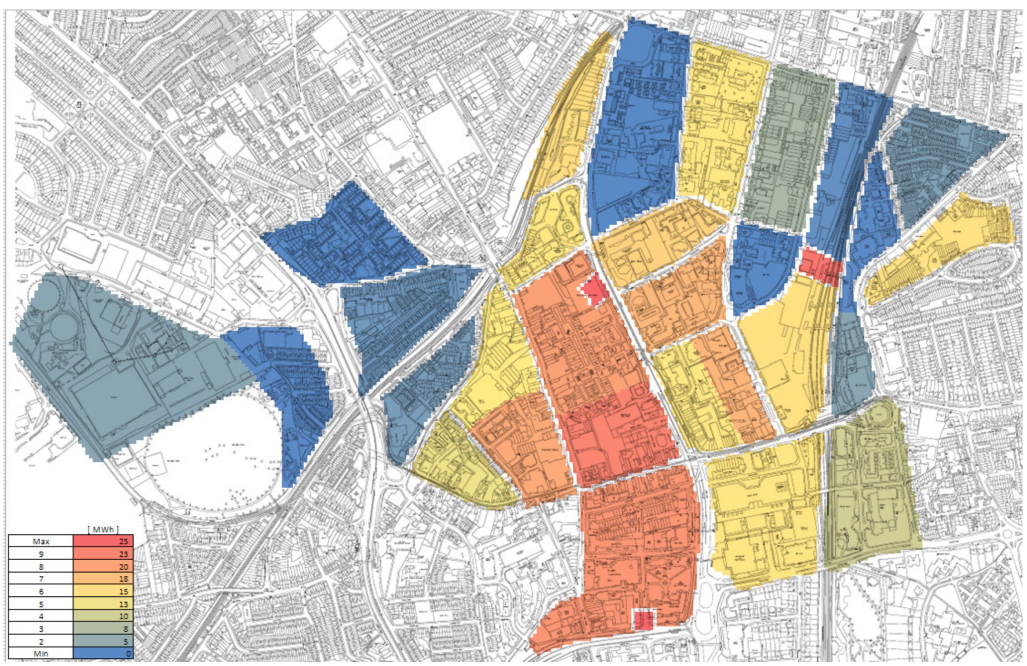


Figure 23 Beyond 2015 Croydon – Cooling peak demand (MW) and peak capacity of cooling to be supplied by Energy Centres in MW

Section D

Examines the feasibility of conversion and utilisation of the existing Rolls Royce power plant in factory Lane

A single large CHP plant is often difficult to develop in a town centre area due to the lack of a suitable site and the relatively high value of the land area. However in Croydon this option can be pursued because there is an existing power station close to the centre within an industrial zone.

There was a power station in Croydon for many years however the old station was closed down and in 2005 a new station commenced operation. This is owned by Rolls Royce Power Developments Ltd and is operated by Rolls Royce Energy. It comprises an open cycle gas turbine, the Trent 60 and generates approximately 50MWe.

Discussions have been held with Rolls Royce (on October 12th 2009 and December 16th 2009 with the HSE and Asset Management Director Mike Strutt) to determine the commercial and technical issues associated with its conversion to operate as a CHP plant.

Existing contracts

The plant is currently selling its output under two contracts running in parallel. The first is for Short-term Operating Reserve (STORE) and the second is for winter peak period grid support. The STORE contract runs until April 2011 and the winter support contract runs until April 2012. Beyond this date new contracts could be negotiated for the more extended running that may arise with operation as a CHP plant.

The STORE contract runs through the summer and is designed to meet sudden peaks in demand when the unit is required to start-up and run at full output under instruction from the National Grid. The winter support contract is designed to provide power typically in the peak winter period from 3pm to 9pm each day of the week.

Suitability for CHP operation

Although the existing Trent is currently running less than 1,000 hours p.a. it would be possible to extend its running hours. The Trent has been installed as a CHP plant at Rolls Royce's own site in Ansty which runs as base load.

The Croydon plant operates under a permit from the Environment Agency and this permits up to 5,250 hours p.a. operation. Emissions from the plant have been monitored over the last 3 years and have been shown to be within the limits of the permit. The existing stack is 67m high which ensures a high degree of dispersion of pollutants.

Heat recovery options

There are two ways in which the unit can be converted to CHP:

As open cycle

This option involves the addition of a waste heat recovery boiler which will use the exhaust gases from the gas turbine to produce hot water for direct use in district heating. The flow of exhaust gases will be controlled by means of dampers either through the boiler to a new stack or, if heat is not required through to the existing stack. The dampers will enable a degree of control of the flow of exhaust gases through the boiler so that the output can be controlled. There appears to be sufficient space on the existing site to install the boiler and new stack to the south-west of the existing stack. As all of the heat is available as high temperature gases the district heating can be produced at temperatures up to 125°C which is an advantage compared to gas-engine CHP. Higher flow temperatures will reduce the cost of the heat network and reduce the cost of absorption chillers if these were to be used within the system.

As Combined Cycle

In the combined cycle mode, the exhaust gases are used to raise high pressure steam which is then used in a steam turbine to generate additional electricity. Heat can be provided either by extracting steam from the steam turbine or by using a back-pressure steam turbine where the steam is lowered only to a pressure to suit the temperature of the district heating supply. A combined cycle plant generates additional electricity so it is thermodynamically more efficient however the plant is much more complex, more costly and requires substantial space for both the steam boiler, the turbine and heat rejection equipment. Our current view is that this option could only be implemented if additional adjacent land could be made available.

CO_2 emissions

The efficiency of the existing plant in electricity only mode is about 36%. This is similar to that which would be obtained from gas-engines. This efficiency is relatively high for gas turbine CHP partly because the Trent is an efficient aero-derivative and partly because the gas supply pressure is a minimum of 19 bar which means the power used by the gas compressors is relatively small (total parasitic load is estimated at 1MWe). When heat is extracted during periods when the gas turbine would have been operating under its current contracts the heat is produced with no additional CO_2 emissions and so has zero CO_2 content. When the gas turbine is operating at other times the CO_2 reductions achieved will be similar to that obtained from gas-engines.

Benefits of adapting the existing RR Trent as a CHP plant

In comparison with the other CHP options there appears to be a number of advantages to the use of the existing power station:

- Lower capital costs as the prime mover already exists and the costs are only related to the heat recovery boiler; other costs avoided are the cost of the land, the grid connection and fuel supply

- Low operating costs as for much of the winter the plant would be running commercially so that the heat production cost during these periods is effectively zero

- Very large potential for heat supply, up to about 35MW of heat

- Gas turbines have lower NOx emissions than gas-engines and the high stack means pollutants are well dispersed so a net improvement in air quality would be expected from CHP operation as emissions from low level boilers are displaced.

The low cost of heat and low capital costs will need to offset the costs of the heat transmission main required to transport the heat to the town centre area.

Additional potential economic benefits

The plant is large enough to operate within the EU Emissions Trading System. Under the current phase, if the plant is converted to CHP operation additional free allowances can be claimed. This would provide an additional income to the site which would assist in financing the waste heat boiler.

A second incentive is that part of the electricity output will qualify as good quality CHP and will then qualify for exemption from the Climate Change Levy when it is sold.

Thermal storage

Heat demands form buildings vary significantly over the day and over the year. The heat output from a CHP plant can be varied over the year by operating fewer hours in each day and storing the heat produced for use over the 24 hour period or by using multiple smaller units in combination with turndown of the plant. The gas turbine is not efficient at part load and is likely to be relatively large in relation to the heat demand especially in the early years of the scheme. The gas turbine currently operates in the winter for about 5 hours per day between 3pm and 9pm. Whilst there will be some heat load in this period the heat demand of commercial offices occurs mainly in the morning. A significant amount of thermal storage will therefore be needed to store the surplus heat produced in the afternoon and evening for use the following morning.

The store could be installed either centrally at the gas turbine or remotely within the load centres in the zones or a combination of these approaches. Initial analysis indicates that the lowest cost option would be to locate thermal stores throughout the heat network operating at low temperature (95℃ maximum flow temperature). This minimises the cost of the stores and improves reliability. The space available at the RR power station is also limited. The capacity of the transmission main from the RR power station will be sized to deliver the maximum heat output from the gas turbine CHP plant.

Heat recovery system

The exhaust gases from the gas turbine contain almost all of the heat rejected and a heat recovery boiler has been sized to deliver around 35MW of heat by cooling the gases from 444℃ to 180℃. Further heat could be extracted using lower exhaust temperatures however this may impact on the dispersion of pollutants and may require a larger and taller stack.

The company Greens Power Ltd was approached to provide an outline design and budget price. Their proposals comprise:

A finned tube heat exchanger over which the gases will pass with dimensions:

Tube length 7m, 40 tubes per row, 6 rows high

The overall plan dimensions would be 8.3m long, 4.1m wide, 1.9m high

Operating temperatures

The advantage of the gas turbine is that all of the heat is available at high temperature and so there is a wide choice available for operating temperatures.

To minimise the cost of the heat network the return temperature needs to be as low as possible. This temperature is however determined mainly by the return temperature of the buildings heating systems. Existing buildings will typically be designed with a 71℃ return temperature and so allowing for a temperature rise across a heat exchanger at the point of connection the DH return temperature would be about 75℃. New developments could be designed with lower temperatures around 40℃ resulting in a DH return of 45℃. The overall network return temperature will therefore vary depending on the balance of new and existing buildings connected. It is also possible that the return temperature of existing heating systems can be reduced as the heat emitters are likely to be oversized. We have therefore selected a return temperature of 65℃ as being a conservative assumption if lower temperatures are achieved this would improve the economics of the scheme.

The upper limit of the flow temperature is determined by the life of the polyurethane foams used in pre-insulated district heating pipes which is around 130°C.

A high flow temperature will result in lower flow rates and a lower cost network. The volume of water needed to store a given quantity of heat will also be less. The cost of storage will however be higher as a pressurised store will be needed increasing costs.

For the initial analysis we have assumed a 95°C flow temperature for the network within the town centre zones as this is compatible with gas-engine CHP and will result in lower heat losses and thermal store costs.

For the transmission main from the RR power station there will be benefits in minimising the flow rate by increasing the flow temperature to 125°C so that the pipe size can be minimised. Heat losses will be higher but these will be relatively small with the large diameter pipeline.

Business Case Assumptions

The business case for the RR power station CHP option assumes that the operating hours remain at 5 hours per day from November to March only. This restricts the amount of heat available and so it has been assumed that the supply will be to Zone 1 heat demands only. Although in principle there is no significant cost to RR for supplying heat a heat purchase price of 0.5p/kWh has been assumed in the model to provide an incentive. Capital costs for the heat recovery boiler and transmission heat main and pumps have been included.

If the district heating is expanded to Zones 2 and 3 then it would be possible to increase the operating hours of the gas turbine CHP and the additional operating costs would be met by an increase in the heat purchase price. An alternative would be to install a gas-engine CHP in addition to the gas turbine heat supply to operate in summer and in the peak winter period.

Section E

Indentifies other potential locations for energy centres from which thermal and electrical energy could be produced and distributed to the town centre and any possible outlying residential areas

Based upon our opportunities and constraints analysis for the decentralised energy network, as shown in previous sections of this report, we have identified three energy zones of customers. These zones are:

1. Zone 1: South Croydon
2. Zone 2: East Croydon
3. Zone 3: West Croydon

It makes practical sense to serve each of these energy zones with energy from energy centres located within the zone it serves.

Zone 1: South Croydon Energy Centre

There is currently a basement plantroom in Taberner House, which serves Taberner House above and provides hot water for heating and domestic hot water to the L-shaped building, the Town Hall and the Library.

This location offers many advantages to an energy centre, these include:

- High floor to ceiling height
- Existing precedent for ventilation to outside, via grilles, for boiler air make-up, chiller refrigerant vent and purge and general cooling ventilation
- Access for maintenance plant removal and replacement
- A new tall building proposed above in which to incorporate a boiler/ CHP engine flue to exhaust at roof level, high enough to address pollution disbursement and air quality issues.
- Access for vehicular delivery off Fell Road
- Plant access for maintenance air movement
- Local to energy demand
- Ease of egress for energy pipes out into Queen’s Gardens and out under Croydon flyover
- Potential link route identified for pipe connection to the Rolls Royce power station

Zone 2: East Croydon Energy Centre

The proposed location for Zone 2 energy centre has been given a rough location to the East of Landsdowne Road at its North end. As there is no clear energy centre site this approximate area has been designated in order to address the feasibility of pipework distribution and to measure the pipe distances from source to POC for the costing exercise.

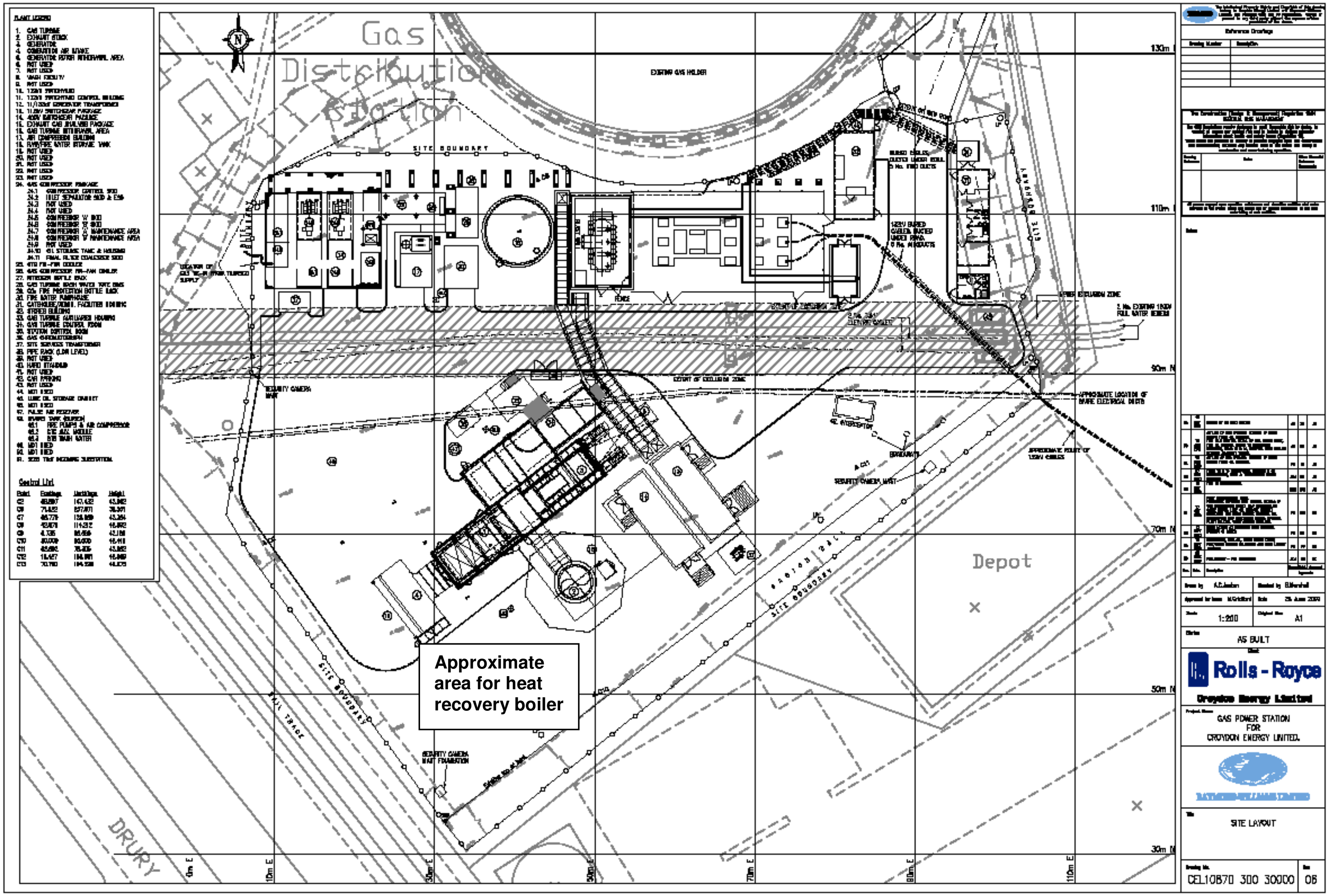
Zone 3: West Croydon Energy Centre

The proposed location for Zone 3 energy centre has been given a rough location in the loading bay area in the lowest level basement at the North end of the Whitgift Centre. As there is no clear energy centre site this approximate area has been designated in order to address the feasibility of pipework distribution and to measure the pipe distances from source to POC for the costing exercise. Also, in order to identify the potential customers in Zone 3 is good to understand the approximate location of the energy source.

Rolls Royce Gas Turbine

The proposed heat recovery boiler and second stack would be located to the south-west of the existing stack. This location has been discussed on site with Rolls Royce and is considered feasible, subject to detailed design development.

Factory Lane Support Energy Centre



Capabilities on project:
Energy
Environment

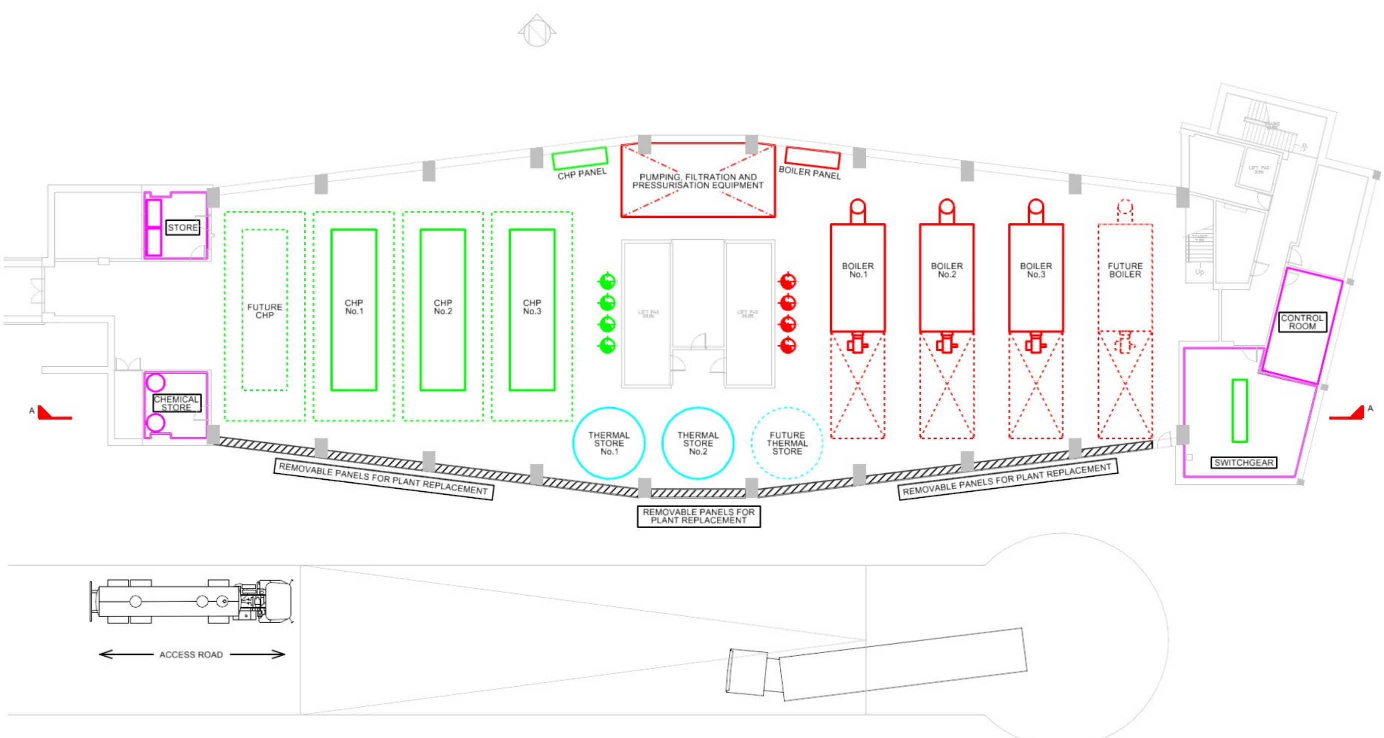
Section F

Estimates the spatial requirements for the energy centres and their energy outputs

Energy Centre 1: Taberner House

The diagram below provides the current estimated spatial requirements for the energy centre serving energy zone 1 is the basement levels, B1 and B2, of Taberner House.

SECTION A-A

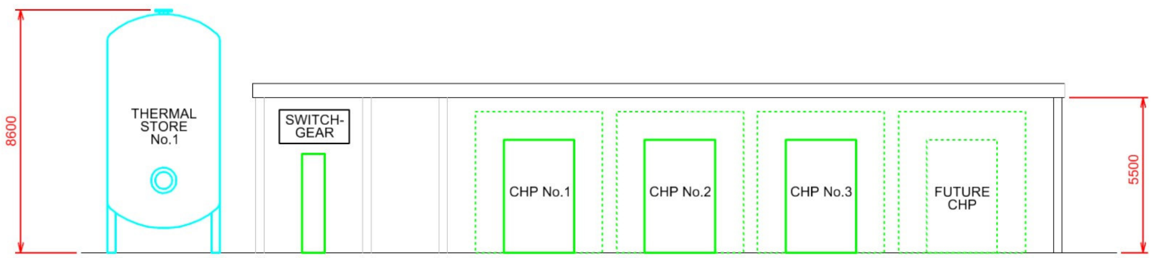


PLAN

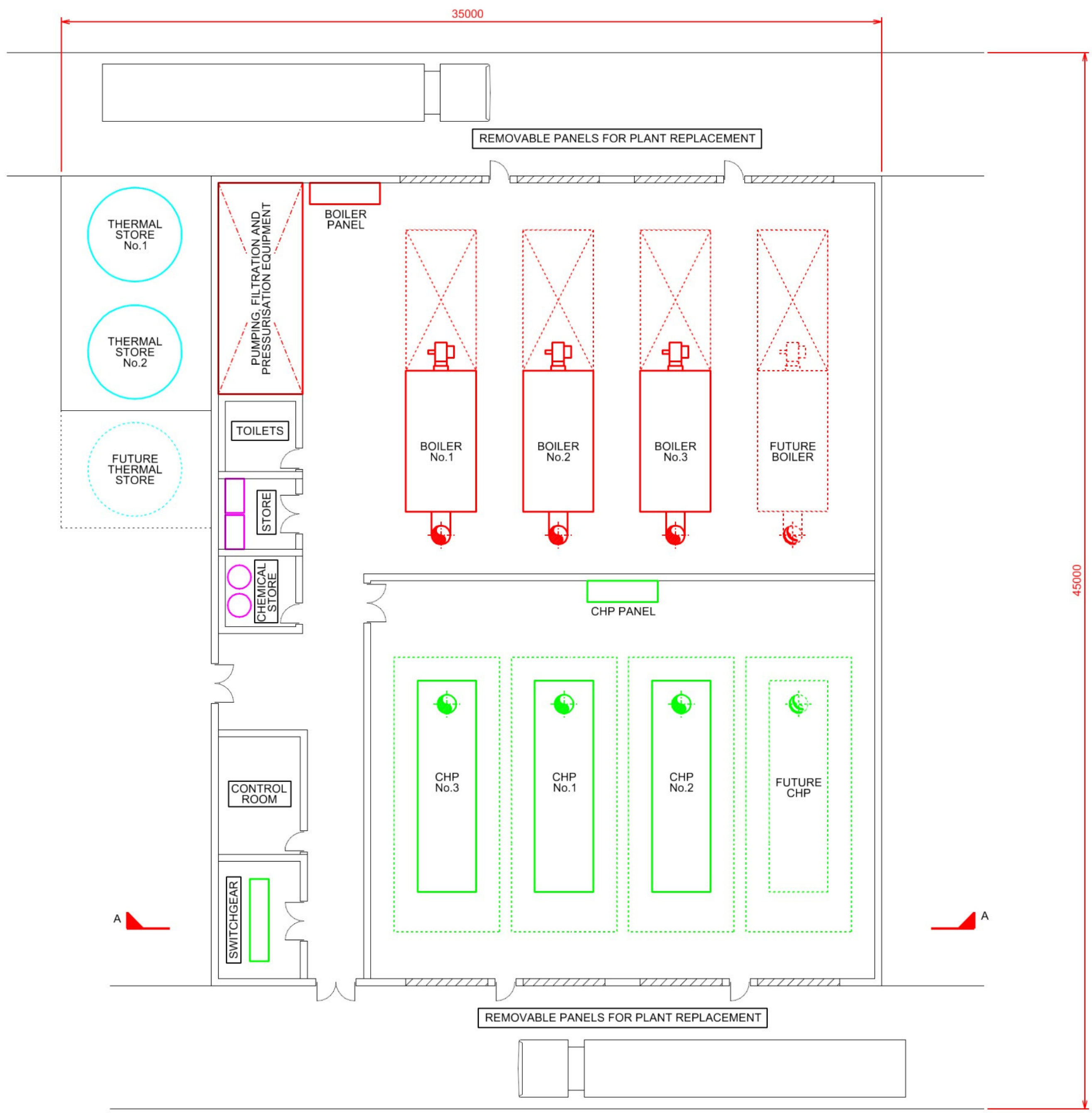
Alternative Energy Centres

The diagram below provides the current estimated spatial requirements for the energy centre serving energy zone 2 and the energy centre serving energy zone 2.

Capabilities on project:
Energy
Environment



SECTION A-A



PLAN

Section G

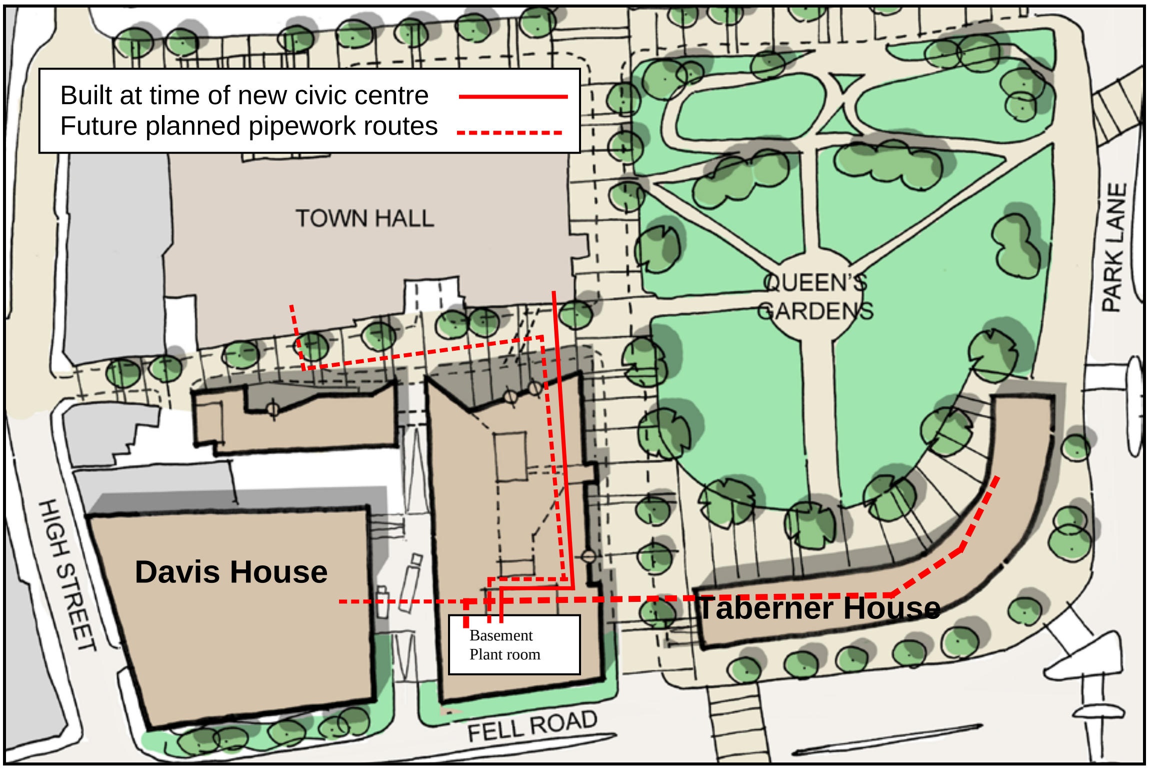
Based on these potential demands, reviews the construction and routing of the required pipe distribution system considering:

a. **The interconnection of new and existing energy loads**
b. **The obstacles faced and how these might be overcome**

This section of the report should be read in conjunction with the Croydon Decentralised Energy Study plan. The proposed strategy is to provide three separate energy distribution networks with interconnection link points to provide network back up and redundancy. Each energy network is connected into the other two networks. These zones are:

1. Zone 1: South Croydon
2. Zone 2: East Croydon
3. Zone 3: West Croydon

Each network has its own energy centre providing hot water flow and return pipework. Energy customers have their own point of connection. Primary pipework leaves the energy centre and runs along main routes. On some networks primary pipe runs split to form secondary runs. Tertiary branch connections provide flow and return hot water to customer points of connection.



Zone 1: South Croydon Energy Network

The proposed source of the pipe distribution system for zone 1 is at Taberner House energy centre. Energy flows out of Taberner House in two directions, across Fell Road to serve the C-CURV and Mid-Croydon energy clusters and across Queens's Gardens and Park Lane to serve the College Green and Law Courts energy clusters.

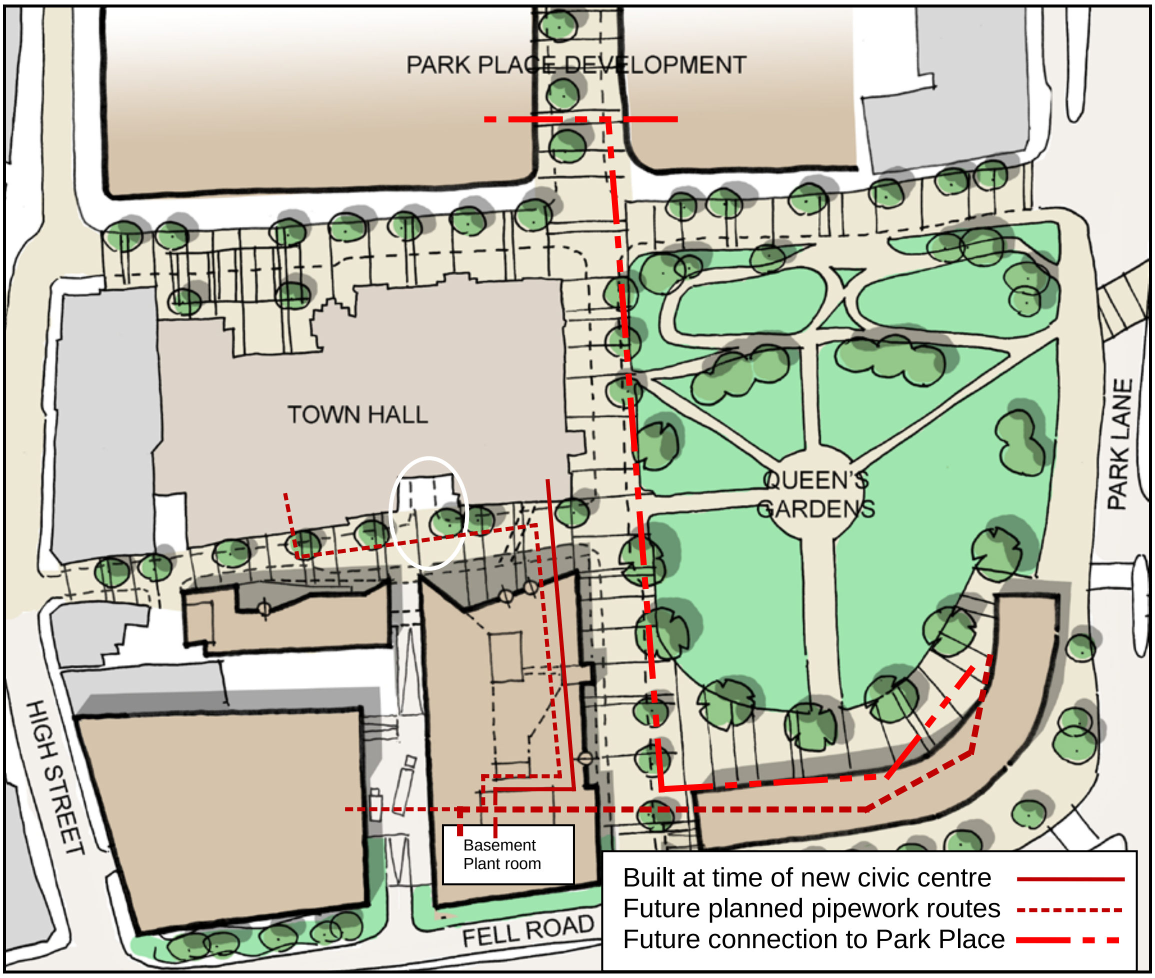
A third pipe link to Taberner House is a potential energy feed from the Rolls Royce power station. This is discussed later in this section.

Taberner House to C-CURV

There is an existing underground pipework route, which currently serves the, soon to be demolished, Croydon Register Office, Davis House and the Town Hall. The intent would be to reuse this route across Fell Road. The new C-CURV PSDH building which will replace the Croydon Register Office will have its own energy centre and will serve the role of the disconnected Taberner House plantroom by serving hot water feeds to C-CURV PSDH, Davis House and the Town Hall. We would propose that the new C-CURV building design accommodates the provision for pipework to traverse across it to serve Davis House, the Town Hall and Mid-Croydon from Taberner House. i.e. the pipework service routes currently being proposed in the basement of the C-CURV PSDH building are oversized to cater for the connection back onto the Taberner House energy centre and across through to Mid-Croydon.

C-CURV to the Town Hall

There is an existing underground pipework route, originating at Taberner House feeding through Croydon Register Office and underneath Mint Walk to serve the Town Hall and the Library. The intent would be to reuse this route if possible.



