A District Heating Utility for the Tees Valley:

Strategic Framework

2nd November 2010

PARSONS BRINCKERHOFF

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Revision B

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Prepared for

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B	2nd Nov 2010	Inclusion of client comments and Hartlepool addendum
A	30th July 2010	Draft issued to Client for comment
0	-	Work in progress

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Acronyms

Acronym	Term
BAU	Business as Usual
BB	Biomass Boiler
CEM	Contract Energy Management
CHP	Combined Heat and Power
CMP	Carbon Management Plan
COM	Covenant of Mayors
CRC	Carbon Reduction Commitment
CSH	Code for Sustainable Homes
CSOA	Census Super Output Area
CV	Control Valve
DH	District Heating
DNO	Distribution Network Operators
DPCV	Differential Pressure Control Valve
DUoS	Distribution Use of System
EIB	European Investment Bank
ESCo	Energy Service Company
GIS	Geographic Information System
HEFCE	Higher Education Funding Council for England
NFFO	Non Fossil Fuel Obligation
NPV	Net Present Value
O&M	Operation and Maintenance
PB	Parsons Brinckerhoff
PPO	Pure Plant Oil
RHI	Renewable Heat Incentive
ROC	Renewable Obligation Certificate
TRV	Thermostatic Radiator Valve
TVU	Tees Valley Unlimited

Units

°C	Degrees Celsius
bar	Pressure, bar
hr	Hour
GWh	Gigawatt hour (1,000,000 kWh)
kg	kilogram

kPa	kilopascals
kW	Power, kilowatt (10^3 watts)
kWh	Kilowatt hour
l	litre
m	metre
mm	millimetre
MW	Power, megawatt (10^6 watts)
MWth	Thermal Power – hot water, mega watt (10^6 watts)
pa	Pressure, pascal
p.a.	per annum
s	second
tC	tonnes of Carbon
tCO_2	tonnes of Carbon Dioxide

EXECUTIVE SUMMARY

What are the Key Drivers behind this project

Moving to a secure, low-carbon economy in a cost-effective way is extremely challenging. It requires major investment to decarbonise our existing buildings, deployment of new technologies and cleaner power generation. It also requires major changes in the way energy is used by individuals, institutions and industry. The public sector has a key role in driving the transition to a low carbon economy, principally by using its own building stock to catalyse investment in the deployment of renewable and low carbon energy technology. In the Tees Valley the key public sector drivers for reducing CO_2 are:

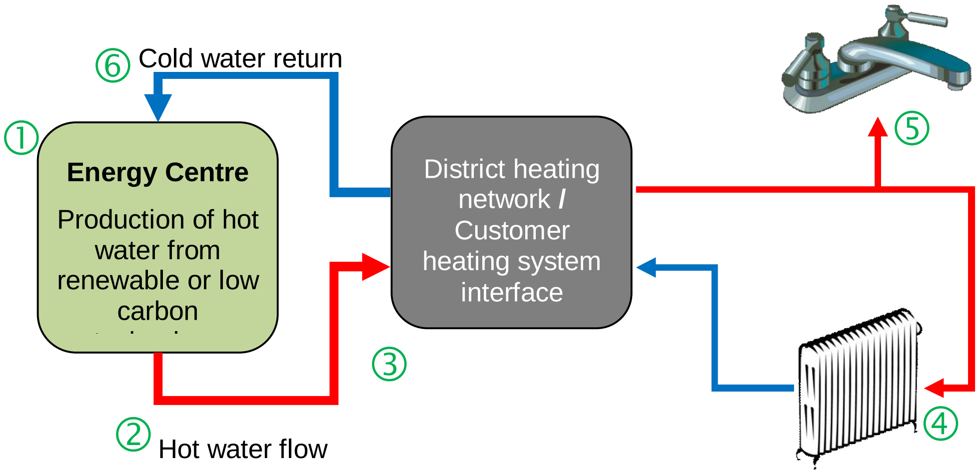
- A need to stimulate regeneration in a sustainable and cost-effective manner, delivering low carbon housing and commercial buildings
- Delivering the Covenant of Mayors (CoM) commitment[1]
- National Indicator 185 – requiring local authorities to monitor and publish their CO_2 emissions
- Minimising exposure to the Carbon Reduction Commitment (CRC)
- Adherence to local authority Carbon Management Plans (CMP) that will require significant cuts in the emissions within each local authority area.

How can district heating help to reduce carbon emissions?

District heating (DH) is a tried and tested means of delivering sustainable, low-carbon and low-cost heat. DH is able to produce a CO_2 saving because the heat supplied to customers has a lower carbon content than that supplied from traditional heating systems. The following illustration shows how a district heating system could supply customers in the Tees Valley: ① heat is produced in an energy centre from renewable or low carbon technology, ② it is then transported to individual customers in buried insulated pipes, ③ each customer has an interface unit from which their ④ heating and ⑤ hot water demands are met in place of a conventional boiler and water heater, ⑥ cool water is then returned to the energy centre via the interface and buried pipes.

[1] Committing the local authorities to a 20% reduction in carbon emissions by 2020 against a 2005 baseline

Figure 1: Elements of a district heating system



What are the key factors that make DH schemes successful?

A review of the deployment of district heating in both the UK and Europe reveals a number of key factors that are common to successful schemes:

- Strong commitment from an elected official or senior council officer who will act as a 'local champion' for district heating. They must be able to provide ongoing political and financial support for the district heating scheme, helping to progress it from concept to delivery
- Identifiable and sustainable CO_2 and financial saving for supplying heat from district heating rather than from conventional means
- Strong public sector commitment, involvement in promoting and sponsoring the scheme
- Access to public funding, particularly in the early development stages
- Strong regulatory support for connecting to a district heating network if present
- A clear risk allocation structure which only transfers those risks between parties that can be properly managed by each
- Use of experienced and competent resources
- A recognition of the commercial drivers and limitations of the private sector partners
- Clear and standardised arrangements for ongoing connections to the scheme and charging for use of system

PB's report identified that many of these factors are present in the Tees Valley Schemes

How were potential district heating schemes in the Tees Valley identified

The viability of district heating is strongly influenced by the density of heat demand available for connection to the proposed network; an area of high heat demand density would be considered more viable than an area of lower density. A heat demand density map of the Tees Valley was generated and 13 areas with a high concentration of heat demand were identified. A quantitative, multi-factor analysis of the areas was undertaken and the techno-economic viability of five areas, listed below, was tested.

- Darlington town centre / Central Park development
- Stockton / Northshore area
- Middlesbrough town centre / Middlehaven development
- Greater Eston area/ Low Grange
- Hartlepool town centre

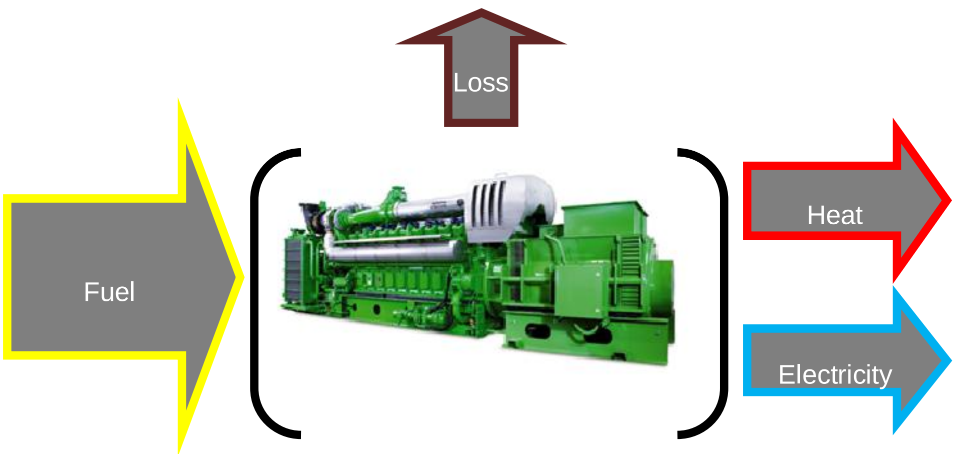
For each scheme two potential variants were analysed: **Core network**: based around existing, known heat loads, and **Extended network**: which takes into account the potential loads from future development in addition to the existing buildings.

What renewable or low carbon technology could supply the district heating network?

The following renewable and low carbon technologies were examined as potential heat sources for the district heating schemes in the Tees Valley:

- **Combined Heat and Power (CHP)** – Heat and electricity is produced by an internal combustion engine connected to a generator. The heat from the engine cooling systems and exhaust is recovered and transferred to the district heating network. It is possible to operate a CHP unit using either **fossil or renewable fuel**. The carbon saving achievable with CHP is derived from the efficient use of fuel to produce heat and power compared with using conventional boilers and national grid electricity. If the CHP uses renewable fuel the carbon saving is greater still. This study has examined both **natural gas CHP** and **bio-fuel CHP**[2]; the carbon saving achievable with bio-fuel CHP is considerably higher than using natural gas CHP because the bio-fuel is sustainably sourced and considered renewable.

Figure 2: Principle of Combined Heat and Power production



[2] The study assessed the use of Pure Plant Oil (PPO) derived from UK sourced rape seed oil

- **Biomass boilers** – wood fuel is burned in a solid fuel boiler to produce low carbon heat. The heat from a biomass boiler is lower in carbon content than that from a fossil fuel boiler because the wood fuel is sustainably sourced and considered renewable.

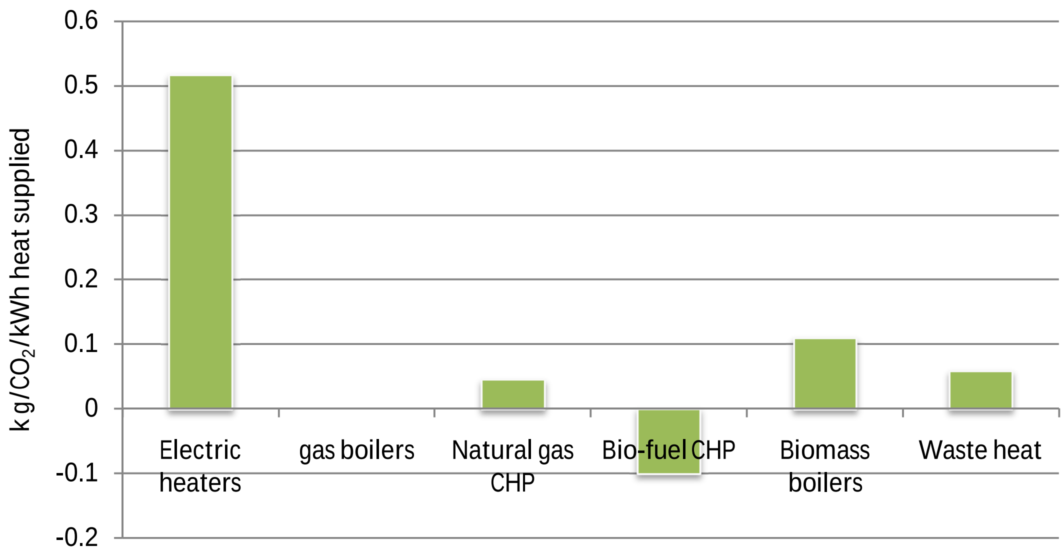
- **Waste Heat** – heat produced from power generation or process industry can be used to supply district heating networks. The CO_2 content of this heat depends on how the heat is produced, it can be considered to be zero or very low carbon in many cases.

The heat demand data was used to construct an integrated technical and economic model to evaluate the schemes' economic and environmental performance. The model simulates how renewable and low carbon technologies could potentially supply DH schemes in the Tees Valley. The technical, environmental and economic performance of each technology was assessed in order to identify the whole life cost and carbon reduction potential for each of the schemes listed above.

What is the CO_2 content of heat from district heating?

The carbon content of the heat supplied from a district heating network is a function of the fuel conversion efficiency of the technology selected and the type of fuel used[3]. The figure below provides a comparison of the various heat supply technologies available for individual building solutions as well as district heating. :

Figure 3: CO_2 content of heat from various technologies



It is evident that there is a significant CO_2 reduction advantage to be gained from using CHP or biomass boilers. The generation of electricity from a CHP unit has a considerable CO_2 reduction benefit, this is maximised if bio-fuel, rather than natural gas is used as the CHP fuel. The bio-fuel

[3] For each technology the impact of fuel efficiency and heat supplied from auxiliary gas boilers has been accounted for

CHP is able to produce a negative carbon value because of the significant carbon benefit attached to the electricity generated combined with the near zero carbon content of the bio-fuel itself.

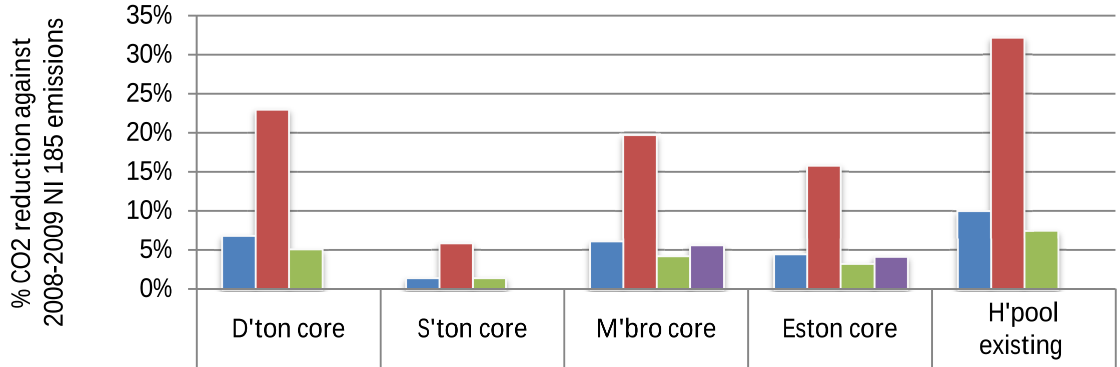
How was the economic viability of the district heating schemes tested

The report assessed the viability of DH using a Whole life costing methodology as recommended by HM Treasury. The lifecycle costs of each scheme are discounted back to present costs and expressed as a Net Present Value (NPV). A positive NPV indicates that annual cash flows are sufficient to yield a return on initial investment. The annual cash flow has been discounted using two real discount rates, intended to reflect the cost of borrowing for public (3.5%) and private sector (9%) borrowing. The following analysis presents the findings at 3.5% real discount rate because of the strong public sector component of the schemes.

How can district heating help meet reduce NI 185 emissions?

The core schemes supply existing local authority buildings in each of the Tees Valley town centres; as such these schemes have the potential to contribute towards reducing local authority CO_2 emissions as measured by National Indicator 185. The figure below illustrates the percentage reduction against the published NI 185 emissions for 2008/2009. When the reductions shown below are compared against the Covenant of Mayors targets the reduction achieved by district heating is minor. The use of district heating would however demonstrate leadership from the local authorities and would act to promote the wider use of renewable and low carbon technologies. Once established a DH scheme can be expanded to connect other local authority and private sector buildings, thereby increasing the potential for CO_2 reduction.

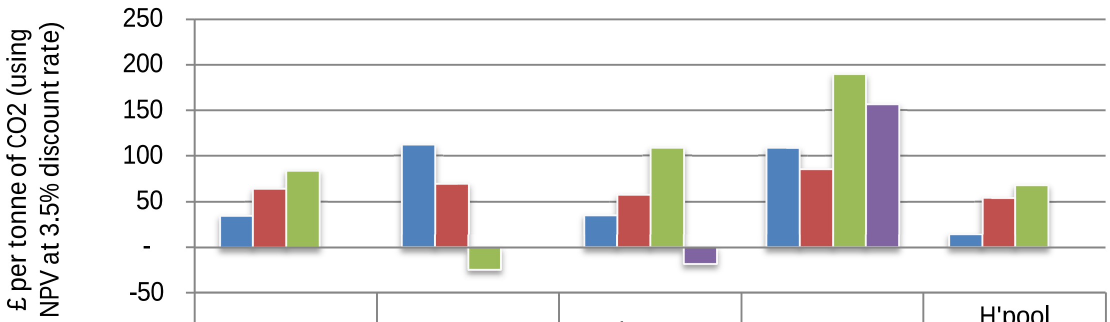
Figure 4: CO_2 reduction for core schemes against NI 185 emissions for 2008/2009



	D'ton core	S'ton core	M'bro core	Eston core	H'pool existing
Gas CHP	7%	1%	6%	4%	10%
Bio-fuel CHP	23%	6%	20%	16%	32%
Biomass boiler	5%	1%	4%	3%	7%
Waste heat	0%	0%	6%	4%	0%

The use of **gas fuelled CHP reduce NI 185 emissions by 5-10%** and the use of **bio-fuel could deliver reductions of 15-30%.** The cost of CO_2 reduction for each of the schemes, as displayed in figure 5 shows that the lowest cost technology varies between schemes. Detailed financial results can be found in section four of the main report.

Figure 5: Whole life cost of CO_2 reduction for core schemes



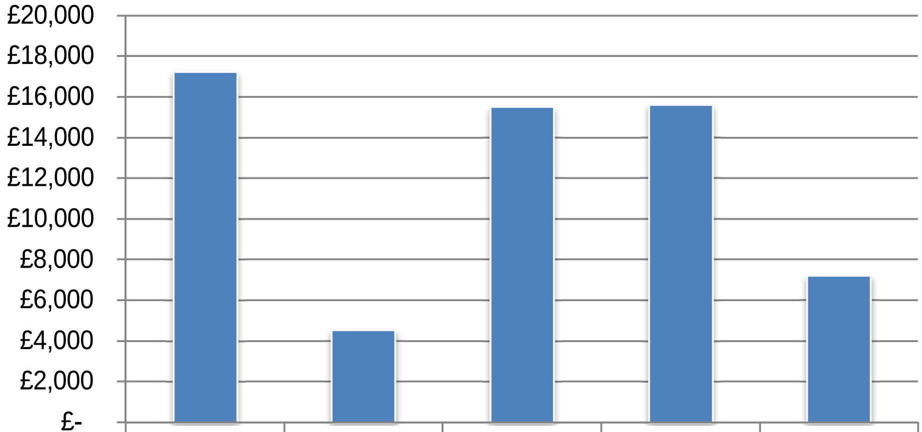
	D'ton core	S'ton core	M'bro core	Eston core	H'pool existing
Gas CHP	35	112	35	109	15
Bio-fuel CHP	64	70	58	86	54
Biomass boiler	84	-24	109	190	69
Waste heat			-18	157	

For each scheme the lowest cost technology can save: Darlington **7%**; Stockton **1%**; Middlesbrough **6%**; Eston **16%** and Hartlepool **10%** against the NI 185 emissions for 2008-2009. The use of a biomass boiler to supply the Stockton core scheme is eligible for support from the Renewable Heat Incentive. An application has been submitted for a biomass power station that could potentially supply ‘waste’ heat to the Middlesbrough core scheme. This scheme would be considered financially viable if supplied from this source, however it would carry a significant risk associated with the procurement of heat from a not-as-yet built 3rd party heat source. The Darlington and Eston core schemes would need capital assistance in the order of £1 million and £3 million respectively to be considered financially viable at 3.5% real discount rate.

How can district heating reduce exposure to Carbon Reduction Commitment?

CRC is payable on fuel and electricity consumption; the use of district heating will offset the use of natural gas, thereby reducing the quantity of carbon allowances that have to be bought.

Figure 6: Reduction in CRC payment for core schemes



	D'ton core	S'ton core	M'bro core	Eston core	H'pool existing
Reduction in CRC payment (£)	£17,241	£4,548	£15,512	£15,598	£7,215

Figure 6 indicates that a modest saving could be made if local authority buildings were supplied from district heating.

How can district heating facilitate regeneration?

The extended schemes examined in this study supply new developments in addition to the existing buildings supplied by the core schemes. The construction of a DH network that serves new development with low carbon heat, will allow Developers to avoid costs that they would otherwise bear to comply with carbon-performance targets contained in Building Regulations or the Code for Sustainable Homes (CSH)[4]. Therefore, it can be expected that if low-cost and low carbon heat is available in the vicinity of the development site developers and house builders will have an incentive to connect to a DH network and contribute to the cost of the installation of that infrastructure up to the same level of cost that they would otherwise have seen[5]. The presence of a DH network will facilitate regeneration where the cost to the developer is considerably less than the alternative cost of compliance with mandatory CO_2 reduction targets. The analysis herein assumes the entire development would be constructed to CSH level 4 OR CSH level 6. No phasing of development has been taken into account in this study.

The Hartlepool extended scheme has not been included because the planning application for these developments was lodged prior to 2006.

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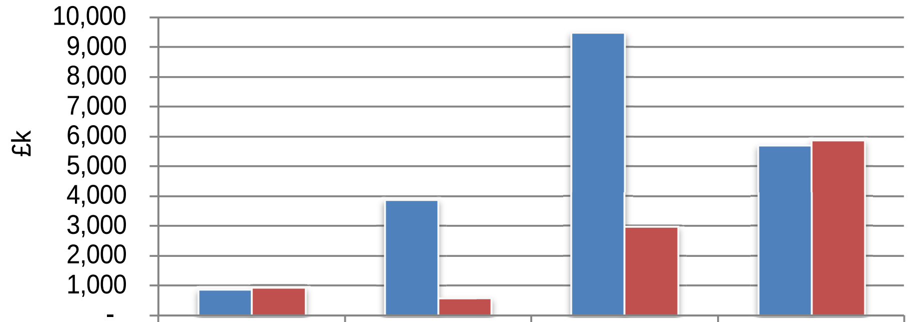
[4] http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf

[5] The developer contribution used for non-residential development reflects the cost of complying with 2010 building regulations, because the costs associated with achieving higher CO_2 reduction targets are less well defined than for residential buildings.

Code for sustainable homes level 4: A CO_2 reduction of around 45% can be achieved through the use of gas engine CHP, this can be equated to compliance with CSH level 4. Published data indicates that compliance with CSH level 4 will cost developers at least £4,750 per unit. Figure 7 indicates the sum of the developer contribution **Stockton and Middlesbrough are both able to deliver CSH level 4 development at a lower cost than the alternative**. The cost of implementing DH in Darlington and Eston is marginally higher than the alternatives.

Figure 7: Potential developer contribution for CSH level 4 vs. NPV at 3.5% discount rate for extended schemes using gas engine CHP

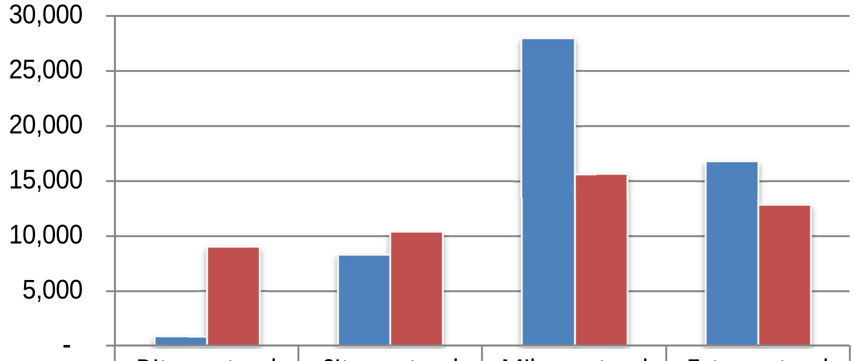


	D'ton extend	S'ton extend	M'bro extend	Eston extend
Potential CSH level 4 developer contribution	860	3,880	9,500	5,700
Contribution needed (to achieve zero NPV @ 3.5% discount rate)	929	577	2,972	5,868

Code for sustainable homes level 6: It is necessary to use bio-fuel CHP to achieve the significant CO_2 reduction that is required to achieve CSH level 6. The use of bio-fuel CHP is in itself a high risk strategy owing to the emerging nature of this technology in the UK. In addition the techno-economic model demonstrates that this technology is not economically viable without an annual subsidy to cover the cost of the bio-fuel. Published data indicates that compliance with CSH level 6 will cost developers at least £14,000 per unit. Figure 8 demonstrates how the developer contribution could be used to subsidise the operation of this technology, therefore facilitating the delivery of homes compliant with CSH level 6.

The annual subsidy required to make the bio-fuel CHP options financially viable could be levied from developers as an annual contribution rather than a one-off payment. The mechanism by which this fund is administered has not been resolved in this study and should be explored by the local authority directors of finance.

Figure 8: Potential developer contribution for CSH level 6 vs. NPV at 3.5% discount rate for extended schemes using bio-fuel CHP



	D'ton extend	S'ton extend	M'bro extend	Eston extend
Potential CSH level 6 developer contribution	860	8,320	28,000	16,800
Contribution needed (to achieve zero NPV @ 3.5% discount rate)	9,028	10,387	15,672	12,853

The **Middlesbrough** and **Eston** schemes are dominated by residential development; as such they can potentially level a significant developer contribution, which in both cases has the potential to allow compliance with **CSH level 6 at a lower cost than alternative solutions**.

How can district heating be delivered in the Tees Valley?

A number of commercial structures are available for DH network deployment. It is possible that the schemes identified in the Tees Valley could be delivered under the stewardship of an overarching umbrella organisation. The role of this organisation could potentially be to:

- Maintain a technical and commercial knowledge base and share lessons learned
- Provide customer management, metering and billing services for all schemes
- Provide technical staff for operation and maintenance of schemes
- Allow reduced fuel cost from increased purchasing power available through aggregated purchasing
- Pool funding, which may provide access to additional funding arrangements
- Depending on the structure and terms of reference of the central organisation support could be provided from successful schemes to allow less viable schemes to proceed
- Hold and manage contracts for the supply of heat and electricity
- Coordinate the supply of heat from a number of sources

Despite the evident benefits of a single umbrella organisation a project by project approach would allow more flexibility on the timing and details of each project. There could potentially be a hybrid by which the umbrella organisation controls/drives the projects with flexibility on final delivery of individual projects. The commercial structure for each of the four schemes will depend critically on the funding routes identified and the body which will lead the procurement.

What opportunities can district heating offer the Tees Valley?

1. If district heating were to supply existing local authority buildings the use of gas engine CHP could reduce NI 185 emissions by 5-10% whereas bio-fuel CHP produce a reduction of 15-30% against 2008/2009 levels.

2. A modest reduction in CRC exposure, in the order of £k5 to £k15, could be achieved if local authority buildings were supplied from district heating.

3. The use of gas engine CHP and district heating would allow the Northshore development in Stockton and the Middlehaven development Middlesbrough to achieve Code for Sustainable Homes level 4 at a lower cost than alternative technical solutions.

4. The use of bio-fuel CHP and district heating would allow the Middlehaven development in Middlesbrough and the Low Grange development in Eston to achieve Code for Sustainable Homes level 6 at a lower cost than alternative technical solutions

5. There is the long term potential to identify investment that would enable the supply of heat from industrial sources. This would serve to increase the competitive advantage to process industry and assist in reducing CO_2 emissions.

What are the headline risks of implementing district heating in the tees valley?

1. The viability of Stockton core scheme relies on support from the Renewable Heat Incentive, the implementation of which is uncertain[6].

2. The common factor between all technology options is the significant impact that the heat sales price has on the viability of the four district heating schemes. Aside from the capital cost the heat sales tariff is the over which the operator will have the greatest control during the contract negotiation stage.

3. Whilst the use of bio-fuel CHP as a heat source from DH networks in the region would lead to significant decarbonisation of exiting and future buildings its use requires an annual subsidy to be commercially viable.

4. The commercial structure and delivery vehicle needs to address the requirements of each of the five local authorities in the Tees Valley.

5. To be viable the district heating schemes in the Tees Valley need to include new development.

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[6] A decision on the RHI is expected in late October 2010, with implementation anticipated from April 2011

What are the next steps?

- The Tees Valley local authorities should commit to the use of district heating as a key technology to facilitate CO_2 reduction and stimulate new development. Other available technical solutions should only be adopted if district heating has been demonstrated to be unviable.
- The Tees Valley political leaders and directors of finance need to investigate funding options and the mechanism by which district heating could be delivered. All concerned should be aware that the delivery of district heating schemes will be staggered, with schemes in different Local Authority areas delivered at different times.
- As for all emerging DH schemes, it is critical to ensure that early and continuing dialogue with potential heat customers is pursued and maintained. The ultimate goal of this dialogue as schemes progress is to have firm commitment to connect to a scheme's heat supply when it becomes available. This process should ensure that scheme development pays attention to the natural business cycles of the organisations that are to connect, and allows heat sales prices to capture the value of avoided alternative costs.
- District heating can help to facilitate the delivery of new development in the Tees Valley. The Tees Valley councils should strongly consider incorporating requirements for connection to district heating, where appropriate, in their planning guidance.
- The Tees Valley councils, in conjunction with TVU and NEPO, should work together to draw up heads of terms for the formation of an Energy Service company that will act as an umbrella organisation to oversee the design, implementation, operation and ongoing growth of district heating schemes in the Tees Valley. The outcomes of the soft market testing, when available, should be used to inform the procurement of district heating in the Tees Valley.
- Industrial operators that have the ability to sell 'surplus' heat, for example, BEI, Sembcorp and MGT, have the potential to supply district heating schemes in Middlesbrough and Eston with low carbon heat. Middlesbrough and Redcar and Cleveland Councils should keep a watching brief on this opportunity.

SECTION 1

INTRODUCTION

1 INTRODUCTION

This report provides the findings of a study into the viability of deploying district heating across the Tees Valley region.

District heating is a well-established technology widely used elsewhere in Europe, that provides economic and environmental benefits through the efficient production, distribution and use of low cost, low carbon heat. Furthermore, it is evident from the performance of Denmark[7] and Sweden[8] that district heating can play a major role in de-coupling economic growth from carbon growth, thereby facilitating transition to a low carbon economy.

PB has investigated the practicality of installing district heating networks in the Tees Valley and has identified four priority schemes across the district. The methodology adopted, analysis of results, and recommendations for future actions are contained within this report.

1.1 KEY DRIVERS

The drivers for considering the deployment of district heating in the Tees Valley include: reducing CO_2 emissions from existing and future buildings, reducing incidence of fuel poverty, using waste heat from power generation and process industries, providing a clear solution for developers to comply with CO_2 reduction targets therefore encouraging regeneration of the region. The key drivers are all related to CO_2 reduction and have the potential to significantly influence the business case for deploying district heating. A selection of formal documents promoting low-carbon development is listed below:

1. Climate Change Act
2. Covenant of Mayors – The Tees Valley authorities have signed up to a 20% CO_2 reduction against a 2005 baseline as part of the Covenant of Mayors agreement.
3. The Code for Sustainable Homes requires that all new development is net ‘zero carbon’ by 2016, and the Code for Sustainable Buildings is expected to require new non-residential buildings to be net ‘zero carbon’ by 2019.

[7] http://www.danskfjernvarme.dk/In%20English.aspx

[8] http://www.svenskfjarrvarme.se/

4. Policy 38 of the North East Regional Spatial Strategy[9] which requires major new developments to secure at least 10% of their energy supply from decentralised and renewable or low-carbon sources.

1.2 GROWTH POINT STATUS

The Tees Valley region has been included in the second round of Growth Point funding. The Growth Point programme, led by the Homes and Community Agency, helps local authorities to deliver increased volumes of sustainable housing. The Growth Point scheme can provide initial funding for infrastructure projects that will facilitate the delivery of the new housing. The aspirations[10] of the Tees Valley local authorities, coordinated by Tees Valley Unlimited are to:

- Providing a much improved housing offer which encourages more people to live in the heart of the city region, rather than the new suburbs, rural towns and villages
- Reducing social polarisation by providing high quality private sector housing in the centre of main towns and thereby making a major contribution to regenerating older housing areas
- Reducing the carbon footprint of the Tees Valley through the construction of low energy homes, improving the viability of public transport and linking major new energy developments to new housing areas

It is anticipated that the Growth Point funding could be used, in part, to fund elements of the district heating infrastructure. The case for using growth point funding is that the presence of a district heating system has the potential to allow developers to comply with carbon reduction targets at a lower cost than alternative approaches. It is uncertain whether using the growth point for the entire Tees Valley to fund one or two schemes within specific local authority areas would be politically acceptable. In reality it is unlikely that the growth point fund would be able to contribute meaningful amounts of capital expenditure towards the implementation of district heating schemes in the Tees Valley.

[9] Revoked under the new lib-con administration, but anticipated to be in force until further notice

[10] Second Round Growth Points, Partnerships for Growth, Department for Communities and Local Government: London, July 2008

The increasingly stringent CO_2 reduction targets for the Code for Sustainable Homes have the potential to impact the viability of new developments. Offering developers a lower cost alternative is therefore likely to stimulate the delivery of sustainable development in the Tees Valley.

1.3 DELIVERING DISTRICT HEATING IN THE TEES VALLEY

Nationally, there is a supportive regulatory climate that is providing more encouragement to DH. Examples are measures such as the Renewable Heat Incentive and the Carbon Reduction Commitment, or the planning process for new power plants that requires consideration of heat provision. The UK Government's recent Low Carbon Industrial Strategy also included new funding for development of DH schemes.

Not only do these represent opportunities for DH development, but DH could in turn make significant contributions to economic and environmental improvement in the Tees Valley:

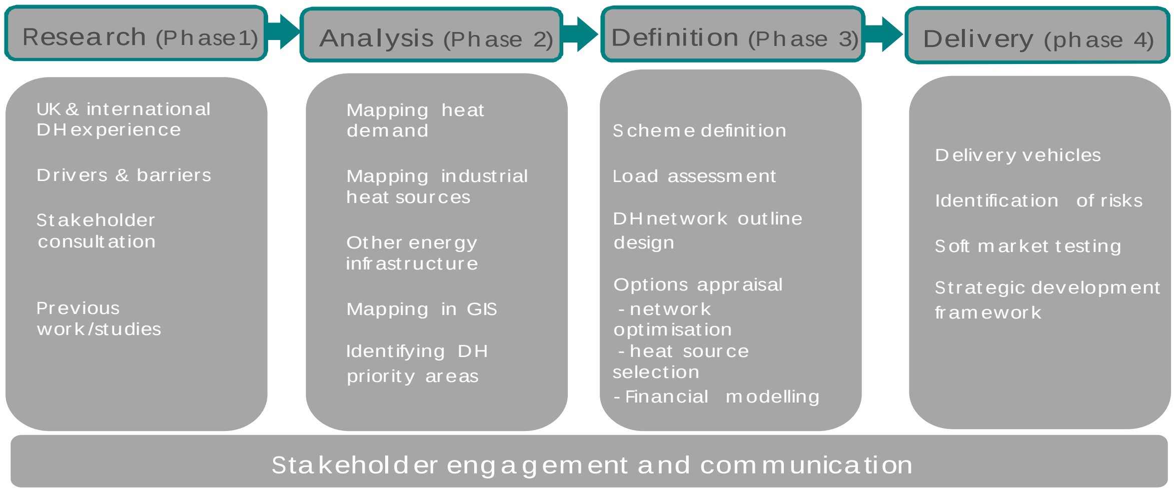
- Provide extra revenue to industrial heat suppliers, improving their competitiveness.
- Provide lower cost heat to new and existing heat users in the area.
- Reduce carbon emissions for the area as a whole through improved efficiency of generation. This in turn can allow industry and businesses to avoid future carbon costs.

The high up-front capital costs for implementing district heating means that DH schemes do not happen "of their own accord". It is not straightforward for any single heat supplier or customer to take on the burden of development. Our experience is that DH schemes need to be driven forward collectively, usually with leadership and facilitation from the public sector.

1.4 REPORT STRUCTURE

PB has attempted to keep this report accessible to a wide audience. As such a large proportion of the technical evidences used to develop the techno-economic models has been included as appendices to this report.

PB has divided the study into four discrete stages, as follows:


Research (Phase1)
Analysis (Phase 2)
Definition (Phase 3)
Delivery (phase 4)
UK & international DH experience
Drivers & barriers
Stakeholder consultation
Previous work/studies
Mapping heat demand
Mapping industrial heat sources
Other energy infrastructure
Mapping in GIS
Identifying DH priority areas
Scheme definition
Load assessment
DH network outline design
Options appraisal
- network optimisation
- heat source selection
- Financial modelling
Delivery vehicles
Identification of risks
Soft market testing
Strategic development framework
Stakeholder engagement and communication

SECTION 2

PHASE ONE: RESEARCH

2 PHASE ONE: RESEARCH

This section provides background to the use of district heating in the UK and Europe and outlines the common factors that have initially stimulated the need for district heating and supported its development once established. The drivers and barriers to the implementation of district heating in the Tees Valley are discussed with a view to mitigating them.

2.1 DISTRICT HEATING EXAMPLES

PB have undertaken a review of district heating schemes in the UK and Europe concentrating on the factors that have allowed the district heating schemes to grow beyond their original scope. The review, included in Appendix A, provides concise case studies for the following district heating schemes:

Copenhagen – Supplying almost the entire city of Copenhagen with heat from a range of heat sources

Dunkirk & Saint-Pol-sur-Mer – utilising waste heat from a steel manufacturer to supply customers throughout the city

Pimlico District Heating Undertaking, London – uses gas engine CHP to supply social housing, schools and new development

Southampton – using geothermal heat and CHP to supply buildings around the Southampton waterside

Nottingham – using heat from an energy from waste plant to supply public sector, commercial and residential development

The Warren, Woolwich – Gas engine CHP to supply a small development in south London

Birmingham District Energy Company – meets the heating needs of two areas of the city from gas engine CHP

Kings Cross – Metropolitan – The scheme supplies a major redevelopment around Kings Cross in London using biomass boilers and gas engine CHP

Olympic Park and Stratford City – The heat and power needs for the Olympic Park and the Stratford City development are supplied from two energy centres. Heat sources include gas engine CHP and bio-oil boilers.

Caithness Heat and Power – using biomass CHP to supply a small scheme comprised from residential and commercial customers

The research has revealed several common factors in successful district heating schemes which have developed beyond their initial scope, these are:

1. Continued financial advantage in supplying heat from district heating rather than conventional means
2. Strong public sector involvement in promoting and sponsoring the scheme
3. Maximising access to public funding, particularly in the early development stages
4. Strong regulatory support for connecting to a district heating network if present
5. A clear risk allocation structure which only transfers those risks between parties that can be properly managed by each
6. Use of experienced and competent resources
7. A recognition of the commercial drivers and limitations of the private sector partners
8. Clear and standard arrangements for ongoing connections and charging
9. Ongoing public sector monitoring and involvement – potentially as regulator of the service or operator of last resort
10. A local champion – the local champion can be an elected official or council officer who is able to provide ongoing support for the district heating scheme, helping to progress it from concept to delivery.

The potential development of DH schemes across the Tees Valley as outlined in this report should be read with these key success factors in mind.

2.2 DRIVERS AND BARRIERS TO DEPLOYING DISTRICT HEATING IN THE TEES VALLEY

PB have collated the perceived drivers and barriers to the deployment of district heating in the Tees valley using information gathered from a stakeholder workshop held on the 14th April 2010. These have been supplemented where appropriate with information garnered from previous projects in the UK. PB has suggested means of mitigating against the barriers where possible.

For ease of interpretation the drivers and barriers have been divided into the following categories:

- Commercial
- Regulatory
- Strategy/political
- Operational

2.2.1 COMMERCIAL DRIVERS AND BARRIERS

Table 2-1: Commercial drivers and barriers for deploying district heating in the Tees Valley

Drivers	Barriers	Potential mitigation
Lower cost of delivery for compliance with Part L and code for sustainable homes/buildings	Capital to install infrastructure and revenue - the business case needs to add up for all key / anchor parties	Strategy to develop schemes is to work with major heat suppliers / customers and develop business plan in collaboration with these partners. Opportunity to tie in to other investment possibilities (e.g. EIB)
Opportunity to obtain long	Contract arrangements for heat	Contracts to be developed with

term, secure, sustainable and affordable energy supply	supply and purchase	financial modelling and business case in conjunction with partners / customers.
	Uncertainty in long term energy prices and impact upon ability to develop a workable business case.	Contracts to be suitably index-linked and developed with partners.
Reduction in space take for energy supply plant in new buildings, potential to outsource to ESCo	Cost of heat to customers and to what extent can costs be protected? How can the offer be attractive with such a long tie in to householders?	There is the potential to guarantee that prices to consumers will be lower than a 'basket' of market alternatives. In general the DH schemes will not be reliant on housing only.
Home and Community Agency (Low Carbon Infrastructure Fund) and Community Energy Saving Programme (follows on from Carbon Emissions Reduction Target) funding. Warm Homes, Greener homes places obligation on supplier		

2.2.2 REGULATORY DRIVERS AND BARRIERS

Table 2-2: Regulatory drivers and barriers for deploying district heating in the Tees Valley

Drivers	Barriers	Potential mitigation
Increasingly stringent requirements for part L/Code for sustainable homes/buildings, CRC, EUETS	Planning issues for installation of infrastructure and generating plant	Consider changes to local planning policies to encourage DH – (e.g. Local Development Orders) Implementation of Planning Policy needs to provide a driver

		- i.e. the framework of regional and local planning policy needs to provide details and priorities to assist planning authorities and developers to connect to DH or make developments compatible with future DH connection)
PPS1 has been re-issued and includes requirements for Local Authorities to carry out energy planning and heat mapping and use this as an evidence base to assist developers with their investment decisions.		
NI 185/186 reporting for local authorities – requirement for CO_2 reduction		

2.2.3 STRATEGY/POLITICAL DRIVERS AND BARRIERS

Table 2-3: Strategy/policy drivers and barriers for deploying district heating in the Tees Valley

Drivers	Barriers	Potential mitigation
Regulatory and other targets and incentives (e.g. Carbon Budgets, CRC, University HEFCE targets, Covenant of Mayors)		
Potential for growth of schemes to encompass neighbouring areas		
Acts to attract developers to the Tees area if proven sustainable solution available.	Scepticism as to whether projects will actually be developed reduces commitment from	Scheme must develop a clear timetable and implementation programme that takes account of key potential users needs

	stakeholders. Different customers have different requirements at different times – key players could miss out if there are delays in drawing up contracts - as some may have to develop immediate solutions.	and business cycles.
Political support is strong. Good publicity value for strategic positioning of the area – in relation to transition of the Tees Valley.	Multiple Local Authorities may mean establishing more complex, cross-border arrangements.	'Umbrella' procurement and operation vehicle
Energy from waste heat and low carbon solutions - potential to provide sustainable energy.	Industry reluctant to deal with multiple heat customers.	Potential for industry to contract with single ESCo which then is responsible for the delivery of heat to individual customers.
The Tees Valley Investment Programme (£60m) has an objective to create new jobs in low carbon technology	Many industry sites have distant ownership – and therefore a reduced ability to make local decisions or to commit to local "engagement".	
	Perceptions on cost and reliability	Build trust on basis of site visits to successful operational schemes.

2.2.4 TECHNICAL/OPERATIONAL DRIVERS AND BARRIERS

Table 2-4: Technical/operational drivers and barriers for deploying district heating in the Tees Valley

Drivers	Barriers	Potential mitigation

	Impractical / unviable to supply heat to low density residential customers	Proposed schemes not reliant on low-density residential areas. Also, in new regulatory environment, the alternative methods of regulatory compliance will also be expensive.
	Easements, disruptions to existing services	Good planning and programming to minimise disruptions when unavoidable.
Potential for industrial heat providers to benefit from additional revenue stream from heat sales, therefore diversifying their income.	Some industrial heat sources may not be available/secure over the long term (e.g. due to plant closure, change in operations etc.).	Ensure the contractual agreements with heat suppliers protect the heat network customer base
Industrial heat suppliers may be eligible for Renewable Heat Incentive through the supply of 'waste' heat from renewable sources.	The nature of some industrial operations means heat availability from them may not be guaranteed – heat availability may be intermittent, or may need to be cut-off at short notice.	Agree to heat availability guarantees in contract, provide sufficient top-up and standby boiler plant in system.

The drivers and barriers listed above have been taken into consideration when selecting the schemes to be examined in more detail and, where possible, in developing the design of the four proposed schemes.

2.3 REVIEW OF NEW DEVELOPMENTS

PB have reviewed the new developments planned for the Tees Valley area using information from the Tees Valley Unlimited Flagship regeneration projects[11], that form part of the Growth Point programme, as a starting point.

Middlesbrough - Middlehaven

Extending over 100 acres around the reclaimed dock and along the river, this flagship project will add its own iconic structures to the Transporter Bridge and Riverside Stadium at either end. The masterplan maximises the inherent drama of the waterfront, embracing offices of superior quality, apartments and family housing, the relocation of Middlesbrough College, leisure attractions, hotels and destination retail, bars and restaurants. The vision is for an environment radical and exciting enough to reposition Middlesbrough and the Tees Valley internationally. More than 2,500 residential units are proposed for Middlehaven, split over three development phases.

Stockton – North Shore

This is a crucial piece in Stockton's continuing renaissance and will extend the town centre along the River Tees to encompass up to 50 hectares creating a vibrant new south facing research-based business and education park, in addition to waterfront houses and apartments, offices, leisure and retails facilities including cafes, restaurants, bars and shops together with hotel accommodation. North Shore is anticipated to have at least 1,000 new homes, making it a significant regeneration site.

Darlington – Central Park

Taking full advantage of Darlington's nodal position in the North's communication network, this 30 hectare town centre site borders the railway immediately north of the East Coast Main Line station. It will provide extra, much needed modern office accommodation, up to 600 apartment and town house homes and a strategically positioned hotel and conference centre - all in a landscaped setting. The centre piece is the £33 million home for Darlington College of Technology (opened in 2007).

[11] The Victoria Harbour and Cotham Links projects has been excluded because they are no longer being actively progressed by Hartlepool and Redcar and Cleveland councils respectively.

Eston Masterplan

The Greater Eston Delivery Plan, published in 2009, is an ambitious series of interventions building on strategies and assessments undertaken over recent years including new and refurbished homes, creation and improvement of public spaces and creation of health and safe communities.

Redcar and Cleveland council have promoted Low Grange area as "the flagship development for Greater Eston". The "Urban Village" will be located on land adjacent to the Trunk Road and Normanby Road in South Bank and will create a new mixed-use hub for the people of Greater Eston. PB have focused on the Low Grange area of Eston because of its strategic importance and the anticipated higher heat load density associated with this key redevelopment scheme within Eston. Low Grange is anticipated to have the following composition:

- Health & Social Care Village (now open)
- Elderly Care Facility
- District retail centre incorporating a major superstore
- 1000+ Mixed-tenure, low carbon, sustainable houses

2.4 PREVIOUS STUDIES LOW AND ZERO CARBON ENERGY PROJECTS

Darlington Renewables Study

The Darlington Renewable Energy and Low Carbon Technologies Study is a two phase study funded by the Carbon Trust. This study concludes that the preferred approach to CO_2 reduction would be through the implementation of a district heating scheme to supply public sector and commercial buildings in the town centre. PB has reviewed the stage 2 report and views this study as a valuable piece of evidence that can be used to help develop the techno-economic model for delivering district heating in Darlington.

2.5 DISCUSSIONS WITH HEAT SUPPLIERS

The Tees Valley has a significant number of industrial and power generation plants that have the potential to supply heat to a district heating network. Heat from an industrial process can be classified as waste heat if it would otherwise be rejected to the atmosphere. Where heat could still be used for another process the carbon content of the heat has been calculated, for example when heat is taken from power generation the impact on the electrical efficiency is taken into account.

PB has held discussions with the following potential heat suppliers and has requested that they complete a questionnaire about the quantity of and characteristics of the heat available. These discussions follow on from work undertaken as part of the Energy work stream of the North-South Tees Project:

Potential heat provider	Source of heat	Potential customers
Teesside power station	Confidential information	Greater Eston
Wilton International - Sembcorp	Biomass CHP, gas turbine, gas boilers	Greater Eston
Gaia power	Biomass CHP	Billingham
Bio-Energy International	Biomass CHP	Middlesbrough
MGT power	Biomass CHP	Greater Eston
Koopers	Gas engine CHP	Middlesbrough

Where not bound by confidentiality agreements PB have included completed heat supply questionnaires in Appendix B. The following section provides a brief overview of the potential heat supply available to supply district heating schemes in the Tees Valley.

Teesside Power Station - PB have signed a confidentiality agreement with Teesside power station and are not able to disclose any details regarding the potential heat provision from this source

Wilton International – A core business of Sembcorp, the owners of the Wilton site, is the sale of heat, usually in the form of high and intermediate pressure steam, to tenants on the Wilton site. Representatives of Sembcorp have indicated that they would be receptive to the concept of supplying low temperature hot water to customers in the vicinity of the Wilton site. Sembcorp have indicated that the cost of heat would need to cover any lost revenue from electrical generation resulting from the supply of heat.

Gaia Power – The Gaia biomass power station is planned for the north shore of the Tees in the vicinity of Billingham. The biomass power plant will have an electrical output of 50MW and will supply heat to a wood fuel pellet production facility adjacent to the site. Although Gaia power are open to the idea of supplying additional heat there is no incentive for them to do so because they can get full ROC benefit from the supply of the pellet production plant. The plant has planning permission and all permits are in place. Financial close is dependant on the government decision on the 'grandfathering' for ROC eligible biomass power plant.

BEI – The developers of BEI plan to construct a 50MWe biomass CHP plant on the North shore of the Tees, close to Port Clarence. The development has been awarded planning permission. They have had discussions with the developers of Middlehaven regarding the supply of heat from their plant to the new development via a new pipeline under the Tees. The supply of heat to Middlehaven, and even Middlesbrough from this pipe would help BEI to receive the full ROC allowance for their plant. BEI have stated that they would be willing to consider funding the pipe under the Tees and a proportion of the district heating network cost if it would allow the organisation to receive double ROCs for their generation.

MGT Power – The MGT Tees biomass power plant will provide 300MW of electricity as a baseload generator. A considerable amount of heat could be available from this plant with a minimal impact on the electrical efficiency. The representatives of MGT power are keen to be involved in discussions regarding the provision of heat to district heating schemes in the Tees Valley.

Koppers ltd – Koppers have a 2MWe gas engine CHP to produce steam and power for their process. They are adjacent to the BEI site on the North bank of the Tees and are keen to make use of low grade heat that they have available. They would be interested in supply heat across the river should BEI fund the infrastructure.

A map illustrating the location of the potential heat supplier is provided below:

Figure 2-1: Location of potential heat suppliers in the Tees Valley

SECTION 3

PHASE TWO: ANALYSIS

3 PHASE TWO: ANALYSIS

This section provides the evidence base from which the techno-economic appraisal can be undertaken. PB identifies the means by which energy demands are calculated and outlines the mechanisms used to select the four schemes to be examined in the next phase of the project.

3.1 HEAT LOAD MAPPING

3.1.1 INTRODUCTION

The viability of district heating is heavily dependant on the density of heat load being supplied. A network to supply an area with low heat load density will require a greater amount of district heating pipe per unit of heat demand supplied compared to a scheme with high heat load density. PB has gathered heat usage data across the entire Tees Valley region and constructed a map using Geographical Information Software (GIS) onto which the spatial variation in heat demand is shown. The intention is that the feasibility of implementing district heating would be focussed on the areas with higher heat density.

3.1.2 DATA SOURCES AND KEY ASSUMPTIONS

Data for heat load mapping has been drawn from a number of sources.

Table 3-1 - Key data sources and assumptions in heat load mapping

Building type	Data source and key assumptions
Existing social housing	Census 2001 data on dwelling numbers and tenure, benchmarks from published sources for existing stock – only social housing selected[12]
Future Domestic	Dwelling numbers as advised by the relevant local authorities for future development, benchmarks from published models of dwellings achieving high levels of the Code for Sustainable Homes
Existing Non-Domestic	Display Energy Certificates for public buildings. Private / commercial buildings excluded.
Future Non-Domestic	Benchmarks derived from published datasets, with improvements factors to account for increasing stringency in energy performance standards, quantum of development as advised by the relevant local authorities.

A description of the methodology used to construct the heat density maps is included below, the assumptions used to calculate heat density can be found in appendix C.

3.1.3 HEAT LOAD DENSITY AND GIS MAPPING

Each of the loads identified in the process outlined above was located geographically on a map of the Tees Valley. Social tenure domestic loads were displayed as a heat load density in each Census Super Output Area, (CSOA). Other loads were identified either as polygon for development or as an identified point with shading representing the magnitude of the identified heat demand. The following section provides a low resolution map depicting the headline outputs from the GIS mapping exercise, full resolution copies can be found in appendix D.

3.1.3.1 SOCIAL HOUSING

The heat demand of all the social housing within each CSOA was divided by the total area of the relevant CSOA in order to calculate the social housing heat load density. The density is indicated using a colour gradient, with darker shades of red representing higher heat load densities.

[12] Only social housing heat load density was used because the cost of connecting privately owned housing stock to district heating is considered to be prohibitively high. Social housing is under the ownership of a single landlord and is generally higher density, therefore making connection more cost effective.

3.1.3.2 EXISTING PUBLIC SECTOR BUILDINGS

Existing public sector loads were plotted onto the base map using grid coordinates (if available) or the post code (converted to grid coordinates) of each building. The latter method does have the drawback that multiple buildings have the same post code and so the grid coordinates for multiple buildings in the same post code are the same. Where necessary the building positions were reviewed and corrected. Each building was plotted as a numerically referenced point; a colour gradient was applied to each point to denote the heat demand.

3.1.3.3 FUTURE DEVELOPMENT

The location of future residential and non residential developments was provided to PB by TVU in the form of polygons that are spatially referenced to the base map. The annual heat demand and the area of the polygons were used to calculate the heat load density. A colour gradient was used to donate the anticipated heat load density for each new development.

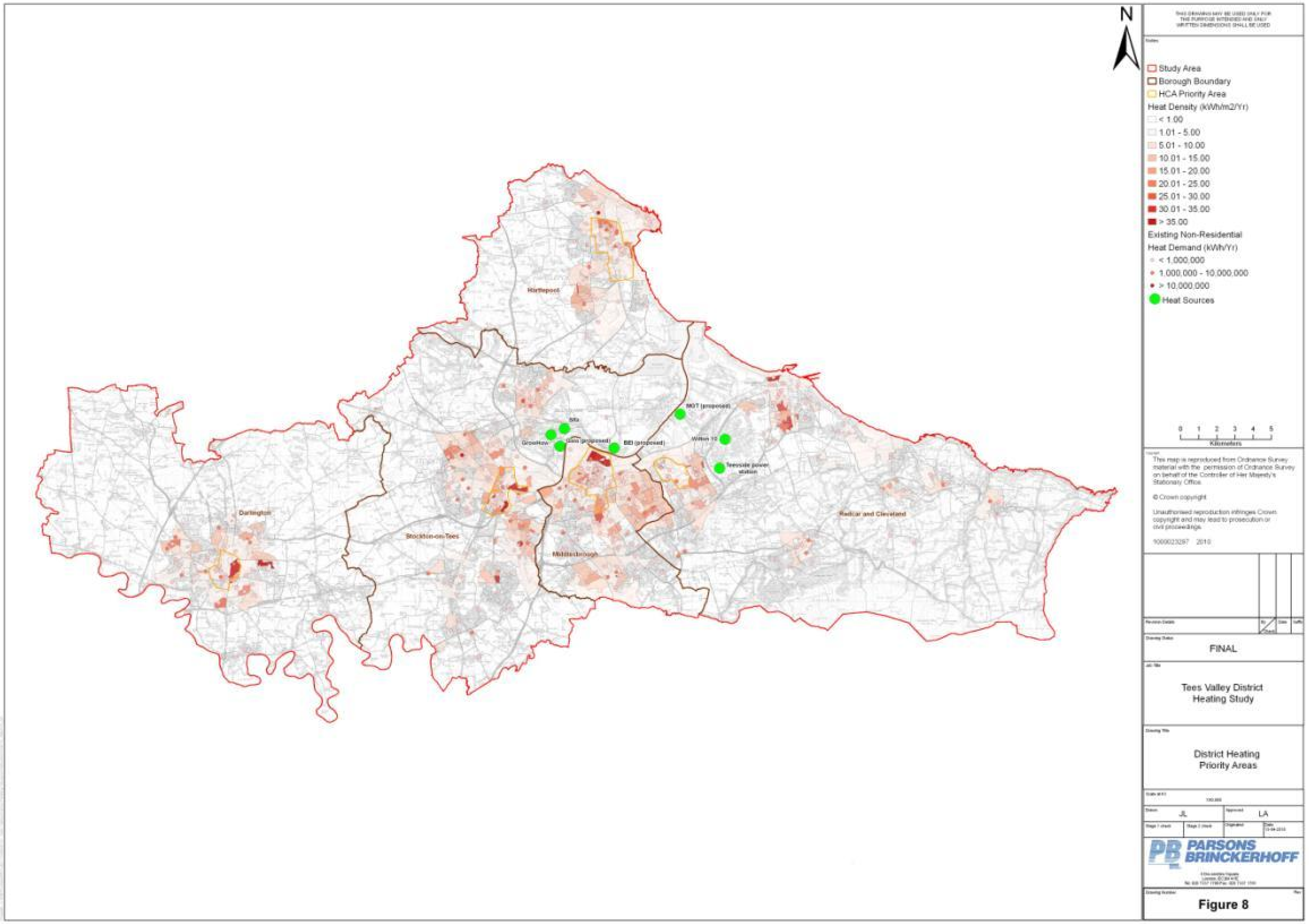
3.1.3.4 OTHER GIS LAYERS

Other layers plotted on the GIS map include:

a. Location of potential heat sources (industrial and power generation)

b. Homes and Community Agency Growth Point ‘focus areas’

Figure 3-1: Low resolution version of GIS mapping produced for the Tees Valley district heating utility study



3.2 DISTRICT HEATING SCHEME DEFINITION

PB has taken the heat mapping information contained in the GIS maps and identified district heating priority areas that are deemed by PB, following analysis of heat load density patterns, to have a good potential for the viable deployment of district heating. This section outlines the methodology that was followed to first identify the district heating propriety areas and then rank them in order to select the four district heating schemes for which designs will be developed.

3.2.1 IDENTIFICATION AND ASSESSMENT OF DISTRICT HEATING CLUSTERS

The following sections describe how the heat load mapping was used to identify areas in the Tees Valley in which district heating might be viable.

3.2.1.1 IS THERE A CLUSTERING OF POTENTIAL HEAT CUSTOMERS LOADS?

The first selection criteria has been applied to the entire data set in order to highlight potential clusters of heating loads that might have the potential to form a viable district heating scheme. The heat density map is examined for new developments and existing public sector heat loads that are close to one another and form a natural cluster. A boundary has been marked on the map to delineate the loads to be included in each district heating cluster, a reference given to each cluster, and only those loads within a cluster are examined further.

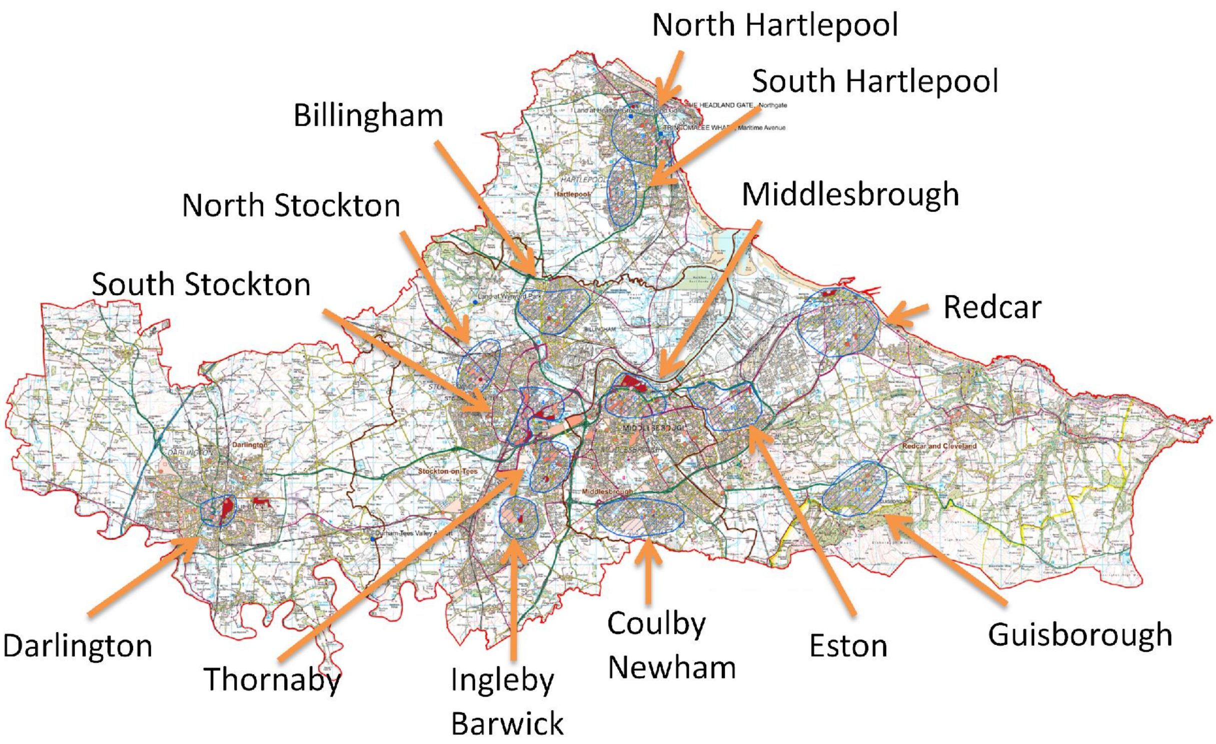
The following table lists the district heating clusters that were identified from the heat density map.

