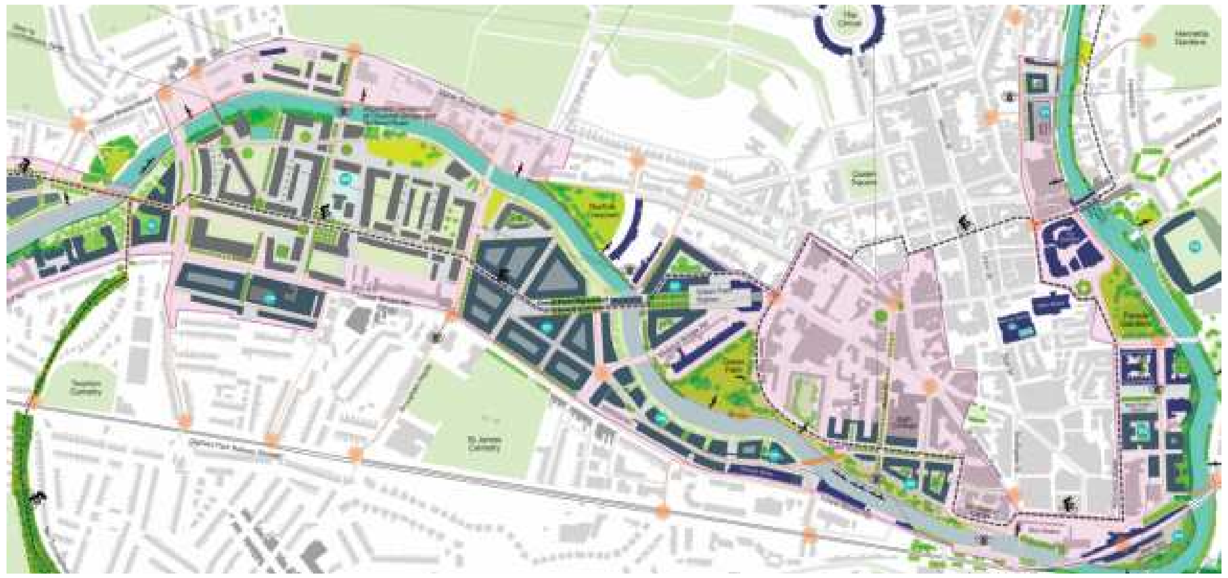
BUROHAPPOLD ENGINEERING

Bath & North East Somerset Council

DEPARTMENT OF ENERGY & CLIMATE CHANGE



District Heating at Bath Riverside Enterprise Area

Phase 1 Feasibility Study

034004

1 October 2015

Revision 03

Revision	Description	Issued by	Date	Checked
00	Draft for client comment	BS	17/07/15	CC
01	Updated draft incorporating Stakeholder Workshop notes	BS	24/08/15	CG
02	Issue incorporating B&NES comments	BS	22/09/15	CG
03	Alterations to appendices	BS	01/10/15	CG

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Glossary

Term	Definition
AQMA	Air Quality Management Area
B&NES	Bath and North East Somerset
BH	BuroHappold Engineering
BWR	Bath Western Riverside
BWCE	Bath and West Community Energy
CHP	Combined heat and power
DEC	Display Energy Certificate
DECC	Department of Energy and Climate Change
DH	District heating
DHW	Domestic Hot Water
ESCo	Energy Services Company
HNDU	DECC Heat Networks Delivery Unit
HIU	Hydraulic Interface Unit
IRR	Internal Rate of Return
JV	Joint Venture
MUSCo	Multi Utility Services Company
NPV	Net Present Value
O&M	Operations and Maintenance
PV	Photovoltaic
RHI	Renewable Heat Incentive
SPV	Special Purpose Vehicle
SWHM	South West Heat Map
VOA	Valuation Office Agency

1 Executive Summary

BuroHappold Engineering have been commissioned to assess the technical and economic feasibility of district energy within the Bath Enterprise Area. A masterplan for the area has been developed and this identifies nine key development sites within the Enterprise Area. Previous studies have identified the potential for district heating within the Enterprise Area and B&NES Core Strategy Policy CP4 District Heating identifies two priority areas in which new development can be compelled to connect or make provision for connection to a district heating network. District heating can also help B&NES Council achieve Core Strategy Policy CP3 Renewable Energy and it's overarching requirement to reduce CO_2 emissions by 45% from 1990 levels by 2029.

This report covers the findings from Phase 1 of the Enterprise Area District Heating Feasibility Study. The aims of this work were to engage with key stakeholders and gather relevant data, carry out technical and economic assessment of a number of district heating options, identify the most viable options and identify potential governance approaches for a district heating scheme. The preferred options will be analysed in more detail in Phase 2 of the works in order to establish whether there is a viable business case.

Initial constraints mapping, a review of previous studies and discussions with B&NES Council led to the identification of potential district heating consumers with the study area. From this a long list of 10 potential network options was developed and a short list of 5 network options was selected for techno-economic assessment. For each network option, two low carbon technologies were tested.

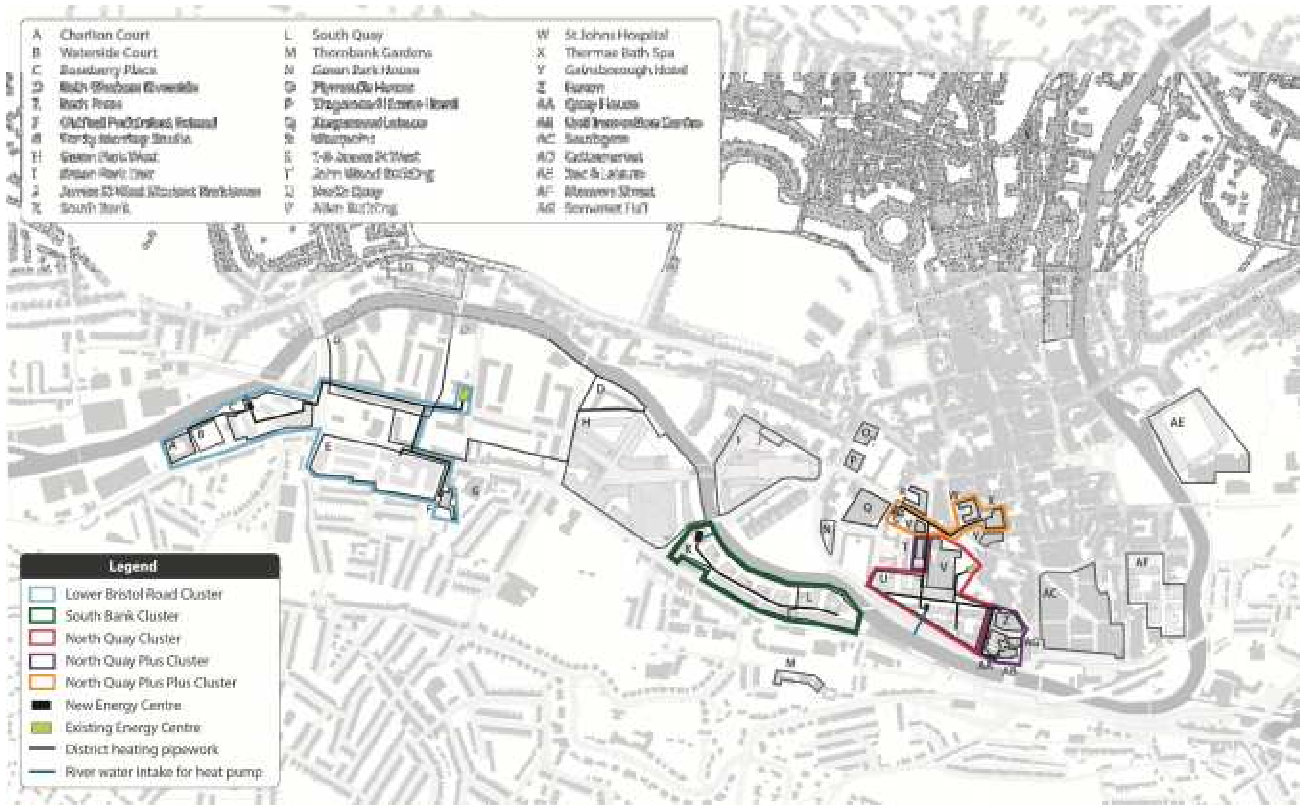


Figure 1—1 Enterprise Area network options

A summary of the techno-economic modelling results is shown in Table 1—1. This quantitative assessment of the options was combined with a qualitative assessment of other viability criteria, such as scheme deliverability, in a decision matrix in order to select a preferred option to develop in more detail. The results of the overall assessment are shown in Figure 1—2, where a score of 100% indicates a top scope in each viability category.

Table 1—1 Summary of techno economic modelling results

Option	Heat demand (MWh/year)	CO_2 savings – 2015 (tonnes/year)	CO_2 savings – 2035 (tonnes/year)	Gross capital cost (£)	Year 1 net revenue (£)	25 year NPV at 3.5% discount factor (£)
North Quay - Heat Pump	6,200	241	952	£3,600,000	£40,800	-£2,450,000
North Quay - CHP	6,200	580	-778	£3,100,000	-£62,700	-£3,150,000
North Quay Plus - Heat Pump	7,500	263	1,070	£4,350,000	£47,800	-£3,100,000
North Quay Plus - CHP	7,500	585	-835	£3,850,000	-£60,900	-£3,850,000
North Quay Plus Plus - Heat Pump	11,600	465	1,791	£5,650,000	£114,300	-£3,550,000
North Quay Plus Plus - CHP	11,600	1,087	-1,438	£5,300,000	-£67,600	-£5,300,000
South Bank - Heat Pump	2,400	71	340	£2,500,000	£18,100	-£1,650,000
South Bank - CHP	2,400	105	-222	£2,350,000	-£41,700	-£2,250,000
Lower Bristol Road - Heat Pump	3,800	45	474	£3,000,000	£49,600	-£1,800,000
Lower Bristol Road - Biomass	3,800	433	464	£2,850,000	£49,200	-£1,700,000