C-CURV to Mid-Croydon

The intent would be to pickup the extra capacity pipework within the Town Hall and carry load across Katharine Street into the underground car park below Park Place. It may be more practical to take a separate feed form the PSDH building up Fell Road to Park Place thus bypassing the Town Hall. The possible links across Katharine Street and the extent of the underground car park below Park Place would have to be investigated. A suitable point of connection in the car park could be identified and pipework linked to this through a trench across the road in Katharine Street. Once in the car park pipework would distribute to the base of the Mid-Croydon energy risers at high level.

Energy Zone 1 to Energy Zone 3 Link
To generate the interlinking of energy zones we would propose connecting to the base of the Wellesley Road green energy spine with interconnecting pipework running up Park Lane next to or through the underpass.

Taberner House to College Green
The main barrier between Taberner House and College Green is the six lanes of Park Lane. A route across this barrier is the pedestrian subway, which goes from Queens Gardens to the front of Fairfield Halls. As you pass through this pedestrian subway there is access off to the left into the huge underground car park below College Green. A route would have to be found within Queen's Gardens and the pedestrian subway would have to become a service tunnel.

College Green Distribution
Once in the huge and high underground car park below College Green pipework would distribute at high level to the base of the College Green energy risers. This would pick-up all the buildings of the Croydon Learning and Cultural Quarter as well as Croydon College and the three buildings to the North along George Street (Suffolk House, Essex House and Chroma).

College Green the Law Courts
At the North East corner of the College Green underground car park pipework could rise up adjacent to the open stairwell and link up to the underside of the car park access bridge at the West end of Hazledean Road over the railway line. The feasibility of running pipework under-slung below this bridge would have to be verified. Once East of the railway line further investigations would be required to identify the distribution routes to the Law Courts, Croydon Park Hotel, Altitude 25 and No. 1 Croydon.

Energy Zone 1 to Energy Zone 2
To generate the interlinking of energy zones we would propose crossing George Street with interconnecting pipework from the North-west corner of College Green to the South edge of the Ruskin Square site.

Rolls Royce Power Station Connection
There is an alternative proposal for use the energy centre at location under Taberner House, to use it as a receptor station. The proposal would be to receive the medium temperature hot water produced at the Rolls Royce power station and convert it through heat exchangers to low temperature hot water for distribution and use around energy zone 1. Due to the nature of frequency of production of hot water by the Rolls Royce power station additional support plant in the form of boilers and/or CHP engines would still be required at the receptor station.

Roll Royce to Wandle Park
The proposed pipework route from the Rolls Royce power station to the West side of Wandle Park would be along the side of the railway lines. It is our understanding that a gas main pipe also runs along this stretch of railway line and that there may be a proposal to bury this pipe in this location. There would therefore be potential to share the cost of the pipe burial, by burying the energy pipe at the same time.

Crossing Wandle Park
One of the proposals for Wandle Park is to lift the Wandle River out of the underground culverts in which it currently flows up to the surface and reinstate the river flow through the park. Should this happen, with the river above ground, the underground culverts would be redundant. Therefore one of the proposals is to use these culverts as energy pipework corridors to cross Wandle Park underground from West to East.

Wandle Park to Roman Way
Once the pipes have resurfaced to the West side of Wandle Park the task would be to get the connection across to Roman Way. The most direct route would be to lay the pipe in the road along the length of Rectory Grove.

Roman Way to Taberner House

Once the pipework reaches the underside of Roman Way the road is elevated. This elevated section goes from Roman way which becomes Mitcham Road/Old Town to the South. At this point the elevated section drops back to being a surface street. The stretch of pipe between Roman Way and the roundabout at the junction with the Croydon Flyover would have to be laid in the road. Once at the elevated Croydon Flyover the pipework could potentially be run on the underside of the Croydon Flyover structure. The pipework would then follow the Croydon Flyover to the East until it reached Taberner House.

Zone 2: East Croydon Energy Network

The proposed source of energy for the pipe distribution network for zone 2 is in a general location at the North end of Landsdowne Road.

Along Lansdowne and Dingwall Roads

From the energy centre the network pipe would pass down Lansdowne Road, in the pavement or road in front of the Ruskin Square site. Some arrangement for energy network infrastructure on the Ruskin site could be arranged with the developer to save digging up the road along Lansdowne Road. The proposal would then be for branch connections to feed energy customers on either sides of these roads.

Energy Zone 2 to Energy Zone 3

To generate the interlinking of energy zones we would propose a link along the West end of Lansdowne Road with interconnecting pipework from the Lansdowne Road/ Dingwall Road junction to join onto the Wellesley Road green energy spine.

Ruskin Square to Cherry Orchard Road
As part of the proposals for a bridge over the railway line to the North of East Croydon station we have proposed a pipework link crossing integrated within the structure of the bridge. This link would provide a piped energy links, from West to East, from the Ruskin square development across to the Cherry Orchard Road development.

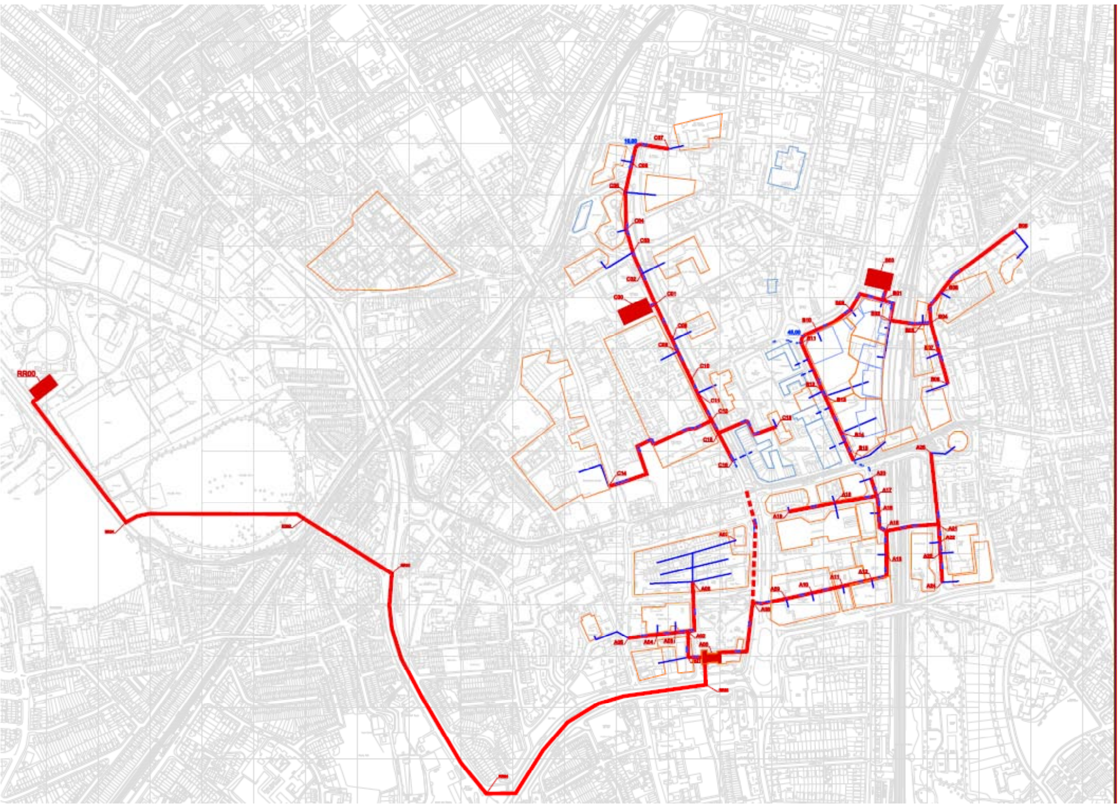
Cherry Orchard Road
We would propose that an energy spine runs in the road along Cherry Orchard Road between the Oval Primary School in the North and Head Post office to the South.

Zone 3: West Croydon Energy Network

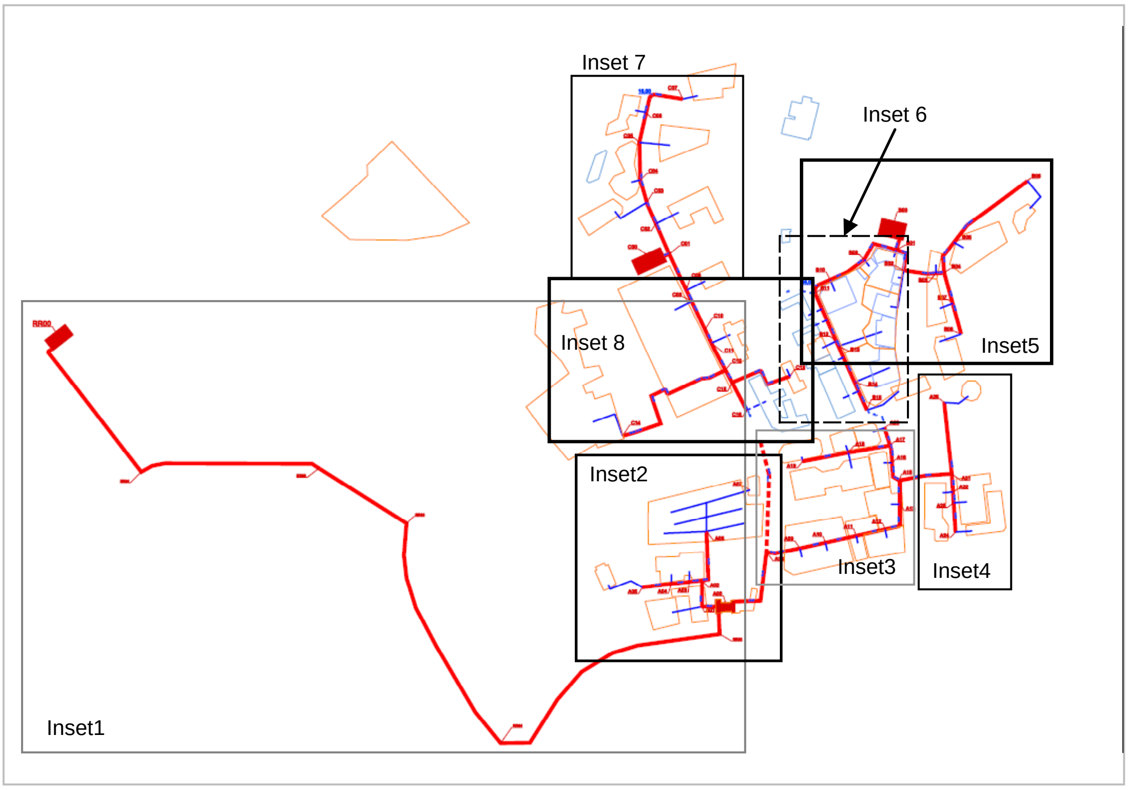
The proposed source of energy for the pipe distribution network for zone 3 is in a general location along Wellesley Road. For the purposes of this exercise we have located it in the lowest basement levels of the Whitgift Centre.

Wellesley Road Green Energy Spine

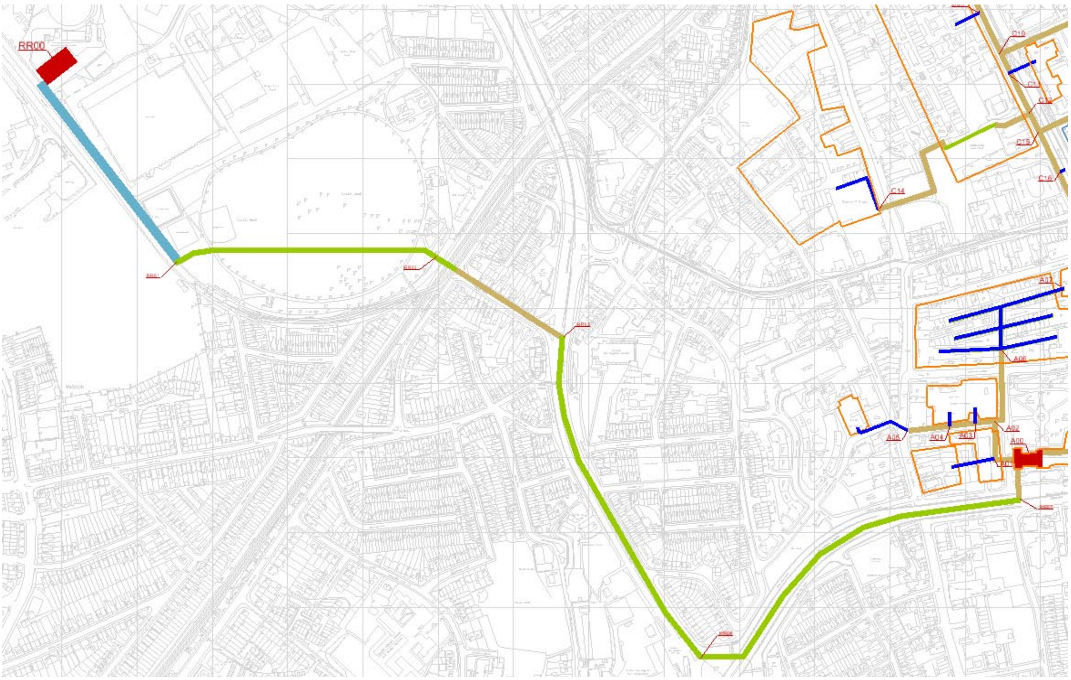
The Wellesley Road green energy spine will be integrated within the masterplan proposals for Wellesley Road. A multi-service trench with potential for both wet and dry services will run down the centre of Wellesley Road, with access panels along its length.



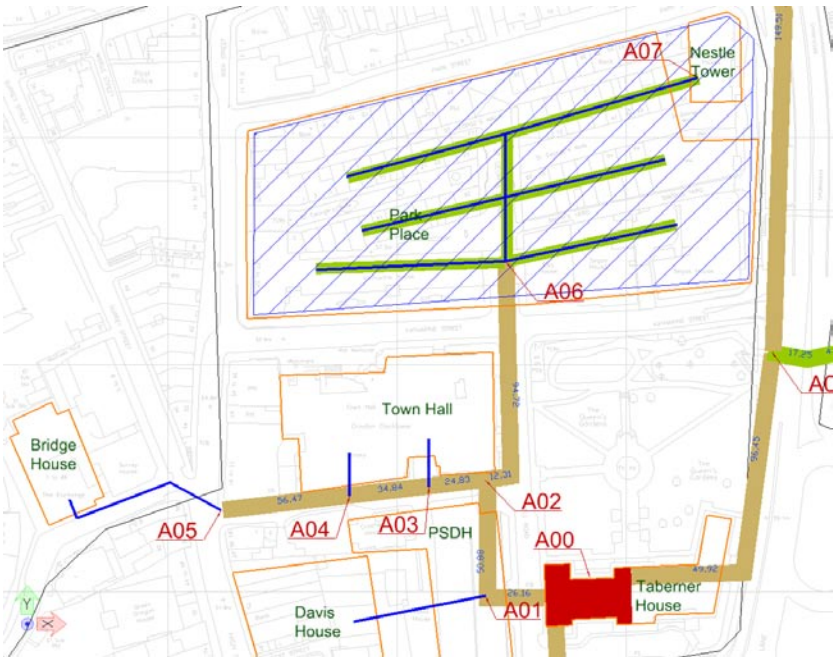
Map of the overall DE scheme network



Map Inset Boxes

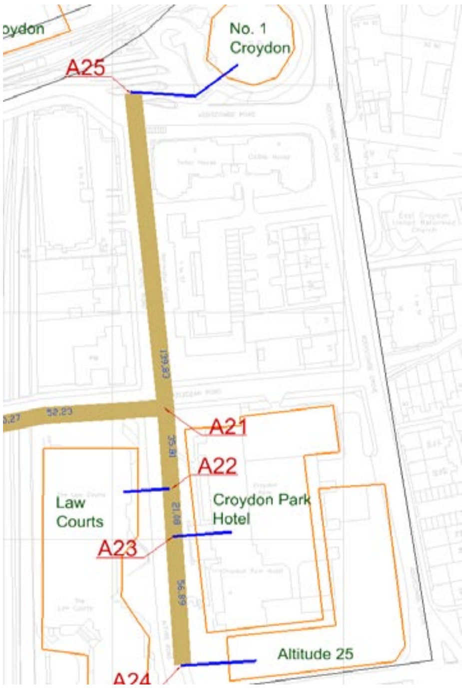


Inset 1 - Network between the Rolls Royce power plant to Energy Centre 1

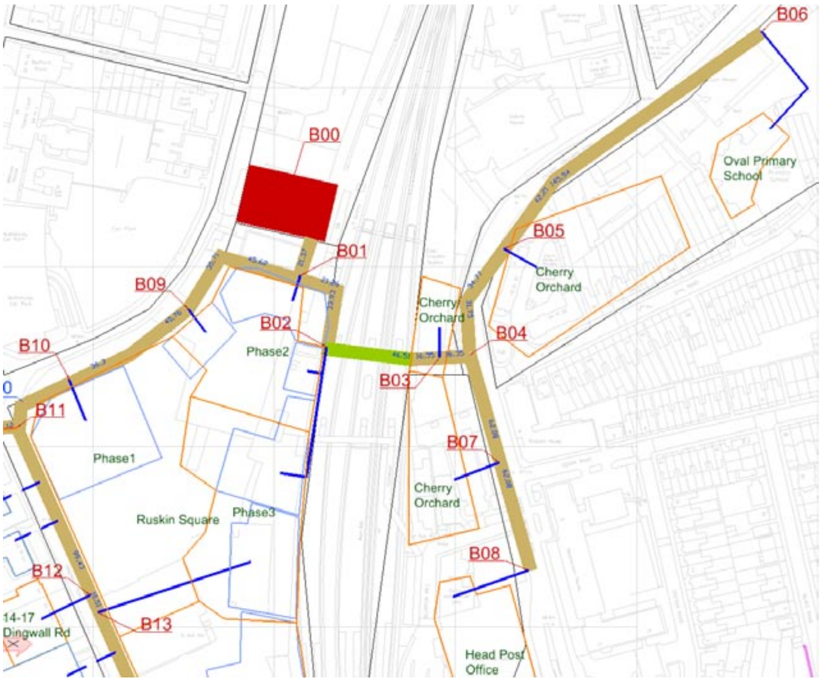


Inset 2 - Network branching out of Energy Centre 1 into Energy Cluster 1 feeding into the CURV PSDH building, David House, Town Hall, Bridge House, the Park Place development site and the Nestle Tower. Hashed zone is indicative of underground car park space

Inset 3 - Network in Energy Cluster 2 feeding into the Croydon College site. Hashed zone is indicative of underground car park space

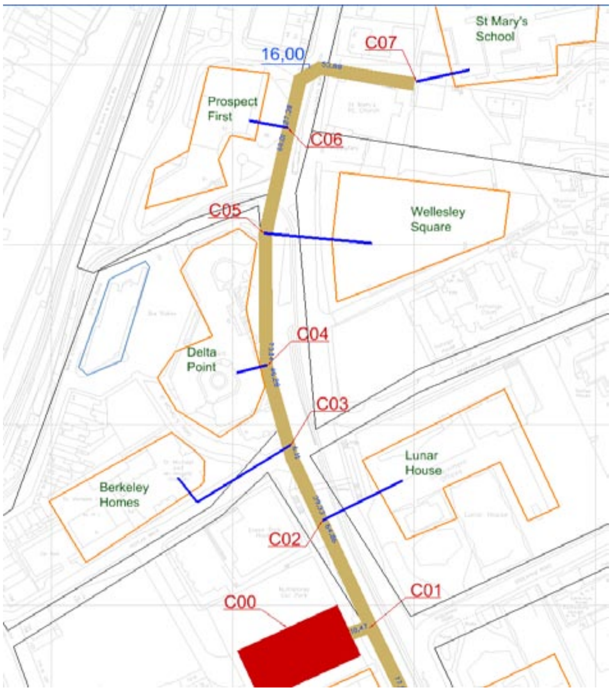


Inset 4 - Network branching into Energy Cluster 3 feeding into the Law Courts, Croydon Park Hotel, Altitude 25 and Croydon No.1 buildings

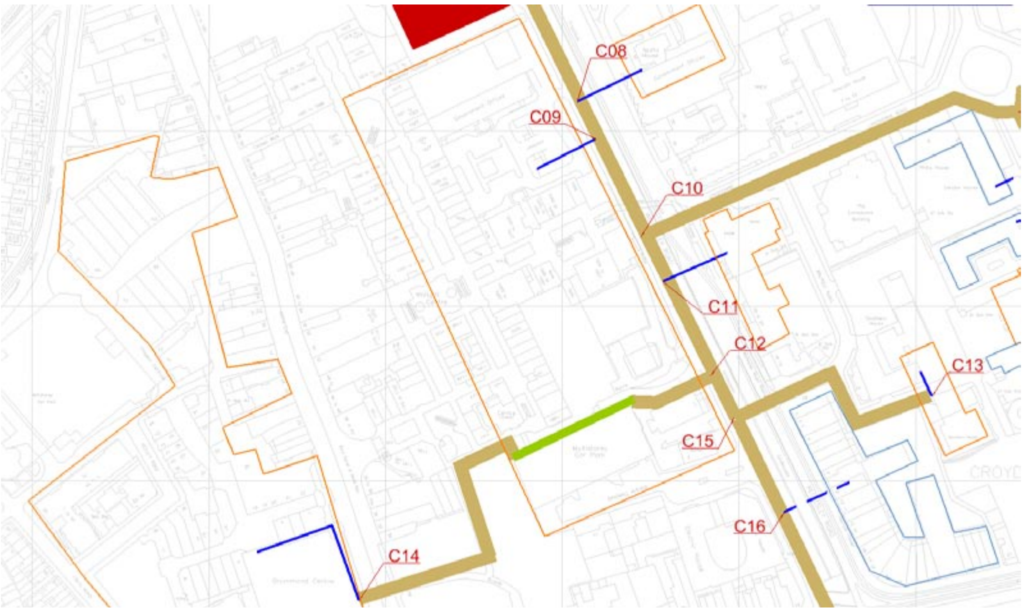


Inset 5 - Network branching from Energy Centre 2 into Energy Cluster 4, 5, 16 and 17 feeding into the Ruskin Square development site, the Cherry Orchard Road development site, the Oval Primary School and the Head Post Office

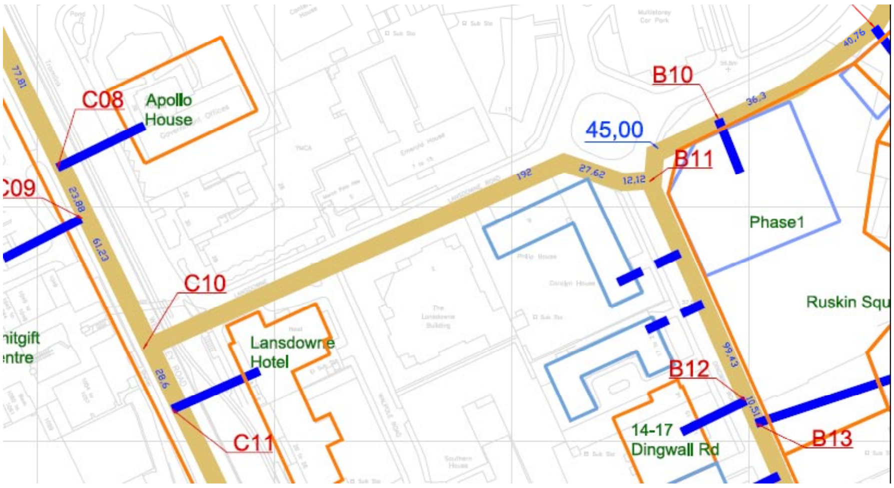
Inset 6 - Network branching from Energy Centre 2 into Energy Cluster 6 feeding into developments along Dingwall Road, parts of the Ruskin Square development and the East Croydon Station



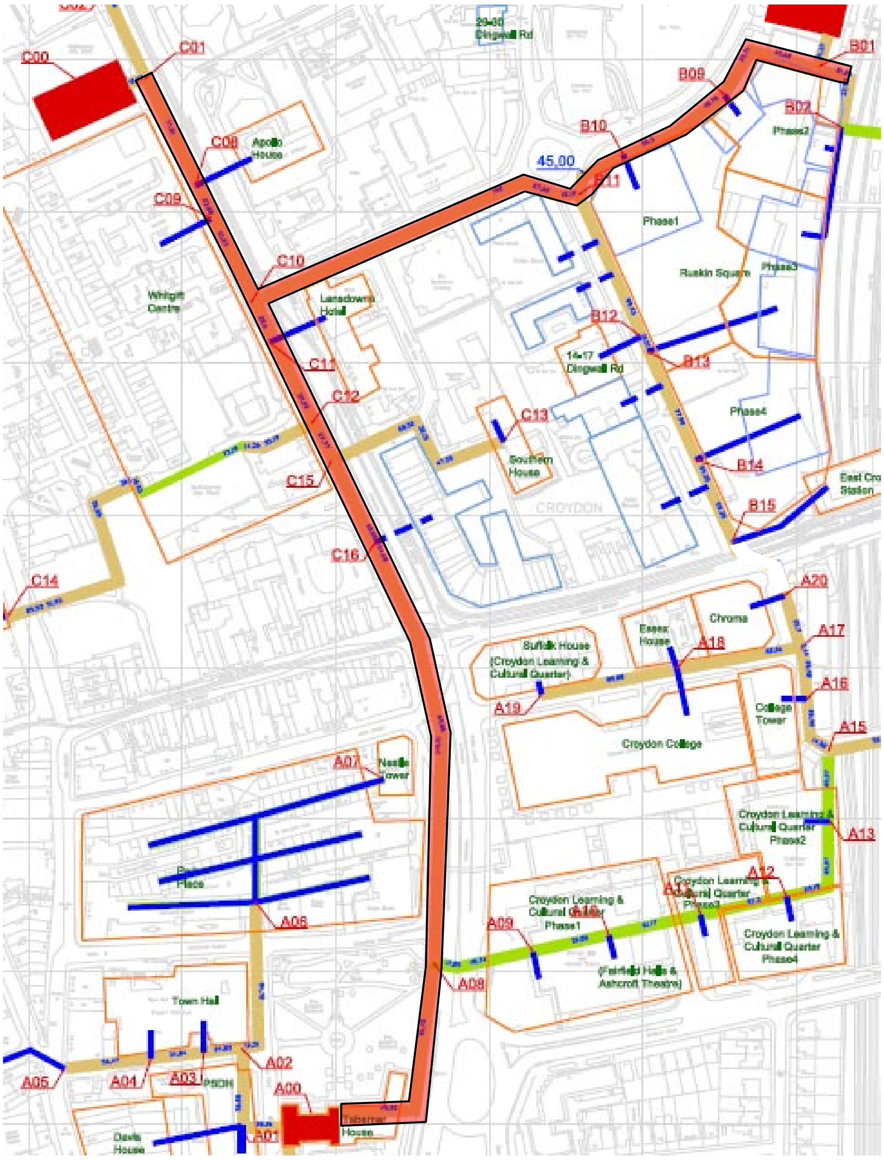
Inset 7 - Network branching from Energy Centre 3 into Energy Cluster 22, 23, 24, 25 and 26 feeding into Lunar House, Berkeley Homes, Delta Point, Wellesley Square, Prospect Point and St Mary's High School



Inset 8 - Network branching from Energy Centre 3 into cluster 7, 9, 13 and 14 feeding into Apollo House, the Whitgift Centre, the Centrale, Lansdowne Road Hotel and Southern House



Wellesley Road: North



Wellesley Road: South

Section H

Examines the potential impact of a district wide tri-generation system on the existing infrastructure i.e. considers the impact of increased loading on infrastructure where energy centres are located and reduced local demand for gas and electrical energy where buildings are supplied with heat and cooling from a district wide energy scheme.

The introduction of CHP to supply the Croydon town centre area will have an impact on both the gas and electricity distribution systems. We discuss these under the three options which we have analysed.

Base Case

Gas network

The demand for gas will increase as a result of the new developments planned. This will be offset by some expected improvements over time of the energy efficiency of the existing retained buildings. Where buildings are demolished and rebuilt a significant decrease in heat demand and therefore gas consumption would be expected. Overall however we would still expect a net increase in gas demand of the area as the new developments include areas currently undeveloped (e.g. Ruskin Square).

Electricity network

Similarly the electricity demand is expected to increase and there is already evidence that substantial reinforcement costs will be needed to service the new developments with a new primary substation being planned.

Option 1 – Gas-engine CHP in three locations

Gas network

In this case the total gas demand of the area will increase beyond that of the base case as both electricity and heat will be produced from the gas supplied. The increase will however be concentrated at the three Energy Centres and there will be progressively less gas used across the network as more buildings are connected to the DH network. This will have implications for the revenues to support the maintenance of the local gas network, however the increase in gas sales overall would provide a compensatory factor. Initially at least, buildings which have a gas connection may wish to maintain this gas supply for back-up purposes.

The response of the gas network company to the reduction in gas sales from smaller gas customers would be to increase costs for gas transmission but as these costs would be shared across the region any impact on local customers would be small.

Electricity network

In this case there would be a reduction in the amount of electricity delivered into the town centre area from the national grid as the CHP units would be generating part of the demand. The peak capacity needed to be provided may not decrease however given that the CHP units are likely to be sized for optimum energy efficiency and not for providing a firm supply, i.e. it would be more efficient to have a one or two CHP units rather than the larger numbers that would be needed to provide a firm supply.

The CHP units will require regular maintenance and in this downtime it would be assumed that the national supply will provide back-up power. The effect of this will be that the distribution costs will be supported by fewer electricity units sold and therefore these costs will increase. As the distribution area is much larger than the town centre though these increases will be small.

Option 2 – One large CHP plant

Gas network

In this case the additional gas use will be concentrated at one point and although the overall gas use will increase the concentration may result in the need for a new dedicated pipeline or additional reinforcement costs combined with lower revenues to support the local network. Overall this option is likely to impact more on the gas network than for Option 1.

Electricity network

In this case the large CHP electrical output in one location would be significant in the local network and a specific connection to a new high voltage substation is likely to be needed. This would require additional costs however the downstream electricity system would be relatively unaffected. Again there would be less electricity supplied to the area from outside over the year but the capacity of the network would not be able to be reduced. Distribution costs would rise but this rise would be spread over a wide area of the network and the impact would be very small.

Option 3 – Existing Rolls Royce

Gas network

The existing Rolls Royce gas turbine may be used more over the year than before but with limited impact on the gas network as the gas supply to this power station will be unaltered. Within the town centre the gas demand would be expected to fall as existing buildings are connected however the back-up boilers would still need to have sufficient capacity to meet the peak demands. So although there will be no change in the overall capacity of the network the annual gas consumption will be lower and more concentrated in a few locations.

Electricity network

In this case all of the electricity generated is at an existing plant and so there would be no significant impact on the electricity distribution system. This may prove to be a significant advantage for this option.

Conclusion

It is clear from the above that the impacts of the CHP/DH are potentially negative for the gas and electricity network operators and that discussions with the electricity and the gas networks businesses are needed to establish the impacts, the way in which CHP plant could be connected to gas and electricity and the need for reinforcement.

Section I

Considers the impact of local air quality that arise from elimination of local combustion of gas and biofuels and the concentration of combustion at district energy centres

Introduction

AECOM was commissioned to undertake an air quality assessment as part of the Croydon Decentralised Energy Study. The air quality assessment considered current and future emissions to air within Croydon as well as existing local air quality in order to provide a baseline against which the future proposal of replacing existing domestic and commercial power sources with the proposed Decentralised Energy scheme could be assessed.

The effect of the proposed scheme on emissions of NO_x and PM_{10} was calculated and the subsequent impact on local concentrations of NO_2 and PM_{10} predicted using dispersion modelling. The significance of predicted impacts was assessed with reference to the relative change in pollutant emissions and the predicted changes in pollutant concentrations.

Legislative Background

Local Planning Guidance
The council is currently in the transitional process of replacing the Unitary Development Plan (UDP) which included the Structure Plan and City Local Plan 2001, with the Local Development Framework (LDF) as the main collection of planning policy documents within the council.

The London Plan
The consolidated London Plan was published on 19 February 2008. Replacing the previous strategic planning guidance for London issued by the Secretary of State, Regional Planning Guidance 3 (RPG3), the London Plan is a requirement of the Greater London Authority Act 1999 and only deals with matters that are of strategic importance to Greater London.

Specifically in terms of air quality the Plan makes reference to the Mayor of London's Air Quality Strategy and states the following proposal:

Policy 4A.6 Improving air quality
The Mayor will, and boroughs should, implement the Mayor's Air Quality Strategy and achieve reductions in pollutant emissions and public exposure to pollution by:

- improving the integration of land use and transport policy and reducing the need to travel, especially by car (London Plan Policy 3C.1);
- promoting sustainable design and construction (London Plan Policy 4A.3)
- promoting sustainable construction to reduce emissions from the demolition and construction of buildings (London Plan Policy 4A.22);
- ensuring at the planning application stage, that air quality is taken into account along with other material considerations, and that formal air quality assessments are undertaken where appropriate, particularly in designated Air Quality Management Areas;
- seeking to reduce the environmental impacts of transport activities by supporting the increased provision of cleaner transport fuels, including hydrogen, particularly with respect to the refuelling infrastructure;
- working in partnership with relevant organisations, taking appropriate steps to achieve an integrated approach to air quality management and to achieve emissions reductions through improved energy efficiency and energy use (London Plan Policy 4A.7).

Unitary Development Plan (UDP)
The current Unitary Development Plan sets out the following policies relevant to this study:

SP13
The Council will seek to minimise the energy requirements of new developments and will expect the use of renewable energy technologies and sustainable materials.

EP1 Control of Potentially Polluting Uses
Development that may be liable to cause or be affected by pollution of water, air or soil, or pollution through noise, dust, vibration, light, heat or radiation will only be permitted if:

- the health, safety and amenity of users of the site or surrounding land are not put at risk; and the quality and enjoyment of the environment would not be damaged or put at risk.

The Council will impose conditions, or seek a planning obligation, to implement this policy.