Table 3-2: District heating clusters identified

Reference	Description
1	Darlington
2	North Stockton
3	Ingleby Barwick
4	South Stockton
5	Thornaby
6	Middlesbrough
7	Coulby Newham
8	Hartlepool South
9	Hartlepool North
10	Eston

11	Guisborough
12	Redcar
13	Billingham

Figure 3-2: District heating clusters identified



3.2.1.2 PRESENCE OF MAJOR PHYSICAL CONSTRAINTS

The presence of a major physical barrier within a DH cluster has the potential to adversely impact on the viability of a scheme. In this process major physical constraints are defined as major roads; railways and rivers. A score has been allocated to the presence of each constraint type to reflect the difficulty of crossing it. For example it is considered more costly and technically challenging to cross a mainline railway than a branch railway.

Table 3-3: Scoring scheme for physical constraints within DH clusters

Constraint	Score
Major road	1
Mainline railway	2
Branch railway	1
River[13]	1

PB has examined each DH cluster for the presence of constraints that bisect the cluster. The occurrence of constraints in each cluster has been tallied using the scoring scheme above. An unconstrained scheme would score 5, each constrain that is present would be subtracted from this number. therefore Clusters with a greater number of constraints will score lower than an unconstrained cluster; the total for each cluster is given in the table below.

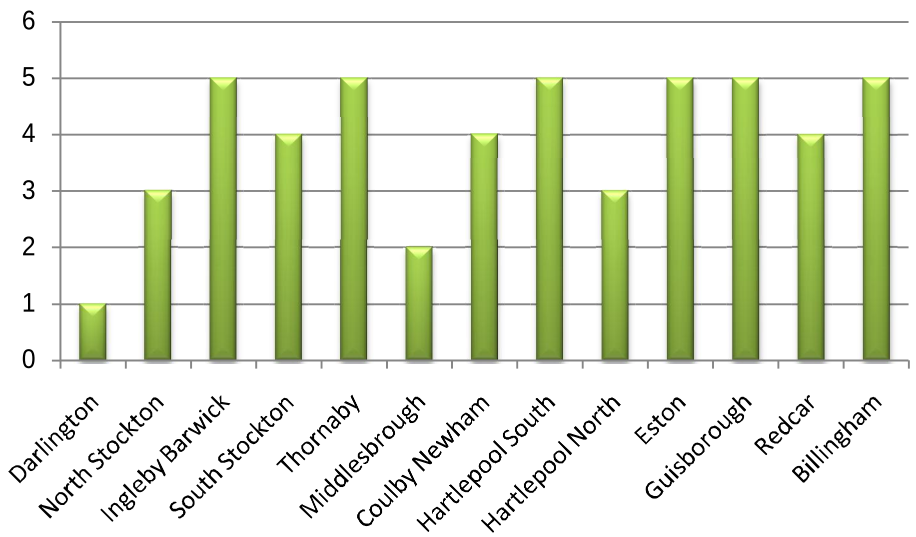
Figure 3-3: Examples of high and low scoring clusters for constraints criteria[14]

Darlington has a main line railway, river, major roads within the cluster, it is therefore considered to be constrained	Thornaby is considered to be relatively unconstrained because there are no major physical barriers to the implementation of district heating

[13] The cost of crossing rivers is likely to be dependant on the size of the river. PB has not considered any schemes that require crossing the Tees, all other rivers in the area are of a similar size.

[14] NB the blue number contained with these illustrations denotes the scheme designation NOT the score attributed to each area.

Figure 3-4: Constraints scoring for DH clusters



3.2.1.3 POTENTIAL FOR SUPPLYING NEW DEVELOPMENT

Supplying new development from DH offers developers the potential to comply with national and local carbon reduction targets. In order to quantify the potential of each DH cluster for supplying new development the total heat demand for new development was calculated for each cluster. The DH clusters were then scored according to the magnitude of heat demand that could be supplied relative to the other DH clusters. The clusters with the greatest potential heat load scored higher than those with a limited potential to supply new development.

Figure 3-5: Examples of high and low scoring clusters for new development criteria

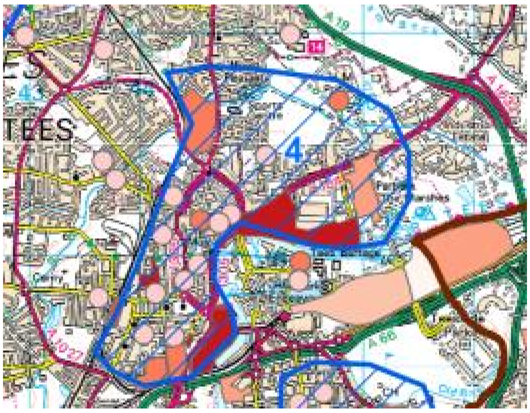
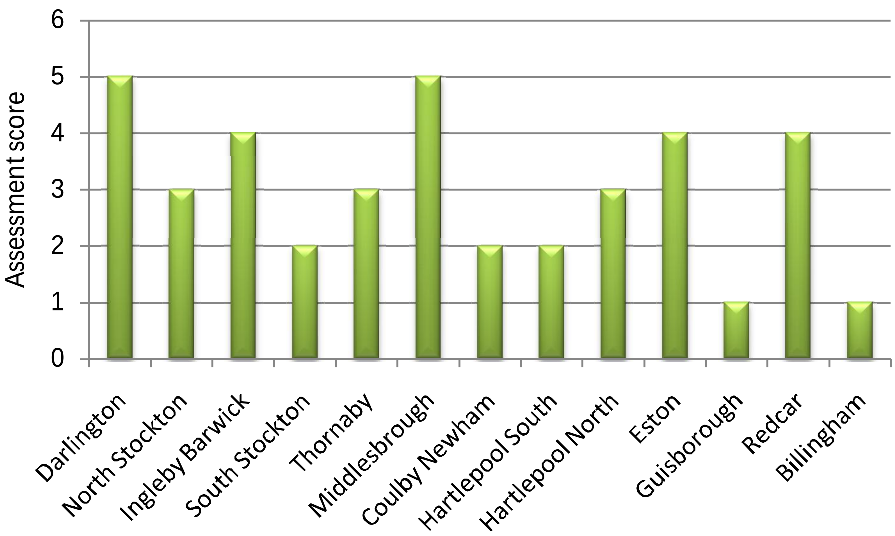
	
South Stockton has a significant amount of social housing development planned within the cluster, this gives it a high score for this assessment factor	Billingham has no significant areas of social housing it therefore has a low score

Figure 3-6: New development scoring for DH clusters



3.2.1.4 POTENTIAL FOR SUPPLYING EXISTING SOCIAL HOUSING

District heating offers the potential to supply social housing with low cost, low carbon heat. The retrofitting of district heating into existing social housing can help to decarbonise the existing stock whilst helping to reduce incidence of fuel poverty. PB has scored each DH cluster according to the density of existing social housing heat load within the boundaries of the cluster. An area with a significant proportion of high social housing heat density will receive a higher score than an area with little or no social housing.

Figure 3-7: Examples of high and low scoring clusters for social housing criteria

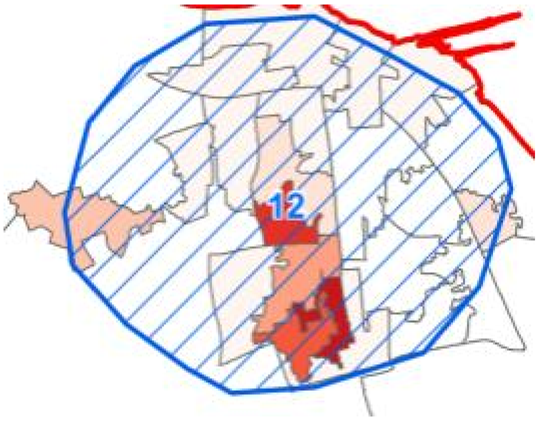
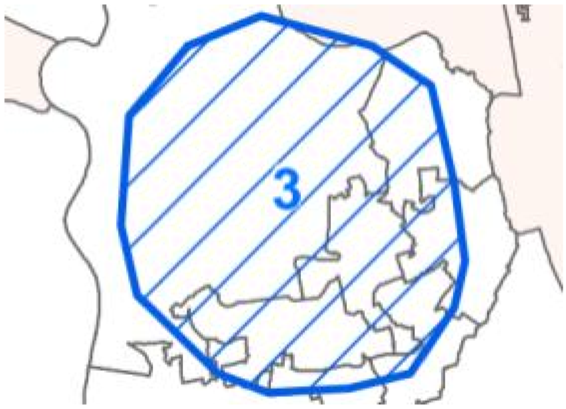
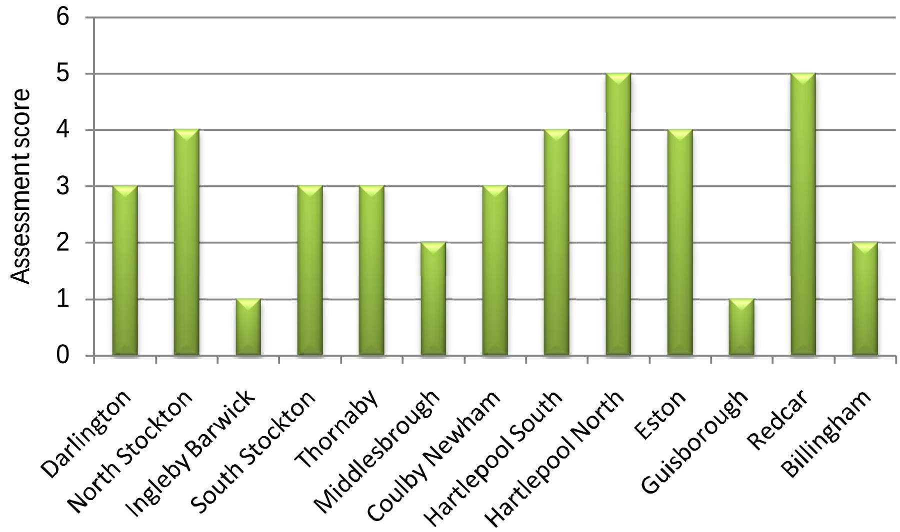
	
Redcar has a significant amount of social housing development planned within the cluster, this gives it a high score for this assessment factor	Inglby Barwick has no significant areas of social housing it therefore has a low score

Figure 3-8: Social housing scoring for DH clusters



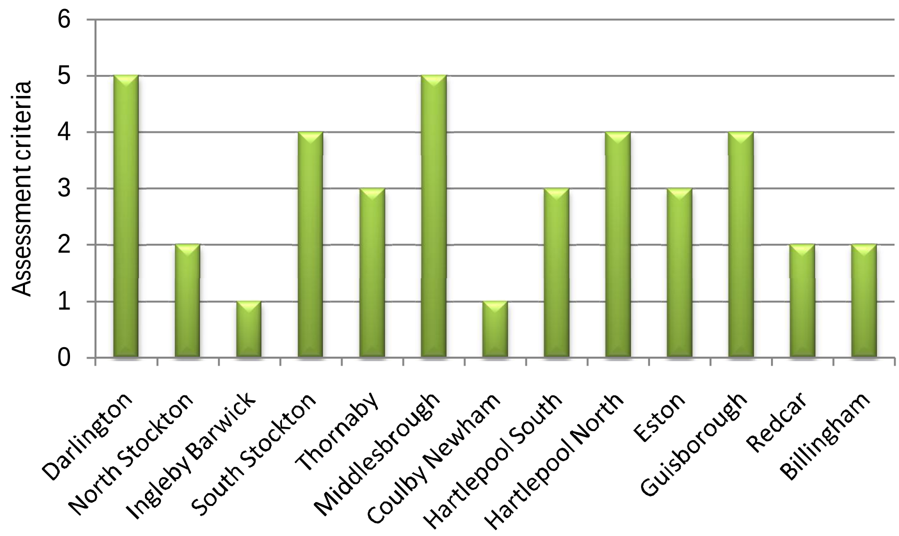
3.2.1.5 COMPACTNESS OF SCHEME

A significant proportion of the district heating capital cost is contained within the pipe work. Keeping the length of the district heating network to a minimum therefore helps to improve the viability of a scheme. The distance between existing public sector loads has been used as a proxy for the compactness of a network. The nearest neighbour for each existing public sector load was measured, with an average distance between loads calculated for each cluster, with the most compact networks receiving the highest score.

Figure 3-9: Examples of high and low scoring clusters for nearest neighbour criteria

Middlesbrough has a large number of loads that are close to one another	The loads in Colby Newham are dispersed, resulting in a low nearest neighbour score

Figure 3-10: Nearest neighbour scoring for DH clusters



3.2.1.6 CLOSE TO SOURCE OF INDUSTRIAL HEAT

Surplus heat from process or power generation has the potential to supply the DH clusters. The viability of using industrial heat is mostly dependant to the cost of the heat sold by the heat producer and the cost of the infrastructure required to supply heat to the DH cluster(s). The first variable is currently not known and is therefore discounted, the second variable can however be easily quantified. Each of the DH clusters has been scored according to its distance to the nearest source of industrial heat. PB has considered the following potential industrial heat sources in this study.

Figure 3-11

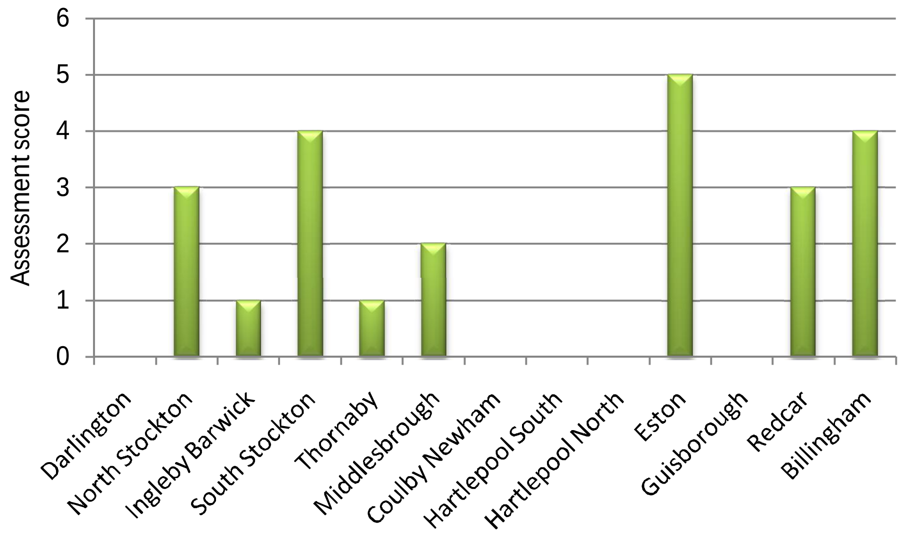
- MGT
- Sembcorp
- Teesside power station

- Sita EfW
- GrowHow
- Gaia (proposed)

Figure 3-12: Location of potential sources of waste heat in the tees valley

The main sources of waste heat are located adjacent to the Tees, close to many of the urban centres

Figure 3-13: Proximity of industrial heat scoring for DH clusters



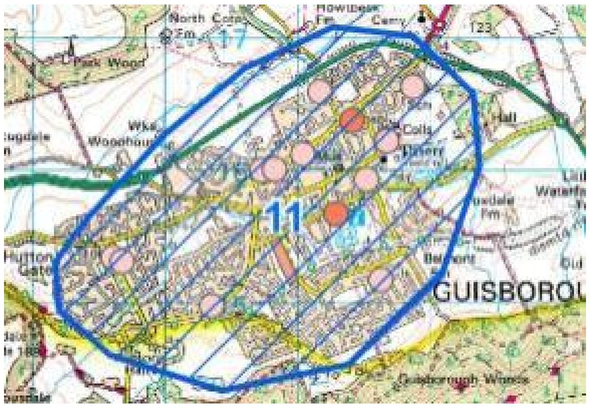
3.2.1.7 POTENTIAL FOR NATURAL GROWTH OF SCHEME

The long-term viability of a DH scheme can be improved if there is the potential to connect additional customers above those originally connected to the scheme. Connecting new customers along the route of existing DH pipes offers the potential for increased revenue for a relatively low additional capital cost. The potential for growth has been quantified as follows:

Criteria	Score
Significant additional loads close to boundaries of cluster	5
A few additional loads close to boundaries of cluster	3
No additional loads close to boundaries of cluster	1

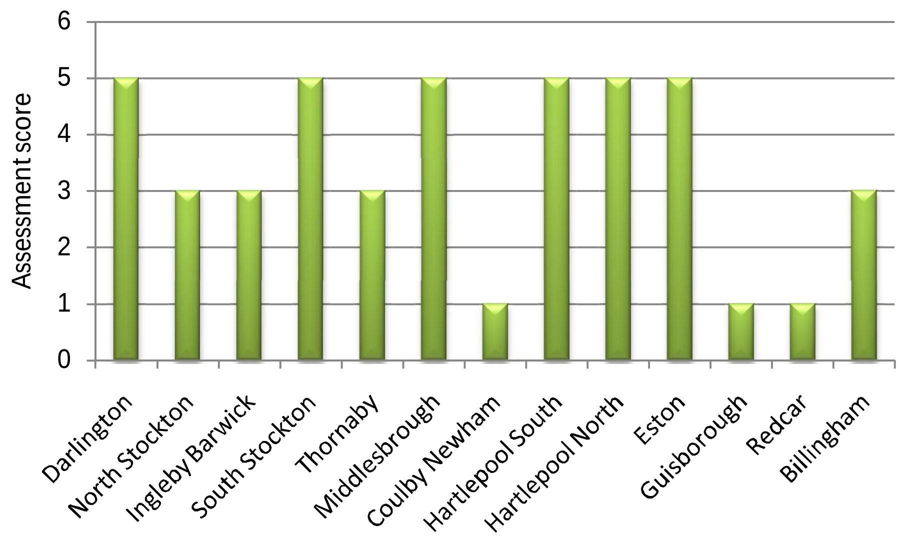
Figure 3-14: Examples of high and low scoring clusters for potential for growth criteria

Hartlepool has good potential for growth because of the adjacent DH clusters and spatial distribution of loads



Guisborough has limited potential for a DH scheme to expand beyond its original scope.

Figure 3-15: Potential for growth scoring for DH clusters

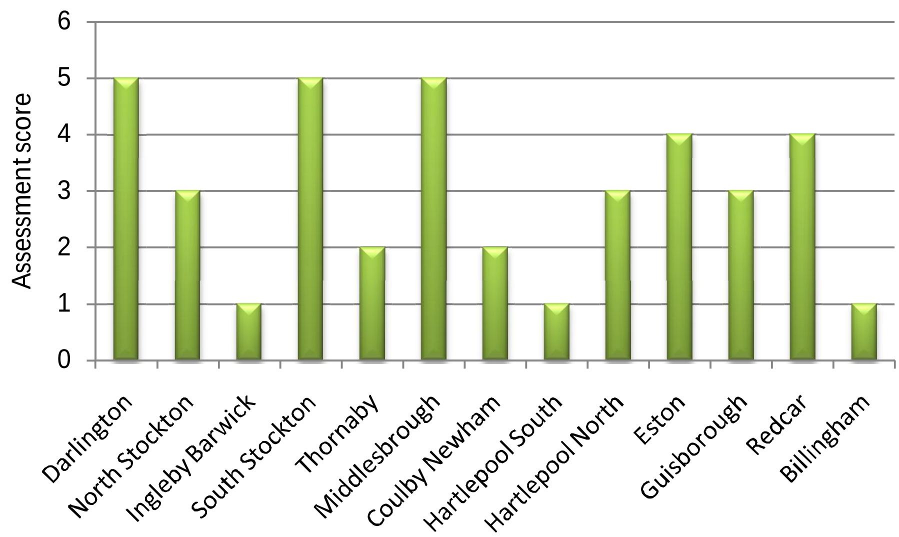


3.2.1.8 DIVERSITY OF BUILDING TYPE IN CLUSTER

The presence of a variety of different building types in each cluster helps to increase the viability because it is likely that there will be a more constant heat demand. The presence of a large heat customer or 'anchor load' will further improve the viability of the scheme. The following criteria have been used to quantify the diversity of building types present.

Criteria	Score
Presence of one or more 'anchor customers'	2
Variety of building types	1
Significant new development	2

Figure 3-16: Diversity of building types scoring for DH clusters

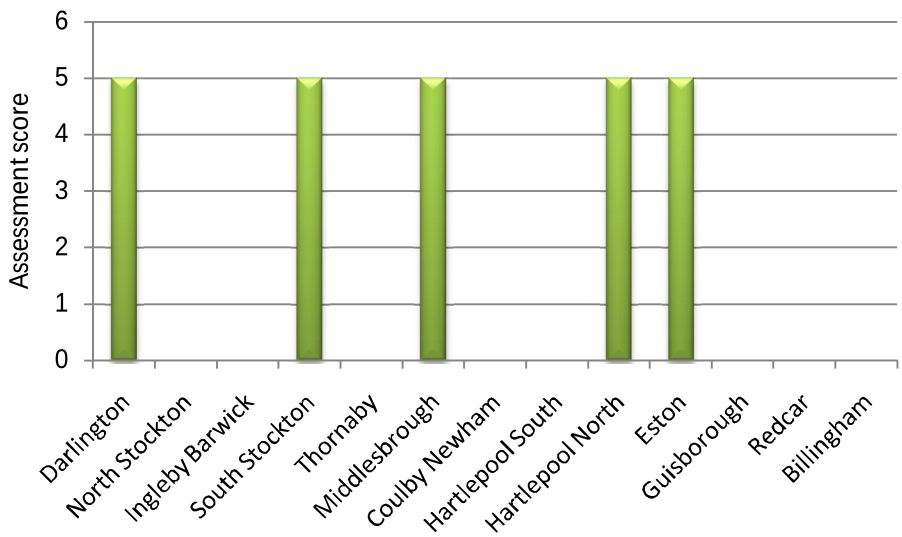


3.2.1.9 GROWTH POINT 'FOCUS AREAS'

The entire Tees Valley area has been awarded 'Growth point' funding by the HCA. In order to focus the spending of this funding Tees Valley Unlimited has indicated five areas which contain a number of regeneration projects. If a DH cluster falls within one of the 5 growth point 'focus areas' then it was awarded 5 points. The 5 growth point 'focus areas' are centred on:

- Darlington
- Stockton
- Middlesbrough
- Hartlepool
- Eston

Figure 3-17: Growth point focus area scoring for DH clusters



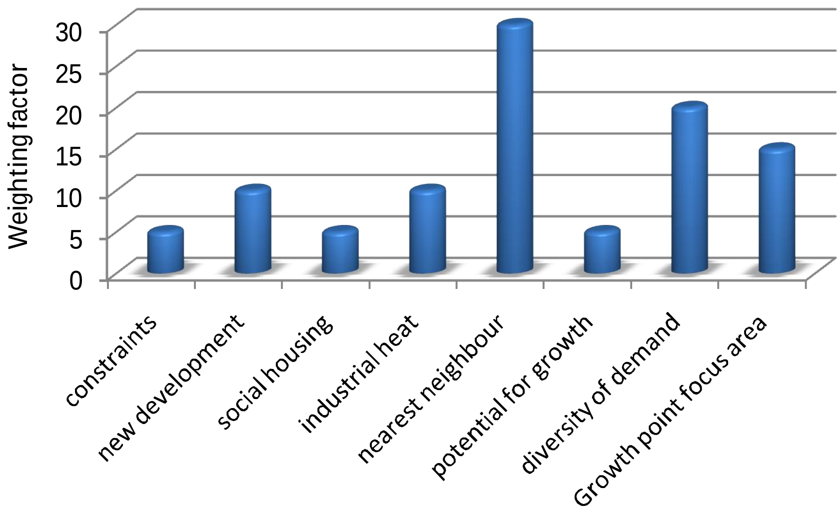
3.2.1.10 WEIGHTING OF ASSESSMENT CRITERIA

A weighting factor has been applied to each of the assessment criteria because not all have the same influence on the viability of the district heating scheme. The following weighting score has been applied to the criteria:

Assessment criteria	Weighting factor
Constraints	5
New development	10
Social housing	5
Industrial heat	10
Nearest neighbour	30
Potential for growth	5
Diversity of demand	20
Growth point focus area	15

The weighting has been applied to the total score for each scheme, the results of which are shown in Figure 3-18. The most important criterion is deemed to be the nearest neighbour because the compactness of the scheme is key to keeping the cost of the district heating infrastructure to a minimum. Also of importance are the diversity of demand, which assists with maximising revenue generation, and growth point funding, which may assist with capital funding for the scheme.

Figure 3-18: Weighting factor applied to assessment criteria



3.2.1.11 Selection of Four District Heating Schemes

It is clear from the figure below that there is a two tiered distribution to the total weighted score with 5 of the 13 schemes having notably higher total weighted scores than the rest. The top five schemes are:

1. Middlesbrough
2. Darlington
3. South Stockton
4. Eston
5. Hartlepool

PB has developed district heating scheme designs for the top five schemes as per the project brief.

Figure 3-19: total weighted assessment criteria score for all DH clusters

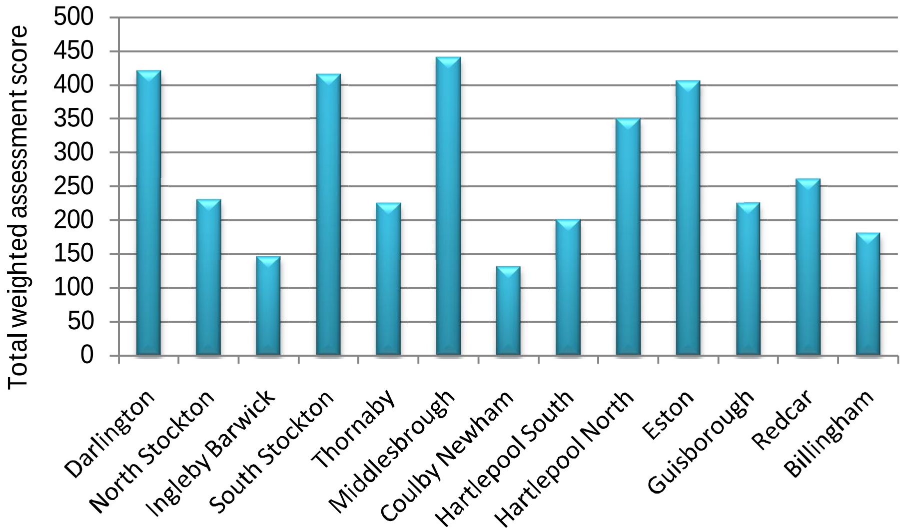


Figure 3-20: Location of top five district heating clusters in the Tees Valley

3.2.2 DISTRICT HEATING SCHEME DEFINITION

PB used the information contained within the heat density map to identify specific buildings within the five district heating clusters that would be supplied from district heating, thereby defining the loads that will be modelled in this study. Site surveys were undertaken in each of the town centres in order to:

a) Assess the practicalities of connecting the public sector buildings
b) Identify the potential for supplying existing social housing
c) Investigate the means by which new development could be connected to a district heating scheme
d) Identify potential energy centre locations
e) Investigate preferred routes for district heating pipework

The following section provides details of the buildings to be supplied, indicative district heating routes and potential energy centre locations for each of the four schemes.

SECTION 4

PHASE THREE: DEFINITION

4 PHASE THREE: DEFINITION

This section includes the techno-economic appraisal of the four potential district heating schemes. Each scheme is examined in turn, with the economic performance made explicit. Where a scheme is not determined to be financially viable PB has provided potential mechanisms, for example using contributions from developers, which could be employed to enhance its viability.

4.1 LOAD PROFILING

As outlined in Section 3.1 and Appendix C, the annual demands of the various elements that might form the loads on a notional network have been calculated from a variety of sources. These annual loads have then been assigned to energy demand usage profiles for a notional year. This process allows an indicative energy usage profile of the aggregated loads of an entire scheme to be constructed. This energy usage profile is of interest when indicating the degree to which a base heat load would appear to be available and hence the number of run-hours and scale of a suitable prime-mover for the scheme, as well as the degree to which thermal storage would be useful in helping to 'smooth' demand peaks.

There is little published information on heat usage patterns on an hourly basis for buildings, and hence largely the profiles adopted in modelling have been based upon PB's experience of modelling similar buildings.

At this stage, without the benefit of detailed building physics models this profiling process cannot provide an exact prediction of the energy usage pattern of each building. However the broad trends of daily and seasonal variation demands will be reflected by the construction of profiles from first principles and estimations of outline parameters such as anticipated building occupancy periods and levels of hot water demand.

The individual profiles adopted in the construction of the aggregate area profile are contained within Appendix C.

In all areas, two profiles are displayed here, the 'Core Scheme' loads, which represent the loads of the existing building stock that has been selected for inclusion within the scheme, and the 'Core Scheme with Future Development' loads, that includes the identified future development associated with each site.

4.1.1 PRIORITY AREA 1 – DARLINGTON

Figure 4-1 Core Scheme

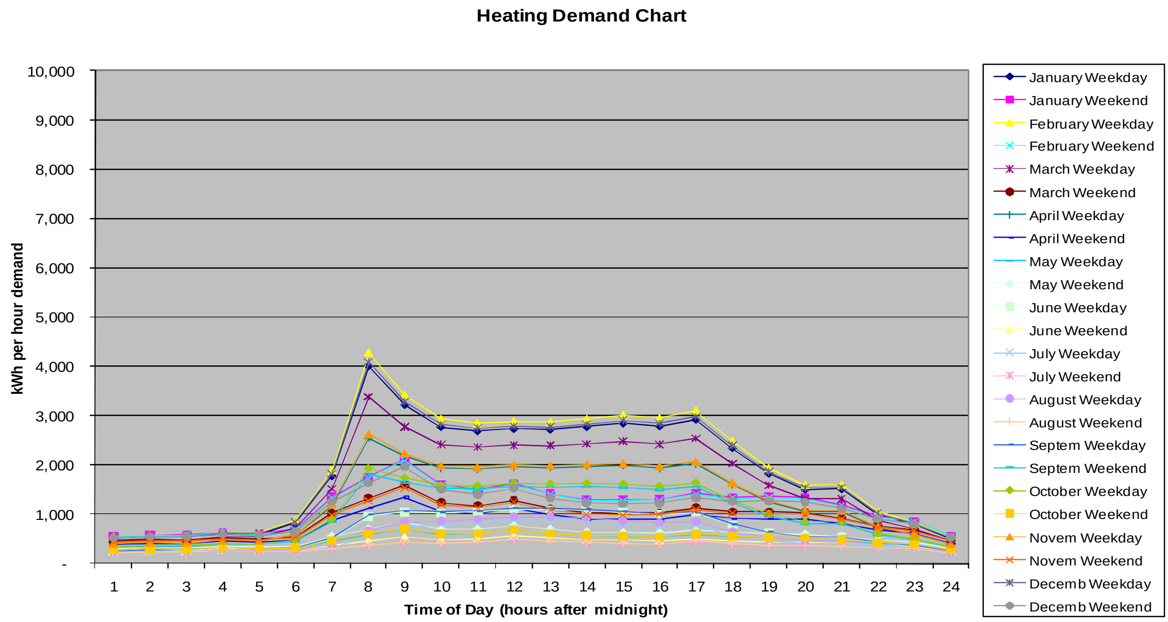
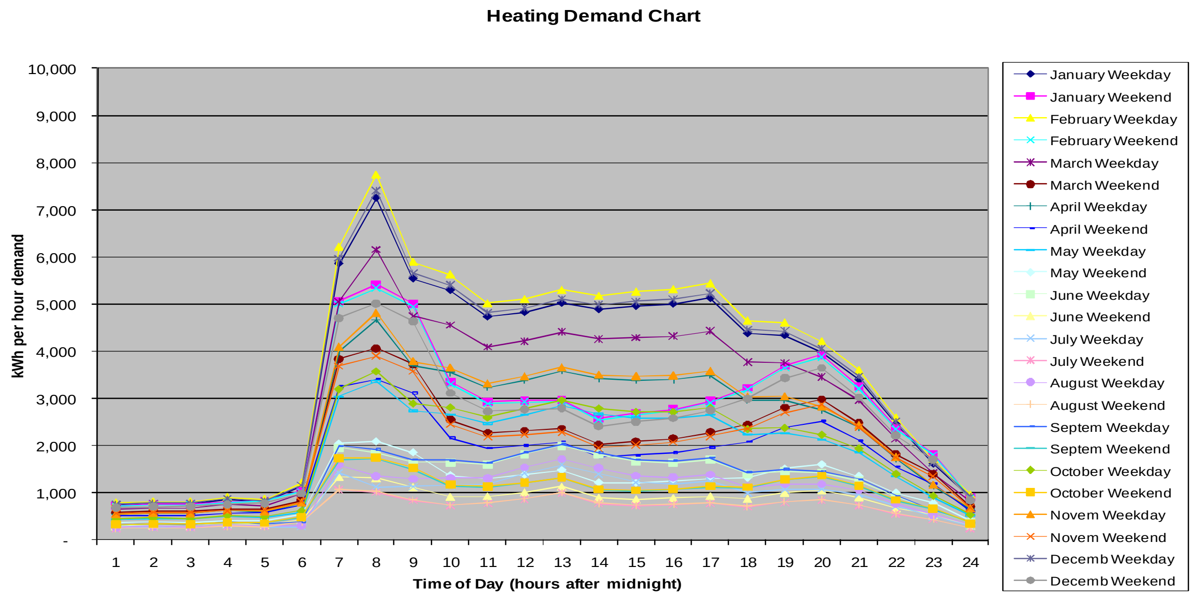


Figure 4-2 Core Scheme with Future Development



It can be seen from the charts above that there is a significant difference between the magnitude of the total loads anticipated with and without the inclusion of the Central Parks development area. However both schemes also illustrate that there is little night-time load, and hence that suitable thermal storage would be an essential element of good energy centre scheme design.

4.1.2 PRIORITY AREA 4 – STOCKTON

Figure 4-3 Core Scheme

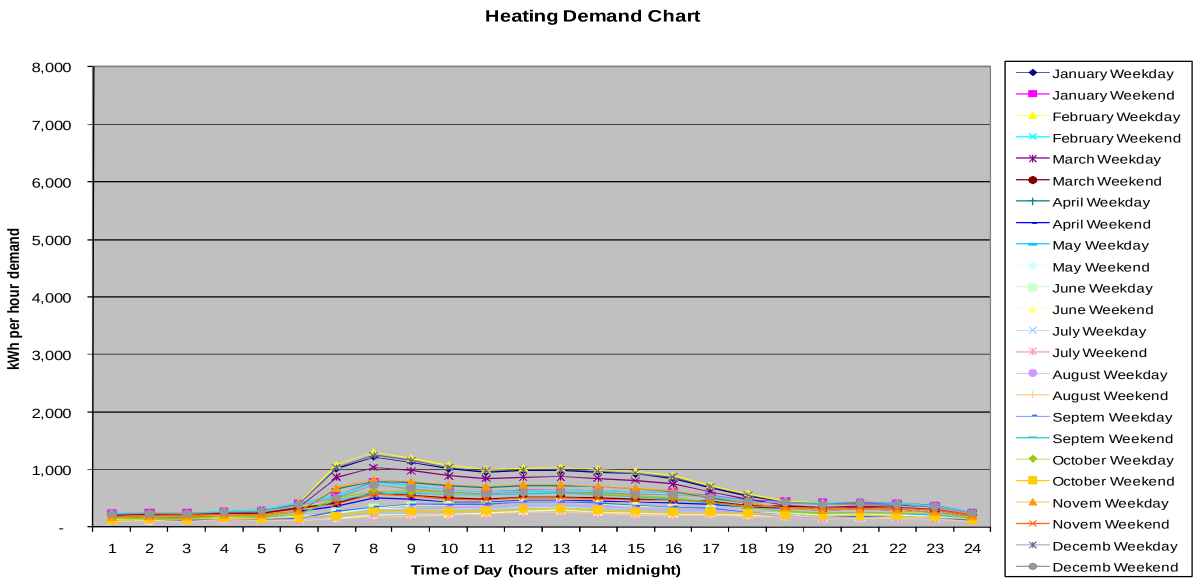
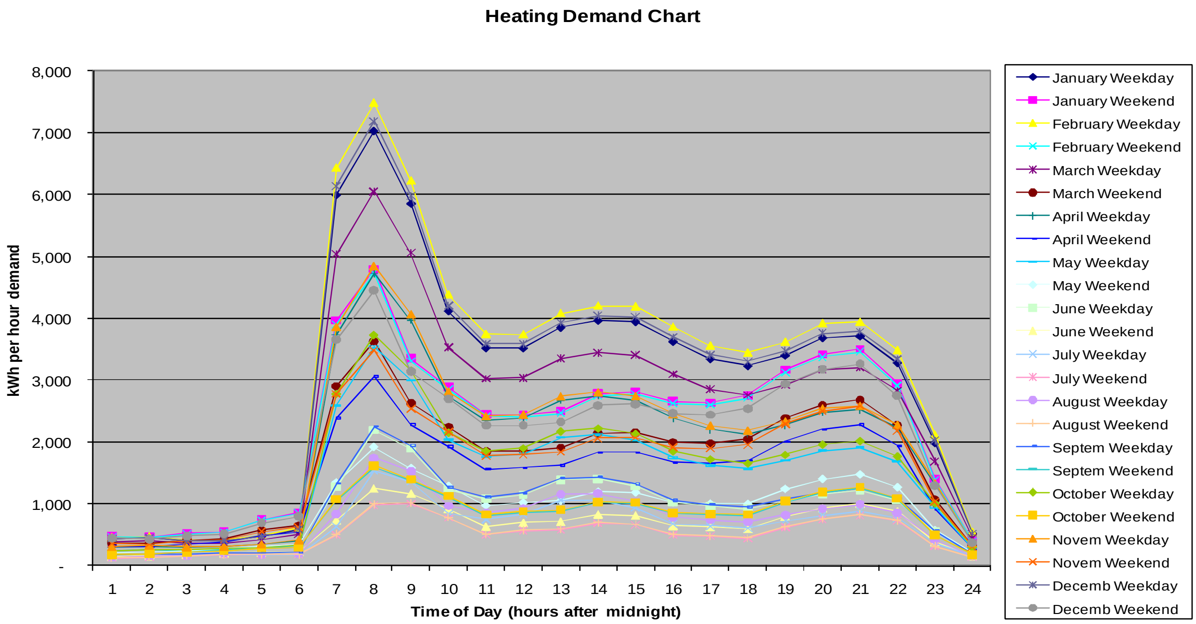


Figure 4-4 Core Scheme with Future Development (Stockton)



These graphs illustrate the significance of new development for the Stockton Scheme. The North Shore loads represent almost three times more heat demand than has been identified on the core network. Whilst the Splash Centre is an important load for the Core Network, its significance in terms of offering a continuous demand for heat (for pool heating) reduces in the context of the extended scheme.

4.1.3 PRIORITY AREA 6 – MIDDLESBROUGH

Figure 4-5 Middlesbrough Core Scheme

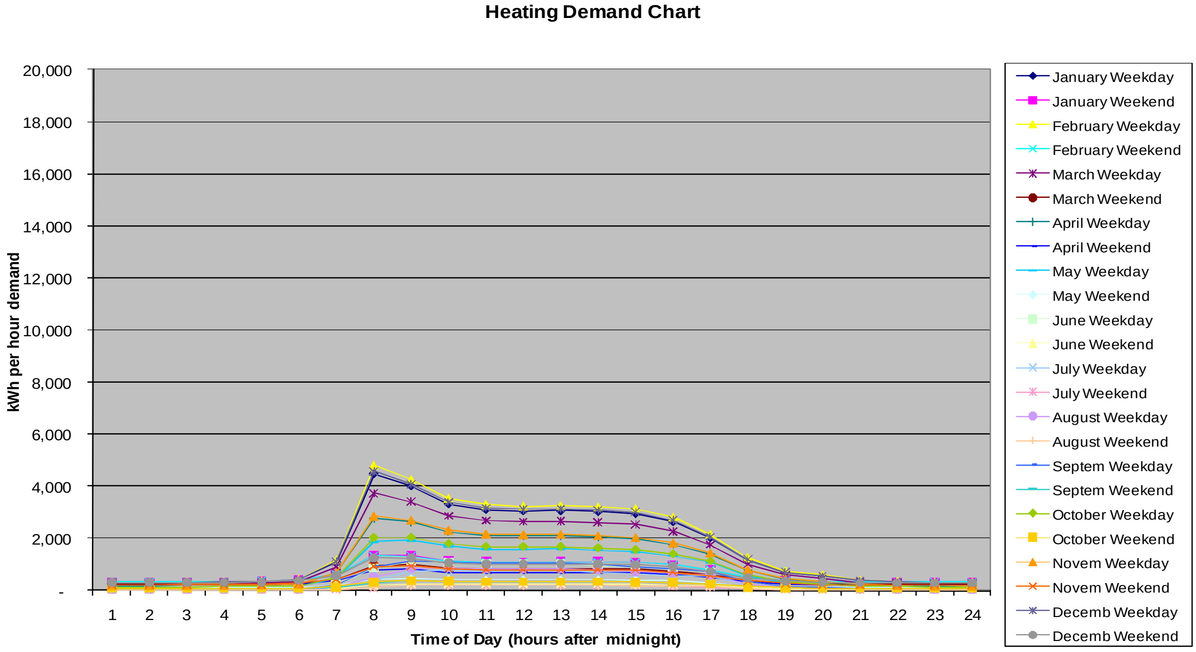
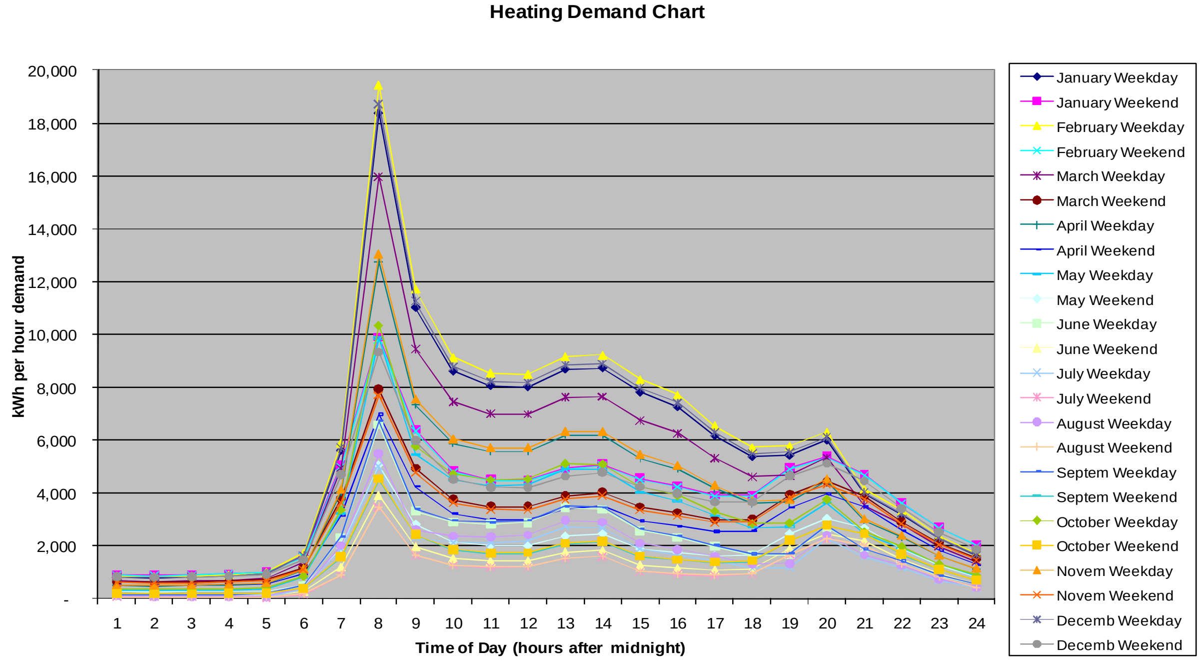


Figure 4-6 Core Scheme with Future Development



This set of charts for Middlesbrough illustrate that the Middlehaven loads will represent a significant addition to the core scheme demands. The core scheme is shown to be predominantly made up of office-hours premises, and hence the use of significant thermal storage capacity would be recommended in order to allow efficient power generation though the evening period when electricity values are high.

4.1.4 PRIORITY AREA 10 - ESTON

Figure 4-7 Eston Core Scheme

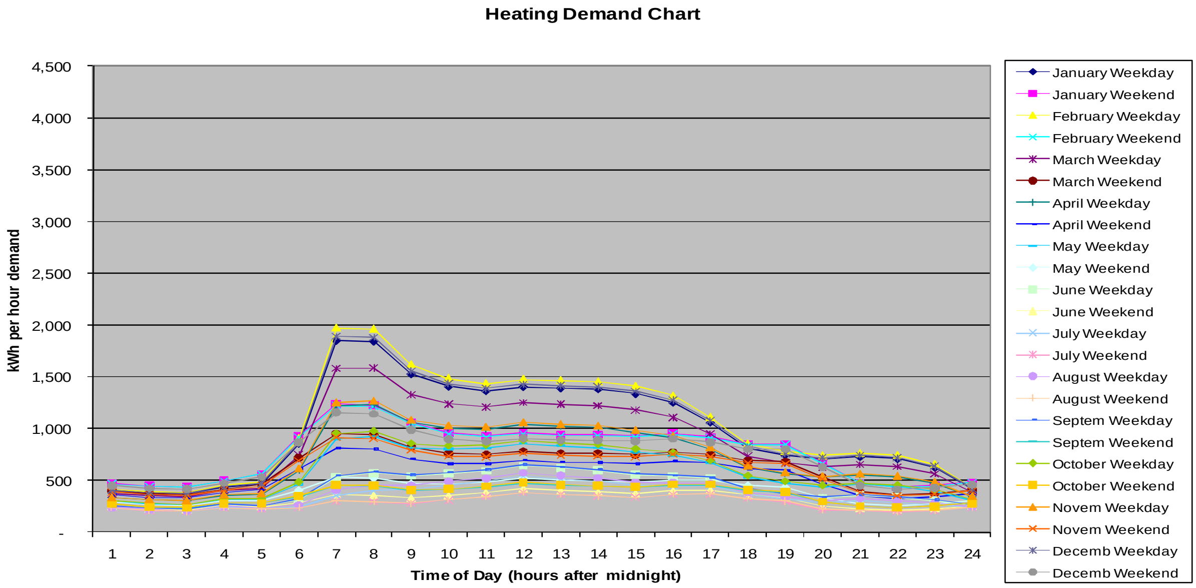
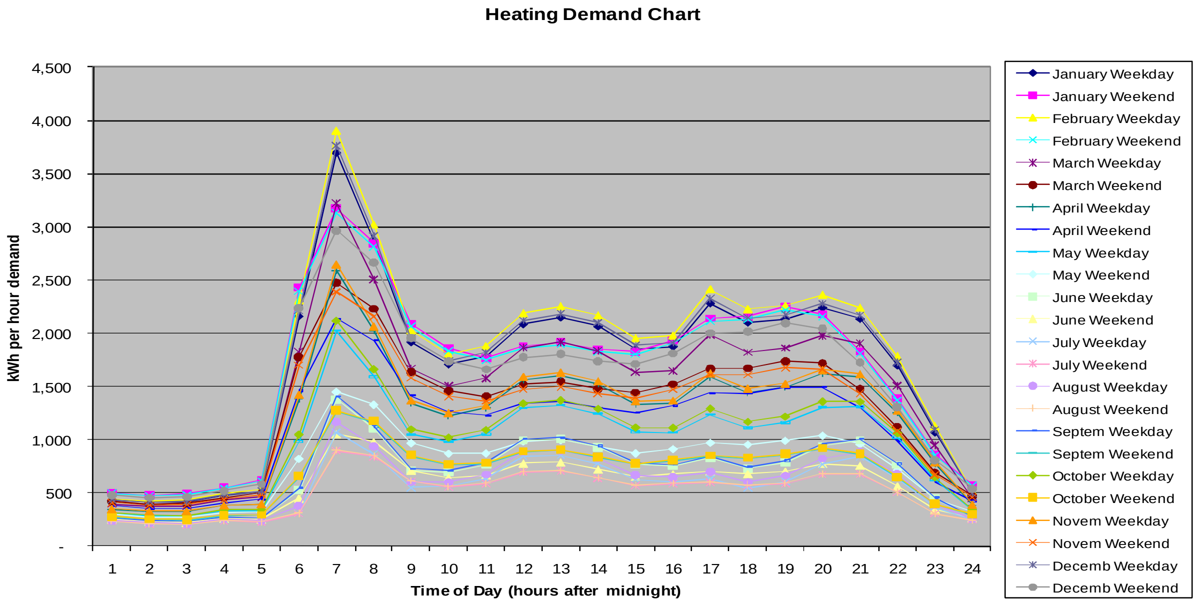


Figure 4-8 Core Scheme with Future Development (Eston)



The anticipated largely residential development anticipated for this scheme area complements the Core scheme load profile by extending evening running hours.

4.1.5 PRIORITY AREA 9 – HARTLEPOOL NORTH

In Hartlepool two schemes appear to offer most potential:

- Scheme A: Centered around the Civic Centre on Victoria Rd / Avenue Rd, this scheme encompasses many of the civic buildings in the town centre, whilst also linking to the Millhouse Leisure complex and the Hartlepool College of Further Education. This is called the 'Town Centre' scheme in this report.

- Scheme B: This scheme revolves around the development of the Marina (Trincomalee Wharf) and the 'South of Maritime Avenue' areas, whilst also linking to the existing town via the Niramax site and the Hartlepool Neighbourhood Services building in Church St. This scheme is referred to as the 'Seafront' scheme in this report.

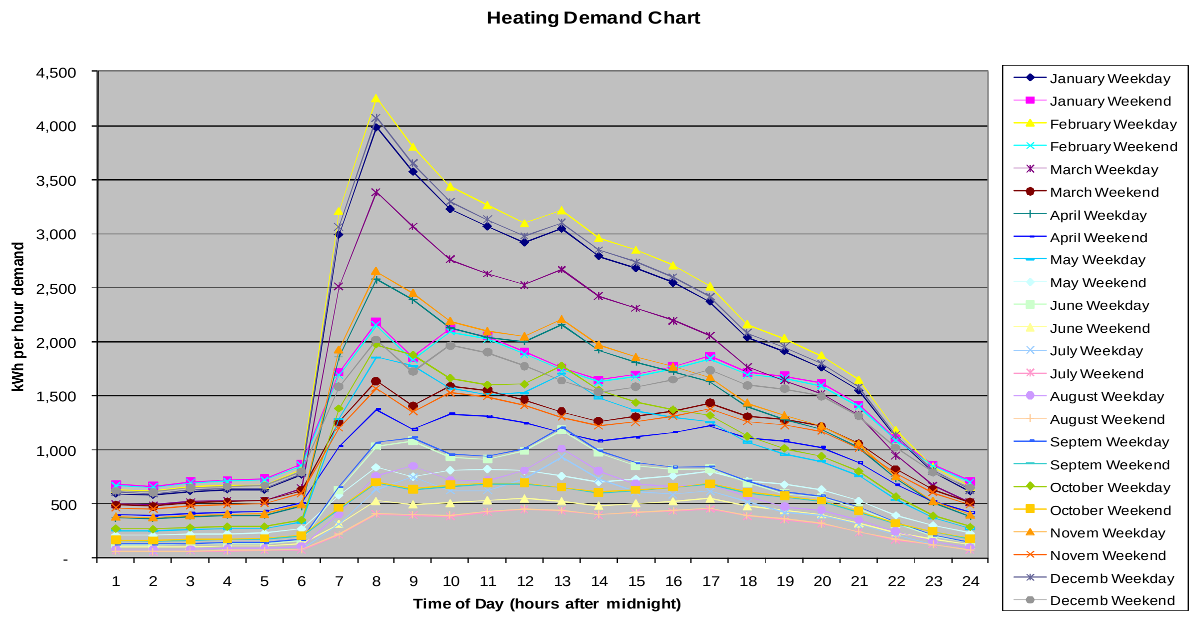
4.1.6 Hartlepool scheme A - Existing Town centre Buildings

Table 4-1: Loads to be supplied in town centre scheme

ID	Site Name -	Heat Demand (kWh p.a.)
1	Millhouse Leisure	1,551,899
2	Aneurin Bevan House	89,206
3	Register Office	20,247
4	Townhall Theatre	301,663
5	Police Station	1,261,552
6	Civic Centre / Magistrates Court	925,812
7	JobCentrePlus DWP	133,944

8	Leadbitter Buildings	83,873
9	Art Gallery and Tourist Information	123,929
10	Hartlepool College of Further Education	1,166,131
11	Hartlepool College of Further Education (AUTMOTIVE ENGINEERING)	293,748
12	Hartlepool Bowls	709,234
13	Engineers Social Club	229,899
14	Tavistock Grand Hotel	1,010,807
15	Wesley Leisure Club	631,630
16	Victoria Football Ground	396,833
17	Morrison's Supermarket	441,420
18	JHP Training	72,796

Figure 4-9 Scheme A



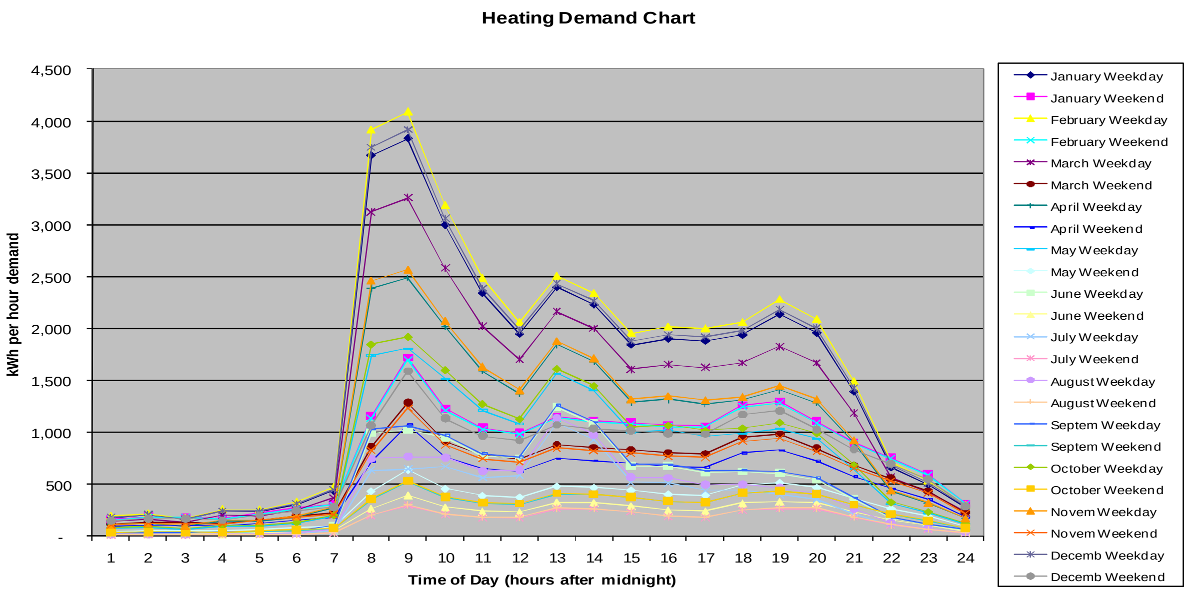
4.1.7 Hartlepool scheme B – seafront scheme Buildings

Table 4-2: Loads to be supplied in seafront scheme

ID	Site Name -	Heat Demand (kWh p.a.)
1	Neighbourhood Services Office	801,505
2	Niramax Site / Mainsforth Terrace (domestic)	311,679
3	South of Maritime Avenue (domestic)	1,316,425
4	Mixed Use Maritime Avenue (non-domestic)	572,316
5	Mixed Use Maritime Avenue East of Victoria	200,194

	Terrace(domestic)	
6	Block 19 Marina (domestic)	207,300
7	Trincomalee (non-domestic)	3,169,513
8	Trincomalee (domestic)	358,287

Figure 4-10 Scheme B – Seafront Scheme



It can be seen from the charts above that there the magnitudes of the overall loads of both schemes are similar. However both schemes also illustrate that there is little night-time load (particularly in Scheme B) , and hence that suitable thermal storage would be an essential element of good energy centre scheme design for both.

4.2 TECHNOLOGY SELECTION

A review of available technologies in contained within appendix G to this report.

The technology that supplies the heat to the district heating network, a combined heat and power unit or boiler, is called the energy source. The choice of energy source for each scheme will affect the financial performance and the potential for carbon reduction. A large number of technologies could in theory be used to supply heat to a district heating network, each having its own pros and cons. , PB has conducted a qualitative scoring exercise to screen the potential technologies and identify those that will be examined in this report. This scoring exercise has categorised the potential performance of various technologies and then scored each technology against this category. The categories were then weighted to reflect PB's view of the importance of the various criteria for the Tees Valley. The weighted scores were then ranked to derive the top three technologies.

The following parameters have been applied to each technology option in turn, each technology was then scored from 1 to 5 according to its specific performance against the criteria in question.

1. **CO_2 reduction potential** – measured according to the outputs from the technical modelling undertaken by PB. The basecase scores 0 because it is not able to realise a CO2 reduction.

2. **£/tonne saved** – The initial capital cost and the whole life CO2 saving over a 25 year project were used to calculate the£/CO2 saved over the project lifespan. The base case scores 0 because it does not have either an initial capex or a CO2 saving..

3. **Technology risk** – The technical and commercial viability of a technology is determined in part by the risk posed. The operational track record of each technology has been used here as a proxy for technology risk. High risk options are less likely to be acceptable to ESCOs.

4. **Availability of fuel supply** – the ability to procure sufficient fuel for the technology is determined by the fuel supply chain. Natural gas is considered to be the most available with pure plant oil being the least available.

5. **Heat supply resilience** – options that utilise more than one technology or multiple units are considered to offer a greater degree of heat supply resilience.

6. **Air quality** – The burning fossil fuel creates airborne pollutants, this problem can be exacerbated if biomass and bio-oil are the primary fuel source.

7. **Noise pollution** – the operation of LZCT can lead to increased noise pollution from the operation of the CHP engines, fans and heat rejection equipment.

8. **Future proofed** – Technologies that do not rely on natural gas and are able to deliver significant CO_2 reductions are more likely to be fit for purpose in the future than conventional boilers or gas engine CHP.

9. **'Green credentials'** – the public perception of the district heating scheme depends somewhat on how 'green' it is perceived to be. Renewable technology is considered to be more green than plant that uses natural gas.