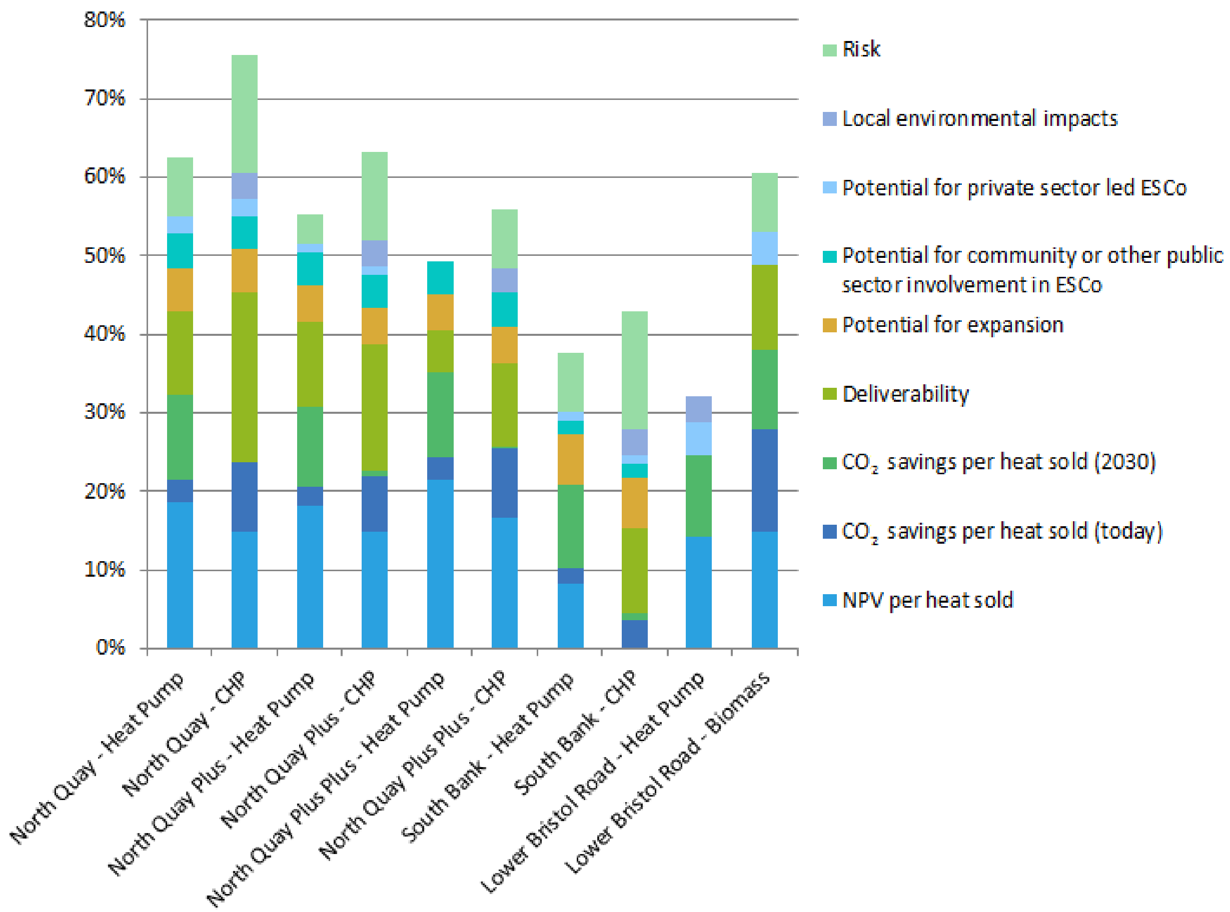


Figure 1—2 Options assessment viability matrix

None of the options assessed achieved a positive NPV after 25 years at a 3.5% discount rate based upon the input assumptions for the financial model. The option that was viewed as being most viable was a gas CHP led scheme at North Quay. The sensitivity of the financial viability to a number of financial model input assumptions was tested and it was established that the North Quay scheme could be viable with an increased electricity sales price (e.g. private wire connection), an increased heat sales price and a capital grant. The extent to which district heating provided a lower cost alternative to other routes to reducing carbon emissions (such as building energy performance standards) was not explored as part of the study.

Governance options for a district heating scheme were reviewed, and a number of potential models for the role of the Council identified, building on earlier work on the role of the Council in local Energy Service delivery. Consideration was also given to consumer or community ownership of district heating schemes, which is currently uncommon in the UK. The key precedents for community ownership are focused on renewable generation, with limited examples applied to district heating. However, it would appear that there are features of district heating – particular the impact of monopoly pricing – that make it appropriate to develop some form of customer involvement in scheme management particularly in the longer term.

The key conclusions of this study in relation to heat supply technology options are:

- River source heat pump – there are significant risks associated with using this technology for initial heat network development as its financial viability relies very heavily on the RHI and the Environment Agency may object to the river water intakes on flood risk grounds. It also only delivers small CO_2 savings compared to the combination of local gas boilers and imported electricity, based upon the CO_2 emissions associated with electricity today. However, as the grid decarbonises over the next 15 years it will deliver significant CO_2 savings. On this basis a river source heat pump may be better utilised as a second stage technology after the initial network is developed with another technology.
- Gas CHP – this technology is relatively low risk and can deliver a reasonable operational margin if electricity can be sold at close to commercial retail prices. The risk associated with the relative price changes of gas and electricity is less than that around changes to the RHI. The technology delivers significant CO_2 savings compared to local gas boilers based upon the CO_2 emissions associated with electricity today. However, as the grid decarbonises this savings reduce and by 2030 it is likely that gas CHP will have higher CO_2 emissions than local gas boilers. Gas CHP could act as an initial technology to enable the development of heat network infrastructure and then be replaced with a lower carbon heat source at the end of its useful life.
- Biomass boiler – this technology provides significant CO_2 savings both now and in the future. It relies on the RHI to deliver an operating margin as the cost of biomass is similar to that of gas. It is not suitable for the city centre sites due to space constraints, access requirements and potential air quality issues.

The key conclusions of this study in relation to network options are:

- North Quay and wider options – these have the highest heat density of the options considered and the most opportunity for expansion. The Council has a strong influence over the schemes as it is the landowner and developer of the Avon Street car park site. There is potential for B&NES Council to establish a joint venture to take forward the scheme, potentially involving City of Bath College or the University of Bath. There is also potential for other forms of partnership agreement, such as a concession let to a private sector ESCo, which would allow greater risk to be transferred from the Council but at the expense of control. A CHP led option could be viable for the scheme if an electricity sales price of £90/MWh can be achieved and there is a capital grant (or equivalent) for the scheme. This cluster is the most of viable of the options considered and should be developed further in Phase 2.
- South Bank – this scheme is too small to support a viable heat network. The majority of the site is office buildings, which have a limited heat demand. It is recommended that policy CP4 is used to ensure that the buildings are future-proofed for district heating connections as the development of the Green Park area could lead to heat network connections being viable as part of a larger scheme.
- Lower Bristol Road - this scheme has a low heat demand density; the length of pipework required compared to the annual heat demand for the current configuration means this scheme is not viable as a standalone network. There could be potential for an expansion of the Bath Western Riverside scheme with an extended energy centre and the Bath Western Riverside Phase 2 pipework being used to distribute heat to Roseberry Place and Bath Press. However, there may be practical and legal issues with this option. The commercial sensitivity of E.ON's business model means that it has not been possible to explore the financial viability of this option in this work. B&NES Council could act as an enabler and coordinate discussions between key stakeholders such as E.ON, Crest Nicholson, Spenhill and Deeley Freed.

The recommended next steps are:

- Further investigation of the North Quay cluster to establish the required conditions to make the scheme viable. This would include:
  - Refinement of the technical design
  - Exploration of options to reduce net capital costs borne by the scheme
  - Exploration of options to increase revenue, such as private wire supply
- Investigation of options for the expansion of the Bath Western Riverside network to serve Bath Press and Roseberry Place, to allow B&NES to act as a facilitator to support the private sector to understand the potential of scheme expansion.

2 Introduction

BuroHappold Engineering have been commissioned to assess the technical and economic feasibility of district energy within the Bath Enterprise Area. The Enterprise Area covers an area of 98ha adjacent to the River Avon and has been designated a key zone for economic growth by the West of England Local Enterprise Partnership. A masterplan for the area has been developed and this identifies nine key development sites within the Enterprise Area. Previous studies have identified the potential for district heating within the Enterprise Area.

This study forms part of a wider suite of work that is being undertaken by B&NES Council and BuroHappold in relation to the delivery of energy services in B&NES. B&NES Council's aims for energy services are:

1. Enable customers to access lower cost, local energy
2. Increase the amount of low carbon energy produced in our area
3. Retain the economic benefits from low carbon energy and retrofitting in the local area
4. Provide a better return for local renewable energy generators
5. Maximise opportunities for demand reduction through energy efficiency
6. Maximise local community ownership of energy assets and services
7. Generate revenue

This report covers the findings from Phase 1 of the Bath Riverside Enterprise Area District Heating Feasibility Study. The aims of this work were to engage with key stakeholders and gather relevant data, carry out technical and economic assessment of a number of district heating options, identify the most viable options and identify potential governance approaches for a district heating scheme. The preferred options will be analysed in more detail in Phase 2 of the works in order to establish whether there is a viable business case.

This work has been delivered with support from the Department of Energy and Climate Change's Heat Networks Delivery Unit.

2.1 Scope of study and methodology

The scope and methodology of the work carried out as part of Phase 1 is shown in and the approach taken to techno-economic modelling is illustrated graphically in Figure 2—1.