The Core Strategy
A key document within the LDF is the Core Strategy which sets out the Councils vision for future development throughout the borough and identifies suitable locations for new development such as industrial, commercial, and residential. Whilst drawing together the new portfolio of documents the council will still make reference to the existing plans and policies as set out in the UDP.

Interim Policy Guidance: Standards and Requirements for Improving Local Air Quality
This document provides detailed advice on how the Council will consider, and how developers should deal with, planning applications that could have an impact on air quality. The document is designed to help ensure consistency in the approach to dealing with air quality and planning in Croydon and help ensure that development contributes to delivering the Government's and the Council's air quality objectives. This Interim Policy Guidance (IPG) amplifies the requirements of policies in the Croydon Unitary Development Plan (adopted 13th July 2006), and conforms to Government policy.

Overview of Recent Air Quality Literature and Policy
The provisions of Part IV of the Environment Act 1995 establish a national framework for air quality management, which requires all local authorities in England, Scotland and Wales to conduct local air quality reviews. Section 82(1) of the Act requires these reviews to include an assessment of the current air quality in the area and the predicted air quality in future years. Should the reviews indicate that the standards prescribed in the UK Air Quality Strategy[1] and the Air Quality Standards Regulations 2007[2] will not be met, the local authority is required to designate an Air Quality Management Area (AQMA). Action must then be taken at a local level to ensure that air quality in the area improves. This process is known as 'local air quality management'.

The provisions of Part IV of the Environment Act 1995 establish a national framework for air quality management, which requires all local authorities in England, Scotland and Wales to conduct local air quality reviews. Section 82(1) of the Act requires these reviews to include an assessment of the current air quality in the area and the predicted air quality in future years. Should the reviews indicate that the standards prescribed in the Air Quality Regulations 2000[3] and the Air Quality (Amendment) Regulations 2002[4] will not be met, the local authority is required to designate an Air Quality Management Area (AQMA). An Action Plan must then be prepared to ensure that air quality in the area improves. This process is known as 'local air quality management (LAQM)'. The European Union has set mandatory limit values which are

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[1] Defra; The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2007.
[2] Defra; The Air Quality Standards Regulations, 2007.
[3] The Air Quality (England) Regulations 2000 (SI 2000/928)
[4] The Air Quality (Amendment) (England) Regulations 2002 (SI 2002/3043).

similar to the AQS objectives. These are transposed into the Air Quality Standards Regulations 2007[5].

The AQS identifies ten ambient air pollutants that have the potential to cause harm to human health and three pollutants that have the potential to affect vegetation and ecosystems. Of the ten pollutants that have the potential to cause harm to human health, seven of these are associated with local air quality (benzene, 1,3-butadiene, carbon monoxide, lead, sulphur dioxide, NO_2 and PM_{10}). The Air Quality Regulations 2000 and the subsequent amendment in 2002 set standards and objectives for these seven pollutants. These objectives aim to reduce the health impacts of the pollutants to negligible levels.

The air quality objectives and limit values currently applying to the UK can be split into two groups, detailed in Appendix 3. Each has a different legal status and is therefore handled differently within the framework of UK air quality policy. These are:

- UK air quality objectives for the purposes of local air quality management; and
- EU limit values which are mandatory.

The UK air quality objectives and limit values for NO_2 and PM_{10} are set as:

- 40 µg/m^3 for annual mean NO_2 concentration to be achieved by 2005 and 2010 for the objective and limit value respectively;
- 40 µg/m^3 for annual mean PM_{10} concentration to be achieved by 2004 and 2005 for objective and limit value respectively; and
- 50 µg/m^3 for daily mean concentration, not to be exceeded more than 35 days in a year to be achieved by 2004 and 2005 for objective and limit value respectively.

Assessment of Results

In order to determine the significance of the assessment results, reference was made to the following planning guidance and strategic documents:

- the policy and technical guidance notes, LAQM.PG(09)[6] and LAQM.TG(09)[7], issued by the Government to assist local authorities in their Local Air Quality Management responsibilities;
- the UK Air Quality Strategy;
- Planning Policy Statement 23 (PPS 23): Planning and Pollution Control[8];
- Institute of Air Quality Management, Position on the Description of Air Quality Impacts and the Assessment of their Significance[9];
- Interim Policy Guidance: Standards and Requirements for Improving Local Air Quality; and
- London Borough of Croydon Air Quality Review and Assessment Reports[10].

Significance Criteria for Air Quality Impacts

In line with the Council IPG guidance, the significance of the predicted air quality impacts have been assessed against the criteria recently promoted by the IAQM:

IAQM Significance Criteria

Air quality impacts of a proposed scheme may be considered to be significant if air quality objectives are predicted to be breached or if the development leads to significant impacts on air quality at sensitive receptors. According to the Institute of Air Quality Management (IAQM)

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5 The Air Quality Standards Regulations 2007 (SI 2007/64)

6 Defra; Local Air Quality Management, Policy Guidance LAQM.PG(09), 2009.

7 Defra; Local Air Quality Management, Technical Guidance LAQM.TG(09), 2009.

8 Office of the Deputy Prime Minister; Planning Policy Statement 23: Planning and Pollution Control, 2004.

9 Institute of Air Quality Management, Position on the Description of Air Quality Impacts and the Assessment of their Significance (http://www.iaqm.co.uk/text/News/IAQM_PS_Significance_16_11_2009.pdf), November 2009.

10 London Borough of Croydon Air Quality Review and Assessment http://www.croydon.gov.uk/environment/pollution/airpollution/review .

there are two main aspects which need to be taken into account when describing predicted impacts. These are:

- the magnitude of the change; and
- the absolute concentration in relation to air quality objectives.

The first aspect is addressed in Table 1, in which impacts are assigned a magnitude according to the absolute change in pollutant concentrations, derived based upon the predicted change in pollutant concentrations relative to the specific air quality objective or limit value in question.

Table 1: Assessment of the Magnitude of Change

Magnitude of Change	Annual Mean NO_2/PM_{10}
Large	Increase / decrease >4 µg/m^3
Medium	Increase /decrease 2-4 µg/m^3
Small	Increase / decrease 0.4-2 µg/m^3
Imperceptible	Increase / decrease <0.4 µg/m^3

The magnitude of change can then be compared to the absolute concentration in relation to the relevant air quality standard in order to describe predicted air quality impacts as detailed in Table 2.

Table 2: Air Quality Impact Descriptors

Absolute Concentration in Relation to Standard	Magnitude of Impact		
	Small	Medium	Large
Above Objective/Limit Value With Scheme (>40 µg/m^3)	Slight Adverse / Beneficial	Moderate Adverse / Beneficial	Substantial Adverse / Beneficial
Just Below Objective/Limit Value With Scheme (36-40 µg/m^3)	Slight Adverse / Beneficial	Moderate Adverse / Beneficial	Moderate Adverse / Beneficial
Below Objective/Limit Value With Scheme (30-36 µg/m^3)	Negligible	Slight Adverse / Beneficial	Slight Adverse / Beneficial
Well Below Objective/Limit Value With Scheme (<30 µg/m^3)	Negligible	Negligible	Slight Adverse / Beneficial

The IAQM suggest that the following factors should be taken into account when determining the overall significance of predicted air quality impacts:

- The magnitudes of the changes and the descriptions of the impacts at the receptors;
- The number of people affected by increases and/or decreases in concentrations and a judgement on the overall balance;
- Where new exposure is being introduced into an existing area of poor air quality, then the number of people exposed to levels above the objective or limit value will be relevant;
- Whether or not an exceedence of an objective or limit value is predicted to arise in the study area where none existed before or an exceedence area is substantially increased;
- Whether or not the study area exceeds an objective or limit value and this exceedence is removed or the exceedence area is reduced;
- Uncertainty, including the extent to which worst-case assumptions have been made; and
- The extent to which an objective or limit value is exceeded, e.g. an annual mean NO_2 of 41 µg/m^3 should attract less significance than an annual mean of 51 µg/m^3.

Capabilities on project:
Energy
Environment

Pollutants of Concern

Nitrogen Dioxide (NO_2)

Overview

The Government and the Devolved Administrations adopted two Air Quality Objectives for NO_2 to be achieved by the end of 2005. In 2010, mandatory EU air quality limit values on pollutant concentrations will apply in the UK (unless the government is successful in applying for derogation). The EU limit values for NO_2 are the same as the national objectives for 2005:

- An annual mean concentration of 40 µg/m^3; and
- An hourly mean concentration of 200 µg/m^3, to be exceeded no more than 18 times per year.

In practice, meeting the annual mean objective has been and is expected to be considerably more demanding than achieving the 1-hour objective. The annual mean objective of 40 µg/m^3 is currently widely exceeded at roadside sites throughout the UK, with exceedences also reported at urban background locations in major conurbations.

There is considerable year-to-year variation in the number of exceedences of the hourly objective, driven by meteorological conditions which give rise to winter episodes of poor dispersion and summer oxidant episodes. Analysis of the relationship between 1-hour and annual mean NO_2 concentrations at roadside and kerbside monitoring sites indicate that exceedences of the 1-hour objective are unlikely where the annual mean is below 60 µg/m^3. Exceptions were found to be related to a regional pollutant event in December 2007.

NO_2 and nitric oxide (NO) are both oxides of nitrogen, and are collectively referred to as NO_X. All combustion processes produce NO_X emissions, largely in the form of NO, which is then converted to NO_2, mainly as a result of its reaction with ozone in the atmosphere. Therefore the ratio of NO_2 to NO is primarily dependent on the concentration of ozone and the distance from the emission source.

In addition, in recent years a trend has been noted whereby NO_2 concentrations have been increasing at certain roadside monitoring sites, despite emissions of NO_X falling. The 'direct NO_2' phenomenon is having an increasingly marked effect at many urban locations around the country and must be considered when undertaking modelling studies and in the context of future local air quality strategy.

Particulate Matter

Overview

This assessment considers the annual mean and daily mean air quality objectives, as specified in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Two objectives have been adopted for PM_{10}, to be achieved by the end of 2010:

- An annual mean concentration of 40 µg/m^3 (gravimetric); and
- A 24-hour mean concentration of 50 µg/m^3 (gravimetric) to be exceeded no more than 35 times per year.

Particulate matter is composed of a wide range of materials arising from a variety of sources, and is typically assessed as total suspended particulates or as a mass size fraction. National objectives and European limit values apply to the PM_{10} and $PM_{2.5}$ fractions. These express particulate levels as the total mass size fraction at or below an aerodynamic diameter of 10 and 2.5 µm respectively.

Both short-term and long-term exposure to ambient levels of particulate matter are consistently associated with respiratory and cardiovascular illness and mortality as well as other ill-health effects. Particles of less than 10 µm in diameter have the greatest likelihood of reaching the thoracic region of the respiratory tract.

It is not currently possible to discern a threshold concentration below which there are no effects on the whole population's health. Recent reviews by WHO and the Committee on the

Medical Effects of Air Pollutants have suggested exposure to a finer fraction of particles ($PM_{2.5}$, which typically make up around two thirds of PM_{10} emissions and concentrations) give a stronger association with the observed ill health effects, but also warn that there is evidence that the coarse fraction (between PM_{10} – $PM_{2.5}$) also has some effects on health.

Emissions of PM_{10} have decreased considerably since 1970, mainly due to the decline in coal use and the result of legislative and technical control of emissions from both road traffic and industrial sources. Industrial processes and road transport were the main sources of PM_{10} in 2005. In general diesel vehicles emit a greater mass of particulate per vehicle kilometre than petrol-engined vehicles.

Capabilities on project:
Energy
Environment

Baseline Conditions

Summary of Local Air Quality Management

The first round of the review and assessment process for the London Borough of Croydon identified exceedences of the air quality objectives for annual mean NO_2. Consequently, Croydon Council designated a network of busy roads in the centre of Croydon as an AQMA on the 2nd October 2000. The AQMA was further revised and extended to cover the whole Borough of Croydon on the 24th April 2003. The remaining six pollutants in the Government's Air Quality Strategy (benzene, 1,3 butadiene, carbon monoxide (CO), lead, particulate matter (PM_{10} and sulphur dioxide (SO_2) were found not to exceed air quality objectives.

Following a second stage of Review and Assessment, no changes were reported with continued exceedences of the objective for annual mean NO_2 highlighted; therefore the Borough's AQMA status was maintained.

An Updating and Screening Assessment (USA)[11], carried out in August 2006 as part of the third round of review and assessment, concluded that NO_2 continued to exceed the annual objective near busy roads. Similar conclusions were presented in the most recent Air Quality Action Plan & Review and Assessment progress report 2007/2008[12]. Exceedences of the annual mean NO_2 objective were determined at three of the continuous monitoring locations in the Borough. The hourly NO_2 objective was also breached at the George Street air quality monitoring station which may be attributed to construction works involving the nearby tramline. As a result, the existing AQMA for annual mean NO_2 was upheld and not re-designated to include the hourly mean NO_2 objective.

Local Air Quality Monitoring

Continuous monitoring of NO_2 is carried out at four sites across the Borough. Information about site types and locations are presented in Tables 3 and 4, alongside fully ratified monitoring results for NO_2 and PM_{10} respectively.

Table 3: Annual Average NO_2 Monitoring Results

Ref.	Monitoring Site	Type	Grid Ref	Ratified Annual Mean NO_2/µg/m^3			
				2005	2006	2007	2008
CR2	Purley Way	Roadside	531121, 164294	**45**	**48**	**46**	**45**
CR4	George Street	Roadside	532584, 165630	**58**	**54**	**59**	**49**
CR5	London Road, Norbury	Kerbside	530630, 169696	**70**	**64**	**66**	**66 (51)***
CR6	Euston Road	Suburban	531369, 166096	34	35	34	32

Note: Figures in bold indicate an exceedance of the relevant national air quality objective.
**Figures in brackets represent hourly exceedences of the 1 hour objective, 18 exceedences of 200 µg/m^3 are permitted each year. .*

With the exception of CR6 Euston Road, a suburban site, annual mean concentrations of NO_2 exceeded the UK annual mean NO_2 objective of 40 µg/m3 between 2005 and 2008, at all sites. Concentrations of NO_2 measured at CR5 London Road were the highest in all three years. The only year showing an exceedence of the hourly mean of >200ug/m3 (not to be exceeded more than 18 times a year) was 2008 at CR5, which shows 51 exceedences.

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[11] Cambridge Environmental Research Consultants On Behalf of London Borough of Croydon , Updating and Screening Assessment for the London Borough of Croydon, 2006.

[12] London Borough of Croydon, Air Quality Action Plan & Review and Assessment Progress Report 2007/8.

PM_{10} is also measured at two sites in the Borough. The monitoring results, both annual mean and the number of days where PM_{10} concentrations exceeded 50 µg/m3, from 2005 to 2008, are presented in Table 4 below.

Table 4: PM_{10} Continuous Monitoring Results

Ref.	Monitoring Site	Type	Grid Ref	Annual Mean PM_{10}/µg/m^3				Number of Days PM_{10} > 50 µg/m^3			
				2005	2006	2007 c	2008	2005	2006	2007 c	2008
CR 3	Thornton Heath	Suburban	532330, 168943	24	23	22	20	3	6	7	11
CR 4	George Street	Roadside	532584, 165630	29	30	32	22	11	17	31	14

Note: Figures in bold indicate an exceedance of the relevant national air quality objective.

Continuous monitoring of PM_{10} indicates that the UK annual mean PM_{10} objective of 40 µg/m3 was achieved at both sites within the Borough during the period 2005 to 2008. The UK daily mean PM_{10} objective (not more than 35 days) was also achieved during this period.

Table 5: Nitrogen Dioxide Diffusion Tube Monitoring Results

Ref.	Monitoring Site	Type	Grid Ref	Annual Mean NO_2/µg/m^3		
				2006	2007	2008
CY59	Park Lane	532553, 165384	Roadside	**59**	**59**	**56**
CY98	George Street Continuous Monitoring Station (Co-located tubes)	532597, 165637	Roadside	**53**	**55**	**47**
CY58	Wellesley Road Northbound	532383, 165957	Roadside	**76**	**76**	**74**

Note: Figures in bold indicate an exceedance of the relevant national air quality objective.

Croydon Council also operate a network of NO_2 diffusion tubes at 16 sites across the Borough. The results from three of these sites are presented in Table 5. These sites have been presented as they are within the study area.

The results displayed in Table 5 show the 40 µg/m3 annual mean NO_2 objective was exceeded at all locations from 2005 to 2008.

Emissions of NOx and PM_{10} within Croydon
Total emissions of NOx (as NO_2) and PM_{10} for the London Borough of Croydon were obtained from the National Atmospheric Emissions Inventory (NAEI)[13] for the year 2007 (the latest year for which data are available). These data are reproduced below in Table 6.

Table 6: NO_x and PM_{10} Emissions in London Borough of Croydon (2007)

Pollutant	Emissions in LB Croydon (T/yr)
NO_x (as NO_2)	1,897
PM_{10}	125

13 http://www.naei.org.uk/mapping/mapping_2007.php

Capabilities on project:
Energy
Environment

Modelling Methodology

Scope of the Assessment

The assessment of the proposed scheme has considered a number of scenarios in terms of both local air quality impacts as well as changes in overall emissions.

Existing and future road traffic was modelled using the AAQuIRE regional dispersion model with both area and point sources modelled using BREEZE AERMOD. The assessment was undertaken for the base year 2008, and the proposed opening year 2020.

The following scenarios have been assessed:

- Existing (2008). Sources include major roads, the Rolls-Royce station, emissions from commercial premises and large residential developments;
- Future (2020) Do-Minimum. The same sources as the existing scenario with an assumed level of traffic growth, if identified. It was assumed that new commercial development would not be powered by proposed Energy Centres but would be powered fom boilers within each new building;;
- Future (2020) Do-Something 1. The same sources as the existing scenario with an assumed level of traffic growth, if identified. It was assumed that new commercial development (and relevant identified existing development) would be powered by the proposed Energy Centres;
- Future (2020) Do-Something 2. The same sources as the existing scenario with an assumed level of traffic growth if identified. It was assumed that heating for new commercial development (and relevant identified existing development) would be delivered via pipe by excess heat from the present operation at the Rolls Royce plant. The Rolls Royce plant would be operated for more hours each year to provide this additional heat.

Air Quality Assessment Methodology

Local Air Quality Assessment – AAQuIRE

Concentrations of NO_2 and PM_{10} were predicted at locations across the study area using the AAQuIRE regional dispersion model, which was developed by AECOM and has been used widely for the past 15 years. The model uses the dispersion algorithms, CALINE4 and AERMOD, which have been independently and extensively validated. A more detailed description of the AAQuIRE dispersion model is included in Appendix 3.

There are four main categories of air pollutant sources: road traffic sources; industrial sources (Part A and B processes); diffuse sources (e.g. domestic heating); and mobile sources (e.g. airports, rail and shipping).

The modelling procedure adopted calculates the NO_2 and PM_{10} annual mean concentrations at receptors covering the study area using a Cartesian grid of receptors at a height of 1.5 metres above ground level to simulate human exposure. The receptors were evenly spaced at 20 metre intervals to ensure a sufficiently high level of spatial resolution was obtained. The results produced allowed the generation of NO_2 and PM_{10} concentration contours, as shown in the Appendix 3.

Local Air Quality Assessment – BREEZE AERMOD

Concentrations of NO_2 and PM_{10} emitted from the Energy Centre have been calculated using Breeze AERMOD (Version 6.1.2.4), which is a new generation air quality modelling system supplied by Trinity Consultants. The proposed energy centres were modelled as point sources. Emissions from existing and future commercial and residential; development were modelled as area sources.

AERMOD is a state-of-the-science dispersion modelling system that simulates essential atmospheric physical processes and provides refined concentration estimates over a wide range of meteorological conditions and modelling scenarios. AERMOD includes two data pre-processors for streamlining data input:

- AERMET, a meteorological pre-processor, computes boundary layer and other necessary parameters for use with AERMOD and accepts data from both on-site and off-site sources.
- AERMAP is a terrain pre-processor that simplifies the computation of receptor elevations and effective height scales for numerous types of digital data formats, including USGS 1 Degree and 7.5 minute digital elevation model (DEM) files and U.K. Ordnance Survey® digital elevation data.

For the purpose of this assessment likely pollutant release heights for the modelled area sources were estimated from the known height of existing buildings. These are given in Appendix 3.

Background Pollutant Concentrations

A large number of small sources of air pollutants exist, which individually may not be significant, but collectively, over a large area, need to be considered in the modelling process. The emissions from these background sources were applied to the model as background concentrations. NO_X and PM_{10} background concentrations used in this study were sourced from the UK National Air Quality Information Archive[14] listed for the 1-km square centred on (530500, 166500), as shown below in Table 7. The concentrations were determined for the relevant future year according to the method outlined in LAQM.TG(09).

The UK background concentration mapping, aggregates all emissions sources over each 1km grid square, therefore it is important to disaggregate (where possible) the sources being modelled as part of the assessment, to prevent double counting. For the purpose of this assessment the following sources have been disaggregated from the background PM_{10} and NO_x maps.

- Roads traffic sources; and
- Industrial and commercial combustion sources.

The resulting background pollutant concentration values used in the assessment is shown in Table 7.

Table 7: Background Pollutant Concentrations for Base Year and Opening Year (µg/m^3)

Pollutant	Base Year 2008	Future Year 2020
NO_2	27.5	19.0
NO_X	40.0	25.0
PM_{10}	22.7	20.6

Meteorological Data

As agreed with the Council a meteorological dataset was compiled using data from Gatwick 2005, which is considered to be representative of the study area.

The windrose for this location is shown in Appendix 3 along with further details about the methodology used to compile the meteorological data ready for the model.

[14] www.airquality.co.uk

Traffic Data
Traffic data were obtain from the London Atmospheric Emission Inventory (LAEI) and input in the form of AADT flows and HDV percentages. This data is shown in Appendix 3.

Conversion of NO_x to NO_2 for Road Traffic Emissions
The proportion of NO_2 in NO_X varies greatly with location and time according to a number of factors including the amount of ozone available and the distance from the emission source.

AQEG[15] reported that urban NO_X concentrations had declined since the early 1990s as a result of decreasing road traffic emissions. Decreases in NO_2 were not as distinct, resulting in an increase in the NO_2/NO_X ratio. The magnitude of the increase was inconsistent with the increase expected solely as a consequence of reduced NO_X concentrations. The findings were supported by monitoring data from a number of locations in London and AURN data from across the UK.

The observations prompted research into the NO_2/NO_X relationship and an updated version of the relationship were published.[16]. The spreadsheet[17] provides a revised methodology for converting NO_X to NO_2 for any given year. This methodology has been used for the purpose of this assessment for all scenarios as the best representation of the NO_2/NO_X relationship for Croydon.

Assessment of Overall Emissions of NO_x and PM_{10}
Local air quality is characterised by pollutants with short term, immediate impacts, but many of these pollutants can travel longer distances, and can have impacts on a regional, national, or international scale. These impacts, which include acidification, excess nitrogen deposition and generation of tropospheric (ground level) ozone, may be felt by humans or ecosystems at considerable distance from the source of emissions.

As well as local air quality impacts therefore, consideration must be given to the potential impacts of the proposed schemes on emissions at a regional level. In order to do this total emissions of NOx and PM_{10} associated with each of the proposed schemes has been calculated and compared to the Do-Minimum scenario as well as existing emissions within the London Borough of Croydon.

Estimating the economic benefits of air quality improvements
Some air quality improvements can be valued using economic evidence to produce monetary estimates. For example, improved air quality leads to health benefits, reducing the numbers of cases of respiratory hospital admissions from high pollution episodes, and thus reduced health care costs, lost time at work, and the pain and suffering of individuals. These benefits can then be valued using economic evidence from resource savings, health valuations, productivity losses etc.

Detailed methods have been developed to quantify and value the health and environmental benefits of air pollution improvements. These methods were used in the economic analysis to inform the 2007 review of the Air Quality Strategy. Similar methods were also used by the European Commission in developing the Thematic Strategy on Air Quality, published in 2008.

The approach taken for the Air Quality Strategy review was very detailed, and used modelling together with the impact pathway approach, following an estimation of emissions, dispersion and pollution modelling, calculation of receptor exposure, quantification of impacts and valuation. However, summary values were also provided that can be used in appraisal. These are known as damage costs and present the monetary benefits of marginal air quality improvements per tonne of pollutant reduced.

Damage costs are based on values for a range of health impacts, including mortality and morbidity effects, and non-health impacts such as damage to buildings and effects on crop yields. They also take account of both primary and secondary air pollution changes. The

[15] Air Quality Expert Group; Nitrogen Dioxide in the United Kingdom; 2004
[16] Deriving NO_2 from NO_x for Air Quality Assessments of Roads –Updated to 2006, Air Quality Consultants.
[17] UK Air Quality Archive, NO_x from NO_2 Calculator, 2008.

damage cost approach is intended for use across government in project appraisals (project cost-benefit analysis) and Regulatory Impact Assessments (policy cost-benefit analysis). It is not, however, considered a replacement for detailed modelling and analysis. The use of damage costs is only recommended for policies aiming to reduce pollution over a period of less than 20 years, as part of a filtering mechanism to narrow down a wide range of policy options into a smaller number that are then taken forward for more comprehensive assessment, or where air quality impacts are expected to be ancillary to the primary objectives or are relatively small.

IGCB damage costs are given for primary PM_{10}, SO_2 and NO_x. Multiple values are given for PM_{10} to reflect the different types of environment that the pollutant might be released in and the number of people likely to be exposed in each. For some secondary pollutants - particulates forming from NO_x and SO_2 - one uniform value has been derived for damage costs in the UK. These secondary pollutants form in the atmosphere over time, and so the immediate local environment is not important in determining damage costs.

Damage costs do not presently capture the effects of ozone formation. The use of a single value for ozone (i.e. for precursor emissions of NO_x and VOCs) is more uncertain than other pollutants, especially in relation to NO_x, which is strongly non-linear due to the titration effects in urban sites. However, ozone damage when monetised is small compared to secondary PM effects, and so has little effect on the results for NO_x.

Not all potential benefits of air quality have been assigned damage costs because in some cases quantification is not possible or highly uncertain, for example impacts on ecosystems. The values also only include the benefits that occur in the UK i.e. they do not include benefits from reductions in trans-boundary pollution. It should be noted that the economic benefits of air quality improvements change over time. This has been accounted for by using the damage cost calculator produced by Defra[18] which has been used in this assessment.

External costs of air pollution vary according to a range of environmental factors, including overall levels of pollution, geographic location of emission sources, height of emission source, local and regional population density, meteorology and so on. The damage cost numbers take these issues into account to a certain degree only. Although the values are potentially more relevant for central government policies than specific local analysis, they can still play a useful role in the latter.

[18] http://www.defra.gov.uk/ENVIRONMENT/airquality/panels/igcb/tools.htm

Model Results and Discussion

Model Verification

For a detailed dispersion modelling assessment such as this, it is necessary to consider and account for random errors in both the modelling and the monitoring data. The modelling results discussed in this section were verified by a consideration of the errors associated with the modelling process and the model input data.

Systematic errors in modelling results can arise from many factors, such as uncertainties in vehicle flows, speeds and the composition of the vehicle fleet. Such errors can be addressed and corrected for by making comparisons with monitoring data.

The accuracy of the future year modelling results is relative to the accuracy of the base year results, therefore greater confidence can be placed in the future year concentrations if good agreement is found for the base year.

NO_2

Concentrations modelled using the AAQuIRE model were verified against monitored data collected at the two kerbside monitoring sites given in Table 8.

Initially, the AAQuIRE model under-predicted NO_2 concentrations at the monitoring sites and with no further improvement of the model considered feasible (such as reducing vehicle speeds or using different pollutant background, etc), an adjustment factor (F), of 3.4 was calculated to adjust modelled roadside NO_x concentrations, in accordance with LAQM.TG(09).

A summary of the comparison between monitored NO_x concentrations and modelled NO_x results (adjusted and unadjusted) and calculated verification factor is shown in Table 8.

Table 8: Model Verification (NO_x)

Site	OS Grid Reference	Monitored (roads)	Modelled roads (Unadjusted)	Modelled roads(Adjusted)	Factor (NO_x)
CY59	532559,165360	69.5	34.4	116.8	3.4
CY58	532383,165957	157.4	30.8	104.5	

PM_{10}

The option of using PM_{10} monitoring at Site CY4 (the only site in the study area) for the purpose of model verification was discounted due to unexpected local roadside concentrations which were below the mapped background for that area. Therefore in line with LAQM.TG(09) the model has been adjusted using the same adjustment factor calculated for NO_x.

Random Error of the Model

In addition to the systematic errors the model is still likely to predict concentrations slightly different to actual ambient values. This is termed random error, and must also be considered. It is possible to account for the degree of random error, according to guidance provided by the Environmental Protection UK (formerly known as the NSCA).

'Stock U Values', figures provided by Environmental Protection UK, allow the standard deviation of the model (SDM) to be calculated. The Stock U Value for NO_2 is between 0.1 and 0.2 for an annual mean (it is higher for shorter averaging periods). The SDM can be calculated according to:

$$SDM = U \times Co$$

Where Co is the air quality objective (40 µg/m^3 for the NO_2 UK annual mean objective).

Therefore:

SDM = 0.1 x 40 = 4 µg/m^3

This calculation quantifies the uncertainty in the identification of areas where an exceedence of the air quality objective can be considered possible. This region, therefore, extends between 36 µg/m^3 to 44 µg/m^3 at 1 standard deviation from the objective.

The following terminology is used in conjunction with the modelling uncertainty results.

Table 9: Probability of Exceedence of Annual Mean NO_2 Objective

Probability of Exceedence	Uncertainty	Concentration Range (µg/m^3)
Very likely	> Mean + 2 SD	>48
Likely	Mean + 1 SD – Mean +2 SD	44 – 48
Probable	Mean - Mean + 1 SD	40 – 44
Possible	Mean - Mean – 1 SD	36 – 40
Unlikely	Mean - 1 SD – Mean - 2 SD	32 – 36
Very Unlikely	< Mean – 2 SD	< 32

The concentration range given in Table 9 can be directly compared to the contour plots in Appendix 3.

Local Air Quality Assessment Results

The following impacts have been identified for assessment as a result of the proposed scheme:

- changes in local air quality pollutants over the study area as a result of new developments coming on line in the Do-Minimum scenario; and
- changes in local air quality pollutants at specific locations as a result of the proposed Energy Centres in the Do-something Scenario (1) and the increase output from the existing Rolls Royce gas turbine plant, in the Do-something Scenario (2) compared with the Do-Minimum scenario.

Concentrations of NO_2 and PM_{10} were predicted over the entire study area and are presented as contour plots in the Appendix 3. In order the show the relative impacts of the different scenarios the following plots are presented.

All Sources (including local traffic and existing background)

- 2008 baseline NO_2 and PM_{10} concentrations for all sources;
- 2020 Do-minimum NO_2 and PM_{10} concentrations for all sources;
- 2020 Do-Something (1) NO_2 and PM_{10} concentrations for all sources; and
- 2020 Do-Something (2) NO_2 and PM_{10} concentrations for all sources.
- Impact plots to demonstrate the relative change between the 2020 Do-Minimum and Do Something scenarios.

Overall Results.

Results of Emissions Assessment

NO_x and PM_{10} Emissions Results

The emissions associated with each of the sources considered within this assessment have been calculated based upon the emission factor determined for each source in grammes per second (presented in Appendix 3) multiplied by the number of seconds in a year. The total emissions calculated for each of the scenarios considered in this assessment are described below in Table 10.

Table 10: Predicted Emissions of NO_x and PM_{10} (T/yr)

Pollutant	Scenario			
	Base 2008	DM 2020	DS 1 2020	DS 2 2020
NO_x	34.5	55.5	51.4	86.2
PM_{10}	0.31	0.61	0.44	0.44[A]

[A] In the absence of PM_{10} emission factors for the Rolls Royce Gas engine, it is assumed that PM_{10} emissions associated with this process will approximate to emissions associated with the proposed CHP plants for which emission factors are available.

Reduction in Emissions as a result of Electricity Generation

Whilst the emissions associated with the operation of the proposed CHP plants and Rolls Royce gas engine have been assessed, the equivalent reduction in emissions as a result of the electricity generated during their operation, which would otherwise have been generated regionally, also needs to be taken into account. The emission factors in Table 11 were produced for the Electricity Supply Industry based upon the assumption that 20% of energy demand in 2020 will be met using renewable sources[19].

Table 11: Electricity Supply Industry Emission Factors (g/kWh)

Pollutant	2000	2005	2010	2015	2020
NO_x	1.22	0.58	0.47	0.44	0.41

The reduction in regional emissions of NO_x as a result of the electricity generated by the proposed CHP plants or Rolls Royce gas engine has been calculated by multiplying the factor for 2020 in Table 11 above by the number of kWh of electricity predicted to be generated by the CHP plants or Rolls Royce gas engine. The results of this assessment are shown below in Table 12.

Table 12: Predicted Reduction in Regional Emissions

	2020
MWh of electricity per year from proposed schemes	154,170
Regional NO_x emissions from ESI (T)	63.2

It should be noted that PM_{10} emission factors for the electricity supply industry are not readily available and so the reduction in regional PM_{10} emissions associated with the electricity generated by the proposed schemes has not be taken into account in the figures below.

The overall emissions associated with each scheme, once regional emissions associated with electricity generation have been taken into account, are shown below in Table 13.

[19] http://www.dft.gov.uk/pgr/rail/researchtech/research/railemissionmodel.pdf

Capabilities on project:
Energy
Environment

Table 13: Predicted Regional Emissions of NO_x and PM_{10} (T/yr)

Pollutant	Scenario		
	DM 2020	DS 1 2020	DS 2 2020
NO_x	118.7[A]	51.4	86.2
PM_{10}	0.61[B]	0.44	0.44[C]

[A] Includes emissions associated with regional electricity generation equivalent to electricity generated by proposed schemes.
[B] Excludes emissions associated with regional electricity generation equivalent to electricity generated by proposed schemes.
[C] In the absence of PM_{10} emission factors for the Rolls Royce Gas engine, it is assumed that PM_{10} emissions associated with this process will approximate to emissions associated with the proposed CHP plants.