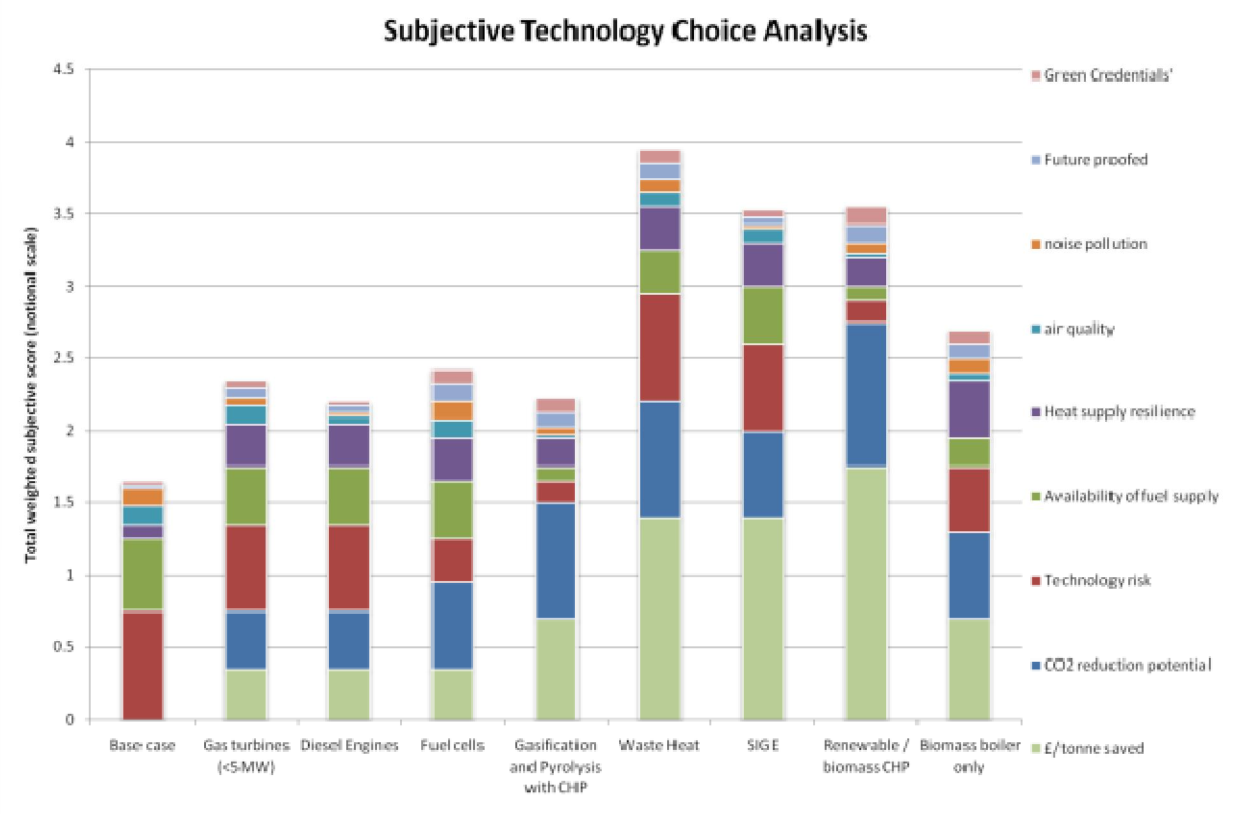
A weighting factor was applied to the scores for each technology in order to reflect the perceived importance of the assessment criteria, the factors used are as follows:

Table 4-3 Technology Selection Weightings for Subjective Evaluation

Item	Weighting
CO_2 reduction potential	20%
£/tonne saved	35%
Technology risk	15%
Availability of fuel supply	10%
Heat supply resilience	10%
Air quality	2.5%
Noise pollution	2.5%
Future proofed	2.5%
'Green Credentials'	2.5%

The following results were derived from the evaluation:

Figure 4-11 Results of Subjective Technology Analysis



The three last options on this graph are those that score highest, and which have been taken forward for further analysis:

Option	Name used in report tables
Spark-ignition gas engine CHP	Gas CHP
Renewable fuel CHP	PPO CHP
Biomass boilers	Biomass
Waste heat	Heat from power generation

4.3 ENERGY BALANCE AND VIABILITY MODELLING

For each of the scheme configurations which is outlined above (e.g. Core Scheme and Core Scheme with Future Development), energy balance and financial modelling has been undertaken in order to assess the carbon savings that would result from the plant operation, and the financial viability of each scheme.

4.3.1 ASSUMPTIONS

A number of assumptions have been adopted in energy balance and viability testing. This section highlights some key modelling assumptions, whilst the majority of detailed assumptions are contained within the appendices to this document. This tries to provide transparency in the methodology adopted, and to allow updates / improvements in accuracy easily to be incorporated in future revisions.

4.3.1.1 BASE CASE SCENARIO

A key assumption in the approach to the financial modelling conducted here is the Business-As-Usual (BAU) scenario against which the DH schemes proposed are evaluated. It is important to be clear what level of obligations and costs would be seen by developers and existing customers under a non-DH scenario. This will then provide a suitable benchmark case against which the case for district heating can be made.

There are effectively three key end-user types for the schemes proposed. The obligations on each are outlined here, alongside the approach to cost evaluation of these commitments.

Existing non-domestic end-users - Existing buildings will have heat-generation plant that is already operational and providing a suitable level of service to the building. Therefore, for these buildings, the incentive to connect to a DH scheme will derive either from the potential cost savings or the reduction in carbon emissions that would result from the supply of heat from a DH scheme. The cost savings would arise from. both the unit costs of energy and from avoided maintenance and replacement costs., Low carbon heat could help meet targets such those contained within NI185/186, and would therefore help avoid expenditure to meet these targets via other means. The cost of meeting NI185/186 performance targets have not been factored into modelling. Avoided Carbon Reduction Commitment (CRC) costs due to gas displacement in public sector buildings have been factored into the heat sales price used in the mode, this is discussed in section 4.3.1.7.

New non-domestic buildings – There are increasingly stringent standards of performance required for new buildings (via the Building Regulations) and compliance is linked to carbon emission performance (among other factors). The low-carbon character of DH supplied heat will therefore likely constitute a valuable asset for new-build non-domestic developers. The availability of low carbon heat would allow developers to avoid costs that would otherwise be borne in the fabric of the building or the inclusion of low / zero-carbon plant. It is difficult to predict the cost of compliance with Building Regulations across varying building types and design, and PB has not included any of these avoided costs in modelling. The current economic climate is likely to result in a greater percentage of the new units being built to a higher code level than has been modelled in this study.

New domestic buildings – domestic properties are equally subject to increasingly stringent performance standards, and hence the availability of low-carbon heat will enable cost savings to be made by developers through avoided plant or fabric costs. The generalised business-as-usual assumption included here is that a gas-condensing boiler would be installed, and that other plant would further be required to meet Code for Sustainable Homes (and other) targets. However, the avoided cost of this plant is not included in modelling, we have included these costs in the alternative route to building regulation compliance in the next section.

The table overleaf illustrates some key cost assumptions for the BAU and DH Scheme scenarios.

Table 4-4 Cost assumptions for scheme elements

Cost type	Cost Item	Business as Usual	Proposed DH Scheme	DH Scheme impact on Developers	DH Scheme impact on	DH scheme impact on building owner / occupier
Capital cost	Heat emitters in buildings	Funded by building developers	Funded by building developers	Potential change in specification to heat emitters under DH scheme scenario (to deliver lower return temperatures than under BAU case).	No impact	No impact
	Heat source (domestic)	Individual gas condensing boilers and other measures to achieve required CSH levels, funded by building developers	Hydraulic interface units, funded by building developers	It has been assumed that the installation / capital cost of gas boilers or an HIU is cost neutral, but that the use of low carbon DH heat would allow developers to avoid cost in construction	No impact	No impact
	Heat source (non-domestic)	Centralised gas boiler system and other LZC measures to achieve planning targets and BR compliance, funded by developers	Consumer Interface Unit costs included within DH scheme costs	The DH Scheme pays for the CIUs, whilst the building Developers see an avoided cost under the DH scenario.	Capital Cost for ESCo	No impact
	Gas network to domestic properties	Cost of gas network installation under BAU is assumed to be funded by the gas transporter / supplier.	No gas network required	Cost neutral	No impact	No impact
	Interal building distribution systems	None required in domestic properties	Required within DH scheme costs, assumed to be funded by Developers	Additional cost seen by Developers over BAU	No impact	No impact
	Heat / gas metering system	Included as part of gas network installed funded by gas transporter / supplier	Heat metering costs included within HIU costs funded by developer	Included above in HIU costs	No impact	No impact
	Heat distribution network	Not required	Heat network costs included within DH scheme costs	Potential requirement for Developer to contribute to DH network cost	Capital Cost for ESCo	No impact
	Energy Centre and all plant and utility connections	Not required	Included within DH scheme costs	Potential requirement for Developer to contribute to DH network cost	Capital Cost for ESCo	No impact

Cost type	Cost Item	Business as Usual	Proposed DH Scheme	DH Scheme impact on Developers	DH Scheme impact on	DH scheme impact on building owner / occupier
Operational	Energy purchase	End-users pay traditional energy supply companies	Gas / other fuel procurement at energy centre	No impact	Operational cost for ESCo	Payment to ESCO rather than traditional supply company
	Heat metering and billing	Included within gas purchase cost (main suppliers have very large customer base and streamlined operations)	Passed to customers through Heat Charge (heat metering and billing likely to be more costly than equivalent gas charging)	No impact	Operational cost for ESCo	End users deal with ESCo rather than traditional supply company
	Plant maintenance	End-users pay for gas boiler maintenance contract	ESCo undertakes maintenance of DH network, interface units and plant items in energy centre	No impact	Operational cost for ESCo	End-users effectively pay for maintenance and service levels through heat charges
	Energy (heat) sales	n/a	End-users pay ESCo	No impact	Operational revenue	Payment to ESCO rather than traditional supply company
	Energy (electricity sales)	n/a	Energy supply companies pay ESCo for generated power	No impact	Operational revenue	No impact
	Subsidies	n/a	Government support for low / zero carbon technologies/ avoided cost of CRC	No impact	Operational revenue	No impact
	Plant replacement - boilers	End of life replacement by user - typical life 15 yrs domestic 15-20 yrs commercial dependant on scale	End of life replacement by DH Co - typical HIU replacement included in maintenance allowance	No impact	Operational cost for ESCo	Payment to ESCO as element of heat charge rather than end of life single payment

It can be seen that a number of potential avoided costs for new-build (and to a lesser extent existing) development are not included here due to the difficulty of developing accurate or appropriate assumptions. The approach adopted in this report is rather to demonstrate what level of financial performance each DH scheme generates given a set of assumptions, and to evaluate this against the alternative measures that would be required to generate similar levels of carbon savings.

4.3.1.2 ALTERNATIVE COMPLIANCE COSTS FOR DEVELOPERS

The level of costs that would be borne by developers under the BAU scenario has been estimated on the basis of published estimated costs of Code for Sustainable Homes compliance (DCLG)[15]. The DH recommended schemes selected from this analysis are shown to deliver carbon emissions savings in the region of 44% - equivalent to CSH level 4, and hence the following text in the Cost review document is relevant:

> At Code Level 4 the lowest cost energy strategy varies between Better fabric with an ASHP and the Good fabric with community gas CHP, depending on the development type. Note that in some cases the Good fabric with community gas CHP provides the lowest wholelife cost of compliance, even though the Better fabric with ASHP has a lower initial capital cost means of achieving a 44% reduction of DER/TER.[16]

On this basis it appears appropriate to compare realistic developer contribution with the Better Fabric and ASHP solution.

> The least cost energy strategy at Code Level 4 (Best fabric with an air source heat pump or good fabric with community gas CHP, depending in the development scenario) has an associated extra-over cost of in the range from £4,750 to £6,000[17].

It is also important to note that some schemes include dwellings that are anticipated to need to achieve Code Level 6 compliance. Therefore, the cost of this compliance under a DH scenario must be weighed up against the alternatives that Developers would face to achieve Code 6 by other means. These have also been costed on a generalised basis in work done for DCLG, and the cost for Code 6 energy standards compliance are shown to vary, based on building types and development situations from approximately £14k to £34k per dwelling.

15 Code for Sustainable Homes Cost Review 2010, DCLG website, http://www.communities.gov.uk/publications/planningandbuilding/codecostreview?view=Standard, accessed 22nd July 2010.
16 Ibid, page 49
17 Ibid, page 52

Further assumptions have been adopted for Developer compliance costs for non-domestic buildings. Costs for this are derived from the 'Implementation Stage Impact Assessment of Revisions to Parts F and L of the Building Regulations from 2010" (DCLG, 2010), and are quoted in terms of a percentage cost uplift on construction costs. The figures are as follows:

Table 4-5 Cost uplifts calculated for offices to comply with BR2010

Building sector	Percentage increase
Shallow plan office (naturally ventilated)	1.3%
Shallow plan office (air conditioning)	2.9%
Deep plan office (air conditioning)	1.1%

Given that for the schemes analysed, details of the development are not known, the 1.1% cost uplift figure has been applied to generic building cost figures derived from SPONS (an average figure of £1,400 has been adopted for construction), as a conservative estimate.

The current economic circumstance may result in developers being forced to delay development, thereby increasing the proportion of development that will be constructed to higher code levels.

4.3.1.3 GENERAL FINANCIAL ASSUMPTIONS

For all schemes, capital costs are borne one year before any revenues are seen.

Future revenue / expenditure streams are all based upon today's prices – e.g. utility prices and heat sales revenue remain constant over time.

Whole life costs are presented at 3.5% and 9% discount rates.

Avoided cost of CRC is assumed at £12 whereas likely to rise after 2013, no inflation of the value of carbon has been assumed in this study

Costs do not include VAT.

4.3.1.4 SUPPORT MECHANISMS

The renewable heat incentive (RHI) was proposed by the last Government administration, but PB's understanding is that the funds for this support mechanism were to be derived from general taxation. In the current economic climate there is an element of regulatory risk associated with the further development of this mechanism given the strains on general taxation. In modelling the proposed level of support contained with recent consultation documents has been included, but TVU should be aware of the financial / regulatory risk associated with technologies that would benefit from the RHI (e.g. biomass). The Annual Energy Statement published on 27 July 2010 indicates that the way forward for support of renewable heat will be outlined as part of the Spending review in October 2010.

Feed-in tariffs do not apply directly to the scale of scheme analysed here.

If ROCs are claimed for electricity production from biomass CHP, the heat produced will still offset natural gas use by customers and can therefore be used to reduce exposure to CRC.

4.3.1.5 DISTRICT HEATING NETWORK ASSUMPTIONS

All DH networks between the energy centre and consumer units would be direct buried, welded steel pre-insulated sections, with appropriate reinstatement.

The capital costs have been estimated based on the assumption that installation would require excavation and reinstatement of highway or other hard finished ground.

Where existing buildings are to be connected, a temperature differential between flow and return pipework of 20°C has been assumed (e.g. 95°C flow, 75°C return) to reflect typical heating system arrangements.

Where new buildings are connected, a 40°C temperature differential has been assumed (e.g. 95°C flow, 55°C return). This reflects current good practice in heating system designs.

Network heat losses have been calculated on the basis of proposed network length, and an average temperature differential between district heating pipework and average ground temperature. Figures for heat loss per metre of different diameter pre-insulated pipework have been derived from pipework manufacturers' details.

For connection to new domestic blocks of flats, it has been assumed that the property developer would pay for:

- the internal pipework between an interface unit situated in the base of the block, and each flat

- the hydraulic interface units at each flat
- the internal radiator / other heat emitters in individual dwellings.

For new non-domestic connections, similarly, it has been assumed that the developer would pay for all internal systems, and that the notional ESCo for the site would be responsible for the installation of the interface unit for the building.

It is important to note that the algorithms used to size the district heating main spine are conservative and tend to slightly oversize the network. It is possible to operate the network to supply a higher load than that originally designed for, therefore providing a degree of future proofing. It is expected that an additional 10-15% of load can be added to the network by increasing pressure loss and pumping head. The amount of additional load that can be added would need to be investigated at the later design stages of a project using detailed hydraulic modelling and whole life cost optimisation.

4.3.1.6 Electricity Sales

It is assumed in this model that electricity generated in CHP schemes would be exported to the grid under a Power Purchase Agreement.

There are two means by which electricity generated from the CHP units can generate revenue:

- The CHP generation is supplied directly to a single building or multiple buildings connected to a single high-voltage distribution system. The use of CHP electricity used will reduce the quantity of electricity purchased from the grid at the tariff paid for that site. The CHP generation therefore has the same value as the standard electricity purchase tariff. This approach has the greatest benefit when the electrical demand profile is well matched to the CHP generation profile, therefore minimising the amount of electricity that cannot be used by the building and is therefore exported to the grid.
- Electricity is sold directly to the national grid under a power purchase agreement. Depending on the structure of the agreement the electricity is valued at or slightly higher than wholesale electricity price. The value of electricity is therefore typically 2-3 p/kWh less than the value that could be gained offsetting grid import.

The default assumption is that electricity generated in CHP schemes would be exported to the grid under a Power Purchase Agreement. Where it is possible to connect the CHP directly to a significant electrical load PB has assumed that 70% of the CHP generation can be valued at the existing electrical tariff paid by that building.

PB has investigated the means by which the value of decentralised energy generation exported directly to the grid can be maximised. Ofgem issued a revision to the electricity supply licence in 2009; this offers the potential for decentralised energy schemes to save on the cost of self supply via a 'light electricity supply licence'; thereby realising a greater value to the electricity that they generate.

The main concern when looking at this option is that it is difficult to see where the additional value to the operator of the scheme would come from. The 'light electricity supply licence' arrangement would still require the Supply Company (which operates the market systems on behalf of the generation plant operator) to undertake all the normal processes (and therefore incur the same costs as they would under their normal operations). There are no changes to the use of network (DUoS) charges and indeed in some cases the Distribution Network Operators (DNO) have argued that the DUoS charges should be higher where assets are notionally used both up and down the voltage chain. In addition the scheme operator would have to carry the costs of customer management which may actually be higher than for a larger supplier. It is interesting to note that there have been no applications for a licence under this regime since it was put into operation in March 2009.

Our conclusion is that there is no rationale or evidence to indicate that electrical generation from the CHP should be valued other than at or slightly above grid wholesale value, i.e. significantly lower than the price of electrical import paid by large individual organisations currently.

4.3.1.7 Heat Sales

Heat sales prices for existing buildings are based upon no reduction against the price that would be paid under a 'business as usual' (BAU) scenario. The price of heat calculated under a BAU scenario includes the cost of fuel, and an assumed cost of boiler maintenance and replacement. Where applicable, the cost implications of the Carbon Reduction Commitment for public sector buildings have also been taken into account.

Heat sales prices to new build properties are based on the same principles.

This method of setting a heat sales price effectively means that connected customers would pay the same price for heat that they would under a business-as-usual scenario, yet they would receive low-carbon heat. E.g. no premium has been added to the heat sales price to reflect the low-carbon attribute of the energy supply.

4.3.1.8 Utility Connections / Diversions

It has not been possible to make all the relevant detailed applications to the relevant utility companies in order to obtain quotations for diversion and new utility connections. Hence assumptions have been made in terms of several key items (e.g. gas and electrically infrastructure reinforcement) that can have a significant impact on capital costs of projects (see appendix F)

4.3.2 MODELLING METHODOLOGY

The loads calculated (as described in Section 4.1) have been entered into a network viability model which encompasses the main cost elements of district heating scheme development. The model works in several stages:

1. Load selection – the user can select loads to include / exclude from the scheme.

2. Heat sales values – as indicated above heat sales price are based on existing gas costs, plant maintenance and replacement costs and the impact of the Carbon Reduction Commitment.

3. The characteristics of a core and future network main spine are entered (e.g. lengths, loads connected, anticipated temperature differential), as well as the distance of each potential load from this main spine infrastructure. The core network would supply existing loads, and the future network the loads of new development. These loads entered form the basis of a hydraulic calculation of an appropriate pipe diameter for the connection to maintain a suitable pressure drop across the network.

4. The lengths of network and the loads selected for inclusion in the scheme allow calculation of a total network cost (also including the cost of interface units at each building).

5. Further capital cost elements are included to allow for provision of sufficient heat supply capacity margins against peak demands.

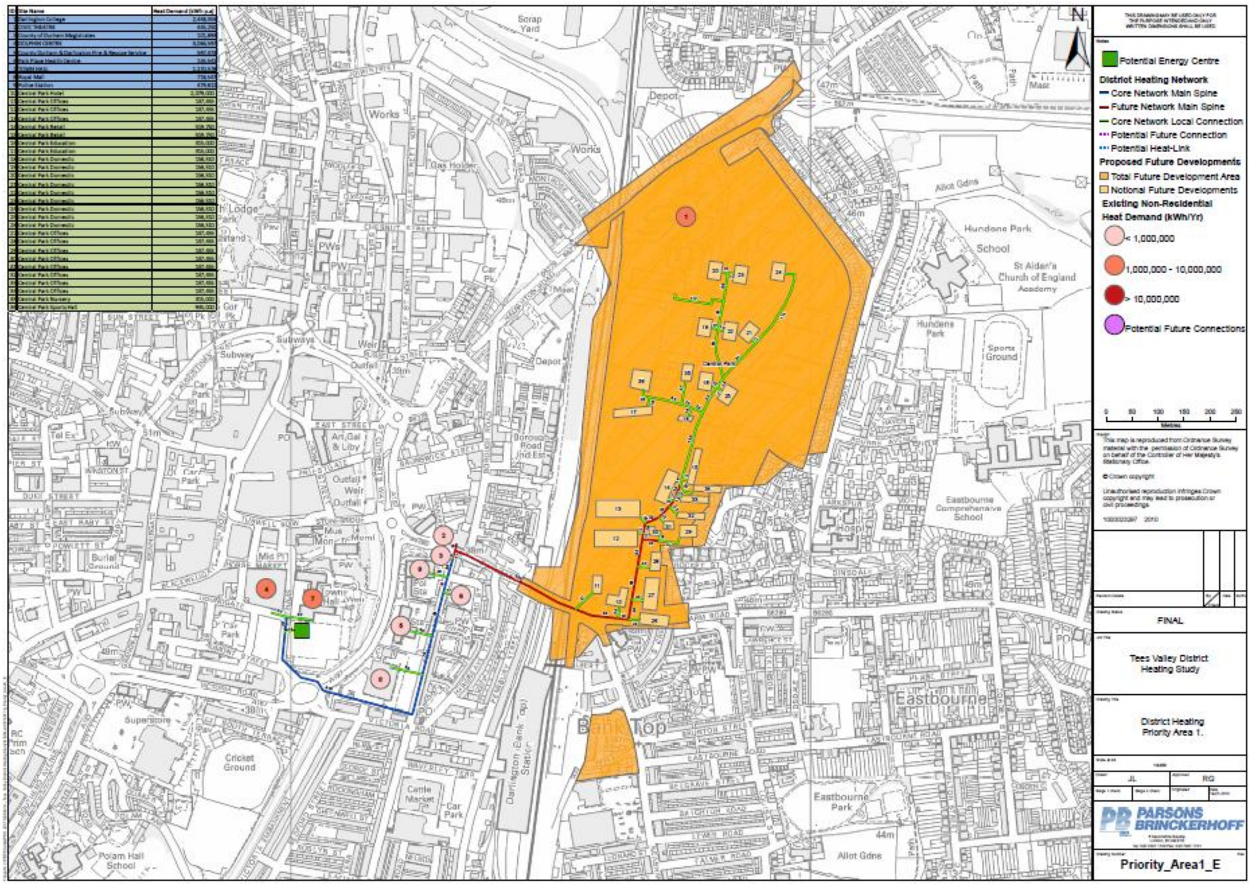
6. The total revenues from the scheme are then compared with scheme costs to calculate annual operational revenue. The lifecycle maintenance and replacement costs of main plant items have also been factored into the analysis, to give a whole life cost for each scheme calculated at different discount rates and over varying project lifes.

4.3.3 PRIORITY AREA 1 – DARLINGTON

The spatial distribution of the Darlington Scheme is very linear, particularly in terms of expansion of the network to accommodate future development. For this scheme in particular it would be desirable to ensure that sufficient 'spare' capacity is in-built into the network in early phases to deliver a future-proofed solution.

The distribution of loads for this scheme has been based upon Masterplan drawings for the area. These are not definitive and are, of course, subject to change, but are useful in providing indications of the anticipated character of various parts of the development area.

Figure 4-12 Low resolution version of Darlington Scheme Illustration



4.3.3.1 CORE SCHEME

The key loads of the Darlington core scheme are the Dolphin Centre and the Town Hall. A high resolution map of the scheme, inducing loads supplied is provided in appendix D.

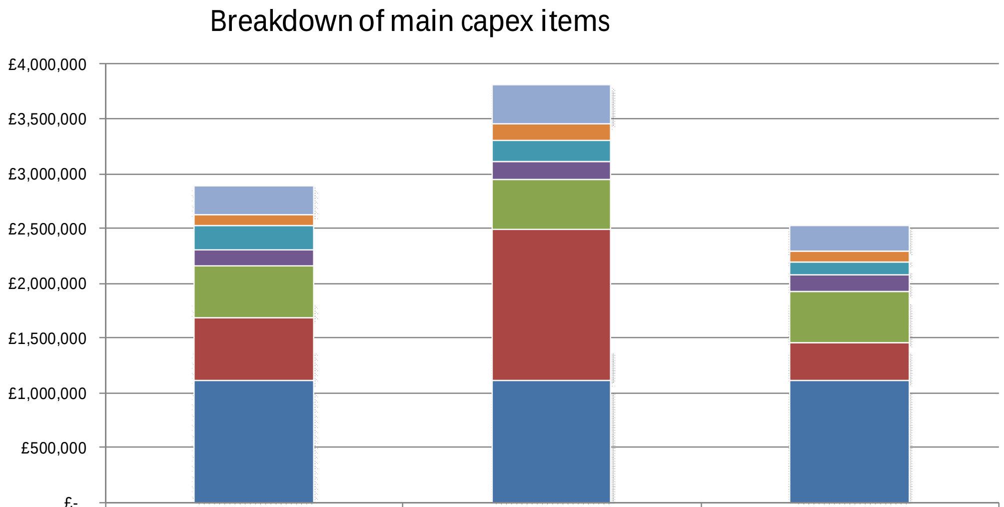
For the Core Scheme, the following energy balance, capex breakdown and financial performance (operational revenue and whole life costs) have been modelled:

Table 4-6 Darlington Core Scheme Energy Balance Results

		Primary Heat Source		
		Gas CHP	PPO CHP	Biomass
Prime mover capacity	kWe (CHPs), kWth (biomass)	844	1,178	889
Thermal storage size	cubic metres	251	266	241
Gas boiler capacity	kWth	4,330	4,330	4,330
Prime Mover				

Electrical generation	MWh p.a.	4,840	5,950	
Heat generation	MWh p.a.	5,310	4,960	4,891
Fuel type		Gas	PPO	Biomass
Fuel consumption	MWh p.a.	12,930	17,235	6,113
Secondary / Top-up and Standby Heat Source				
Heat generation	MWh p.a.	1,677	2,026	2,096
Fuel type		Gas	Gas	Gas
Fuel consumption	MWh p.a.	2,020	2,441	2,525
Electricity Balance				
Parasitic Electricity Demand	MWh p.a.	169	238	245
Electricity generated and used on site	MWh p.a.	156	209	
Electricity Export	MWh p.a.	4,684	5,741	
Electricity Import	MWh p.a.	14	29	245
Emissions				
Carbon savings over BAU	tonnes CO_2 p.a.	1,234	4,108	924

Table 4-7 Darlington Core Scheme Capex Breakdown

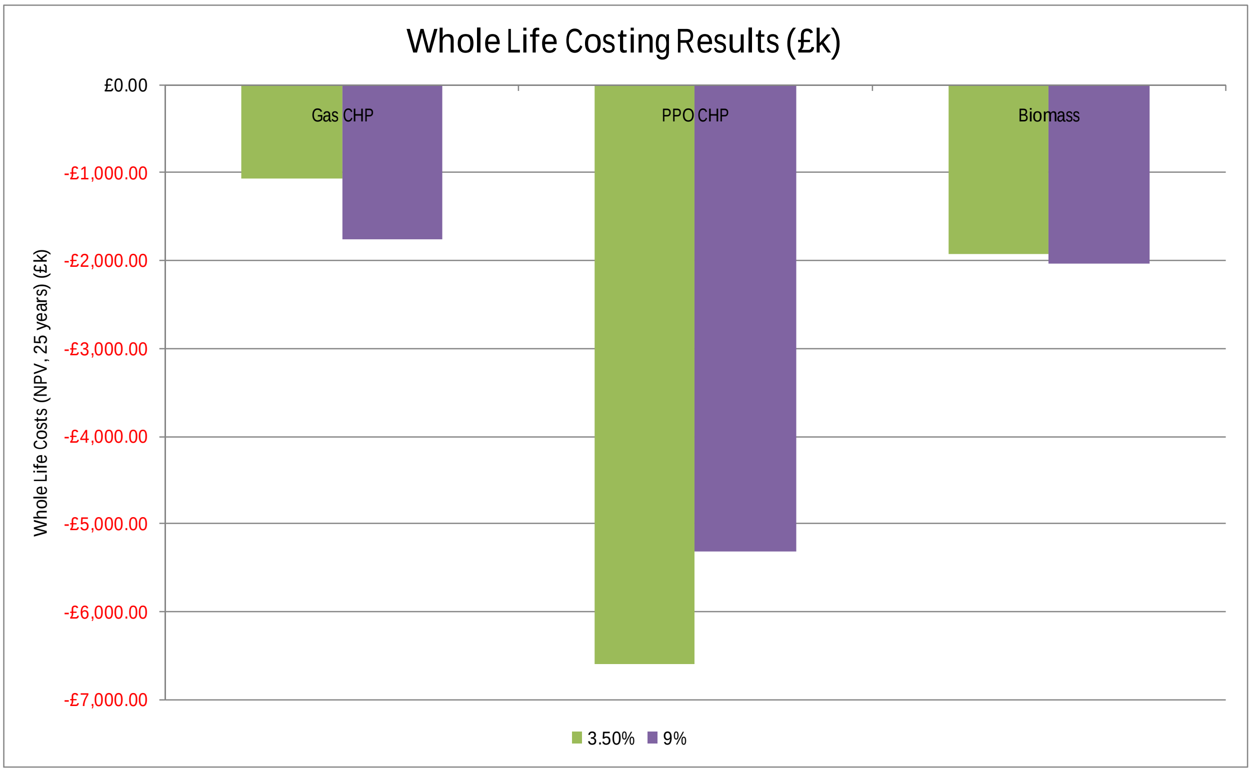


	Gas CHP option 844kWe gas CHP 250 m3 TS, and 4300kWth boilers	PPO CHP option 1185kWe CHP 270m3 TS, and 4300kWth boilers	Biomass option 895kWth boiler 240m3 TS, and 4300kWth boilers
Contingency	£265,313	£348,014	£231,470
Soft costs	£112,282	£152,068	£100,590
Utilities	£210,222	£201,739	£117,339
Energy Centre Land and Building	£150,099	£150,099	£150,099
Balance of Plant	£468,843	£468,843	£468,843
Prime mover and thermal storage	£577,003	£1,372,714	£343,150
DH Network Costs	£1,113,831	£1,113,831	£1,113,831

Table 4-8 Operational Revenue Calculation – Darlington Core Scheme

£k	Gas CHP	PPO CHP	Biomass
Prime mover fuel costs	£247	£1,051	£153
Top-up boilers fuel costs	£42	£60	£62
Energy centre elec import	£1	£2	£20
Plant maintenance (inc DH) / administration	£77	£99	£35
Heat Sales	£264	£264	£264
Electricity Sales	£229	£281	£0
TRIAD benefit	£5	£7	£0
ROC / RHI support[18]	£0	£551	£78
TOTAL Expense	£367	£1,212	£270
TOTAL Income	£498	£1,103	£343
Operational Revenue	£131	-£109	£73

Figure 4-13 Whole Life Cost Results (Darlington Core Scheme)



[18] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

The network costs assumed within the capital costs for the Core Scheme allow for the installation of a future-proofed network to accommodate the future development as outlined below.

At neither 9% nor 3.5% real discount rate over the 25 year project lifespan does the Darlington Core scheme offer a positive net present value. Therefore, it would appear that this scheme would require grant funding to a level of approximately £1.1m in order to deliver a viable scheme (when considered at a 3.5% discount rate). It is interesting to note that this corresponds closely to the calculated cost of the DH network.

4.3.3.2 CORE SCHEME WITH FUTURE DEVELOPMENT

The Central Park area of new development within Darlington is fairly diffuse; PB has based its notional network design on a Napper Masterplan[19] drawing that illustrates that there are three main areas:

- The office / commercial area to the south of the site;
- The diffuse residential area in the north east;
- The college area in the north west.

PB has conducted a number of modelling scenarios for the Darlington area in order to try to optimise the configuration of DH network for the expanded scheme. The residential area in the north east is considered too diffuse to be viable for DH, and given the high standards of insulation that the increasingly stringent standards of the Code for Sustainable Homes, even the terraced housing around the college interface area (central northern section) are not thought to add commercial value to the DH network as a whole. As a result, the proposed expanded network for Darlington only encompasses the commercial / office area at the southern end of the regeneration area.

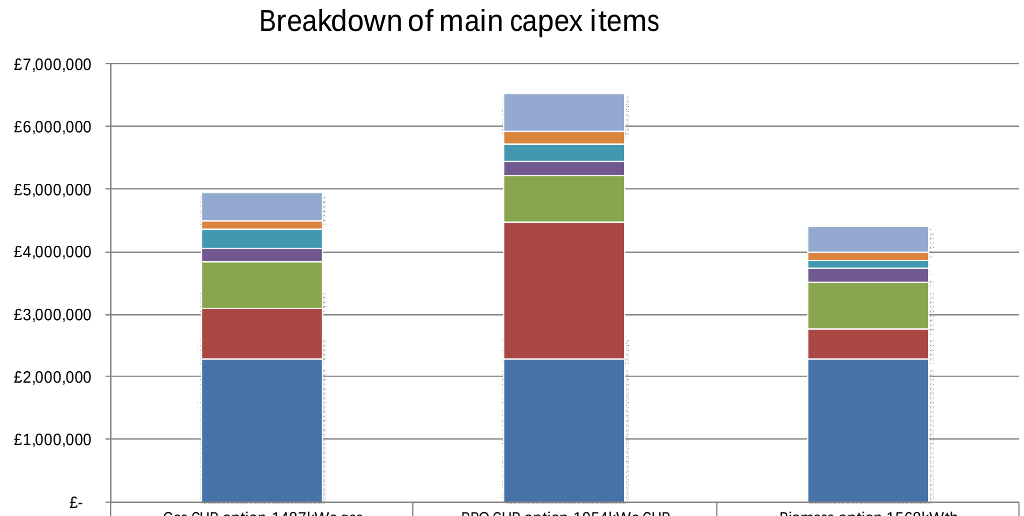
Table 4-9 Darlington Extended Scheme Energy Balance Results

		Primary Heat Source		
		Gas CHP	PPO CHP	Biomass
Prime mover capacity	kWe (CHPs), kWth (biomass)	1,487	1,954	1,568
Thermal storage size	cubic metres	308	329	297
Gas boiler capacity	kWth	9,089	9,089	9,089

[19] Provided by Darlington Council

Prime Mover				
Electrical generation	MWh p.a.	8,584	9,869	
Heat generation	MWh p.a.	9,363	8,747	8,624
Fuel type		Gas	PPO	Biomass
Fuel consumption	MWh p.a.	22,764	26,709	10,780
Secondary / Top-up and Standby Heat Sources				
Heat generation	MWh p.a.	2,957	3,573	3,696
Fuel type		Gas	Gas	Gas
Fuel consumption	MWh p.a.	3,562	4,305	4,453
Electricity Balance				
Parasitic Electricity Demand	MWh p.a.	300	395	431
Electricity generated and used on site	MWh p.a.	276	347	
Electricity Export	MWh p.a.	8,307	9,521	
Electricity Import	MWh p.a.	24	47	431
Emissions				
Carbon savings over BAU	tonnes CO_2 p.a.	2,149	6,900	1,570

Table 4-10 Darlington Extended Scheme Capex Breakdown



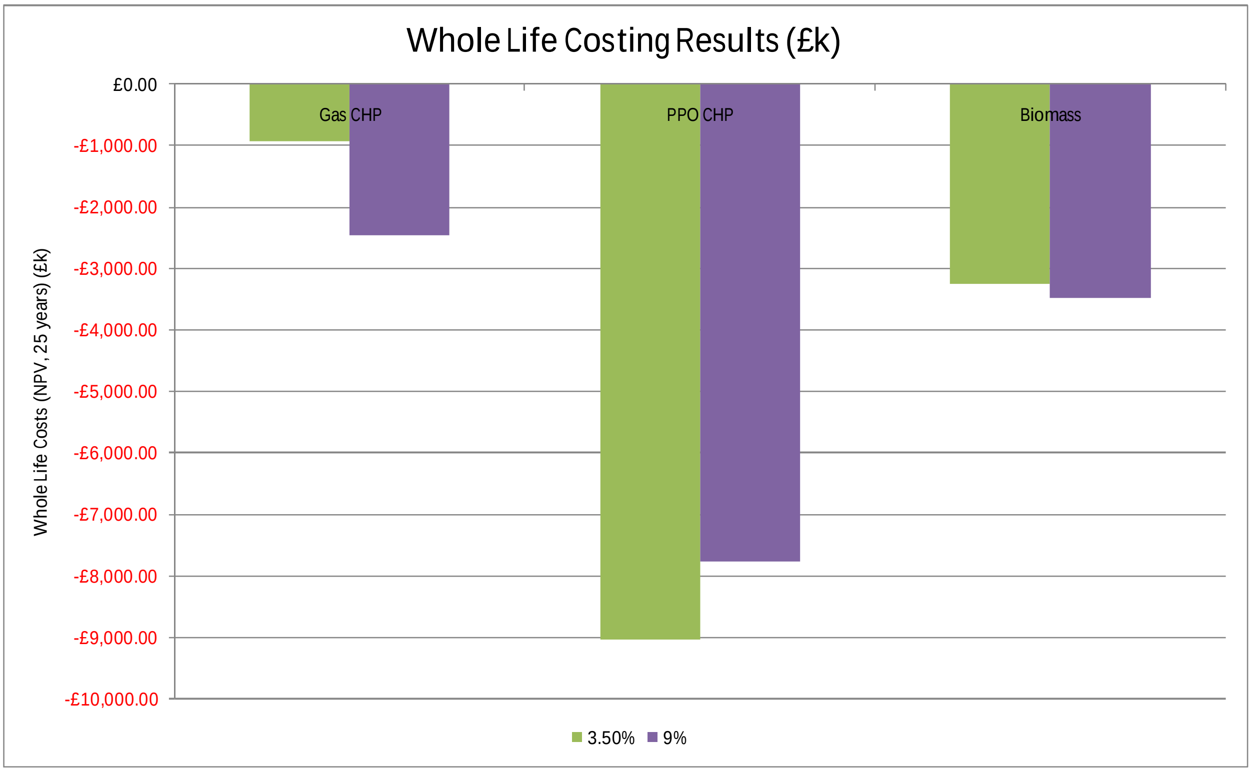
	Gas CHP option 1487kWe gas CHP 310 m3 TS, and 9100kWth boilers	PPO CHP option 1954kWe CHP 330m3 TS, and 9100kWth boilers	Biomass option 1568kWth boiler 300m3 TS, and 9100kWth boilers
Contingency	£453,419	£597,017	£403,028
Soft costs	£140,667	£209,399	£124,104
Utilities	£292,145	£284,765	£136,065
Energy Centre Land and Building	£215,067	£215,067	£215,067
Balance of Plant	£746,890	£746,890	£746,890
Prime mover and thermal storage	£809,584	£2,184,212	£478,314
DH Network Costs	£2,290,345	£2,290,345	£2,290,345

Table 4-11 Operational Revenue Calculation – Darlington Core Scheme

£k	Gas CHP	PPO CHP	Biomass
Prime mover fuel costs	£411	£1,629	£269
Top-up boilers fuel costs	£70	£100	£103
Energy centre elec import	£2	£4	£36
Plant maintenance (inc DH) / administration	£119	£174	£60
Heat Sales	£461	£461	£461
Electricity Sales	£406	£465	£0
TRIAD benefit	£9	£11	£0
ROC / RHI support[20]	£0	£914	£138
TOTAL Expense	£601	£1,908	£469
TOTAL Income	£875	£1,852	£599
Operational Revenue	£274	-£56	£130

[20] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

Figure 4-14 Whole Life Cost Results (Darlington Extended Scheme)



There is a relatively high density of commercial loads at the southern end of the proposed Central Park development area, and this forms a beneficial cluster of loads for the scheme to supply. This analysis shows that the use of gas-CHP offers the least cost option, but that at both 9% and 3.5% discount rates that the scheme has a negative NPV, not including potential developer contributions.

As noted above, the diffuse domestic development in the northern section of the new development area is not proposed to be connected to the DH system, and hence a level of potential developer contribution to the scheme has been calculated on the basis of potential avoided costs in the construction of commercial / office space. As per the assumptions section above, a 1.1% cost uplift figure has been applied to generic building cost figures derived from SPONS. For the non-domestic development proposed to be connected to the DH system, this calculation results in a level of Developer Contribution for the non-domestic element of the development of £0.86m.

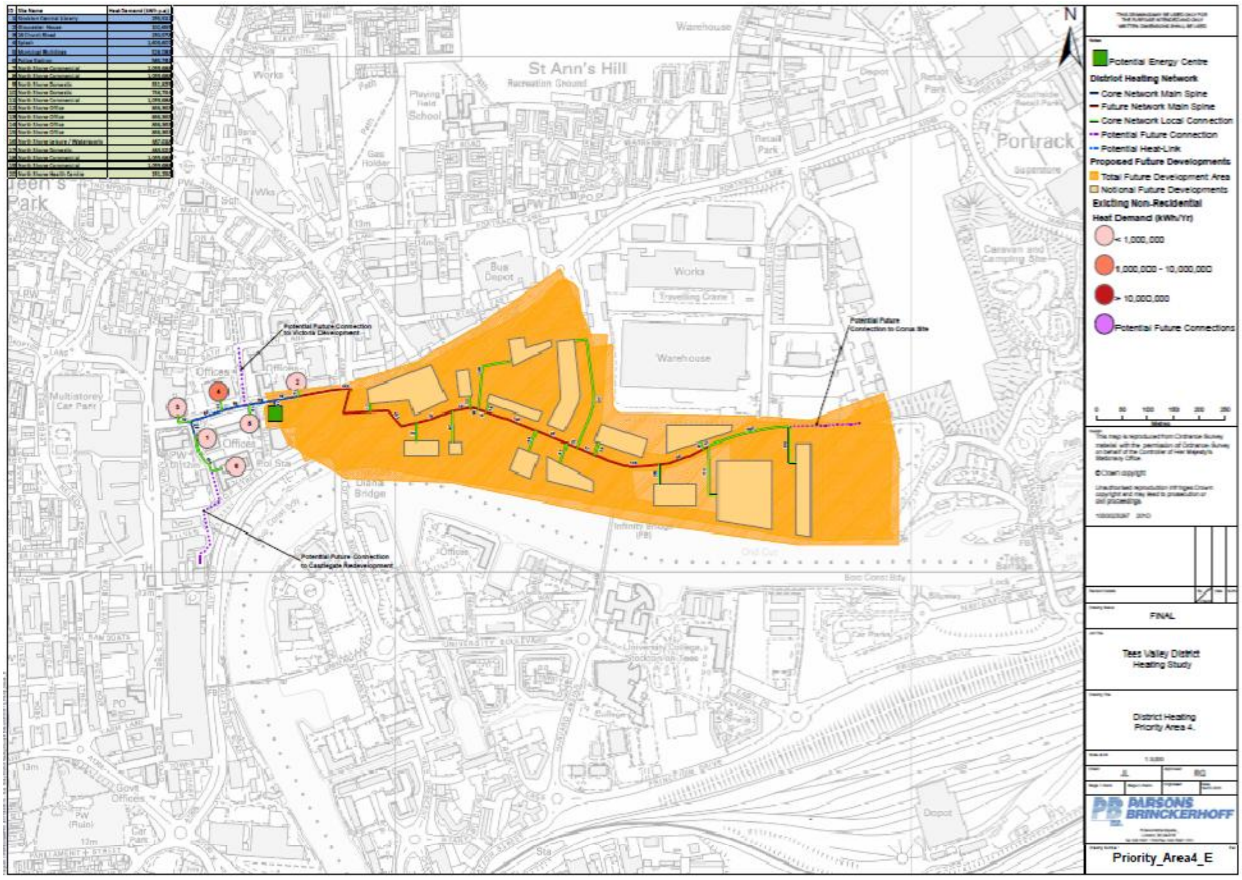
For the extended scheme as outlined here, the notional calculated level of Developer Contribution to the scheme (£0.86m) is close to the level of 'funding gap' identified at a 3.5% discount rate (£0.93m). This scheme would therefore appear to be on the boundary of economic viability assuming that low-cost finance is available.

The only marginal benefit for connecting to district heating in Darlington means that developers will not necessarily connect to the network. PB would advocate the incorporation of strong planning guidance that obliges developers to connect the district heating network. Examples of the type of planning guidance required are included in section 5.3.

4.3.4 PRIORITY AREA 4 – STOCKTON

The illustration below shows the Stockton Core network, and the assumption made of building layouts for the North Shore development. This is purely indicative and notional, in order to provide a starting point for the analysis of a potential scheme, and the following analysis must be viewed in the light of this broad approach.

Figure 4-15 Stockton Scheme Illustration



4.3.4.1 CORE SCHEME

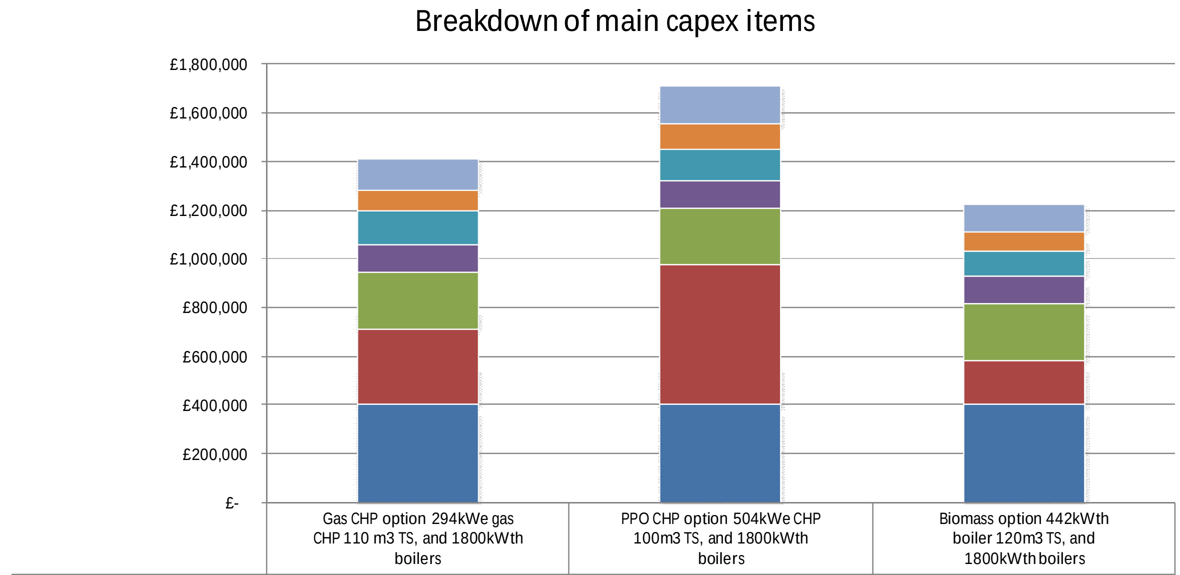
The Stockton core scheme is the most compact of the schemes analysed, and represents the least capital intense option, as a result of both the relatively short network length and the comparatively small energy centre required. A high resolution map of the scheme, inducing loads supplied is provided in appendix D.

For the Core Scheme, the following energy balance, capex breakdown and financial performance (operational revenue and whole life costs) have been modelled:

Table 4-12 Stockton Core Scheme Energy Balance Results

		Primary Heat Source		
		Gas CHP	PPO CHP	Biomass
Prime mover capacity	kWe (CHPs), kWth (biomass)	294	504	442
Thermal storage size	cubic metres	109	102	120
Gas boiler capacity	kWth	1,781	1,781	1,781
Prime Mover				
Electrical generation	MWh p.a.	1,654	2,799	
Heat generation	MWh p.a.	2,257	2,083	2,430
Fuel type		Gas	PPO	Biomass
Fuel consumption	MWh p.a.	4,834	8,231	3,038
Secondary / Top-up and Standby Heat Sources				
Heat generation	MWh p.a.	1,215	1,389	1,041
Fuel type		Gas	Gas	Gas
Fuel consumption	MWh p.a.	1,464	1,673	1,255
Electricity Balance				
Parasitic Electricity Demand	MWh p.a.	58	112	122
Electricity generated and used on site	MWh p.a.	53	99	
Electricity Export	MWh p.a.	1,601	2,700	
Electricity Import	MWh p.a.	5	13	122
Emissions				
Carbon savings over BAU	tonnes CO_2 p.a.	457	1,876	462

Table 4-13 Stockton Core Scheme Capex Breakdown



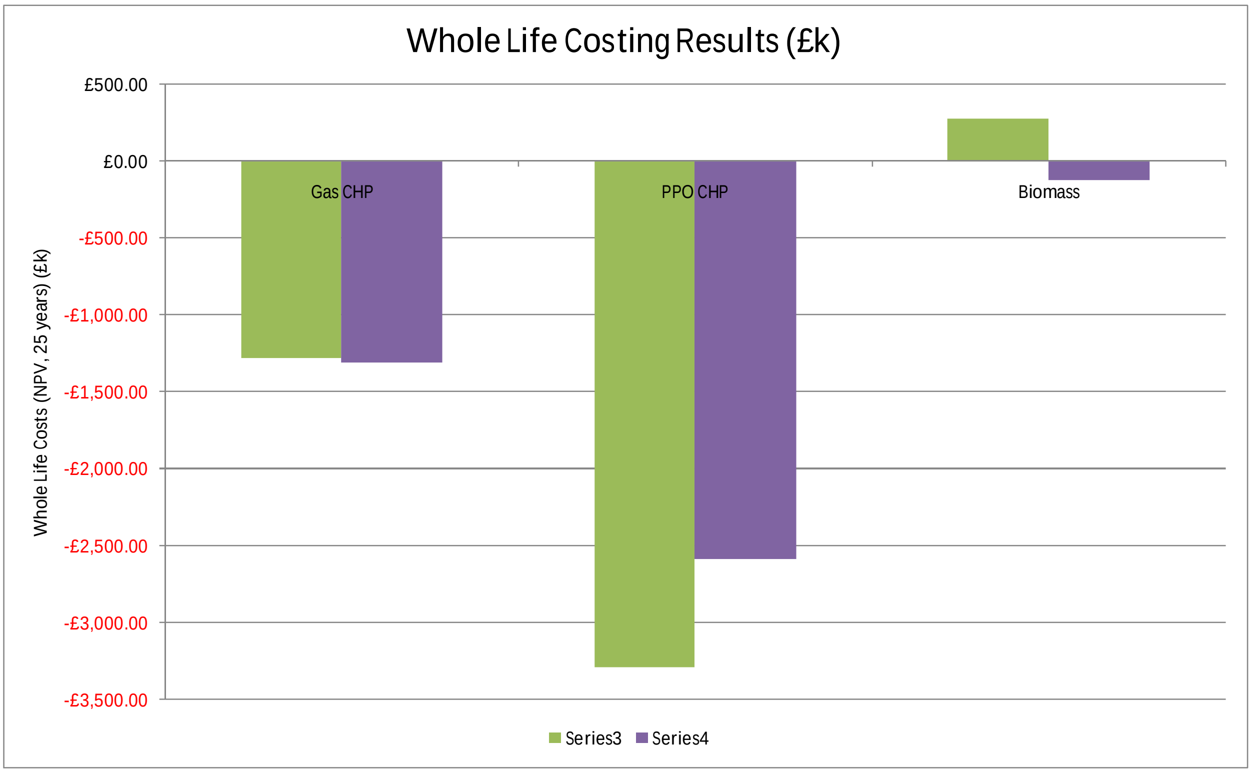
	Gas CHP option 294kWe gas CHP 110 m3 TS, and 1800kWth boilers	PPO CHP option 504kWe CHP 100m3 TS, and 1800kWth boilers	Biomass option 442kWth boiler 120m3 TS, and 1800kWth boilers
Contingency	£128,995	£156,038	£111,962
Soft costs	£85,551	£98,680	£79,091
Utilities	£135,277	£129,995	£100,595
Energy Centre Land and Building	£115,306	£115,306	£115,306
Balance of Plant	£232,097	£232,097	£232,097
Prime mover and thermal storage	£312,766	£575,353	£183,575
DH Network Costs	£401,176	£401,176	£401,176

Table 4-14 Operational Revenue Calculation

£k	Gas CHP	PPO CHP	Biomass
Prime mover fuel costs	£101	£502	£76
Top-up boilers fuel costs	£33	£43	£33
Energy centre elec import	£0	£1	£10
Plant maintenance (inc DH) / administration	£58	£49	£25
Heat Sales	£129	£129	£129
Electricity Sales	£78	£132	£0
TRIAD benefit	£2	£3	£0
ROC / RHI support[21]	£0	£259	£158
TOTAL Expense	£192	£595	£144
TOTAL Income	£209	£523	£287
Operational Revenue	£17	-£72	£143

[21] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

Figure 4-16 Whole Life Cost Results (Core Scheme)



This figure indicates that the preferred heat source for the Core Scheme at Stockton would be a biomass boiler. However, it must be noted that there is an element of risk associated with this, as the main source of income for this technology as modelled here is the Renewable Heat Incentive. As discussed in Section 4.3.1 there is regulatory risk associated with this potential support mechanism, as at this stage there is uncertainty surrounding its implementation. The scale of this scheme and a suitable biomass boiler allows it to qualify for a higher level of subsidy than larger schemes, which accounts for the technology's improved performance here in comparison with other schemes.

It is therefore recommended that for this scheme, that the development of a detailed business plan and finance model is deferred until the current administration confirms whether (and in what form) the RHI is to be implemented. However, if RHI support is confirmed, then this scheme is likely to be extremely attractive to ESCos who have access to low-cost borrowing.

As per the modelling results above, the 'funding gap' (e.g. the difference between calculated negative NPV and zero at a commercial discount rate (9%, over 15 years)) is £77k for the biomass option.

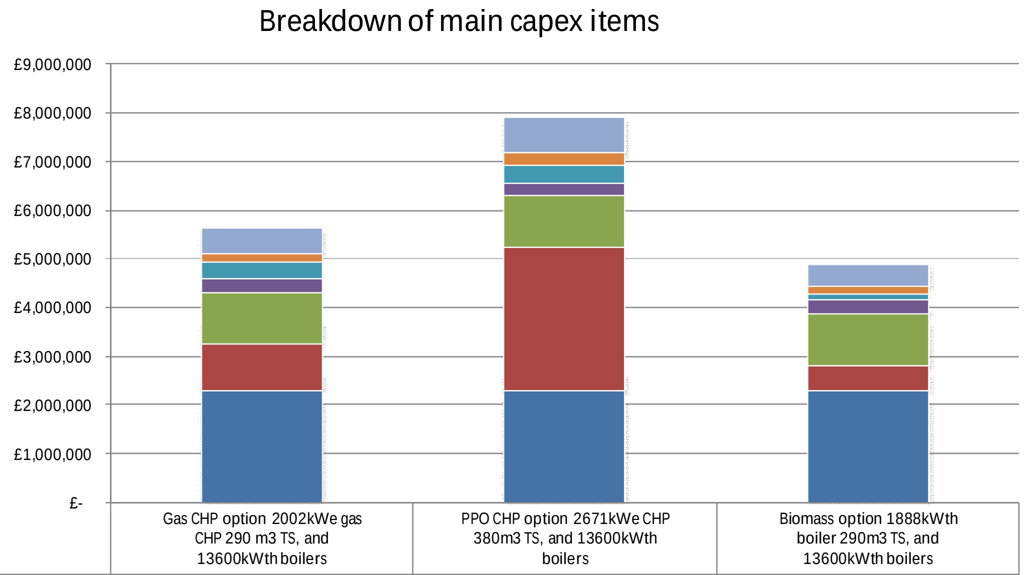
4.3.4.2 EXTENDED SCHEME

The extended scheme for Stockton includes the North Shore development.

Table 4-15 Stockton Extended Scheme Energy Balance Results

		Primary Heat Source		
		Gas CHP	PPO CHP	Biomass
Prime mover capacity	kWe (CHPs), kWth (biomass)	2,002	2,671	1,888
Thermal storage size	cubic metres	294	377	290
Gas boiler capacity	kWth	13,597	13,597	13,597
Prime Mover				
Electrical generation	MWh p.a.	11,159	10,817	
Heat generation	MWh p.a.	10,679	9,938	10,383
Fuel type		Gas	PPO	Biomass
Fuel consumption	MWh p.a.	27,860	28,147	12,978
Secondary / Top-up and Standby Heat Sources				
Heat generation	MWh p.a.	4,153	4,895	4,450
Fuel type		Gas	Gas	Gas
Fuel consumption	MWh p.a.	5,004	5,897	5,361
Electricity Balance				
Parasitic Electricity Demand	MWh p.a.	391	433	519
Electricity generated and used on site	MWh p.a.	359	381	
Electricity Export	MWh p.a.	10,799	10,436	
Electricity Import	MWh p.a.	31	52	519
Emissions				
Carbon savings over BAU	tonnes CO_2 p.a.	2,780	7,664	1,893

Table 4-16 Stockton Extended Scheme Capex Breakdown



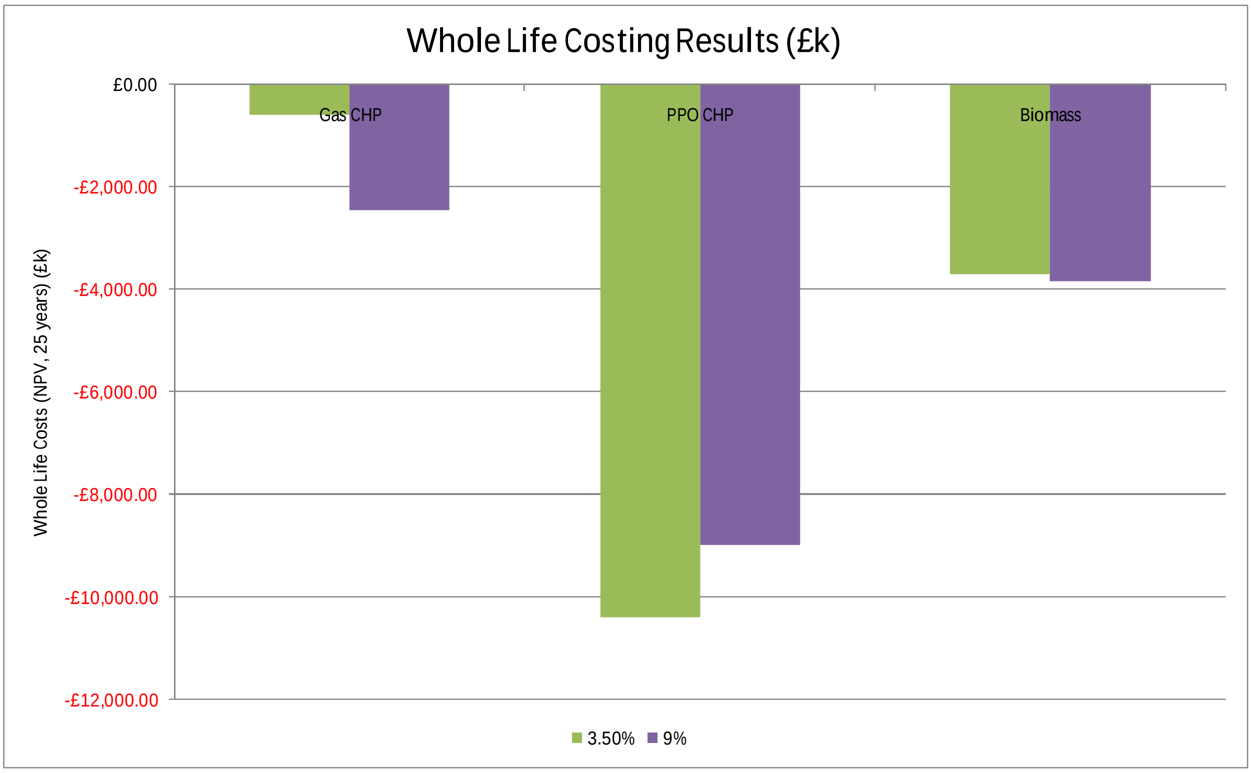
	Gas CHP option 2002kWe gas CHP 290 m3 TS, and 13600kWth boilers	PPO CHP option 2671kWe CHP 380m3 TS, and 13600kWth boilers	Biomass option 1888kWth boiler 290m3 TS, and 13600kWth boilers
Contingency	£516,357	£723,843	£449,815
Soft costs	£166,123	£265,131	£144,175
Utilities	£350,249	£345,938	£145,738
Energy Centre Land and Building	£276,602	£276,602	£276,602
Balance of Plant	£1,058,690	£1,058,690	£1,058,690
Prime mover and thermal storage	£954,258	£2,934,420	£515,301
DH Network Costs	£2,301,904	£2,301,904	£2,301,904

Table 4-17 Operational Revenue Calculation

£k	Gas CHP	PPO CHP	Biomass
Prime mover fuel costs	£491	£1,717	£324
Top-up boilers fuel costs	£96	£133	£122
Energy centre elec import	£3	£4	£43
Plant maintenance (inc DH) / administration	£207	£297	£133
Heat Sales	£614	£614	£614
Electricity Sales	£528	£510	£0
TRIAD benefit	£12	£16	£0
ROC / RHI support[22]	£0	£1,002	£166
TOTAL Expense	£797	£2,152	£622
TOTAL Income	£1,153	£2,142	£780
Operational Revenue	£356	-£10	£158

[22] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

Figure 4-17 Whole Life Cost Results (Extended Scheme)



Without the benefit of the higher level of support for biomass at the scale suitable for the extended scheme, gas-fired CHP is shown to perform best in economic terms. However, at a discount rate of 9% the funding gap is calculated to be £2.46m in net present value terms.

The North Shore development is predominantly commercial / office with a residential component of around 480 dwellings. In this instance, therefore, a realistic level of Developer Contribution towards the cost of the scheme must be estimated based on the avoided costs of compliance with anticipated Building Regulations for non-domestic buildings, as well as the avoided costs of compliance with different levels of the Code for Sustainable Homes.