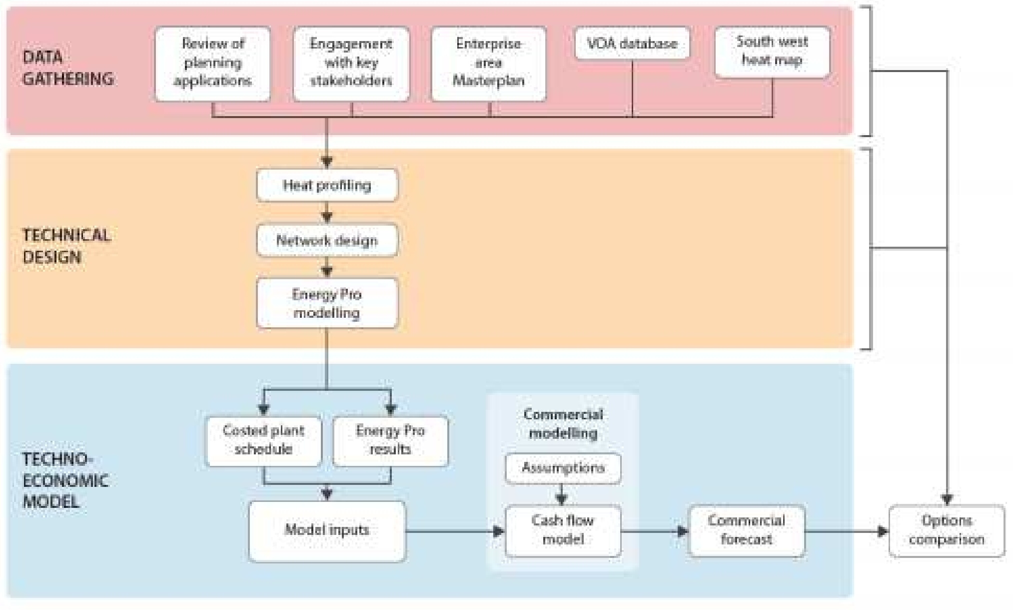


Figure 2—1 Techno-economic modelling approach

Table 2—1 Methodology

Task	Approach
Review of potential consumers	Identification of potential consumers in study area. Development of assessment matrix to cover issues such as annual and peak demand size, likely annual demand profile, compatibility of systems, potential demand variability and customer motivation/likelihood of connection. Initial contact will be made with key stakeholders, facilitated by the Council.
Data collection and analysis	Collection and interpretation of relevant information relating to potentially connectable buildings. Sources will include: • Metered data • Greenhouse gas emissions data for B&NES public buildings for DECC reporting • Floor space, building typology and benchmarks • South West Heat Map • Visual inspection of key plant rooms
Low carbon energy sources assessment	Development of assessment matrix of low carbon energy supply sources to cover issues such as maturity of technology, scale required for viability, issues relating planning approval and environmental licensing, fuel source issues etc. Identification of technologies that are unlikely to be viable for the 'core scheme' for the Enterprise Area but could potentially be used in the future as part of a transition from fossil fuel energy sources.
Review of existing energy producers	Identification of existing energy producers in the area, their capacity and what role they could potentially play in supplying energy to the Enterprise Area.
Development and selection of options for assessment	Development of a long list of potential options for building connections, infrastructure routes and plant type. Discussion and selection of shortlist of options for initial technical and commercial modelling with client team and key stakeholders.
Options demand assessment	Development of annual energy demand profile for each shortlisted option based on hourly time-steps. Assessment of peak demand requirements. Assessment of impact of phasing of development within the Enterprise Area on the demands. Discussion of potential impact of improved energy efficiency standards, tariffs and demand side management on energy demands.
Options technical modelling	Undertake technical modelling of energy system using EnergyPro software where applicable or computational calculation to optimise plant size and thermal storage based on annual load profiles and operating parameters. Outputs to be used in commercial model include fuel consumption, operational data, carbon savings and heat output.
Options energy centre and network layout	Review potential energy centre locations, their suitability for additional CHP/biomass/boiler and flues. Energy centre location, size and type (e.g. stand-alone or integrated) will be suggested as appropriate. Preliminary pipe-work routing and sizing Determine infrastructure connections required for the development of the network and make initial enquires with utilities providers.
Options costing	Develop capital costs for each option for input into financial model.
Options technical viability assessment	Based on the options design development an assessment of the technical viability of each option will be carried out and the key risks highlighted (for inclusion in the project risk register). Discussion of potential alternative approach to deliver the same scale of carbon reduction,
Initial financial appraisal	Development of lifecycle cash flow model covering each option. Key inputs will be CAPEX, OPEX, fuel costs, energy sales, income from incentives, interest rates, maintenance and overheads. Key outputs will be payback period, IRR, NPV and CO_2 savings.
Social value appraisal	Calculation of CO_2 savings and energy savings of each option compared to a business as usual baseline. Socio-economic comparison of each option against the overall aims of the project. Discussion of the potential role of social enterprise and community benefits models
Governance assessment	Mapping of the Enterprise Area scheme against different governance approaches Identification of the role of the Council and key stakeholders. Identification of opportunities relating to planning and development opportunities and land ownership. Discussion of opportunities for MUSCo approach.
Preferred option assessment	Multi-criteria decision making assessment of options, covering technical, economic and social issues.

3 Context

3.1 Policies and targets

B&NES Core Strategy Policy CP4 District Heating[1] identifies two district heating priority areas that are within the study area – Bath Central and Bath Riverside. The extent of these areas is shown in Figure 3—1. Within these areas "development will be expected to incorporate infrastructure for district heating, and will be expected to connect to existing systems where and when this is available, unless demonstrated that this would render development unviable." The district heating priority areas do not cover all of the Enterprise Area sites (extent shown in Figure 3—8), most notably Roseberry Place, Bath Press and the western part of Bath Western Riverside.

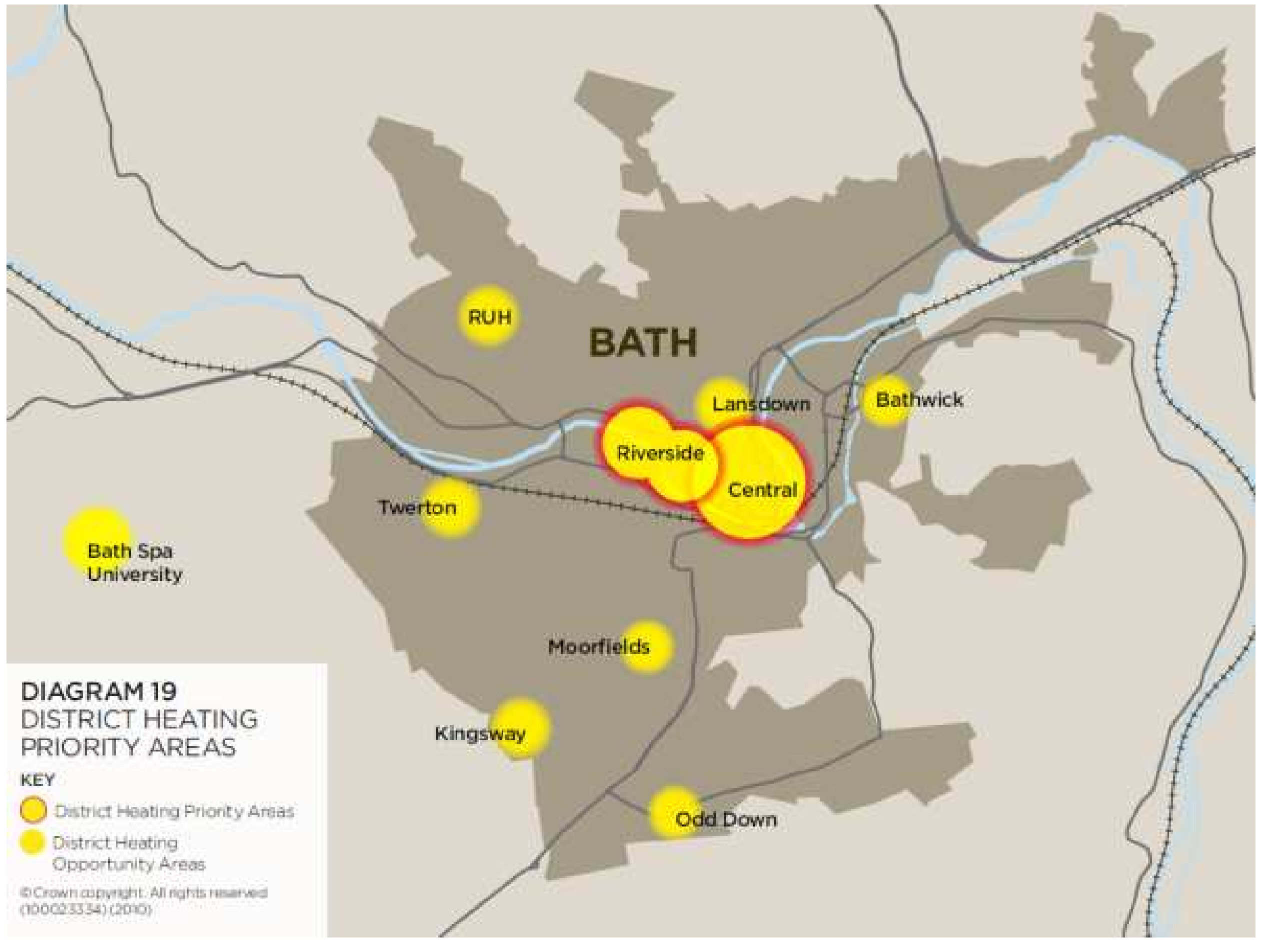


Figure 3—1 District heating priority areas (B&NES Core Strategy 2014)

B&NES Core Strategy CP3 Renewable Energy states that development should contribute to achieving 165MWth of renewable heat and 110 MW renewable electric generation by 2029.

B&NES also has broader CO_2 emissions reductions targets of 45% by 2029 and 80% by 2050, relative to a 1990 baseline.

In addition to local policies, the national requirements of Part L of the Building Regulations are also relevant as connecting to a low carbon district heating system will help new buildings comply with Part L1A and Part L2A CO_2 emission requirements.

[1] http://www.bathnes.gov.uk/services/planning-and-building-control/planning-policy/core-strategy-examination

Bath Western Riverside Supplementary Planning Document Part 1 – Strategic Framework[2]

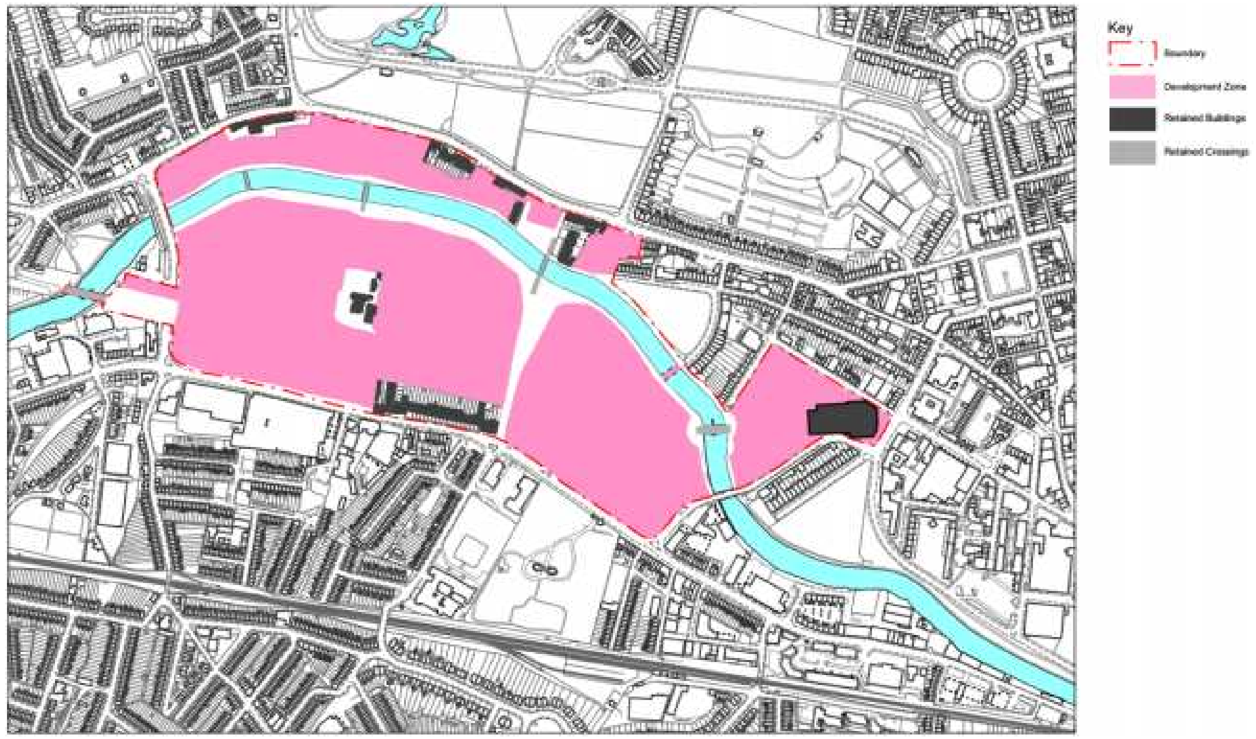


Figure 3—2 Area covered by Bath Western Riverside Supplementary Planning Document

The Bath Western Riverside Supplementary Planning Document (SPD) (2008) is a Spatial Masterplan to guide the redevelopment and regeneration of Western Riverside. The SPD has a number of energy targets for development within the Spatial masterplan, including:

- Code for Sustainable Homes Level 3 of residential buildings
- BREEAM 'Excellent' for non-residential buildings
- Application of the energy hierarchy to design
- 10% of energy to be provided by on-site renewable energy
- Buildings to be future proofed to allow for conversion to full renewable or zero carbon energy as technology develops

3.2 Previous studies

District Heating Opportunity Assessment Study, AECOM 2010[3]

This study was commissioned to provide the evidence base for Core Strategy Policy CP4. It explored opportunities for district heating within B&NES and identified 15 cluster zones of which 3 key areas were addressed in more detail, including high level financial analysis and deliverability. Two areas (Riverside and Central) are within the Bath Enterprise Area, and were included within CP4 as Priority Areas for district heating because they had the highest technical and financial potential and would be the easiest to deliver practically within B&NES.