The overall impact of each scheme on emissions of NO_x and PM_{10} is summarised below in Table 14 with a negative value denoting a net reduction in emissions (T/yr) or monetary benefit (£). It should be noted that the economic benefits below have been equated over a five year appraisal period from 2020 to 2024.

Table 14: Overall Impact of Proposed Schemes on NO_x and PM_{10} Emissions

Pollutant	Scenario			
	DS 1 2020		DS 2 2020	
	T/yr	£	T/yr	£
NO_x	-67.3	-£395,781	-32.5	-£194,284
PM_{10}	-0.17[A]		-0.17[A,B]	

[A] Excludes emissions associated with regional electricity generation equivalent to electricity generated by proposed schemes.
[B] In the absence of PM_{10} emission factors for the Rolls Royce Gas engine, it is assumed that PM_{10} emissions associated with this process will approximate to emissions associated with the proposed CHP plants.

Local Air Quality Results

Emissions from the CHP Energy Centre are lower than that shown for the Do-Minimum Scenario, where as emissions from the Rolls-Royce centre in Do Something Scenario 2, is lower in particulates but higher in levels of NO_x than would occur from boilers. However, the use of tall stacks to disperse the emissions and the fact that emissions from boilers are reduced at lower levels means that predicted concentrations at the modelled height of 1.5m across the study area are lower in both Do Something Scenarios. These impacts are shown in Figures A3.10/11 of Appendix 3, the significance of which set out in Table 15 below.

Conclusions

AECOM was commissioned to undertake an air quality assessment as part of the Croydon Decentralised Energy Study.

The effect of the proposed schemes on emissions of NO_x and PM_{10} were calculated and the subsequent impact on local concentrations of NO_2 and PM_{10} predicted using dispersion modelling.

Total NO_x and PM_{10} Emissions

It can be seen that each of the proposed schemes are predicted to lead to a net reduction in emissions of NO_x and PM_{10} when considered in terms of total regional emissions including that associated with electricity generated during their operation, which would otherwise have been generated regionally.

In the case of the CHP Energy Centres, it is assumed that this reduction reflects the greater efficiencies associated with larger and more modern power plants and the fact that it is easier and more cost effective to control emissions from larger combustion sources than for smaller, more spatially aggregated sources.

It should be noted that the reductions in emissions shown above are relatively small when compared to the emissions from Croydon in 2007 (approximately 3.5% and 1.7% for NO_x respectively and 0.1% for PM_{10}). The monetary values associated with these reductions are also relatively minor.

Local Air Quality Assessment

The significance of predicted impacts was assessed with reference to the relative change in pollutant emissions and the predicted changes in pollutant concentrations. A summary for the overall changes and considered significance is presented in Table 15.

The use of tall stacks to disperse the emissions and the fact that emissions from boilers are reduced at lower levels means that predicted concentrations at the modelled height of 1.5m across the study area are lower in both Do Something Scenarios. NO_2 concentrations were predicted to be lower with both the Do-Something scenarios compared with the Do-Minimum scenario across the study area with a maximum reduction of 0.75 µg/m^3 and 0.85 µg/m^3 with Do-Something 1 and 2 scenarios respectively.

Table 15: Summary of Impacts

Phase	Assessment	Pollutant	Magnitude of Change	Magnitude of Impact
Do-Something (1)	Local Air Quality	NO_2	Imperceptible to Small	Negligible to Slight Beneficial
		PM_{10}	Imperceptible	Negligible
Do-Something (2)	Local Air Quality	NO_2	Imperceptible to Small	Negligible to Slight Beneficial
		PM_{10}	Imperceptible	Negligible
Do-Something (1)	Change in Emissions	NO_2	small reduction	Negligible to Slight Beneficial
		PM_{10}	small reduction	Negligible to Slight Beneficial
Do-Something (2)	Change in Emissions	NO_2	small reduction	Negligible to Slight Beneficial
		PM_{10}	small reduction	Negligible to Slight Beneficial

Section J

Identifies opportunities and implications for the pipe distribution networks to accommodate gas/liquid biofuels and hydrogen in the future

A gas-fired CHP system currently reduces CO_2 emissions for two reasons: as a result of the higher efficiency of energy use and as a result of fuel switching from coal to gas. Over the next 10 years it is expected that the use of coal in the power station mix will decline and so the CO_2 benefits from gas-fired CHP will also decline over time.

In planning a CHP system it is therefore necessary to consider how the system might develop in the longer term in an era where the electricity system, is decarbonised with nuclear, renewable energy and coal-fired power stations with carbon capture and storage. All of these sources will have a low carbon content and will be expected to be used in preference to gas-fired CCGT power stations which will become the marginal plant in the longer term

At present the average electricity emissions factor is around 520g/kWh with coal-fired marginal plant at around 800g/kWh. At 520g/kWh, heat from a large gas-engine CHP with 37% electrical efficiency has zero CO_2 content but if the longer term marginal plant is older gas-fired CCGT with an electricity emissions factor of 430g/kWh then the heat content would increase to around 90g/kWh. This is still less than half the emissions from gas boilers as shown in Figure J1.

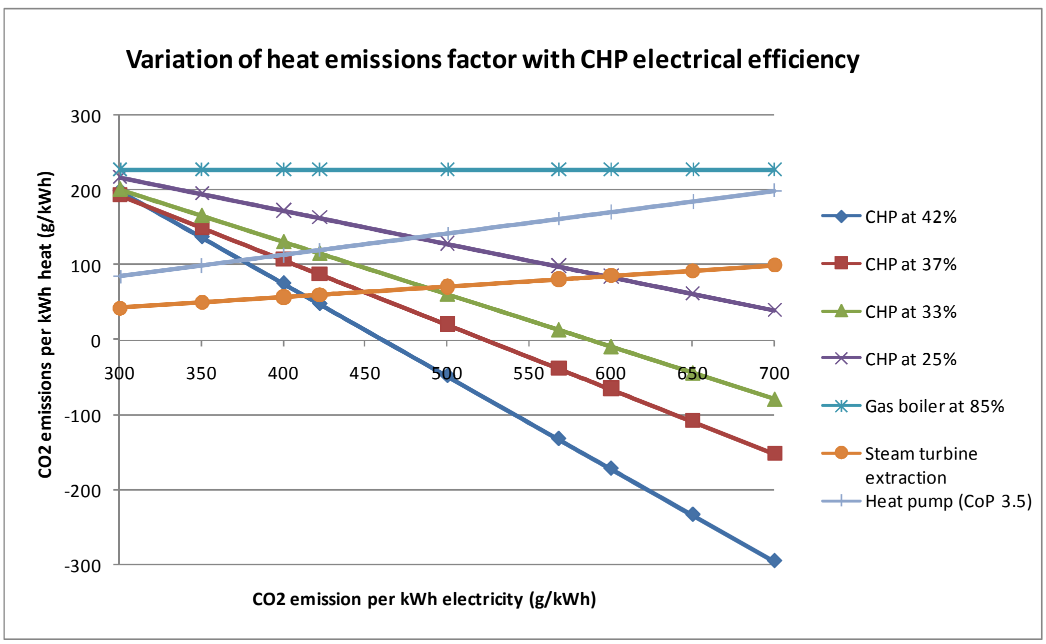


Figure J1 – Variation of heat emissions factor with electricity emissions factor

This heat content is however comparable to heat pumps with a seasonal CoP of 3.5. To maintain its advantage over heat pumps, CHP will either need to improve its electrical efficiency to use an alternative lower carbon source or to extract heat from a steam turbine where the benefit would typically be twice that of a heat pump with an effective CoP of 7.

Higher electrical efficiency systems can be achieved for larger-scale using CCGT technology so one future option is to grow the scheme to enable all three clusters to be interconnected and CCGT technology could be used.

An alternative approach is to change the fuel used for CHP to improve the CO_2 savings. Lower carbon fuels can be obtained through:

- Production of biomethane from anaerobic digestion of waste
- Production of biomethane from gasification of biomass
- Production of syngas from energy from waste using gasification or pyrolysis

These gas sources can be used in three ways:

- directly in a CHP engine or in the future fuel cells on the same site
- directly in a CHP engine but transporting the biogas by a separate pipeline
- indirectly through injection into the gas grid after treatment and/or methanisation to achieve equivalent natural gas standards.

The latter is generally more likely given that it is difficult to find sites for energy from waste plants close to built up areas where the CHP would be sited and the cost of a dedicated biogas pipeline would be avoided. However in Croydon the waste transfer station is located to the west of the town centre adjacent to the Rolls Royce power plant. There is therefore the potential, subject to space requirements and planning permission, to use an advanced thermal process to obtain energy from waste at this site and to transport heat to the Croydon centre district heating scheme.

An alternative would be install a biogas pipeline from the waste transfer site (or similar remote site) into the town centre to supply each of the local CHP Energy Centres. These new gas pipelines could convey hydrogen rich gas derived from energy from waste pyrolysis. The transport of hydrogen involves some technical issues however. As it is a light gas it is not contained within conventional polyethylene gas pipework and steel pipe would be required. It is possible that a steel heat transmission main could be used for hydrogen in the future, provided suitable sites were available in the town centre for CHP plant.

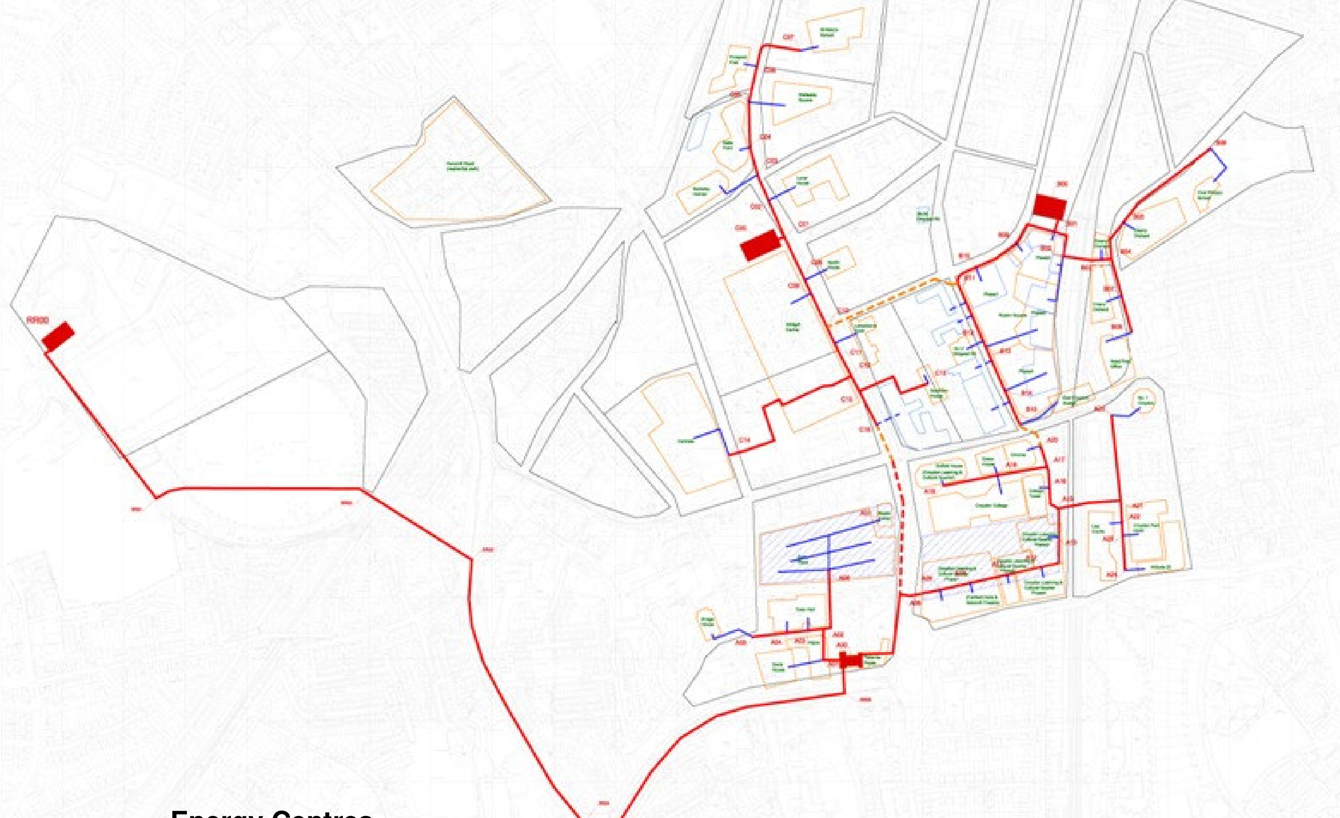
It is also likely that there will be 20-30 years before the grid is sufficiently decarbonised (i.e. no CCGT left) for gas-fired CHP to have limited benefit compared to other operations such as heat pumps. As a result we recommend that a start is made on a gas-engine based CHP, or the Rolls Royce gas turbine CHP to supply the district heating network whilst investigations continue on the viability of an energy from waste facility at or nearby the waste transfer station. The system as proposed has a number of options for moving towards lower carbon fuels in the future and it will be important that these future opportunities are safeguarded as the scheme is developed.

Section K

Consider the long term maintenance and replacement of existing and provision of new services within the pipe distribution network.

This section of the report should be read in conjunction with the Croydon Decentralised Energy Study plan. Here we look at the life-cycle of the pipe distribution network in terms of the plant in the energy centres and the pipework network distributed around Croydon town centre. The three key areas addressed are:

1. Maintenance
2. Replacement
3. Additional services



Energy Centres

The main items of plant in the energy centres are the boilers and the CHP engines. In order to address maintenance, the ESCo company would retain responsibility for plant maintenance. This may be contractually backed off by them with arrangements, warranties etc. with the plant manufacturers.

Energy centre location and plant selection would be chosen and designed by or in collaboration with the ESCo company. The strategic location of the energy centre would be selected for ease of access for plant replacement, the plant selection would promote common manufacturers and modularisation for ease of parts replacement and energy centre management.

Provision should be made for future plant and plant replacement with new plant installation strategies in place. With modularised plant items selected and space provided in the energy centre space layouts and configurations provision should be made for energy centre capacity change for expansion and contraction to respond to the energy load life-cycle.

Distribution Network

Taberner House to C-CURV

There is an existing underground services corridor between Taberner House basement and CCURV. The connection is made through pipework suspended from the ceiling of the services corridor. This corridor will provide access for maintaining pipework, replacing pipework lengths and has capacity to support additional services if required.

C-CURV PSDH

We would propose that the new C-CURV building design for the basement plantroom and service corridor provision accommodates pipework to traverse across it to serve Davis House, the Town Hall and Mid-Croydon from Taberner House. i.e. the pipework service routes currently being proposed in the basement of the C-CURV PSDH building are oversized to cater for the connection back onto the Taberner House energy centre and across through to Mid-Croydon.

C-CURV to Mid-Croydon

The route between the PSDH building and Park Place runs in the road/ pavement up Fell Road and across Katharine Street. Although direct access to this pipework from above would mean digging up the road there would be good access from either end from the PSDH basement to the South and the Park Place underground car park to the North.

Energy Zone 1 to Energy Zone 3 Link

The interlinking of energy zones would be part of the Wellesley Road green energy spine with interconnecting pipework running up Park Lane next to or through the underpass. More detail of the Wellesley Road green energy spine is given later in this section.

Taberner House to Wellesley Road

To carry pipework across Queens Gardens we would propose an accessible concrete trench. This trench would have a wet side and a dry side for services with lift up access panels along its length. This would provide flexibility to pick up the various types of services proposed for the Wellesly Road green spine.

Queens Gardens to College Green

The proposed route across Park Lane is the current pedestrian subway, which goes from Queens Gardens to the front of Fairfield Halls. This would form a subterranean service tunnel with walk through access and spare services capacity provision.

College Green Distribution

Once in the underground car park below College Green pipework would distribute at high level to the base of the Croydon Learning and Cultural Quarter energy risers. This pipework network would be easily accessible and with the clear eights offered through the car park there would be spare room to run services to provide additional capacity.

College Green to the Law Courts

If services are allowed to be under-slung below the Hazledean Road bridge over the railway line these exposed services would be reasonably accessible. Once East of the railway line services would need to be buried in the roads.

Along Lansdowne and Dingwall Roads

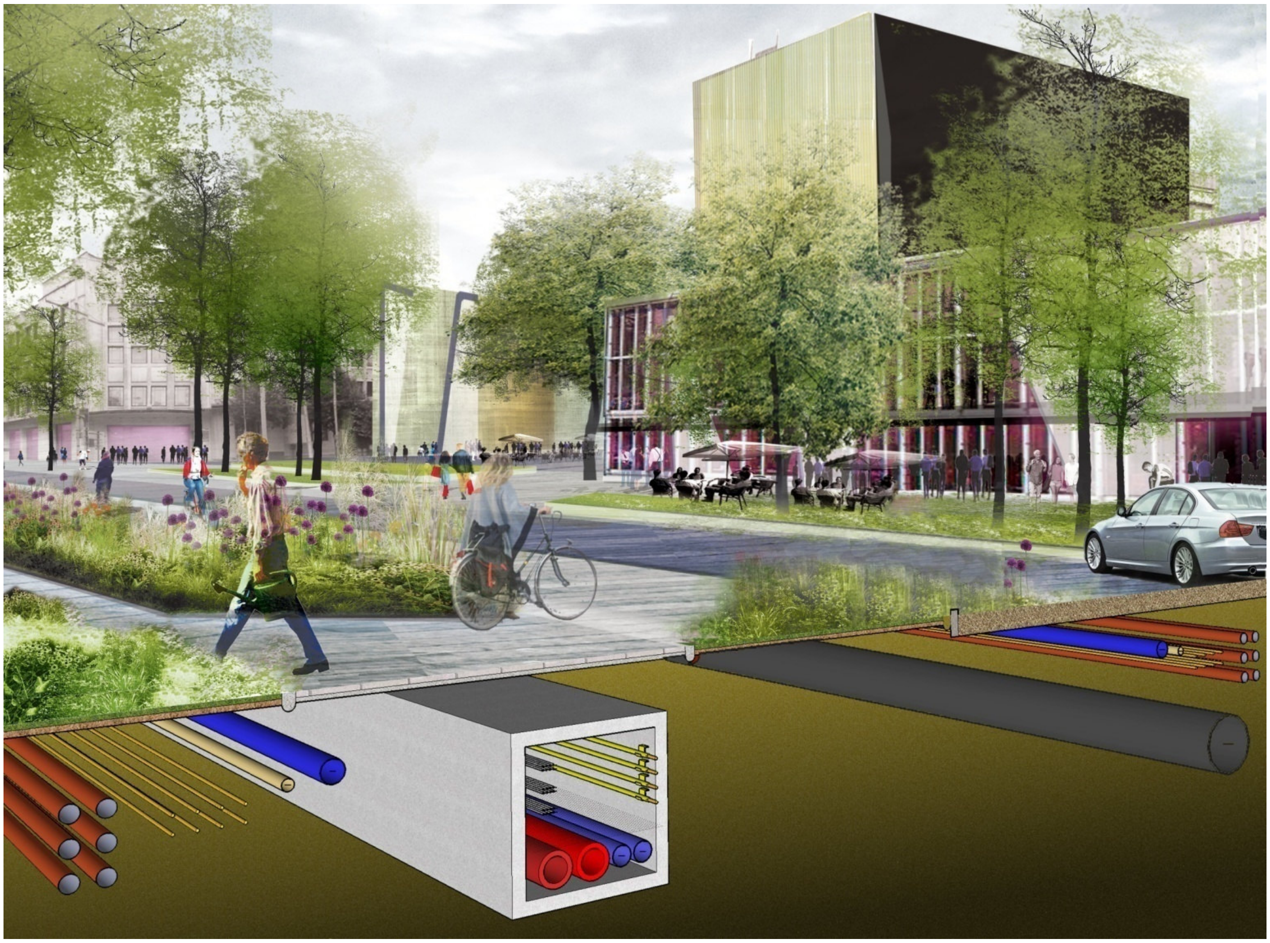
Rather than running pipework in the pavement along Landsdowne Road, the preference would be to come to run it across the Ruskin Square development. If some arrangement with the developer could be made then an accessible services trench could be proposed down the West side of the site.

Ruskin Square to Cherry Orchard Road

As part of the proposals for a bridge over the railway line to the North of East Croydon station we have proposed a pipework link crossing integrated within the structure of the bridge. If this requirement can be incorporated in the design then provision can be made of access pull out panels and platforms etc.

Wellesley Road Green Energy Spine

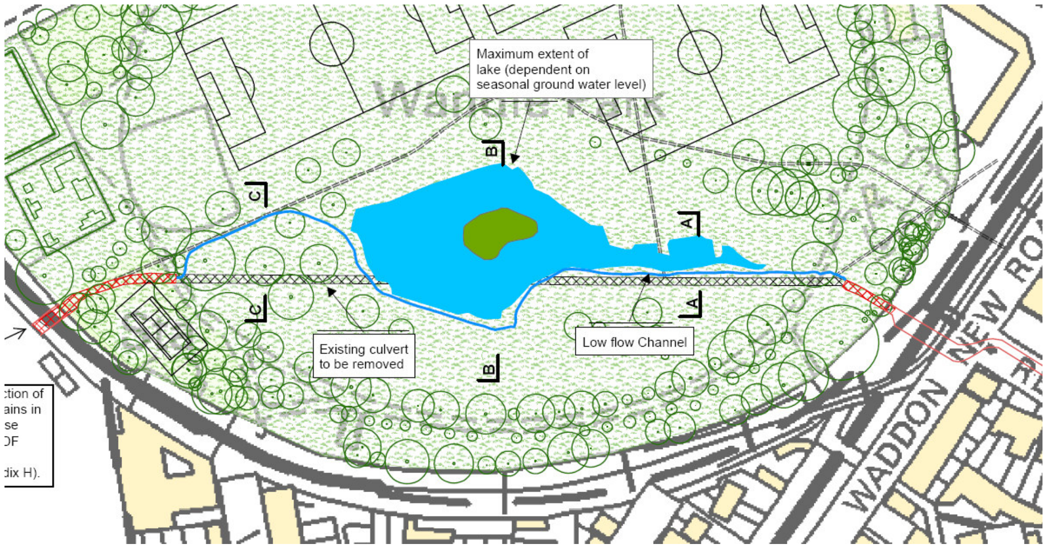
The Wellesley Road green energy spine will be integrated within the masterplan proposals for Wellesley Road. A multi-service trench with potential for both wet and dry services will run down the centre of Wellesley Road, with access panels along its length.

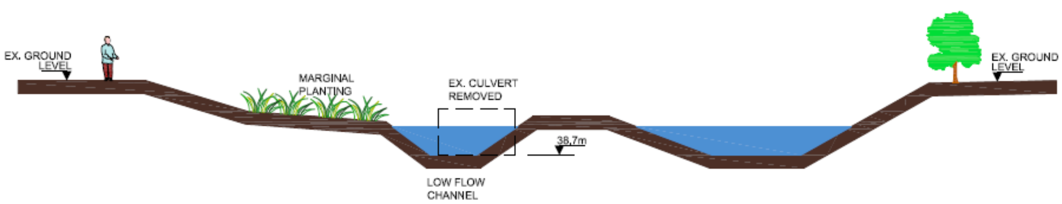


Rolls Royce Power Station Connection

Roll Royce to Wandle Park

The proposed pipework route from the Rolls Royce power station to the West side of Wandle Park would be along the side of the railway lines. These exposed services would be reasonably accessible.





SECTION A - A

Crossing Wandle Park

There is a proposal to use the River Wandle culverts crossing under Wandle Park as energy pipework corridors. At this point it is our understanding that the culverts are relatively small compared to their size further downstream and is not large enough for a maintenance person to walk down. Therefore lift off access panels will be required along its length.

Croydon Flyover

Once the pipework network has reach the elevated Croydon Flyover the pipework could potentially be run on the underside of the Croydon Flyover structure. These exposed services would be reasonably accessible.

Section L – Business Case, Energy Services Contracts and Risk Analysis

Estimates the costings together with potential incomes streams for each scenario

1. Business Case

This section describes the business case models that have been set up to establish the commercial viability of the various CHP options.

A number of assumptions have been made to develop the business case.

The two business case models consider CHP power output differently. The prudent model views CHP power output as meeting base heat load matched to the demand and has an utilisation factor of 2.5. (Electrical power output 42 MWe p.a. total). The optimistic model assumes CHP output delivers 70% of heat consumption regardless of the power network demand and has an utilisation factor of 8.0. (Electrical power output 134 MWe p.a. total). The supporting documentation relates to the electrical power output of 42MWe at Utilisation Factor 2.5.

The Energy Centre business case models can stand alone as three separate EC or be interconnected to provide resilience or to defer future energy equipment capex and improve plant utilisation. The models take a prudent view. The optimistic view would need a value engineering exercise applied to identify deferred capex to improve IRR toward that shown in table 1. There has been no phasing of capital spend.

The initial economic models showed that the schemes would not be attractive enough to proceed with private sector finance. The model therefore assumes that the projects will attract a grant and the balance is an equity / loan mix. The numbers are bases on a 70:30 split, i.e. 30% grant funding. The loan period is set at 15 years at a nominal 3.5% interest rate.

The district heating main infrastructure spine is sized to be flexible on where heat is input into the system.

The EC plant is modular based on $2MW_e$ CHP engines delivering $2.1MW_{th}$ with a total efficiency of 77%; 2MW gas fired boilers with 88% efficiency; 4 x $50m^3$ thermal store.

CHP is sized to meet base load which is taken as 20% of peak demand.

All electrical power is sold at the EC boundary under a Power Purchase Contract (PPC) negotiated with a licensed supplier. There has been no electrical network design provided to consider separation of private wire to commercial premises and licensed network to other premises. The electrical capex includes 2 x 33kV primary substations but excludes any off site works and connections to the existing distribution system. The Capex associated with the electricity network is excluded from the business models to reflect that electricity distribution revenues are never linked to generation and / or supply underpinned by legislation. (Utilities Act 2000).

The onsite distribution network is operated by a Licensed Distribution Network Operator. Customers contract supplies with their choice of supplier.

Heat selling price has been set at 5.1p/kWh which reflects both fuel, maintenance and avoided capital costs. Gas purchase price for the primary fuel CHP and boilers is £21 / MWh. Heat unit sales price would need to link to gas purchase. The power purchase price is set at 5.9p / kWh and will be dependent upon market demand and consistency of power output.

Cooling would need to be sold for 1.38 p / kWh to be competitive with electric chillers due to the lower COP of absorption chillers taking heat at 95°C. As a result the supply of cooling was not found to be economic.

It should be noted that the models take no account of phasing within each cluster zone and the bulk of the connections within each zone occur on the first 3 years of commencement. The capex is front loaded which impacts significantly on the IRR for each of the two scenarios.

The appendices show some further detail on the cashflows.

Appendix L1 - Energy Centre Zone 1 Summary

Appendix L2 - Energy Centre Zone 2 Summary

Appendix L3 - Energy Centre Zone 3 Summary

Appendix L4 - Single Energy Centre Summary

The option of heat from the Rolls Royce power station has not been analysed in detail due to the uncertainties on the costs that would result from extended operating hours. However, there is the potential for this option to deliver a limited amount of heat to the scheme for a modest capital cost of £2.1m (less than 5% of the cost for the full build-out of the scheme). The heat purchase price would be similar to the heat supplied by gas-engine CHP but the capital cost per MW of heat capacity is much less. Hence it is recommended that this option is pursued further through discussions with Rolls Royce Power Ventures Ltd.

Business Model Summary Table 1

Business Model Croydon Decentralised Energy Scheme

	Capex	Grant	Steady state income	Steady State Cost	IRR over 25 year term
EC Zone 1	-£17,784,145	£5,000,000	£4,142,442	-£2,613,678	7.19%
EC Zone 2	-£8,219,865	£2,500,000	£2,028,145	-£1,351,872	3.98%
EC Zone 3	-£15,742,004	£5,000,000	£3,513,547	-£2,313,633	7.02%
Single Energy Centre	-£41,746,013	£15,000,000	£5,541,693	-£3,665,504	7.82%
RR Heat connection	-£2,126,832	-	-	-	-

Table 1 - Data is based on a CHP Utilisation Factor of 2.5

Business Model Croydon Decentralised Energy Scheme

	Capex	Grant	Steady state income	Steady State Cost	IRR over 25 year term
EC Zone 1	-£17,784,145	£5,000,000	£6,547,191	-£3,774,106	16.24%
EC Zone 2	-£8,219,865	£2,500,000	£3,259,392	-£1,946,018	11.03%
EC Zone 3	-£15,742,004	£5,000,000	£5,695,304	-£3,412,893	15.65%
Single Energy Centre	-£41,746,013	£15,000,000	£8,954,696	-£5,358,911	16.52%
RR Heat connection	-£2,126,832	-	-	-	-

Table 2 - Data is based on a CHP Utilisation Factor of 8

CAPEX summary

Capex Summary

	Electric	Plant	District Pipework	Sub Total	Contingency	Prelims	Total
Zone 1	£4,704,100	£11,783,200	£1,503,296	£17,990,596	£1,799,060	£2,698,589	£22,488,245
Zone 2	£489,350	£5,893,300	£584,722	£6,967,372	£696,737	£1,045,106	£8,709,215
Zone 3	£4,458,430	£11,124,100	£577,817	£16,160,347	£1,616,035	£2,424,052	£20,200,434
Total	£9,651,880	£28,800,600	£2,665,835	£41,118,315	£4,111,831	£6,167,747	£51,397,893
Lnk 1 - 2			£250,800	included in 1 - 2 in costs			
Lnk 1 - 3				included in 1 - 2 costs			
Lnk 2-3			£113,160	included in Zone 3 costs			
RR				£2,126,832			£2,126,832
total	£9,651,880	£28,800,600	£3,029,795	£43,245,147	£4,111,831	£6,167,747	£53,524,725

2. Types of Contracts

The feasibility of an energy services company (ESCO) entering into a public private partnership (PPP) to deliver a decentralised energy network to buildings in the town centre and any viable outlying residential areas, in particular considering an estimation of public sector funding and development intervention by the LDA that would be required to deliver a commercially attractive scheme.

This section looks at the feasibility of an Energy Services Company (ESCo) entering into a Public Private Partnership (PPP) to deliver a decentralised energy Network

There are 5 levels of activity to consider Design, Build, Own, Operate and Maintain. The ESCo label is applied to all of these but can mean different things to different clients. It is important that the client considers his preferences. At its minimum it is taken that an ESCO will operate and maintain a decentralised energy scheme at Croydon.

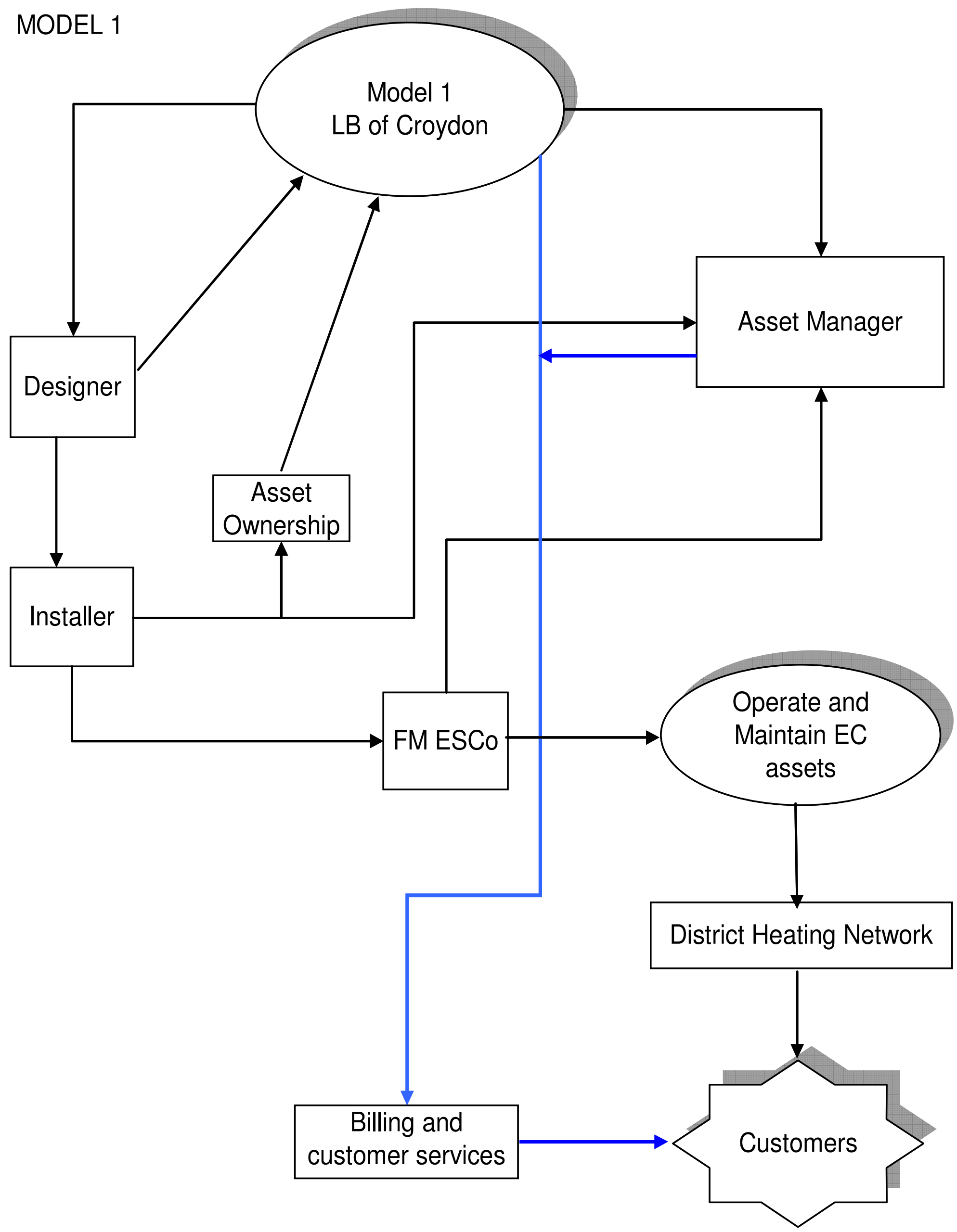
There are a number of models that can be considered. In the recent past, there was an appetite for capital funding schemes by the ESCO and this has been met with mixed approaches in the way that ESCo and the Client are prepared to manage the risk. Now, ESCos are not as prepared to fund schemes without security over the risk and investment periods that extend beyond 40 years. This has resulted in clients taking a different view over capital funding and the risk of tie in with an ESCo for this length of time.