For the dwellings on the DH network, the supply of heat is calculated to deliver carbon savings in the region of 55% of regulated emissions under the best-performing option (gas-fired CHP). Therefore as a benchmark of realistic potential contribution for the residential component published costs for achieving Code 4 of the CSH homes have been used. For the residential component of development, maximum realistic Developer contributions would be £2.28m (eg.. 480 dwellings x £4.75k).

On the basis of the assumed level of Developer contributions for the non-domestic element of the scheme (as per Section 4.3.1.2), for the North Shore development area, this calculation results in a level of Developer Contribution for the non-domestic element of the development of £1.6m.

This sum of anticipated achievable domestic and non-domestic Developer Contributions (£3.88m) is therefore in excess of the funding gap identified (£2.46m) in modelling, and therefore this DH scheme is considered viable.

A further possible breakdown of Developer Contributions for the North Shore scheme is illustrated below. This is notional and is included here as an illustrative example of how Contributions might be structured into a split between Connection Charge and Availability Charges. These charges would be in addition to unitised costs of energy delivered.

Table 4-18 Potential breakdown of developer contributions (North Shore)

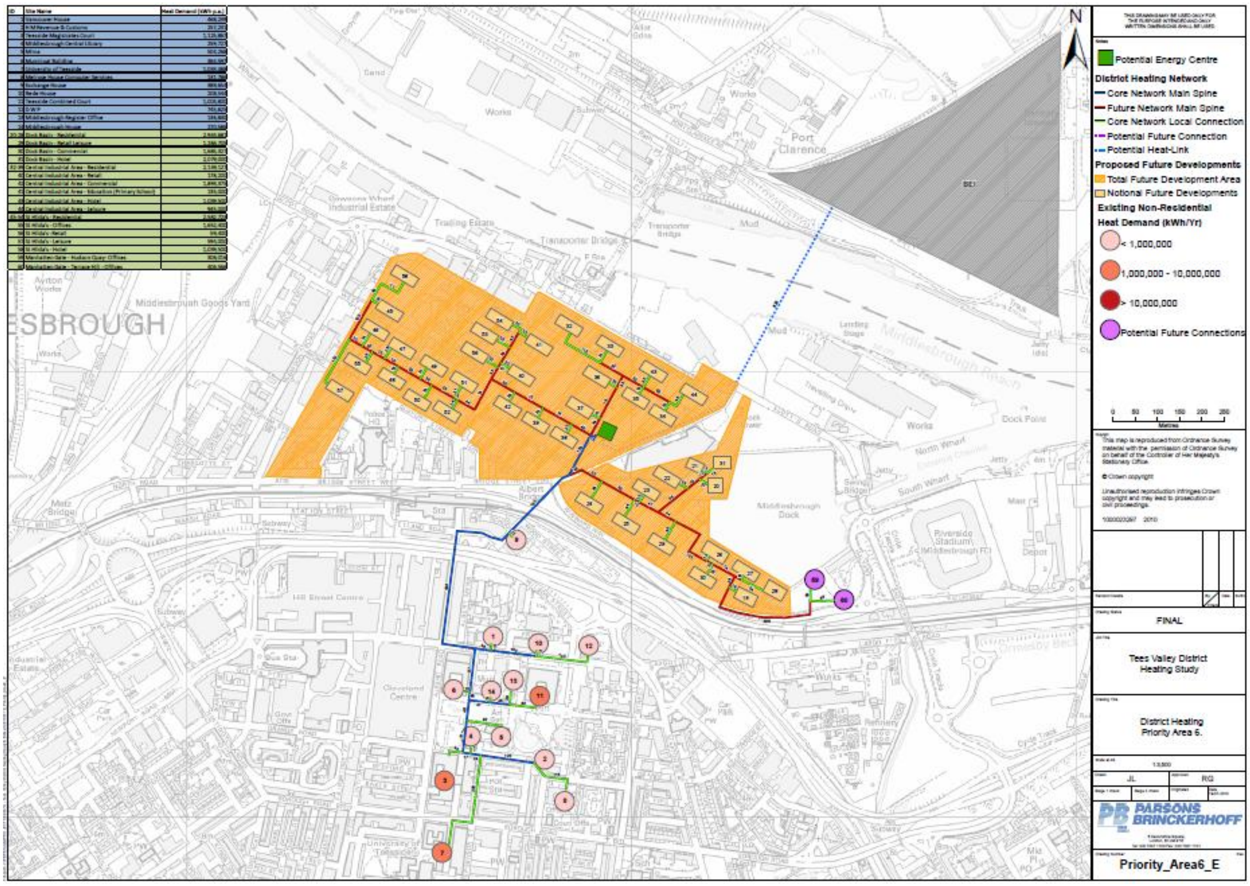
	Developers Contribution Lump sum (e.g. Connection Charge)	Monthly payments per dwelling where applicable (e.g. Availability charge)	Monthly payments per non-domestic connection where applicable (e.g. Availability charge)
North Shore Commercial	£ 97,937	£ -	£ 202
North Shore Commercial	£ 97,937	£ -	£ 202
North Shore Domestic	£ 2,665	£ 6.89	£ -
North Shore Domestic	£ 2,665	£ 6.89	£ -
North Shore Commercial	£ 97,937	£ -	£ 202
North Shore Office	£ 77,157	£ -	£ 160
North Shore Office	£ 77,157	£ -	£ 160
North Shore Office	£ 77,157	£ -	£ 160
North Shore Office	£ 81,580	£ -	£ 169
North Shore Leisure / Watersports	£ 32,530	£ -	£ 67
North Shore Domestic	£ 2,665	£ 6.89	£ -
North Shore Commercial	£ 103,551	£ -	£ 214
North Shore Commercial	£ 103,551	£ -	£ 214
North Shore Health Centre	£ 13,507	£ -	£ 28

The lump sum element of this contribution can broadly be considered to correspond to saved costs that the developer would otherwise have borne in order to bring down the carbon emissions of the development in line with required standards (e.g. increased insulation / local low carbon technologies), and the monthly availability payments would correspond to avoided on-going maintenance and replacement costs.

4.3.5 PRIORITY AREA 6 – MIDDLESBROUGH

Only approximate totals for the quantum of development are known at this early stage for the Middlehaven and surrounding development areas of Middlesbrough. Hence, in order to allow modelling of potential schemes to progress a notional layout of buildings has been adopted. This forms the basis of the cost estimates of required district heating network, and hence the analysis of the Middlesbrough must be read with this assumption in mind.

Figure 4-18 Middlesbrough Scheme Illustration



4.3.5.1 CORE SCHEME

The key loads within the Core scheme include the University and the Court buildings (Combined Court and Magistrates Court). A high resolution map of the scheme, inducing loads supplied is provided in appendix D.

It can be seen from the network illustration above that the notional energy centre location is at some distance from the core scheme. This effectively adds a significant element of capital cost to the core scheme, but results from PBs survey work, which did not lead to the identification of a suitable energy centre location in the core scheme area. This has the effect of decreasing the economic viability of the core scheme, but increasing the extended scheme viability.

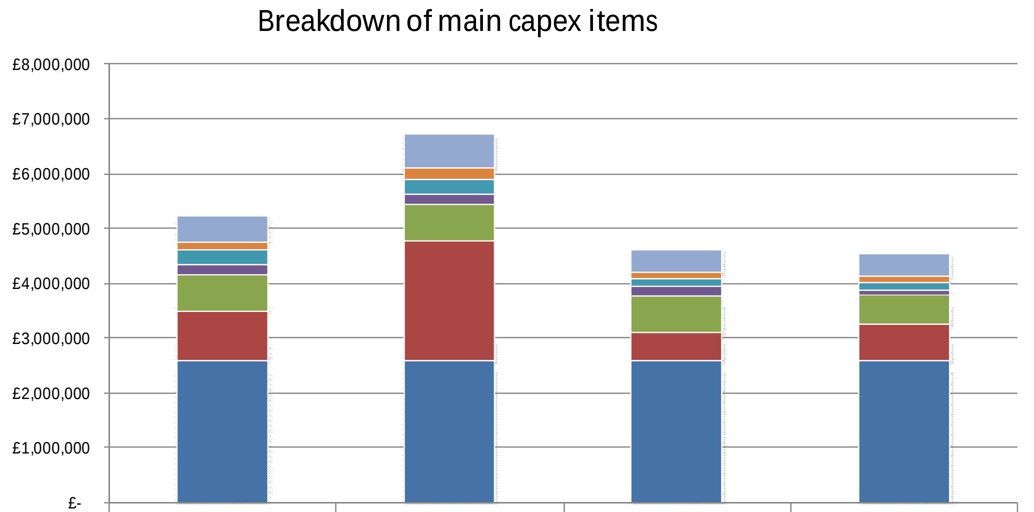
For both Core and Extended schemes in Middlesbrough, there has been discussion of the possibility of connection to a proposed biomass CHP facility on the northern bank of the Tees to the East of Port Clarence. Whilst yet to be confirmed formally, initial discussions have indicated that the power station developer would be willing to fund the installation of the link to the Middlesbrough Scheme and to provide free or very low-cost heat to the ESCo operator. This is assumed to be on the basis of an increased value of power generation subsidy (via the ROC system and CHPQI value) available to the power station developer when the waste heat from the power generation process is usefully used, rather than rejected to atmosphere. This scenario would mean less capital expense at the energy centre, and lower maintenance costs.

In the modelling outlined below, heat from the power station developer is assumed to be passed at no cost to an ESCo, and that the power station developer funds the connection between their facility and the DH Scheme Energy Centre. It has further been assumed that the DH scheme energy centre would still require full heat back-up boiler plant, in order to be able to guarantee security of supply to connected customers. Heat from the power station developer has been assumed to be available to meet 95% of scheme demands on an annual basis.

Table 4-19 Middlesbrough Core Scheme Energy Balance Results

		Primary Heat Source			
		Gas CHP	PPO CHP	Biomass	Heat from power station
Prime mover capacity	kWe (CHPs), kWth (biomass)	1,487	1,876	1,418	
Thermal storage size	cubic metres	439	448	384	-
Gas boiler capacity	kWth	7,006	7,006	7,006	7,006
Prime Mover					
Electrical generation	MWh p.a.	8,172	9,474		
Heat generation	MWh p.a.	8,914	8,357	7,800	10,586
Fuel type		Gas	PPO	Biomass	Waste Heat
Fuel consumption	MWh p.a.	21,673	25,776	9,750	
Secondary / Top-up and Standby Heat Source					
Heat generation	MWh p.a.	2,229	2,786	3,343	557
Fuel type		Gas	Gas	Gas	Gas
Fuel consumption	MWh p.a.	2,685	3,356	4,028	671
Electricity Balance					
Parasitic Electricity Demand	MWh p.a.	286	379	390	106
Electricity generated and used on site	MWh p.a.	263	333		
Electricity Export	MWh p.a.	7,909	9,140		
Electricity Import	MWh p.a.	23	45	390	106
Emissions					
Carbon savings over BAU	tonnes CO_2 p.a.	2,041	6,608	1,416	1,887

Table 4-20 Middlesbrough Core Scheme Capex Breakdown[23]



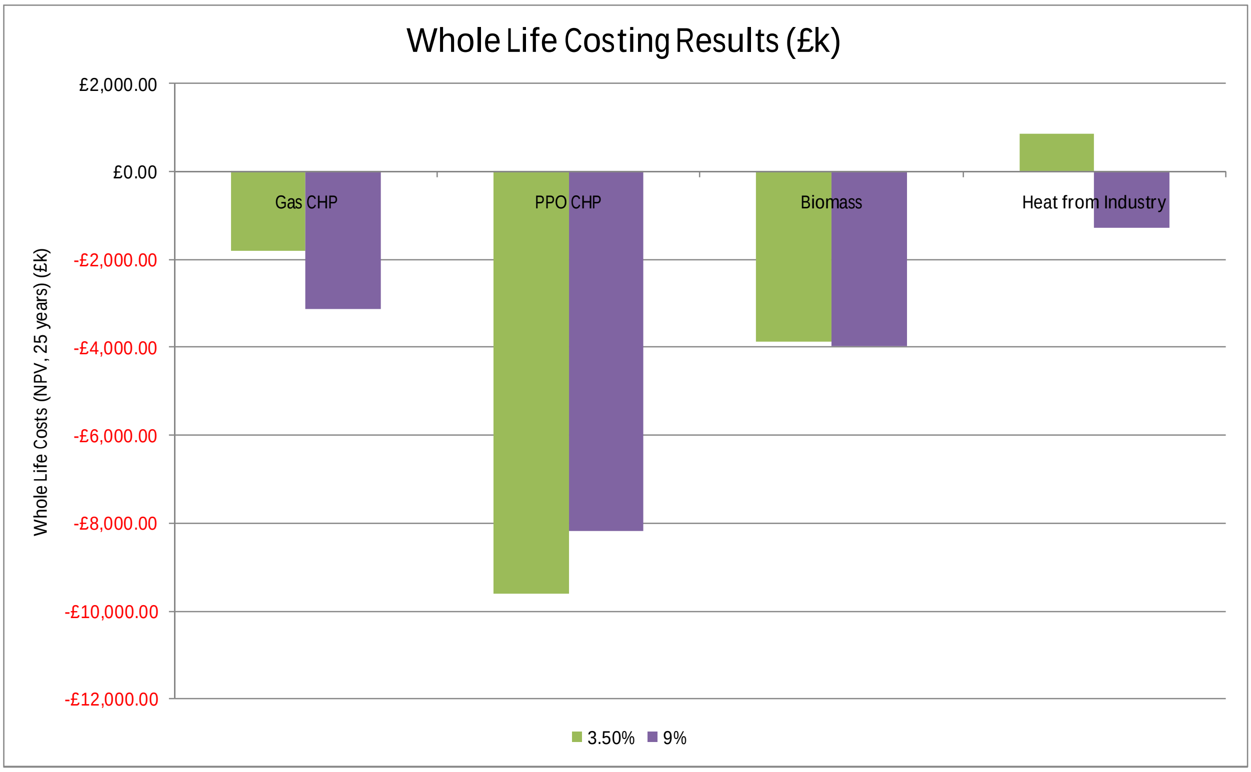
	Gas CHP option 1487kWe gas CHP 440 m3 TS, and 7000kWth boilers	PPO CHP option 1876kWe CHP 450m3 TS, and 7000kWth boilers	Biomass option 1418kWth boiler 380m3 TS, and 7000kWth boilers	Heat from Industry
Contingency	£479,589	£613,869	£423,508	£416,059
Soft costs	£139,606	£204,010	£120,443	£115,818
Utilities	£287,624	£277,953	£129,253	£129,253
Energy Centre Land and Building	£186,626	£186,626	£186,626	£93,313
Balance of Plant	£654,515	£654,515	£654,515	£524,405
Prime mover and thermal storage	£901,500	£2,189,569	£518,227	£668,572
DH Network Costs	£2,590,461	£2,590,461	£2,590,461	£2,600,590

[23] NB the Heat from Industry option has a “prime mover and thermal storage” cost as significant thermal storage capacity would be recommended for this option, so that the scheme can benefit from maximising the amount of heat supplied to customers that is derived from the heat link. E.g. this reduces the cost of the heat link, whilst allowing spikes in heat demand to be met by heat derived from BEI, and stored in the ‘ESCo’ energy centre.

Table 4-21 Operational Revenue Calculation – Middlesbrough Core Scheme

£k	Gas CHP	PPO CHP	Biomass	Heat from power station
Prime mover fuel costs	£394	£1,572	£244	£0
Top-up boilers fuel costs	£53	£80	£94	£19
Energy centre elec import	£2	£4	£32	£9
Plant maintenance (inc DH) / administration	£117	£171	£62	£38
Heat Sales	£406	£406	£406	£406
Electricity Sales	£387	£447	£0	£0
TRIAD benefit	£9	£11	£0	£0
ROC / RHI support[24]	£0	£877	£125	£0
TOTAL Expense	£566	£1,827	£432	£65
TOTAL Income	£801	£1,741	£531	£406
Operational Revenue	£235	-£85	£99	£341

Figure 4-19 Whole Life Cost Results (Middlesbrough Core Scheme)



[24] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

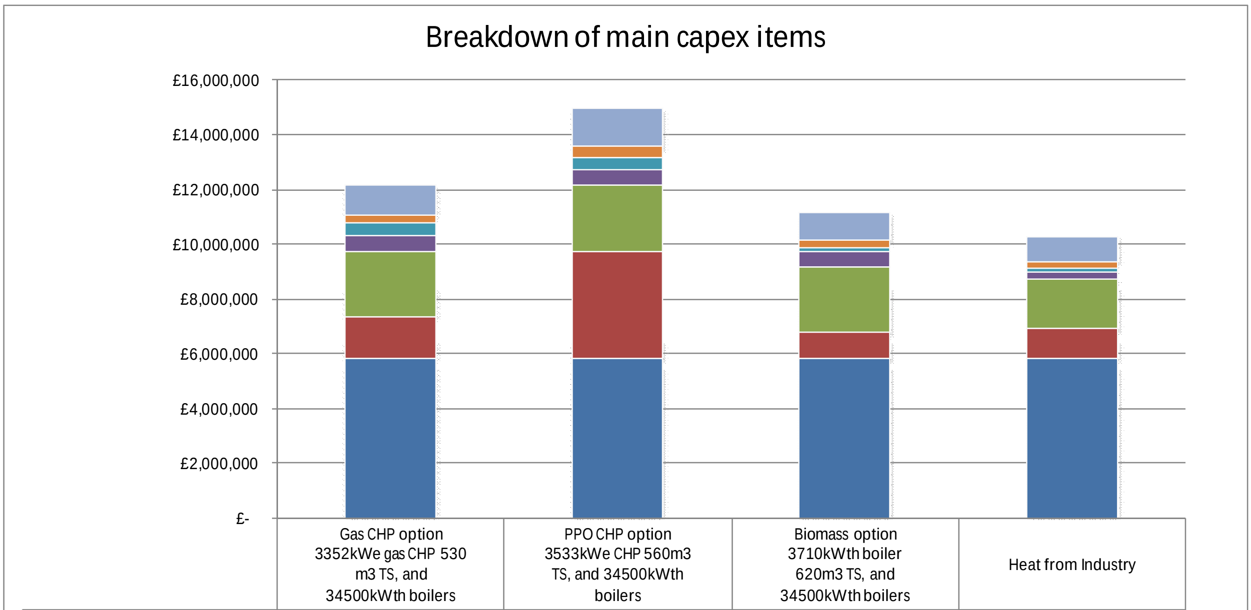
This set of results indicates that the link to the power station would appear to offer the most economic solution for the delivery of heat to customers on the core scheme. At a 3.5% discount rate, the power station link delivers a positive NPV, and at a 9% discount rate, the scheme has a negative NPV of £1.29m. As in this instance the customers connected to the network are all existing buildings, there is no opportunity for Developer Contributions to help fund the infrastructure costs of the scheme. However, one potential means of reducing this funding gap would be through dialogue with the power station developer, in order to ascertain whether there is potential additional margin available from the useful distribution of heat.

4.3.5.2 EXTENDED SCHEME

Table 4-22 Middlesbrough Extended Scheme Energy Balance Results

		Primary Heat Source			
		Gas CHP	PPO CHP	Biomass	Heat from power station
Prime mover capacity	kWe (CHPs), kWth (biomass)	3,352	3,533	3,710	n/a
Thermal storage size	cubic metres	534	559	620	-
Gas boiler capacity	kWth	34,529	34,529	34,529	34,529
Prime Mover					
Electrical generation	MWh p.a.	19,267	17,842		
Heat generation	MWh p.a.	18,364	16,907	20,405	27,692
Fuel type		Gas	PPO	Biomass	Waste Heat
Fuel consumption	MWh p.a.	47,887	44,887	25,506	
Secondary / Top-up and Standby Heat Source					
Heat generation	MWh p.a.	10,785	12,243	8,745	1,457
Fuel type		Gas	Gas	Gas	Gas
Fuel consumption	MWh p.a.	12,994	14,750	10,536	1,756
Electricity Balance					
Parasitic Electricity Demand	MWh p.a.	674	714	1,020	277
Electricity generated and used on site	MWh p.a.	620	628		
Electricity Export	MWh p.a.	18,646	17,214		
Electricity Import	MWh p.a.	54	86	1,020	277
Emissions					
Carbon savings over BAU	tonnes CO_2 p.a.	4,627	12,583	3,510	4,741

Table 4-23 Middlesbrough Extended Scheme Capex Breakdown



	Gas CHP option 3352kWe gas CHP 530 m3 TS, and 34500kWth boilers	PPO CHP option 3533kWe CHP 560m3 TS, and 34500kWth boilers	Biomass option 3710kWth boiler 620m3 TS, and 34500kWth boilers	Heat from Industry
Contingency	£1,117,030	£1,370,071	£1,025,506	£944,484
Soft costs	£273,139	£393,044	£244,927	£207,831
Utilities	£463,164	£475,583	£140,383	£140,383
Energy Centre Land and Building	£562,326	£562,326	£562,326	£281,163
Balance of Plant	£2,397,909	£2,397,909	£2,397,909	£1,811,495
Prime mover and thermal storage	£1,526,538	£3,924,625	£962,292	£1,079,567
DH Network Costs	£5,831,641	£5,831,641	£5,831,641	£5,841,770

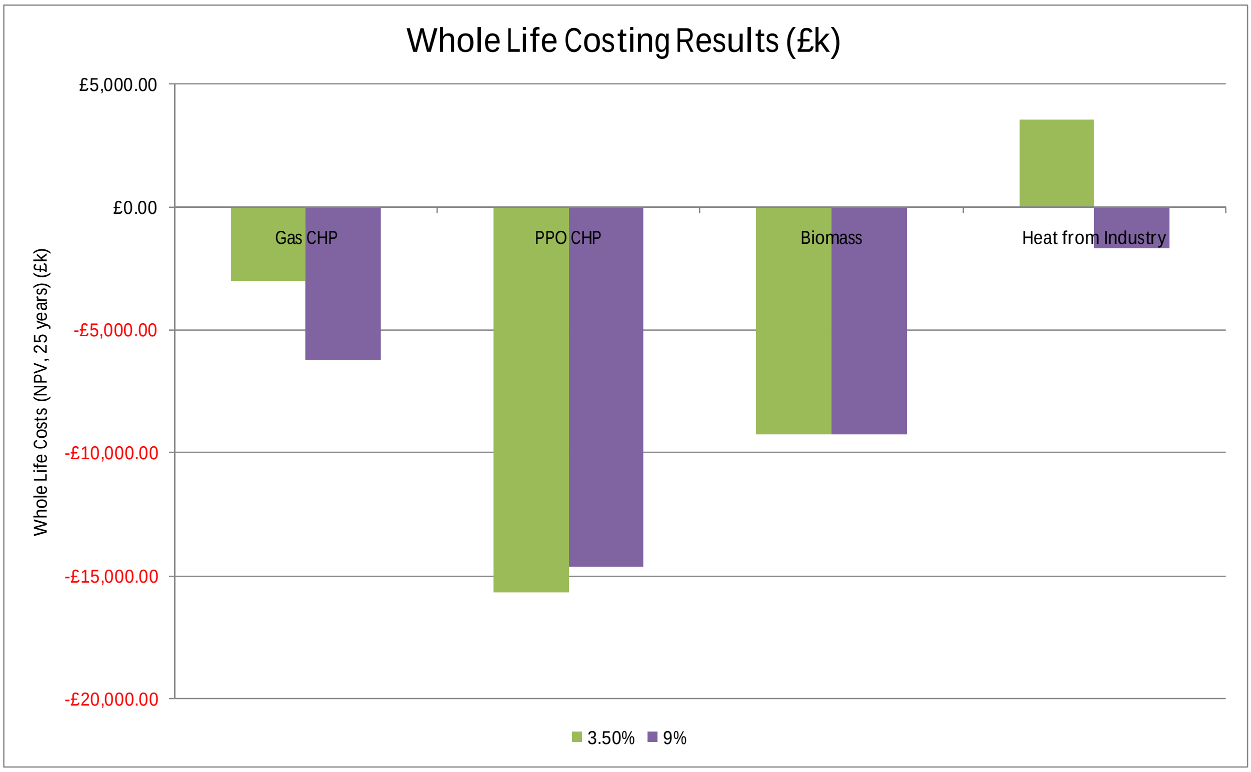
Table 4-24 Operational Revenue Calculation – Middlesbrough Core Scheme

£k	Gas CHP	PPO CHP	Biomass	Heat from power station
Prime mover fuel costs	£794	£2,738	£638	£0
Top-up boilers fuel costs	£237	£306	£226	£44
Energy centre elec import	£4	£7	£85	£23
Plant maintenance (inc DH) / administration	£584	£636	£432	£366
Heat Sales	£1,369	£1,369	£1,369	£1,369
Electricity Sales	£911	£841	£0	£0
TRIAD benefit	£20	£21	£0	£0
ROC / RHI support[25]	£0	£1,653	£326	£0
TOTAL Expense	£1,619	£3,688	£1,380	£434
TOTAL Income	£2,301	£3,884	£1,696	£1,369

[25] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

Operational Revenue	£682	£197	£316	£936

Figure 4-20 Whole Life Cost Results (Middlesbrough Extended Scheme)



As for the Core Scheme, these results also indicate that the link to the power station would appear to offer the most economic solution for the delivery of heat. At a 3.5% discount rate, the power station link delivers a positive NPV, and at a 9% discount rate, the scheme has a negative NPV of £1.68m. However, this does not take account of any level of Developer Contribution.

In this instance, there are approximately 2,000 dwellings proposed for the Extended Scheme areas, across the Dock Basin Central Industrial Area and St Hilda's. The calculated level of carbon savings that the use of 'waste heat' from power station would deliver is equivalent to 46% of regulated emissions in an average dwelling. This suggests that the residential developers would be able to avoid costs roughly equivalent to the costs of compliance with the energy component of the CSH Level 4. As outlined in Section 4.3.1 these costs are estimated to be in the region of £4.75 to £6k per dwelling. Therefore, across the residential properties of the scheme as a whole, developer contribution as a result of avoided costs could be anticipated to be greater than £9.5m (e.g. 2000 dwellings @ £4.75k). This level of avoided cost considerably exceeds the funding gap and hence this scheme is considered to be viable.

Use of waste heat to achieve Code 6 Compliance

It is also important to note additional measures beyond the use of heat from the power station would be required to allow dwellings to achieve Code Level 6 compliance. The use of Pure Plant Oil CHP is shown to be the least commercially viable option on a whole life costing basis above (Figure 4-20 Whole Life Cost Results (Middlesbrough Extended Scheme), however this is also the only solution of those analysed that delivers a level of carbon saving equivalent to 125% of average dwelling regulated emissions. This means that Code 6 compliance with this technology would be achievable with some relatively minor additional measures (e.g. to offset the remaining element of appliance / non-regulated electricity use). When the funding gap for the PPO option is compared against the cumulative avoided costs for Developers to achieve Code Level 6 on a widespread basis, this option also appears feasible.

4.3.6 PRIORITY AREA 10 – ESTON

The Eston scheme is the most diffuse of schemes proposed here, and this is reflected in the relatively high capital costs of the network to serve the identified loads.

Outline discussions have been held with Sembcorp and the potential to supply heat from their industrial installation to the network illustrated below.

Figure 4-21 Eston Scheme Illustration

4.3.6.1 CORE SCHEME

The key loads within the Core scheme include the Sports Academy and the Eston Park Business and Enterprise School. A full resolution map of the scheme is provided in appendix D.

Sembcorp does not have the same potential subsidies available from the generation of renewable power from CHP as the prospective Middlesbrough power station, and hence the basis on which heat charges have been calculated is different. The Sembcorp site has a combined cycle power plant, and the extraction of heat at a suitable temperature for district heating distribution would reduce the efficiency of power generation on the steam cycle. The rate of loss of power generation with heat extraction is called the z-factor. The cost at which Sembcorp would be willing to sell heat has been calculated on an assumed z-factor and power import prices. E.g. the extraction of heat from Sembcorp's turbine means that additional power would have to be imported[26]. The heat price assumed to be acceptable to Sembcorp is 1.0p/kWh. On this basis the DH Scheme operator / ESCo would fund the heat network link to the Sembcorp site.

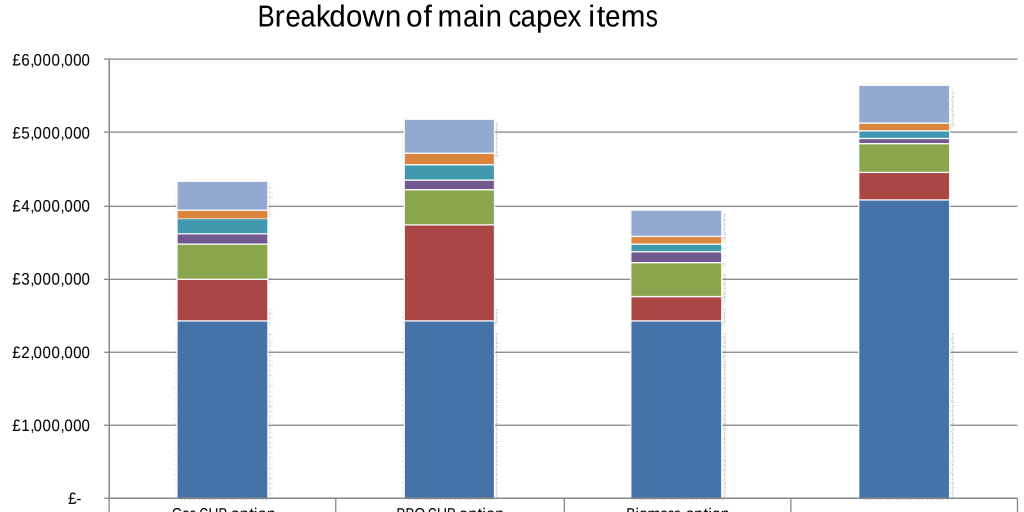
It has further been assumed that the DH scheme energy centre would still require full heat back-up boiler plant, in order to be able to guarantee security of supply to connected customers. Heat from Sembcorp has been assumed to be available to meet 90% of scheme demands. PB has assumed this level of availability because although Sembcorp has sufficiently resilient plant capacities to supply heat for 100% of the time, it is unlikely that they would be able to do so for a heat price of 1p/kWh, as supplying peak demands would potentially mean both the very high pressure drops in the heat transmission main, and also the use of higher-cost heat supply plant at the Sembcorp site. It is considered that contractually a scheme would be easier to implement if a single entity (e.g. the ESCo) can take responsible for service resilience (e.g. through ownership of its own standby heat supply plant).

[26] In this instance it has be assumed that no additional Levy Exemption Certificate revenue would be available to Sembcorp as a sufficiently large proportion of their total heat output is assumed to be usefully used to allow their total power output to qualify as Levy Exempt.

Table 4-25 Eston Core Scheme Energy Balance Results

		Primary Heat Source			
		Gas CHP	PPO CHP	Biomass	Heat from Sembcorp
Prime mover capacity	kWe (CHPs), kWth (biomass)	844	1,140	845	kWth
Thermal storage size	cubic metres	251	256	229	539
Gas boiler capacity	kWth	3,908	3,908	3,908	3,908
Prime Mover					
Electrical generation	MWh p.a.	4,660	5,758		
Heat generation	MWh p.a.	5,112	4,780	4,648	5,975
Fuel type		Gas	PPO	Biomass	Waste Heat
Fuel consumption	MWh p.a.	12,450	16,755	5,809	
Secondary / Top-up and Standby Heat Source					
Heat generation	MWh p.a.	1,527	1,859	1,992	664
Fuel type		Gas	Gas	Gas	Gas
Fuel consumption	MWh p.a.	1,840	2,240	2,400	800
Electricity Balance					
Parasitic Electricity Demand	MWh p.a.	163	230	232	60
Electricity generated and used on site	MWh p.a.	150	203		
Electricity Export	MWh p.a.	4,510	5,555		
Electricity Import	MWh p.a.	13	28	232	60
Emissions					
Carbon savings over BAU	tonnes CO_2 p.a.	1,109	3,890	800	1,022

Table 4-26 Eston Core Scheme Capex Breakdown

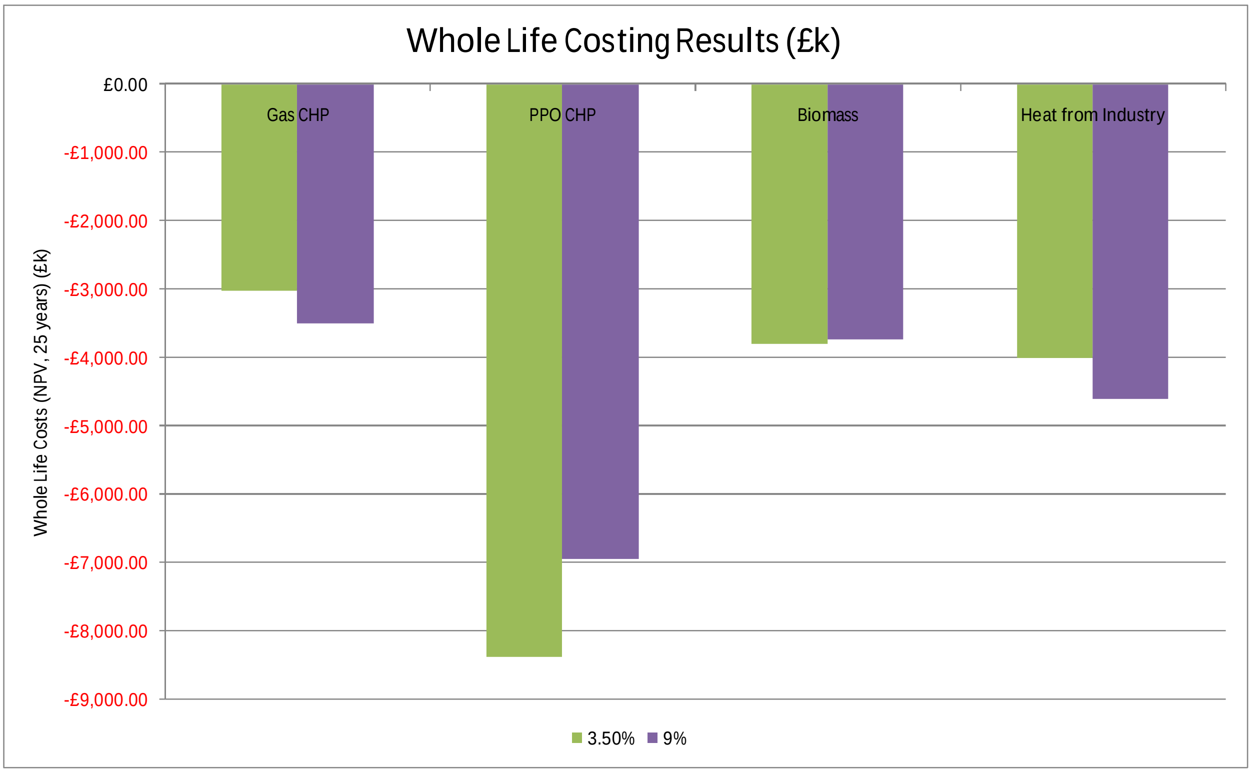


	Gas CHP option 844kWe gas CHP 250 m3 TS, and 3900kWth boilers	PPO CHP option 1140kWe CHP 260m3 TS, and 3900kWth boilers	Biomass option 845kWth boiler 230m3 TS, and 3900kWth boilers	Heat from Industry
Contingency	£396,078	£473,144	£360,374	£509,705
Soft costs	£112,403	£149,530	£99,849	£93,066
Utilities	£208,418	£199,427	£115,027	£115,027
Energy Centre Land and Building	£144,340	£144,340	£144,340	£72,170
Balance of Plant	£475,470	£475,470	£475,470	£383,056
Prime mover and thermal storage	£577,003	£1,319,529	£325,916	£377,398
DH Network Costs	£2,423,093	£2,423,093	£2,423,093	£4,088,489

Table 4-27 Operational Revenue Calculation – Eston Core Scheme

£k	Gas CHP	PPO CHP	Biomass	Heat from Sembcorp
Prime mover fuel costs	£239	£1,022	£145	£60
Top-up boilers fuel costs	£38	£55	£59	£22
Energy centre elec import	£1	£2	£19	£5
Plant maintenance (inc DH) / administration	£90	£111	£50	£49
Heat Sales	£240	£240	£240	£240
Electricity Sales	£220	£272	£0	£0
TRIAD benefit	£5	£7	£0	£0
ROC / RHI support[27]	£0	£533	£74	£0
TOTAL Expense	£369	£1,191	£273	£135
TOTAL Income	£466	£1,052	£315	£240
Operational Revenue	£97	-£139	£42	£105

Figure 4-22 Whole Life Cost Results (Eston Core Scheme)



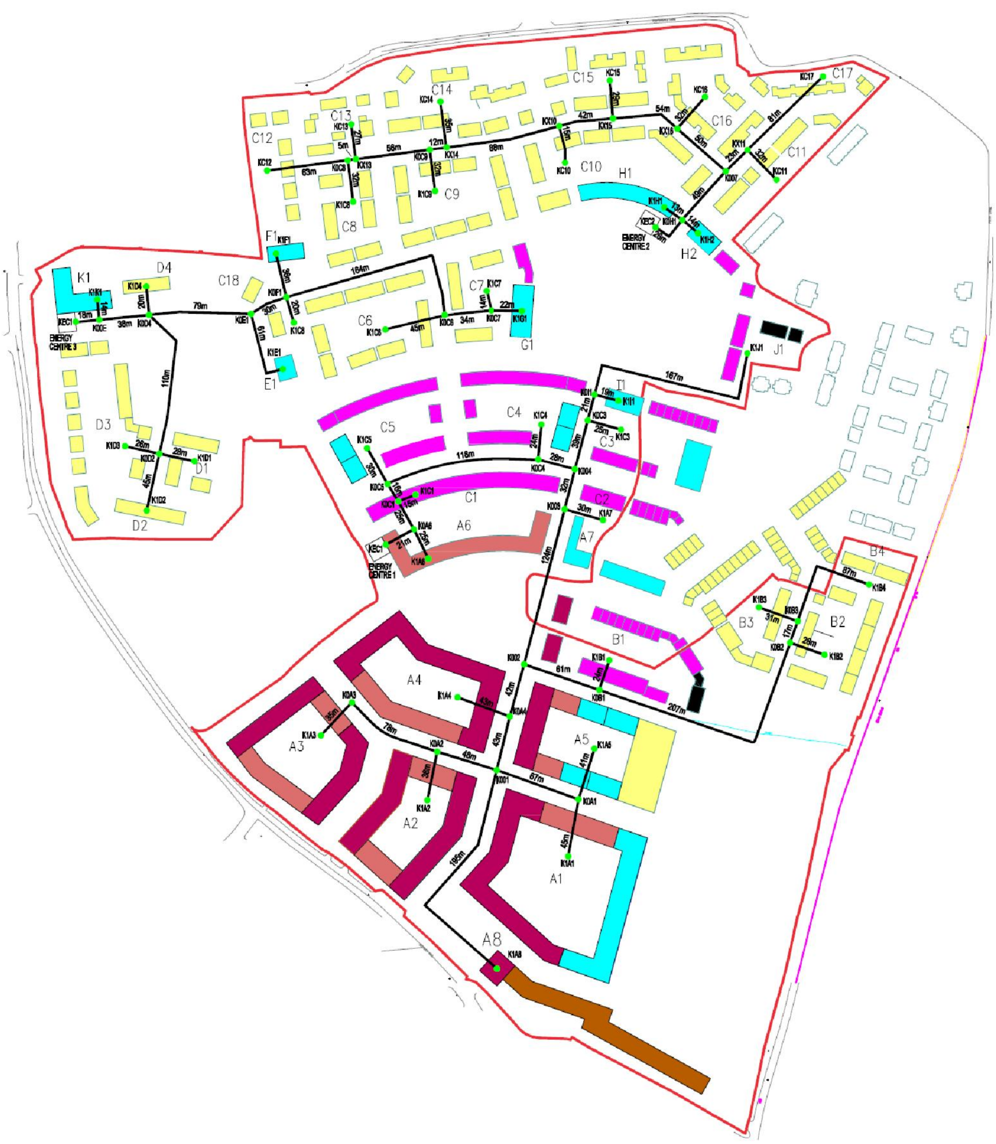
[27] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

This set of results indicates that a gas-fired CHP solution offers the most economic solution for the delivery of heat to customers on the core scheme. However, at both 3.5% and 9% discount rates the schemes deliver negative NPVs greater than £3m. As in this instance the customers connected to the network are all existing buildings, there is no opportunity for Developer Contributions to help fund the infrastructure costs of the scheme.

4.3.6.2 CORE NETWORK WITH FUTURE DEVELOPMENT

Only outline information is available in relation to the design / layout of the Eston residential development area, and hence a proxy from another urban scheme has been adopted to estimate network costs. This proxy scheme is illustrated below.

Figure 4-23 Network layout used as proxy for Eston residential development area



This masterplan stage drawing illustrates a comparable city-based development with a district heating network to serve the majority of the buildings of the development. In the absence of other information on Eston and the make-up of the residential development, this model has been used as a proxy to estimate the length of the network required to serve the Greater Eston residential development area. The total land area inside the redline above is 312,000m2 (31 hectares), and 2,200 dwellings are envisaged for this space. E.g. a dwelling density of approximately 70 dwellings per hectare.

By way of comparison, the area assumed for Greater Eston residential development (from information received) is measured from an approximate illustration of the zone for development to be 350,000m2 (35 hectares), and 1,200 dwellings are understood to be planned for this site.

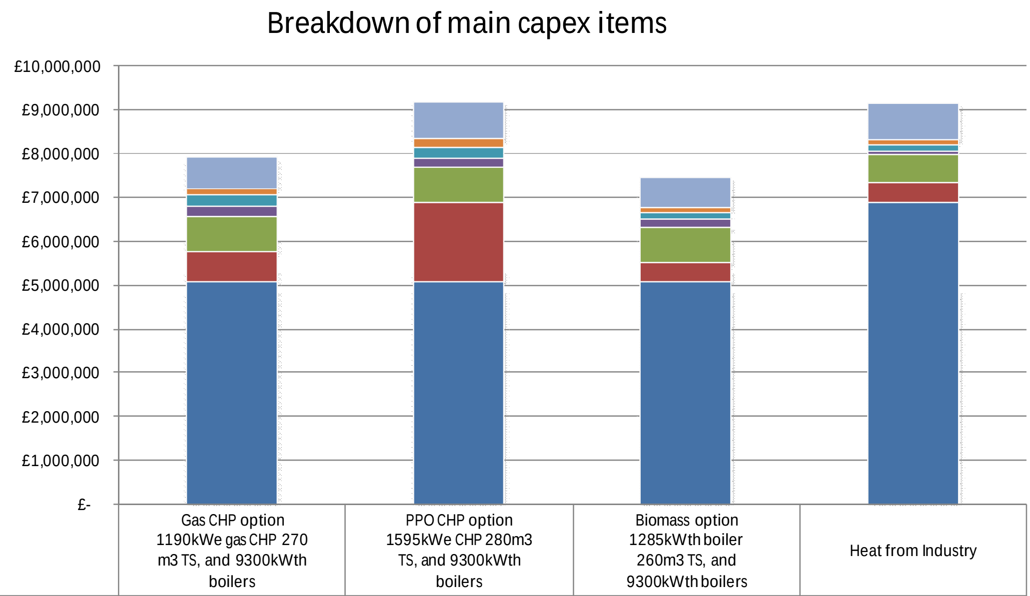
Hence whilst the masterplan drawing above has a higher density of dwellings per hectare, the masterplan drawing scheme is generally higher-rise development. Hence in terms of overall district heating network requirement, it is proposed here that the network length would be similar between the two sites. Through interpolation between the two areas, the length of district heating network calculated for the Greater Eston site is 3,500m, where this takes the supply of heat into the main blocks of dwellings. It has been assumed that 25% of the Greater Eston dwellings (by number (assumed to be equivalent to 30% of the total domestic heat demand) are detached semis or terraces, and the remainder apartments / flats within blocks. For this site it has been assumed that only the apartments / flats would be connected to the DH system, and that the larger dwellings would have individual low carbon supply systems to meet upcoming regulatory targets.

In terms of network design assumptions, it has been assumed that a length of 1,900m would be main spine, and the remainder (e.g. 1,600m) connections to individual blocks of dwellings.

Table 4-28 Eston Extended Scheme Energy Balance Results

		Primary Heat Source			
		Gas CHP	PPO CHP	Biomass	Heat from Sembcorp
Prime mover capacity	kWe (CHPs), kWth (biomass)	1,190	1,595	1,285	
Thermal storage size	cubic metres	265	282	263	620
Gas boiler capacity	kWth	9,324	9,324	9,324	9,324
Primary Heat Source					
Electrical generation	MWh p.a.	6,861	8,053		
Heat generation	MWh p.a.	7,472	6,968	7,069	9,088
Fuel type		Gas	PPO	Biomass	Waste Heat
Fuel consumption	MWh p.a.	18,190	22,383	8,836	
Secondary / Top-up and Standby Heat Source					
Heat generation	MWh p.a.	2,625	3,130	3,029	1,010
Fuel type		Gas	Gas	Gas	Gas
Fuel consumption	MWh p.a.	3,163	3,771	3,650	1,217
Electricity Balance					
Parasitic Electricity Demand	MWh p.a.	240	322	353	91
Electricity generated and used on site	MWh p.a.	221	283		
Electricity Export	MWh p.a.	6,640	7,769		
Electricity Import	MWh p.a.	19	39	353	91
Emissions					
Carbon savings over BAU	tonnes CO_2 p.a.	1,561	5,428	1,130	1,468

Table 4-29 Eston Extended Scheme Capex Breakdown



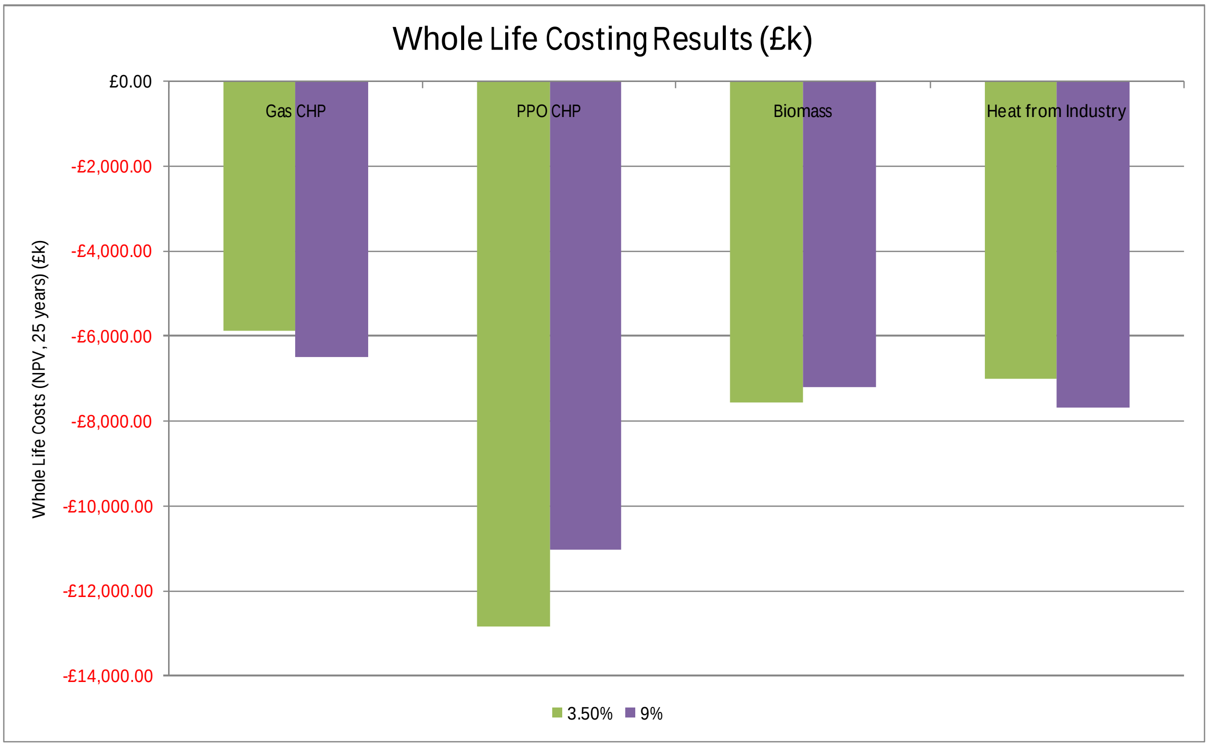
	Gas CHP option 1190kWe gas CHP 270 m3 TS, and 9300kWth boilers	PPO CHP option 1595kWe CHP 280m3 TS, and 9300kWth boilers	Biomass option 1285kWth boiler 260m3 TS, and 9300kWth boilers	Heat from Industry
Contingency	£722,777	£837,828	£681,313	£829,839
Soft costs	£136,958	£192,028	£123,164	£109,930
Utilities	£261,682	£255,725	£136,725	£136,725
Energy Centre Land and Building	£218,267	£218,267	£218,267	£109,134
Balance of Plant	£793,656	£793,656	£793,656	£636,318
Prime mover and thermal storage	£690,759	£1,792,156	£414,872	£433,736
DH Network Costs	£5,090,968	£5,090,968	£5,090,968	£6,898,533

Table 4-30 Operational Revenue Calculation – Eston Extended Scheme

£k	Gas CHP	PPO CHP	Biomass	Heat from Sembcorp
Prime mover fuel costs	£335	£1,365	£221	£91
Top-up boilers fuel costs	£63	£89	£86	£32
Energy centre elec import	£2	£3	£29	£8
Plant maintenance (inc DH) / administration	£299	£339	£249	£246
Heat Sales	£547	£547	£547	£547
Electricity Sales	£325	£380	£0	£0
TRIAD benefit	£7	£9	£0	£0
ROC / RHI support[28]	£0	£746	£113	£0
TOTAL Expense	£699	£1,797	£586	£376
TOTAL Income	£878	£1,682	£660	£547
Operational Revenue	£179	-£115	£74	£171

[28] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

Figure 4-24 Whole Life Cost Results (Eston Extended Scheme)



As for the core scheme, a gas-fired CHP solution offers the most economic solution, however, at both 3.5% and 9% discount rates the schemes deliver negative NPVs greater than £5.8m.

The gas-fired CHP solution is calculated to deliver an average level of 45% regulated emissions savings to dwellings, and hence in the new-build predominantly residential development, a realistic level of Developer contribution towards the scheme would approach CsH Level 4 energy criteria compliance costs. Across the 1,200 dwellings assumed for the area, a maximum level of contribution that could be anticipated is £5.7m (1,200 dwellings @ £4.75k per dwelling). However, even at this level of developer contribution, a funding gap would still remain at both 3.5% and 9% discount rates, and hence this scheme's performance is only at best marginal unless additional grant funding could be secured.

Depending on the density and masterplan design of the residential area, this area could offer a case for exploiting the potential of the avoided costs seen in new development to form an initial core network within the new housing development, and then expanding this core scheme organically back towards existing buildings.

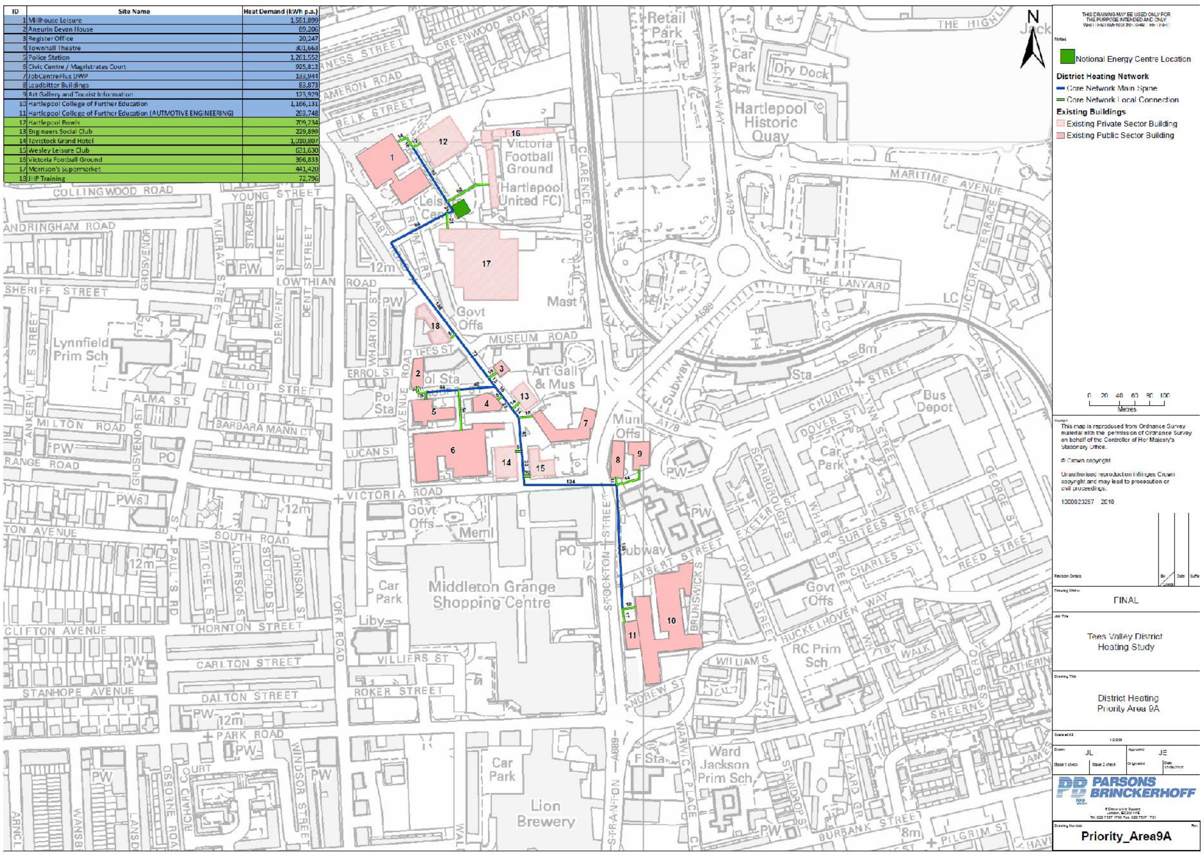
4.3.7 PRIORITY AREA 9 - HARTLEPOOL NORTH –

4.3.7.1 TOWN CENTRE

The spatial distribution of the Hartlepool Town Centre Scheme is fairly linear, as a result of the location of the two largest loads, the College of Further Education and the Millhouse Leisure centre at the two ends of the network. Connection to the Millhouse pools is desirable as this form an excellent base load for the scheme, and the College of Further Education is a significant load that is also close to the Lion Brewery and Middleton Grange Shopping Centre, which may represent loads for expansion at a future date.

Two sets of results are presented here. The first includes only the public sector loads on the scheme, as per the other schemes examined in this report.

Figure 4-25 Hartlepool Town Centre Illustration (showing both public and private sector loads) (low res)



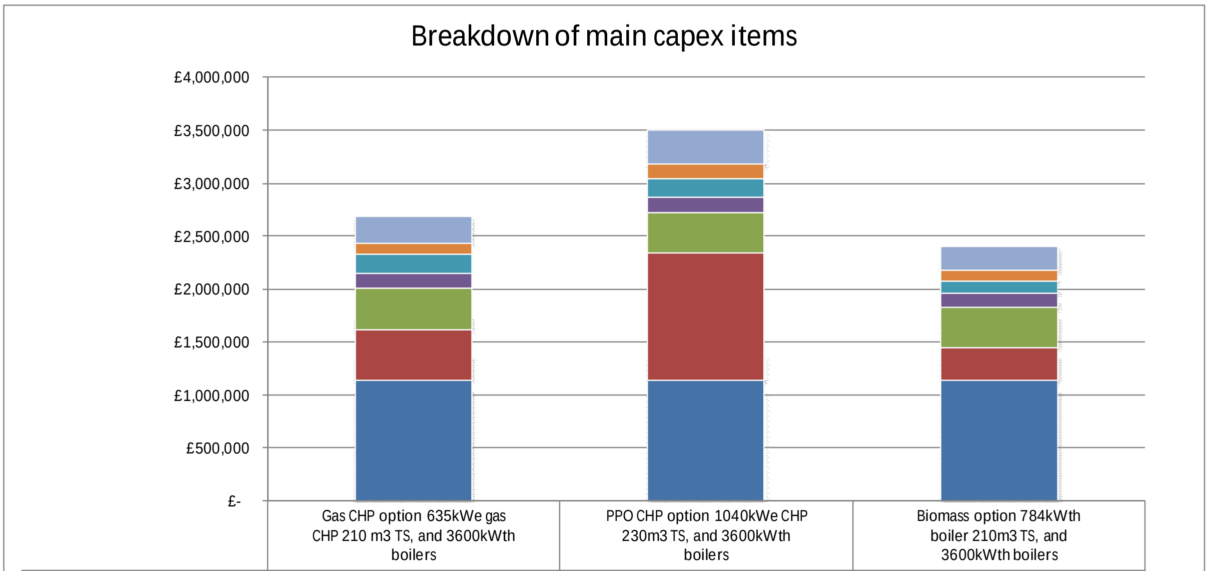
The energy centre location illustrated above has been adopted in modelling of scenarios. However, it may be that more suitable locations can be found elsewhere on, or adjacent to the scheme as conceived here. Due to the linear nature of the scheme, assuming an Energy Centre location can be found somewhere along, or close to the network route, its exact position will have only a marginal impact on overall scheme performance.