[2] http://www.bathnes.gov.uk/services/planning-and-building-control/planning-policy/supplementary-planning-documents-spds
[3] http://www.bathnes.gov.uk/services/planning-and-building-control/planning-policy/energy-networks

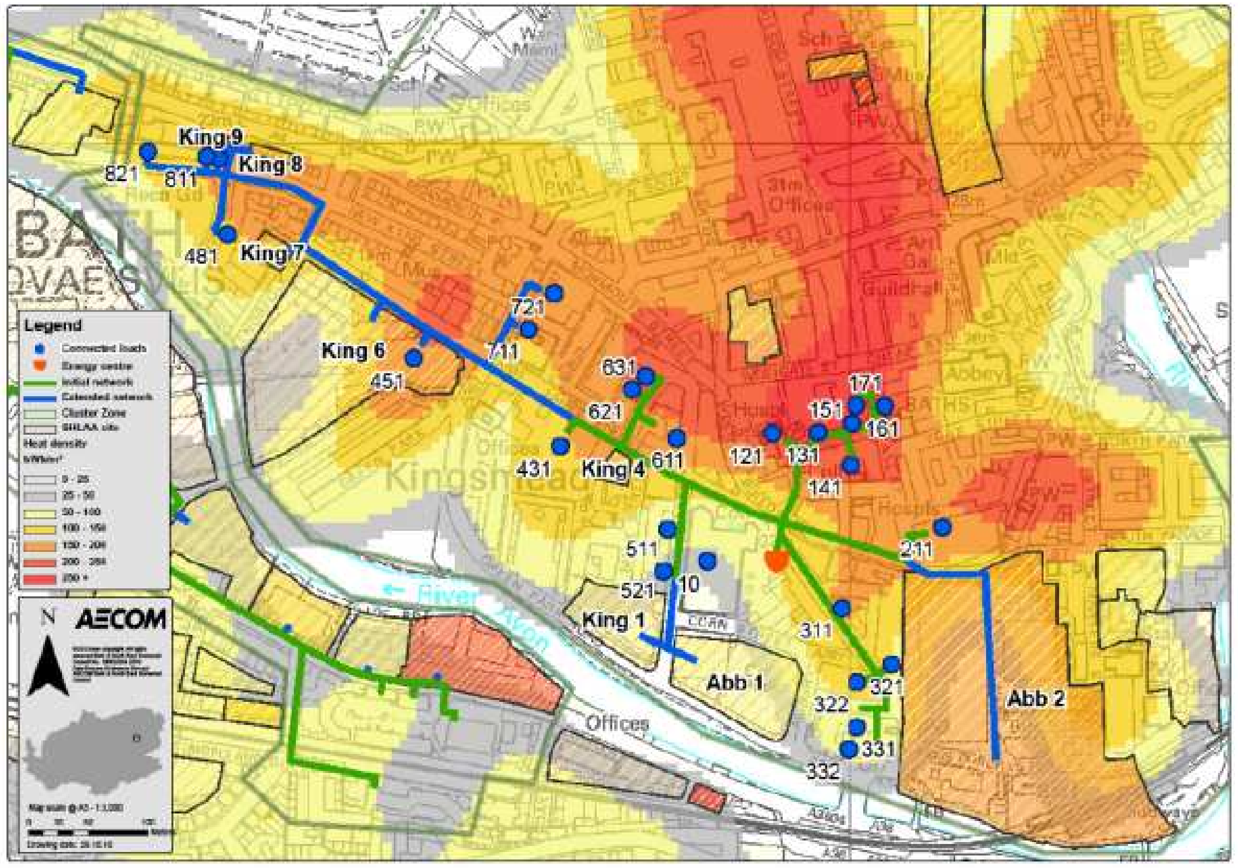


Figure 3—3 Bath City Centre network map from AECOM study

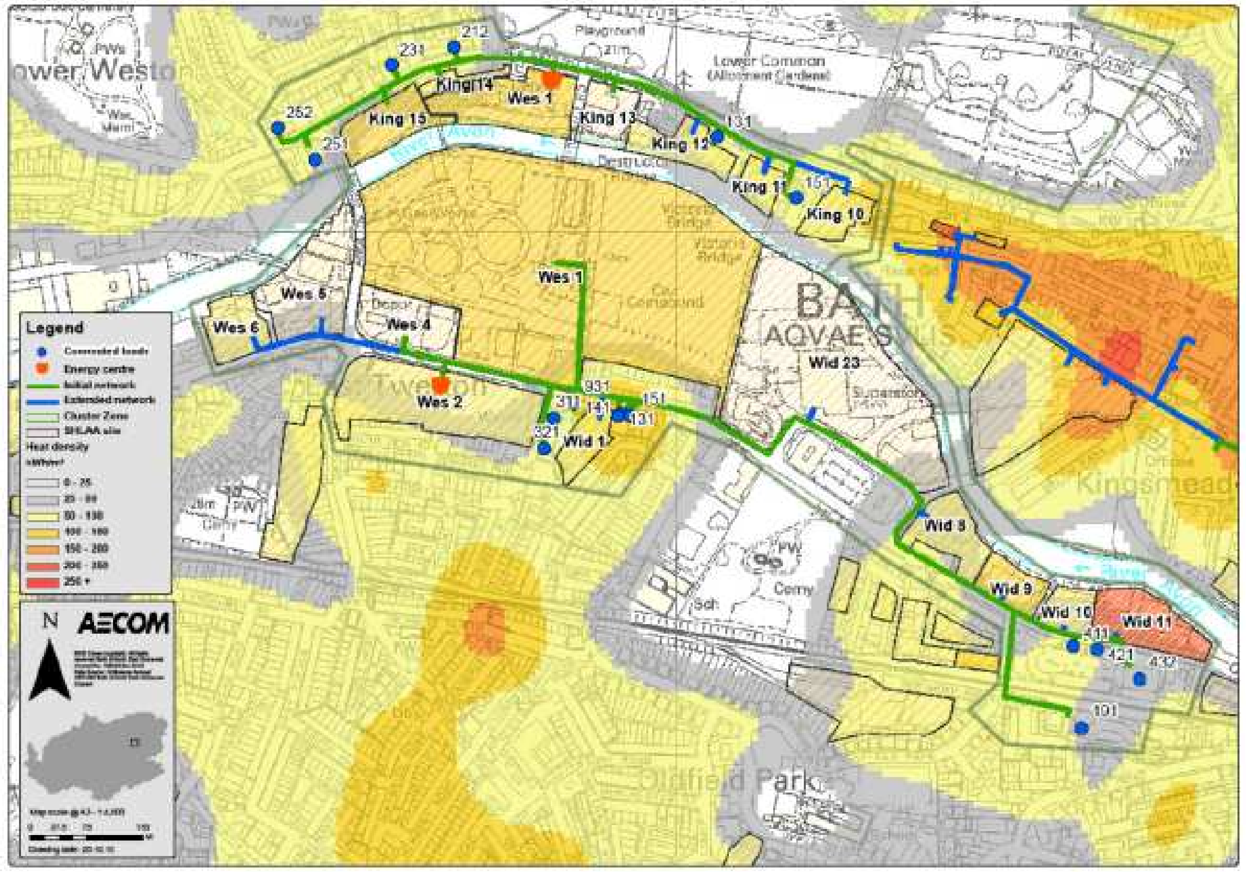


Figure 3—4 Riverside network map from AECOM study

Bath City Riverside Enterprise Area Masterplan, Fielden Clegg Bradley and BuroHappold 2014

An internal engineering study to support the development of the Enterprise Area masterplan considered the high level viability of district heating for the Enterprise Area development sites. The key conclusions were that Roseberry Place, Bath Press and Green Park West could form part of a larger network connecting to Bath Western Riverside, and that North Quays, South Quays and South Bank could form a network if additional existing heat loads could be added to the network.

Solar PV Energy Assessment: Placemaking Plan Development Sites, RegenSW and University of Exeter 2014

This internal study assessed the potential for solar PV for development sites that were being considered for inclusion in the B&NES Council Placemaking Plan, which included a number of sites in the Enterprise Area study area. This concluded that there was potential to install a total of 3.8MW on sites within the Enterprise Area of which 1.0MW was associated with residential sites and 2.8MW was associated with non-residential sites.

3.3 CO_2 emissions projections

In selecting an appropriate heating fuel supply source for heat networks it is important to consider how CO_2 emissions associated with energy production will change over the next 25 years (indicative plant lifetime) to 40 years (indicative district heating network lifetime). Heat pumps and gas CHP are the two major district heating technologies that will be significantly affected by changes in the grid electricity carbon intensity.

A phased decarbonisation of the electricity grid is predicted to meet national CO_2 targets based on Government policy and technical feasibility. Currently a reliance on fossil fuels means that natural gas is a significantly more low carbon fuel than electricity; utilising gas CHP to offset electricity with associated high CO_2 emissions gives significant CO_2 savings and is highlighted in national policy as a key technology as part of transition towards low and zero carbon heat.

Figure 3—5 shows how this picture may change in future years based on DECC electricity grid emissions projections[4], assumptions on heat pump and CHP efficiencies and an assumption of a 10% penetration of 'green gas' into the natural gas network by 2050.