There remains at a high level two possible models. In the first model the Client makes all the capital investment and contracts an ESCo to operate and maintain the energy centre and expects little or no return. The second is where the client makes an active investment expecting to see a return over time. The principle difference is that the former allows the client to enter into shorter term contracts (typically 3 – 5 years plus, say 1) with an ESCo who has no claim on or duty to the assets employed. The latter are longer term contracts where on going revenues fund capital replacement and fully support operating costs. Within the two structures there is an Asset Manager (AM) role which either acts directly for the client (in the first case) or on behalf of the ESCo.

Whichever model is employed there are benefits and disadvantages. When considering the AM function, under model 1 the client needs to decide whether to appoint the AM to procure the installer, procure the operator, manage the billing and customer interface, distributing revenues and passing surpluses to the client for a management fee or in model 2 vests the AM role in the ESCO. Model 2 aligns itself more closely to a public private partnership (PPP) where an investment is made into the PPP from a Developer Consortium, London Borough of Croydon (LBC), public sector funding from the LDA and investment from other bodies including the ESCo itself. The capital funding can be equity or debt supported by a suitable structure that manages the areas of identified risk. If a de centralised scheme is viable it is assumed that LB of Croydon would be a major backer of any scheme.

The diagram below of Model 1 shows the relationship between LBC and other parties to perform the functions described above.

MODEL 1


Model 1
LB of Croydon
Asset Manager
Designer
Asset
Ownership
Installer
FM ESCo
Operate and
Maintain EC
assets
District Heating Network
Billing and
customer services
Customers

The next level to consider is design and build. If model 2 is adopted then it is highly likely (and preferable) that the ESCo partners (for the purpose of reference a working name of Croydon JV – CJV is now used) undertakes design or at a minimum approves any design with modifications if appropriate. This is important if CJV are expected to guarantee performance and delivery of heat to end users. CJV could also operate any district heating network for the delivery of heat from the EC to the customer. Under model 1 guarantees of performance remain with the client and the liabilities with their appointed designer (who may or may not be the asset manager). LBC will have a closer if not direct relationship to the end user customers as it would not be desirable for the FM ESCo operator to have access to the commercial arrangements that LBC will have in place. The likelihood is that the timing of the asset manager appointment is later in the process in model 1 as focus would need to be on the design and related network modelling.

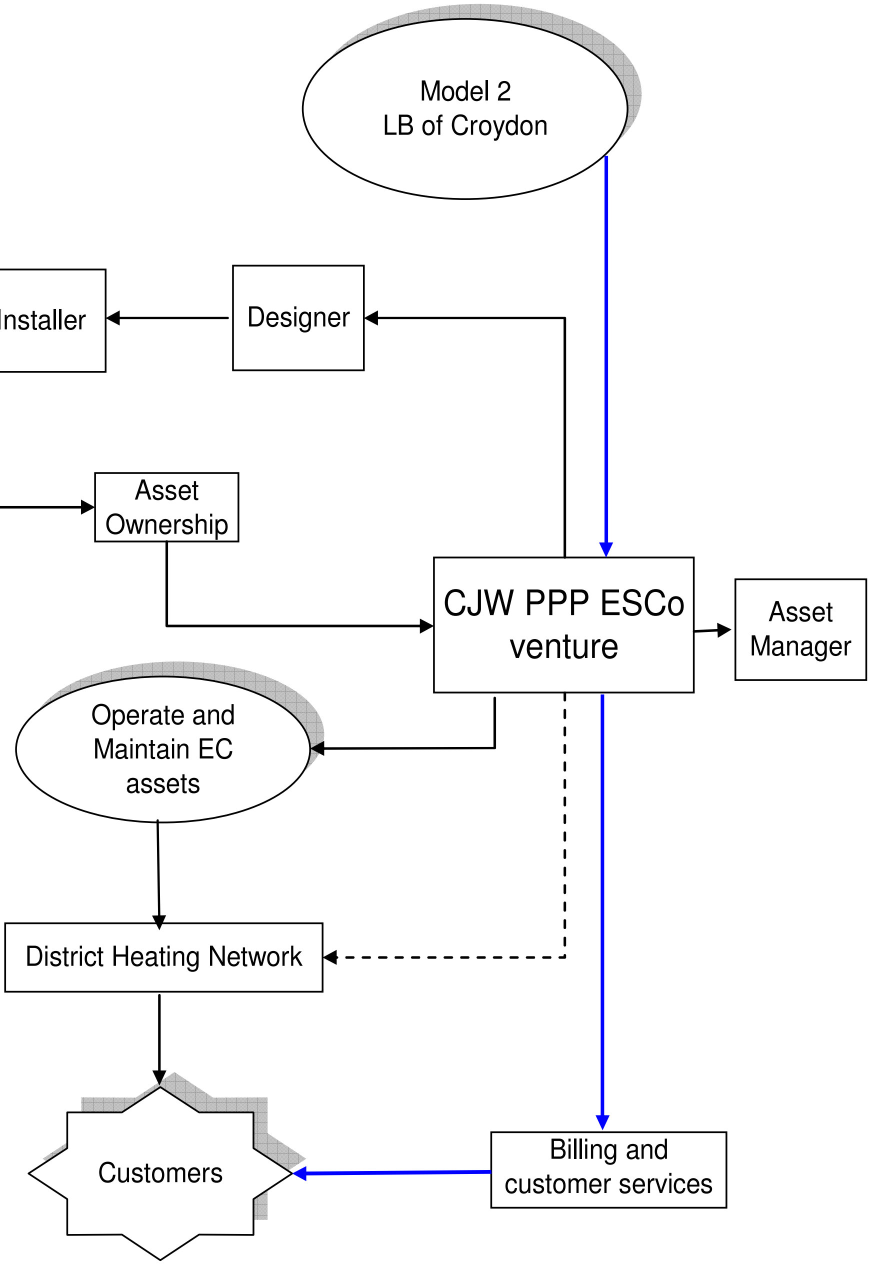
Combining the ESCo and AM role is an option but moves the solution toward Model 2 without addressing LBC funding aspirations and the relationship with end user customers.

Separating heat distribution from heat production and operating as a different facility is viable providing that heat sales remains with the heat producer. Heat network distribution, unlike power or gas networks, is an unlicensed activity but the costs of distribution can be structured in a way that reflects a licensing regime and provides protection for customers.

A customer should be protected from monopoly pricing and maintain a relationship with the energy producer. Gas and electric customers generally are protected by a competitive market so similar protection is needed here but without a choice of supplier. This is another reason why the PPP CJV model is preferred as it creates distance between LBC and any dissatisfied customers. It also allows LBC to create an exit strategy and recover any debt or loan and liquidate any equity.

Model 2 shown below places LBC away from the direct customer interface. Customers will always deal with the party to whom they pay their bills. The model aims to reflect as closely as possible the arrangements in the power and gas industry. It is not really conceivable that the FM ESCo becomes responsible for all the billing transactions and has visibility of the overall profitability.

MODEL 2


Model 2
LB of Croydon
Installer
Designer
Asset
Ownership
CJW PPP ESCo
venture
Asset
Manager
Operate and
Maintain EC
assets
District Heating Network
Customers
Billing and
customer services

Building the EC plant can be contracted to any suitably skilled M&E contractor. The ESCo specialist skill is not building the plant although it may be a prerequisite from LBC that the installation contractor is appointed early. Logically this suggests that a scheme design is needed which leads toward a model 1 option which is not conducive to the PPP solution. The client needs to be comfortable that selection of who to build the energy centre is addressed as a part of a second stage procurement strategy.

Experience tells us that a model 2 solution allows for a more flexible funding option. The design allows in a higher transfer of risk to the CJV away from LBC. In those cases where the ESCo avoids a higher proportion of risk, he is likely to secure recovery of his investment ahead of the longer term CJV interest. The ESCo AM fees form a large proportion of his income so the JV starts to reflect model 1 where operating the asset becomes separated from managing the asset.

Model 1 would be funded entirely by LBC with a high up front capital contribution for any of the four options discussed in section 3F.

Model 2 allows for funding to be a mix of debt and equity between CJV, LBC, LDA and third party funders. Some equity should be held back to allow for either future funding as the development builds out or for debt to equity swap. The ESCo partner may be prepared to fund a proportion of the initial capital but should be incentivised with an equity stake (whether gifted or bought) to deliver CJV into profitability. The model we develop in the next phase will show capital costs attributable to the different works, but there should be no expectation that the future revenues from heat and power sales will fund the construction of the energy distribution networks.

As it has been pointed out previously the high capital investment required at the front end does not start to deliver reliable revenue streams for some years. The aspiration for a decentralised energy scheme providing distributed heat, cooling and potentially power rests with LBC and the planning authorities. Developers will buy into a scheme if it is a condition rather than optional and are prepared to fund distribution assets required on any development phase. A developer may provide funding through a S106 obligation for the Energy Centre(s).

3. Comparison between ESCo and Facilities Management Type Contracts

There are a number of contract possibilities that can be considered. Section 2 above makes reference to two high level models each with its own risks to consider.

This section attempts to highlight some of the key risks and guide LBC to select one or the other business model based upon their preferred risk profile. The paper does not attempt to detail any risk management strategies.

Model 1 – FM role

- Client owns equipment the FM operates and maintains energy supply plant and associated distribution networks only.
- FM does not guarantee energy supplies. It provides the agreed services to meet KPIs set by Client.

Model 2 – CJV PPP

- ESCo owns, operates and maintains energy supply plant and associated distribution networks.
- ESCo guarantees energy supplies in accordance with contract terms including pricing and performance SLAs.

• Client bears all initial capital cost. FM recovers its operational costs and profit from service charges set by Client.	• ESCo recovers return on its capital investment and ongoing operational costs through the Client's contribution and tariff charges (standing and metered) over an agreed concession period.
• Client responsible for energy supply asset replacement strategy. FM to deliver its service irrespective of replacement strategy.	• ESCo chooses optimal replacement strategy for energy supply assets to meet the SLA requirements and deliver a return on investment.
• Client bears risk of early asset replacement.	• ESCo will bear all, or majority of, risk of early asset replacement depending on contractual terms.
• Client receives all tariff income and responsibility for associated debt. FM undertake billing but not bad debt liability.	• ESCo receives all tariff income revenue a proportion of which can be shared with Client. ESCo manages bad debt liability.
• Client bears risk in fluctuation of wholesale fuel costs.	• ESCo manages risk in fluctuation of wholesale fuel costs.
• FM has no requirement for capital investment.	• ESCo tends to have easier access to financial resources (off balance sheet).
• FM can exploit economies of scale in market place to deliver more efficient operational costs only.	• ESCo can exploit economies of scale in market place to deliver more efficient capital and operational costs.

The above table charts comparisons in key areas. However model 1 clearly places anumber of the risks upon the Client (LBC).

A number of further considerations need to be made which apply across both models.

- Price control, charging methodology and structure of charges; who sets these?
- Duration of the concession period, period extension and exit strategy at the end of the concession period
- Different financial models exist for each option as model 1 over shorter period would not include plant replacement and whole lifecycle cost
- Level of capital contribution available or required
- Completion of valuation schedules
- Proposed ESCo structure and financial security
- Proposed financing arrangements and capital funding
- Proposals to fulfil Section 106 obligations
- Delivery plan and programme
- Proposed operating arrangements

These can be summarised into

1. Tenant Risks
    - Increases in fixed charges (funding of asset replacement costs/ non realisation of anticipated revenue)
    - Tariffs
    - Comparison with market rates
    - Quality and reliability of service provided
    - Where do I go when things go wrong?

2. Landlord Risks
    - Absorbing or passing on increases in fixed charges costs (funding of asset replacement costs/ non realisation of anticipated revenue)
    - Setting market reflective tariffs
    - Maintaining Quality of service
    - Costs associated with non occupancy
    - Funding of replacement of plant failure before the end of it life cycle
    - Ownership of assets on termination
    - CRC Energy Efficiency Scheme Liabilities

There are 5 key questions

1. What risk does LBC want to carry in regard to design, programme and funding?
2. What is LBC preferred option in regard to capital contributions and fixed / standing charges for tenants?
3. Are LBC seeking any tax benefits (from ECA for example)?
4. Are LBC prepared to take on the risk of tariff management?
5. Do LBC want a long term stake or an exit strategy to suit them?

In addition to this LBC will have to consider what procurement strategies the wish to adopt.

In summary these are the risk exposures and where they might reside.

	LBC	**Model 2 CJV PPP**
1	Maintains supply equipment	Owns and maintains supply equipment
2	Provides the agreed services to meet KPIs	Guarantees supply in accordance with contract terms
3	Recovers ongoing costs from service charges. Client bears all initial capital cost.	Recovers costs through clients contribution to initial capital investment and tariff charges
4	Assets replaced at landlord's instigation	Assets replaced at their discretion
5	Client bears risk of early asset replacement	Bears risk of early asset replacement
6	Client receives all tariff income	Receives all tariff income
7	Client bears variation in tariff income	Bears variation in tariff income
8	Client provides billing and customers services and has the contract relationship the tenants	Acts as an energy supplier for heat (and possibly power)

Capabilities on project:
Energy
Environment

Appendix L1

Energy Centre Zone 1 Summary

District Heating yr	0	2012	2013	2014	2015	2016	2017	2018	2019	2020
annual consumption MWh EC zone 1		0	19254	36854	42244	44246	54281	54281	54281	54281
income (£)		0	1,078,204	2,055,816	2,354,351	2,467,541	3,049,374	3,049,374	3,049,374	3,049,374
expenditure(£)		0	-620,408	-1,189,316	-1,363,783	-1,428,021	-1,746,961	-1,746,961	-1,746,961	-1,746,961
Cooling yr		2012	2013	2014	2015	2016	2017	2018	2019	2020
Power yr		2012	2013	2014	2015	2016	2017	2018	2019	2020
annual consumption MWh EC zone 1		0	6283	12567	14559	15132	17097	17097	17097	17097
income (£)		0	401,690	803,450	930,839	967,490	1,093,068	1,093,068	1,093,068	1,093,068
expenditure(£)		£0	-£571,796	-£743,175	-£797,515	-£813,149	-£866,717	-£866,717	-£866,717	-£866,717
interest charges (£)			-£134,234	-£134,234	-£134,234	-£134,234	-£134,234	-£134,234	-£134,234	-£134,234
total income (£)		0	1,479,894	2,859,266	3,285,189	3,435,030	4,142,442	4,142,442	4,142,442	4,142,442
total costs (£)		0	-1,326,438	-2,066,724	-2,295,532	-2,375,403	-2,747,911	-2,747,911	-2,747,911	-2,747,911
margin		£0	£153,456	£792,542	£989,658	£1,059,627	£1,394,530	£1,394,530	£1,394,530	£1,394,530
CAPEX		-£17,784,145								
Grant Funding		£5,000,000								
Loan repayment			-	-	-	-	-	-	-	-
CASHFLOW		-£12,784,145	-£12,630,689	-£11,838,147	-£10,848,490	-£9,788,863	-£8,394,332	-£6,999,802	-£5,605,272	-£4,210,741
IRR 7.186%										

District Heating yr	2021	2022	2023	2024	2025	2026	2027	2028	2029
annual consumption MWh EC zone 1	54281	54281	54281	54281	54281	54281	54281	54281	54281
income (£)	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374
expenditure(£)	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961
Cooling yr	2021	2022	2023	2024	2025	2026	2027	2028	2029
Power yr	2021	2022	2023	2024	2025	2026	2027	2028	2029
annual consumption MWh EC zone 1	17097	17097	17097	17097	17097	17097	17097	17097	17097
income (£)	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068
expenditure(£)	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717
interest charges (£)	-£134,234	-£134,234	-£134,234	-£134,234	-£134,234	-£134,234	-£134,234		
total income (£)	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442
total costs (£)	-2,747,911	-2,747,911	-2,747,911	-2,747,911	-2,747,911	-2,747,911	-2,747,911	-2,613,678	-2,613,678
margin	£1,394,530	£1,394,530	£1,394,530	£1,394,530	£1,394,530	£1,394,530	£1,394,530	£1,528,764	£1,528,764
CAPEX									
Grant Funding									
Loan repayment	-	-	-	-	-	-	-	-£3,835,244	-
CASHFLOW	-£2,816,211	-£1,421,681	-£27,150	£1,367,380	£2,761,911	£4,156,441	£5,550,971	£7,079,735	£8,608,499
IRR **7.186%**									

District Heating yr	2030	2031	2032	2033	2034	2035	2036	2037
annual consumption MWh EC zone 1	54281	54281	54281	54281	54281	54281	54281	54281
income (£)	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374	3,049,374
expenditure(£)	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961	-1,746,961
Cooling yr	2030	2031	2032	2033	2034	2035	2036	2037
Power yr	2030	2031	2032	2033	2034	2035	2036	2037
annual consumption MWh EC zone 1	17097	17097	17097	17097	17097	17097	17097	17097
income (£)	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068	1,093,068
expenditure(£)	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717	-£866,717
interest charges (£)								
total income (£)	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442	4,142,442
total costs (£)	-2,613,678	-2,613,678	-2,613,678	-2,613,678	-2,613,678	-2,613,678	-2,613,678	-2,613,678
margin	£1,528,764	£1,528,764	£1,528,764	£1,528,764	£1,528,764	£1,528,764	£1,528,764	£1,528,764
CAPEX								
Grant Funding								
Loan repayment	-	-	-	-	-	-	-	-
CASHFLOW	£10,137,263	£11,666,027	£13,194,791	£14,723,555	£16,252,318	£17,781,082	£19,309,846	£20,838,610
IRR **7.186%**								

Appendix L2

Energy Centre Zone 2 Summary

District Heating yr	0	2012	2013	2014	2015	2016	2017	2018	2019	2020
annual consumption MWh EC zone 2		2938	5106	6906	7133	7133	17362	26207	26207	26207
income (£)		164,338	285,603	385,803	402,931	402,931	971,276	1,468,487	1,468,487	1,468,487
expenditure(£)		-94,690	-164,579	-222,713	-229,993	-229,993	-560,635	-845,164	-845,164	-845,164
Cooling yr		2012	2013	2014	2015	2016	2017	2018	2019	2020
Power yr		2012	2013	2014	2015	2016	2017	2018	2019	2020
annual consumption MWh EC zone 2		969	1686	2313	2359	2359	6007	8754	8754	8754
income (£)		61,966	107,788	147,912	150,809	150,809	384,052	559,658	559,658	559,658
expenditure(£)		-£294,407	-£313,953	-£331,069	-£332,305	-£332,305	-£431,799	-£506,708	-£506,708	-£506,708
interest charges (£)		-£60,059	-£60,059	-£60,059	-£60,059	-£60,059	-£60,059	-£60,059	-£60,059	-£60,059
total income (£)		226,304	393,390	533,715	553,741	553,741	1,355,328	2,028,145	2,028,145	2,028,145
total costs (£)		-449,156	-538,591	-613,841	-622,357	-622,357	-1,052,493	-1,411,930	-1,411,930	-1,411,930
margin		-£222,852	-£145,200	-£80,125	-£68,616	-£68,616	£302,835	£616,215	£616,215	£616,215
CAPEX	-£8,219,865									
Grant Funding	2,500,000									
Loan repayment		-	-	-	-	-	-	-	-	-
CASHFLOW	-£5,719,865	-£5,942,717	-£6,087,917	-£6,168,042	-£6,236,658	-£6,305,274	-£6,002,438	-£5,386,223	-£4,770,008	-£4,153,794
IRR 3.977%										

District Heating	yr	2021	2022	2023	2024	2025	2026	2027	2028	2029
	annual consumption MWh EC zone 2	26207	26207	26207	26207	26207	26207	26207	26207	26207
	income (£)	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487
	expenditure(£)	-845,164	-845,164	-845,164	-845,164	-845,164	-845,164	-845,164	-845,164	-845,164
Cooling	yr	2021	2022	2023	2024	2025	2026	2027	2028	2029
Power	yr	2021	2022	2023	2024	2025	2026	2027	2028	2029
	annual consumption MWh EC zone 2	8754	8754	8754	8754	8754	8754	8754	8754	8754
	income (£)	559,658	559,658	559,658	559,658	559,658	559,658	559,658	559,658	559,658
	expenditure(£)	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708
	interest charges (£)	-£60,059	-£60,059	-£60,059	-£60,059	-£60,059	-£60,059			
	total income (£)	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145
	total costs (£)	-1,411,930	-1,411,930	-1,411,930	-1,411,930	-1,411,930	-1,411,930	-1,351,872	-1,351,872	-1,351,872
	margin	£616,215	£616,215	£616,215	£616,215	£616,215	£616,215	£676,273	£676,273	£676,273
CAPEX										
	Grant Funding									
	Loan repayment	-	-	-	-	-	-	-£1,715,959	-	-
CASHFLOW		-£3,537,579	-£2,921,364	-£2,305,149	-£1,688,934	-£1,072,719	-£456,504	£219,769	£896,043	£1,572,316
	IRR 3.977%									

District Heating	yr	2030	2031	2032	2033	2034	2035	2036	2037
	annual consumption MWh EC zone 2	26207	26207	26207	26207	26207	26207	26207	26207
	income (£)	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487	1,468,487
	expenditure(£)	-845,164	-845,164	-845,164	-845,164	-845,164	-845,164	-845,164	-845,164
Cooling	yr	2030	2031	2032	2033	2034	2035	2036	2037
Power	yr	2030	2031	2032	2033	2034	2035	2036	2037
	annual consumption MWh EC zone 2	8754	8754	8754	8754	8754	8754	8754	8754
	income (£)	559,658	559,658	559,658	559,658	559,658	559,658	559,658	559,658
	expenditure(£)	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708	-£506,708
	interest charges (£)								
	total income (£)	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145	2,028,145
	total costs (£)	-1,351,872	-1,351,872	-1,351,872	-1,351,872	-1,351,872	-1,351,872	-1,351,872	-1,351,872
	margin	£676,273	£676,273	£676,273	£676,273	£676,273	£676,273	£676,273	£676,273
CAPEX									
	Grant Funding								
	Loan repayment	-	-	-	-	-	-	-	-
CASHFLOW		£2,248,590	£2,924,863	£3,601,137	£4,277,410	£4,953,684	£5,629,957	£6,306,231	£6,982,504
	IRR 3.977%								

Appendix L3
Energy Centre Zone 3 Summary

District Heating	yr	0	2012	2013	2014	2015	2016	2017	2018	2019
annual consumption MWh EC zone 3			5388	18606	35832	45382	45382	45382	45382	45382
income (£)			291,829	1,030,734	1,990,259	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840
expenditure(£)			-177,109	-602,296	-1,158,509	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942
Cooling	yr		2012	2013	2014	2015	2016	2017	2018	2019
Power	yr		2012	2013	2014	2015	2016	2017	2018	2019
annual consumption MWh EC zone 3			2778	6898	12860	16195	16195	16195	16195	16195
income (£)			170,082	422,367	787,482	991,707	991,707	991,707	991,707	991,707
expenditure(£)			-£480,751	-£593,115	-£755,732	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691
interest charges (£)			-£112,791	-£112,791	-£112,791	-£112,791	-£112,791	-£112,791	-£112,791	-£112,791
total income (£)			461,911	1,453,101	2,777,741	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547
total costs (£)			-770,651	-1,308,202	-2,027,032	-2,426,424	-2,426,424	-2,426,424	-2,426,424	-2,426,424
margin			-£308,740	£144,899	£750,709	£1,087,124	£1,087,124	£1,087,124	£1,087,124	£1,087,124
CAPEX		-£15,742,004								
Grant Funding		5,000,000								
Laon Repayment			-	-	-	-	-	-	-	-
CASHFLOW		-£10,742,004	-£11,050,744	-£10,905,845	-£10,155,136	-£9,068,012	-£7,980,889	-£6,893,765	-£5,806,642	-£4,719,518
IRR	**7.015%**									

District Heating	yr	2020	2021	2022	2023	2024	2025	2026	2027	2028
annual consumption MWh EC zone 3		45382	45382	45382	45382	45382	45382	45382	45382	45382
income (£)		2,521,840	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840
expenditure(£)		-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942
Cooling	yr	2020	2021	2022	2023	2024	2025	2026	2027	2028
Power	yr	2020	2021	2022	2023	2024	2025	2026	2027	2028
annual consumption MWh EC zone 3		16195	16195	16195	16195	16195	16195	16195	16195	16195
income (£)		991,707	991,707	991,707	991,707	991,707	991,707	991,707	991,707	991,707
expenditure(£)		-£846,691	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691
interest charges (£)		-£112,791	-£112,791	-£112,791	-£112,791	-£112,791	-£112,791	-£112,791		
total income (£)		3,513,547	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547
total costs (£)		-2,426,424	-2,426,424	-2,426,424	-2,426,424	-2,426,424	-2,426,424	-2,426,424	-2,313,633	-2,313,633
margin		£1,087,124	£1,087,124	£1,087,124	£1,087,124	£1,087,124	£1,087,124	£1,087,124	£1,199,915	£1,199,915
CAPEX										
Grant Funding										
Laon Repayment		-	-	-	-	-	-	-	-£3,222,601	-
CASHFLOW		-£3,632,395	-£2,545,271	-£1,458,147	-£371,024	£716,100	£1,803,223	£2,890,347	£867,660	£2,067,575
IRR	**7.015%**									

District Heating	yr	2029	2030	2031	2032	2033	2034	2035	2036	2037
annual consumption MWh EC zone 3		45382	45382	45382	45382	45382	45382	45382	45382	45382
income (£)		2,521,840	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840	2,521,840
expenditure(£)		-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942	-1,466,942
Cooling	yr	2029	2030	2031	2032	2033	2034	2035	2036	2037
Power	yr	2029	2030	2031	2032	2033	2034	2035	2036	2037
annual consumption MWh EC zone 3		16195	16195	16195	16195	16195	16195	16195	16195	16195
income (£)		991,707	991,707	991,707	991,707	991,707	991,707	991,707	991,707	991,707
expenditure(£)		-£846,691	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691	-£846,691
interest charges (£)										
total income (£)		3,513,547	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547	3,513,547
total costs (£)		-2,313,633	-2,313,633	-2,313,633	-2,313,633	-2,313,633	-2,313,633	-2,313,633	-2,313,633	-2,313,633
margin		£1,199,915	£1,199,915	£1,199,915	£1,199,915	£1,199,915	£1,199,915	£1,199,915	£1,199,915	£1,199,915
CAPEX										
Grant Funding										
Laon Repayment		-	-	-	-	-	-	-	-	-
CASHFLOW		£3,267,490	£4,467,404	£5,667,319	£6,867,233	£8,067,148	£9,267,063	£10,466,977	£11,666,892	£12,866,806
IRR	**7.015%**									

Appendix L4

Single Energy Centre Summary

		0	2012	2013	2014	2015	2016	2017	2018	2019
District Heating	yr	0	2012	2013	2014	2015	2016	2017	2018	2019
	annual consumption MWh EC all zones		27580	60565	84982	96761	106795	117024	125869	125869
	income (£)		456,167	1,316,337	2,376,062	2,924,771	2,924,771	3,493,116	3,990,327	3,990,327
	expenditure(£)		-271,799	-766,875	-1,381,222	-1,696,935	-1,696,935	-2,027,577	-2,312,106	-2,312,106
Cooling	yr		2012	2013	2014	2015	2016	2017	2018	2019
Power	yr		2012	2013	2014	2015	2016	2017	2018	2019
	annual consumption MWh EC all zones		10,030	21,150	29,733	33,687	35,651	39,299	42,045	42,045
	income (£)		633,738	1,333,605	1,866,233	2,110,006	2,235,585	2,468,827	2,644,433	2,644,433
	expenditure(£)		-1,346,955	-1,650,243	-1,884,316	-1,992,145	-2,045,713	-2,145,207	-2,220,115	-2,220,115
	interest charges (£)		-£280,833	-£280,833	-£280,833	-£280,833	-£280,833	-£280,833	-£280,833	-£280,833
	total income (£)		2,168,109	4,705,757	6,596,646	7,502,319	8,209,730	9,011,317	9,684,134	9,684,134
	total costs (£)		-2,546,245	-3,913,517	-4,936,404	-5,424,184	-5,796,692	-6,226,828	-6,586,265	-6,586,265
	margin		-378,136	792,240	1,660,241	2,078,135	2,413,038	2,784,489	3,097,869	3,097,869
CAPEX		-£41,746,013								
	Grant Funding	15,000,000								
	Loan Repayment									
CASHFLOW		-£26,746,013	-£27,124,150	-£26,331,909	-£24,671,668	-£22,593,533	-£20,180,495	-£17,396,005	-£14,298,137	-£11,200,268
IRR	7.819%									

District Heating yr	2020	2021	2022	2023	2024	2025	2026	2027	2028
annual consumption MWh EC all zones	125869	125869	125869	125869	125869	125869	125869	125869	125869
income (£)	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327
expenditure(£)	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106
Cooling yr	2020	2021	2022	2023	2024	2025	2026	2027	2028
Power yr	2020	2021	2022	2023	2024	2025	2026	2027	2028
annual consumption MWh EC all zones	42,045	42,045	42,045	42,045	42,045	42,045	42,045	42,045	42,045
income (£)	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433
expenditure(£)	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115
interest charges (£)	-£280,833	-£280,833	-£280,833	-£280,833	-£280,833	-£280,833	-£280,833		
total income (£)	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134
total costs (£)	-6,586,265	-6,586,265	-6,586,265	-6,586,265	-6,586,265	-6,586,265	-6,586,265	-6,279,182	-6,279,182
margin	3,097,869	3,097,869	3,097,869	3,097,869	3,097,869	3,097,869	3,097,869	3,404,952	3,404,952
CAPEX									
Grant Funding									
Loan Repayment								-£8,023,804	
CASHFLOW	-£8,102,399	-£5,004,530	-£1,906,661	£1,191,208	£4,289,076	£7,386,945	£10,484,814	£5,865,962	£9,270,914
IRR 7.819%									

District Heating	yr	2029	2030	2031	2032	2033	2034	2035	2036	2037
	annual consumption MWh EC all zones	125869	125869	125869	125869	125869	125869	125869	125869	71588
	income (£)	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327	3,990,327
	expenditure(£)	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106	-2,312,106
Cooling	yr	2029	2030	2031	2032	2033	2034	2035	2036	2037
Power	yr	2029	2030	2031	2032	2033	2034	2035	2036	2037
	annual consumption MWh EC all zones	42,045	42,045	42,045	42,045	42,045	42,045	42,045	42,045	24,949
	income (£)	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433	2,644,433	1,551,365
	expenditure(£)	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-2,220,115	-1,353,398
	interest charges (£)									
	total income (£)	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134	9,684,134	5,541,693
	total costs (£)	-6,279,182	-6,279,182	-6,279,182	-6,279,182	-6,279,182	-6,279,182	-6,279,182	-6,279,182	-3,665,504
	margin	3,404,952	3,404,952	3,404,952	3,404,952	3,404,952	3,404,952	3,404,952	3,404,952	1,876,188
CAPEX										
	Grant Funding									
	Loan Repayment									
CASHFLOW		£12,675,866	£16,080,818	£19,485,770	£22,890,722	£26,295,674	£29,700,626	£33,105,578	£36,510,530	£38,386,718
IRR	7.819%									

Section M

Estimates potential carbon savings achieved by the envisaged decentralised energy scenario(s) compared to conventional systems.

Current CO_2 emissions within Croydon

The data available from DECC has enabled the total CO_2 emissions of the Borough to be calculated, principally from the consumption of gas and electricity.

	tonnes CO2 p.a.
Total gas use domestic	*499,428*
Total gas use non-domestic	*110,871*
Total elec use domestic	*338,531*
Total elec use non-domestic	*390,392*
TOTAL for Borough	*1,339,221*

This data is shown graphically in Figure M1.

The CO_2 emissions associated with the heat demand is largely the gas emissions which is about 610,000 tonnes p.a. the majority of which is in the domestic sector.

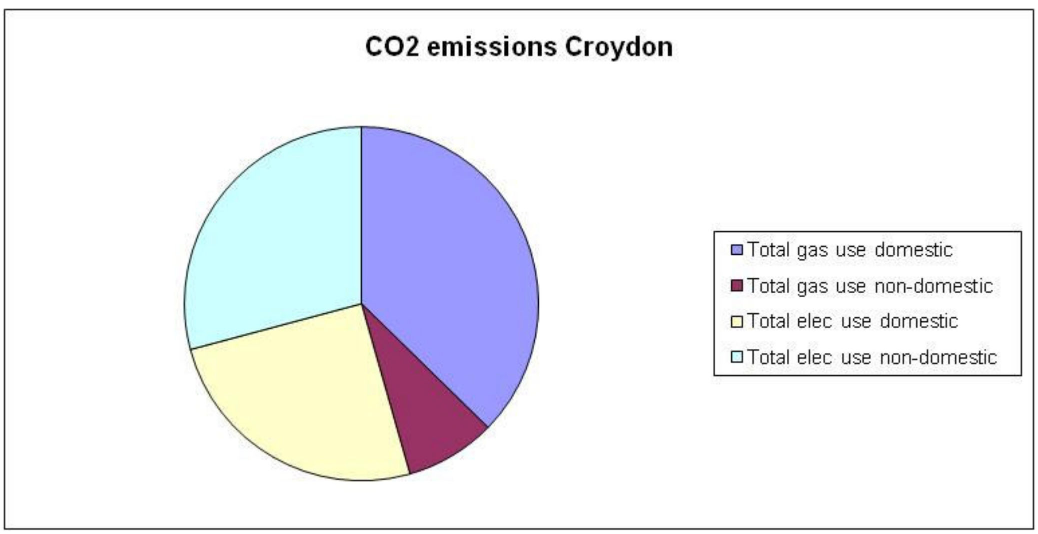


Figure M.1 – Croydon Carbon Emissions

There is an approximately equal split between the CO_2 associated with space and water heating (derived from gas) and electricity use, especially as some electricity use may be used for space or water heating. The CO_2 associated with domestic gas use is much larger than that of the non-domestic buildings. Although much of the housing is in lower density areas and less suitable for district heating any opportunity to supply the domestic sector should be taken as this is a major element of the emissions.