For the Town Centre Scheme, the following energy balance, capex breakdown and financial performance (operational revenue and whole life costs) have been modelled based on the public sector loads alone:

Table 4-31 Hartlepool town centre Scheme – Town Centre Energy Balance Results

		Primary Heat Source		
		Gas CHP	**PPO CHP**	**Biomass**
Prime mover capacity	kWe (CHPs), kWth	635	1,040	784
Thermal storage size	cubic metres	207	231	212
Gas boiler capacity	kWth	3,620	3,620	3,620
Prime Mover				
Electrical generation	MWh p.a.	3,830	5,254	-
Heat generation	MWh p.a.	4,620	4,312	4,312
Fuel type		Gas	PPO	Biomass
Fuel consumption	MWh p.a.	10,748	15,454	5,390
Secondary / Top-up and Standby Heat				
Heat generation	MWh p.a.	1,540	1,848	1,848
Fuel type		Gas	Gas	Gas
Fuel consumption	MWh p.a.	1,855	2,227	2,227
Electricity Balance				
Parasitic Electricity Demand	MWh p.a.	134	210	216
Electricity generated and used	MWh p.a.	123	185	-
Electricity Export	MWh p.a.	3,707	5,069	-
Electricity Import	MWh p.a.	11	25	216
Emissions		-	-	-
Carbon savings over BAU	tonnes CO_2 p.a.	962	3,592	798

Table 4-32 Hartlepool town centre Scheme Capex Breakdown



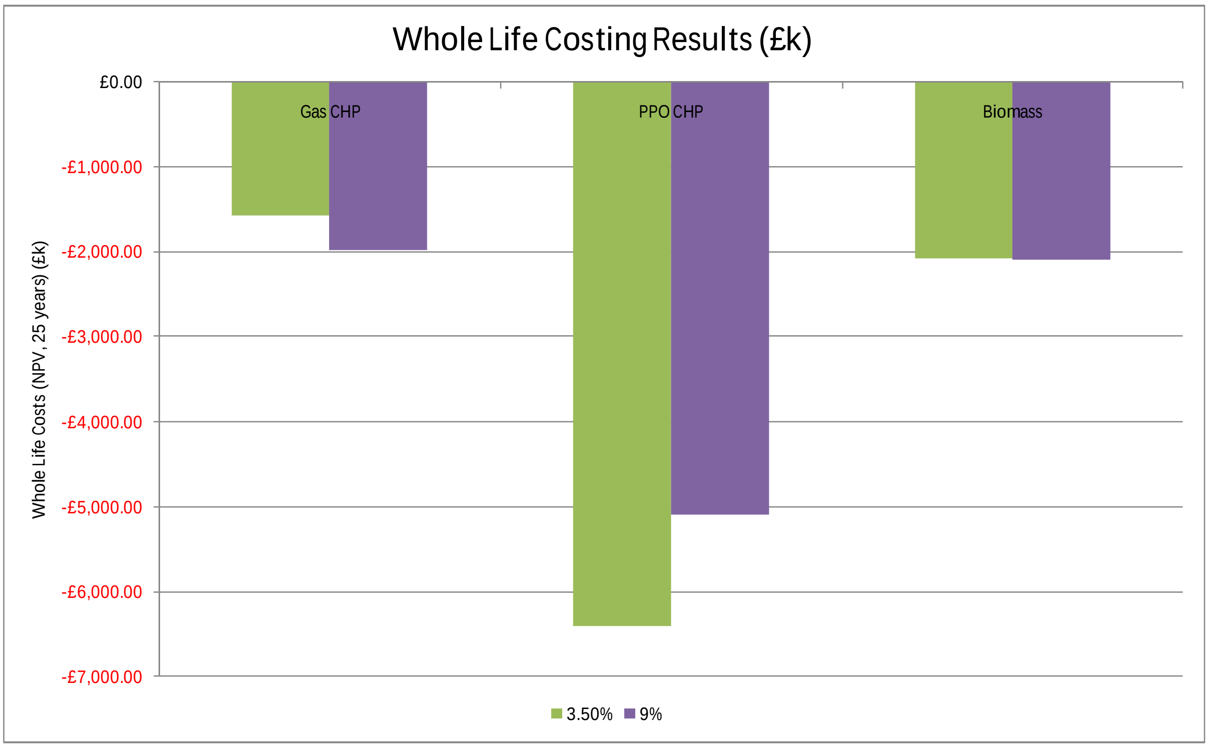
	Gas CHP option 635kWe gas CHP 210 m3 TS, and 3600kWth boilers	PPO CHP option 1040kWe CHP 230m3 TS, and 3600kWth boilers	Biomass option 784kWth boiler 210m3 TS, and 3600kWth boilers
Contingency	£245,191	£319,840	£219,263
Soft costs	£102,838	£138,746	£93,876
Utilities	£184,458	£176,866	£113,366
Energy Centre Land and Building	£140,416	£140,416	£140,416
Balance of Plant	£383,077	£383,077	£383,077
Prime mover and thermal storage	£484,077	£1,202,249	£304,848
DH Network Costs	£1,140,673	£1,140,673	£1,140,673

Table 4-33 Operational Revenue Calculation – Hartlepool town centre Scheme

£k	**Gas CHP**	**PPO CHP**	**Biomass**
Prime mover fuel costs	£209	£943	£135
Top-up boilers fuel costs	£39	£55	£55
Energy centre elec import	£1	£2	£18
Plant maintenance (inc DH) / administration	£79	£92	£38
Heat Sales	£224	£224	£224
Electricity Sales	£181	£248	£0
TRIAD benefit	£4	£6	£0
ROC / RHI support[29]	£0	£487	£69
TOTAL Expense	£327	£1,092	£245
TOTAL Income	£409	£965	£293
Operational Revenue	**£81**	**-£127**	**£48**

[29] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

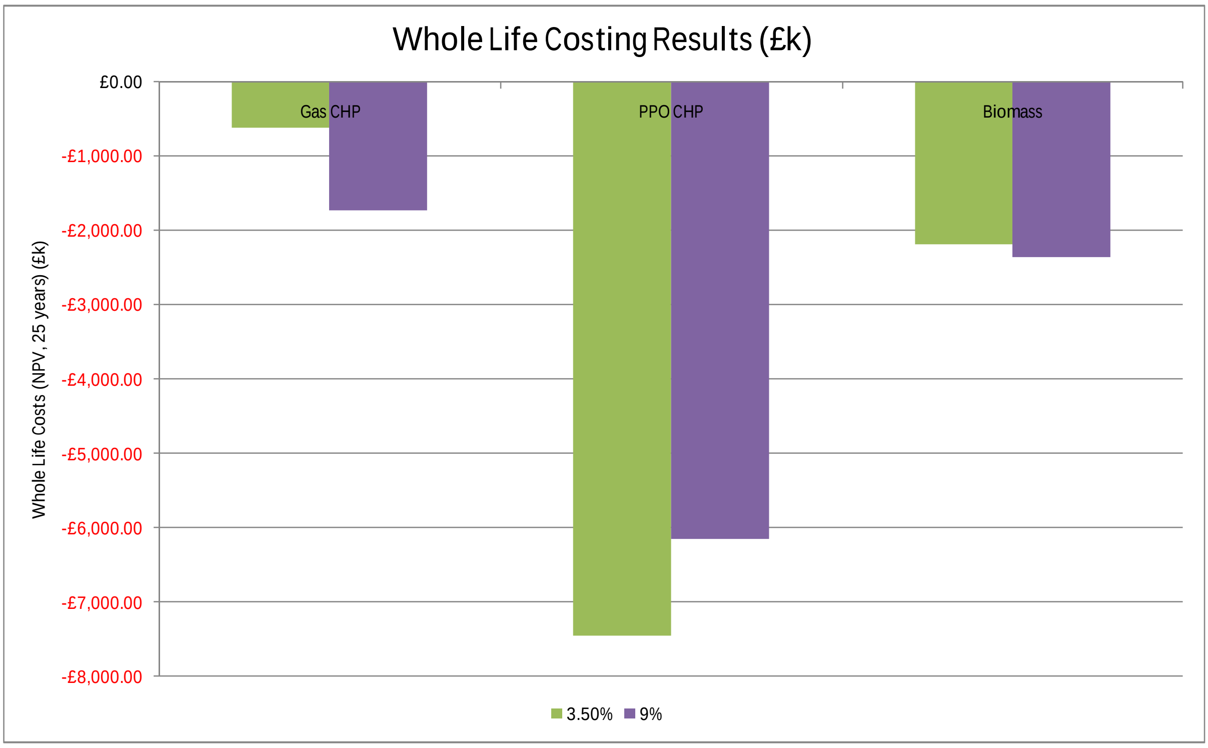
Figure 4-26 Whole Life Cost Results (Hartlepool town centre Scheme public sector only)



At neither 9% nor 3.5% real discount rate does the Hartlepool Town Centre scheme appear to offer a positive net present value. Therefore, it would appear that this scheme would require grant funding to a level of approximately £1.6m in order to deliver a viable scheme (when considered at a 3.5% real discount rate).

PB has also analysed the viability of this scheme assuming that all of the private sector loads shown on the scheme map were also included within the customer base. The NPV results of this analysis are as follows:

Figure 4-27 Whole Life Cost Town Centre Scheme including Private Sector Connections

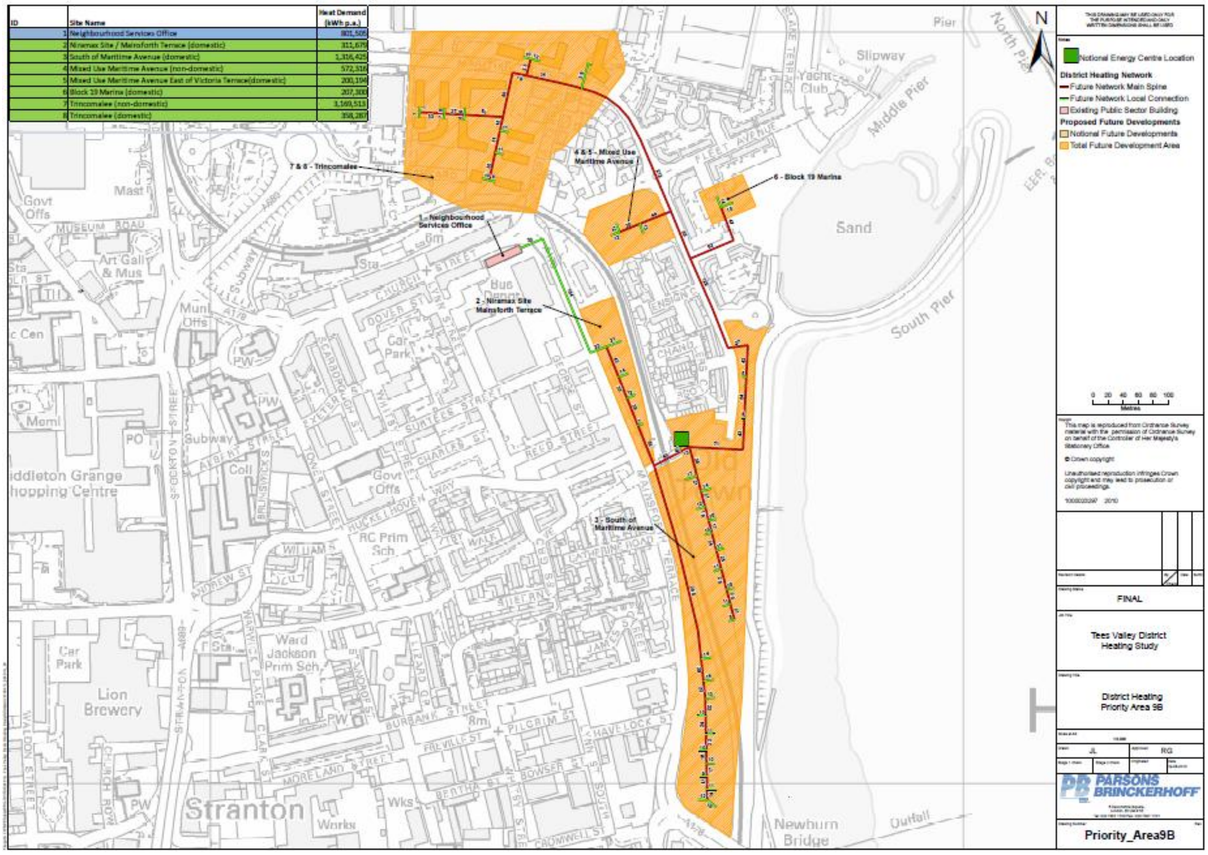


This illustrates that even with the connection of private sector loads along the route of the network, the whole life cost analysis does not show a positive NPV over 25 years. The level of grant support required to deliver a viable project when calculated at a 3.5% real discount rate is reduced to £600k with the addition of these loads.

4.3.7.2 Hartlepool North – Seafront

The key loads of the Hartlepool Seafront scheme are the new development areas as outlined in planning applications HFUL/2001/0638 (South of Maritime Avenue) and H/2007/0918 (Trincomalee Wharf). The details of these developments are not yet fixed, and the results of the following analysis must be viewed with this in mind. PB has contacted Hartlepool Council in order to obtain recent information regarding these development areas, and an indicative map of the scheme is shown below (and a higher quality version in the appendices).

Figure 4-28 Hartlepool Seafront Scheme (low res)



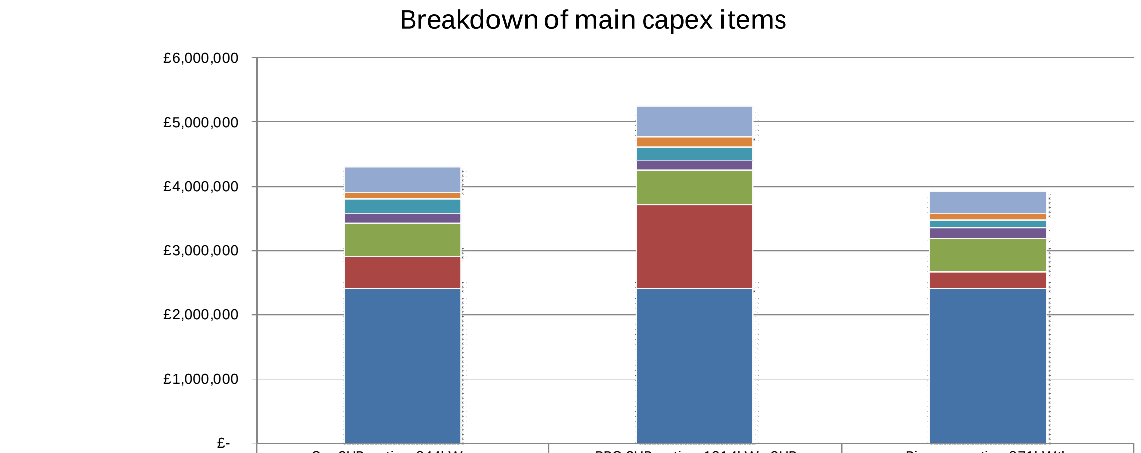
The two planning applications noted above overlap geographically, and for this area of overlap, only the more recent application's quantum of development has been adopted.

Within the development areas PB has assumed an Energy Centre Location that is reasonably central to the development areas. However, this location would have to be confirmed at a later stage of scheme testing should this project progress.

Table 4-34 Hartlepool Scheme B – Seafront Scheme Energy Balance Results

		Primary Heat Source		
		Gas CHP	**PPO CHP**	**Biomass**
Prime mover capacity	kWe (CHPs), kWth	844	1,214	871
Thermal storage size	cubic metres	134	147	126
Gas boiler capacity	kWth	5,372	5,372	5,372
Prime Mover				
Electrical generation	MWh p.a.	4,990	6,133	-
Heat generation	MWh p.a.	5,474	5,132	4,790
Fuel type		Gas	PPO	Biomass
Fuel consumption	MWh p.a.	13,331	17,690	5,988
Secondary / Top-up and Standby Heat				
Heat generation	MWh p.a.	1,369	1,711	2,053
Fuel type		Gas	Gas	Gas
Fuel consumption	MWh p.a.	1,649	2,061	2,473
Electricity Balance				
Parasitic Electricity Demand	MWh p.a.	175	245	240
Electricity generated and used on site	MWh p.a.	161	216	-
Electricity Export	MWh p.a.	4,829	5,917	-
Electricity Import	MWh p.a.	14	29	240
Emissions				
Carbon savings over BAU	tonnes CO_2 p.a.	1,194	4,161	830

Table 4-35 Hartlepool Seafront Scheme Capex Breakdown



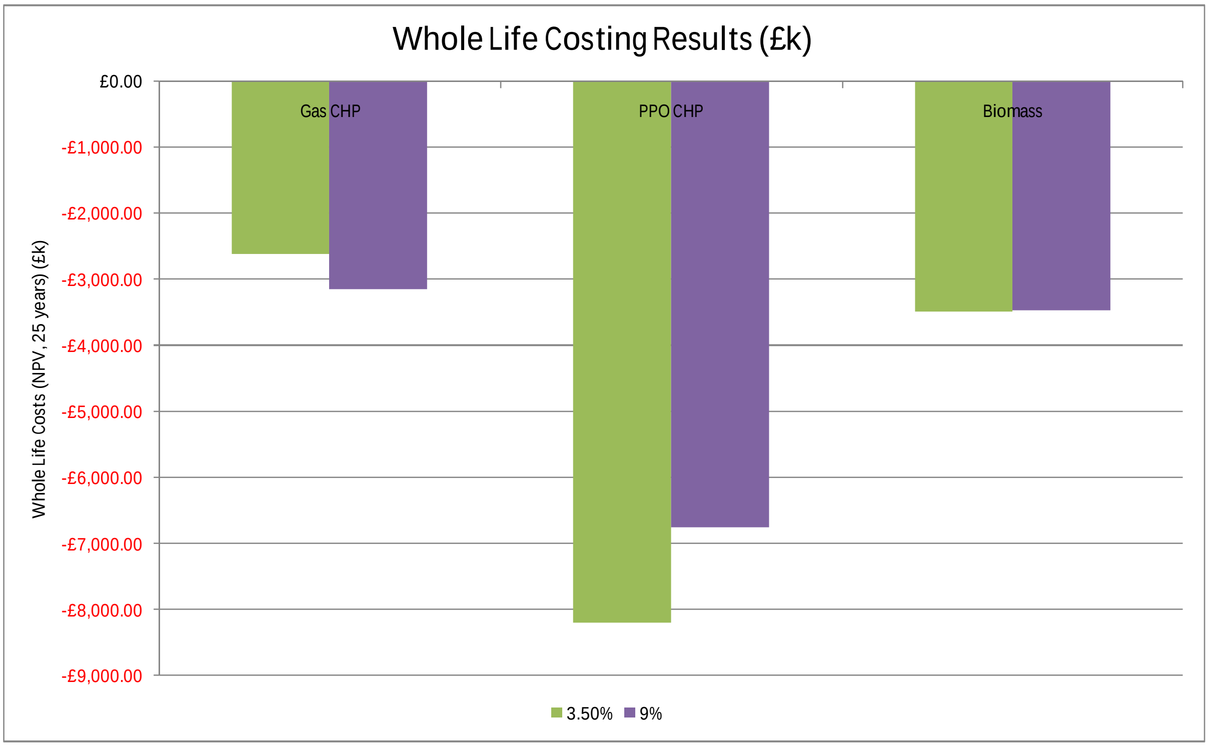
	Gas CHP option 844kWe gas CHP 130 m3 TS, and 5400kWth boilers	PPO CHP option 1214kWe CHP 150m3 TS, and 5400kWth boilers	Biomass option 871kWth boiler 130m3 TS, and 5400kWth boilers
Contingency	£393,702	£479,273	£359,606
Soft costs	£111,315	£152,415	£99,449
Utilities	£214,282	£206,893	£122,493
Energy Centre Land and Building	£164,335	£164,335	£164,335
Balance of Plant	£521,072	£521,072	£521,072
Prime mover and thermal storage	£495,032	£1,317,030	£257,723
DH Network Costs	£2,408,163	£2,408,163	£2,408,163

Table 4-36 Operational Revenue Calculation – Hartlepool Seafront Scheme

£k	**Gas CHP**	**PPO CHP**	**Biomass**
Prime mover fuel costs	£255	£1,079	£150
Top-up boilers fuel costs	£34	£51	£61
Energy centre elec import	£1	£2	£20
Plant maintenance (inc DH) / administration	£227	£249	£184
Heat Sales	£419	£419	£419
Electricity Sales	£236	£289	£0
TRIAD benefit	£5	£7	£0
ROC / RHI support[30]	£0	£568	£77
TOTAL Expense	£517	£1,382	£414
TOTAL Income	£660	£1,283	£495
Operational Revenue	**£142**	**-£99**	**£81**

[30] Only applicable for first 15 years of installation lifecycle in the case of RHIs.

Figure 4-29 Whole Life Cost Results (Hartlepool seafront Scheme)



At neither 9% nor 3.5% real discount rate does the Hartlepool Town Centre scheme appear to offer a positive net present value without taking potential developer contributions into account. This scheme consists almost entirely of new build construction, and hence it might appear that there is potentially an opportunity to demonstrate to the developer that compliance could be achieved in a more cost effective manner via district heating than via other means.. However, PB understands that the developer (Jomast Developments Limited) secured planning consent for these sites in approx 2001 (South of Maritime Avenue) and 2007/2008 (Trincomalee Wharf), and hence that there are likely to be comparatively 'light' targets in place in terms of achieving carbon emissions reductions at these sites. On this basis there is though to be limited scope for the demonstration of cost savings against the alternative means of achieving the energy efficiency standards required in these applications.

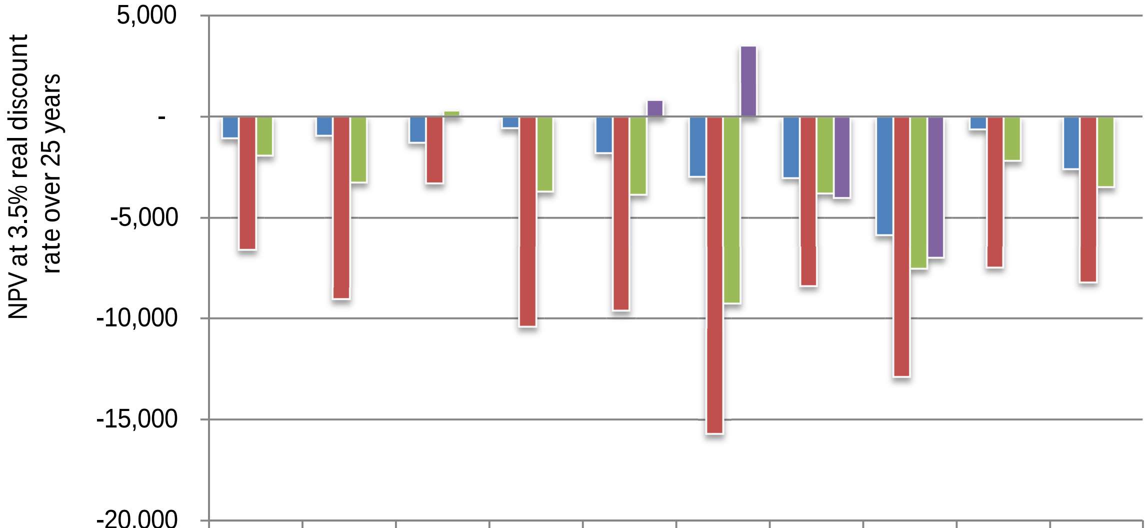
PB would therefore not consider there to be great opportunity for realising developer contributions to the benefit of the DH scheme's financial viability, and would not consider this scheme to be viable without significant grant support.

4.3.8 COMPARISON OF SCHEMES

The following graphs illustrate the comparative performance of the options across the Tees Valley.

This graph below illustrates the performance of each technology for each scheme at 3.5% real discount rate.

Table 4-37 NPV Results for all schemes, excluding developer contributions



	D'ton core	D'ton extend	S'ton core	S'ton extend	M'bro core	M'bro extend	Eston core	Eston extend	H'pool existing	H'pool future
Gas CHP	-1,068	-929	-1,282	-577	-1,809	-2,972	-3,024	-5,868	-621	-2,606
Bio-fuel CHP	-6,585	-9,028	-3,287	-10,38	-9,595	-15,67	-8,373	-12,85	-7,458	-8,184
Biomass boiler	-1,930	-3,253	279	-3,701	-3,870	-9,246	-3,789	-7,544	-2,188	-3,491
Waste heat					842	3,520	-4,001	-7,006		

This chart summarises the economic performance of the various schemes analysed in this study, and illustrates the following key points.

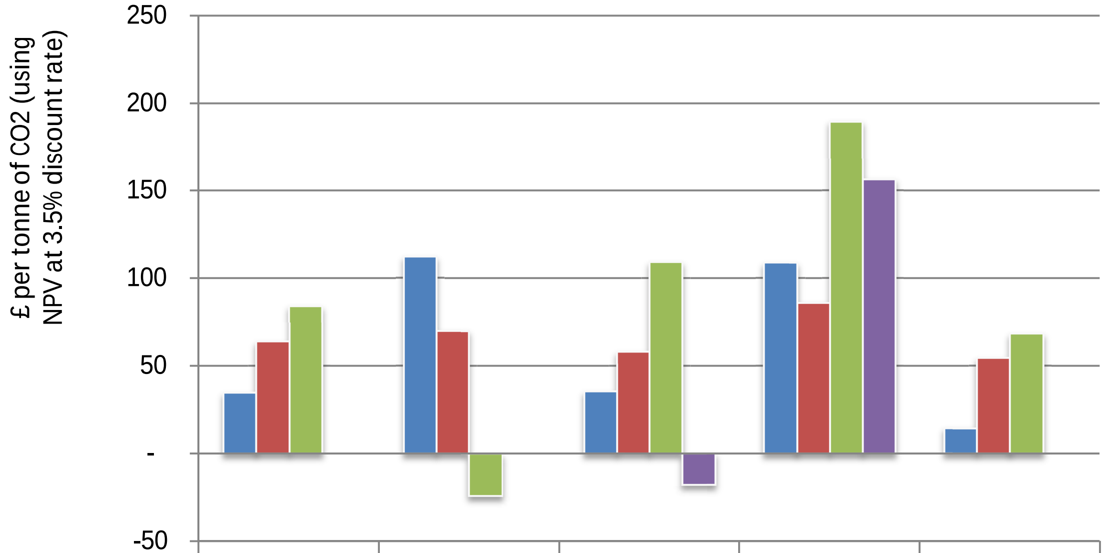
- Gas engine CHP to supply the Darlington Extended scheme is calculated to be on the cusp of viability.
- A biomass boiler to supply the Stockton Core scheme is considered viable assuming the availability of the Renewable Heat Incentive subsidy. The gas engine option represents the least cost option for the extended scheme

- The supply of waste heat from the proposed power station for the Middlesbrough schemes offers the greatest viability both in the Core Scheme and the extended scheme. This is dependent upon the availability of both heat at zero cost from the power station developer and them funding the connection to their facility across the Tees. Gas engine CHP represents the next best option for both the core and extended schemes, neither of which are considered viable without developer contribution.

- The Eston scheme is not considered viable without significant grant support, neither on a basis of a stand-alone energy centre, nor via a heat mains link to Sembcorp.

- The Hartlepool Town Centre Scheme offers the better financial performance of the two schemes analysed within Hartlepool.

- *Figure 4-30 Comparative Cost of Carbon Reduction*



	D'ton core	S'ton core	M'bro core	Eston core	H'pool existing
Gas CHP	35	112	35	109	15
Bio-fuel CHP	64	70	58	86	54
Biomass boiler	84	-24	109	190	69
Waste heat			-18	157	

This graph illustrates that the cost of carbon reduction is comparatively low for the Darlington, Middlesbrough and Hartlepool core scheme at between £35 and £15 per tonne. When compared with the anticipated floor price for carbon of £12 per tonne this scheme would only need a modest shift in scheme economics or carbon price to represent an economic means of CO_2 reduction.

The figures presented in this graph have been calculated by taking the net present value of the scheme performance over the NPV evaluation period (e.g. 25 years), and dividing this present value figure by the cumulative tonnes of carbon saved by the scheme over the same period.

The negative figures here represent those schemes where the reduction of carbon emissions is profitable (e.g. has a positive NPV over 25 years).

4.3.9 POTENTIAL FOR USING DEVELOPER CONTRIBUTION TO FACILITATE DEVELOPMENT

The extended schemes examined in this study supply new developments in addition to the existing buildings supplied by the core schemes. The construction of a DH network that serves new development with low carbon heat, will allow Developers to avoid costs that they would otherwise bear to comply with carbon-performance targets contained in Building Regulations or the Code for Sustainable Homes (CSH)[31]. Therefore, it can be expected that if low-cost and low carbon heat is available in the vicinity of the development site developers and house builders will have an incentive to connect to a DH network and contribute to the cost of the installation of that infrastructure up to the same level of cost that they would otherwise have seen[32]. The presence of a DH network will facilitate regeneration where the cost to the developer is considerably less than the alternative cost of compliance with mandatory CO_2 reduction targets. The analysis herein assumes the entire development would be constructed to CSH level 4 OR CSH level 6. No phasing of development has been taken into account in this study.

The Hartlepool extended scheme has not been included because the planning application for these developments was lodged prior to 2006.

4.3.9.1 CODE FOR SUSTAINABLE HOMES LEVEL 4

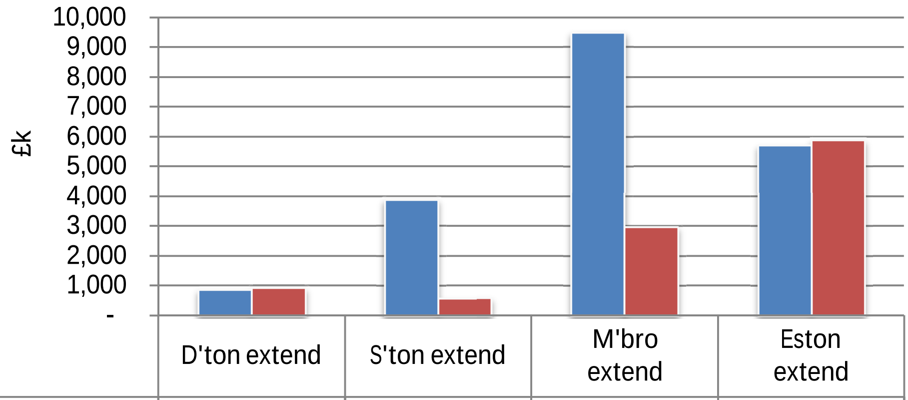
A CO_2 reduction of around 45% can be achieved through the use of gas engine CHP, this can be equated to compliance with CSH level 4. Published data indicates that compliance with CSH level 4 will cost developers at least £4,750 per unit. Figure 7 indicates the sum of the developer contribution Stockton and Middlesbrough are both able to deliver CSH level 4 development at a lower cost than

[31] http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf

[32] The developer contribution used for non-residential development reflects the cost of complying with 2010 building regulations, because the costs associated with achieving higher CO_2 reduction targets are less well defined than for residential buildings.

the alternative. The cost of implementing DH in Darlington and Eston is marginally higher than the alternatives.

Figure 4-31: Potential developer contribution for CSH level 4 vs. NPV at 3.5% discount rate for extended schemes using gas engine CHP



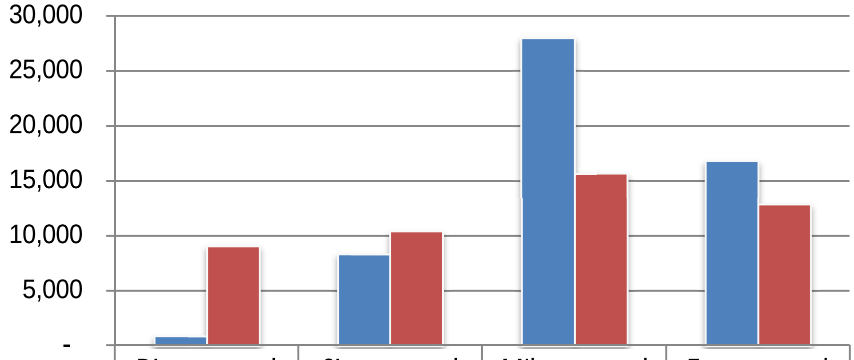
	D'ton extend	S'ton extend	M'bro extend	Eston extend
Potential CSH level 4 developer contribution	860	3,880	9,500	5,700
Contribution needed (to achieve zero NPV @ 3.5% discount rate)	929	577	2,972	5,868

4.3.9.2 CODE FOR SUSTAINABLE HOMES LEVEL 6:

It is necessary to use bio-fuel CHP to achieve the significant CO_2 reduction that is required to achieve CSH level 6. The use of bio-fuel CHP is in itself a high risk strategy owing to the emerging nature of this technology in the UK. In addition the techno-economic model demonstrates that this technology is not economically viable without an annual subsidy to cover the cost of the bio-fuel. Published data indicates that compliance with CSH level 6 will cost developers at least £14,000 per unit. Figure 8 demonstrates how the developer contribution could be used to subsidise the operation of this technology, therefore facilitating the delivery of homes compliant with CSH level 6.

The annual subsidy required to make the bio-fuel CHP options financially viable could be levied from developers as an annual contribution rather than a one-off payment. The mechanism by which this fund is administered has not been resolved in this study and should be explored by the local authority directors of finance.

Figure 4-32: Potential developer contribution for CSH level 6 vs. NPV at 3.5% discount rate for extended schemes using bio-fuel CHP



	D'ton extend	S'ton extend	M'bro extend	Eston extend
Potential CSH level 6 developer contribution	860	8,320	28,000	16,800
Contribution needed (to achieve zero NPV @ 3.5% discount rate)	9,028	10,387	15,672	12,853

The Middlesbrough and Eston schemes are dominated by residential development; as such they can potentially level a significant developer contribution, which in both cases has the potential to allow compliance with CSH level 6 at a lower cost than alternative solutions.

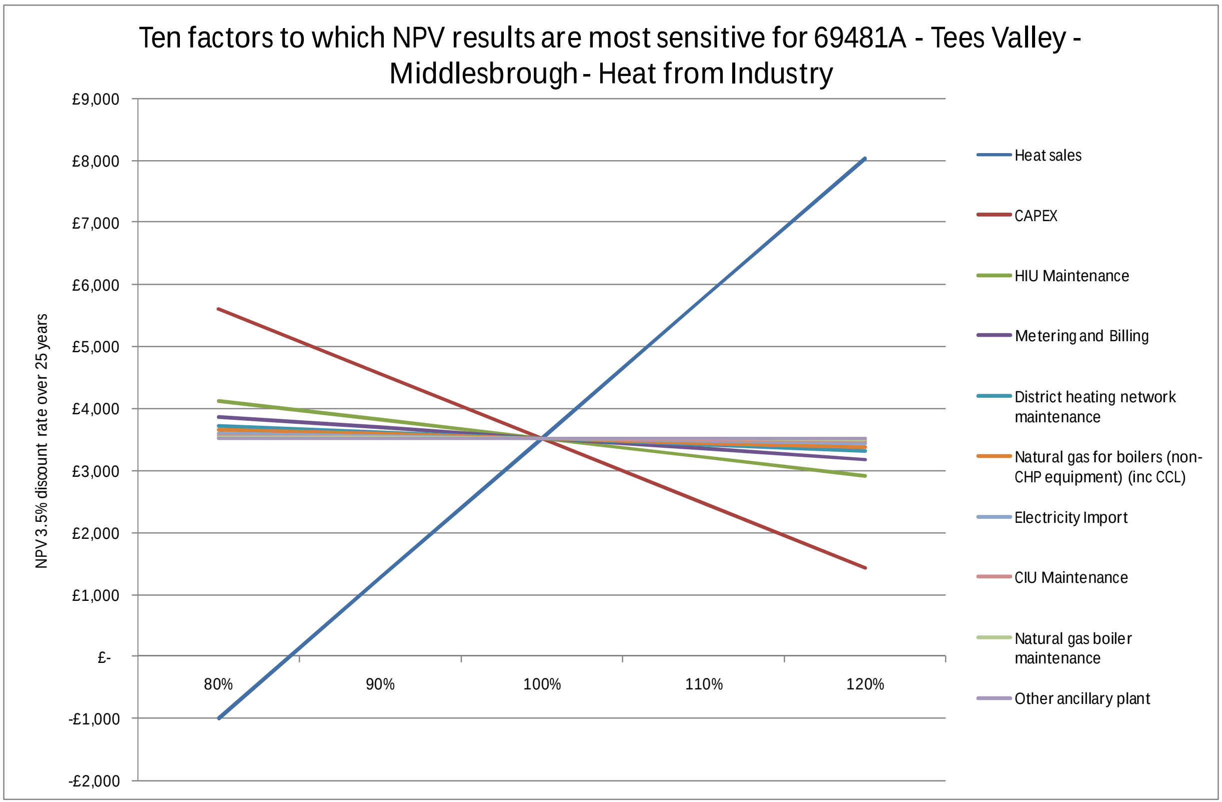
4.4 SENSITIVITY ANALYSIS FOR SCHEMES

At this stage in the development of schemes, it is clear that there are a large number assumptions that underpin the evaluations in this report. We have presented these assumptions clearly at each stage but understand that it is important to investigate the impact that variations in key input assumptions may have on scheme viability.

We have therefore undertaken a sensitivity analysis against variations in key factors. The results of this sensitivity analysis show near identical trends across all of the schemes for a specific technology option. We therefore present below one graph representative of the sensitivities for each technology. The graphs below represent the variation in NPV of the selected schemes (before Developer Contributions), at 3.5% discount factor, over 25 years.

4.4.1 HEAT FROM INDUSTRY

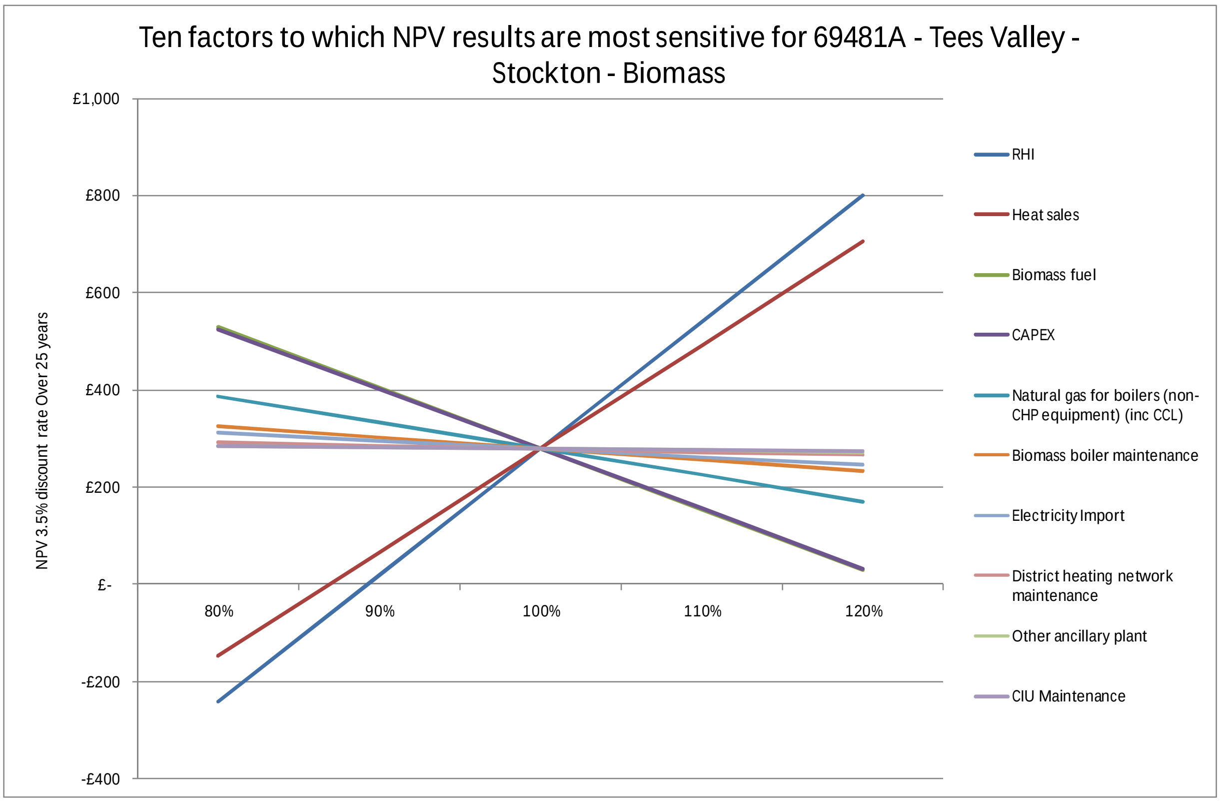
Figure 4-33 Middlesbrough Heat from Industry Sensitivity Analysis



This chart illustrates two clear factors in the Middlesbrough Extended scheme to which the scheme is very sensitive – heat sales value(i.e a reduction in volume or price), and the capital cost of the scheme. A third factor that is not shown on this chart but to which the scheme will be equally sensitive is the heat purchase price from the power station developer[33]. An increase in this price from the assumption of zero would effectively reduce the net price obtained for heat and so the impact is the same as show for heat sales value.

4.4.2 BIOMASS

Figure 4-34 Stockton Core Scheme Sensitivities



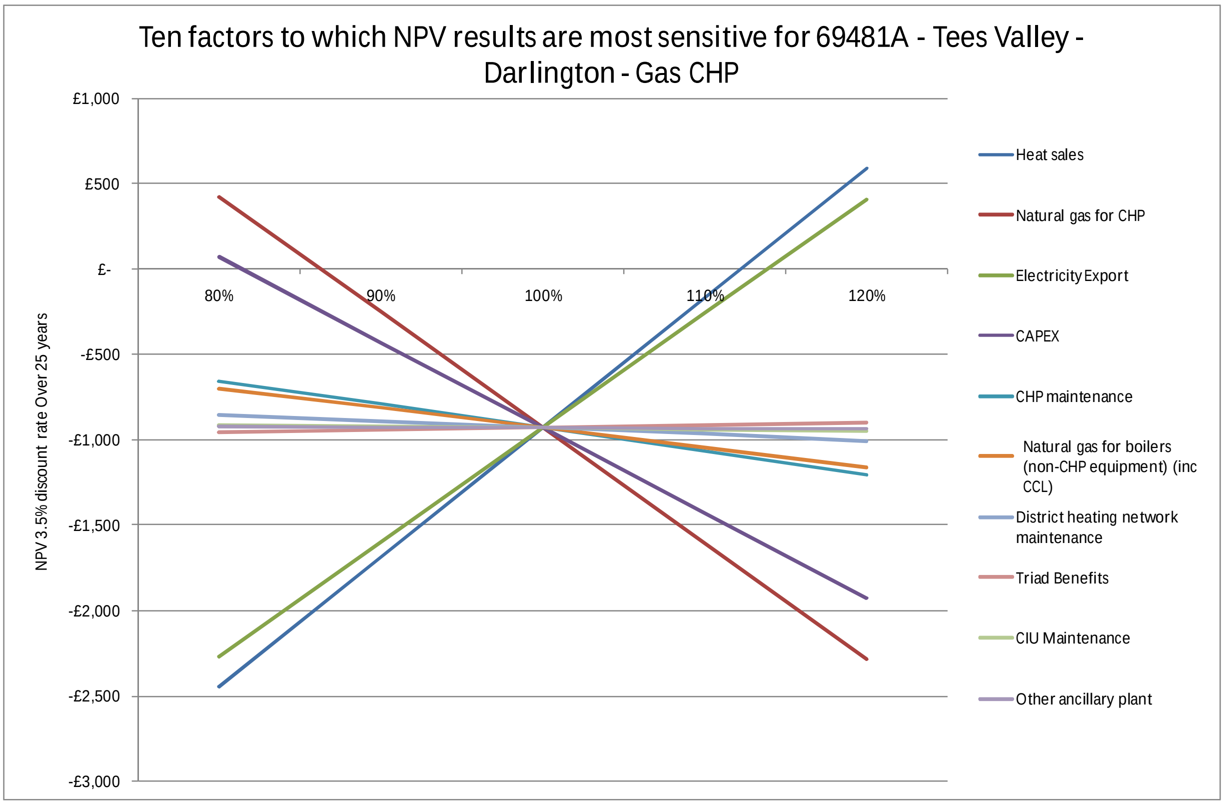
This graph illustrates the degree to which the Renewable Heat Incentive supports the viable use of biomass in Stockton. This chart illustrates that the Stockton Core scheme is most sensitive to the level of RHI support, closely matched by the heat sales price which is effectively the same metric. Other key factors for this scheme are the capital cost of installation, biomass fuel costs (almost obscured by the capital cost line on the graph above) and the utility purchase cost for the natural gas boilers that provide top-up and standby heat for the scheme.

[33] This factor does not show on the graph as the base assumption is of zero cost, and the calculation method assumes a percentage variation around a base value (e.g. 80% * 0p/kWh (heat purchase price) = 0 p/kWh (heat purchase price), therefore no change in NPV)

4.4.3 GAS-FIRED CHP

The Darlington Extended scheme illustrates sensitivities for gas-fired CHP schemes.

Figure 4-35 Sensitivity Analysis of Gas-fired CHP - Darlington Extended Scheme



This graph illustrates that for this extended CHP scheme, there are four factors to which the economic performance of the scheme is broadly equally sensitive. These are the electricity export value, the heat sales price, capital cost of scheme installation, and natural gas for CHP purchase price. It should be noted that electricity export values and gas prices are currently linked by a factor known as the “spark spread”. Electricity in the UK is predominantly generated by gas fired stations and so these two prices are somewhat linked. The key sensitivity here is therefore to any change in this spark spread. This is an important graph to bear in mind in terms of contract negotiations and utility procurement strategies. Efforts must be made to seek to maximise the profitability of CHP, and these areas are where incremental improvements in unit purchase / sales values will result in greatest dividends.

4.4.4 CONCLUSIONS FROM SENSITIVITY ANALYSIS

The common factor between all technology options is the significant impact that the heat sales price has on the viability of the four district heating schemes. Aside from the capital cost the heat sales tariff is the over which the operator will have the greatest control during the contract negotiation stage. The price that customers are prepared to pay for heat is a function of the cost of supplying heat from alternative means and the added benefit for using low carbon heat. PB recommends that when calculating the heat sales tariff thorough consideration is given to all the avoided costs and financial benefits that customers will receive when using DH heat; the customers being supplied from the network should be fully and actively engaged to ensure that the maximum value for district heating heat can be gained.

For all of the schemes, it is perhaps further worth noting that the high capital costs of infrastructure installation means that even at the relatively low discount rate analysis applied above, that the capital element is shown to be a critical factor in economic performance. This can further be broken down into key elements of the overall capital make-up. This break-down shows that for all of the schemes the DH pipework installation costs are a very significant element. Therefore, a competitive procurement process must strive to find an appropriate balance for this element of the scheme make-up between quality and cost.

SECTION 5

PHASE FOUR: DELIVERY

5 PHASE FOUR: DELIVERY

This section outlines the technical and commercial means by which district heating could be delivered in the Tees Valley. The risks and opportunities associated with delivering district heating for each of the four schemes are also outlined.

5.1 INDICATIVE TECHNICAL DELIVERY

PB has investigated the means by which existing and new buildings can be supplied from district heating. This section describes the domestic hot water and heating design strategies to be considered in buildings which are to be connected to the proposed district heating networks in the Tees Valley.

The design philosophy for the DH is based on fixed operational flow and return temperatures and variable flow rate to suit the annual fluctuations in customer demand; all the following information and technical recommendations rest on these assumptions.

In the discussion that follows, the following terminology will be used to describe the various sub-systems that exist within the distribution network:

The **Energy Centre** is the building that contains the prime mover and all ancillary equipment needed to supply the district heating system with hot water. It will also contain he electrical infrastructure needed to export the electricity generated by a CHP if present;

The **primary network** refers to the distribution system that connects the energy centre to each individual building development or existing building or groups of buildings on an estate. It is the source of the low temperature hot water supply to each building;

The **interface unit** links the primary network to the secondary network via a hydraulic break and controls to ensure correct operation of each system;

The **secondary network** is the local network within each building or group of buildings that supplies hot water to the loads.

5.1.1 THE ENERGY CENTRE

An indicative energy centre design for the least cost option identified in section 4.3 for each scheme has been produced; these are included in appendix H. The design for each energy centre illustrates the plant required for both the core and extended schemes. It may be necessary to replace or upgrade some of the equipment installed for the core scheme where the extended scheme is considerably larger.

5.1.2 THE PRIMARY NETWORK

The primary network is a variable flow rate system that responds to the individual instantaneous heating demands of the connected buildings. Ideally, a constant differential temperature is imposed on the primary circuit irrespective of the demand requirement. The return temperature should be kept as low as possible[34] to maximise the thermal efficiency of the network and minimise pumping costs.

To meet these requirements, it is essential that the primary and secondary networks are compatible in their design.

The design of the secondary network in new developments to be connected to a DH network can more easily be made compatible with the primary system than the modification of existing systems. This section provides suggestions on the means by which existing buildings can be connected to a DH, in addition to containing guidance on the design of new secondary systems.

5.1.3 PRIMARY AND SECONDARY NETWORK INTERFACE

PB have produced indicative schematics that illustrate the means by which new and existing buildings could be connected to the district heating schemes, these are included in Appendix H.

Although it is possible to connect the building network directly to the district heating supply, the preferred option is to use an indirect interface unit. A heat exchanger is used to transfer heat from the primary LTHW supply to the secondary building LTHW system. The advantage of the heat exchanger is that it provides hydraulic separation of the two circuits. This creates a contractual demarcation and eliminates the risk of contamination of the primary LTHW supply

[34] Customers could be offered a financial incentive to keep return temperatures within an agreed range

network by the secondary (consumer) systems and vice versa. Plate heat exchangers, if correctly insulated have a very high efficiency. Temperature differentials between primary and secondary systems can be cost effectively designed to 5°C or even less.

The hydraulic interface is achieved via an interface unit (sometimes known as a heat substation) located in a plant room within the building. To achieve compatibility with the primary network, it is important that these interface units are designed, installed and operated to a common set of rules that are described in the next section.

5.1.4 CONNECTION OF NEW BUILDINGS TO THE DH SYSTEM

Depending on the required load of the individual connection, the interface unit may incorporate up to 3 heat exchangers. These will operate in parallel to provide the peak requirement, whilst incorporating a level of resilience. The primary circuit nominal temperatures used to size the networks and the devices on the interface units are as follows,

Flow temperature (Maximum)	95°C
Return temperature (maximum)	55°C

It will be an obligation of the end user to provide suitable designs of the secondary system mechanics and control functions. This design must ensure that the return temperature on the primary system is maintained in line with the maximum figure indicated in the table above. It is important that this requirement is maintained throughout the annual demand profiles down to an acceptable minimum requirement of nominally 10% of the maximum demand. It should be noted that incentives for good operation and provision of the required design return temperatures will be incorporated into the energy supply agreements for each customer.

A reasonable design temperature differential (e.g. 5°C) should be maintained between the primary and secondary flow temperatures and between the primary and secondary return temperatures to ensure adequate control margins, therefore, it is recommended that the return temperature in the secondary systems does not exceed 50°C under any load conditions.

The following basic design parameters are assumed:

- The primary circuit will be sized for a nominal maximum pressure of 16 bar (PN16);
- The head loss at the primary circuit connections within the building and the plant room will be a maximum of 1bar.

A differential pressure control valve (DPCV) should also be installed at each connection, with the actuator capillary lines connected across the heat exchanger and / or the control valve (CV). Once commissioned, the DPCV will self regulate to limit the flow rate to the maximum design figure, irrespective of fluctuations within the main system and will close down in parallel with any flow regulation requirement of its associated CV, which regulates to suit the demand of the connection.

A form of flow measurement device will need to be included at each connection to allow for flow checks and to commission the installed DPCV. We would propose that energy metering should be incorporated at the connection point and the flow-sensing element of this package would be suitable for measuring flow rate. Due to their compactness and their ability to operate with close approach temperatures between the primary and secondary return, the heat exchanger at the hydraulic interface is generally a plate heat exchanger. One of the benefits of these systems to the developer is the potential to save space over a conventional boiler solution, since interface units are significantly smaller than boiler plant (occupying as little as one tenth of the space). However, because plate heat exchangers are prone to fouling, the use of strainers and side-stream filters is essential, as is a suitable water treatment regime of the secondary circuit.

5.1.4.1 DOMESTIC HOT WATER SUPPLY

Domestic hot water DHW will be supplied from the customer secondary side system and should be designed such that the mix of return temperatures from this and the other heating circuits will provide the overall required return temperature at times of peak demand. An instantaneous heating approach should be considered for the domestic hot water heating. This provides the benefits of space reduction, heat loss reduction from standing water and the reduction of the risk of infection from Legionella. It will also benefit in providing the lowest possible return temperature as the cold feed is connected directly to the heat exchanger and this can be sized to give close approach temperatures.

Alternatives to this would include a traditional storage system with an internal heating coil, although this will raise return temperatures as the cylinders are recharged, or a plate heat exchanger with integral storage cylinder.

5.1.4.2 DESIGN AND CONTROL METHODS

Secondary systems can be either variable temperature or constant temperature depending on the requirements of the building servicing strategy; all connected loads must use a variable flow rate system. The required terminal load is used to regulate the control valve opening, ensuring that the pump is kept at the optimum operation point for the overall circuit. This keeps the electrical consumption of the pump to a minimum and maintains a maximum temperature differential between the flow and the return. It is recommended that the pump speed regulation is controlled through the differential pressure measured at the secondary circuit index run. This is normally the most distant load.

Due to the possibility that all the regulation valves may be closed it is necessary to install an automatic temperature controlled bypass valve adjusted to keep a minimal flow within the circuit. This will ensure that the temperature does not drop below a minimum level at times of low or zero demand. It is very important that this is a controlled bypass or the secondary return will tend to the flow temperature during low demand periods. This will lead to excessive heat loss, lower performance in the energy supply system..

The differential pressure set-up value should be nominally the same as the head loss downstream of the pressure sensor including a margin. Alternatively a controlled by-pass can be incorporated linked to the differential pressure set point and the minimum speed requirement of a single pump operation.

5.1.5 CONNECTION OF EXISTING BUILDINGS

PB would advocate the connection of large single point loads to a DH system because they generally assist with diversifying the heating peak and lead to a greater heating baseload. Such buildings are usually supplied from gas boilers that supply internal heating systems and domestic hot water supply. The DH would supply the building systems via a heat exchanger for the reasons previously explained. The heat exchanger would replace the existing gas boiler with resilience being provided by gas boiler located in the DH energy centre. In situations where multiple gas boilers are fitted it may be possible to retain one or more gas boilers to provide a degree of local resilience.

The vast majority of secondary systems of the majority of buildings currently supplied from stand-alone gas boiler heating systems utilise an 82°C/71°C flow and return temperature for the secondary systems. If these systems are to be supplied from a CHP/DH system there are significant implications on efficiency and total annual operating hours if return temperatures exceed 75°C. If return temperatures exceed 70°C the CHP will be forced to shut down because it requires the return water to cool the engine. There are three potential solutions to this issue:

1. Lower the flow temperature of the secondary system so that it operates with the same ΔT but has a flow return temperature of 75°C/64°C. Existing radiators in existing

domestic and non-domestic buildings are generally oversized and are able to supply sufficient heat into buildings at the reduced temperatures. The flow temperature on the primary system will be variable in order to allow for systems to be returned to 82°C/71°C during extreme cold periods.

2. Ensure loads that produce low return temperatures, for example swimming pools and modern developments with underfloor heating and instantaneous DHW provision, are connected to the system. For example a swimming pool may produce return temperatures of around 45°C, which when combined with a 82°C/71°C existing building load has the potential to produce a return temperature at the energy centre of less than 70°C; this however depends on the relative flow rates of the connected loads and needs to be considered during the design stage of a DH scheme.

3. Rebalance the radiators to deliver a 64°C return temp instead of 71°C. This reduces the heat output but not by as much as 75/64. Flow rates are reduced as well which reduces pumping energy. This approach will involve visits to all buildings proposed to be connected and may need new Thermostatic Radiator Valves (TRVs) installed to facilitate the balancing.

5.2 IDENTIFYING THE RISKS AND OPPORTUNITIES SURROUNDING THE DEPLOYMENT OF DISTRICT HEATING IN THE TEES VALLEY

The identification and quantification of the risks and opportunities associated with deploying district heating in the Tees Valley is vitally important throughout the design stages and when developing the commercial structures for the schemes.

PB has held two stakeholder workshops as part of the study. The first was to identify and document the perceived drivers, barriers and risks associated with the project. A follow up workshop was held to identify and quantify risks and opportunities specific to the four district heating schemes. Mitigation strategies were discussed for all of the major risks that were identified.

PB has developed a project risk register that is documents all identified risks and mitigation strategies. The risks have been divided into political, financial and technical risks for ease of understanding and to allow the register to be easily updated.

The risk register, documenting the outputs of the second workshop in appendix **I**.

PB has included a summary of the key risks that will impact the viability of the district heating schemes. These were not necessarily identified during the risk workshops and are therefore included here to ensure that they are given sufficient consideration when developing the district heating schemes discussed in this report.

5.2.1 COMMON RISKS ASSOCIATED WITH DISTRICT HEATING PROJECTS

Risk description	Proposed mitigation strategy
Adequate gas, electricity and water utility connections to energy centre. Utilities will need to undertake detailed connection studies when large generation assets are being considered.	Ensure utilities are given sufficient prior notice to provide detailed quotations for utility connection so that these can be included in detailed business case proposals.
Constraints to installing DH infrastructure. The presence of barriers to installation of district heating infrastructure, for example	Undertaken a constraints assessment during design stage to allow cost of installation to be accurately costed, taking all service

existing buried utilities and transport corridors.	deviations etc into account. This could be undertaken in collaboration with specialist DH instalers
Gaining environmental permits for energy centre. The permitting of an energy centre is a time consuming and complex process that requires a lot of detailed information regarding the emissions from the scheme.	Sufficient consideration should be given to this process to ensure that the information is available and sufficient resource is allocated to this task
Fuel supply and energy sales contracts. The economics of operating decentralised energy schemes is highly sensitive to the cost of fuel used and the value of energy sold to customers.	Contracts with fuel suppliers, particularly in the case of bio-fuel, need to be expertly negotiated in order to maintain scheme viability in changing energy markets. The value of electrical export is equally vital, any means by which the value of electricity sold from the energy centre can be maximised should be vigorously pursued. Discussions with NEPO should be held at the earliest stage.
Identifying capital funding for scheme. The high up-front capital costs for implementing decentralised energy schemes makes the identification of adequate funding at acceptable terms paramount to scheme viability	The balance between the capital cost and revenue generation is a measure by which potential investors will assess a district heating scheme Ensuring that the heat load density on the network is maximised is perhaps the most important factor when keeping an acceptable balance between capital and revenue.
Planning permission for the energy centre and DH infrastructure. The visual impact and perceived noise pollution from the energy centre can hinder or even prevent planning permission being granted.	The successful granting of planning can be facilitated through stakeholder consultation and education from the outset. The choice of energy centre location will strongly influence the likelihood of a smooth planning application process.

Retention of district heating customers. The business case for district heating is dependant on selling heat to customers. If customers request to be removed from the district heating scheme this will adversely affect the ongoing viability of the scheme.	The retention of heat customers can be achieved in a number of ways: • Long term energy purchase agreements with sufficiently prohibitive break clauses • Heat sales tariff that are lower than alternatives • Making sure that there are limited alternatives – eg. Inadequate gas infrastructure for new developments to allow switch to individual gas boilers.
Sign up of initial heat customers. The district heating scheme needs to sign-up all of the customers identified during the design stage to ensure the scheme is viable.	One of the first steps to be taken when taking a project from concept to design stage is to agree heads of terms with the proposed customer base and get memoranda of understanding with key customers to ensure that the anticipated heat load/sales revenue will materialise.
Sign up of public sector bodies as heat customers Potential public procurement issues with long term contracted supply of heat	Need to be able to demonstrate best value both for initial connection and over project life.
Oversizing the infrastructure to future-proof the scheme. The network should be designed so that it can be extended to supply new customers not considered during the design stage	The extent to which the network is future proofed will affect the viability of the initial scheme. If a scheme has to 'carry' the cost of future proofing for customers that may not materialise for several years it may not be considered financially viable. A key question is who pays for the strategic future-proofing of the network to meet long term CO_2 reduction aspirations?
Opportunities	

Job generation from biomass fuel supply chain	
Sign-up of customers not included in scheme design, for example commercial/retail for minimal additional cost if they are situated along the main DH spine.	

5.2.2 SUMMARY OF 'HEADLINE RISKS' FOR THE TEES VALLEY DISTRICT HEATING UTILITY PROJECT

The following section provides a summary of the project risks and opportunities, identified during the workshop, that have the potential to significantly affect the delivery of district heating in the Tees Valley. These risks and opportunities are specific to the individual schemes. Common risks are included in the previous section. Where possible mitigation strategies have been suggested in an attempt to reduce either the impact or probability of the risk occurring. The headline risks and opportunities are presented scheme by scheme.

5.2.2.1 HEADLINE POLITICAL RISKS AND OPPORTUNITIES FOR DARLINGTON

Table 5-1: Headline risks for the Darlington scheme identified during risk workshop

Risk description and explanation	Potential mitigation strategy
Rail crossing points limited and physically constrained	Early engagement with Network Rail and inclusion of rail qualified staff in design team
Congested roadways and contaminated land risk - extra delays/cost once ground-works begin	Early route option development works including reviews of detailed utility drawings and contaminated land assessments. Possible site investigations based on result so initial desktop studies.
Opportunity description	

There are proposals for redevelopment of the "town centre fringe" between the town centre and the railway - opportunity for new loads
Town centre fringe proposals also include new rail crossing to link to Central Park - opportunity for easier rail crossing and energy centre location
Proposal for new public and private sector offices opposite the proposed energy centre location in the town - opportunity for new loads/expansion
Proposals to narrow St Cuthbert's Road - these works may provide opportunity to put in some of the pipes

5.2.2.2 HEADLINE POLITICAL RISKS FOR STOCKTON

Table 5-2: Headline risks for the Stockton scheme identified during risk workshop

Risk description and explanation	Potential mitigation strategy
Risk of contaminated land pushing up development costs and rendering scheme unviable	Consider alternative development solutions for most contaminated areas
Risk of relocation of council offices - e.g. loss of heat load for scheme.	considered minor impact as building would be used by another tenant /occupier
Opportunity description	
Potential for river crossing to supply loads on the south shore – Thronaby scheme	
Development of the Castlegate retail and commercial area as well as Victoria development, represent additional potential load.	

5.2.2.3 HEADLINE POLITICAL RISKS FOR MIDDLESBROUGH

Table 5-3: Headline risks for the Middlesbrough scheme identified during risk workshop

Risk description and explanation	Potential mitigation strategy
Potential public procurement issues with single source heat supplier	Advice required from procurement experts.
Availability of BEI heat demand at an acceptable heat sales price	Ensure commercial team has a clear understanding of the value to BEI of heat offtake. Careful negotiation strategy planning.
Heat from BEI not able to get homes zero carbon status	
Is the fact that no social housing is being supplied in phase 1 of the schemes a barrier or risk to the project? Will this reduce political will? Or could social housing be supplied in due course? Later phases of project	
Opportunity description	
The BEI plant offers the opportunity for low cost low carbon heat, every effort should be made to facilitate the use of this heat source.	
Significant quantity of commercial/retail in the town centre that could potentially be connected to the scheme at relatively little additional cost.	

5.2.2.4 HEADLINE POLITICAL RISKS FOR ESTON

Table 5-4: Headline risks for the Eston scheme identified during risk workshop

Risk description and explanation	Potential mitigation strategy
Presence of railway and chemical pipelines will make connecting to MGT difficult	Early engagement with Network Rail and inclusion of rail qualified staff in design team. Early engagement with other infrastructure owners to develop acceptable routes. The work undertaken as part of the North-South Tees Project identified the public sector role in supporting strategic pipeline routes and gaining necessary wayleaves.
Heat from Sembcorp and MGT is not likely to be free – will the schemes be able to make sufficient revenue from heat sales?	May need a different technical and commercial approach.
Timing - would the infrastructure be in place in time to supply the new build sites	
Opportunity description	
The scale of the MGT power plant has the potential to supply significant quantities of waste heat. Every effort should be make to take advantage of this potential source.	