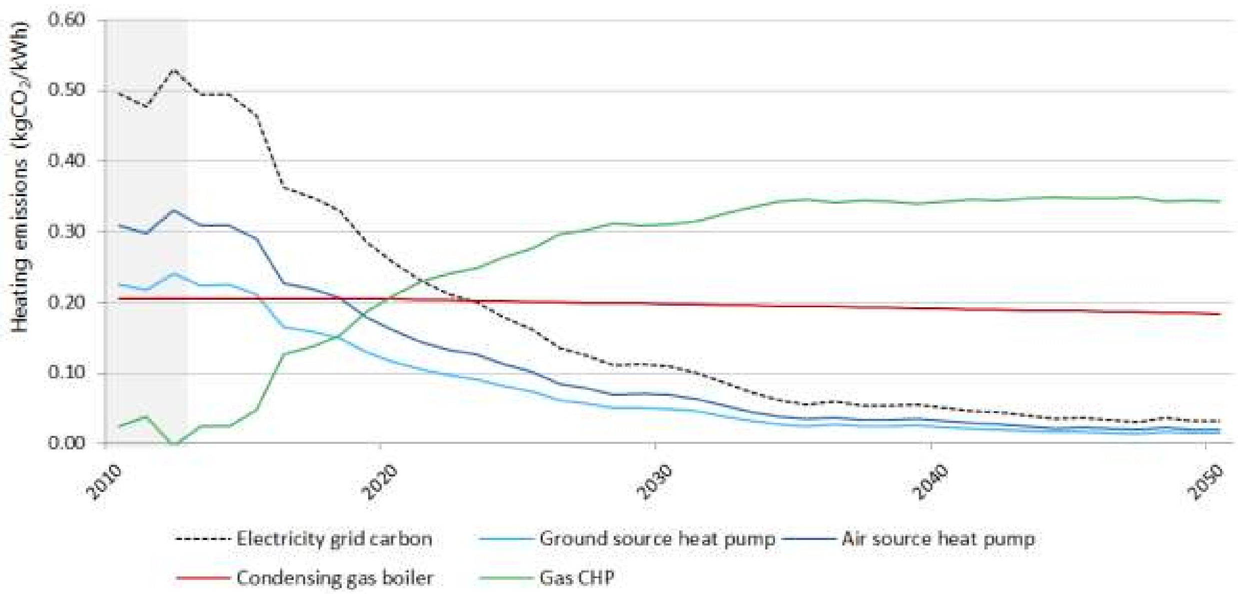


Figure 3—5 Impact of DECC electricity emission factor projections on heating CO_2 emissions (source: DECC[1])

The grey area on the graph shows where we are today – gas CHP remains a preferable low carbon technology up until the point that the grid decarbonises to the extent that the electricity offset by a gas CHP engine is of a higher CO_2 content than the electricity grid. As this happens, using heat pumps becomes a more attractive method of reducing emissions, notwithstanding concerns around the future financing of such schemes and the vulnerability of the Renewable Heat Incentive (RHI).

In theory heat pumps and gas CHP become similar in terms of emissions as soon as 2020, however this is reliant on a number of assumptions around decarbonisation of the electricity grid including the fast uptake of renewables in the UK, the generation mix and the decommissioning of fossil fuel power stations, alongside uncertainty on the amount of 'green' gas that can help decarbonise the gas grid. For this reason both CHP and heat pumps have been prioritised for future consideration, the former as a reaction to the current energy market and achieving CO_2 emission reductions against today's building regulations, the latter as a future technology in line with the projected grid decarbonisation and compatible as a replacement or additional supply source to a district heating network.

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360323/20141001_Supporting_Tables_for_DECC-HMT_Supplementary_Appraisal_Guidance.xlsx

3.4 Energy prices

There are many factors that affect the price of energy, including global and local demand, wholesale prices, transportation prices and government policy. It is not possible to predict future energy prices with a strong amount of confidence but in general it is expected that energy prices will rise at a higher rate than general inflation. Figure 3—6 shows DECC's electricity and gas price projections to 2035, it can be seen that electricity prices are predicted to rise more than gas prices. The difference between gas and electricity prices is referred to as the 'spark gap'. The spark gap affects the relatively viability of CHP and heat pump systems, the greater the spark gap the more viable CHP is, while a smaller spark gap makes heat pumps more viable. Figure 3—7 shows that DECC predicts that the spark gap will generally increase from current levels.

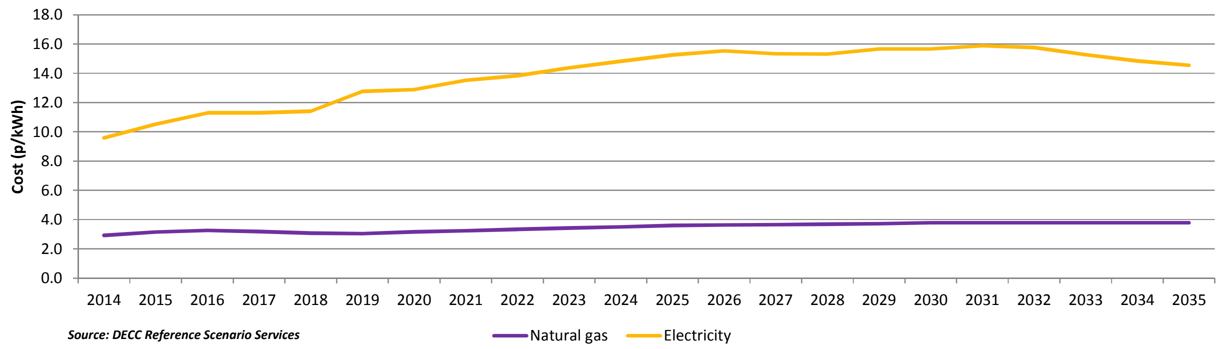


Figure 3—6 DECC electricity and gas projections to 2035

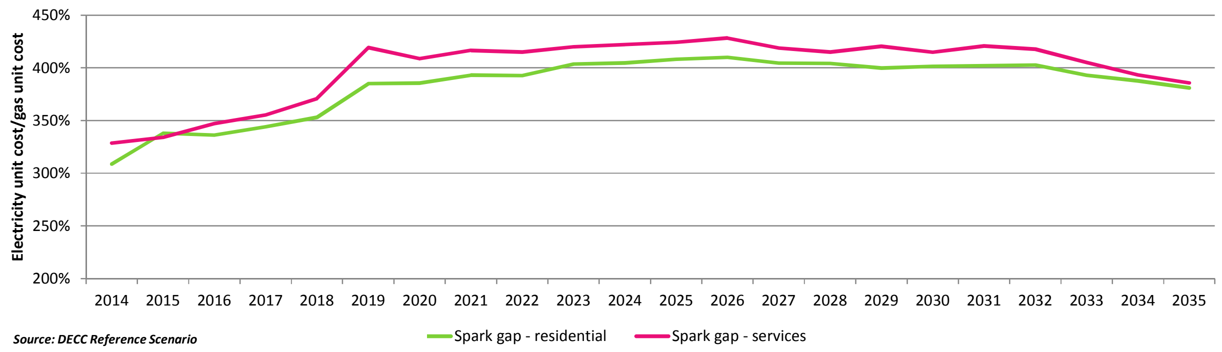


Figure 3—7 Spark gap projection to 2035 based upon DECC energy price projections

3.5 Enterprise Area characteristics

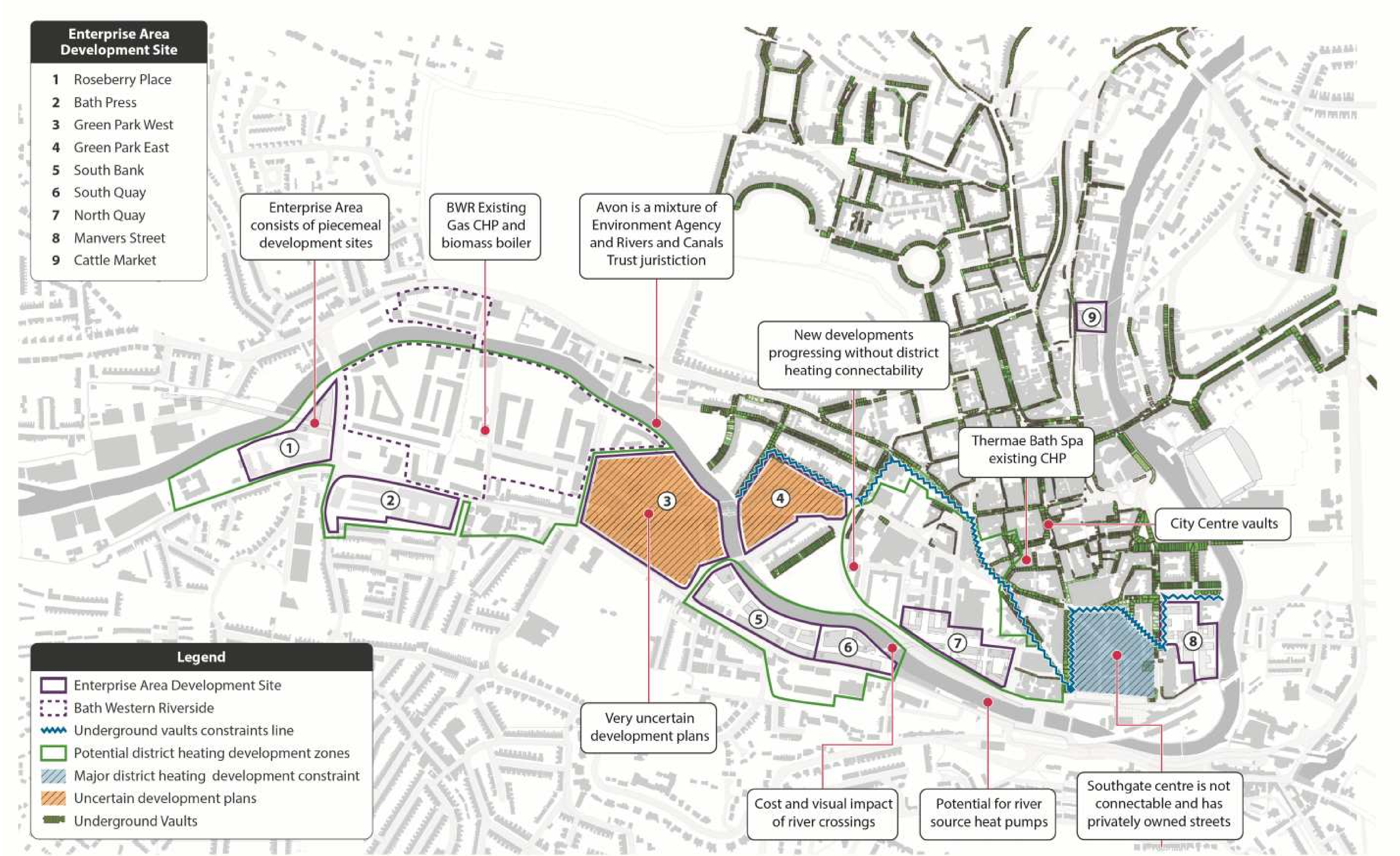


Figure 3—8 Enterprise Area characteristics plan

Figure 3—8 illustrates the key characteristics, opportunities and constraints relating to district heating within the study area. These are discussed in more detail below.