CO_2 benefits from CHP

CHP systems can produce heat with a low CO_2 content as the CHP process is more energy efficient than the production of electricity at power stations and heat in boilers. The energy efficiency improvement is about 30% and is illustrated in Figure M.2 which shows that an energy input of 100 units for a CHP system delivers heat and power that would need 140 units from conventional sources.

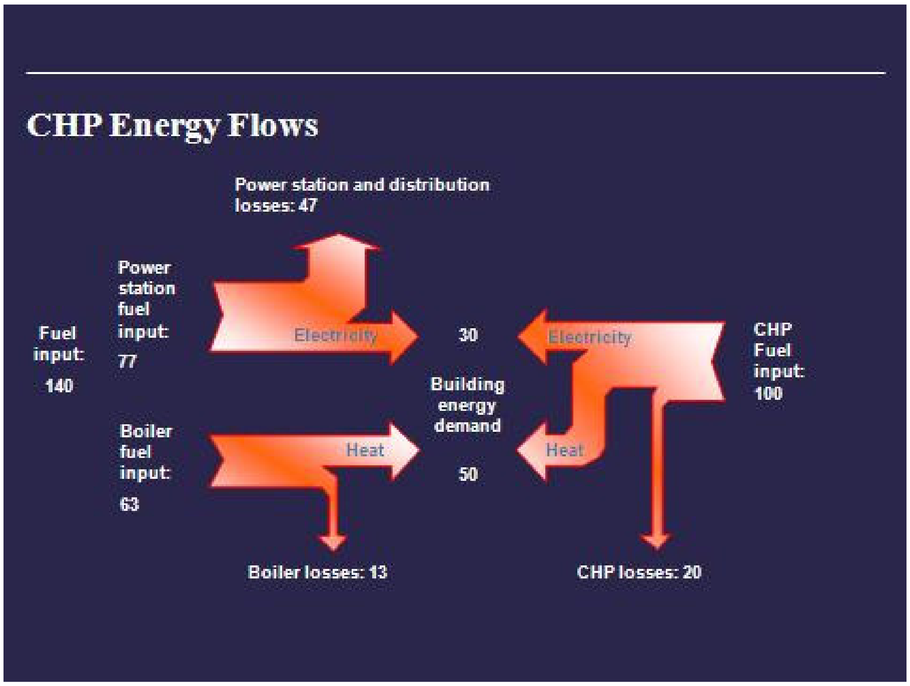


Figure M2 – Energy Efficiency of CHP

In addition to this benefit, there is a further benefit from the use of gas-fired CHP which is the displacing of coal-fired power stations. As electricity from coal-fired power stations has a much higher CO_2 content than gas-fired electricity production (even from smaller-scale less efficient systems such as gas-engine CHP) there is an added benefit from the operation of CHP. This second benefit will however reduce in time as the coal-fired power stations are closed down.

The CO_2 savings can be quantified by defining the CO_2 content of heat from CHP as follows:

CO_2 content of heat equals CO_2 emitted from gas used in CHP less CO_2 displaced at power stations by the electricity generated by CHP divided by heat supplied by the CHP.

This CO_2 content per unit of heat supplied can then be compared with the CO_2 content of heat supplied from other heating systems.

A critical part of the calculation is the emissions factor used in calculating the CO_2 displaced from power stations. As the mix of power stations changes this factor will also change. Figure M3 shows how the CO_2 content of heat from CHP will vary with the grid emissions factor assumed. At present the average grid emissions factor is about 520g/kWh and the power stations displaced by CHP will generally have a higher figure. In the longer term an emissions factor of 430g/kWh is predicted as used by the Government in national analysis of future CO_2 savings.

Figure M3 also shows the benefits of improving the electrical efficiency of the CHP systems, Typically an efficiency of 37% will be achieved for larger gas-engines or gas turbine supplying district heating.

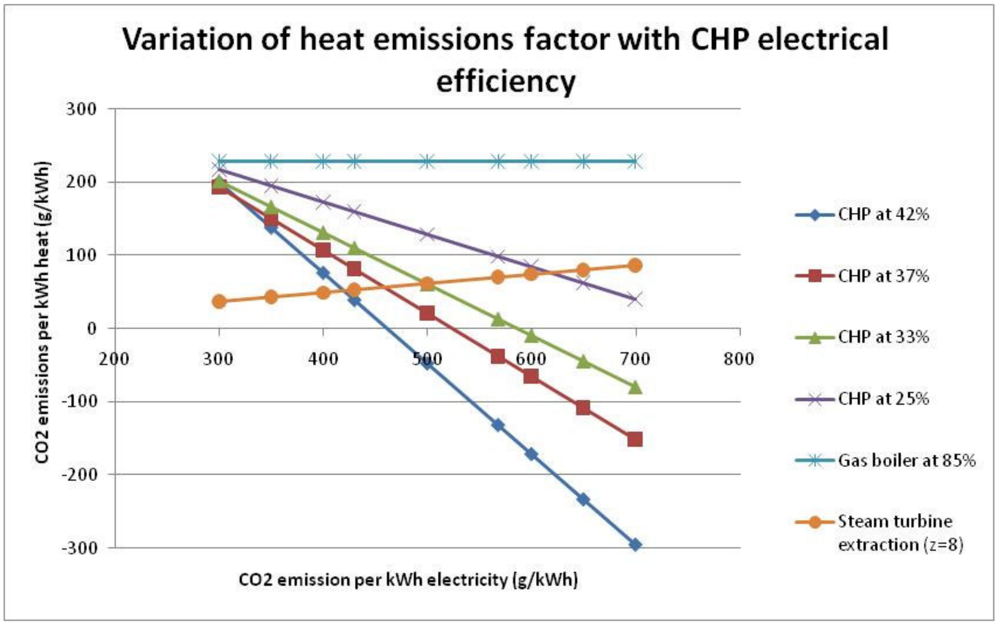


Figure M3 – CO_2 content of heat from CHP

The graph also shows the CO_2 emissions from heat extracted from a steam turbine based CHP system. This could be from a large energy from waste plant, a biomass-fired power station or a combined cycle gas turbine power station. It can be seen that in the longer-term when the electricity emission factor will be lower the steam turbine CHP systems would deliver lower CO_2 emissions.

If an emissions factor of 520g/kWh is assumed then the CO_2 content of the CHP heat will be about zero compared to around 220g/kWh for heat from gas boilers.

The analysis shows that for all three Zones supplied by gas-engine CHP heat delivering about 70% of the annual heat demand the CO_2 saving is 36,993 tonnes p.a. This is approximately a third of the total emissions associated with heat from the non-domestic buildings sector.

CO_2 savings from absorption chillers

The district heating supply can also be used to generate CO_2 savings through the use of absorption chillers. Again, the level of saving is dependent on the emissions factor for electricity.

At 500g/kWh electricity emissions factor the heat from CHP has a CO_2 content of around 40g/kWh. The CoP of a single effect absorption chiller is about 0.67 so the CO_2 content of cooling from a CHP/absorption chiller combination will be about 60g/kWh. This can be compared with the CO_2 content of cooling from a vapour compression chiller with a CoP of say 4 which at 500g/kWh electricity emissions factor would be 125g/kWh. There is therefore the potential for a 50% saving in CO_2 emissions from the supply of cooling from the CHP system.

However, as the grid emissions factor falls there will be a reduction in this saving as illustrated on the figure 8.4. At about 430g/kWh there will be negligible CO_2 savings.

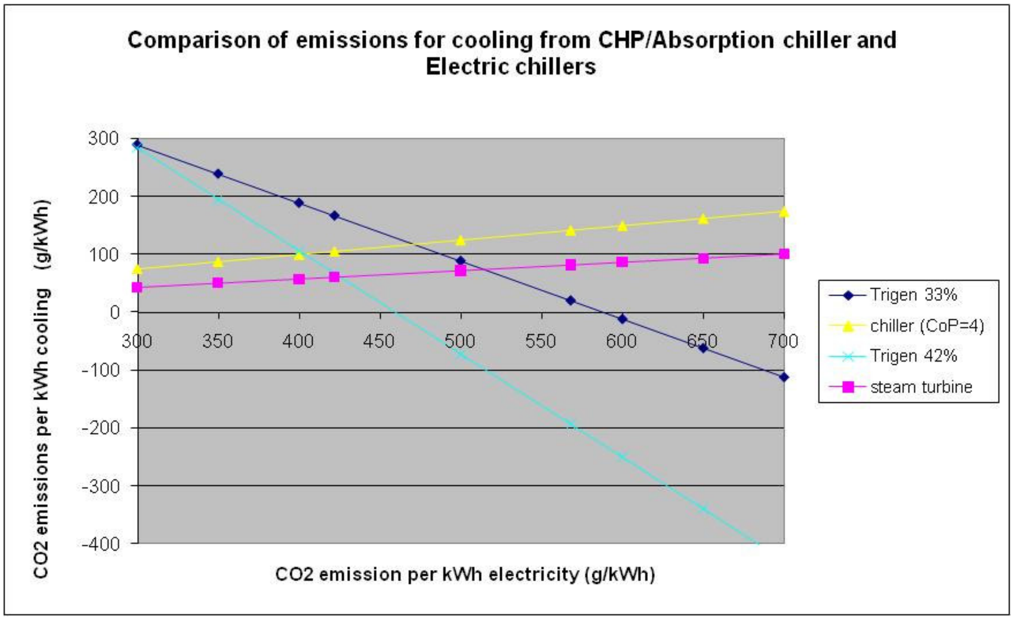


Figure 8.4 – Emissions savings from CHP and absorption chillers

CHP/DH should be seen as only one element of a strategy to reduce CO_2 emissions in the Borough and reductions in energy use through energy efficiency measures also need to be encouraged.

Project:	**Croydon Decentralised Energy Study**	Job No:	**60103445**
Subject:	**Draft Note about Initial CHP and District Heating Network sizing for Croydon Energy Clusters**		
Prepared by:	**Noah Nkonge**	Date:	**11th December 2009**
Checked by:	**Peter Concannon**	Date:	**11th December 2009**
Approved by:		Date:	

Development of monthly Energy demand Profiles

Assumptions
Residential developments are assumed to be new flats

Table 1 shows the assumed split of the annual heating demand and DHW based on our past experience and building models.

Table 1 – Assumed split of annual heating demand between space heating and DHW

55%	% of new office annual heat demand attributable to Space heating
45%	% of new office annual heat demand attributable to DHW
54%	% of new residential annual heat demand attributable to Space heating
46%	% of new residential annual heat demand attributable to DHW
95%	% of Space heating demand for existing & other buildings
5%	% of DHW demand for existing & other buildings

Profile Generation
In order to carry out CHP modelling, it was necessary to create a monthly profile describing the energy demands in terms of space heating, DHW, cooling and electricity for each energy cluster. A brief explanation of how these profiles are derived is given below.

New office – monthly profile of space heating and DHW use is based on previous IES model of a proposed office building. The monthly space heating and DHW demands falling in each month were calculated as a percentage of the annual demand from this model and these percentages were then used to apportion the monthly space heating and DHW demand for the current office models for the Croydon DES study
Existing office – Monthly space heating profile based on monthly London degree day profiles. DHW demand is split according to the number of days in the month
Residential – based on monthly output from cSAP software for a flat built to be PartL2010 compliant. The monthly space heating and DHW demands falling in each month were calculated as a percentage of the annual demand from the cSAP model and these percentages were then used to apportion the monthly space heating and DHW demand for the proposed residential developments for the Croydon DES study. It is also assumed that there is no space heating demand between June and September.
All other buildings - Monthly space heating profile based on monthly London degree day profiles. DHW demand is split according to the number of days in the month

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Table 2 - Annual energy demand breakdown by Energy Cluster

	Heating MWh p.a	Cooling MWh p.a	Electricity MWh p.a
Energy centre 1	54,286	22,394	36,207
Energy centre 2	29,372	14,935	23,933
Energy centre 3	45,479	24,369	32,332
All clusters	**129,137**	**61,698**	**92,472**

Figure 1 - Monthly Energy demands for Energy Cluster 1

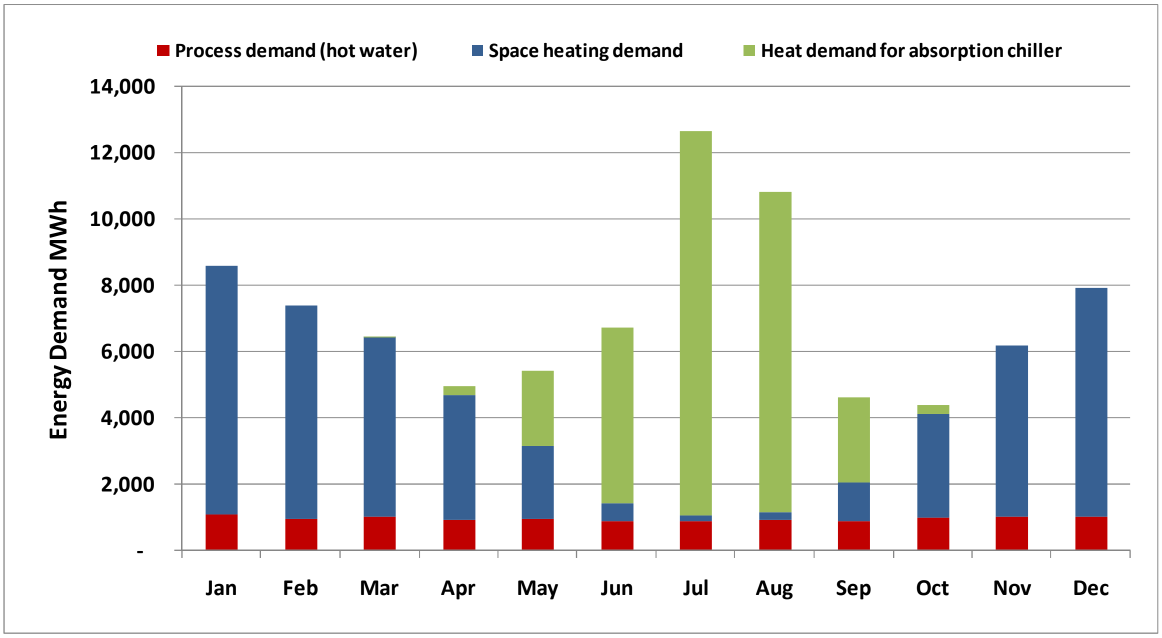

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Figure 2 - Monthly Energy demands for Energy Cluster 2

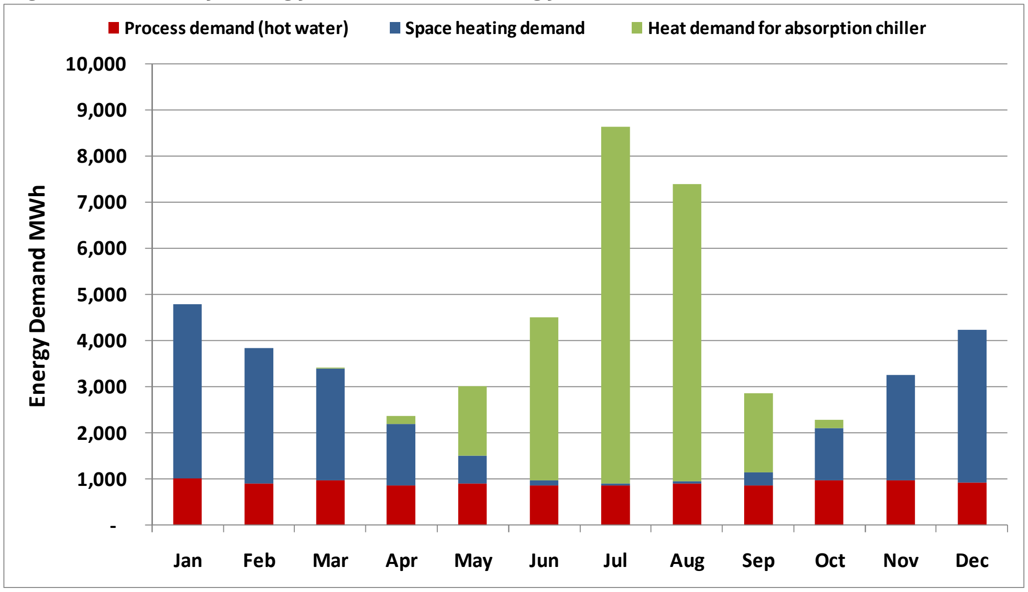
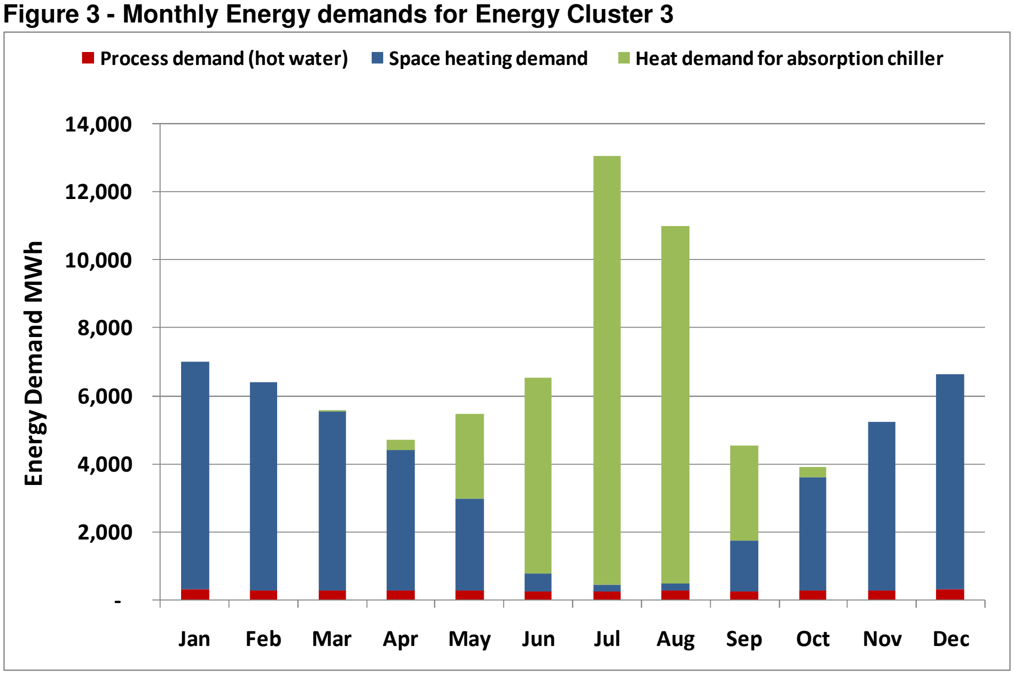


Figure 3 - Monthly Energy demands for Energy Cluster 3



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CHP Sizing

Assumptions

CHP runs for 17 hours per day
CHP provides heat for space heating and DHW demand first, then absorption chiller second if there is a cooling demand to be met.
Remaining cooling demand not met by absorption chiller is met by conventional chiller
CHP sized to meet 70% of each energy cluster heating demand (excluding absorption chiller heat demand)
Conventional chiller CoP: 4
Absorption chiller CoP: 0.7
CHP annual availability: 90%
Base case boiler efficiency: 88%
CHP analysis based on Jenbacher CHP units
DHN distribution losses are 5% of total heating demand

Figure 4 - Monthly Energy outputs and demands for Energy Cluster 1

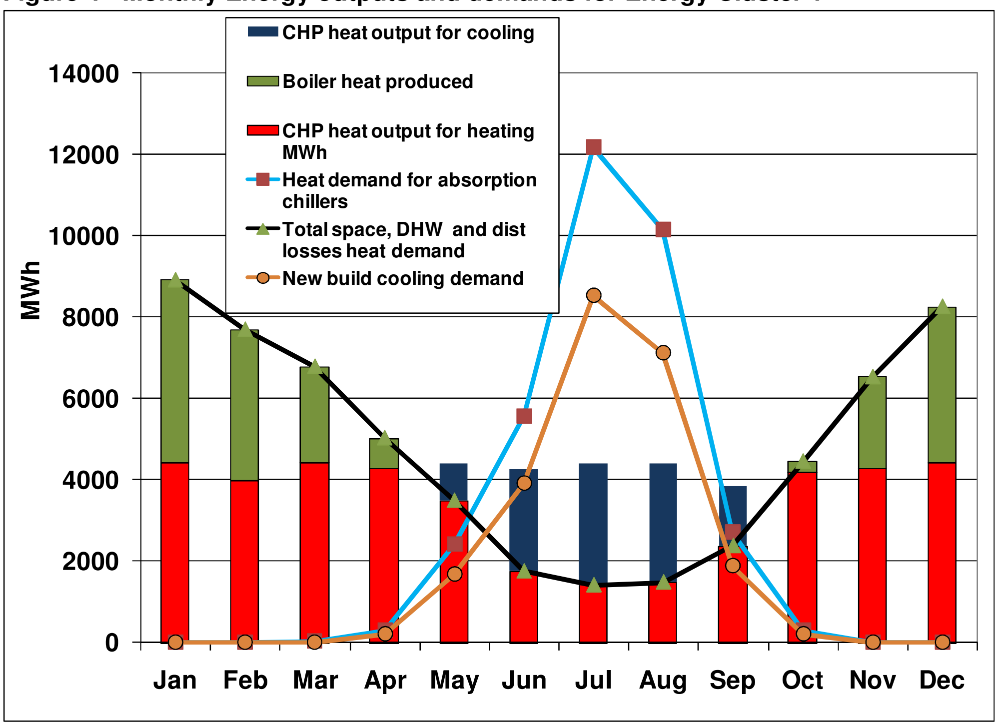

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Figure 5 - Monthly Energy outputs and demands for Energy Cluster 2

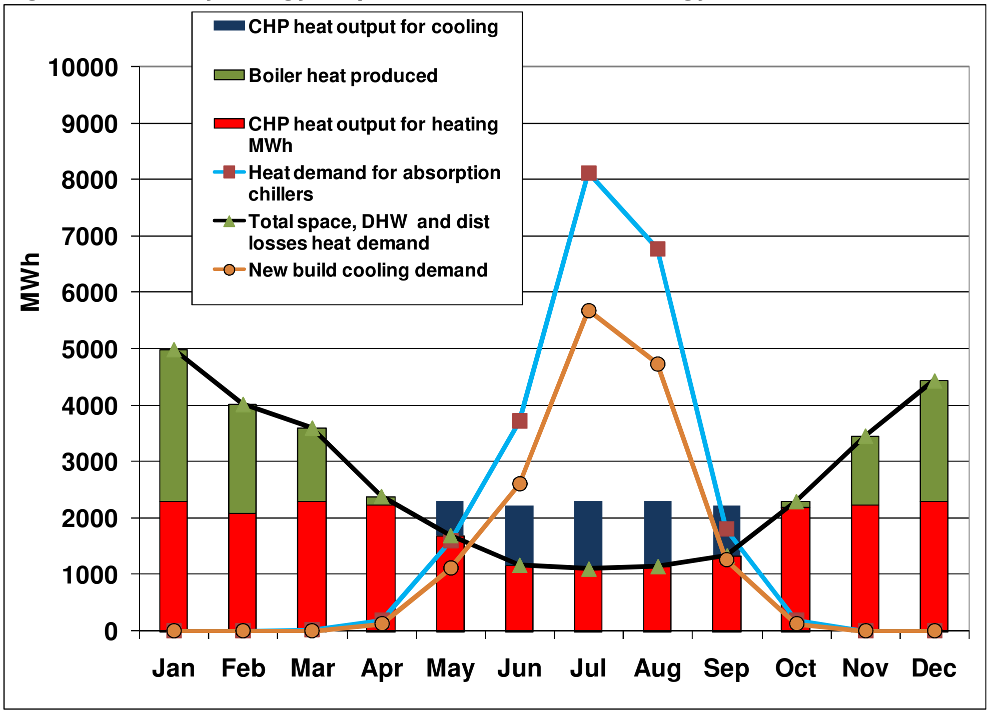

Figure 6 - Monthly Energy outputs and demands for Energy Cluster 3

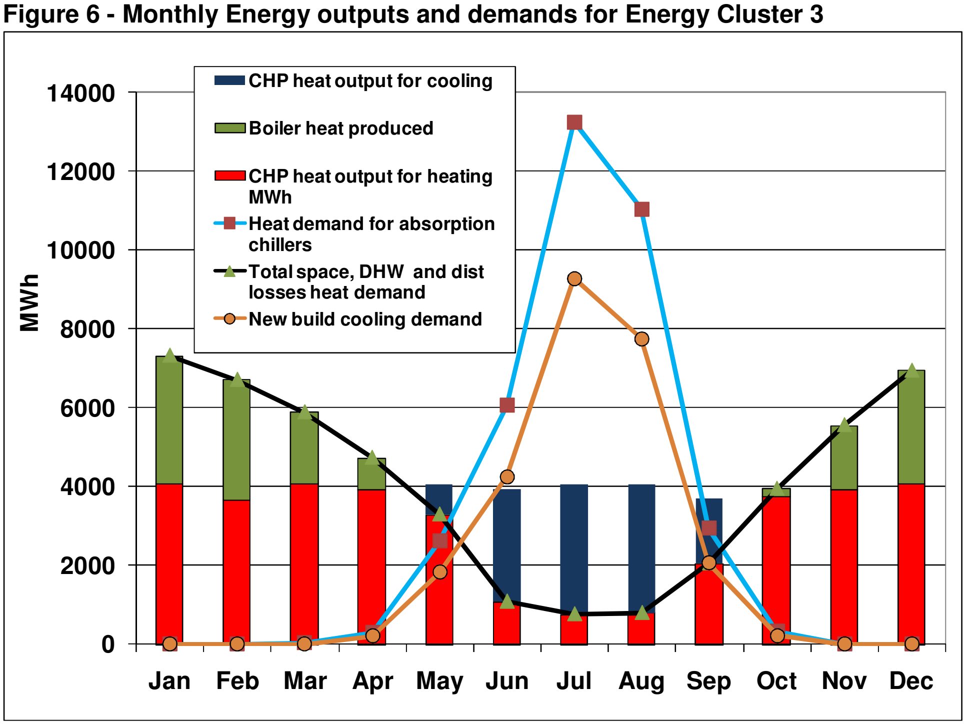

Table 3 shows the assumed proportion of energy produced in the energy centres by building type. This is based on the proportion that each building type makes up of the relevant annual energy demand.

Table 3 - Proportion of energy produced attributed to building type

	Energy Centre Cluster 1	**Energy Centre Cluster 2**	**Energy Centre Cluster 3**
% of heat demand for existing commercial	9%	7%	83%
% of heat demand for new commercial	50%	55%	2%
%heat demand for existing public buildings	6%	5%	0%
% heat demand for new public buildings	11%	0%	0%
% of heat demand for new residential	24%	33%	15%
% of cooling demand for existing commercial	18%	11%	99%
% of cooling demand for new commercial	72%	89%	1%
% cooling demand for existing public buildings	0%	0%	0%
% cooling demand for new public buildings	11%	0%	0%
% electricity demand for existing commercial	12%	8%	88%
% of electricity demand for new commercial	55%	65%	1%
Electricity demand for existing public buildings	3%	2%	0%
Electricity demand for new public buildings	7%	0%	0%
Electricity demand for new residential	22%	25%	11%
CO_2 saving tonnes	14,963	7,684	14,346
CO_2 saving %	33%	27%	34%

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Table 4 - CHP Sizing summary table for issue to Davis Langdon

	Units	Zone 1	Zone 2	Zone 3
CHP Electrical capacity	kWe	**10,056**	**5,097**	**9,473**
Total heat demand excluding distribution losses	MWh p.a.	54,286	29,372	45,479
% heat provided by CHP for heating	%	70%	70%	72%
CHP heat produced for heating	MWh p.a.	40,481	22,107	35,420
Gas boiler heat produced for heating	MWh p.a.	17,696	9,517	13,613
Heat sold to customers	MWh p.a.	54,286	29,372	45,479
DH Network heat losses	MWh p.a.	3,890	2,253	3,553
Heat demand for existing commercial	MWh p.a.	5,015	1,910	37,615
Heat demand for new commercial	MWh p.a.	26,946	16,076	858
Heat demand for existing public buildings	MWh p.a.	3,483	1,337	-
Heat demand for new public buildings	MWh p.a.	5,946	109	-
Heat demand for new residential	MWh p.a.	12,896	9,799	7,006
Total heat consumed	MWh p.a.	54,286	29,372	45,479
Total cooling demand	MWh p.a.	23514	15682	25587
Cooling from absorption chillers	MWh p.a.	7,594	3,452	8,286
Cooling from conventional chillers	MWh p.a.	15,920	12,229	17,302
CHP heat for absorption chillers	MWh p.a.	10,849	4,932	11,837
Cooling sold to customers	MWh p.a.	23,514	15,682	25,587
Cooling demand for existing commercial	MWh p.a.	4,160	2,637	23,266
Cooling demand for new commercial	MWh p.a.	16,868	20,822	248
Cooling demand for existing public buildings	MWh p.a.	-	-	-
Cooling demand for new public buildings	MWh p.a.	2,486	-	-
Total cooling produced at Energy Centres	MWh p.a.	23514	15682	25587
Fuel/heat purchase				
Total CHP heat produced for heating and cooling	MWh p.a.	51,329	27,039	47,256
CHP fuel use	MWh p.a.	142,201	72,210	130,917
Gas boiler fuel use	MWh p.a.	20,109	10,815	15,469
Heat from Rolls Royce Power	MWh p.a.			
Total electricity demand	MWh p.a.	36,207	23,933	32,331
Electricity generated by CHP	MWh p.a.	56,151	28,657	51,696
Electricity sold to customers	MWh p.a.	35,672	21,802	32,331
Electricity sold to licensed supplier (export to grid)	MWh p.a.	20,480	6,855	18,825
Electricity demand for existing commercial	MWh p.a.	4,239	1,795	28,552
Electricity demand for new commercial	MWh p.a.	19,744	14,149	372
Electricity demand for existing public buildings	MWh p.a.	1,029	425	-
Electricity demand for new public buildings	MWh p.a.	2,663	29	-
Electricity demand for new residential	MWh p.a.	7,997	5,369	3,407
Carbon dioxide savings				
CO_2 saving tonnes	tonnes	14,963	7,684	14,346
CO_2 saving %	%	33%	27%	34%

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District Heating Network

There are 5 options explored:
DHN serving Energy Centre 1 cluster only
DHN serving Energy Centre 2 cluster only
DHN serving Energy Centre 3 cluster only
DHN serving Energy Centre clusters 1,2 &3
DHN served by Rolls Royce plant via heat interface unit in Croydon Town Centre energy centre

Assumptions
Flow velocity for energy clusters: 2m/s
Flow velocity for pipes connecting Rolls Royce plant to energy cluster 1: 3m/s
Flow and return temperatures for energy clusters: 95/65
Flow and return temperatures for Rolls Royce to energy cluster connection pipe: 125/65
Pipe sizes for each energy cluster based on largest required pipe diameter

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Capabilities on project:
Energy
Environment

Appendix 2

Heat Mapping

The potential for future extension of a pipe work network to urban centres or planned large scale residential developments in neighbouring boroughs.

In order to start to address the potential for future expansion of the pipe work network we have carried out a high level analysis of the Croydon surrounding areas using heat mapping.

Heat mapping at its most basic is a method of graphically representing energy demand or consumption across an area. As its name suggests, the prime motivation is to understand heat distribution across the built environment. This can be heat demand, energy demand for generating heat, or excess heat production, for example from industry or power generation, or a combination of each.

Heat Mapping Methodology

There are no defined or standardised methodologies for heat maps. The method chosen for a particular study will depend on the aims and ambitions of the study, the scale of the mapping, and the availability of data for the particular area.

There are two basic methods of producing a heat map:

Bottom-up. The bottom up approach models heat production from first principles. Using information on the built environment, it is possible to create building models and simulate the heat demand. Combined with data which provides the spatial distribution of buildings, this then allows a spatial map of thermal demand to be created. This theoretical approach allows interrogation of the built form to assess the potential impact of low carbon measures on the heat demand or energy demand.

Top-down. An alternative approach to heat mapping is to take existing measured data and plot this spatially. Currently the most detailed level of utility information available for gas and electricity consumption in the UK is at the middle layer output area (each of which typically comprises circa 6000 homes). This means that data is consistent across an area but limited in resolution to the level at which information is available. At middle layer, the areas are sufficiently large to mean that there could be significant variation between areas which appear similar, for example through the inclusion of parks or high rise flats.

A combination of both approaches can be used to allow the resolution of the bottom up approach to be calibrated against known data in the top down approach.

Heat mapping for Croydon

At the early stages of this study, there is still much information to collect relating to the built form, and current consumption. For this reason, the heat maps presented in this interim report make use of established publicly available data sets. Heat maps are presented at two levels of resolution depending on the methodology used.

Middle Layer heat mapping

The middle layer heat mapping indicates heat use across the Borough of Croydon at middle layer super output area (MLSOA) resolution. The output area system is based on census data collection and the middle layer level represents groups of output areas covering circa 6,000 dwellings. Across the Borough of Croydon, there are 44 MLSOAs.