5.3 PLANNING GUIDANCE TO FACILITATE DELIVERY OF DH SCHEMES IN THE TEES VALLEY

The role of strong planning policy has been demonstrated to be of considerable importance where district heating schemes have been deployed elsewhere, for example Copenhagen and London. PB has identified, in the case of Darlington and Eston that DH offers only a marginal financial benefit to developers in terms of the cost of complying with planning regulations. If developers are obligated to connect to the district heating scheme this will remove the option for developers who may not wish to connect to district heating even though it costs less than or the same as alternative means of complying with building regulations. The following section provides suggested guidance that could be incorporated in planning guidance[35] for each of the local authorities in the Tees Valley:

1) *Each of the Tees Valley Councils should ensure that all new development in Central Park, North Shore, Middlehaven and Low Grange is designed to connect to the heating networks proposed in this study.*

2) *Developers for Central Park, North Shore, Middlehaven and Low Grange must connect to the district heating networks proposed in this study unless they can demonstrate a lower cost means of complying with building regulations.*

3) *All development in the Tees Valley will be required to contribute to the development of DE networks, including by connecting to such networks where these exist within the proximity of the development, requiring development to offset all remaining CO_2 emissions associated with the building through a financial contribution towards measures which reduce CO_2 emissions from the existing building stock.*

4) *Where a potential source of waste heat has been identified the potential suppler of waste heat should be obliged to assist with investigating the means by which district heating can be supplied from this source.*

5) *The councils should work in partnership to identify and to ensure the delivery of these networks and to maximise the potential for existing developments to connect to them.*

[35] Based upon the policies proposed under the London Plan

5.4 FILLING THE FUNDING GAP…

This section outlines potential mechanism for filling the funding gap identified for the Darlington and Eston schemes should the contribution from developers not be sufficient to make the schemes financially viable.

5.4.1 GROWTH POINT FUNDING

The purpose of growth point funding is to facilitate sustainable redevelopment through the part funding of infrastructure projects. PB has demonstrated that the capital contribution required from developers for the Stockton and Middlesbrough schemes is lower than the alternative cost of compliance with building regulations. These schemes should therefore act as a stimulus to the development without the requirement for growth point funding for the district heating system. The analysis outlined in previous sections however suggests that both the Darlington and the Eston DH schemes would require Growth Point Funding in order to make them more viable than an individual-site solution alternative approach to energy provision.

The growth point funding is divided between the five local authorities, the means by which the funding could be used to support DH is potentially politically sensitive. It is uncertain whether it would be politically acceptable for a greater proportion of the funding to be diverted to a single LA in order to fund a DH scheme that would not equally benefit all local authorities.

5.4.2 AVAILABILITY OF CAPITAL FUNDING

Beyond the potential for Grant funding from the Growth Point scheme, the capital funding required to deliver the scheme could be gained from four primary routes:

1. Prudential borrowing available to the Tees Valley councils.
2. European or Green Investment Bank low carbon infrastructure loan – for example via the Elenor application route
3. Investment from a private sector Energy Service Company (via a public private partnership arrangement/supplier obligation).
4. Developer Contributions related to avoided costs for the implementation of a compliant scheme.

5.5 POTENTIAL COMMERCIAL ARRANGEMENTS

This section of the report considers the structures, approaches and funding sources that are available for the formation of a DH scheme, discusses the advantages and disadvantages of these, using case studies to illustrate these, and suggests the most likely procurement route that should be followed by the Tees Valley Councils.

5.5.1 BACKGROUND TO COMMERCIAL ARRANGEMENTS FOR DISTRICT HEATING IN THE UK

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

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

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

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

5.5.2 POTENTIAL APPROACHES FOR DEVELOPMENT OF DH

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

The commercial arrangement for the delivery and operation of district heating alters the exposure to risk and degree of control that the public sector will have over the scheme.

Table 5-5: Potential commercial approached to delivering district heating in the Tees Valley

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

5.5.3 APPRAISAL OF POTENTIAL OPTIONS

The options given in the table above have varying advantages and disadvantages which generally fall under the following headings:

- Cost of funding
- Risk versus control
- Regulations and licensing
- Availability of resources/skills

5.5.3.1 Cost of Funding

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

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

5.5.3.2 Risk versus Control

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

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

Responsibility for risk has important implications financially for the partners engaged in the development of the ESCo; where risk is allocated within a partnership also broadly determines where the financial benefits are distributed. Capital and operational risks will have a proportion of finance or a share of profits associated with them; this is where careful consideration of the objectives of the ESCo from the point of view of the Tees Valley should take place.

5.5.3.3 Regulations and Licensing

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

5.5.3.4 Availability of Resources and Skills

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

5.5.3.5 Operation of Schemes

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

Arrangements will ideally be:

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

5.5.4 ANALYSIS OF TEES VALLEY SCHEMES

PB have reviewed the techno-economic performance of the four Tees Valley schemes in light of the most appropriate means by which they could be taken from feasibility stage through to delivery. The following figure illustrates how the four schemes vary with respect to their customer base, potential heat source and commercial performance of the schemes. This figure is intended to highlight areas where each scheme differs from the others. The question to be asked is, would a single ‘umbrella’ delivery vehicle for all four schemes be suitable, or would separate mechanisms for each scheme be preferable.

Table 5-6: Comparison of scheme characteristics

Scheme	Local authority only customer base?	Potential for local authority operation of scheme	Potential for heat supplier to operate scheme	Viable at 3.5% discount rate?	Lower cost of building regulations compliance for developer?
Darlington core		✓			
Darlington extended		✓			
Stockton core	✓	✓		✓	
Stockton extended		✓			✓
Middlesbrough core		✓	✓	✓	
Middlesbrough extended		✓	✓	✓	✓
Eston core	✓	✓	✓		
Eston Extended		✓	✓		

5.5.5 SUGGESTED COMMERCIAL ARRANGEMENTS

The comparison of the four schemes displayed in PB have reviewed the techno-economic performance of the four Tees Valley schemes in light of the most appropriate means by which they could be taken from feasibility stage through to delivery. The following figure illustrates how the four schemes vary with respect to their customer base, potential heat source and commercial performance of the schemes. This figure is intended to highlight areas where each scheme differs from the others. The question to be asked is, would a single 'umbrella' delivery vehicle for all four schemes be suitable, or would separate mechanisms for each scheme be preferable.

Table 5-6 shows that there are a number of key differences between the schemes despite them being, on the face of it, very similar.

The key difference that has the potential to affect the choice of commercial structure is the composition of the customer base. If all customers are from a single organisation, or closely affiliated to as single organisation, the procurement of the district heating scheme would be easier than if a number of customers with disparate drivers and internal commercial structures was involved. In the case of the Stockton core scheme all of the customers are local authority organisations. There is therefore the potential that Stockton Council could take this scheme forward on their own, using support from contracted 3rd parties where necessary.

All other schemes have a mixed customer base and would therefore need to negotiate the commercial structure that is best suited for all parties involved.

With sufficient contribution from developers, the Stockton extended scheme and the Middlesbrough extended schemes represent a lower cost route to achieving building regulation compliance than alternative approaches. These schemes may therefore be attractive to private sector ESCos and could be wholly owned and operated by these companies. It is likely that the local authorities would wish to retain a degree of control over the operation and expansion of these schemes; representation at board level or though a minority equity share could provide sufficient leverage. Stockton extended and Middlesbrough could therefore be delivered via a joint venture of public private partnership type approach.

In the case of the Middlesbrough and Eston schemes the potential for waste heat being supplied from a private sector organisation opens up another potential commercial structure. It is possible that the heat provider (eg. BEI, Sembcorp, MGT) could provide the heat on a Contract Energy Management (CEM) type arrangement. The customers on the network would contract for a specified capacity and volume of heat, this would then be supplied by the private sector heat provider. The means by which the heat is provided is up to the heat provider. The revenue necessary for the heat provider to pay for the infrastructure required would be realised from the margin between the heat sales tariff and the cost of heat production.

In the case of the Hartlepool schemes, this ease of procurement must be weighed up against the improved techno-economic performance of the scheme through the inclusion of private sector customers. If a third-party ESCo route is pursued (e.g. as would suit a mixed public / private customer base), the significant public sector proportion of loads for the Town Centre scheme is advantageous for the ESCo, as the ESCo will welcome the security that a significant public sector / long-term contract would provide.

It is hard to envisage how a district heating as outlined in the Hartlepool seafront Scheme could be financed and implemented in its current form. Some areas of the development sites included within the seafront Scheme may lend themselves to individual centralised heat supply mechanisms, particularly as (as far as PB understands) there is a single Developer involved. This would then greatly simplify and improve the potential for inter-connection to form a wider district heating scheme, which may become more economic as market conditions change, and as further buildings are developed within the Town Centre / Historic Dock and seafront areas. From this point of view it would be PB's recommendation that centralised, and technically compatible solutions are pursued for the Trincomalee Wharf and other development sites. This should not represent greatly increased costs in development. It is not clear what policy mechanisms could be used to encourage this, and hence it may be that the most effective approach is simply to disseminate information to the developer of the potential benefits of centralised supply to ensure that this type of solution is considered as detailed designs are furthered.

A major factor that needs to be taken into consideration are the state aid rules[36]. The implications of state aid legislation are that there will be limits on the amount of public funding that can be made available to a project from which a private sector organisation will profit. In the case of the Tees Valley schemes only the Stockton Core scheme would not be affected by the possibility of state aid rules being bought into affect. As and when the projects are progressed from feasibility stage a full

[36] the details of which are not discussed here owing to their complexity and case specific nature

and thorough review of the proposed commercial structures for each scheme needs to be undertaken at an early stage to ensure that the state aid legislation is adhered to.

Despite the different potential commercial structures that are available for each of the four schemes it is possible that they could all be delivered under the stewardship of an overarching umbrella organisation. The role of this organisation could potentially be to:

- Maintain a technical and commercial knowledge base and share lessons learned
- Provide customer management, metering and billing services for all schemes
- Provide technical staff for operation and maintenance of schemes
- Allow reduced fuel cost from increased purchasing power available through aggregated purchasing
- Funding for schemes could be pooled and access to additional funding arrangements may be possible
- Depending on the structure and terms of reference of the central organisation support could be provided from successful schemes to allow more difficult schemes to proceed
- Despite the evident benefits of a single umbrella organisation a project by project approach would allow more flexibility on the timing and details of each project. There could potentially be a hybrid by which the umbrella organisation controls/drives the projects with flex on final delivery of individual projects.

In order to progress the delivery of district heating in the Tees Valley councils and TVU should work together to draw up heads of terms for the formation of an Energy Service company that will act as an umbrella organisation to oversee the design, implementation, operation and ongoing growth of district heating schemes in the Tees Valley. The eventual commercial structure for each of the four schemes will depend critically on the funding routes identified and the body which will lead the procurement.

5.6 SOFT MARKET TESTING FOR DH SCHEMES

PB will undertake a soft market testing exercise when this document is being reviewed. The methodology and outcomes will be included the final draft of the report.

5.7 CONCLUSIONS

The implementation of DH networks in both Middlesbrough and Stockton appears to offer the potential to stimulate sustainable regeneration at lower cost than would be seen under individual building solutions.

This suggests that the implementation of DH could increase the likelihood and quality of regeneration of the Middlesbrough and Stockton areas.

The Darlington and Eston schemes in their extended form are only marginally viable, and hence for this area, two key mechanisms to encourage DH development are suggested for the long-term implementation of DH:

- Development and assessment of options for grant funding (e.g. European Investment Bank or Green Investment Bank);
- Planning policy measures to ensure that Developers are encouraged to connect to DH systems.

Where there is no clear financial incentive for Developers to connect to a DH scheme (as in Darlington and Eston), inertia and established business practices will tend to push Developers towards traditional solutions. Hence, whilst Growth Point funding would potentially provide an incentive to Developers and help deliver a viable scheme, the firm implementation of DH favourable Planning Policies would also help to form the essential critical mass of customers that is essential to make this scheme as viable as possible.

The implementation of a DH network in the Town Centre area of Hartlepool does not appear to be economically viable in current market conditions. However, relatively small changes (e.g. approx 10%) to the prices of electricity and gas assumed in these models could allow the scheme to deliver a positive value when calculated at a 3.5% real discount rate factor over 25 years. This is unlikely to offer sufficiently high rates of return to attract the involvement of commercial private sector ESCos, but could allow a public-sector operated scheme to emerge where specialist operations are subcontracted to third parties.

The common factor between all technology options is the significant impact that the heat sales price has on the viability of the five district heating schemes. Aside from the capital cost the heat sales tariff is the over which the operator will have the greatest control during the contract negotiation stage

5.8 RECOMMENDATIONS

1. The Tees Valley local authorities should commit to the use of district heating as a key technology to facilitate CO_2 reduction and stimulate new development. Other available technical solutions should only be adopted if district heating has been demonstrated to be unviable.
2. The Tees Valley political leaders and directors of finance need to investigate funding options and the mechanism by which district heating could be delivered. All concerned should be aware that the delivery of district heating schemes will be staggered, with schemes in different Local Authority areas delivered at different times.
3. As for all emerging DH schemes, it is critical to ensure that early and continuing dialogue with potential heat customers is pursued and maintained. The ultimate goal of this dialogue as schemes progress is to have firm commitment to connect to a scheme's heat supply when it becomes available. This process should ensure that scheme development pays attention to the natural business cycles of the organisations that are to connect, and allows heat sales prices to capture the value of avoided alternative costs.
4. District heating can help to facilitate the delivery of new development in the Tees Valley. The Tees Valley councils should strongly consider incorporating requirements for connection to district heating, where appropriate, in their planning guidance.
5. The Tees Valley councils, in conjunction with TVU and NEPO, should work together to draw up heads of terms for the formation of an Energy Service company that will act as an umbrella organisation to oversee the design, implementation, operation and ongoing growth of district heating schemes in the Tees Valley. The outcomes of the soft market testing, when available, should be used to inform the procurement of district heating in the Tees Valley.

6. Industrial operators that have the ability to sell ‘surplus’ heat, for example, BEI, Sembcorp and MGT, have the potential to supply district heating schemes in Middlesbrough and Eston with low carbon heat. Middlesbrough and Redcar and Cleveland Councils should keep a watching brief on this opportunity.

APPENDIX A

DISTRICT HEATING IN THE UK AND EUROPE

6 DISTRICT HEATING CASE STUDIES IN UK AND EUROPE

The following section contains a number of examples where district heating has been successfully used to provide low carbon low cast heat to a range of customers.

6.1 COPENHAGEN

The development of the Danish district heating networks is often cited as a good example by which district heating can become the 'norm' for heat supply across a large European city. As such the "Danish Model" is often quoted as a district heating success story.

6.1.1 DESCRIPTION

Strong support for CHP and DH in Denmark began as a direct result of the oil crises during the 1970s. The Danish Heat Supply act was first drafted in 1979 and the strong incentives have driven the rise of CHP and DH throughout the country. At the time a handful of oil fired power stations met the needs of the nation along with imported power from other countries such as Norway and Sweden. Today, Denmark is self sufficient with a highly decentralised infrastructure. CHP schemes throughout Denmark, fired with oil, gas, coal and waste, meet the majority of energy requirements of the nation. In addition up to 20% of Denmark's electricity needs are met through wind turbines.[37] A significant amount of energy is still imported from adjacent countries but Denmark now also exports around the same amount. Around 60% of heating requirement in the country is met via DH networks and 80% of this heat is co-generated with electricity.[38]

In Copenhagen the Heat Plan Copenhagen (Varmeplan København) was introduced in 1984, this prompted a massive development of district heating in Copenhagen and the CHP plants to power it. Today 98% of the heat needs of the City of Copenhagen are met via the DH scheme as well as meeting a significant amount of the needs within the greater Copenhagen area. The use of biomass

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[37] European Commission, Directorate General for Energy and Transport, Denmark Renewable Energy Fact Sheet, 23rd January 2008.

[38] International Energy Agency, CHP/DHC Country Scorecard: Denmark, 2008

and waste has been subsidised and as a result 35% of heat supply through the network is met by renewable fuels.

The municipalities in the region set up two companies, VEKS and CTR, to manage and operate the networks in the West and East of the region respectively. Within the region are two smaller "sub-companies", VF, operating a small scheme towards the North of the region and Copenhagen Energy operating the central Copenhagen steam DH system. Since 2008 the companies have invested heavily in a central system, VLE, for managing heat supply from the power companies in the area.

6.1.2 HEAT TARIFF

The Copenhagen scheme over the years has developed complexities in the heat tariff charged to consumers which incentivise them to make best use of their heat. The most recent development is the trial of a tariff within the Roskilde area of the VEKS scheme. This tariff comprises of three different parts and also a "cooling incentive":

- Fixed Annual Charge – The fixed annual charge is a fixed amount to be connected to the scheme and covers some of the fixed operational costs of the scheme.
- Fixed Capacity Charge – The capacity charge is fixed but is dependent upon the size of the connection to the scheme to covers maintenance costs associated with this varying size.
- Variable Heat Charge – This is a charge based on usage via a heat meter and is easy for the customer to see and understand.
- Cooling Incentive – This is the part of the tariff that is on trial in this part of the scheme. Customers are given a discount if they return water to the network having reduced the temperature by more than 35˚C; if they do not then they are charged extra. Customers can ensure they achieve a discounted tariff by making greater use of the heat delivered to them. The advantage of the scheme is an overall decreased return temperature which reduces heat loss from the network and transmission and operating costs. Since this tariff was introduced anecdotal evidence suggests that the local return temperature has been decreased by up to 15˚C and customers have been very supportive of the program.

6.1.3 STRENGTHS OF THE SCHEME

The existence of strong legislation, incentives, investment and the the high heat load density of the Copenhagen area have helped turn the Copenhagen DH scheme into perhaps the scheme most widely recognised as a success around the world.

The Danish Heat law since 1982 has given local authorities the right to make a connection for new and existing properties to a DH scheme or a gas network mandatory; electric heating was also banned for new developments. Since 1994 electric heating has been banned for existing buildings also. This has driven almost all consumers and developers to connect to the DH scheme where possible. Heavy taxation on energy use has also driven consumers to improve efficiency and decrease their energy usage.

6.1.4 CONTINUING DEVELOPMENT

The scheme in Copenhagen is constantly being developed, with more connections, a wider distribution network and more CHP power stations being built. This is a result of the strong incentive framework and the continued commitment to lowering carbon levels by regional and national government.

The Danish Heat Law has never legislated for district cooling. However there has been an increasing call for this facility to be made available, particularly by large office based companies. Copenhagen City is in the process of constructing the first district cooling system in Denmark and it is anticipated that this scheme will drive the method by which a policy on district cooling is introduced.

6.2 SOUTHAMPTON DISTRICT HEATING SCHEME

6.2.1 DESCRIPTION

Again as a result of the oil price shock in the 1970s the Department of Energy (as was) commissioned research investigating the potential for using alternatives to fossil fuel in the UK. The presence of medium grade geothermal heat below Southampton was identified as having the potential to be utilise in a district heating scheme. On the back of this research Southampton City Council set up a partnership with Utilicom [39]forming the Southampton Geothermal Heating Company, SGHC, launching the DH scheme in 1986. GSHC as a company is wholly owned by Utilicom but with representatives from the council providing an advisory role. The original commercial agreement still stands, in 2005 the Council and Utilicom extended their agreement for a further 25 years showing the effective nature of the partnership, a critical part of the schemes successes.

The geothermal source is a mile beneath the surface and provides SGHC with brine at around 74˚C at the surface. The heat is extracted from the brine, it is then pumped to the sea at around 28˚C. Geothermal heat contributes approximately 18% of the total district heating energy, with the rest of demand being met by gas and oil fired CHP. The scheme meets some or all of the heating/cooling requirements of a number of hotels, large retail stores, two housing developments, a hospital, the university and a number of council buildings.

Since 2008 an agreement between SGHC and Associated British Ports Southampton has meant that all electricity produced that is not used to power the DH network has been delivered via a private wire to the Port; this supplies more than 50% of the Port's annual electricity demand.

6.2.2 SUCCESSES FACTORS

The partnership between Utilicom and the Council has been a key reason behind the schemes continuing success. A "learning history" produced by the University of Bath with input from three key people from the Council and Utilicom sheds some light on the reasons why the partnership has worked. In summary some key points are noted here:

- Cross party support has allowed the scheme to go ahead without the concern of the scheme becoming a political issue.
- Both parties meet every six weeks to discuss the scheme, this promotes constant development and pushes the scheme forward constantly.
- A specific resource was identified which gave the scheme as initial foundation.

[39] Now called Cofely District Energy Ltd.

- Risks (financial, reputational) were shared between parties and to the party who was best positioned to mitigate each risk.
- A drive to push through each obstacle along the way, generally by agreeing to financial commitments such as digging a well, laying pipework etc.

6.2.3 OBSTACLES

The scheme has faced particular difficulties at times, in particular Simon Woodward, CEO Utilicom, notes that as of 1996 the scheme had not made a profit despite its numerous connections. Further investment was needed to install a 5.7 MW CHP engine at this point this enabled a long term electricity sales contract to the Port helped, thus make the scheme profitable. The scheme also suffered early on from an unwillingness of potential customers to connect to the scheme; this was due to the unfamiliarity with DH schemes in the UK at the time.

6.2.4 FUTURE DEVELOPMENT

As discussed the agreement between Utilicom and the Council has been extended for a further 25 years. Southampton City Council has a sustainability vision for the future which is heavily focussed on the DH scheme[40]:

- The DH scheme will continue to expand and CHP plants will be added as the customer base expands.
- Renewable energy will be integrated with the DH scheme, initially in the form of a proposed 1MW biomass plant.

6.3 NOTTINGHAM DISTRICT HEATING SCHEME

6.3.1 DESCRIPTION

Another of the largest DH schemes in the UK is found in Nottingham. The scheme utilises steam from the Eastcroft Waste Incinerator to produce electricity and heat to distribute to customers. A scheme

[40] Energising Southampton – A sustainable energy vision for the city to 2026, Southampton City Council, 2006.

has been in operation since 1972 and has been made up of various arrangements throughout the years; in November 2000 the scheme ran into financial difficulty when the NFFO (Non Fossil Fuel Obligaton) agreement of electricity supply expired leading to a significant annual loss. After lengthy negotiations with Dalkia, who were part operating the scheme at the time, Nottingham City council took over the scheme setting up Enviroenergy Limited in 2001 to operate and maintain the facility to produce and distribute the heat and power for the scheme. The Eastcroft incinerator which supplies the steam to Enviroenergy is owned and operated by Waste Recycling Group. Electricity produced by the scheme is distributed to customers via a private wire network.

Some of the commercial customers making use of the energy produced by the scheme include Nottingham Trent University, the Victoria and Broad Marsh Shopping centres and a number of council buildings. In addition the scheme provides heat to some 4,600 domestic properties in the area.

Financial losses were ongoing when the Council took over control of the project but the scheme is now expanding with a £1.9million programme to extend the scheme to a regeneration zone and Nottingham Railway Station. There are also plans to expand the Eastcroft incinerator and it is considered likely that Environenergy will use the extra steam capacity to further expand the scheme.

6.4 DUNKIRK & SAINT-POL-SUR-MER

6.4.1 DESCRIPTION

The City of Dunkirk and its adjacent suburb Saint-Pol-sur-Mer are served by a district heating scheme operated by the Dunkirk Intercommunity District Heating Council, SICURD (Syndicat Intercommunal de Chauffage Urbain de la Région de Dunkerque). The scheme has been operating since 1985 and serves a significant portion of the cities energy needs.

The scheme is powered by the waste heat which is recovered from ArcelorMittal's Steel works. This site has been in use since 1963 and uses over 1% of Frances total generated energy. Energy recovery is done by the extraction of hot air from the cooling beds of the plant, there is currently a total of 28MW of heat available. This contributes just over 60% of the energy used within the network and the rest is met via a number of gas and oil fired auxiliary units throughout the city.

6.4.2 CONTINUED INVESTMENT

The project was begun as a response to the oil crises through the 1970s, a common theme amongst many DH schemes. However just as the network was brought on line in 1986 the drop in oil prices at the time meant the DH scheme was not performing as economically as hoped. Despite this continued investment in the scheme has enabled the scheme to flourish and in fact it is due to increase in size by 20% before 2012.

6.4.3 COMMUNICATION

Every year the schemes' environmental, technical and financial performance is communicated to its customers. Customers also give feedback and recommendations on how the scheme can be improved. This two way communication has helped encourage take up of connections throughout the life of the scheme. In addition every year the price of the scheme is compared against an all gas alternative to maintain the cheap pricing structure. Users have driven the tariff system to a simple structure, with a fixed standing charge and a variable element based upon heat metering. As the cost of recovering energy is not directly tied to the cost of fossil fuels then the variable rate does also not change in its entirety with fossil fuel prices.

6.5 CAITHNESS HEAT AND POWER, CHAP

6.5.1 DESCRIPTION

The CHaP project which was switched on in 2006 was designed to supply heat to the community of Wick in Scotland, an area with higher than average fuel poverty. The scheme has been dogged by technical and commercial problems, many of which remain unresolved. The DH network in Wick was originally designed to meet the needs of housing in the town, the local assembly buildings and the hospital and distillery. Currently 283 homes have signed up for connection to the network.

6.5.2 TECHNOLOGY

The choice of technology for delivery of heat to the network was a wood-chip fuelled gasification CHP. This technology has been around for many decades, however there are very few large scale operations around the world. The principle is that wood is combusted in a controlled low oxygen environment, causing the release of gas from the wood. This gas is then used in a gas CHP engine to produce heat and power. The heat from the process was to be used in the DH network and the electricity was to be sold to the grid to maximise revenue for the scheme. Unfortunately the gasification plant has suffered from problems relating to choice of technology and the nature of the wood fuel supply. The scheme is currently operating on oil fired boilers, resulting in higher operating costs than anticipated.

6.5.3 RISK

The plant has a complex arrangement, with responsibility for various parts of the plant spread over a number of stakeholders. The projects risks were not appreciated by all parties and as such contractual relations were not sufficiently tensioned to ensure the scheme was run to its full potential.

6.5.4 FUTURE OF THE SCHEME

The highland council are currently in the process of selecting a way forward. Potential solutions include a redesign plant or maybe even an entirely new technology to supply the heat and power for the scheme. Once a suitable technology is selected and the contractual relations are resolved there is no reason why the scheme could not be a success in the future, supplying the local community with low carbon, low cost heating.

6.6 THE WARREN, WOOLWICH, SE LONDON – SCOTTISH AND SOUTHERN ENERGY

This project is an example of a single developer site – The Warren is part of the redevelopment of the former Woolwich Arsenal site in South East London. The Warren, which was developed by house builder Berkeley Homes, is a development of approximately 200 apartments with related retail and leisure facilities. Berkeley Homes selected Scottish and Southern Energy (SSE) as their preferred ESCo to provide energy services to the site as part of a competitive tender process.

The SSE ESCo provides a community heating utility service to each apartment. Energy supply to the networks is provided by a gas engine CHP, gas boilers and a connection to the local electricity distribution network. The capital for the development is provided by SSE with the basic recovery for the investment from bills to the residents. A contribution was required from the developer to allow SSE to achieve their required return on the investment. This approach is equivalent to the connection charge normally levied by a utility for connection of a development site. In this case SSE also provided gas and electrical connections to the site for Berkley Homes thus reducing risk for the developer.

SSE was responsible for design, procurement and installation of the utility connections, CHP plant, electrical and heat distribution and individual dwelling hydraulic interface units. SSE provides ongoing operation and maintenance services for the plant and equipment and billing and customer services for the residents.

6.7 KINGS CROSS – METROPOLITAN

The project is being undertaken by the property developer, Argent St George, on a large site in central London, in between the Kings Cross and St Pancras mainline railway stations. It comprises development of over 2,000 residential units and over 600,000m^2 of commercial space (retail, office, hotels, leisure) over a period of around 10 years.

The business structure most closely reflects that of a joint venture whereby the developer went through a competitive bidding process to identify their preferred partner in delivery of the energy infrastructure. The partnership established with Metropolitan, an infrastructure services and management company, involves sharing the burden of capital investment in the energy centre and the buried infrastructure.

The partnership has commissioned engineering contractors to design and construct the energy centre and the heat networks. On completion, the partnership will purchase the energy assets from the contractors and operate them as an ESCo operation. Argent and Metropolitan will charge tenants for connection to the buildings located on the site and Metropolitan, who will take ownership of the buried infrastructure, will charge rents for use of the network systems. The energy centre assets will be taken over by Argent, who is likely to commission a managing party to supervise operations over a contracted term, likely to be at least ten years, with economic performance assessed against Key Performance Indicators. These Key Performance Indicators will incentivise the delivery of services on a value-for-money basis.

This structure reflects a relatively cash positive business model for infrastructure projects whereby there is a financial commitment by tenants at the outset of occupancy and then an ongoing recovery of investment over the project lifetime.

6.8 OLYMPIC PARK - COFELY

The Olympic Delivery Authority and Stratford City Development Limited decided to cooperate in the provision of utilities and low carbon energy to their adjacent sites at Stratford in east London. They undertook a joint procurement to select a Concessionaire for the supply of heating and cooling services to the two developments. Cofely East London Energy Limited (a subsidiary of Gaz de France Suez) was selected and is currently constructing two energy centres, one at Kings Yard and the other in Stratford City, and more than 20 km of heating and cooling distribution mains.

The energy centres will contain combined cooling heating and power plants (CCHP) comprising gas fired CHP, biomass boilers, absorption chillers, gas/oil boilers and electric chillers. Cofely provide all the investment for the system and will own and operate it for a period of 40 years from full operation. Heating and cooling is sold in bulk to commercial users and residential blocks via metered block heat exchange substations, with an option for developers to request Cofely that install and manage the internal systems up to individual HIU's. Electricity generated is sold to a licensed supplier via the DNO connection.

Cofely has exclusive rights to supply heat and cooling within the concession area and a standard tariff and connection agreement has been agreed as part of the appointment process. The agreements set up a local regulatory structure for the concession area, including standards of service and price variation controls, such that Cofely will act as a pseudo utility within the area. The tariff allows for a fee at connection to be collected from an individual developer, based on the connection capacity (kW) or residential area, along with annual availability charges and metered energy charges to be collected from building owners or management companies. Cofely is also able to compete for supply connections outside the concession area on a commercial basis.

This structure allows flexibility for this extensive development area, where the final masterplan development is not yet known and there will be multiple individual development plot areas, whilst guaranteeing a set of environmental targets, set by planning, can be met.

6.9 BIRMINGHAM DISTRICT ENERGY COMPANY

Birmingham City Council identified two potential schemes for district energy in Birmingham in 2003. These were the Broad Street scheme, which would supply the International Conference Centre, National Indoor Arena, a hotel and various BCC buildings, and the Eastside scheme centred around Aston University, Birmingham Children's Hospital (BCH) and other BCC buildings. BCC selected Utilicom as their partners to develop these schemes in 2006.

The Birmingham District Energy Company (BDEC) is wholly owned by Utilicom and currently operates the two originally identified schemes. There are several proposals for further expansion of these schemes but it is not clear that this has been done as yet.

The Broad Street Scheme obtained Community Energy Programme funding and was the first scheme completed in October 2007. The Eastside scheme is being developed in two phases centred around energy centres in Birmingham Children's Hospital and Aston University respectively. The CHP plant for Aston, installed in July 2009, was fully funded by Utilicom and will shortly be operational. The BCH scheme was signed up earlier this year and is applying for funding from the Department of Health. It is not currently clear whether these two phases are interconnected immediately but the future intention to interconnect with the Broad Street scheme is clear. Each scheme has been developed by BDEC under a separate 25 year Energy Services Agreement. The development of the scheme is being supported significantly by the BCC Urban Design team and is championed by Councillor Paul Tilsley.

6.10 PIMLICO DISTRICT HEATING UNDERTAKING

The Pimlico District Heating Undertaking (PDHU) was originally designed to use heat from the Battersea Power station to supply heating to local authority housing in and around the Pimlico district of London. Heat was taken from the power station during the night time, demand on the plant was lower, and stored in a 2,500M^3 thermal store. Heat was then distributed to the customers via burred pipework. When the power station closed in 1980 the scheme continued to operate, supplied from boilers located next to Battersea. The scheme underwent a major overhaul in 2006/07 when two gas engine CHP units and 3 new gas boilers were installed in what used to be the pumping station. The scheme now supplied around 4,000 dwellings and numerous commercial outlets. There are ongoing extension plants that aim to pick up new development in the Victoria area. The London Development Agency has initiated a study to investigate the practicality of connecting the PDHU scheme with a nearby wcheme in Whitehall, thereby creating a area wide district heating scheme to supply the SW1 area of London. The scheme is owned by City west Homes, an Arms Length Management organisation responsible for social housing provision in Westminster.

6.10.1 SUCCESS FACTORS

The ongoing success of the scheme is partly due to the continued public sector support from City West Homes. The majority of the heat customers are ‘captive’ social housing tenants who provide the scheme with guaranteed long-term income from heat sales. The scheme continues to offer non-residential customers heat at a competitive price, therefore providing a low-cost alternative to individual boiler plant. The strong regulatory framework in London actively encourages/forces developers to investigate the practicality of connecting to nearby district heating schemes. For this reason the number of new customers connecting to the PDHU scheme has increased in recent years.

APPENDIX B

HEAT SUPPLY QUESTIONNAIRES

7 HEAT SUPPLY QUESTIONNAIRES

7.1 BIO ENERGY INVESTMENTS

1. Describe the plant and fuel mix used to produce the available heat, including an outline description of all heat generation plant, power plant and thermal storage on site.

200MWt biomass fuelled power plant generating 50MWe for export to the grid, 50MWt will go the stack and other heat losses, leaving 100MWt available. The non chp system would have air cooled condensers for the non recoverable or ‘waste’ heat. There is no thermal storage designed as of yet.

2. Will the plant currently supply heat on-site or to 3rd parties? If so, will it be CHPQA compliant?

The plant may provide heat to an industrial neighbour but would not be enough to comply with GN10 definition.

3. What are the characteristics of the available heat (steam/water, temperature, pressure etc.)?

Under non-chp conditions it would be 40°C under low pressure. Under CHP it could be 95°C

4. What modifications would be needed to supply heat at 95°C with a 30 to 40°C delta T to 3rd parties?

The plant could tap off steam to boost the waste hot water temperature up to 95°C, however we would wish to consider the use of heat pumps to raise the temperature.

5. Have there been any previous studies undertaken to explore the feasibility of operating the plant to supply heat to 3rd parties?

We have undertaken our own studies and are designing the plant to be heat main ready.

6. Are there any known physical constraints to taking heat off site? Where would the preferred site exit point be?

BEI would be able to run the pipes under the Tees to a point on the south bank at Middlesbrough.

7. What is the peak and annual heat off-take that can be accommodated?

There is a constant supply of heat of 100MWt at 40°C. The availability will be roughly 8000 hours a year. Over 90% annually.

8. Are there any restrictions on the magnitude and duration of heat off-take, i.e. what is the heat availability profile?

No restrictions.

9. If supplying heat from an electricity generation plant, how many units of electricity would be lost per unit of heat off-take? Please supply a heat-to-power ratio curve if available.

4 units of heat per unit of electricity.

10. Is there a corporate Climate Change Agreement, CSR or sustainability objective that would be satisfied if the plant were to supply heat to 3rd parties?

No

11. Is there a corporate policy/position statement on the supply of heat to 3rd parties?

Yes, we aim to supply the whole of Middlehaven and large heat users requiring space heating in Middlesbrough.

12. What internal approval mechanisms are needed before you could agree in principle to supply heat to a district heating network?

None.

13. At an appropriate time, would you be willing to sign a Memorandum of Understanding with respect to heat supply?

yes

14. What expectation do you have as to the value of the heat you would supply?

This depends on whether the plant would supply enough heat to become accredited as GQCHP and receive .5 ROC, if not then we would want to see the results of the Renewable Heat Incentive and the value they place on renewable heat.

15. What level of involvement would you seek to take in any heat supply company?

We would be very keen to play a part in the heat supply company.

Completed by: .Matthew Day – Project Director; BEI......................................

7.2 GAIA POWER

1. Describe the plant and fuel mix used to produce the available heat, including an outline description of all heat generation plant, power plant and thermal storage on site.
The plant uses recycled wood to generate steam which is used in power generation. There is a low pressure bleed off the steam turbine to take steam to the thermal host (up to 25 tph at 2.3 bar(a) with slight superheat
2. Does/will the plant supply heat on-site or to 3rd parties? If so, is it/will it be CHPQA compliant?
The plant supplies heat on site and is CHPQA compliant
3. What are the characteristics of the available heat (steam/water, temperature, pressure etc.)?
Up to 25 tph at 2.3 bar (a) slight superheat
4. What modifications would be needed to supply heat at 95°C with a 30 to 40°C delta T to 3rd parties?
The plant uses a river cooled condenser. I believe an intermediate cooling loop could be put in whereby the cooling water exited our site at the required hot water conditions.
5. Have there been any previous studies undertaken to explore the feasibility of operating the plant to supply heat to 3rd parties?
Yes. Steam to local businesses. The steam offtake is sized to suit the local LP steam distribution system
6. Are there any known physical constraints to taking heat off site? Where would the preferred site exit point be?

The largest constraint will be wayleaves over the railway line between the plant and potential users

7. What is the peak and annual heat off-take that can be accommodated?

25tph at 2.3 bar (a)

8. Are there any restrictions on the magnitude and duration of heat off-take, i.e. what is the heat availability profile?

The plant is base load, a flat annual profile is preferred

9. If supplying heat from an electricity generation plant, how many units of electricity would be lost per unit of heat off-take? Please supply a heat-to-power ratio curve if available.

The intention would be to over-fire the boiler so that power output was not effected, hence the limit of 25tph

10. Is there a corporate Climate Change Agreement, CSR or sustainability objective that would be satisfied if the plant were to supply heat to 3rd parties?

Our corporate goal is met by achieving the CHPQA via the thermal sales indicated above

11. Is there a corporate policy/position statement on the supply of heat to 3rd parties?

No

12. What internal approval mechanisms are needed before you could agree in principle to supply heat to a district heating network?

Board Approval

13. At an appropriate time, would you be willing to sign a Memorandum of Understanding with respect to heat supply?

Yes

14. What expectation do you have as to the value of the heat you would supply?
Depends on volumes and reliability

15. What level of involvement would you seek to take in any heat supply company?
Arms length contract

Completed by: ..A Dickinson Gaia Power Limited...................................

7.3 SEMBCORP

Awaiting permission to include data.

APPENDIX C

KEY ASSUMPTIONS IN HEAT LOAD MAPPING

8 KEY ASSUMPTIONS IN HEAT LOAD MAPPING

8.1 EXISTING STOCK – DOMESTIC

The heat demand of the existing social housing has been quantified on the basis of estimations derived from the "Energy Use in Homes: A series of reports on domestic energy use in England: Energy Summary Report". These figures have been combined with the data on social housing numbers as found within the Census 2001 to generate data on the density of social housing by census output area (COA) within the study geography.

Table 8-1 Domestic Energy Use Gas Consumptions

Name	Description	Mean Gas Consumption (kWh/year)
Type 1	House or Bungalow: Detached	24,300
Type 2	House or Bungalow: Semi-detached	20,075
Type 3	House or Bungalow: Terraced (including end-terrace)	17,850
Type 4	Flat, Maisonette or Apartment	Not used
Type 5	Flat, Maisonette or Apartment: In a Purpose-Built Block of Flats	12,500
Type 6	Flat, Maisonette or Apartment: Part of a Converted or Shared House	17,450

Type 7	Flat, Maisonette or Apartment: In a Commercial Building	17,450
Type 8	Caravan or Other Mobile or Temporary Structure	4,400
Type 9	In a Shared Dwelling	16,667

An assumption on average domestic boiler efficiency for the existing stock has been derived based on a Boiler Efficiency Model developed for the Market Transformation Programme. This includes the following assumptions:

Table 8-2 Domestic Boiler efficiency Assumptions

Boiler type	Frequency of occurrence
15 years or older (e.g. G-rated boiler)	7.0%
New Non condensing boilers	41.1%
New Condensing boilers	1.9%

Table 8-3 Domestic boiler efficiency assumptions by boiler type

Seasonal efficiency

Old boiler (heavy weight)	55%
New boiler (non-condensing)	78%
New boiler (condensing	88%

A summary of the average heat energy demand assumption for the key priority areas identified in this report is shown below, derived from the assumptions above:

Table 8-4 Dwelling type mix and average domestic demand for existing stock

Dwelling Mix by Area (*obtained from the 2001 Census data UV56)*

	Detached	Semi-detached	**Terraced**	Flat	Average H/hold heat demand
Darlington	14.3%	33.2%	41.3%	11.2%	13,032
Stockton-on-Tees	22.0%	42.5%	25.3%	10.2%	13,533
Middlesbrough	12.5%	38.6%	37.6%	11.3%	13,033
Redcar/Cleveland	16.0%	44.9%	30.0%	9.1%	13,328

8.2 FUTURE DOMESTIC LOAD ASSUMPTIONS

Future domestic heat (and electrical) demands have been estimated on the basis of calculations carried out using the Building Research Establishment Domestic Energy Model (BREDEM12), which permits the total energy requirement (including emissions associated with lights, appliances and cooking) to be calculated[41]. A base model for 2006 compliant dwellings has been constructed for each dwelling type, and demands at future levels of the Code for Sustainable Homes have been estimated on the basis of these 2006 figures.

The base figures provided are calculated for dwellings built to the Approved Document L1A 2006 regulatory standards. The CO_2 emissions assume that the heating, hot water and cooking fuel is mains gas for all dwelling types. It is assumed that no secondary heating is provided and that all of the space heating and hot water requirement is met by the main heating system (86 per cent efficient).

The figures adopted are as shown below:

Table 8-5 2006 BR Compliant Demands

		Detached	**Semi-detached**	**Terraced**	**Flat**
	ESTIMATED FLOOR AREA (m^2)	104	89	79	61
SH and DHW(HEAT) (kWh/year)	2006 BR - 2009	7,063	5,723	4,980	4,371
ELECTRICITY (kWh/year)	2006 BR - 2009	3,635	3,057	2,719	2,201

[41] Source: Energy Savings Trust, Meeting the 10 per cent target for renewable energy in housing – a guide for developers and planners ,http://www.energysavingtrust.org.uk/Publication-Download/?p=1&pid=862, accessed 21st June 2010

The demand reductions factors assumed in space heating and hot water for the various levels of the CfSH are shown below.

Table 8-6 - SH and DHW demands at different CSH levels

		Detached	Semi-detached	Terraced	Flat
SH and DHW[42]	LEVEL 3 - (2010 -2012)	20%	20%	20%	10%
	LEVEL 4 - (2013-2015)	30%	30%	30%	20%
	LEVEL 6 - (2016 onwards)	45%	45%	45%	40%
	LEVEL 3 - (2010 -2012)	5,651	4,579	3,984	3,934
	LEVEL 4 - (2013-2015)	4,944	4,006	3,486	3,497
	LEVEL 6 - (2016 onwards)	3,885	3,148	2,739	2,623

Table 8-7 Electricity demands at different CSH levels

	Detached	Semi-detached	Terraced	Flat

[42] Expressed as heat demands, not fossil fuel demands

ELECTRICITY	LEVEL 3 - (2010 -2012)	15%	12%	12%	12%
	LEVEL 4 - (2013-2015)	15%	12%	12%	12%
	LEVEL 6 - (2016 onwards)	18%	16%	16%	16%
	LEVEL 3 - (2010 -2012)	3090	2690	2393	1937
	LEVEL 4 - (2013-2015)	3090	2690	2393	1937
	LEVEL 6 - (2016 onwards)	2981	2568	2284	1849

8.3 EXISTING NON-DOMESTIC BUILDING

It was assumed at the heat load mapping stage that the greatest opportunity for district heating network development within the non-domestic sector will come from public buildings. As a result, data from Display Energy Certificates (DECs) have been used to compile an overview of the heat demands of public buildings in each area.

Display Energy Certificates (DECs) show the actual energy usage of a building, and help the public see the energy efficiency of a building. This is based on the energy consumption of the building as recorded by gas, electricity and other meters. Display Energy Certificates are only required for buildings with a total useful floor area over 1,000m^2 that are occupied by a public authority and institution providing a public service to a large number of persons and therefore visited by those persons. They are valid for one year. The requirement for Display Energy Certificates came into effect on 1 October 2008.

Whilst DECs record gas / other fuel consumptions, to generate a heat demand figure, a boiler conversion efficiency of 78.5% has been assumed for existing non-domestic buildings.

8.4 FUTURE NON-DOMESTIC

Demands for non-domestic buildings to be developed in the future have been estimated on the basis of benchmarks contained within the CIBSE Guide TM46:2008 based on the information available of their proposed uses. Guide TM46:2008 expresses energy consumption as fossil fuel use, and a boiler efficiency of 80% has been assumed for this category of uses.

Table 8-8 Future Non-Domestic Energy Usage Assumptions

End Use	CIBSE TM46:2008 Category and Type		Electricity (kWh/m^2)	Fossil thermal (kWh/m^2)
B1	1	General Office	95	120
A2	2	High Street Agency	140	140
A1	3	General Retail	165	165
A3	7	Restaurant	90	370
A4	8	Bar, pub or club	130	350
C1A	9	Hotel	105	330
D1CU	10	Cultural activities	70	200
D2	13	Fitness and health centre	160	440

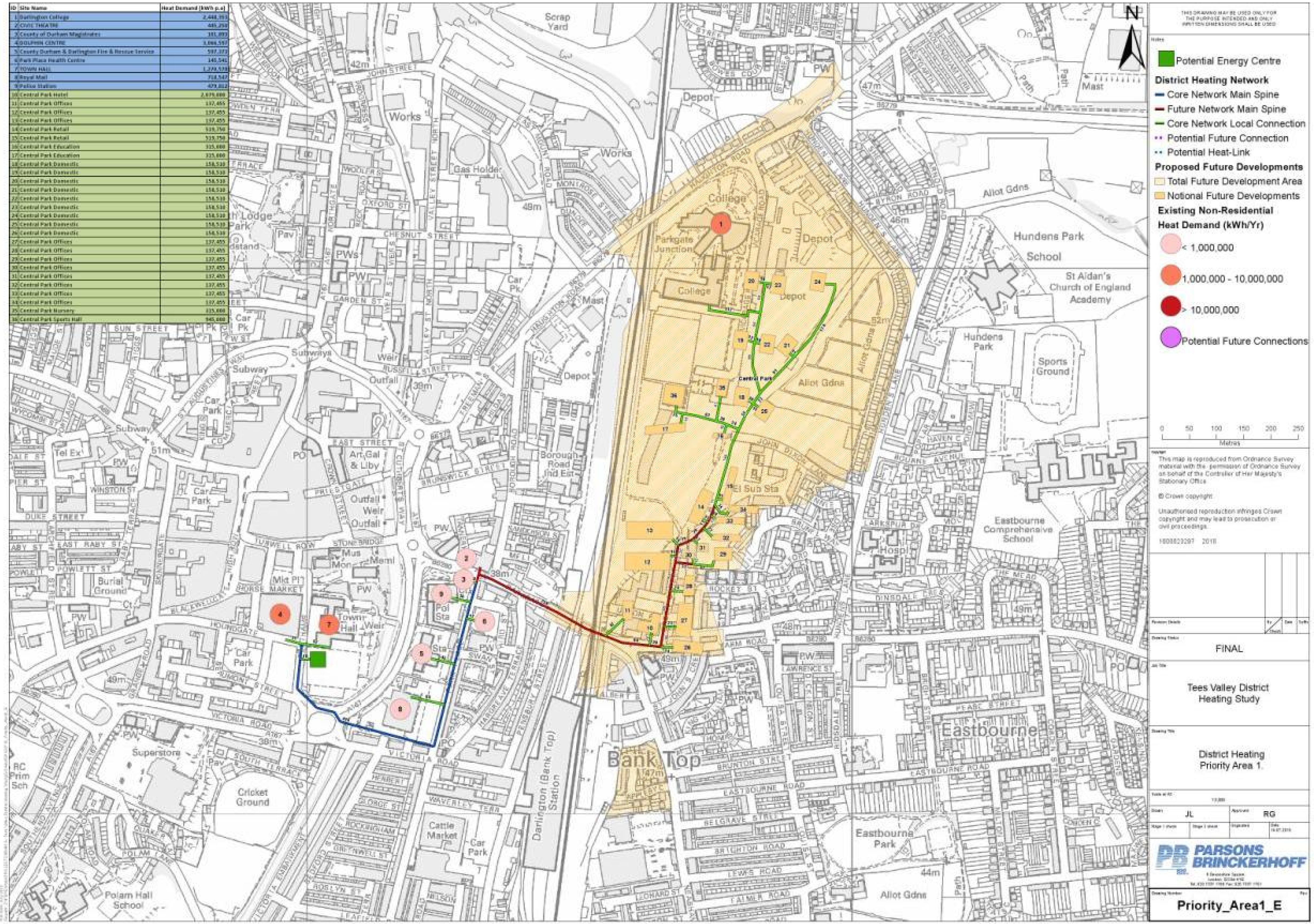
D1ED	17	Schools and seasonal public buildings	40	150
D1CL	19	Clinic	70	200
D1HO	20	Hospital (clinical and research)	90	420
C3S	22	General accommodation	60	300

NB for the identified Priority Areas, a reduction in loads against TM46:2008 figures has been assumed in order to take account of increasing stringency of energy regulation and other incentives for increasing energy efficiency.

APPENDIX D

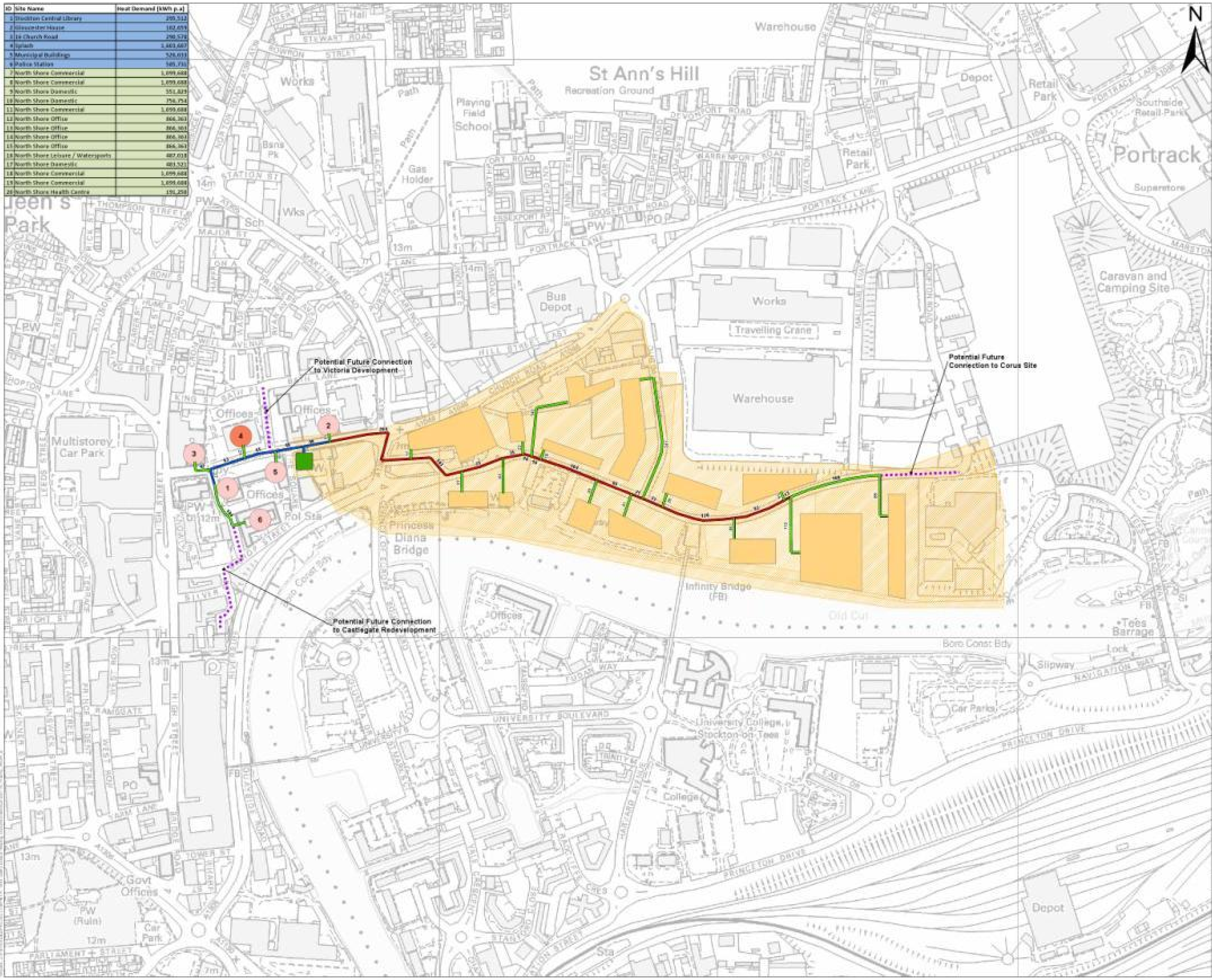
HEAT LOAD DENSITY MAPPING

9 HEAT LOAD DENSITY MAPPING



ID	Site Name	Heat Demand (kWh p.a)
1	Darlington College	2,448,393
2	CIVIC THEATRE	445,250
3	County of Durham Magistrates	181,893
4	DOLPHIN CENTRE	3,866,597
5	County Durham & Darlington Fire & Rescue Service	597,373
6	Park Place Health Centre	140,541
7	TOWN HALL	1,229,578
8	Royal Mail	718,547
9	Police Station	479,812
10	Central Park Hotel	2,079,000
11	Central Park Offices	137,455
12	Central Park Offices	137,455
13	Central Park Offices	137,455
14	Central Park Retail	519,750
15	Central Park Retail	519,750
16	Central Park Education	325,000
17	Central Park Education	325,000
18	Central Park Domestic	158,530
19	Central Park Domestic	158,530
20	Central Park Domestic	158,530
21	Central Park Domestic	158,530
22	Central Park Domestic	158,530
23	Central Park Domestic	158,530
24	Central Park Domestic	158,530
25	Central Park Domestic	158,530
26	Central Park Domestic	158,530
27	Central Park Offices	137,455
28	Central Park Offices	137,455
29	Central Park Offices	137,455
30	Central Park Offices	137,455
31	Central Park Offices	137,455
32	Central Park Offices	137,455
33	Central Park Offices	137,455
34	Central Park Offices	137,455
35	Central Park Nursery	325,000
36	Central Park Sports Hall	945,000

ID	Site Name	Heat Demand (kWh p.a)
1	Stockton Central Library	299,512
2	Gloucester House	182,659
3	16 Church Road	290,576
4	Splash	1,463,687
5	Municipal Buildings	526,033
6	Police Station	585,732
7	North Shore Commercial	1,099,688
8	North Shore Commercial	1,099,688
9	North Shore Domestic	551,829
10	North Shore Domestic	756,754
11	North Shore Commercial	1,099,688
12	North Shore Office	866,363
13	North Shore Office	866,363
14	North Shore Office	866,363
15	North Shore Office	866,363
16	North Shore Leisure / Watersports	487,018
17	North Shore Domestic	483,521
18	North Shore Commercial	1,099,688
19	North Shore Commercial	1,099,688
20	North Shore Health Centre	191,258



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

Notes

Potential Energy Centre

District Heating Network

- Core Network Main Spine
- Future Network Main Spine
- Core Network Local Connection
- Potential Future Connection
- Potential Heat-Link

Proposed Future Developments

- Total Future Development Area
- Notional Future Developments

Existing Non-Residential Heat Demand (kWh/Yr)

- < 1,000,000
- 1,000,000 - 10,000,000
- > 10,000,000
- Potential Future Connections

0 50 100 150 200 250 Metres

Drawing Status: FINAL

Job Title: Tees Valley District Heating Study

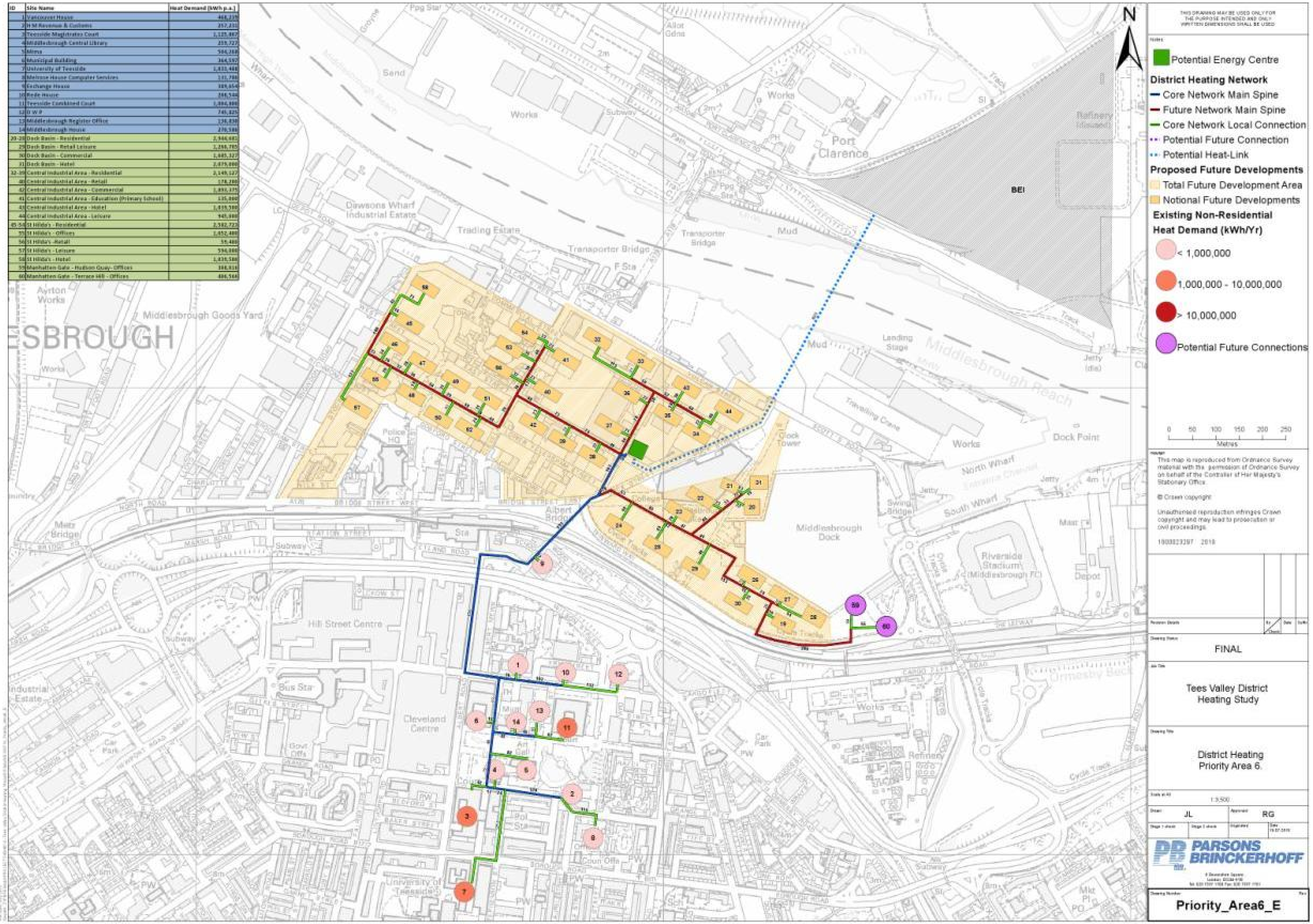
Drawing Title: District Heating Priority Area 4