Enterprise Area development sites

There are nine Enterprise Area development sites, six of which lie within a District Heating Priority Area as defined by Core Strategy Policy CP4. This allows a district heating connection to be compelled at these sites. However, the sites are disparate and will be developed in a piecemeal fashion. The majority of the sites are too small to support an independent district heating network.

Green Park development site

Green Park West and East are the largest of the Enterprise Area development sites. The Enterprise Area masterplan development proposals rely on Sainsbury's existing store closing and moving to the current Homebase site when Homebase's lease expires. This may not occur due to changing supermarket business models and scale of development envisaged for these sites may significantly change. The uncertainty of the development proposals means that the initial phases of any district heating scheme have been assumed not to connect to the Green Park sites. However, there is potential for significant development on these sites and while they are not considered in this feasibility assessment it is recommended that they remain part of the District Heating Priority Area.

Bath Western Riverside

Bath Western Riverside (BWR) is a large, partially constructed residential development located adjacent to three Enterprise Area development sites. BWR has an existing energy centre and district heating network for which E.ON is the operator until 2036. BWR has a planning target of a 10% of energy to be provided through renewable energy as required by the BWR SPD that cannot be met for the entire site by the existing biomass boiler capacity and there is little room to add additional capacity. Therefore, there is an opportunity to sell renewable heat to the existing energy centre to allow BWR to meet its target. Alternately, there is potential for future phases of heat network construction in BWR to supply adjacent development sites.

River Avon

The River Avon is a physical constraint on district heating network development as there is a significant cost (in the region of several hundred thousand pounds) and visual impacts to routing district heating pipe over the river. Crossing at Windsor Bridge and the new South Quays footbridge have been ruled out for this reason.

The river also presents an opportunity in that it can be used as a heat source for a heat pump. This is discussed further in Section 5.

City centre vaults

Many of the public streets in central Bath have privately owned vaults beneath them. This means that there is very little depth of soil available for burying utilities and routing district heating pipes through the city centre will be very costly and in many areas impossible. The vaults are owned by the building owners along the street and therefore it would only take one vault owner in a street to refuse to allow heat networks the pass through the vaults make a network route impossible. In addition, if agreement could be reached with all owners then the number of different parties involved would be likely to be seen as a significant risk to the installation contractor. This risk would be reflected in the price of pipe installation.

Some vaults are owned by the Council and it may be possible for district heating pipes to run through the vaults, however, the potential for this is limited.

Southgate Centre

The Southgate Centre's heating and cooling is provided by tenant fitted-out systems, which are generally electrically operated reversible heat pumps. These are not compatible with connect to a district heating system because the in building heat distribution is with refrigerant rather than hot water.

Recent city centre development

A number of new building and refurbishment projects in the city centre were granted planning permission after the 2010 AECOM study but prior to the adoption of the Core Strategy. Therefore Policy CP4 was not enforceable and a number of these new developments are not suitable for a district heating connection (for example Green Park House, which has electric panels providing heating).

4 Stakeholders and Potential Consumers

4.1 Defining potential consumers

A long list of potential consumers was developed considering all major energy loads across the District Heating Priority Areas. The initial long list was populated from the AECOM 2010 heat map study, which in turn references the South West Heat Map[5]. A review of these loads was carried out with B&NES Council (Sustainability, Planning, Regeneration and Project Delivery teams) to note any major sites missing either as new developments since the publication of AECOM study (2011), changes of building use, or sites know to be being brought forward in the near future.

Added to these sites were all building loads for the proposed Enterprise Area Masterplan[6] and assigned to building loads using BuroHappold energy benchmarks for new buildings. Where planning applications were available for the development of plots within the masterplan area the list of consumers and projected energy demand have been updated. This is the case for Roseberry Place, Bath Western Riverside and Bath Press.

All data derived from third party publications has been validated against other datasets to update the accuracy of information based on the following hierarchy.

1. Metered building data available from existing buildings (Display Energy Certificates for public buildings or collated by occupants)
2. Building floor areas and heating plant configuration (floor areas provided by occupants, public records or Valuation Office Agency records)
3. Building floor areas and assumption of heat supply from 85% efficient gas boiler systems.
4. Heat demands available from the National Heat Map[7]

In every case efforts have been made to contact the facilities management for large sites across the across the city centre. A full list of consumers and data sources used is given in Appendix A. Appendix B contains a record of all stakeholder engagement undertaken.

4.2 Shortlisting consumers

Physical constraints

As noted in section 3.5, the river and city centre vaults are two major physical constraints for the development of heat networks. Consultation with the Council broadband team (also looking at the use of vaults for cabling) confirmed that a route through the city centre for district heating pipework was unlikely to be viable, both in terms of physical barriers and private ownership of vaults.

Pipework crossing points of the river Avon were considered at an early stage of the project, and reviewed at a 'Red Flags' workshop with the Council. It was concluded that crossing the proposed new bridge between North and South Quay with district heating pipework would not be viable, due to the increase in cost of the bridge and the impact on the aesthetics of the bridge as the pipe sleeve diameters would be approximately 0.5m in diameter. Following this workshop it was also concluded that a connection to the Recreation Ground and leisure centre to the east of the city centre would be restricted because of vault locations, in particular along North Parade, which is the only road to bridge to leisure centre.

Motivation for connection

Motivation for connection was also a key consideration for shortlisting the consumer list to consumers that would likely catalyse the development and those that would be more likely connect to an pre-existing heat network in future years. Selection criteria used for this classification is set out in Table 4—1. Engagement with key stakeholders was key to understand these aspects, a record of these engagements is given in Appendix B.

Table 4—1 Motivations for heat network connection and anchor loads

Motivations for connection to district heating scheme	Applies to
Long term CO_2 reductions	Council Universities Other public sector bodies Private sector organisations with strong CSR policy
Meet development targets (e.g. Part L, BREEAM)	Enterprise Area developers Crest Nicholson
Reduced energy bills	Private sector organisations Public sector organisations
Green image	Developers Universities Council

[5] CSE 2010. *The South West Heat Map*. Available from: http://regensw.s3.amazonaws.com/sw_heat_map_report_final_version_reduced_a37841b639008ad4.pdf
[6] Fielden Clegg Bradly area schedule " REV H - 23.04.14"
[7] DECC (2010),. *National heat map.* Available at: http://tools.decc.gov.uk/nationalheatmap/

4.2.2 Heat network clusters

Following stakeholder consultation, a revised shortlist of consumers was selected, split into eight discreet clusters. The sites are listed in, with reference to the map in Figure 4—1. Sites highlighted in grey have been removed from the final consumer list for the reasons listed in Table 4—2. Cluster boundaries are based on physical constraints, land ownership and the need to have key 'anchor loads' to catalyse the heat network development in each cluster. Details of each cluster are discussed in more detail in section 6.

Table 4—2 Excluded consumer list

Site	Reason for exclusion
Waterside Court	Electrically heated student residence, conversion to wet heating system likely cost prohibitive
Green Park West	Future site allocations only. Extent of future development plans are uncertain, insufficient clarity on development to consider modelling building loads at this stage
Green Park East	
James St West Student Residence	Location adjacent to Green Park East remote from other consumers and more suited to connection to any future Green Park East development
Thornback Gardens	Remote location from all other consumers
Green Park House	Electrically heated student residence, conversion to wet heating system likely cost prohibitive
Plymouth House	Vaults prevent connection along Charles Street
Gainsborough Hotel	The hotel is shortly to open and so has brand new boiler plant. Therefore, it is not considered suitable for an initial connection but should be considered for connection in the future when the boilers will need replacement.
Southgate	Electrically heated retail. Currently not suitable for wet system conversion.
Cattlemarket	Remote location from all other consumers
Rec and Leisure Centre	Remote location from all other consumers, location of vaults make preferred pipework connection route prohibitive as described earlier in the report.
Somerset Hall	At the time of writing this was a tenanted office building and not suitable for heat network connection and so building energy demands have not been modelled. It is now understood that this site is to undergo an extensive retrofit and so has been qualitatively been captured within the North Plus Plus cluster.

Table 4—3 Site and cluster identification

Site	Map reference and cluster								
	Lower Bristol Road	South Quay	North Quay Plus	North Quay Plus	North Quay Plus Plus	City Centre	City Centre Plus	City Centre & Enterprise Area	Manvers St
Charlton Court	A							A	
Waterside Court	B								
Roseberry Place	C							C	
Bath Western Riverside	D							D	
Bath Press	E							E	
Oldfield Park Infant School	F							F	
Funky Monkey Studio	G							G	
Green Park West		H						H	
Green Park East		I						I	
James St West Student Residence							J		
South Bank		K						K	
South Quay		L						L	
Thornback Gardens		M							
Green Park House							N		
Plymouth House							O		
Kingsmead House Hotel						P	P	P	
Kingsmead Leisure						Q	Q	Q	
Westpoint						R	R	R	
1-3 James Street West					S	S	S	S	
John Wood Building				T	T	T	T	T	
North Quay			U	U	U	U	U	U	
Allen building					V	V	V	V	
City of Bath College existing buildings			V	V	V	V	V	V	
St John's Hospital					W	W	W	W	
Thermae Bath Spa					X	X	X	X	
Gainsborough Hotel					Y				
Forum				Z	Z	Z	Z	Z	
Quay House				AA	AA	AA	AA	AA	
Innovation Centre				AB	AB	AB	AB	AB	
Southgate							AC		
Cattlemarket							AD		
Rec and Leisure Centre							AE		
Manvers Street							AF	AF	AF
Somerset Hall				AG					