The middle layer heat mapping uses data on gas and electricity consumption available from the Department of Energy and Climate Change (DECC). This provides gas and electricity consumption for domestic and commercial / industrial uses for each MLSOA. To produce the heat map, the gas consumption is converted to heat demand assuming 75% boiler efficiency, and added to the economy 7 electricity consumption from the domestic sector. The data is presented in units of average kW demand per km^2 per year (assuming heat supply spread over 8760 hours), a metric which essentially describes heat power demand density.

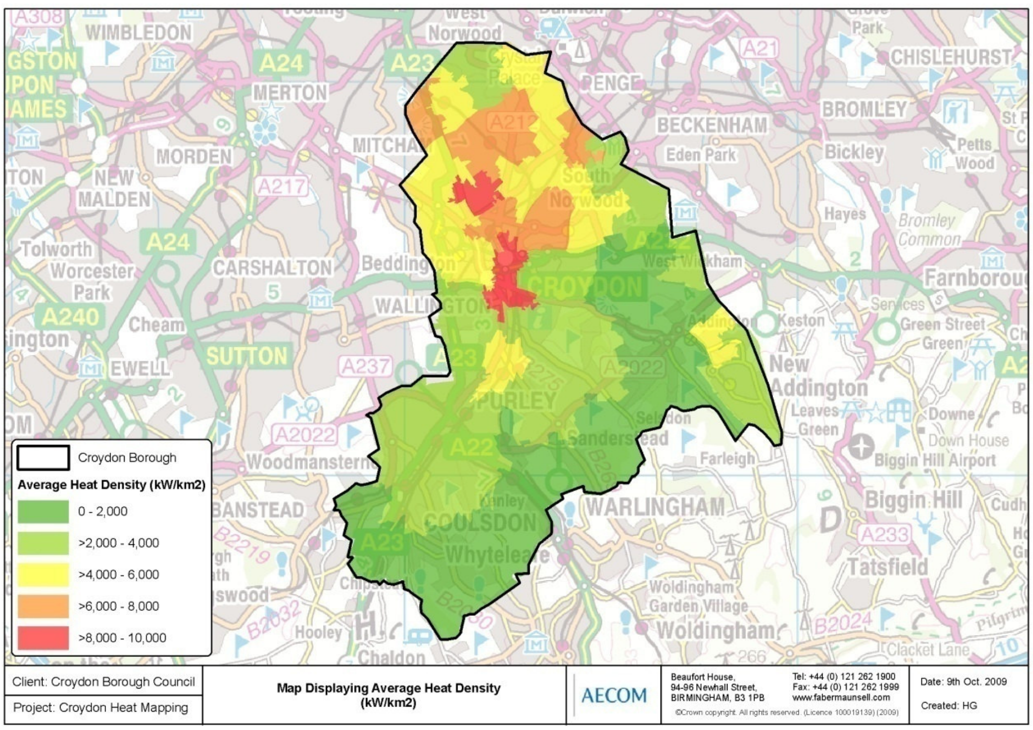


Figure 7.1: MSOA_Average Heat Density

The map clearly shows the high heat demand in the town centre with heat densities of over 8,000 kW / km^2 / yr achieved. In general, the heat density in the more urban northern half is above 4,000 kW / km^2 / yr, whilst the southern half is mostly less than 4,000 kW / km^2 / yr. From prior work by AECOM for DECC[1], it is thought that the viability level for CHP and DH in terms of heat density may lie around 3,000 kW / km^2 / yr suggesting that large parts of Croydon may be suitable for DH (it is important to recognise

[1] The Potential and Costs of District Heating Networks. AECOM and Poyry Energy Consulting. April 2009.

that this viability limit is a very crude high level test for large area studies and further detailed analysis is always required). The areas shown in red in this map have heat densities above 6,000kW/km2 where district heating will be most viable. The outputs from this map show that there are regions of Croydon which merit further analysis to assess the viability for district heating.

Output area heat mapping.
The output area (OA) is the smallest defined geographical area used in the census, representing just over 100 dwellings. The analysis used in this report breaks down the MLSOA data to output area using information from the Census 2001 on dwelling numbers and built form, and statistics on land-use available from the neighbourhood statistics website. For housing, the ratio of heat demand between flats, terraced houses, semi-detached and detached houses is used to pro-rate the MLSOA consumption data to OA level. The ratio splits in heat demand are based on SAP (Standard Assessment Procedure) energy modelling of typical UK dwellings [2].

The commercial energy consumption is pro-rated down to OA level using land use statistics which provide the area of land in each OA used by non-domestic buildings. This relatively simple method does not take into account the height of buildings (and thus total building floor area) but relies on the simplification that within a MLSOA, the non-domestic buildings are relatively uniform in height. This method will be refined in the final report to provide a more accurate assessment.

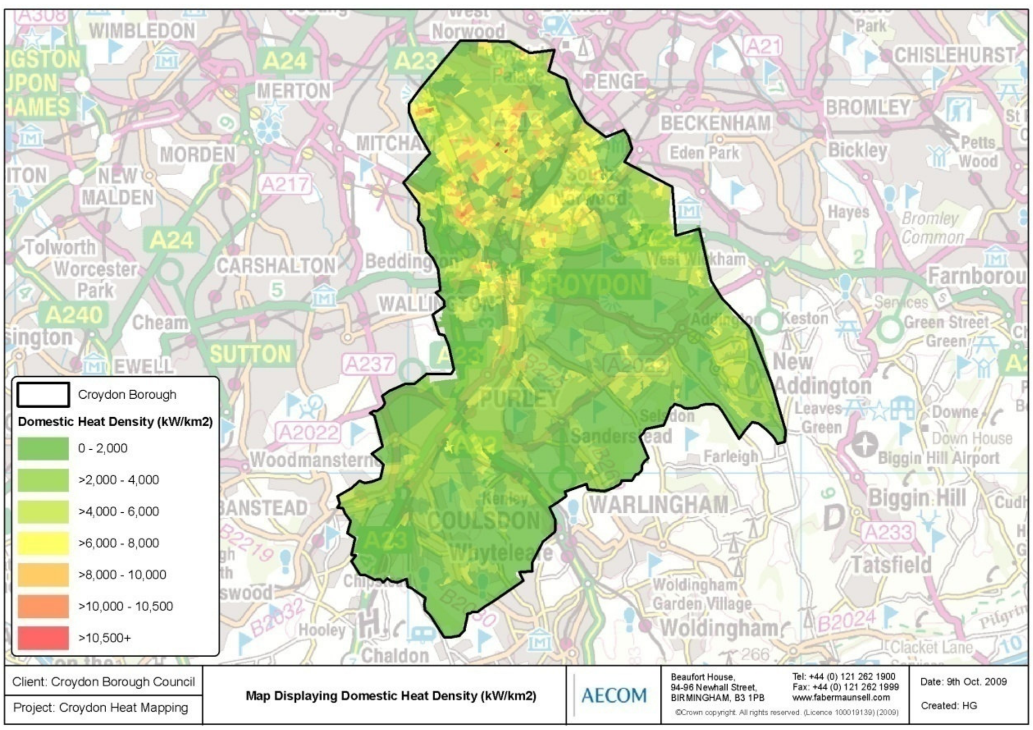


Figure 7.2: OA_Domestic Heat Density

The domestic heat density maps demonstrate that most of the borough is relatively low in domestic heat density, with higher levels achieved in the north of typically up to 8,000 kW / km^2 / yr. There are some isolated pockets of around 10,000 kW / km^2 / yr which will consist of very high density housing or flats.

---

[2] The definition of a "typical UK dwelling" for each form is based on extensive analysis of the English House Condition Survey.

Capabilities on project:
Energy
Environment

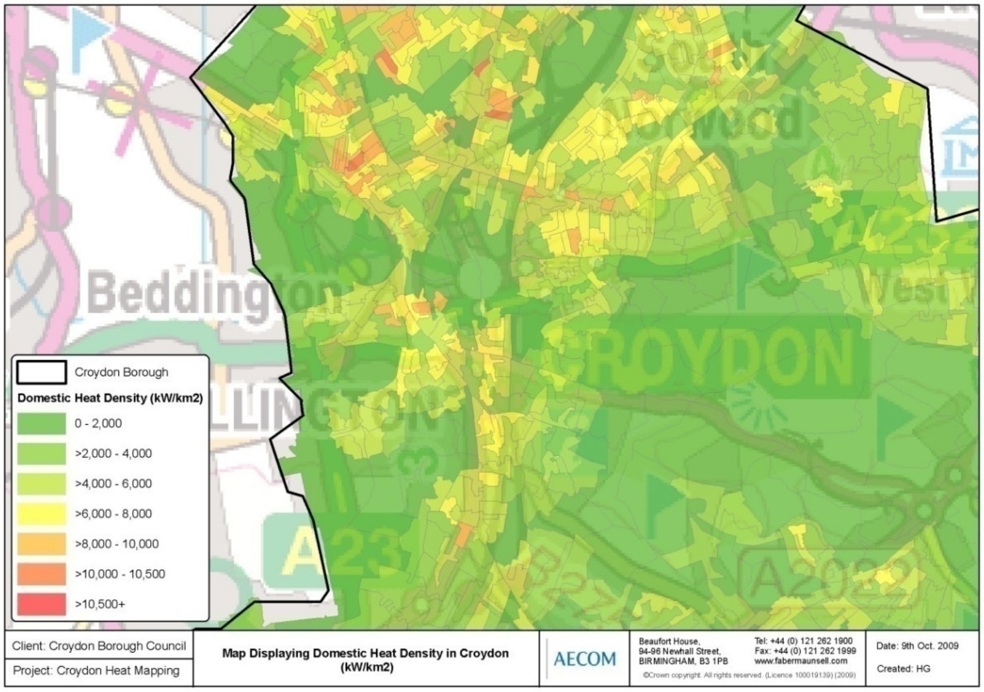
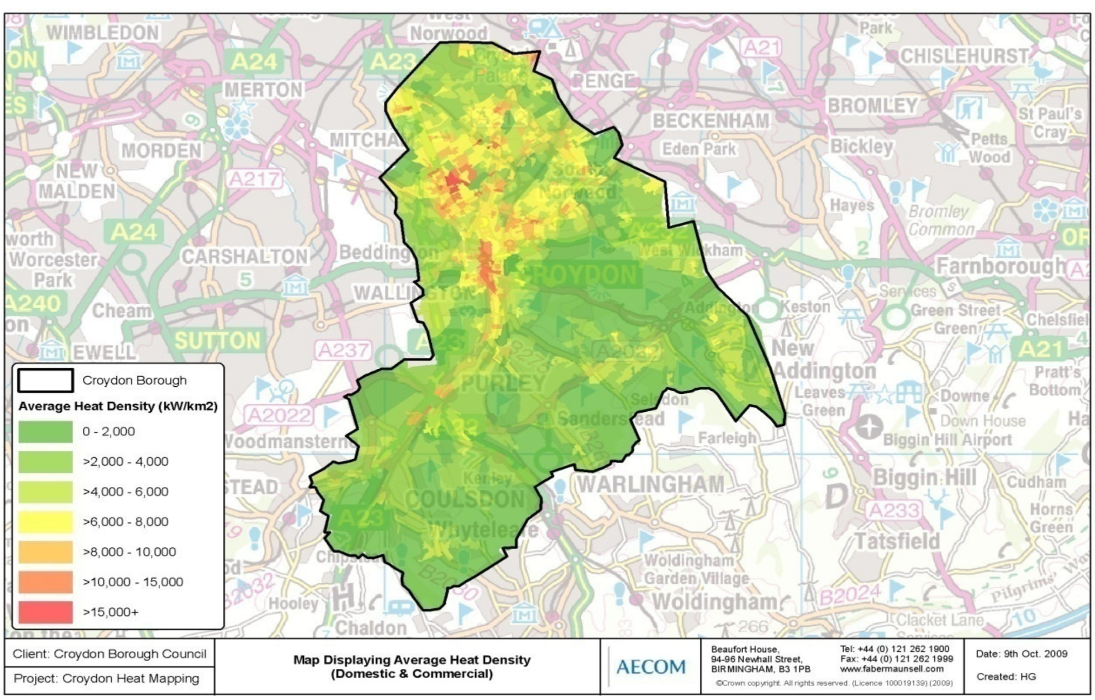


Figure 7.3: - OA_Domestic Heat Density_detail

The detail on Croydon town centre shows a large reduction in heat demand in the very town centre due to the dominance of non-domestic buildings. The impact of the commercial buildings can clearly be seen in the two maps which show the overall average heat density (including domestic). In the Croydon town centre area, the heat density is predicted to reach over 15,000 kW / km^2 / yr, almost entirely due to the commercial buildings. It is possible that the methodology is also under-predicting this density due to not accounting for building height.



Capabilities on project:
Energy
Environment

Figure 7.4: – OA_Average Heat Density

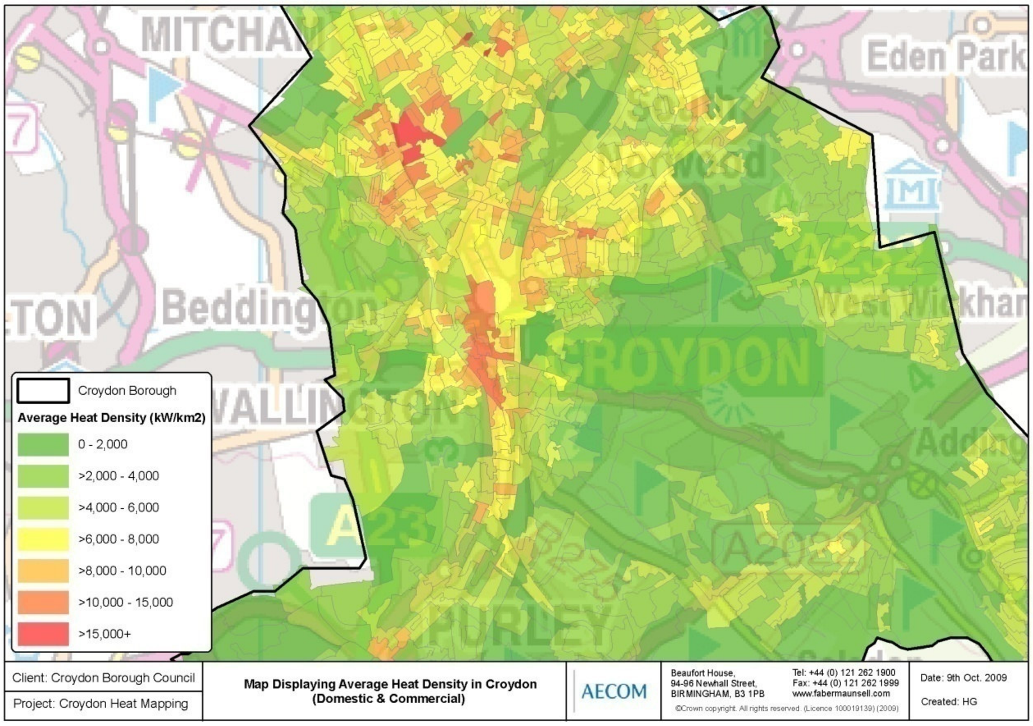


Figure 7.5: - OA_Average Heat Density_detail

The maps can be used to assess potential DH schemes, and opportunities to link additional areas. A number of factors need to be considered when examining larger scale scheme potential and a balance will need to be struck between size of load, and distance between loads. In general, the larger the distance between individual schemes, the larger the loads will need to be to justify the installation of the DH network.

The average heat density map at OA level indicates that a wider scale scheme could potentially incorporate areas in the Borough to the North West and North East of the town centre. These are located along the A222 and A23 roads. Connection to these areas would require a more detailed understanding of the heat demand in these areas.

References

Local Development Framework for Croydon – Core Strategy
http://www.croydon.gov.uk/planningandregeneration/planningpolicy/ldf/corestrategy

Appendix 3: Air Quality

National Air Quality Objectives and EU Directive Limit Values

Table A3.1: UK Air Quality Objectives

Pollutant	Air Quality Objective		Date to be achieved by and maintained thereafter
	Concentration	Measured as	
Benzene	16.25 µg/m^3	Running Annual Mean	31.12.2003
Benzene	5.0 µg/m^3	Annual Mean	31.12.2010
1,3-Butadiene	2.25 µg/m^3	Running Annual Mean	31.12.2003
Carbon Monoxide	10.0 mg/m^3	Maximum Daily Running 8-hour Mean	31.12.2003
Lead	0.5 µg/m^3	Annual Mean	31.12.2004
	0.25 µg/m^3		31.12.2008
Nitrogen Dioxide	200 µg/m^3 not to be exceeded more than 18 times a year	1 Hour Mean	31.12.2005
	40 µg/m^3	Annual Mean	
Nitrogen Oxides (for the protection of vegetation)	30 µg/m^3	Annual Mean	31.12.2000
Particles (PM_{10}) (gravimetric)	50 µg/m^3 not to be exceeded more than 35 times a year	24 Hour Mean	31.12.2004
	40 µg/m^3	Annual Mean	31.12.2004
Particles ($PM_{2.5}$)	Target of 25 µg/m^3	Annual Mean	2020
Particles ($PM_{2.5}$) Exposure Reduction UK Urban Areas	Target of 15% reduction in concentrations at urban background [a]	Annual Mean	Between 2010 and 2020
Sulphur Dioxide	266 µg/m^3 not to be exceeded more than 35 times a year	15 Minute Mean	31.12.2005
	350 µg/m^3 not to be exceeded more than 24 times a year	1 Hour Mean	31.12.2004
	125 µg/m^3 not to be exceeded more than 3 times a year	24 Hour Mean	31.12.2004

NB: [a] 25 µg/ m^3 is a cap to be seen in conjunction with 15% reduction

Table A3.2: EU Limit Values

Pollutant	Objective	Measured as	Date to be achieved by and maintained thereafter
Benzene	5 µg/m^3	Annual Mean	1 January 2010
Carbon Monoxide	10.0 mg/m^3	Maximum Daily 8-Hour Mean updated hourly	1 January 2005
Lead	0.5 µg/m^3	Annual Mean	1 January 2005
Nitrogen Dioxide	200 µg/m^3 not to be exceeded more than 18 times per year	1 Hour Mean	1 January 2010
	40 µg/m^3	Annual Mean	
Nitrogen Oxides (assuming as nitrogen dioxide)	30 µg/m^3	Annual Mean	19 July 2001
Ozone(Target)	120 µg/m^3 not to be exceeded more than 25 times per year	Maximum Daily Running 8-hour Mean updated hourly	1 January 2010
Particles (PM_{10}) (gravimetric)	50 µg/m^3 not to be exceeded more than 35 times per year	24 Hour Mean	1 January 2005
	40 µg/m^3	Annual Mean	1 January 2005
Particles ($PM_{2.5}$)	Target value 25 µg/m^3	Annual Mean	2010
Particles ($PM_{2.5}$)	Indicative limit value 20µg/m^3	Annual Mean	2015
Particles ($PM_{2.5}$) UK urban areas	Target of 20% reduction in concentrations at urban background	Annual Mean	Between 2010 and 2020
Sulphur Dioxide	350 µg/m^3 not to be exceeded more than 24 times per year	1 Hour Mean	1 January 2005
	125 µg/m^3 not to be exceeded more than 3 times per year	24 Hour Mean	1 January 2005
	20 µg/m^3 (for the protection of vegetation)	Annual Mean	19 July 2001

Modelling Methodology

AAQuIRE was developed by AECOM to meet three requirements in predictive air quality studies. The first requirement was an immediate need for a system that produced results that could be interpreted easily by non-air quality specialists to allow for proper informed inclusion of air quality issues in wider fora, the main example being to allow consideration of air quality issues in planning processes. This was achieved by allowing results to be generated over a sufficiently large study area, and at an appropriate resolution, for the issue being considered. The results are also presented in a relevant format, which is normally a statistic directly comparable with an air quality criterion or set of measured data being considered. For example, the AQS PM_{10} 24-hour objective level of 50 µg/m^3 is expressed as a 90th percentile of hourly means. AAQuIRE can also produce results directly comparable with all ambient air quality standards.

The second requirement was for a system to be based, initially, on existing and well-accepted and validated dispersion models. This has two advantages. The primary one is that it avoids the need to prove a new model against the accepted models and therefore enhances acceptability. The second advantage is that when appropriate new models are developed they can be included in AAQuIRE and be compared directly with the existing models, and sets of measured data, using the most appropriate statistics.

The third requirement for AAQuIRE was a consideration of quality assurance and control. An important aspect of modelling is proper record keeping ensuring repeatability of results. This is achieved within AAQuIRE by a set of log files, which record all aspects of a study and allow model runs to be easily repeated.

The ways in which AAQuIRE and the models currently available within it operate are discussed below.

The operation of AAQuIRE can be divided into five main stages. These are:

- the preparation of the input data;
- the generation of model input files;
- dispersion modelling;
- the statistical treatment of dispersion modelling results; and
- the presentation of results.

The first stage in operating AAQuIRE is to prepare the input data. The following data are needed for the year and pollutant to be modelled:

- the presentation of meteorological data expressed as occurrence frequencies for specified combinations of wind speed, direction, stability and boundary layer height;
- road system layout and associated traffic data within and immediately surrounding the study area;
- industrial stack locations and parameters; and
- a grid of model prediction locations (receptors).

The modelling is always carried out to give annual average results from which appropriate shorter period concentrations can be derived.

The second stage is the generation of the model input files required for the study. All the data collated in the first stage can be easily input into AAQuIRE, using the worksheets, drop down boxes and click boxes in the Data Manager section of the software. Data from spreadsheets can be easily pasted into worksheets, so that any complicated procedures required for data manipulation can be achieved before entry into AAQuIRE. Several diurnal and seasonal profiles can be defined for each separate source. The relevant meteorological data can also be specified at this stage.

The third stage is executing the models. The study area will usually be divided up into manageable grids and run separately using the Run Manager in AAQuIRE. The results from the separate files can be combined at a later stage. Pollutant concentrations are determined for each receptor point and each meteorological category and are subsequently combined.

The fourth stage is the statistical processing of the raw dispersion results to produce results in the relevant averaging period. Traffic sources and industrial sources can be combined at this stage provided the same receptor grid has been used for both. Background concentrations should also be incorporated at this stage.

The final stage is presentation of results. Currently the result files from the statistical interpretation are formatted to be used directly by the SURFER package produced by Golden Software Inc. Alternative formats are available to permit interfacing with other software packages. On previous projects the results have been imported into a GIS (e.g. ArcView and Map Info).

Currently AAQuIRE uses the CALINE4 model for the dispersion of road-traffic emissions and AERMOD for all other sources. Both these models are fully validated and have been extensively used worldwide. These are relatively complex models designed for detailed studies of local areas, which are used within AAQuIRE for both local and larger scale studies. This is considered necessary because of the frequent importance of local effects, such as traffic junctions, in properly assessing ‘regional’ effects.

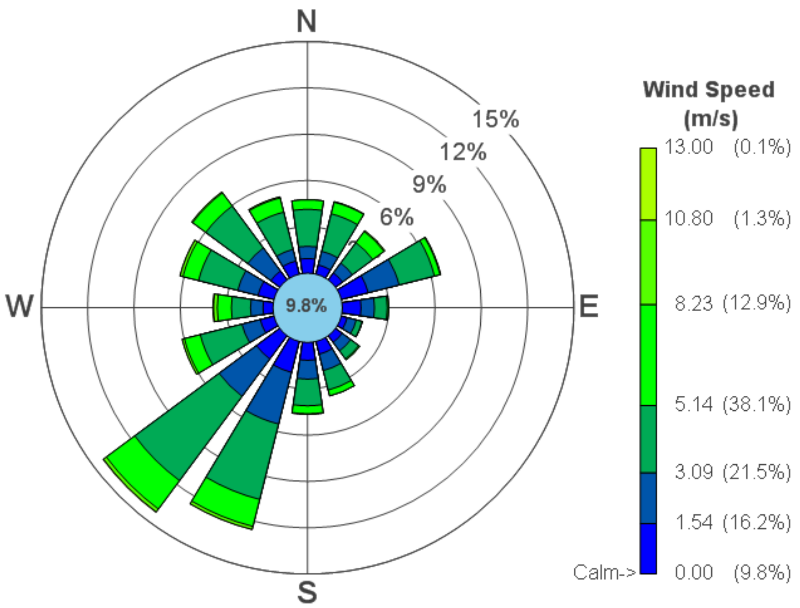
Meteorological Data

Meteorological data measured at Gatwick Air port in 2005 were used for this modelling study. The data consisted of the frequencies of occurrence of wind speed 0 – 2, 2 – 4, 4 – 6, 6 – 10, 10+ m/s), wind direction (30° resolution) and Pasquill stability classes for the road and area sources . Pasquill stability classes categorise the stability of the atmosphere from A (very unstable) through D (neutral) to G (very stable). For AERMOD, hourly meteorological data from Gatwick for 2005 was used with stability defined on the Monin-Obukhov scale.

Interpretation of Windroses

Each windrose bar is designed to illustrate three wind properties: the direction the wind is coming from; the relative number of hours the wind is from this direction; and the magnitude of the wind speeds.

Figure A3.1: Gatwick Airport 2005 Windrose



Dir \ Spd	<= 1.54	<= 3.09	<= 5.14	<= 8.23	<= 10.80	> 10.80	Total
0	0.95	0.79	2.4	0.62	0	0	4.75
22.5	0.62	0.91	2.5	0.78	0.03	0	4.84
45	0.56	0.8	1.64	0.9	0.07	0	3.97
67.5	1.79	2.07	2.36	0.37	0.05	0	6.63
90	1.21	0.87	0.83	0.08	0	0	2.99
112.5	0.39	0.61	0.39	0.02	0	0	1.4
135	0.53	0.7	0.64	0.08	0	0	1.94
157.5	0.84	1.1	1.3	0.39	0	0	3.63
180	1.15	1.22	1.72	0.51	0.03	0	4.65
202.5	2.07	3.45	5.03	1.8	0.21	0	12.56
225	1.87	3.01	6.8	2.29	0.23	0.03	14.25
247.5	0.91	1.22	2.79	1.06	0.15	0	6.13
270	0.64	0.81	1.24	0.91	0.24	0.05	3.89
292.5	1.07	1.35	2.61	1.05	0.18	0.01	6.28
315	0.72	1.86	3.38	1.06	0.07	0	7.09
337.5	0.88	0.78	2.49	0.95	0.07	0	5.16
Total	**16.2**	**21.53**	**38.14**	**12.88**	**1.32**	**0.09**	**90.16**
Calms							**9.84**
Missing							**0**
Total							**100**

Traffic Data

Table A3.3: Traffic Data Used in the Assessment

Road	LAEI Ref	AADT	HGV %	Speed (kph)
PARK HILL ROAD A2039	4284	14262	4.4	32
PARK LANE A212	5133	21206	4.5	48
PURLEY WAY A23	5386	29918	6.9	32
MORLAND ROAD B243	25575	25556	2.3	44
SELBORNE ROAD	25618	333	0.0	32
DAVIDSON ROAD	25640	546	2.2	38
SYDENHAM ROAD	25723	6049	23.1	32
SYDENHAM ROAD	25752	3263	12.5	32
COOMBE ROAD A212	26168	22778	4.4	48
SOUTH PARK HILL ROAD B243	26178	13618	5.4	32
GLOUCESTER ROAD	26326	1096	6.3	32
CHATSWORTH ROAD	26628	3078	7.2	32
ST PETER'S ROAD B274	26766	11659	9.4	32
KATHARINE STREET	26969	595	81.5	32
SOUTH END	27180	26532	6.8	32
WELLESLEY ROAD A212	27216	37299	4.0	48
DUPPAS HILL ROAD A232	27403	34111	4.8	46
GARDENERS ROAD	27411	296	0.0	32
WELLESLEY ROAD (N) A212	27456	25870	7.1	32
LOWER COOMBE STREET A212	27457	12825	5.7	32
SOUTHBRIDGE ROAD A236	27858	12746	3.7	32
RECTORY GROVE	28331	194	2.1	32
HANDCROFT ROAD	28352	70	0.0	32
THE CROYDON FLYOVER A232	28367	34111	4.8	48
DERBY ROAD	28438	4114	8.3	32
PARSON'S MEAD	28449	246	0.0	32
OLD TOWN A236	28543	40736	4.3	48
LOWER ADDISCOMBE ROAD A222	28740	21120	5.5	32
SUMNER ROAD A213	28858	14896	6.9	32
WADDON NEW ROAD	28863	966	4.2	32
MITCHAM ROAD A236	28899	40736	4.3	48
CHERRY ORCHARD ROAD A222	29010	12131	6.6	32
EPSOM ROAD	29278	9022	7.2	32
ST JAMES'S ROAD A222	29373	22760	4.6	32
WADDON ROAD	29430	13606	7.7	32
MITCHAM ROAD A236	29544	22404	6.0	32
BARCLAY ROAD A232	56213	38737	3.7	32
THE CROYDON FLYOVER A232	58237	42672	4.5	48
CHEPSTOW ROAD A232	58681	29184	3.4	36
COOMBE ROAD A212	58695	16502	4.4	48
FAIRFIELD ROAD A232	58699	38737	3.7	28
ADDISCOMBE GROVE A222	58710	12131	6.6	32
ROMAN WAY A236	61121	40736	4.3	41
NORTH END	62137	4350	8.0	32
DINGWALL ROAD	4284	2860	37.2	32
PARK LANE A212	5133	37299	12.3	32
LOWER COOMBE STREET A212	5386	12825	5.7	32
MITCHAM ROAD A236	29592	22404	6.0	32

Point Source Model Inputs and Emission Factors

Table A3.4: Energy Centres (Do-Something 1)

Parameter	CHP UNIT	GAS Boilers	Units
Stack Diameter	300	400	mm
Stack Height	40	40	m
Number of units	4	3	Zone 1 & 3
	3	2	Zone 2
Power	2	10	MW
Exit Velocity	8	8	m/sec
Exit Temp	120	120	degrees C
efficiency	87	95	%
Service demand	0.7	0.3	%

Table A3.5: Energy Centres CHP Emission Factors (Do-Something 1)

Future Boiler outputs (after 2015)				Emission Factor Calculation					
EC	Heat.	Cool.	Electric.	Total Input	Energy Input per CHP Boiler			NOx emissions	
	[MWh]	[MWh]	[MWh]	95% (eff)	MWh	KWh	GJ	g	G/s
EC1	38,000	22,394	36,207	75,349	18,837	18837351	67809	4746633	0.15
EC2	20,560	14,935	23,933	46,354	15,451	15451329	55620	3893424	0.12
EC3	31,835	24,369	32,332	69,058	17,264	17264471	62147	4350299	0.14

Table A3.6: Energy Centres Gas Boiler Emission Factors (Do-Something 1)

Future Boiler outputs (after 2015)				Emission Factor Calculation					
EC	Heat.	Cool.	Electric.	Total Input	Energy Input per Gas Boiler			NOx emissions	
	[MWh]	[MWh]	[MWh]	95% (eff)	MWh	KWh	GJ	g	G/s
EC1	16,286	-	-	15,309	5,103	5102901	18369	1285828	0.04
EC2	8,811	-	-	8,283	4,141	4141382	14908	1043545	0.03
EC3	13,644	-	-	12,825	4,275	4275048	15389	1077226	0.03

Table A3.5: Rolls-Royce Gas Turbine (Do-Something 2)

RR Turbine UNIT	Base Scenario	Do-Something (2)	Units
Stack Diameter	3.5	3.5	m
Stack Height	67	67	m
Number of Units	1	1	N/A
Power Output	50	50	MW
Exit Velocity	77	77	m/sec
Exit Temp.	733	180	degrees C
Annual Demand	11.4	57	%
Exhaust Flow	301.63	301.63	m^3/s
Emission Rate NOx	38	38	mg/m^3
	1.3	6.5	g/sec

Table A3.6: Cluster Area Source Emission Factors (Based on sector emissions from the National Atmospheric Emission Inventory)

Cluster Area	Area (m2)	Heating [MWh]	Cooling [MWh]	Electricity [MWh]	2008 Base		2020 DM		2020 DS*	
					PM_{10}	NO_x	PM_{10}	NO_x	PM_{10}	NO_x
1	63951	15496	16532	24708	2.35E-08	1.56E-06	4.68E-08	3.11E-06	2.35E-08	1.56E-06
2	55329	2896	1961	2548	5.08E-09	3.37E-07	5.21E-08	3.46E-06	5.08E-09	3.37E-07
3	35263	5857	2302	4025	1.61E-08	1.07E-06	1.76E-08	1.17E-06	1.61E-08	1.07E-06
4	11599	3234	2086	2917	2.71E-08	1.79E-06	2.71E-08	1.79E-06	2.71E-08	1.79E-06
5	36405	2753	2421	2850	7.34E-09	4.87E-07	4.04E-08	2.68E-06	7.34E-09	4.87E-07
6	17387	12186	7021	9528	6.8E-08	4.51E-06	7.81E-08	5.18E-06	6.8E-08	4.51E-06
7	18063	6320	5145	5708	3.39E-08	2.25E-06	3.39E-08	2.25E-06	3.39E-08	2.25E-06
8	26819	5053	17440	20840	1.83E-08	1.21E-06	1.83E-08	1.21E-06	1.83E-08	1.21E-06
9	27016	2892	12391	15076	1.04E-08	6.89E-07	4.53E-08	3E-06	1.04E-08	6.89E-07
10	17063	819	1671	2137	4.66E-09	3.09E-07	4.66E-09	3.09E-07	4.66E-09	3.09E-07
11	16789	874	199	520	5.05E-09	3.35E-07	5.05E-09	3.35E-07	7.01E-09	4.65E-07
12	18706	584	1784	2133	3.03E-09	2.01E-07	3.03E-09	2.01E-07	3.03E-09	2.01E-07
13	46248	5512	12175	14662	1.16E-08	7.67E-07	4.26E-08	2.83E-06	1.16E-08	7.67E-07
14	22079	7637	6807	7990	3.36E-08	2.23E-06	3.62E-08	2.4E-06	3.36E-08	2.23E-06
15	14557	0	0	0	0	0	0	0	0	0
16	12835	181	34	85	1.37E-09	9.1E-08	1.37E-09	9.1E-08	1.37E-09	9.1E-08
17	22539	3166	2356	2921	8.02E-09	1.11E-06	3.04E-08	4.21E-06	8.02E-09	1.11E-06
18	28164	405	419	572	8.22E-10	1.14E-07	8.22E-10	1.14E-07	8.22E-10	1.14E-07
19	29651	645	82	257	1.24E-09	1.72E-07	1.24E-09	1.72E-07	1.24E-09	1.72E-07
20	35237	969	636	828	1.57E-09	2.17E-07	1.57E-09	2.17E-07	1.57E-09	2.17E-07
21	37126	2135	1694	2048	3.28E-09	4.54E-07	3.28E-09	4.54E-07	3.28E-09	4.54E-07
22	18522	4417	3937	4601	2.31E-08	1.53E-06	6.13E-08	4.07E-06	2.31E-08	1.53E-06
23	16691	0	1	1	8.14E-13	5.4E-11	2.04E-08	1.35E-06	8.14E-13	5.4E-11
24	33779	49	0	4	8.25E-11	1.14E-08	8.25E-11	1.14E-08	8.25E-11	1.14E-08
25	15171	5378	5005	5890	3.44E-08	2.28E-06	3.44E-08	2.28E-06	3.44E-08	2.28E-06
26	12272	2763	4561	5402	2.18E-08	1.45E-06	2.18E-08	1.45E-06	2.18E-08	1.45E-06
27	29398	1244	129	492	2.41E-09	3.34E-07	2.41E-09	3.34E-07	2.41E-09	3.34E-07
28	32054	1310	0	806	2.33E-09	3.23E-07	2.33E-09	3.23E-07	4.67E-09	6.46E-07
29	25644	207	13	75	4.61E-10	6.37E-08	4.61E-10	6.37E-08	4.61E-10	6.37E-08
30	97463	9419	372	3385	9.38E-09	6.22E-07	9.38E-09	6.22E-07	1E-08	6.64E-07

*area source emissions are the same for both the Do Something (1) and Do Something (2) scenarios.