Scale at A3: 1:3,000

Drawn: JL | Approved: RG

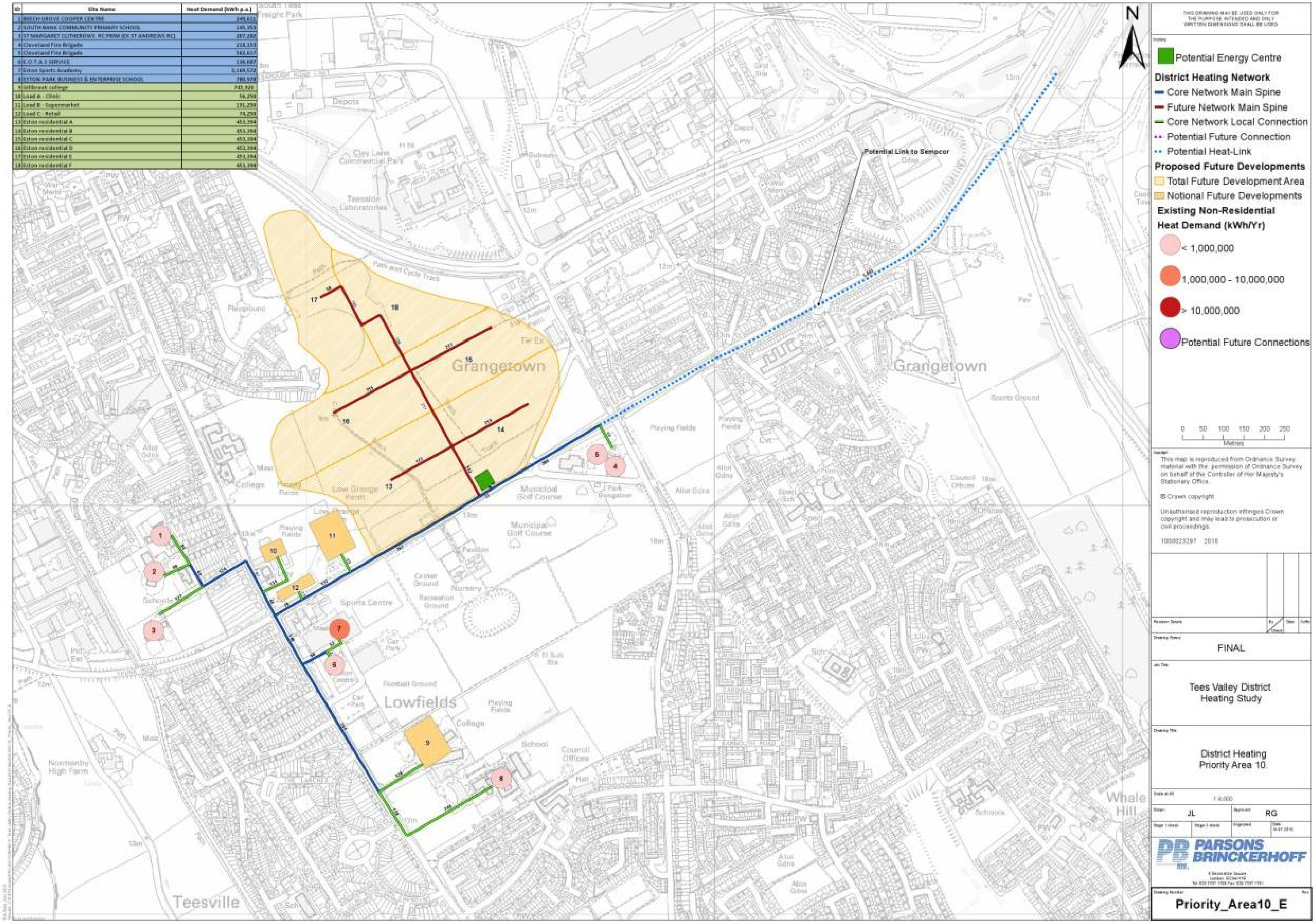
PARSONS BRINCKERHOFF

Drawing Number: Priority_Area4_E



ID	Site Name	Heat Demand (kWh p.a.)
1	Vancouver House	468,239
2	H M Revenue & Customs	257,231
3	Teesside Magistrates Court	1,125,867
4	Middlesbrough Central Library	259,727
5	Mima	594,268
6	Municipal Building	364,597
7	University of Teesside	1,833,488
8	Melrose House Computer Services	131,786
9	Exchange House	389,654
10	Bede House	288,544
11	Teesside Combined Court	1,886,888
12	D W P	745,825
13	Middlesbrough Register Office	136,838
14	Middlesbrough House	279,586
20-28	Dock Basin - Residential	2,946,681
29	Dock Basin - Retail Leisure	1,256,785
30	Dock Basin - Commercial	1,685,327
31	Dock Basin - Hotel	2,875,898
32-39	Central Industrial Area - Residential	3,149,127
40	Central Industrial Area - Retail	178,288
42	Central Industrial Area - Commercial	1,893,375
41	Central Industrial Area - Education (Primary School)	135,898
43	Central Industrial Area - Hotel	1,859,588
44	Central Industrial Area - Leisure	945,888
45-54	St Hilda's - Residential	2,582,723
55	St Hilda's - Offices	1,852,488
56	St Hilda's -Retail	59,488
57	St Hilda's - Leisure	594,888
58	St Hilda's - Hotel	1,839,588
59	Manhattan Gate - Hudson Quay - Offices	388,831
60	Manhattan Gate - Terrace Hill - Offices	486,564

ID	Site Name	Heat Demand (kWh p.a.)
1	BEECH GROVE COOPER CENTRE	249,621
2	SOUTH BANK COMMUNITY PRIMARY SCHOOL	145,354
3	ST MARGARET CLITHEROWS RC PRIM (EX ST ANDREWS RC)	287,282
4	Cleveland Fire Brigade	218,153
5	Cleveland Fire Brigade	562,617
6	K.O.T.A.S SERVICE	136,887
7	Eston Sports Academy	3,169,572
8	ESTON PARK BUSINESS & ENTERPRISE SCHOOL	780,978
9	Gillbrook college	745,920
10	Load A - Clinic	56,250
11	Load B - Supermarket	191,250
12	Load C - Retail	74,250
13	Eston residential A	453,394
14	Eston residential B	453,394
15	Eston residential C	453,394
16	Eston residential D	453,394
17	Eston residential E	453,394
18	Eston residential F	453,394



APPENDIX E

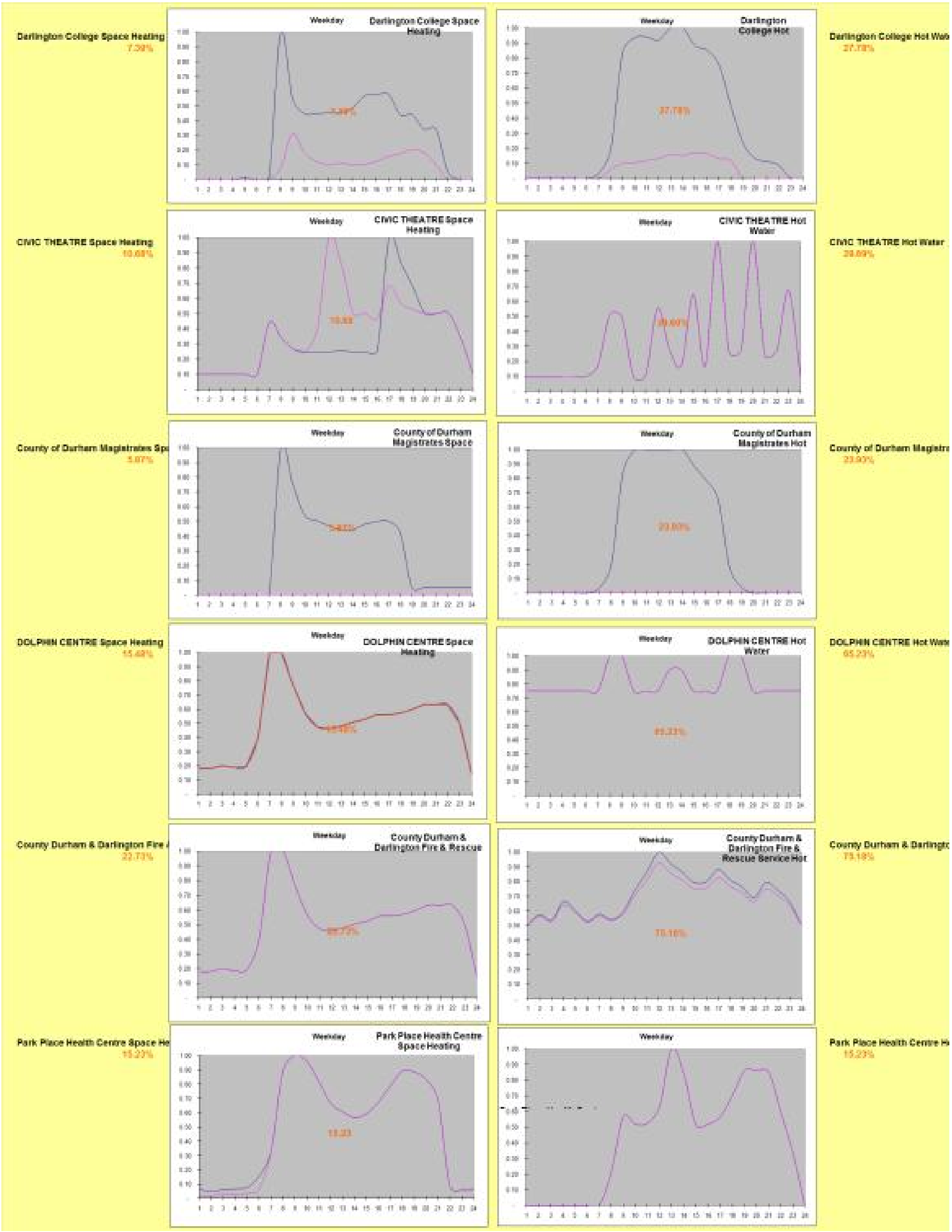
INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS

10 INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS

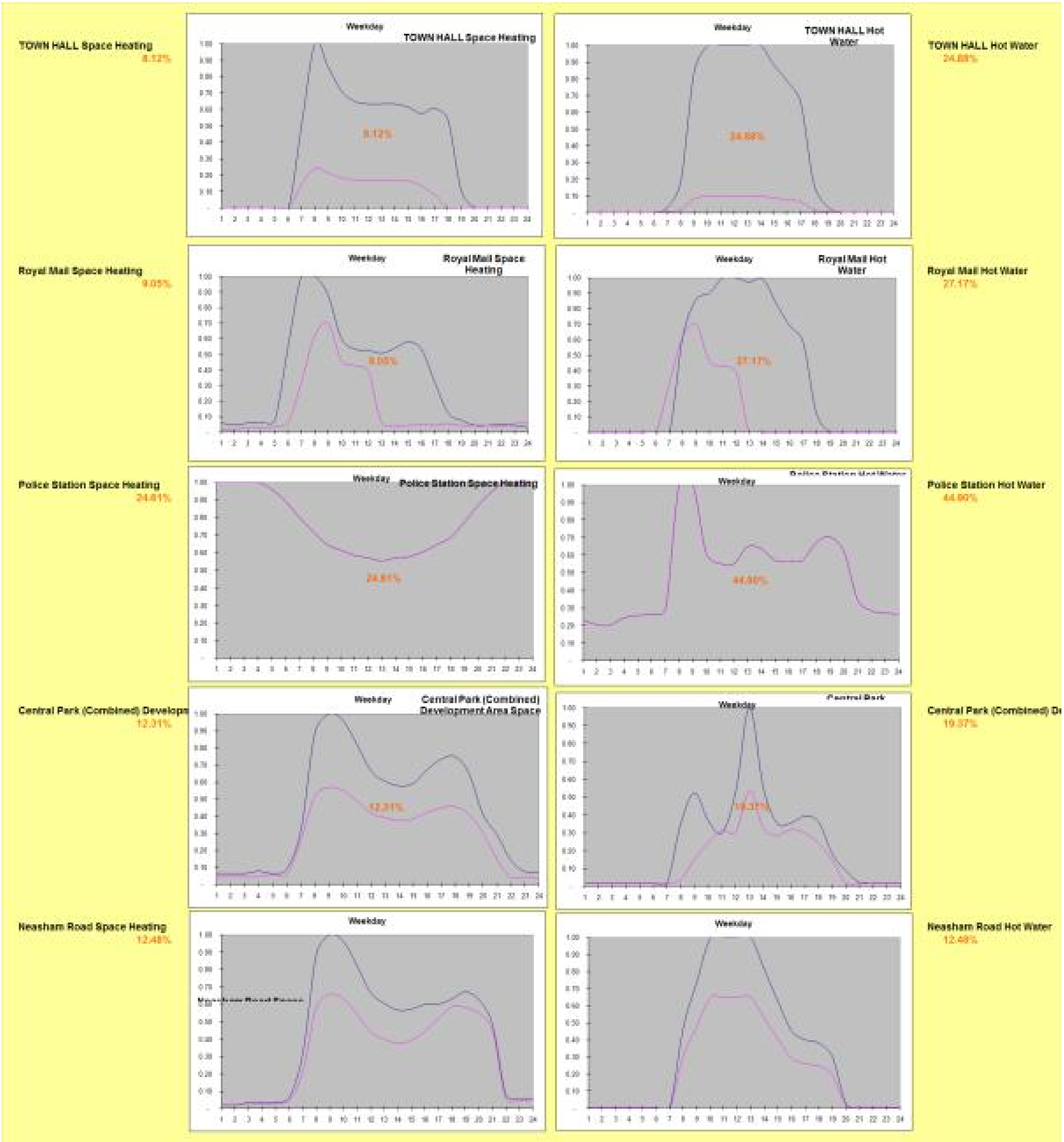
10.1 DARLINGTON

APPENDIX E

INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



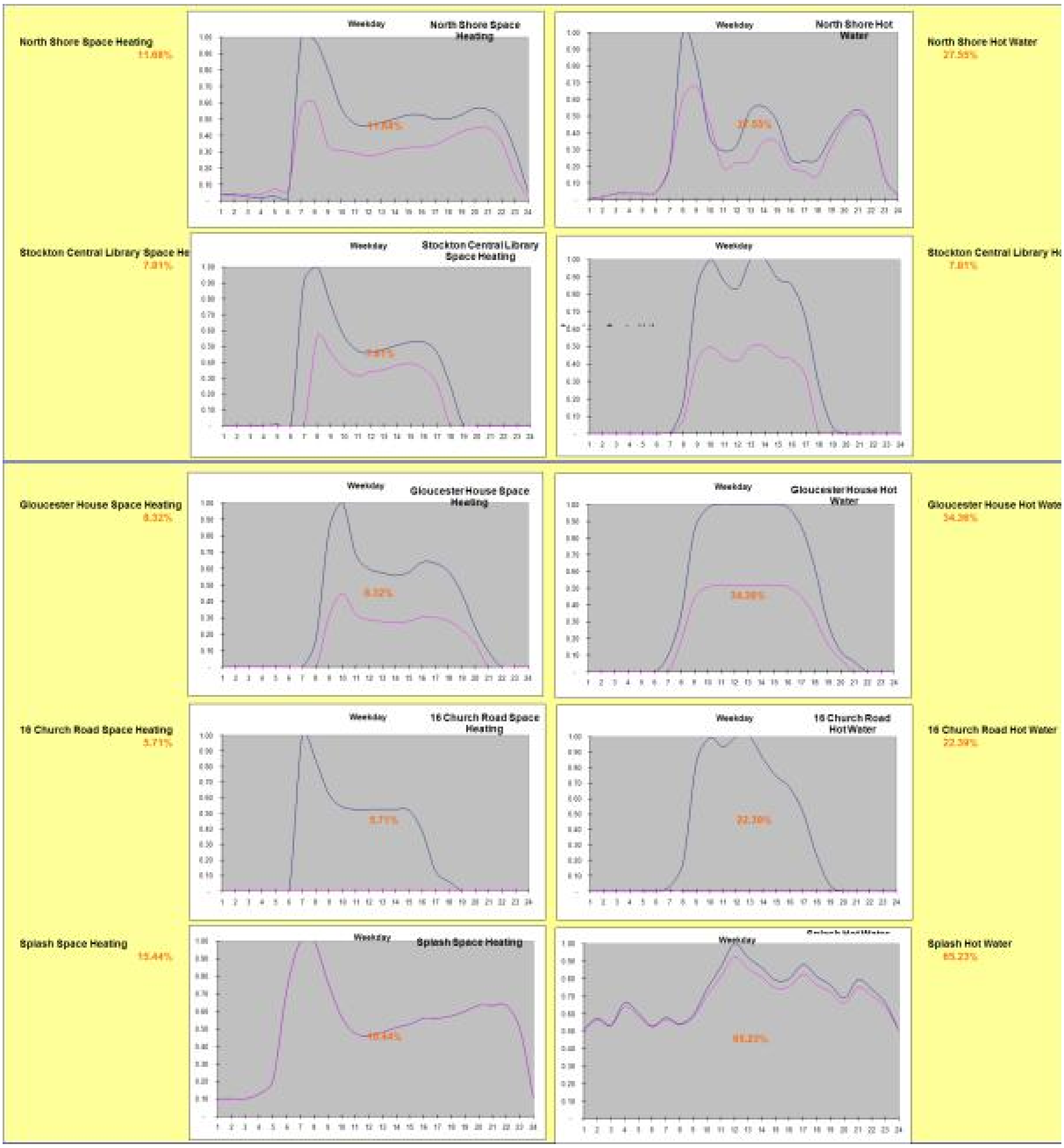
Points to note here include the following:

- The civic theatre ‘spikes’ of demand represent the high demand for hot water during intervals of performances.
- The Dolphin Centre hot water demand profile includes the pool heating demand.
- The police and fire services buildings are assumed to be occupied 24/7.
- The Central Park profile is a combined mixed use profile but reflects the predominantly commercial buildings that are anticipated to connect to the DH network.

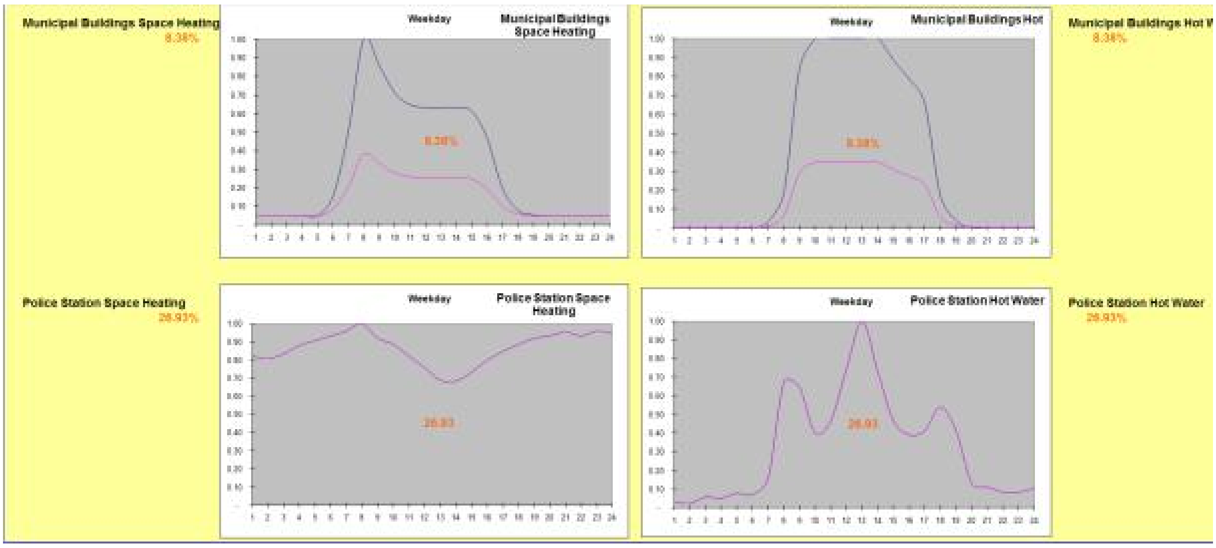
10.2 STOCKTON

APPENDIX E

INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS

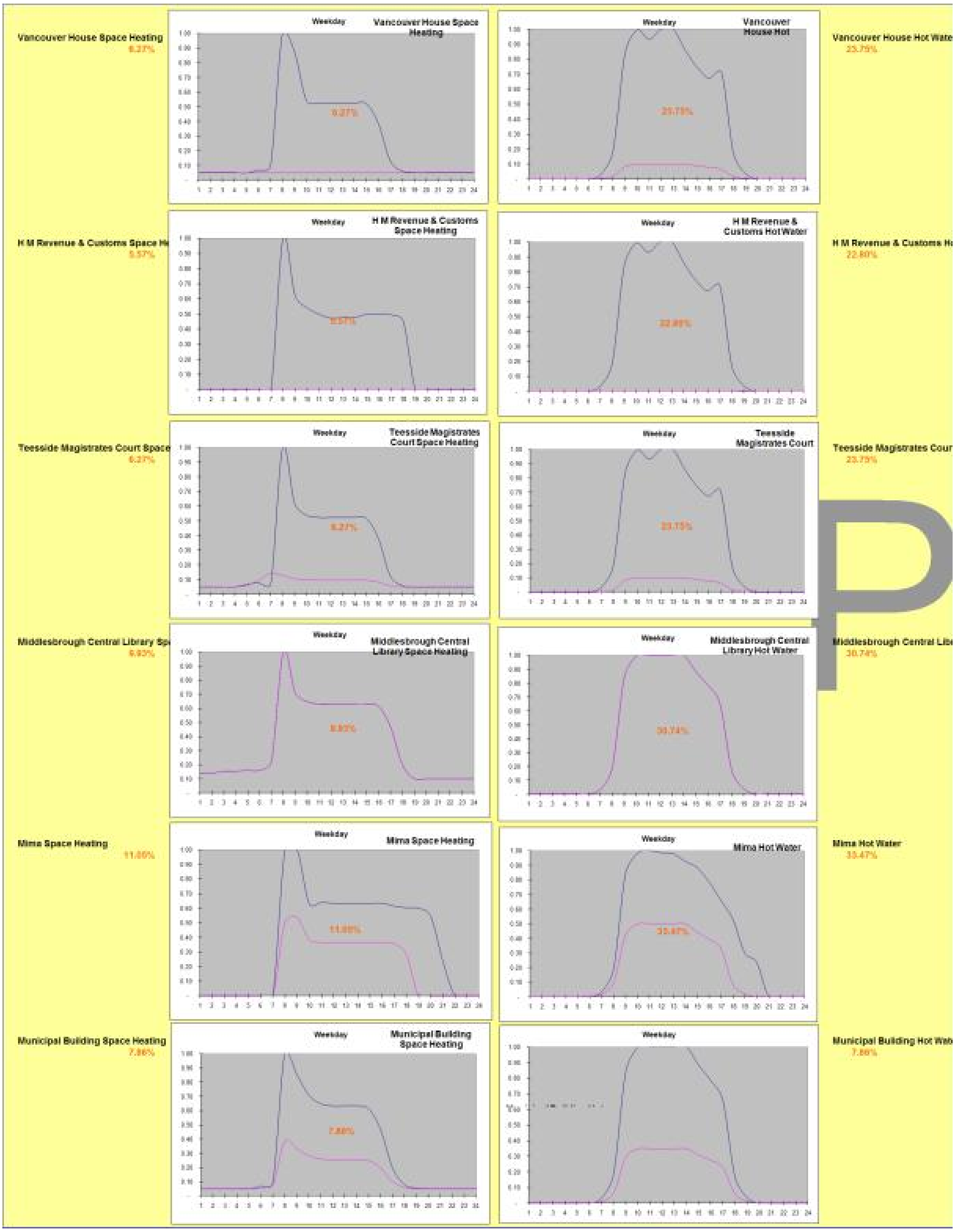


Points to note here include the following:

- North Shore demand profiles here are presented as an aggregate of all new development – e.g. with a non-domestic and domestic component
- The Splash hot water demand profile includes the pool heating demand.
- The police station is assumed to be occupied 24/7.

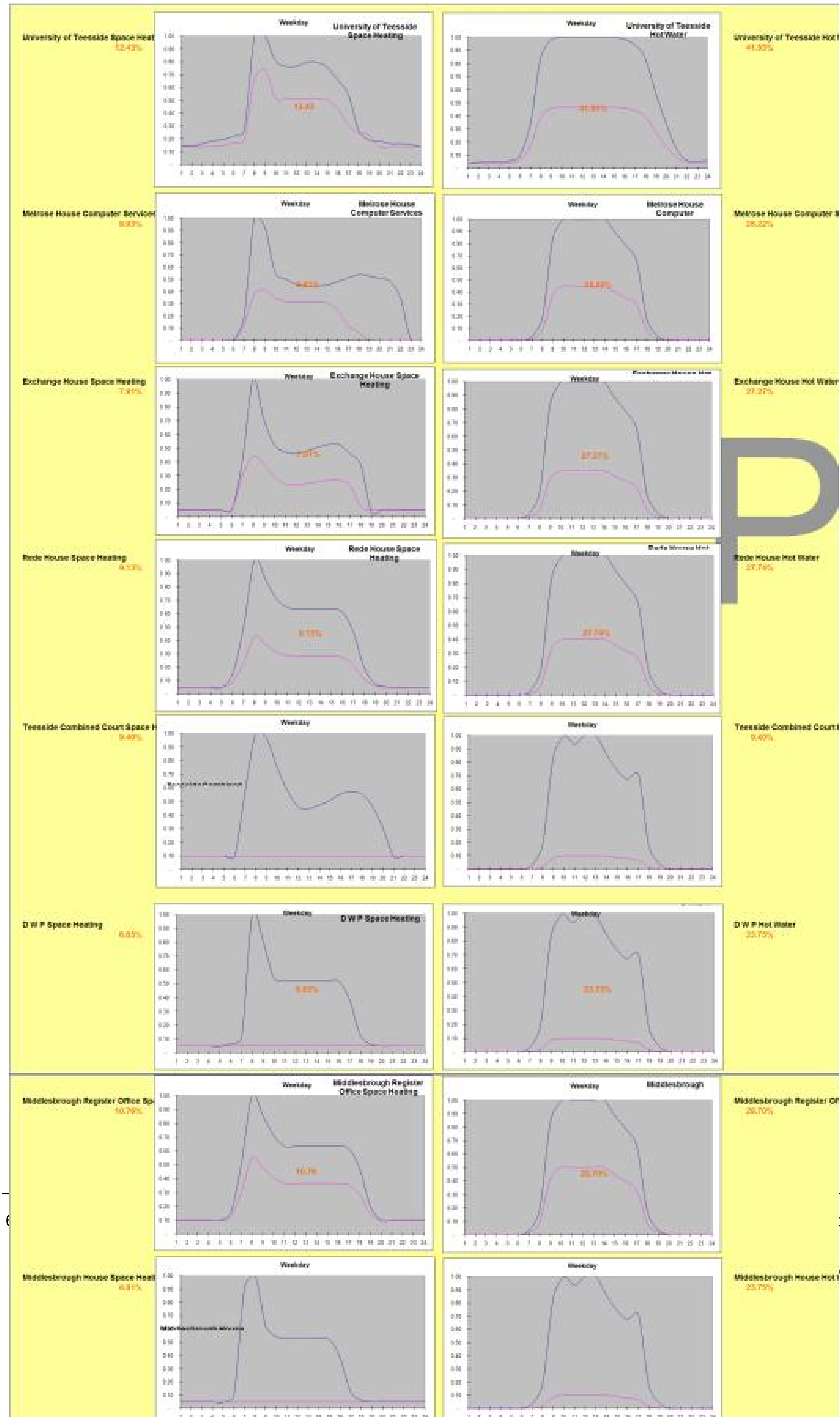
10.3 MIDDLESBROUGH

INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



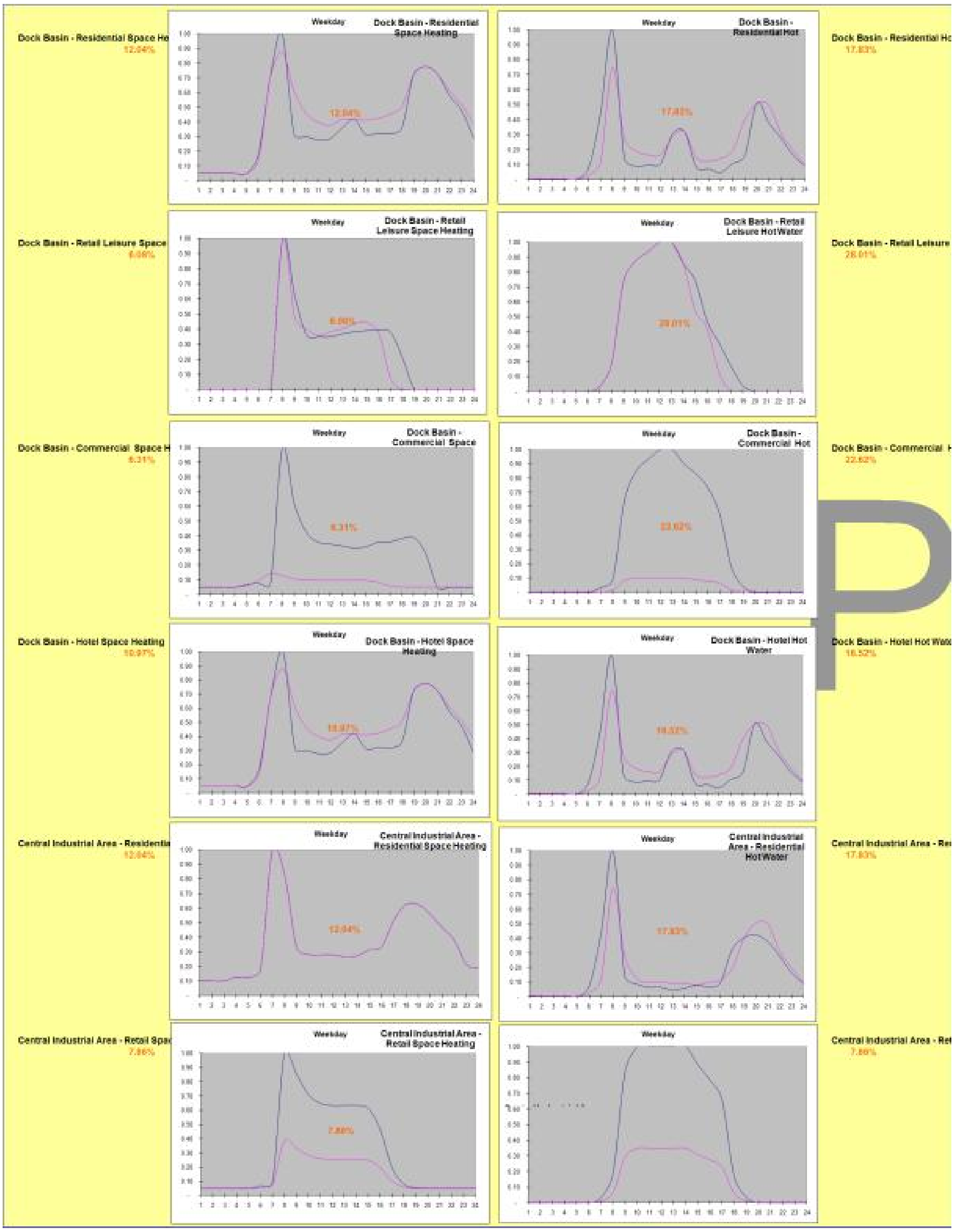
APPENDIX E

INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS

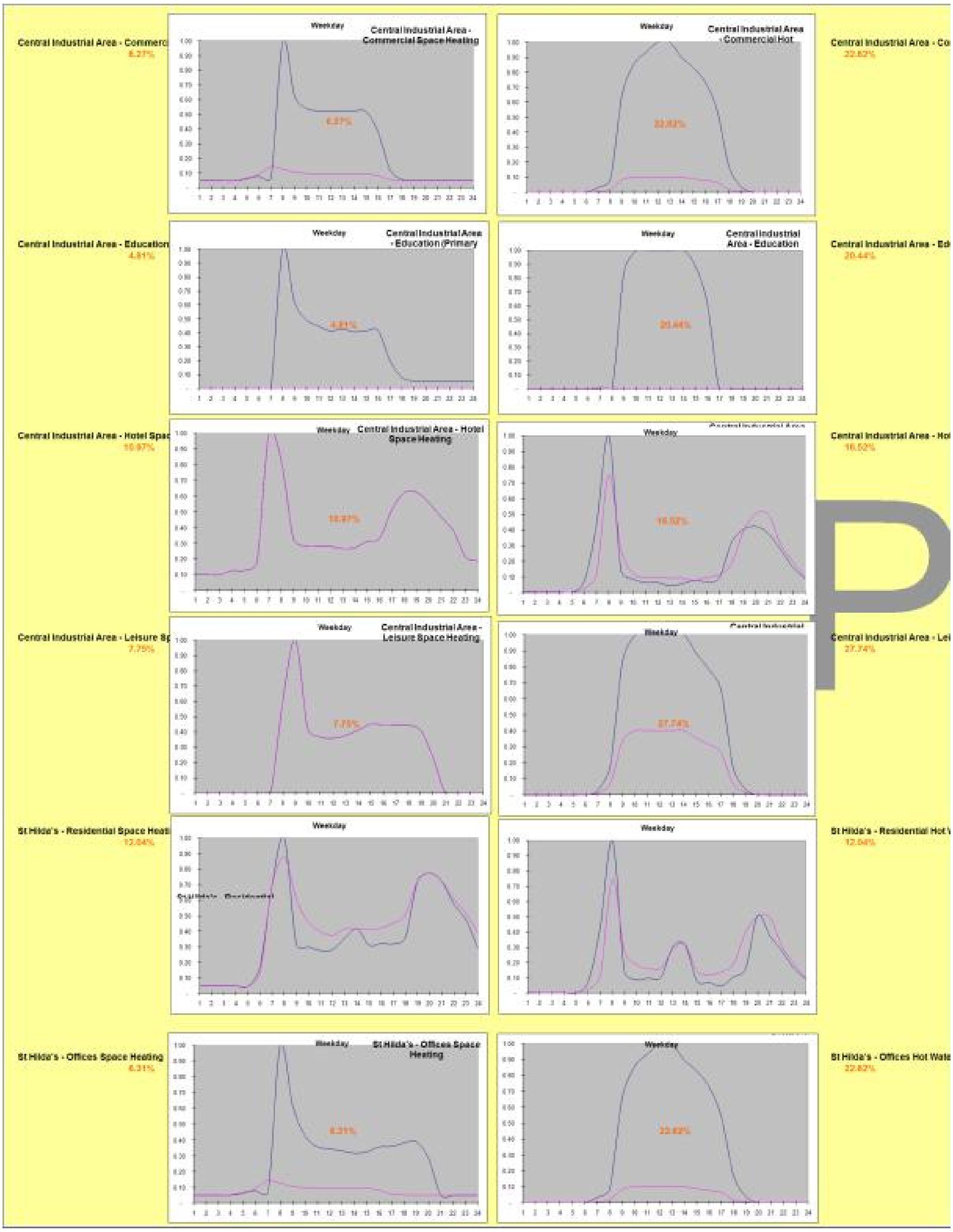


APPENDIX E

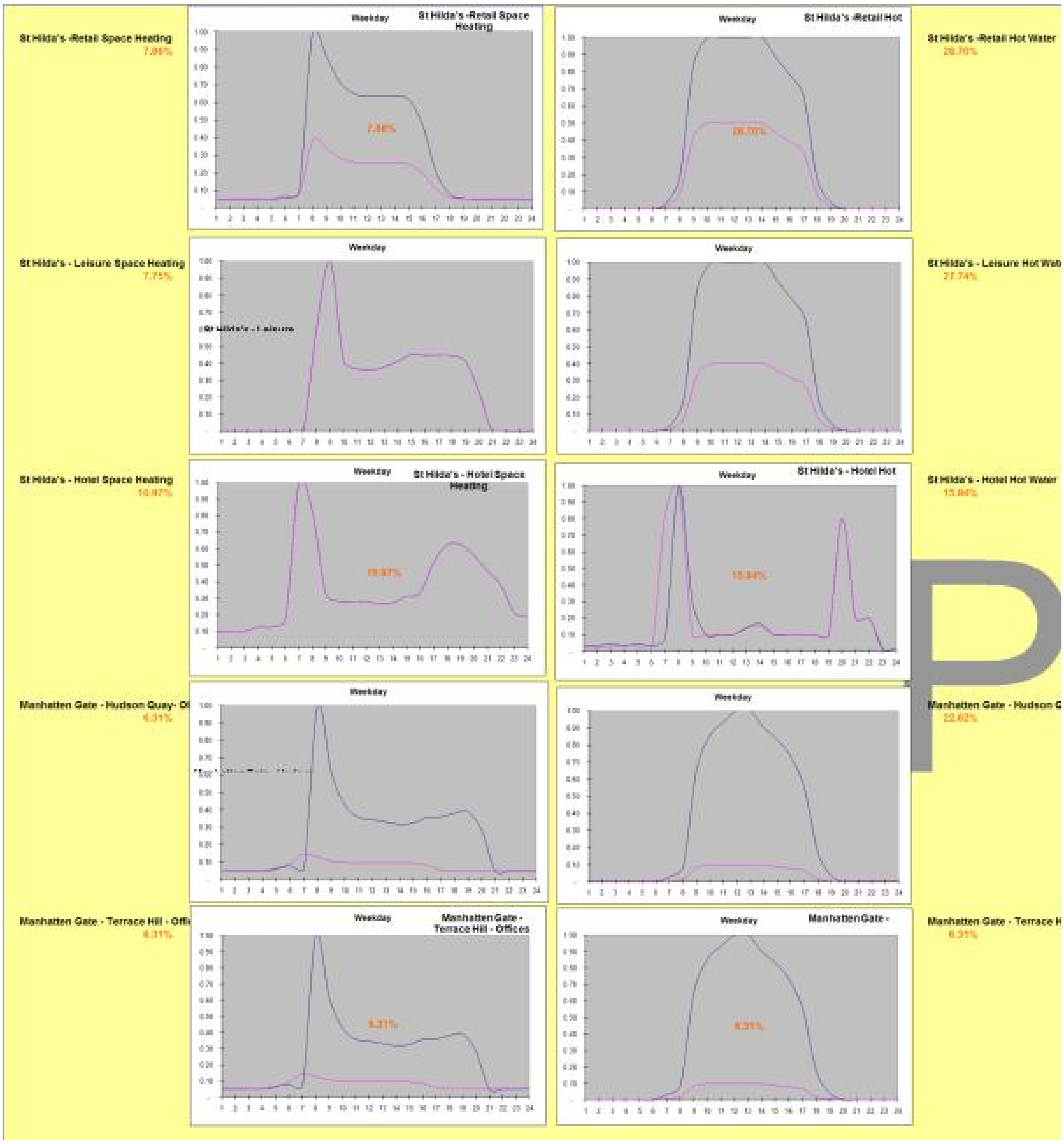
INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



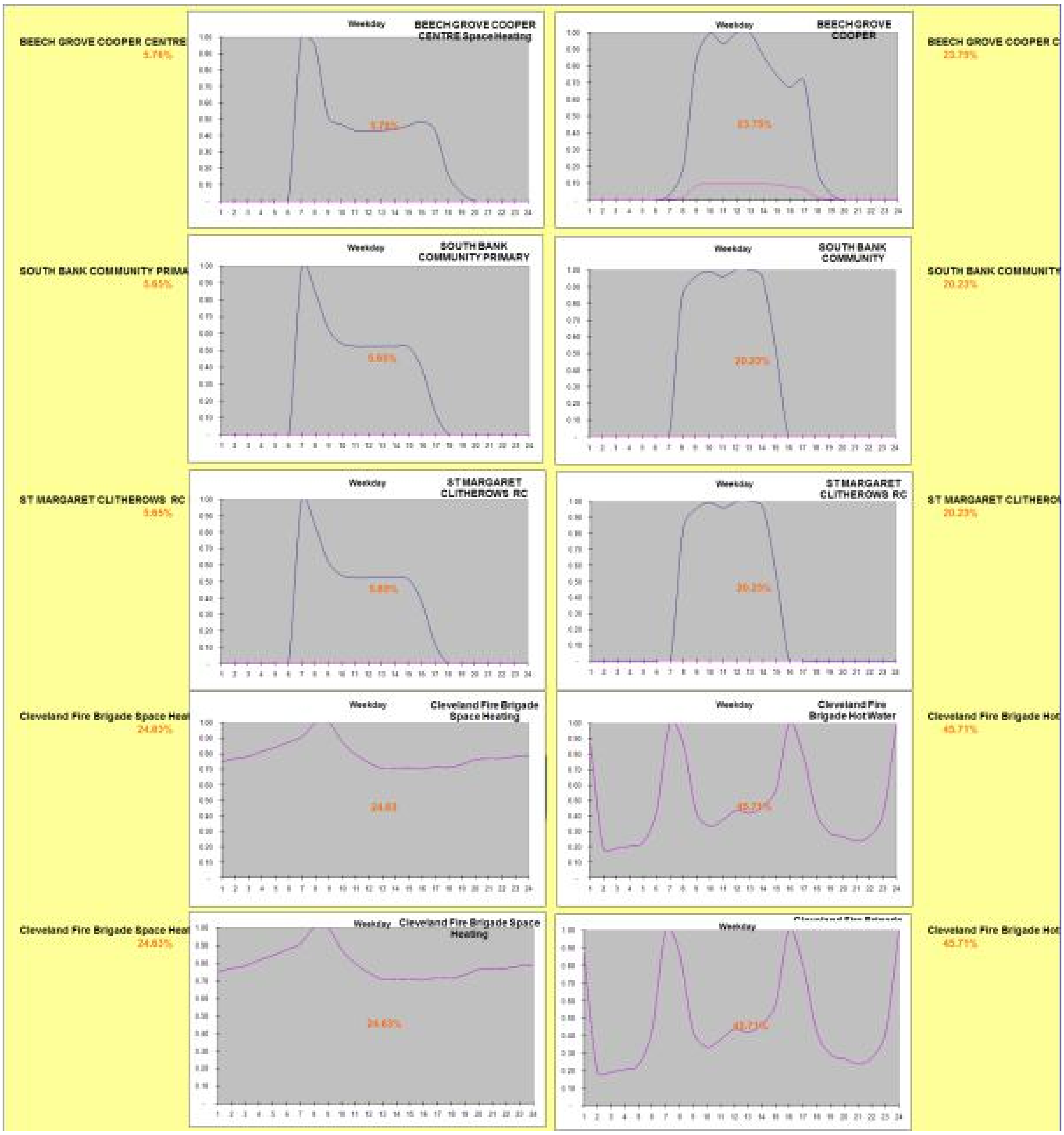
INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



10.4 ESTON

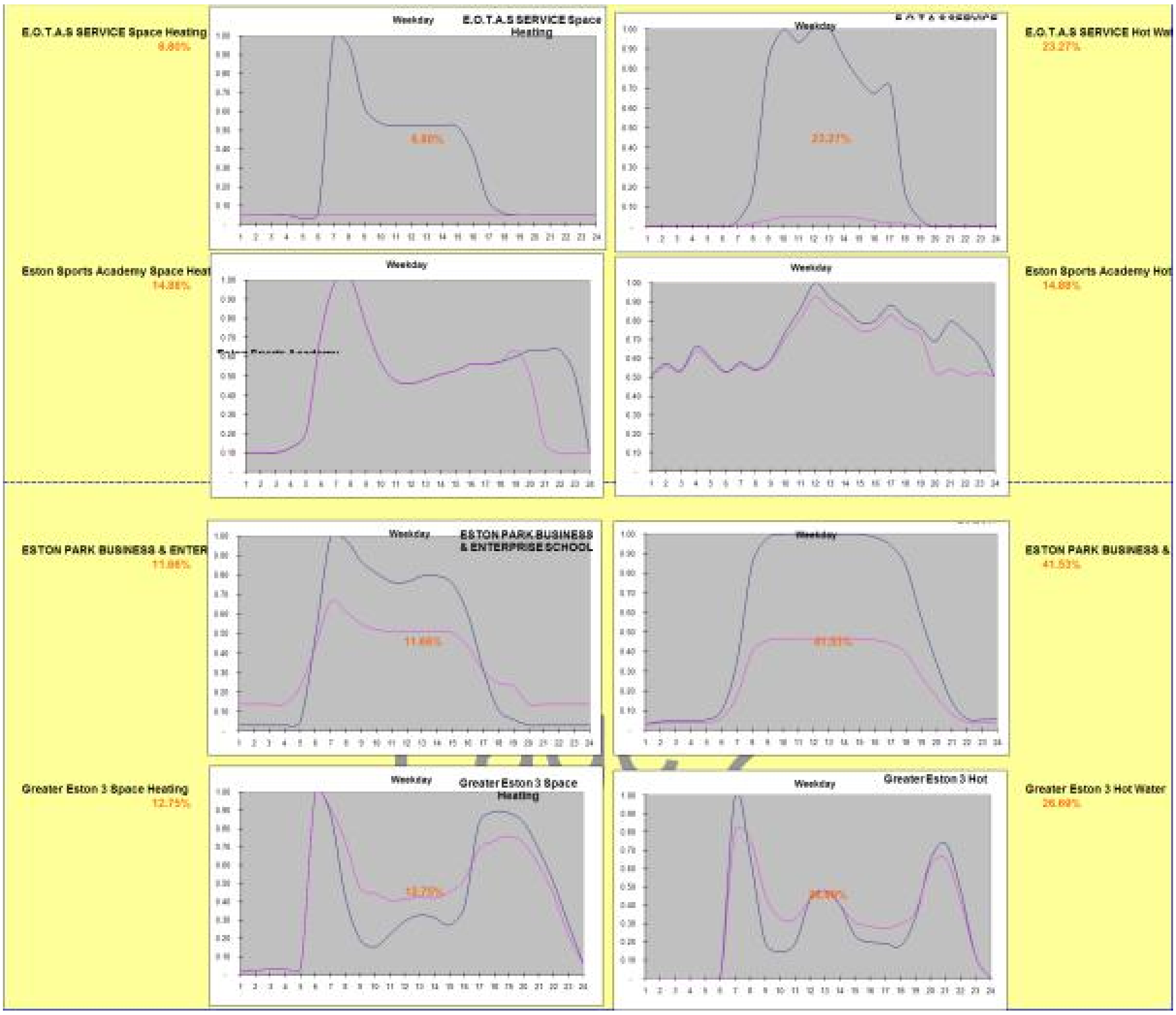
APPENDIX E

INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



APPENDIX E

INDIVIDUAL BUILDING HEAT DEMAND PROFILE ASSUMPTIONS



APPENDIX F

ENERGY BALANCE AND FINANCIAL MODELLING ASSUMPTIONS

11 ENERGY BALANCE AND FINANCIAL MODELLING ASSUMPTIONS

11.1 TECHNICAL ASSUMPTIONS

11.1.1 BOILER EFFICIENCIES

Where site-specific information was not available the following assumptions were made:

Existing boilers – 78.5% efficient (GCV)

New boilers – 83% efficient (GCV)

11.1.2 CARBON EMISSIONS FACTORS

As per Building Regulation Part L 2010. The use of NI185/NI186 factors was considered, but these both change on an annual basis, and do not have a direct relation to the potential for new DH scheme to supply low carbon heat to new developments and help them to achieve the required performance levels for Building Regulation compliance.

11.1.3 CHP ENGINES

Engine performance figures are based primarily upon the Jenbacher 2010 engine range. A table of performance figures is included here:

Elec output	Thermal Output	fuel in (NCV)	Elec efficiency	Heat to power ratio
294	401	781	34.2%	1.36
526	634	1331	35.9%	1.21
635	766	1620	35.6%	1.21
844	926	2050	37.4%	1.10
888	972	2150	37.5%	1.09
1190	1296	2868	37.7%	1.09

1487	1622	3585	37.7%	1.09
2002	1916	4544	40.1%	0.96
2679	2555	6059	40.2%	0.95
3352	3195	7574	40.2%	0.95
4029	3767	9033	40.5%	0.93

11.1.4 BIOMASS BOILERS

Biomass boilers are assumed to operate at 80% efficiency.

11.1.5 PARASITIC LOADS

Annual parasitic loads have been calculated at the following levels of annual prime mover output:

	Gas CHP	PPO CHP	Biomass
Parasitic Electrical Loads	3.5%	4.0%	5.0%

11.1.6 DISTRICT HEATING NETWORK

DH network diameters for a given load have been calculated in a hydraulic model to reflect an allowable pressure loss of 100pa /m. Maximum heat transfer capacities have been based upon 300pa/m pressure drop.

Heat losses for different diameter pipes are assumed as follows per m of trench:

Diameters	Heat loss W/m
0	0
25	10
32	11
40	13
50	14

65	15
80	16
100	18
125	19
150	20
200	25
250	28
300	35
350	42
400	49
450	53
500	56
600	60
700	63
800	67

11.1.7 THERMAL STORAGE SIZING

Proposed thermal storage capacities are based upon 6 hours full output of the primary heat sources.

11.2 FINANCIAL ASSUMPTIONS – ENERGY CENTRE

11.2.1 GAS-FIRED CHP ENGINES

Elec output	CAPEX	
294	£	236,787
526	£	306,287
635	£	338,940
844	£	401,550
888	£	414,731
1190	£	505,201
1487	£	594,174
2002	£	748,452
2679	£	951,261
3352	£	1,152,872
4029	£	1,355,681

Assumed to require replacement at 15 years for gas-fired CHP, and 12 years for PPO CHP, 25 years for biomass boilers

11.2.2 GAS-FIRED BOILER REPLACEMENT COSTS

Full initial cost replacement (£35 per kW output) at 30 years. Boilers sized at 3 boilers, each at 50% of total capacity of scheme.

11.2.3 UTILITY CONNECTION COSTS

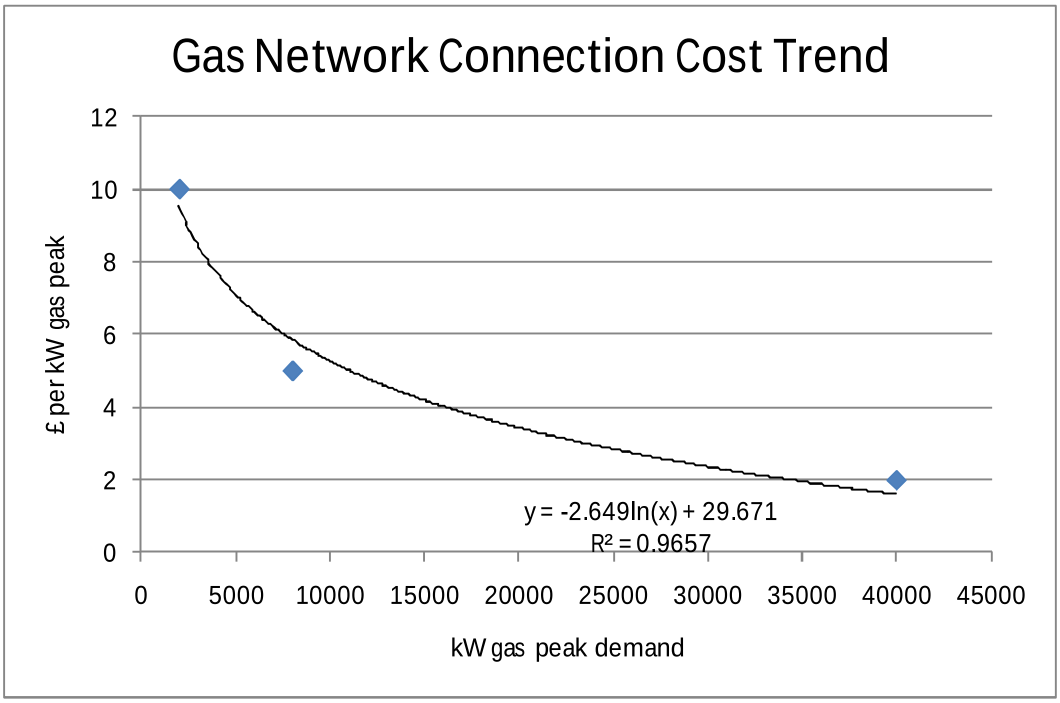
The following factors have been adopted in the costing of utility connections.

Diversions / Water supply connection - £80k

Electrical connection (generation options) - £100k per MWe generation capacity

Gas connection costs – Based on kW gas peak demand, according to the following formula:

Figure 11-1 Gas Network Connection Cost Assumption



11.2.4 UTILITY PRICES

It was considered most useful in the context of the Tees Valley as a whole to maintain consistency in terms of utility prices across the various options and schemes analysed, in order to ensure a 'level playing field' on which the performance of each can be evaluated. This is appropriate given that the projects examined here would have a lifetime measured in decades, whilst typical utility contracts are short term (e.g. 1 or 2 years).

The utility prices adopted are as shown in the table below:

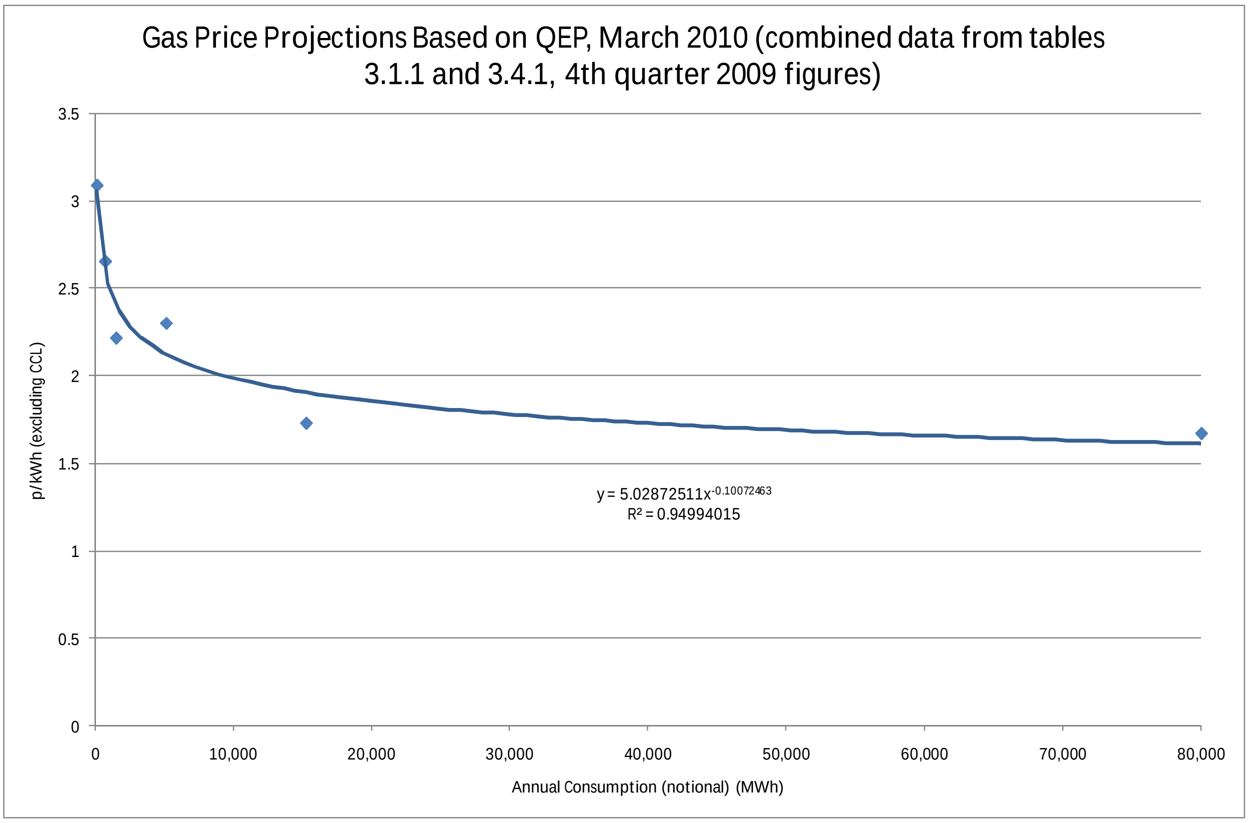
Table 11-1 Utility Price Assumptions

Utility / Other	Cost per kWh (p/kWh)	Notes
Gas for CHP	Variable	QEP, MARCH 2010 edition, Table 3.1.1 and 3.4.1
Gas for boilers	Variable	QEP, MARCH 2010 edition, Table 3.1.1 and 3.4.1

CCL on gas for boilers	0.164	HM Revenues and Customs
PPO for CHP	6.10	Calculation on published costs of pure oils
Biomass	2.5	Based on carbon trust biomass accelerator programme information
Electricity Import (Energy Centre parasitic loads)	8.3	QEP, MARCH 2010 edition, Table 3.1.1 Prices of fuels purchased by manufacturing industry in Great Britain, Excluding the Climate Change Levy, 4th quarter 2009, medium consumer
	£ p.a. per customer	
Metering and billing costs for ESCO	50	Estimated cost per customer (aggregated over whole customer base - e.g. marginal cost of additional customer)
	Value per kWh (p/kWh)	
Electricity Export (DAY) gas CHP	4.89	Based on wholesale prices, DUoS charges, estimated margin and assumed day /night split plus LEC benefit
Electricity Export (NIGHT) gas CHP	3.00	Based on wholesale prices, DUoS charges, estimated margin and assumed day /night split
Levy exemption certificates (LECs)	inc above	Included in export prices above
Renewable Obligation Certificates, PPO Option	9.6	Double ROCS at 4.8 p each.
	Value per kWe (£ / kWe)	
TRIAD benefit	8.79	http://www.nationalgrid.com/NR/rdonlyres/A2EAC348-38D8-403C-8A2D-E080E504B39C/39557/FinalTNUoStariffsfor2010.pdf, Zone 9, North east England / 2010/11, two of three triads assumed to be met.

One of the factors to which the financial results are most sensitive is the price of gas purchased for the energy centres that are under discussion here. The widely varying gas consumption of the proposed schemes has led to a variable gas price being used in modelling. The range of prices used has been based upon both the available non-domestic gas consumption data tables in the publication 'Quarterly Energy Prices'.

Figure 11-2 Gas Price Assumption by Annual Consumption Volume



11.2.5 BALANCE OF PLANT COSTS

'Balance of plant' items encompass all those items (beyond the main plant costed individually) that are required to comprise a fully functioning energy centre. This includes items such as controls, pumps, variable speed drives, make-up water systems, dosing equipment, water treatment systems, filters, degassing, ventilation, alarm and security systems, electrical cabling and switchgear, cleaning and system filling, etc…

The cost of these items is related to the size of the total thermal capacity of the energy centre and network length (e.g. pumps), or has a more significant fixed element (e.g. controls). For many of these items individual formulas based on required capacities have been used, and for all sundries, an algorithm for approximating the sum of remaining elements has been derived from previous PB project experience.

APPENDIX G

LOW AND ZERO CARBON TECHNOLOGY REVIEW

12 LOW AND ZERO CARBON TECHNOLOGY REVIEW

12.1 NATURAL GAS CHP

12.1.1 TECHNICAL CONSIDERATIONS

Gas engine CHP is considered to be a reliable and widely accepted means of supplying high efficiency heat and power. Power is generated from an alternator connected to the engine, heat is recovered from the exhaust gas and the engine cooling system. Engines are able to operate down to a minimum of 50% of maximum rated output with only a small degradation in overall efficiency. The following technical parameters have been used in our low and zero carbon technology model:

Thermal Output (kW)	Heat to power ratio	Fuel in (NCV) (kW)	Elec output (kW)	Elec efficiency
401	1.36	781	294	34.2%
634	1.21	1331	526	35.9%
766	1.21	1620	635	35.6%
926	1.10	2050	844	37.4%
972	1.09	2150	888	37.5%
1296	1.09	2868	1190	37.7%
1622	1.09	3585	1487	37.7%
1916	0.96	4544	2002	40.1%
2555	0.95	6059	2679	40.2%
3195	0.95	7574	3352	40.2%
3767	0.93	9033	4029	40.5%

12.1.1.1 AIR QUALITY

Gas engine CHPs can be designed to be lean burn, therefore minimising the NOx emissions. A catalytic converter can be installed if local air quality is already poor. A correctly maintained and operated engine should not produce elevated levels of particulates and other airborne pollutants compared to a natural gas boiler with the same thermal input.

12.1.1.2 Noise and vibration

It is necessary to install gas engine CHP units within an acoustic enclosure to ensure that noise pollution is kept to within acceptable limits. It is feasible that low frequency noise pollution can be transmitted from the flue. Intake air and heat rejection fans would be baffled to keep noise within acceptable limits.

12.1.2 PHYSICAL CONSIDERATIONS

12.1.2.1 Access

Gas engine CHP units are usually installed in bespoke acoustic enclosures, sufficient access for maintenance is required. Overhead lifting beams may assist with the maintenance of larger units. In general these units can be installed with around 1m clearance all around. The units do not need to be accessed on a daily basis, with maintenance usually undertaken by a 3rd party contractor. System operation is monitored remotely with the majority of day to day maintenance and upkeep undertaken remotely.

12.1.2.2 Fuel supply

Gas engine CHP units operate on natural gas and therefore require connection to an adequate gas supply. The infrastructure may need to be reinforced if megawatt scale gas engine CHP is to be installed because the peak and annual gas demand can place a considerable strain on existing infrastructure.

12.1.2.3 Electrical connection

None of the units proposed for the Tees valley will be connected to a private electrical network, therefore all generation will need to be exported to the national grid. A suitable connection to the local electrical supply network is required in order for the CHP units to export their generation. An official embedded generation connection request will need submitted to the DNO in order for them to model the impact of the additional generation on the network and provide a preferred connection methodology.