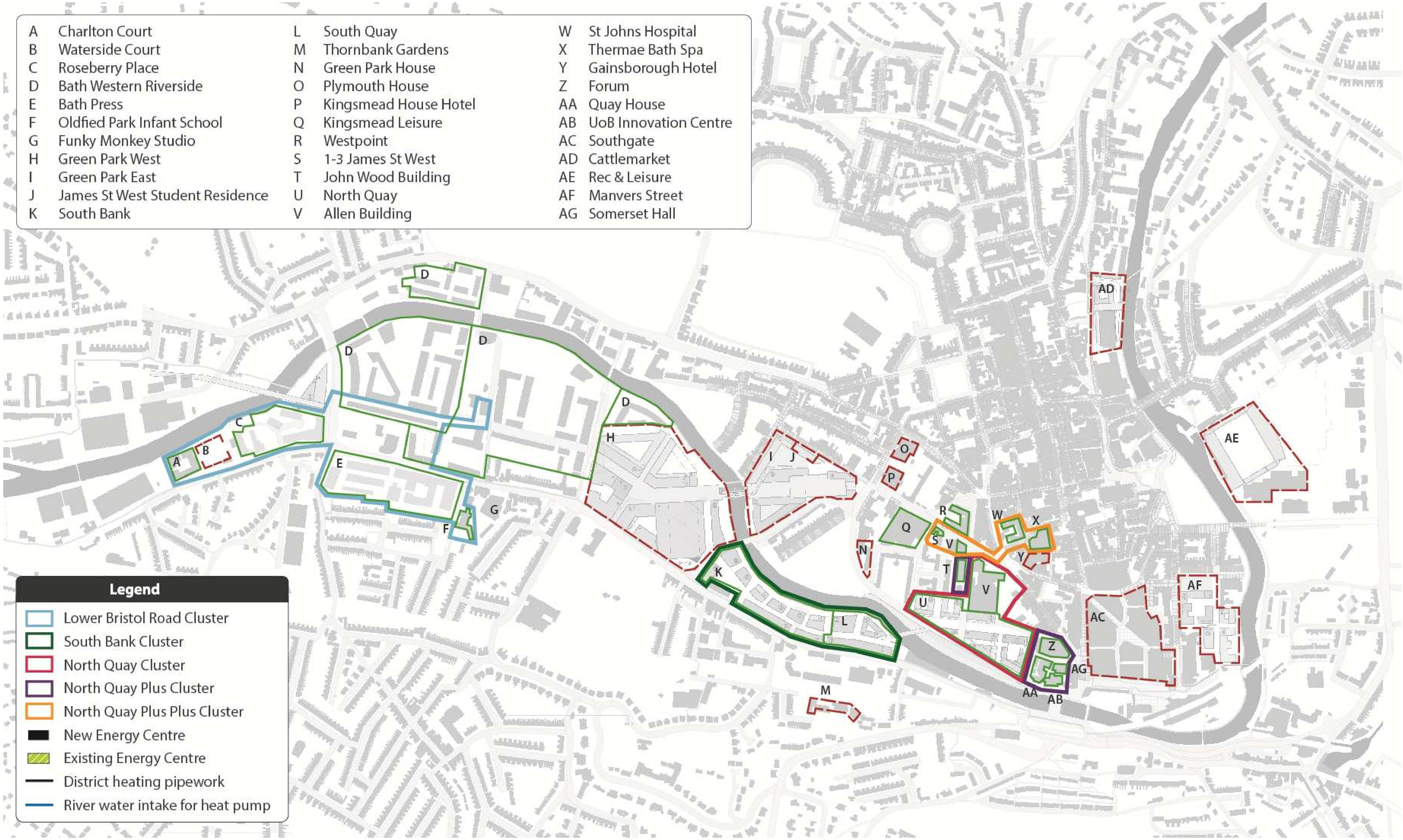


Figure 4—1 Consumer shortlist map

4.3 Stakeholder workshop

A stakeholder workshop was held on Friday 24th July to present initial findings of the study and seek the views of a number of key stakeholders on key issues, opportunities and challenges involved with the options presented.

The workshop was attended by representatives from various B&NES Council departments, B&NES Councillors, private sector developers, Enterprise Area designers, DECC and Enterprise Area building owners. A full list of attendees is included in Appendix I.

Following the presentation of the initial findings of the Enterprise Area feasibility study, a workshop was held to capture the views of the attendees. The workshop included two exercises:

1. An individual exercise where attendees were asked to complete a form answering the following questions:
    a. What do you see as your organisation's role in a district energy network?
    b. What do you see as the benefits of a district energy network for your organisation?
    c. What do you see as the challenges of a district energy network for your organisation?
    d. What does your organisation need in order for a district energy network to be worthwhile for it?
2. A group exercise where three tables discussed the responses developed in the previous exercise and identified where there were common and conflicting views.

This was followed by a group discussion of each group's findings. The notes from each exercise are included in Appendix I.

While there were different views from different participants, the individuals present were open to the concept of district heating and no participant explicitly ruled our involvement in a district heating scheme. Some of the key areas of interest for the participants and their organisations were:

- Financial viability
- Understanding of long term prices
- Reliability
- Whether district heating is the best way to deliver carbon savings for Bath

4.4 Stakeholder classification

The interest of stakeholders in being involved with a district heating scheme and the level of their influence on the schemes success have been mapped in order to categorise the stakeholders into:

- Those to actively engage in the development process
- Those to keep informed of the progress of work
- Those whose requirement must be satisfied in order for the scheme to progress but have little interest in the scheme's success or failure (e.g. utility companies)
- Those which have little influence over the scheme's success but should be monitored in case their position changes

The mapping is shown in Figure 4—2.

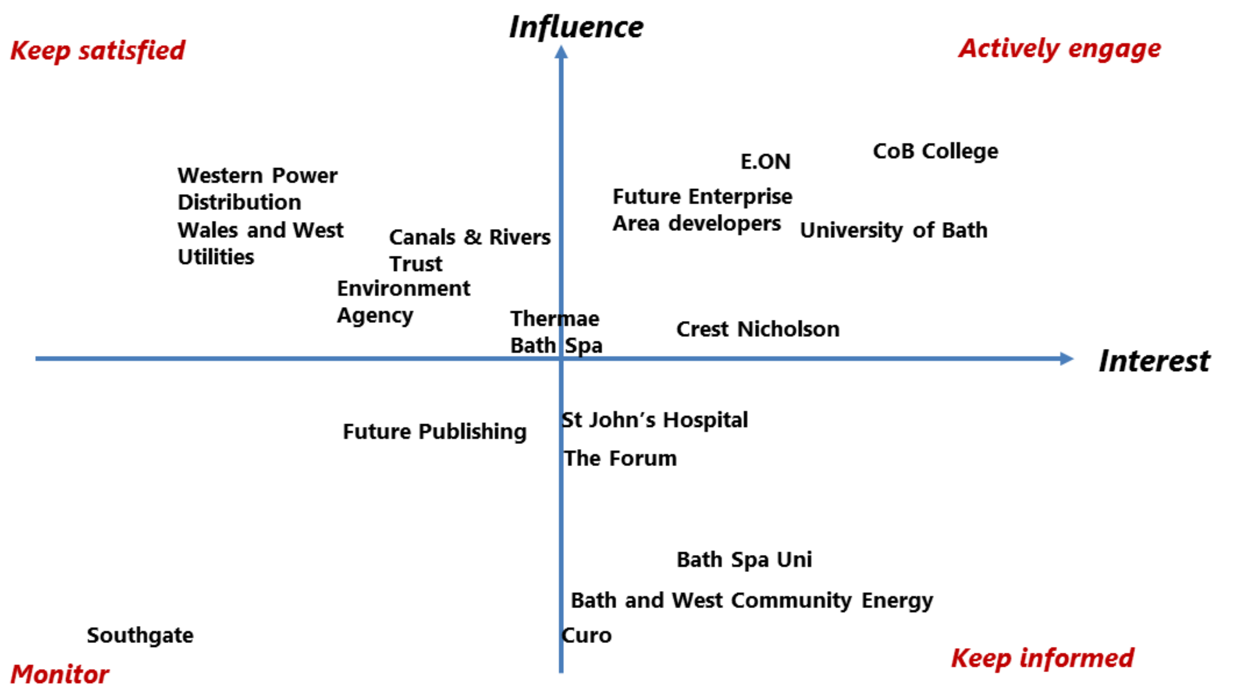


Figure 4—2 Stakeholder classification map

5 Energy Supply Options

5.1 Options development

An assessment matrix has been developed to consider all technologies available for low carbon heat and power supply for the Bath Enterprise Area considering their viability both currently and out to 2050. This includes technologies that are unlikely to be viable for the core scheme for the Enterprise Area currently but could play a role in future supply.

It should be noted that Bath does not contain any major sources of waste heat (e.g. an energy from waste plant as in Sheffield) that could be used as a heat source for district heating plant. It is unlikely that any suitable sources of waste heat will be constructed in the vicinity of the Enterprise Area in the foreseeable future. Therefore, the focus of this feasibility study is on technologies such as gas combined heat and power, biomass boilers and heat pumps.

Feasibility has been identified based on a qualitative assessment across a number of factors including

- Carbon dioxide (CO_2) emissions savings (current and future)
- Costs and revenue
- Operation and maintenance
- UK market maturity
- Planning restrictions
- Opportunities for community involvement (e.g. community energy fund)

Nineteen low carbon energy sources have been considered, listed in and detailed in the assessment matrix in Appendix F. From this, four key low carbon energy sources have been selected for consideration at the options assessment stage, these are gas CHP engines, large water source heat pumps, biomass boilers and solar photovoltaic (PV) panels. The first three are compatible with district heat networks and can be interchanged as the projected decarbonisation of the UK electricity grid increases the carbon credentials of heat pumps in future years. Solar PV panels can be added to the generation mix to reduce the overall site CO_2 emissions by offsetting grid electricity. In addition to these technologies, condensing gas boilers are considered as a reactive means of meeting instantaneous peak demands and to top up the heat supply.

A summary of the CO_2 reduction credentials of the technologies to be progressed to the detailed options stage is given below. These will be assessed in more detail in Phase 2 of the study to comparatively quantify energy revenues, capital costs, funding streams and delivery risks.

Gas CHP: Well proven technology delivering high CO_2 savings through offsetting grid electricity demand. As the electricity grid decarbonises the CO_2 savings offered by gas CHP will fall (see Section 3.3) this this technology is seen as a playing a transitional role towards true low and zero carbon fuel sources.

Gas CHP is most efficient when running at full load, therefore favours district heating where there is a strong diversity of demand and associated consistent baseload. It is a well proven mature technology in the UK. Typically the business case of a gas CHP scheme is highly dependent on the price that can be obtained for the exported electricity (and to the gas price). It is not deemed as a renewable supply source so does not currently qualify for the Renewable Heat Incentive. There are less space required and air quality concerns than biomass equivalent plant but in the longer term, the carbon reduction benefit will reduce as the electricity grid decarbonises. Typically installed in conjunction with gas boilers to meet peak demands.

Water source heat pump: The application of this technology for district heating is less proven than gas CHP, however, some large scale schemes are now operational, such as at Drammen in Norway. The River Avon offers a potential heat source for the system. Water source heat pumps typically have higher efficiencies than air source heat pumps and are less expensive than ground source systems. waterWater source heat pumps could be introduced either as the main heat source from the scheme inception or as a future technology to replace gas CHP in the network in the future as the electricity grid decarbonises.

Limiting constraints include a potential requirement to reinforce local electricity networks and temperature requirements to serve existing buildings as the maximum output temperature is approximately 75°C for a 500kW system. To achieve a 90°C output temperature a 4MW system is required, which is likely to be larger than can be supported by a scheme in the Enterprise Area. There also development risks regarding Environmental and Canals and Rivers Trust permits and licencing. This system is viable in principle but there is only one operating precedent in the UK (Kingston Heights, London).