Figure A3.2: 2008 Baseline Nitrogen Dioxide Concentration Plot (All Sources)

Figure A3.3: 2020 Do Minimum Nitrogen Dioxide Concentration Plot (All Sources)

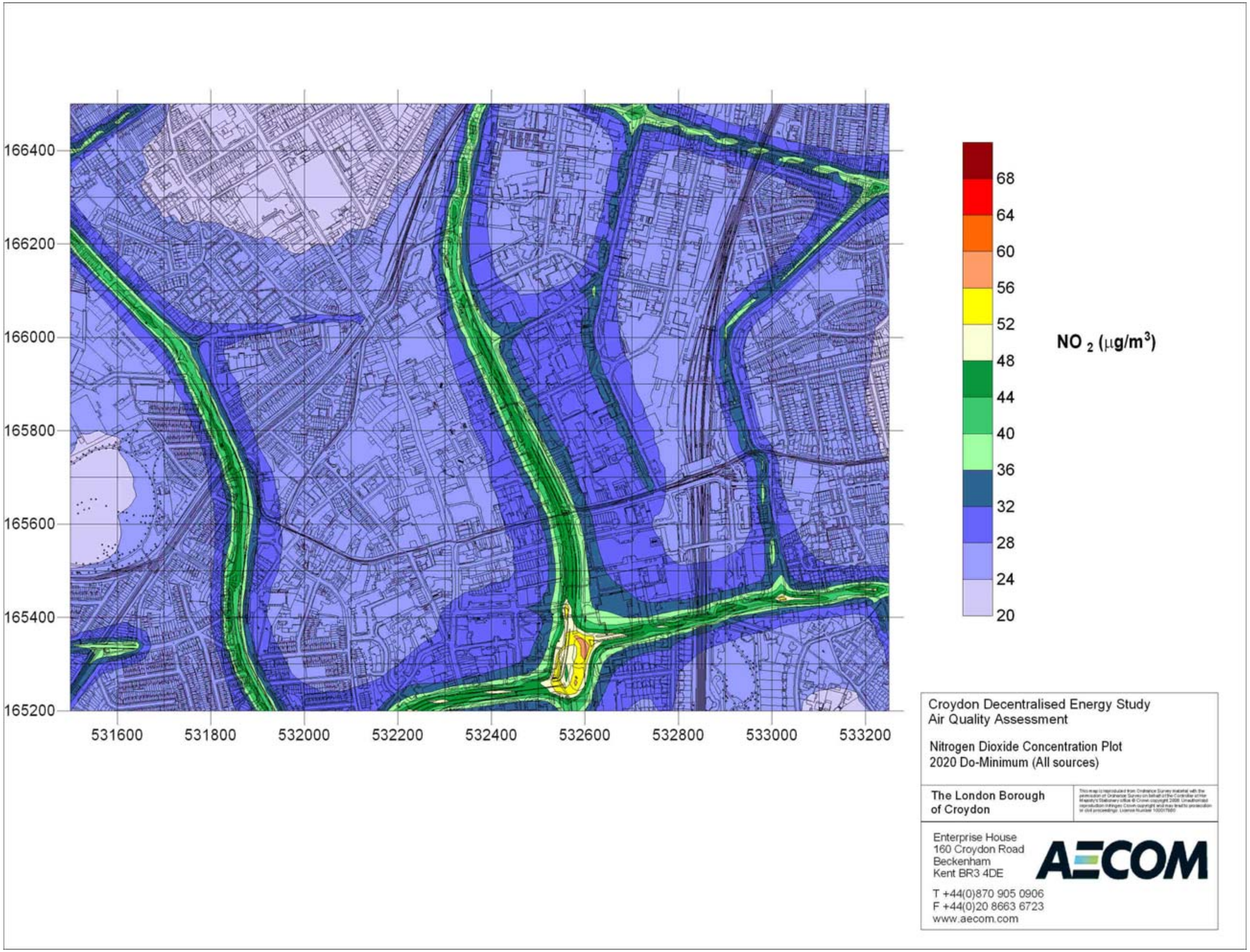


Figure A3.4: 2020 Do Something (1) Nitrogen Dioxide Concentration Plot (All Sources)

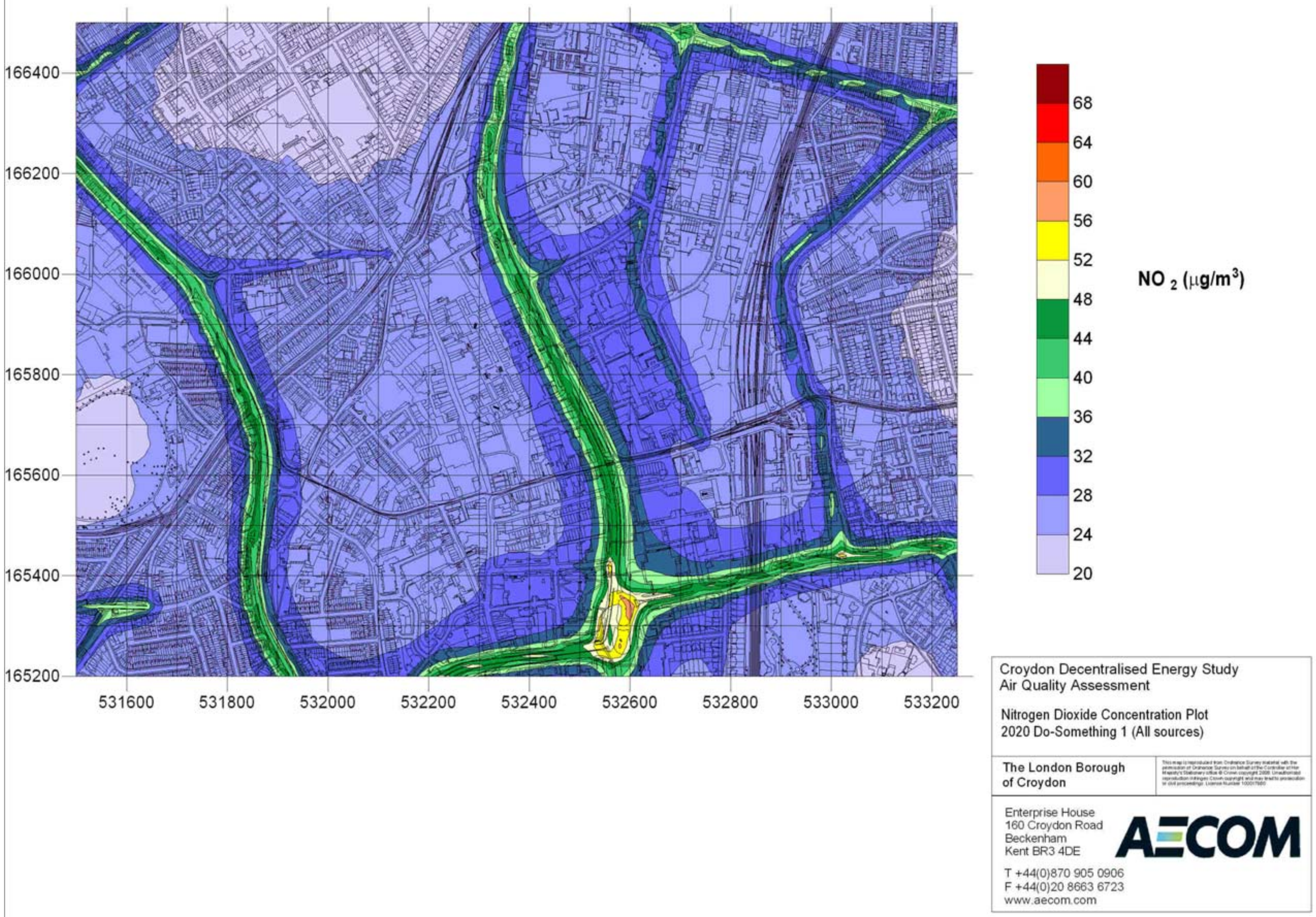


Figure A3.5: 2020 Do Something (2) Nitrogen Dioxide Concentration Plot (All Sources)

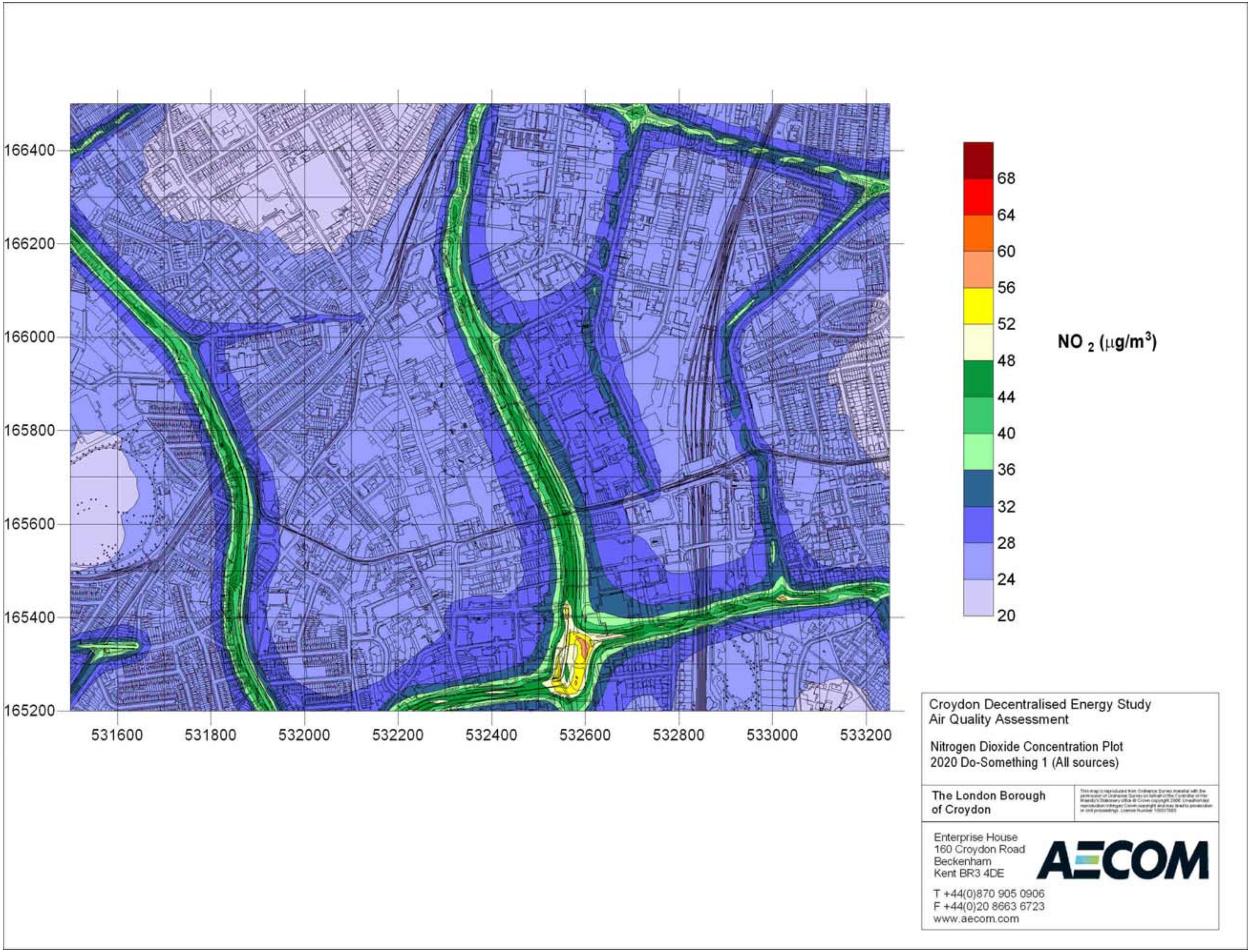
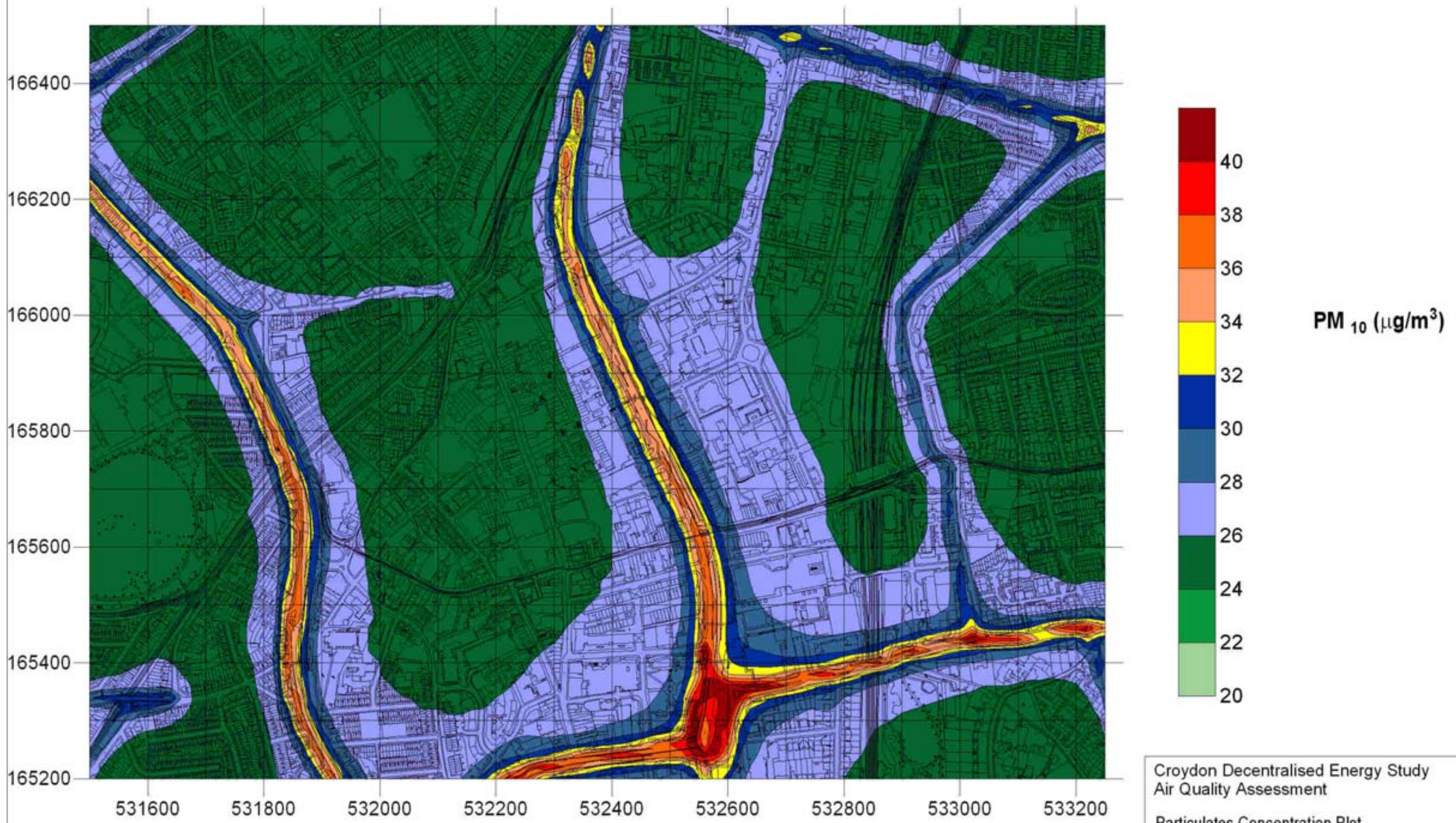


Figure A3.6: 2008 Baseline PM_{10} Concentration Plot (All Sources)



Croydon Decentralised Energy Study
Air Quality Assessment

Particulates Concentration Plot
2008 Base (All Sources)

The London Borough
of Croydon

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Beckenham
Kent BR3 4DE

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F +44(0)20 8663 6723
www.aecom.com

Figure A3.7: 2020 Do Minimum PM_{10} Concentration Plot (All Sources)

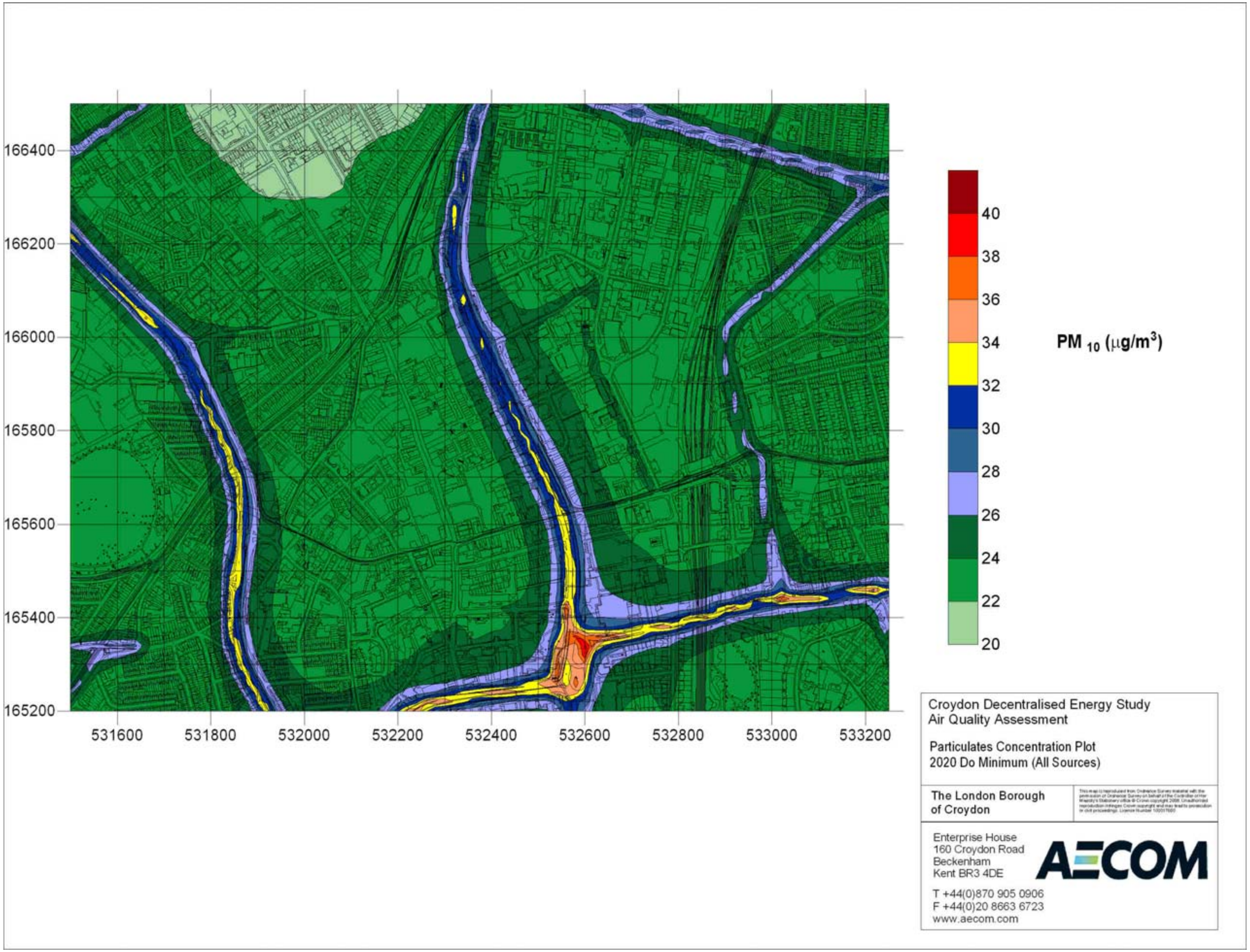

Figure A3.8: 2020 Do Something PM_{10} Concentration Plot (All Sources)

Croydon Decentralised Energy Study
Air Quality Assessment

Particulates Impact Plot
2020 Do Something (All Sources)

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Figure A3.10: Nitrogen Dioxide Impact Plot, Do Something Scenario (1) - Do Minimum

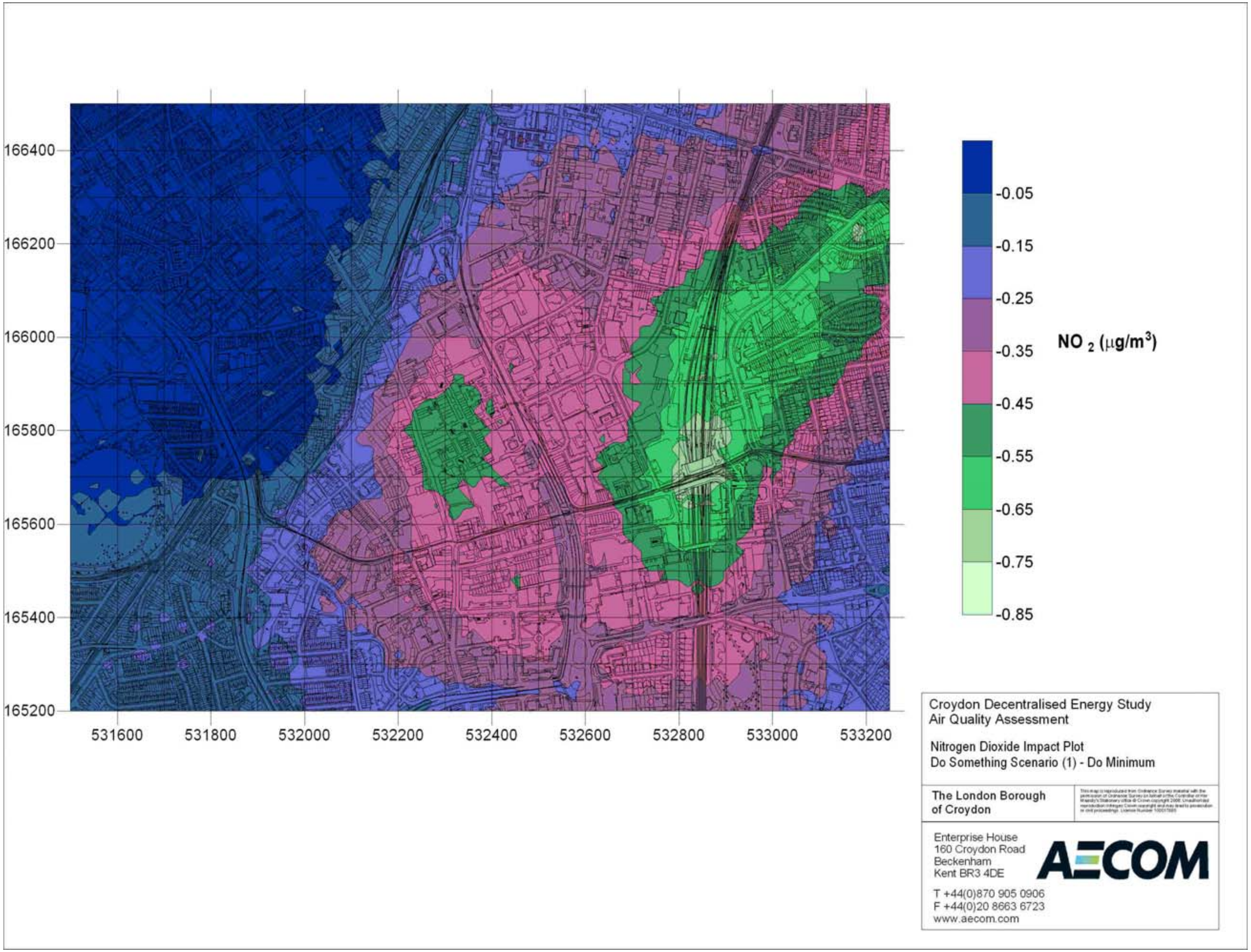


Figure A3.11: Nitrogen Dioxide Impact Plot, Do Something Scenario (2) - Do Minimum

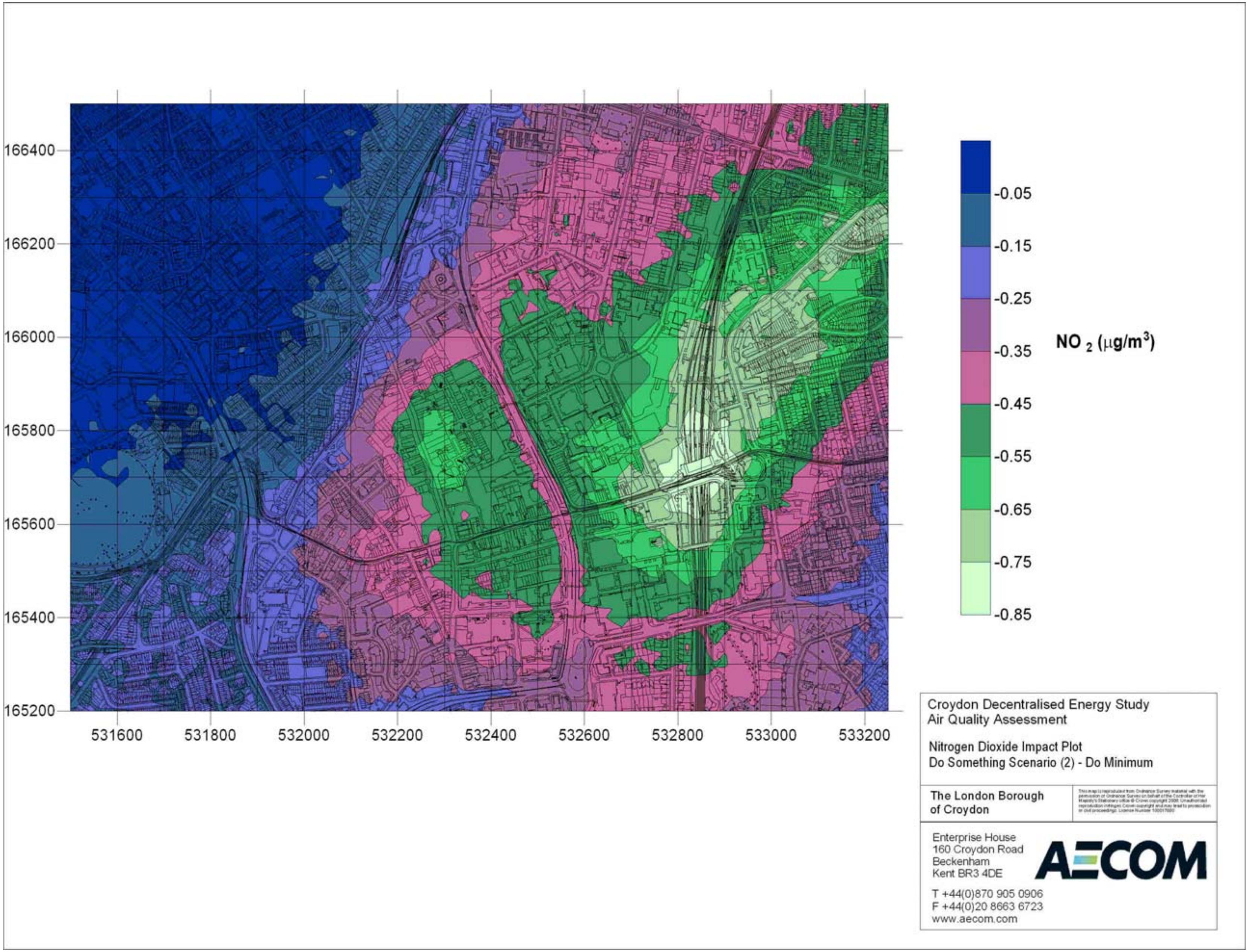
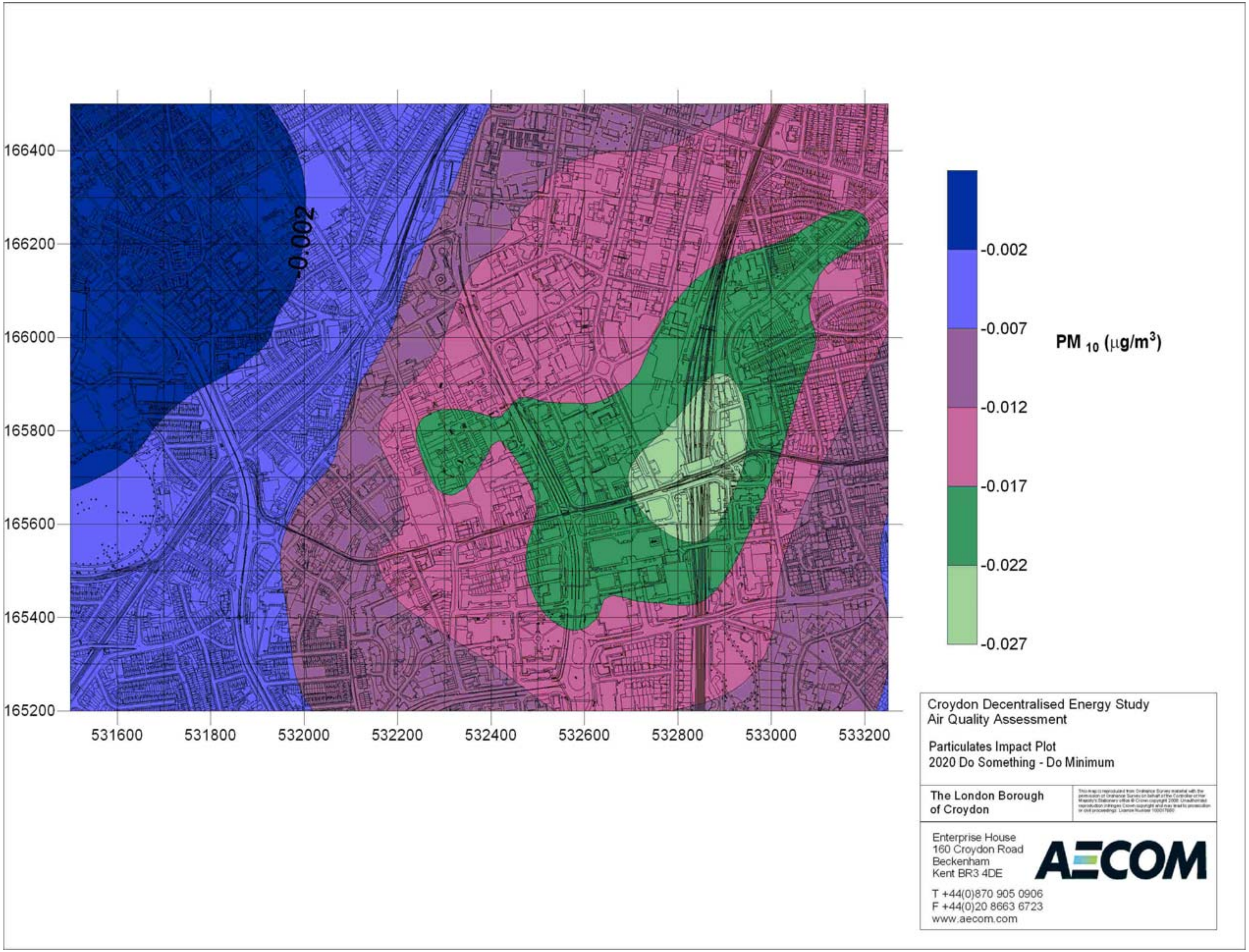


Figure A3.12: Particulates Impact Plot, Do Something Scenario - Do Minimum



BASE DRAWINGS
USED IN COMPILATION OF THIS DRG:

XXX: XXX

NOTES

1. WORK TO FIGURED DIMENSIONS ONLY.

2. XXXXXX

Rev	Date	Details	Made	Chk'd	App

Status:

Architect:

Client:

LONDON BOROUGH OF CROYDON / LDA

Project:

CROYDON DECENTRALISED ENERGY STUDY

Title:

CROYDON DECENTRALISED ENERGY MAP

Eng: ML		CAD: ML	
Chk'd: mech -	elec -	ph -	App'd: RB
Date: 17th DEC 09		Scale: NTS @ A0	

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Reference: ENERGY CLUSTER MAP-001

Rev: -

cm

A0

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