12.2 BIO-OIL FUELLED CHP

12.2.1 ORIGIN OF BIO-FUELS

Biofuels originate from the processing of organic materials, either directly from plants or indirectly from industrial, commercial, domestic or agricultural by-products. Biofuels fall into two main categories: woody biomass (including forest products, untreated wood products, energy crops i.e. crops that are grown specifically for energy) and non-woody biomass (which includes animal wastes, industrial and biodegradable municipal products from food processing and high-energy crops such as rape-seed, sugar cane, maize). Non-woody biomass takes various physical forms but the technology described in this study is fuelled by liquid biomass derived from energy crops and is referred to from herein as "liquid biofuel".

By regulation, bio-fuels can only be classed as renewable if the bio-fuel resource is actively managed to ensure sustainable levels of the resource are maintained. Raw biomass is considered a carbon neutral fuel because the same volume of CO_2 is released during combustion as has been absorbed by the plant during growth so the net contribution to global greenhouse gas levels over the near term is nil. Biomass is therefore only truly carbon neutral if the same quantity of biomass is planted to replace the burned fuel. Liquid bio-fuel does however have a CO_2 emission factor because of the energy required to grow, harvest, process and transport the fuel.

12.2.1.1 BIO-OIL VS BIODIESEL

Pure plant oil is a liquid bio-fuel that has not been refined beyond the filtration stage. Pure plant oil can be produced in the United Kingdom without supplementary energy or chemical use being required for refinement.

The unrefined nature of the fuel dictates that it is considerably more viscous than diesel and has similar properties to fossil medium/heavy fuel oil. Pure plant oil requires heating to reduce its viscosity prior to combustion and additives to compensate for acidity and reduced "lubricity" to safeguard the engine.

The main alternative to using pure plant oil is bio-diesel. This is plant oil (virgin or reclaimed) that has been processed to reduce the viscosity and improve the combustion characteristics of the fuel. Bio-diesel is increasingly being used as a transport fuel, and many compression-ignition engines can use it without modification, or with minimal modification. This could include CHP engines.

Biodiesel is available in a number of grades from B100, which is 100% plant oil derived, B80, an 80/20 mix of biodiesel and mineral diesel respectively and so on. The European standard for biodiesel is EN14214:2003; biodiesel produced to this standard is recognised as having similar combustion qualities to those of mineral diesel. All reputable suppliers sell biodiesel of this grade, but the way it is manufactured may affect claims for ROCs under Renewable Obligation and for Climate Change Levy Exemption Certificates dependent on the feedstocks used. For instance, one process uses methanol from natural gas at around 10% by volume that is removed after the transestrification process (process of turning oils and fats to biodiesel). OFGEM have stated that this process makes fuels ineligible for ROCs. Given the reliance on a fossil fuel derived substance within the manufacturing process OFGEM were forced to issue a decision statement in March 2009 stating that biodiesel formed in certain ways cannot be eligible for ROCs under the Renewable Obligation[43]. This is not the case if the feedstock (including any alcohol) comes from non-fossil fuel sources.

12.2.1.2 TAX FOR BIOFUELS

VAT on biodiesel (and bio-oils) is currently set at 5% and where it is used for electricity generation there is no duty to pay. It will depend on the supplier but most will charge full duty and VAT on delivery which can be reclaimed at a later date.

Fuel duty is more complicated. Road fuel duty on diesel was set at 57.2p/litre (April 2010) but there was an exemption of 20p/litre for biodiesel for road going consumers. Suppliers have historically sold B100 biodiesel at forecourt prices and this 20p/litre has been embedded within their profits, hence they were not interested in the market for electricity generation.

With effect from 1 April 2010, the duty rates for biodiesel and bioethanol are being increased to the same level as conventional petrol and diesel, as the Renewable Transport Fuels Obligation (RTFO) becomes the main support mechanism for biofuels. However, biodiesel produced from waste/used cooking oil will continue to benefit from the 20 p/litre duty differential for a limited 2 additional years[44]. The reduction in the profit of road transport fuels may make biodiesel more interested in selling to other markets including electricity generation.

If duty (57.2p) and forecourt profit against bulk delivery (PB estimate from other projects at 6p/litre) are removed, the “bulk delivered” price without duty is 54p/litre. At approximately 54p/litre bio-diesel is still significantly more expensive than mineral diesel (approximately 38p/litre) and it is well known that electricity generation from mineral diesel oil is not economic compared to the purchasing of electricity from the national grid. Whether there will be any significant supply industrially at 54p/litre or below is not yet known, due the change over being comparatively recent. In this review we have assumed that supplies will continue,

No duty is payable on biofuels (excluding biodiesel and bioethanol)[45]

Due to its higher viscosity pure plant oil cannot readily be used as a transport fuel; as a consequence it has a considerably lower monetary value than bio-diesel and is thus of more interest to stationary applications.

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[43] Biodiesel, glycerol and the Renewables Obligation – Decision Document 10 March 2009, ref 22/09

[44]Notice on 10th May 2010 from HMC&E website (http://www.hmrc.gov.uk/briefs/excise-duty/brief2310.htm)

[45] HMC&E Notice 179E Biofuels and other fuel substitutes October 2009

The following commentary assumes that bio-diesel will remain uneconomic as the main fuel for stationary heating and power generation applications, and pure plant oils will continue to dominate. However there may be a significant advantage in using biodiesel as a back-up fuel to meet specific operational requirements of bio-fuels (see section 2.4), as the use of renewable certified bio-diesel will ensure that generation receives ROCs continuously even when operating on back-up. This will greatly simplify administration.

12.2.2 BIOFUEL COMBINED HEAT AND POWER

Although liquid biofuels can in principle be used in gas turbine or boiler-based CHP (e.g. steam raising or organic Rankine cycle), because of the premium for electricity sales and incentives income, it is most appropriately utilised in reciprocating engines due to superior electrical generation efficiency. Use of reciprocating engines permits the same operation regimes and characteristics adopted currently for natural gas-based CHP by University of Edinburgh.

Table 12-1: Comparison of CHP efficiencies (3-5MWe range)

Liquid bio-fuel CHP technology	Typical electrical generation efficiency
Gas turbine	30-35%
Organic Rankine Cycle (ORC)	15-20%
Reciprocating engine	35-41%
Boiler and Steam Turbine	18-24%

12.2.3 BIO-FUELLED RECIPROCATING ENGINE CHP

Rudolf Diesel's first compression ignition engine was operated in 1893 on vegetable oil. Although modern engines have been optimised to run on mineral oil and biodiesel, it is possible to run modern engines on vegetable and other plant oils again with only minor modification. It is possible to procure a packaged compression ignition[46] CHP engine from 500kW$_e$ up to around 16MW$_e$. There are at least three manufacturers who specify off-the-shelf engines for pure plant oil utilisation (Caterpillar, MAN

[46] Compression Ignition engines are often also referred to as Diesel engines

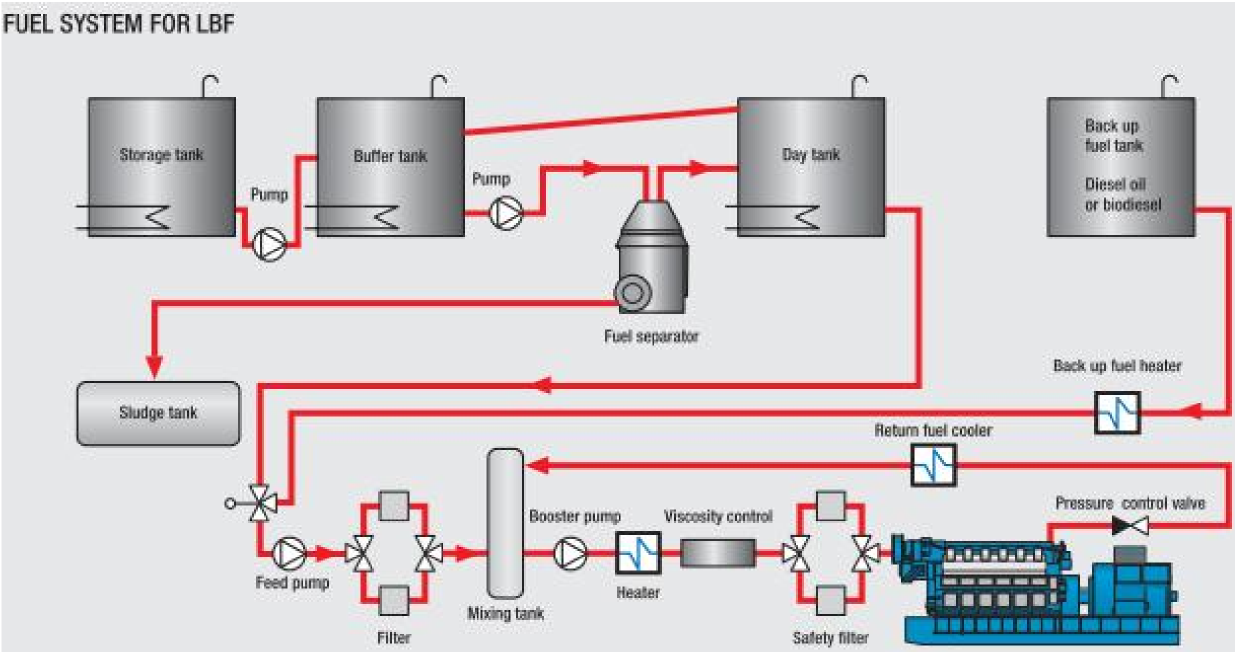
and Wärtsilä). The following technical parameters have been used in PBs low and zero carbon technology model:

Elec output (kW)	Elec efficiency (kW)	Thermal output (kW)	heat to power ratio
1440	35.9%	1180	0.819
2469	36.3%	2130	0.863
1539	39.2%	1423	0.925
5327	43.0%	5520	1.036
7124	43.2%	7302	1.025
8032	43.3%	8198	1.021
8924	43.3%	9112	1.021

In order to be able to use liquid bio-fuels it is necessary to have on-site fuel storage and potentially, (depending on the oil used) fuel line heating systems to avoid solidification of the oil. The plant footprint needs to allow for storage tanks both for the bio-fuel and potentially for additives and waste products that result from the combustion process, depending on the type of bio-fuel used. Bio-fuels have a reduced lubricity compared to diesel oil which may result in increased maintenance requirements though it is to some extent offset by reduced carbon fouling of lubrication oil due to lower combustion temperatures compared to fossil fuel oil operation. The main items of plant are as follows:

- Bio-fuel storage vessels
- Compression ignition CHP engine
- Ancillary fuel/engine additive plant/storage
- Flue filtration plant and liquid waste storage

Figure 12-1: Bio-oil CHP fuel system[47]



Reciprocating engines offer the potential, with the use of additional equipment, to be operated in combined-cycle mode to increase electricity generation efficiency, by around 4 percentage points, in sacrifice of heat recovery. Combined cycle systems are not considered in this study because the increased revenues from the higher ROC values available for renewable CHP versus straight electricity generation are considered to outweigh the increase in revenue from greater electricity sales.

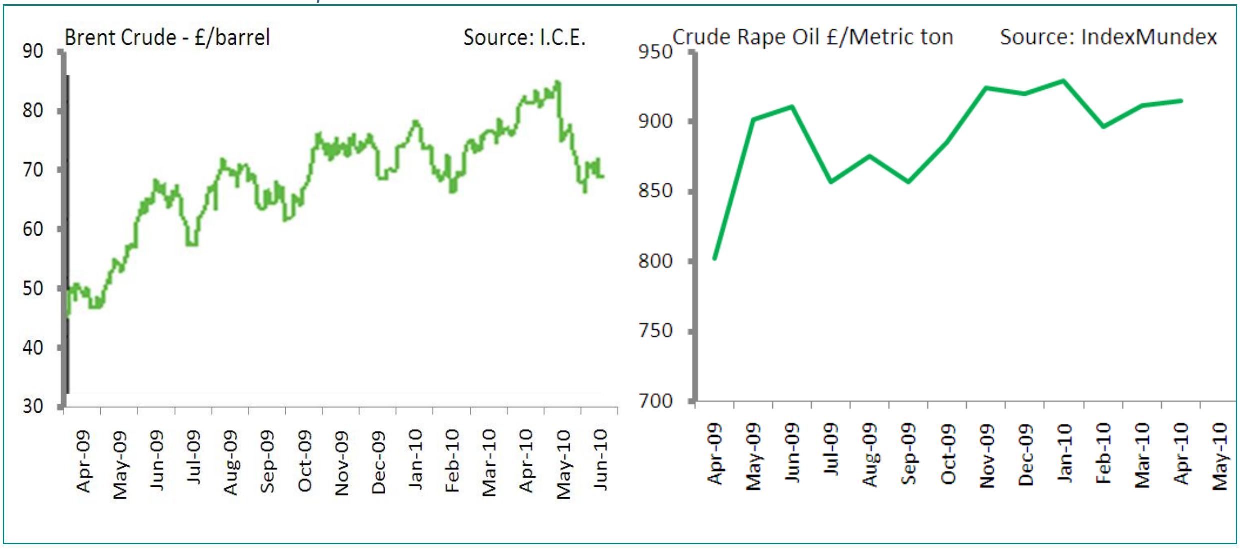
12.2.4 FUEL SUPPLY

The installation of bio-oil CHP(s) represents a security of supply risk for the operator. If for any reason the supply of bio-oil is interrupted, and the CHP has to run on biodiesel or mineral diesel, there will be increased costs and for mineral oil increased CO2 emissions and loss of ROC revenue. It is therefore important that a carefully warranted fuel supply agreement is entered into by the operator prior to implementation of a biofuel scheme, and that the length of the contract is sufficient to recover a significant amount of the University's investment.

[47] From Wartsila liquid biofuel power plants 2007

Although biodiesel prices track regular diesel and in some regards the crude oil market, the prices of vegetable oils are more linked to the successful harvest and food consumption and in general are not as volatile.

Table12-2: Base fuel price volatilities



12.2.5 FUEL SUPPLY - SUSTAINABILITY CONSIDERATIONS

As production of bio-fuels from agricultural commodities is expanding, concerns about social and environmental implications are also rising. Introduction of bio-fuel crops on existing arable land implies competition with other crop uses, especially food production, and requires the use of intensive cultivation methods. Also where expansion of production involves opening up of new land there is the risk of moving into areas with fragile, marginal land or high-value forests.

PB has identified a number of potential suppliers of pure plant oil, including Tees Valley biofuels who are planning to locate a rape seed oil production facility for power generation in the tees valley. PB would advocate UK supplies of rapeseed oil be considered, ideally using seed processed into oil locally. Although the production of bio-oil from agricultural land may be associated with negative sustainability, the impact of bio-oil compared to bio-diesel produced from palm oil is minimal. Sourcing fuel is both politically charged and a maturing discussion that is becoming more sophisticated. As such, a watching breif of all the options for supply should be maintained.

It is anticipated however that mechanisms such as OFGEM's rules for the origins of bio-fuels will ensure that the bio-fuels consumed can be truly considered as renewable and sustainable.

12.2.5.1 FUEL PRICING

Whilst there are published sources of energy price forecasting available, they are subject to scrutiny. The trend for each of the cost items listed in Table 12-3 is likely to continue to be upward. The financial assessment is affected by the price differential between the different fuels so PB has elected to act conservatively – current price indices are used to avoid speculation of the volatile future fuel market because it is our opinion that market trends and interactions are likely to affect each fuel type similarly.

To incentivise development of certain emerging technologies Ofgem reward a Renewable Obligation Certificate (ROC) for every 0.5MWh of power generated from pure plant oil fired generation.

Table 12-3: Fuel cost assumptions

Costs		Reference Source
Liquid biofuel (pence/kWh)	6.1	Based on a UK sourced rapeseed oil price of 6p/khw with 0.1p/kWh for transport

12.2.6 CARBON FOOTPRINT PERFORMANCE

The use of bio-oil has a significant impact on the carbon emissions and ROCs eligibility for CHP.

Table 12-4 shows the emission factors of various bio-oils where it can be seen that both rapeseed oil and soybean oil have emission factors higher than that of natural gas.

Table 12-4: Bio-fuel emission factors[48]

Oil source	Emission factor (kg CO_2/kWh)
Mains natural gas	0.194
Used cooking oil	0.047

[48] *Emission factors are from the UK Renewable Fuels Agency.*

Palm oil	0.169
Rapeseed pure plant oil	**0.009**[49]
Soybean oil	0.281
Fossil diesel	0.310

Taking a conservative approach, we have assumed that the bio-oil would be produced from rapeseed oil as it seems to become the most likely feedstock in the medium term in the UK.

12.2.7 REGULATORY INCENTIVES

There are three principal incentive schemes in place in the UK that provide a revenue income to the generator of renewable energy – these are:

- Renewables Obligations Certificates (ROCs)
- The Feed-in Tariff (FIT)
- The Renewable Heat Incentive (RHI)

PB have contacted Ofgem, DECC and the Environment Agency for clarification on the applicability of these schemes and how they might interact with clients' responsibilities under the Carbon Reduction Commitment (CRC) programme and the following opinions were given:

12.2.7.1 FUTURE ACCOMMODATION OF ROCS, RHI, FIT AND CRC IN UK MARKET

Because of the uncertainty concerning the value of the Carbon Reduction Commitment (CRC) (because of the refunds linked to the league table) there is no accurate picture of how ROC, RHI, and FIT will interact with the Carbon Reduction Commitments (CRC) or the institution's own carbon accounting. For instance, whether it is more cost effective to surrender allowances or should they be claimed and pay the carbon tax. This is likely to be a moving target for the first few years of the CRC as the benefits and penalties grow progressively across the first 3 years.

It is hoped that this position will be clarified shortly by the Government.

12.2.7.2 RENEWABLES OBLIGATION CERTIFICATES (ROCS)

- ROCs guidance is available from Ofgem

[49] SAP 2009 (March 2010)

- ROCs – stations are evaluated on a case-by-case basis, but it is reasonable to interpret guidance so as to conclude:
    - With the generating station boundary drawn around just the pure plant oil CHP engines and their parasitic energy consumption the net electricity generated by these machines will be eligible for 2.0 ROCs/MWhe.
    - If part fuelled with gas then the pure plant oil proportion of electricity generated by the gas turbine is eligible for 1.5 ROCs/MWhe; if only fuelled with pure plant oil then electricity generated will be eligible for 2.0 ROCs/MWhe.

12.2.7.3 RENEWABLE HEAT INCENTIVE (RHI)

- The RHI consultation was released earlier this year and has now closed.
- The Department of Energy and Climate Change (DECC) hinted that the current double ROC “uplift” to promote use of heat in renewable CHP may be revised if RHI is introduced, as there is a risk of over-incentivising renewable CHP.

12.2.7.4 FEED IN TARIFF (FIT)

Solid and liquid biomass technologies are not eligible for FITs “at this stage”.

12.2.8 OPERATING CHARACTERISTICS

It is to be expected that efficiencies, modulation and load following characteristics of bio-oil fuelled engines will be similar but slightly reduced compared to equivalent compression ignition mineral oil fuelled units. The fuel storage and supply system are likely to require more maintenance than mineral diesel fuelled systems, and thus the availability of the bio oil engines has been estimated at 85% compared to 92% for natural gas fired units.

12.2.8.1 BIO-FUEL MANAGEMENT

Bio-oil storage facilities tend to need more on site management than petroleum based fuels, as the fuel tends to deteriorate on standing, and supplies of conventional fuels may be required as back up. Certain bio-fuels may be more problematic than others, and there may be significant variations between batches of apparently the same fuel. Detailed investigation of the fuel type and characteristics should be undertaken during the design of a bio-oil fuelled CHP facility, but typical issues that may be encountered are noted below.

Pure bio-oils have a "shelf life" and can become rancid and generate biofilms if not carefully managed. Proper maintenance is required in the form of sampling, mixing and chemical injection, and possibly regular tank cleaning to avoid these problems. These maintenance requirements will increase the cost of operating the CHP plant relative to natural gas reciprocating engine CHP.

Bio-oil storage tanks and fuel lines often need to be heated and insulated to keep the oil at a temperature at which it can be pumped. Additional heating may be required to reduce viscosity where oil passes through filters, or into the engine injection system.

One of the fuel options, palm oil, needs to be heated to maintain an acceptable viscosity, however if the heating fails for any reason the oil is very likely to solidify. Once this has happened, it can be very difficult to re-liquify the fuel as it does not conduct heat readily in the solid form, hence down-time can be protracted.

When a reciprocating engine is running on bio-oil and trips (emergency stop), the oil left in the fuel lines may need to be cleared and the engine re-started on diesel or diesel equivalent. The oil that is in the lines must be "flushed" into a holding tank, and then once the engine is brought back on line, that mix of diesel and bio oil can be consumed as an add-in at a few percent into the bio-oil. To minimise the amount of flushing required, it is recommended that fuel lines be kept as short as possible.

If ROCs are being claimed, very careful accounting and management is needed to ensure that any generation that occurs whilst running on a non-renewable back-up fuel is excluded from the claim. To satisfy Ofgem's very strict stance on this, it may even be necessary to 'write-off' complete days even when back-up fuel has only been used for a short period. This becomes a strong argument for the use of a renewable biodiesel as a back-up fuel, as the entire generation would then be eligible for ROCs whether running on the main fuel or back-up.

The requirement for a back-up fuel means that the engine needs to be specified with a more expensive digital governor providing different timing mapping for the different fuels.

12.2.9 EMISSIONS AND WASTE MATERIALS

12.2.9.1 EMISSIONS

Carbon monoxide and hydrocarbon emission are low due to the high efficiency of the Diesel cycle used by the reciprocating CHP engines. Water use and vapour emissions are minimal.

12.2.9.2 SOX

Due to there being at most just trace amounts of sulphur present in pure plant oil, SOX emissions from liquid biofuel are negligible relative to that produced during comparative combustion of diesel fuel and similar to natural gas combustion systems.

12.2.9.3 NO_X

NOX gases produced at the combustion stage may be slightly lower than for the equivalent cycle of a natural gas reciprocating engine due to a slightly lower combustion temperature but, irrespective of this, NOX emissions are still of the same order of magnitude. Selective catalytic reduction technologies are capable of reducing NOX emissions by typically 85-90%.

Although historically it has usually been possible to gain planning consent and environmental permits for CHP units based upon lean-burn technologies emitting around 250mg/Nm3 NOx, environmental legislation and focus on local air quality is developing rapidly. Consenting and permitting authorities are likely to take a stricter view, and as it is unlikely that further reductions in NOx emissions can be made without seriously affecting engine efficiency, it is recommended that provision be made for new engines to be fitted with SCR technology. This requires some additional space to be allocated within the energy centre for the urea storage tanks and the catalyst on the exhaust system. This is particularly likely to be required for novel fuels such as bio-oil, where the fuel composition and hence emissions cannot be guaranteed.

12.2.9.4 PARTICULATES

Particulate emissions of liquid biofuel power plants are dependent mainly on the ash content of the fuel. Engine manufacturers state that their experience shows that stringent European standards for particulate emissions levels can be met by use of good-quality liquid biofuels without the requirement for post-combustion flue gas cleaning. Subject to detailed air quality assessment and engine selection, if necessary, bag filtering and/or electrostatic precipitators can be employed in order to clean the flue gas sufficiently to comply with particulates emissions requirements. Dispersion modelling is needed to establish the optimal balance of chimney height and filtration equipment needed.

12.2.9.5 OTHER EMISSIONS

Other flue gas emissions that can be a cause for concern for bio-fuelled engines can include:

- The presence of chlorine in bio-fuels can give rise to the production of dioxins and furans (both carcinogens). This is not usually a problem with internal combustion engines as the combustion temperature is sufficiently in excess of 850°C at which dioxins and furans are destroyed. However, engine faults causing incomplete combustion, or very chlorine-rich fuels can be an issue for environmental regulators.

- The off-loading and storage of vegetable oils can give rise to an odour that might be considered a “nuisance” by the local council. Although it is not hazardous, the proximity of receptors may need to be considered.

12.2.9.6 Waste Materials

Because bio-oil for use in a reciprocating engine has to be very finely filtered, there will inevitably some waste from the filtration process. This will require a storage tank on site, and waste will have to be removed from site for disposal.

The waste material is biodegradable and non-hazardous, but will still need to be disposed of to a licensed waste carrier.

12.3 SOLID BIOMASS BOILERS

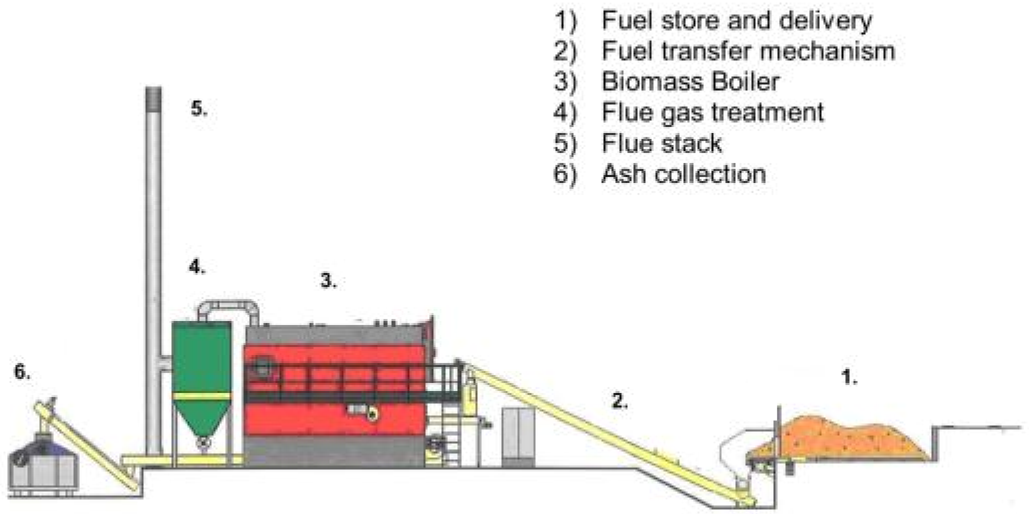
Bio-fuel originates from the processing of organic materials, either directly from plants or indirectly from industrial, commercial, domestic or agricultural by-products. Biofuels fall into two main categories: woody biomass (including forest products, untreated wood products, energy crops i.e. crops that are grown specifically for energy) and non-woody biomass (which includes animal wastes, industrial and biodegradable municipal products from food processing and high-energy crops such as rape-seed, sugar cane, maize). The boilers described in this study are all fuelled by woody biomass.

A biomass boiler burns solid biomass in order to generate hot water. Biomass boilers of the scale considered here are able to burn a wide range of solid woody biomass, namely woodchip, wood pellet and refined mischanthus.

12.3.1 MAIN PLANT

The two main items of plant are the biomass boiler and biomass fuel store/ handling plant. The design of the biomass fuel store depends on the scale of boiler. Larger boilers require bespoke solutions, whereas a packaged fuel hopper can be used for smaller boilers. The biomass is fed from the fuel store into the boiler into the combustion chamber, the design of which is dependent on the characteristics of the fuel used. Once within the boiler, the fuel is combusted in a controlled manner and the residual ash is collected for disposal. The hot flue gasses are re-circulated to ensure that complete combustion has taken place and that NOx emissions are kept to a minimum. The flue gas transfers heat to the heating water circuit before passing through to the flue gas filtration mechanism, where solid matter is removed from the before going up the stack. Ash from the combustion grate and flue gas filtration is collected in a container for disposal.

Figure 12-2: Indicative biomass boiler arrangement



12.3.2 TRACK RECORD AND OPERATING RELIABILITY

Biomass boilers have been produced commercially for the last 50 years in Europe, however in the UK the number of operational installations is relatively limited.

Biomass boilers are available with a wide range of thermal capacities, similar to that possible with conventional gas boilers. The turndown that is possible with biomass boilers is somewhat dependent of the moisture content of the fuel stock, if wood has a moisture content of around 30-40% it is possible to achieve a turndown of 25%. If wet wood, with a moisture content of around 55% is burned then the turndown is limited owing to the requirement to maintain a sufficiently hot furnace to dry the wood on the combustion grate.

The gross calorific value efficiency of a biomass boiler is around is between 75% and 80%, a consistent fuel specification is required to ensure that the boiler is able to achieve the highest possible efficiencies. The net efficiency of the boiler is highly dependant on the moisture content of the fuel delivered – a large amount of the energy in the wood is lost in evaporating water which is then emitted to atmosphere.

Biomass boilers are considered to be a reliable technology as long as the system is correctly designed, has a systematic maintenance regime with adequately alarmed critical systems and uses high quality fuel of the correct specification. The primary cause of unplanned system outage is the fuel feed mechanism. The irregular nature of biomass has the potential to cause blockages at a number of points in the fuel feed mechanism that will cause the boiler to shut down if not attended to. The majority of fuel feed blockages can be rapidly and safely cleared by semi-skilled staff. The re-starting sequence of boilers is another common cause of problems and un-planned shutdown.

Biomass boilers require semi-skilled staff to clear fuel-feed blockages and undertake day-to-day upkeep and maintenance, for example emptying of ash container and ensuring the fuel store is operating correctly. An annual maintenance period of 1 to 2 weeks is required in the summer to undertake inspections and replace any worn parts.

12.3.3 FUEL ECONOMICS

Biomass boilers can accept a wide range of woody biomass, it is however important to note that the specification of the combustion grate and fuel feed mechanism is a function of the fuel characteristics. In general the cost of biomass fuel is a function of the amount of refining that it has undergone. To able to use the lowest cost woodchip fuel the boiler should be able to accept wood with a moisture content up to 50% with a fuel of between 30mm2 by 50mm2. Low-cost wood chip requires a complex and expensive fuel feed mechanism. High-cost refined biomass, for example wood pellets require a lower-cost fully automated fuel silo mechanism because of its uniform nature and low moisture content.

The primary concern associated with biomass is procuring sufficient fuel at an acceptable price, this can be mitigated against through the use of adequate fuel supply contracts and designing the boiler to be able to accept as wide a range of fuel specification as the boiler technology allows.

Careful consideration needs to be given to the basis of the price quoted for woodchip and other unrefined biomass fuels. The impact of high moisture and ash contents on the value of the wood as delivered must be reflected in the price paid. The strong preference would be to pay for the heat supplied rather than the fuel delivered to place the proper incentives on fuel suppliers to invest in provision of drier fuels where economically advantageous. Payments by the wet tonne should be avoided without adjustment mechanisms to take account of the weight of dry wood delivered and the impacts on combustion efficiency.

12.3.4 ENVIRONMENTAL CONSIDERATIONS

The primary emission of concern in relation to local air quality is particulates. Particulate emissions from the biomass boiler are generally controlled by post-combustion cyclones or filtration equipment to ensure that they remain below the permitted emissions limits. In order to maintain the required emission limits it is important to ensure correct maintenance of the filtration system and adequate control of the rate of biomass combustion.

Other potential emissions of concern are oxides of nitrogen, although this is generally only of concern where there are existing high background concentrations, and oxides of sulphur. This latter emission is generally tied to the levels of sulphur in the fuel and relates generally to specific growing conditions. This should be managed through adequate testing of fuels before contracting to ensure that further mitigation measures are not required.

The ash produced by the boiler is considered to be inert if the source wood is uncontaminated. The ash can be used as a construction aggregate or in-fill material. Water produced from boiler blow down and from flue condensate can have a high salt content and require neutralisation before it can be discharged to the drain.

A further environmental consideration is the impact of fuel deliveries on the local road network. To minimise the costs and environmental impact of the fuel supply chain, deliveries should be carried out in the largest available vehicles, proportionate to the scale of the fuel demand. Multiple large vehicle movements may be an issue for local planners when considering an application to install a biomass boiler.

Typically NOx emissions are likely to be around 250mg/Nm3 @ 11% O2. This is a similar level of emission to an unabated gas CHP engine and therefore consideration will need to be given to potential abatement of this emission.

12.3.5 SUSTAINABILITY OF FUEL SUPPLY

In the short term, access to a local wood fuel resource may be an issue, as the supply chain may require investment and development before it can function reliably. This is an issue in the context of acceptable transport distances for wood fuel (suggested by the Forestry Commission to be 40 miles when using road transport). However, providing that progress towards securing reliable local supply appears achievable in the medium, or long term a technology fuelled by biomass is appropriate.

12.3.6 CHOICE OF SOLID BIOMASS FUEL TYPE

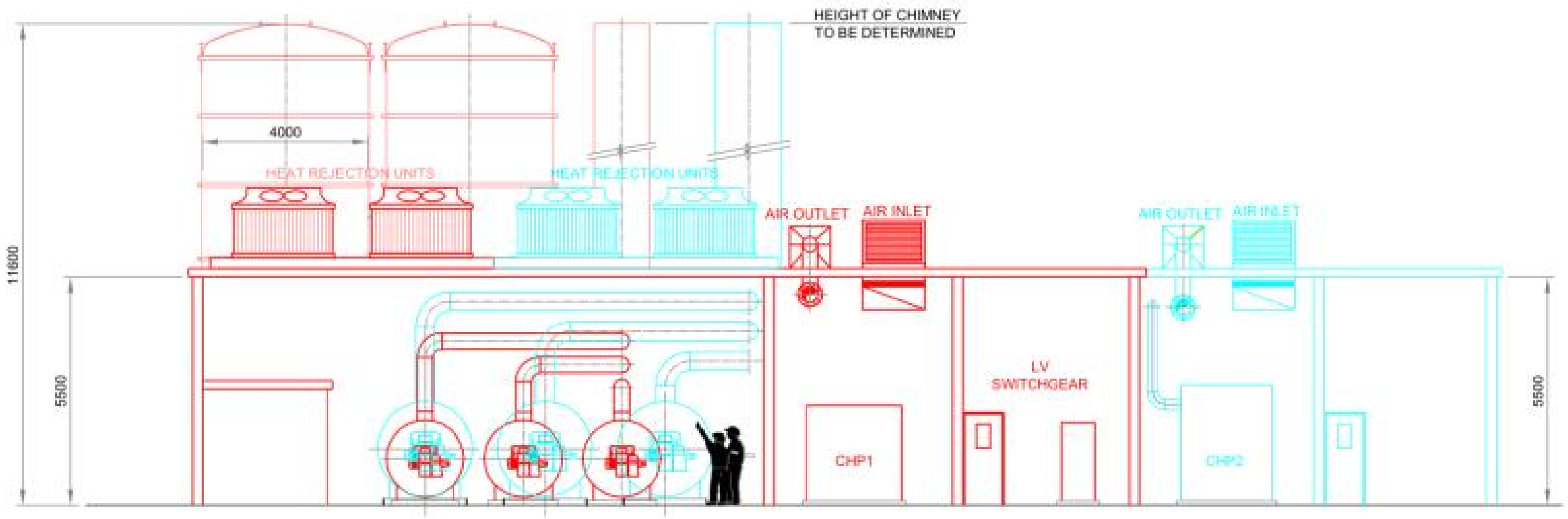
The design of biomass boiler systems is more problematic than fossil fuel boilers as a result of the variability of woody biomass fuel. Two main types of woody biomass are available, chipped and pelletised. Chipped woody biomass is almost exclusively derived from wood and is processed from raw timber into semi-regular chips. Pelletised woody biomass referrers to fuel, either wood or Miscanthus, that has been ground-down and re-formed into uniform pellets. The following table outlines the pros and cons of the two fuel types:

	Pros	Cons

Chipped woody biomass	• Low cost production • Specialised delivery vehicle not required	• Highly variable material • Requires complex fuel handling – high maintenance • Low energy density • No local source of woodchip
Pelletised woody biomass	• Lower maintenance • High energy density • Uniform dimensions • More reliable fuel handling	• Expensive to produce • Requires specialised delivery vehicle • Potential for higher embedded CO_2

APPENDIX H

INDICATIVE ENERGY CENTRE LAYOUTS AND PRIMARY SECONDARY INTERFACES



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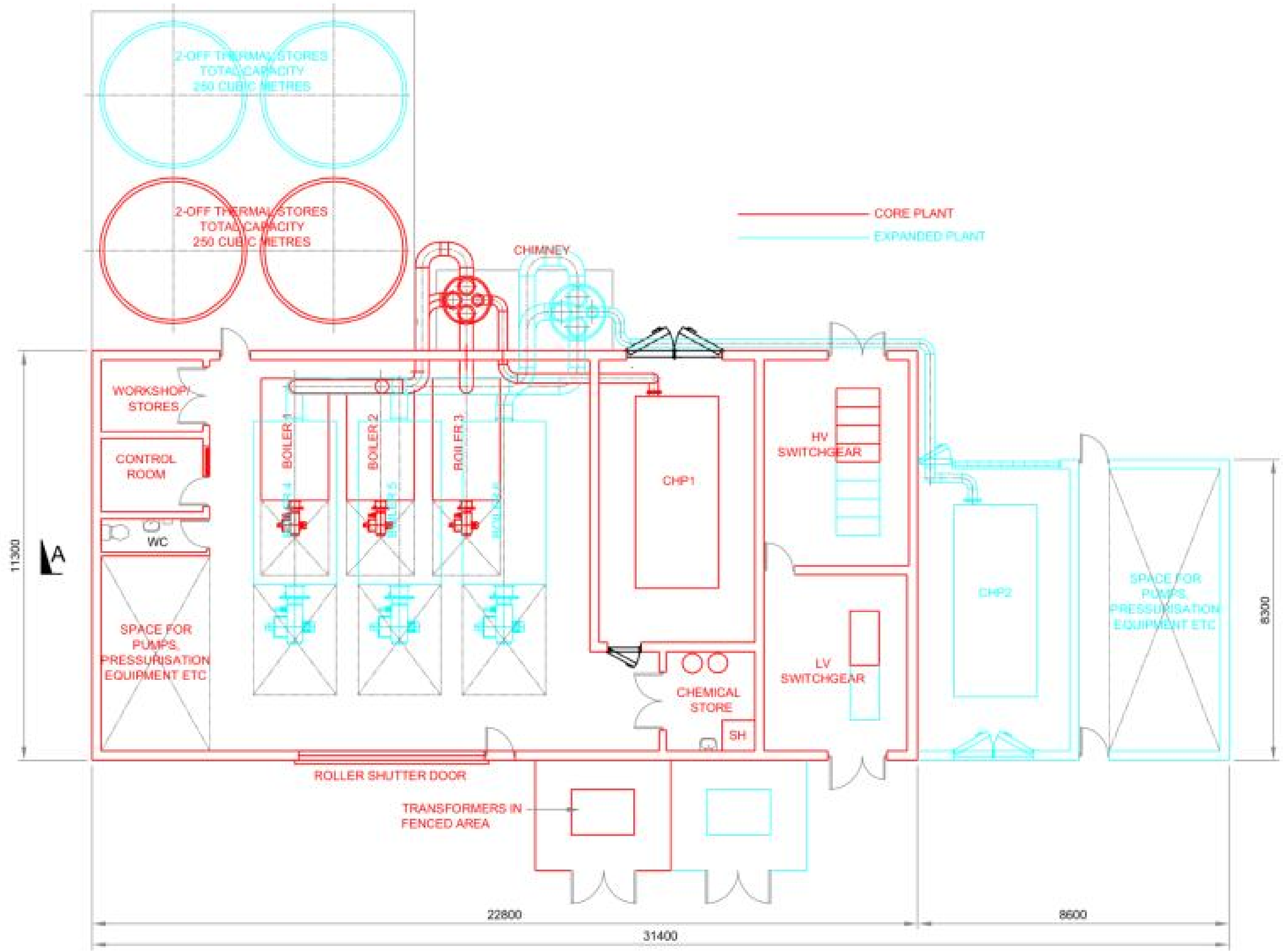

SECTIONAL PLAN

A	ISSUED WITH REPORT	RK	JE	JE	
REV.	DETAILS	DRN	CHK	APPR	DATE

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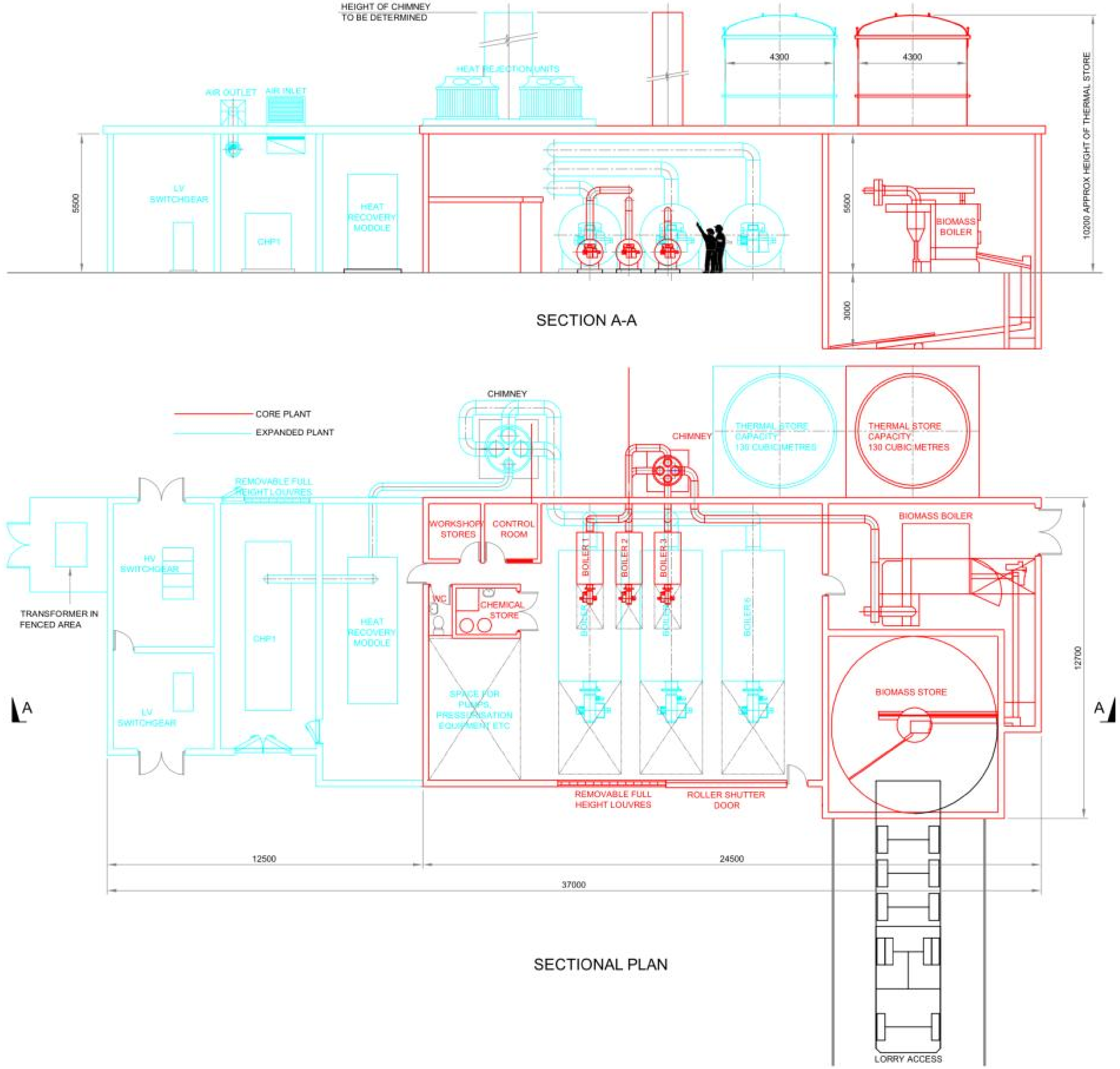
TEES VALLEY DISTRICT HEATING STUDY DARLINGTON SCHEME
- TITLE
ARRANGEMENT OF NEW ENERGY CENTRE

- DATE 20/07/10
- SCALE 1/150@A3
- CAD REF

DRAWN BY RAYK
PRODUCED BY
CHECKED JE
APPROVED JE

- DRAWING NUMBER
69481A-1-M003 | A



A	ISSUED WITH REPORT	RK	JE	JE	
REV.	DETAILS	DRN	CHK	APPR	DATE

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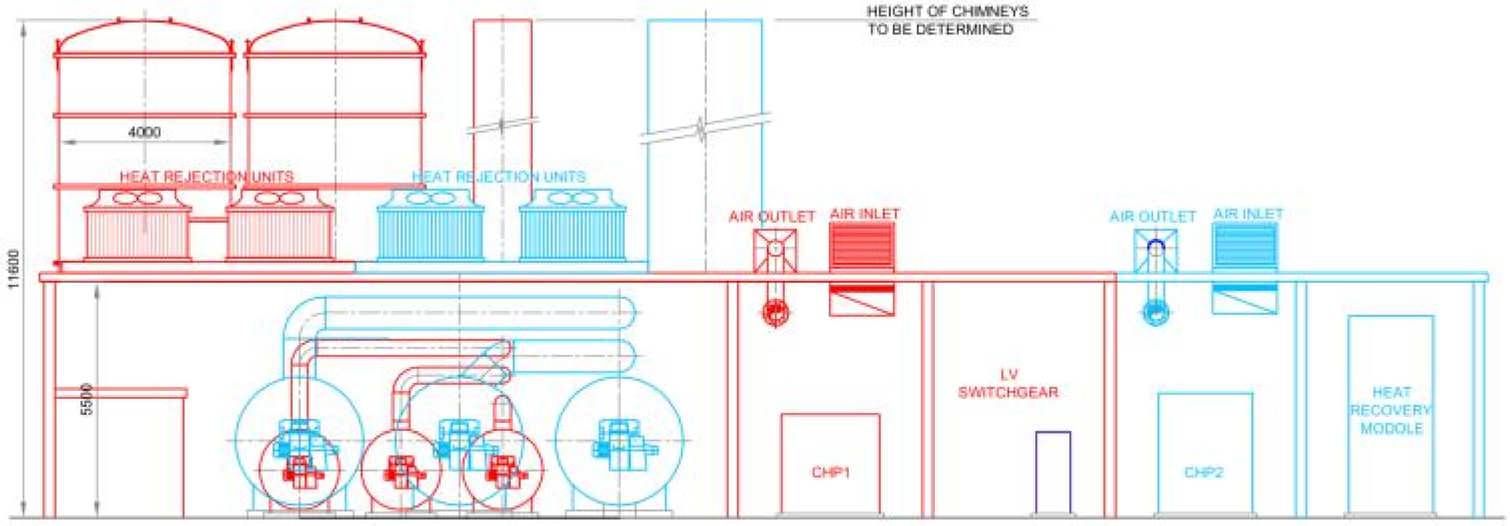
Energy and Sustainable Solutions - Infrastructure

6 Devonshire Square, London EC2M 4YE, UK
Tel: 44-(0)20-7337-1700 Fax: 44-(0)20-7337-1701

- CLIENT/PROJECT: TEES VALLEY DISTRICT HEATING STUDY STOCKTON SCHEME
- TITLE: ARRANGEMENT OF NEW ENERGY CENTRE
- DATE: 20/07/10
- SCALE: 1/150@A3
- CAD REF:

DRAWN BY: RAYK
PRODUCED BY:
CHECKED: JE
APPROVED: JE

- DRAWING NUMBER: 69481A-1-M002 — A



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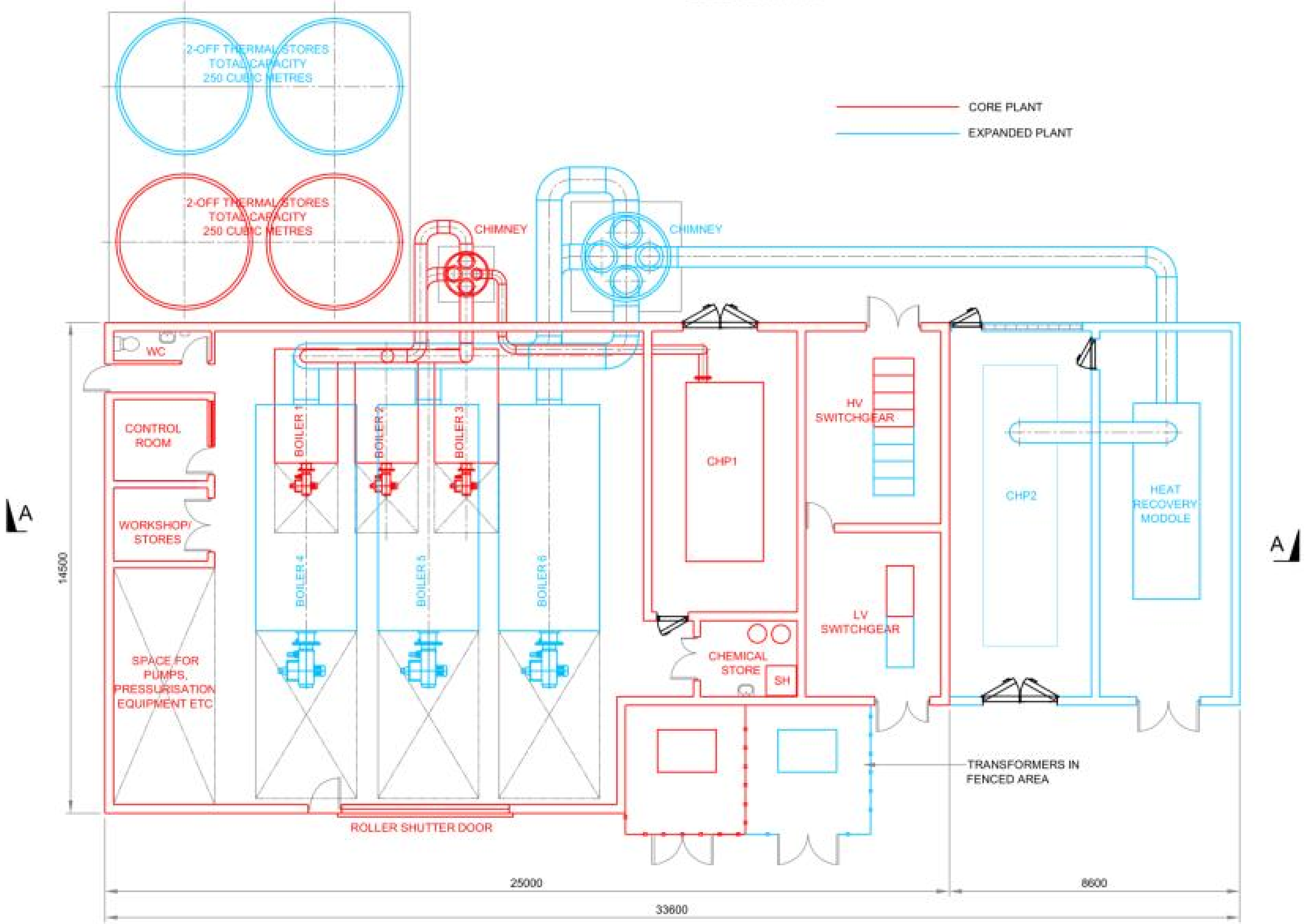

SECTIONAL PLAN

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REV.	DETAILS	DRN	CHK	APPR	DATE

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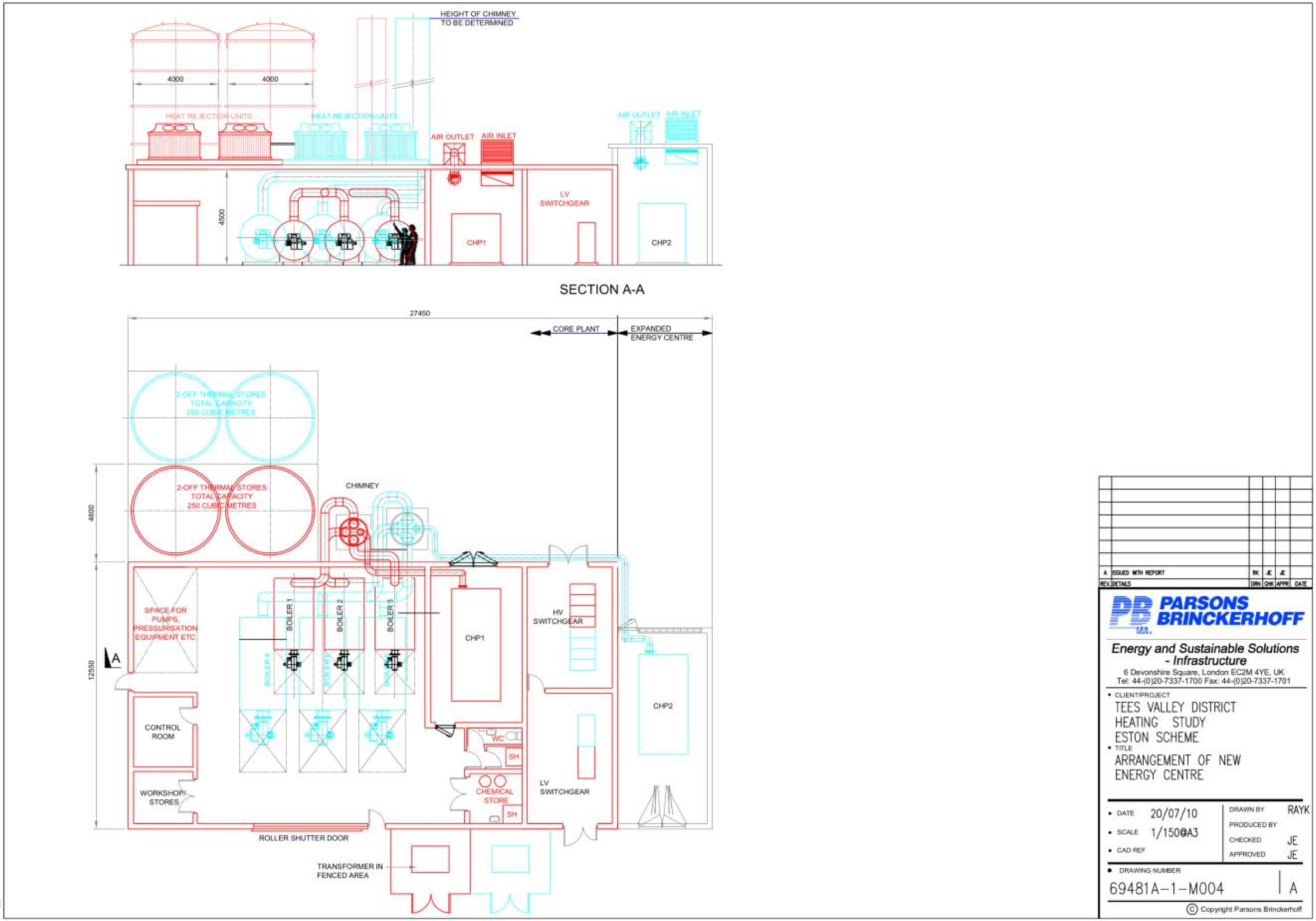
- CLIENT/PROJECT
  TEES VALLEY DISTRICT HEATING STUDY MIDDLEBOROUGH SCHEME
- TITLE
  ARRANGEMENT OF NEW ENERGY CENTRE
- DATE 13/07/10
- SCALE 1/150@A3
- CAD REF

DRAWN BY RAYK
PRODUCED BY
CHECKED JE
APPROVED JE

- DRAWING NUMBER
  69481A-1-M001 | A


HEIGHT OF CHIMNEY
TO BE DETERMINED
4000
4000
HEAT REJECTION UNITS
HEAT REJECTION UNITS
AIR OUTLET
AIR INLET
AIR OUTLET
AIR INLET
4500
LV
SWITCHGEAR
CHP1
CHP2
SECTION A-A
27450
CORE PLANT
EXPANDED
ENERGY CENTRE
2-OFF THERMAL STORES
TOTAL CAPACITY
250 CUBIC METRES
2-OFF THERMAL STORES
TOTAL CAPACITY
250 CUBIC METRES
4600
CHIMNEY
12550
A
SPACE FOR
PUMPS,
PRESSURISATION
EQUIPMENT ETC
BOILER 1
BOILER 2
BOILER 3
BOILER 4
CHP1
HV
SWITCHGEAR
CHP2
CONTROL
ROOM
WC
SH
CHEMICAL
STORE
SH
LV
SWITCHGEAR
WORKSHOP/
STORES
ROLLER SHUTTER DOOR
TRANSFORMER IN
FENCED AREA
A ISSUED WITH REPORT RK JE JE
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CLIENT/PROJECT
TEES VALLEY DISTRICT
HEATING STUDY
ESTON SCHEME
TITLE
ARRANGEMENT OF NEW
ENERGY CENTRE
DATE 20/07/10
SCALE 1/150@A3
CAD REF
DRAWN BY RAYK
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CHECKED JE
APPROVED JE
DRAWING NUMBER
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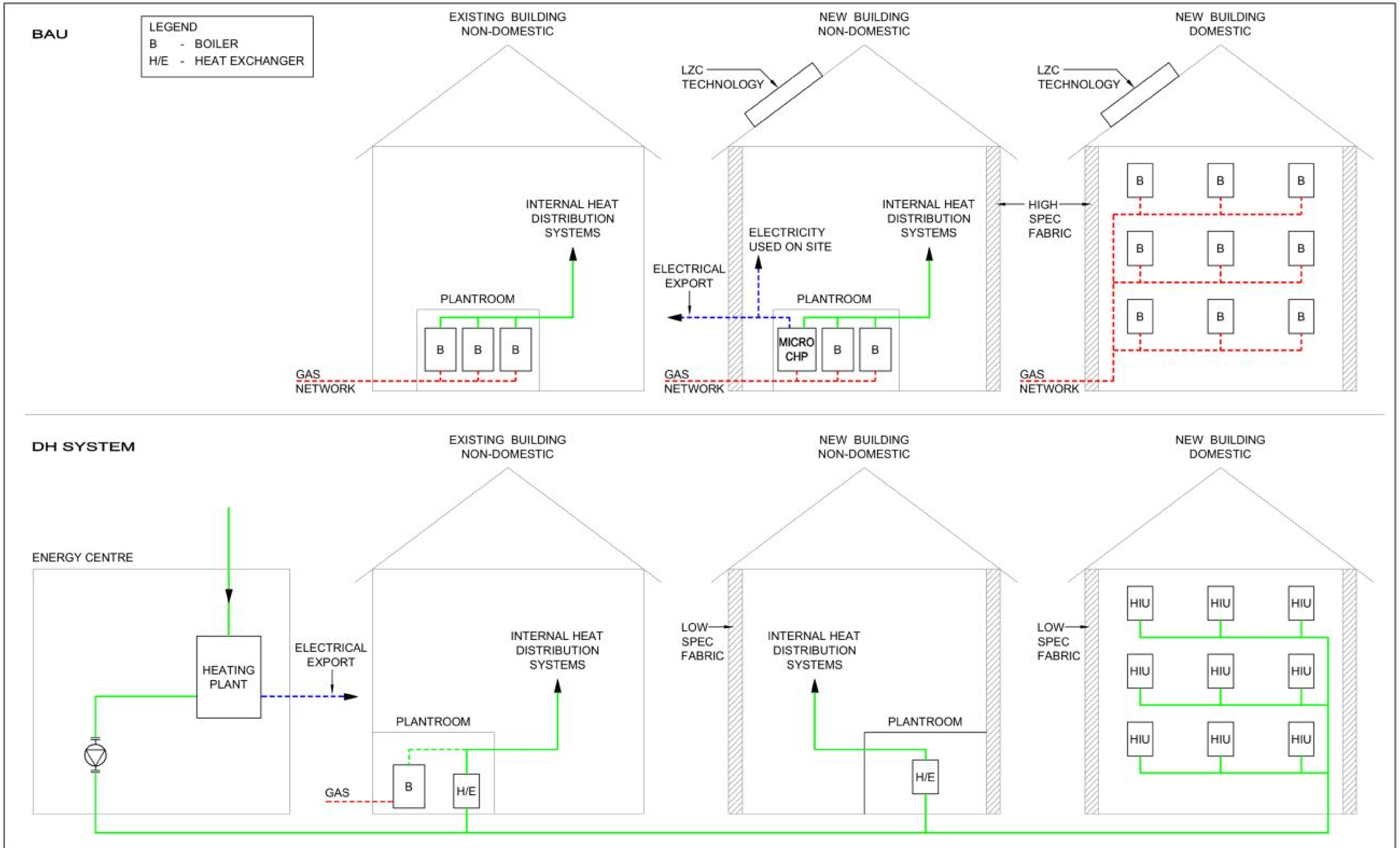

REV	DATE	DESCRIPTION	BY	CHKD	APPD

• NOTES

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Communities - Energy Solutions
6 Devonshire Square, London EC2M 4YE, UK
Tel: 44-(0)20-7337-1700 Fax: 44-(0)20-7337-1701

• CLIENT/PROJECT: TEES VALLEY UNLIMITED

• TITLE: BAU & DH SYSTEM OUTLINE

• DATE: 29/10/09
• SCALE: NTS
• CAD REF

DRAWN BY: SM
PRODUCED BY: JE
CHECKED: JE
APPROVED: DWB

• DRAWING NUMBER: 69481A–1–M005 | A

00/00/00

APPENDIX I

RISK REGISTER FOR TEES VALLEY SCHEMES

13 RISK REGISTER FOR TEES VALLEY SCHEMES

69481-Tees Valley
Risk Workshop Scorin