Heat pumps can be combined with gas CHP or solar PV panels to improve the CO2 savings of the overall system (although at an increased capital cost). This is not considered in the 'base case' scenarios but highlighted as an area for further study as the design develops, and may be applicable where a heat pump is installed in later phases of the project, prior to the decommissioning of an initial gas CHP engine.

Biomass boiler: a biomass boiler can produce near zero carbon heat from recovering the heat from incinerating wood chips or pellets. Wood pellets are preferred over chips on account of their fuel density hence reducing the number of deliveries to site required. A biomass boiler has been successfully installed on the Bath Western Riverside scheme, demonstrating its potential for wider incorporation. Air quality is likely to become a constraining issue if located near to the city centre or close to the existing biomass boiler house. This should be determined at the options assessment stage. Space take is also a greater issue than with gas CHP, requiring space for fuel storage and deliveries.

Solar PV: Roof mounted PV is suggested as a technology for reducing CO_2 savings beyond that of a district heating system. This is likely to be only required where connection to a site wide network is not possible due to local physical constraints. Solar PV supply is limited by roof area, it cannot match savings of gas CHP on a district level. As an example, to provide the equivalent CO_2 emissions savings as a gas CHP engine providing the baseload heat demand of North Quays, South Quays and South Bank (~500tCO_2/yr.) would require approximately 6,900m^2 of PV area. This technology is most suited where the technical constraints are such that connecting a district network is not viable. In this case solar PV's can be used in conjunction with stringent targets on building fabric design for buildings or one of the building scale technologies listed below.

In addition to the technologies discussed above, specific consideration has been given to opportunities relating to the hot springs beneath Bath. There are two potential methods of benefiting from the hot spring:

- Direct extraction from the aquifer – this would involve sinking a borehole into the aquifer and either transferring the hot water through a heat exchanger (open loop) or sinking pipe into the ground to act as heat exchanger (closed loop). A key issue with this is the importance of the hot springs to Bath's tourism industry. There are already a number of boreholes and it is BuroHappold's understanding that the Council is not willing to permit any further boreholes due to risks to the delicate flow and temperature balance within the aquifer. A technical and financial challenge is that the aquifer is an artesian aquifer, which means that any borehole penetration would have to be sealed to prevent the water flowing out under the positive pressure.
- Closed loop systems above the aquifer – Boreholes can be sunk to approximately 30m below ground level without penetrating the aquifer. The ground here is warmer than typical ground temperatures. Closed loop ground source heat pumps could be used. However, due to the limited potential depths of these systems as significant number of boreholes would be needed to provide a large heat output. For a district heating scheme these boreholes would have to located in an open space either owned by the Council or through an agreement with a third party landowner. This approach may be more appropriate on a building by building basis with heat exchanger loops included in piled foundations.

Table 5—1 summarises the options assessment matrix in Appendix F. Low carbon energy supply sources with a high viability will be assessed in more detail at the options assessment stage of this study to prioritise a supply source(s) based on a more detailed site specific evidence base.

Table 5—1 Summary of low carbon energy source assessment

Technology		Viability assessment		Key considerations
		Building	District	
Gas	Condensing gas boilers	medium	high	Flexible and reasonable efficient. Low capital costs
	Gas CHP	medium	high	Highly efficient under optimal conations at district scale
	Hybrid gas boiler	low	low	Embryonic technology
	Gas with CCS	n/a	low	Embryonic technology, large scale
Biomass	Biomass boiler	low	high	High CO_2 savings if transport and air quality concerns mitigated
	Biomass CHP	low	low	Unproven technology except at a very large scale.
	Biomethane CHP	n/a	low	Unproven technology except at a very large scale, no site identified.
Electricity (heating)	Water source heat pump	low	high	Reliant on decarbonisation of electricity grid for competitive CO_2 savings.
	Air source heat pumps	medium	medium	As above, plus heavier reliance on local substation capacity.
	Ground source heat pumps including energy piles	medium	medium	High capital cost if not installed as part in initial development
	Process waste heat & heat pumps	low	low	No suitable sources
Electricity (power)	Solar photovoltaic (PV) cells	high	low	Proven technology, scalable and simple to integrate at building level. Subject to visual amenity concerns.
River	Hydropower	n/a	medium	Very site specific
Other	Deep geothermal	n/a	low	Unproven technology except at a very large scale, no site identified.
	Hot springs geothermal	n/a	low	Placing boreholes into the hot springs aquifer is unlikely to be viable
	Solar thermal	medium	low	Proven technology but competes with PV roof space. Subject to visual amenity concerns.
	Industrial and process heat	n/a	low	No significant supply sources identified.
Hydrogen	Hydrogen fuel cell	low	low	Unproven technology, reliant on decarbonisation of electricity grid.
Wind	Wind turbine	low	low	No local wind resource or suitable site.

5.2 District heating verses individual building heating

The technologies considered in Section 5.1 include those suitable for both application at a district level via heat networks and at a building level with individual plant. Where the demand density of heating is low, an individual building approach tends to work best (such as individual gas boilers running a conventional wet central heating system, or small electric point heaters). Where demand density is high, district heating can work better, reducing costs and enabling technologies with lower CO_2 emissions to be connected (such as gas CHP).

District heating also enables a wider spectrum of opportunities for low carbon heat, as once built the infrastructure facilitates the ability to change future heat sources without modifying building design. It also allows the integration of some large heat sources (e.g. large water source heat pumps) that require a minimum number of heat customers to be considered viable. In theory district heating can provide the most cost effective and technically feasible means of achieving significant CO_2 emissions savings for a large urban development. However care is needed to optimise the commercial and technical aspects of the network to minimise losses and maximise efficiency.

5.3 Fabric First / Minimising Demand

An alternative approach is to minimise heating demands through the adoption of very high specification building fabric and making use of internal heat gains (e.g. equipment) and solar gains to provide the majority of the heat requirements. An example of this is the Keynsham Civic Centre where a large proportion of heat is provided from waste heat from a server room. It should be noted that an innovative approach such as this is simpler where a building is commissioned, owned and operated by a single organisation (as was the case with Keynsham Civic Centre). It is more challenging to deliver successfully for tenanted buildings (such as the office buildings at North Quay) where the future occupants are unknown. This is partly due to industry precedent in the design of tenanted buildings and the resultant expectation of tenants. There is often a reluctance to deviate from tried-and-tested approaches. In these case district heating can provide a good solution to reducing CO_2 emissions as tenants will observe little difference within the building from a more traditional design.

It also should be noted that while fabric standards can significantly reduce heat demands, there is less impact on buildings with high fresh air demands (e.g. auditoria and laboratories) or a high hot water demand (e.g. hotels and apartments).

6 Scheme Options

6.1 Cluster long list

As noted in Section 4.2, nine clusters were considered for initial consideration, with reference to Table 4—3 and Figure 4—1 these were:

Lower Bristol Road - Core scheme connecting Roseberry Place and Bath Press with extensions to Charlton Court student residence and the infant school. Option to sell or buy heat with existing Bath Western Riverside scheme (as there is a requirement for additional renewable heat as existing scheme expands due to the BWR SPD planning requirements and this may not be possible to meet at the existing energy centre).

South Bank - Scheme connecting South Quay and South Bank. An energy centre in the west of the site would favour future expansion to Green Park developments but location to the east would favour phasing as South Quay will be constructed several years in advance of South Bank. The location therefore undetermined at this stage. Connection across bridge to North Quay was not considered due the cost and aesthetic impact on the proposed footbridge. Expansion potential is hard to factor in to initial build until Green Park plot layouts developed further.

North Quay - North Quay new sites plus City of Bath College. Almost all new development so connection can be compelled and pipework can be integrated with highway construction.

North Quay Plus - Expansion to North Quay scheme to include John Wood building (student residential), the Forum, Future Publishing and the Innovation Centre.

North Quay Plus Plus – Northern expansion of North Quay Plus to connect 1-3 James St West, the Allen building, Thermae Bath Spa and St Johns Hospital. Requires more significant road crossings and routing through existing vaults.

Manvers Street - Small cluster considered as standalone scheme. Remote from other clusters and so unlikely to be viable to connect to wider clusters. Riverside development allows consideration of small water source heat pump scheme. Small heat load so may not be attractive for an ESCo but there may be potential if site is brought forward by a single developer

City Centre - Extension of North Quay Plus Plus along James St West. Connection of Westpoint, Kingsmead Leisure and Kingsmead House Hotel. Connection of Plymouth House excluded because of access through vaults. Vaults in James St West require navigation. Possible future connection to Green Park East.

City Centre Plus - Full city centre network extending city centre cluster east to connect Manvers St cluster avoiding vaults. Potential future connection to Southgate but unlikely due to electric heating systems.

City Centre and Enterprise Area – Full city network connecting all clusters.

6.2 Cluster prioritisation

Following a workshop with B&NES Council on the long list of clusters, these were narrowed down to a shortlist of five clusters to study in more detail. This selection process was based on a prioritisation of against the criteria in Table 6—1, weighted dependant on the gauged importance for delivering district heating schemes in Bath. Results are shown in Table 6—2.

- Lower Bristol Road
- South Quay
- North Quay
- North Quay Plus
- North Quay Plus Plus

Table 6—1 Cluster prioritisation attributes

Attribute	Priority weighting	Description
Load size	Med	Overall annual heat demand
Load density	Medium-high	Overall heat demand compared to network area
Expansion potential	Medium	Potential for scheme to expand after initial development
Phasing	Low	Will the phasing of construction of connected buildings have a negative impact on the scheme
Deliverability	High	How challenging will the scheme be to deliver? Council control over connections and new development, major constraints such as trunk road crossings etc.
Council benefit	Low	Could the scheme provide the Council will a CO_2 saving benefit to its estate or a financial benefit
Financial & commercial risk	Medium	How risky is the scheme likely to be in guaranteeing loads and scheme capital cost
Interest to ESCO	Medium	Are the development plans attractive to a private sector ESCo with minimal Council involvement

Table 6—2 Long list assessment results (base score [1-10] x weighting [1-5])

Attribute	Lower Bristol Road	South Bank	North Quay	North Quay Plus	North Quay Plus Plus	City Centre & Enterprise	City Centre Plus	Manvers St	City Centre & Enterprise
Load size	15	6	9	12	18	24	27	3	27
Load density	16	20	24	28	28	12	8	28	4
Expansion potential	24	12	24	18	12	15	12	3	18
Phasing	8	10	16	14	12	6	4	16	2
Deliverability	30	30	45	35	20	15	10	40	5
Council benefit	10	10	14	16	16	12	8	4	10
Financial & commercial risk	24	18	24	21	15	9	6	18	3
Interest to ESCO	27	12	21	21	18	9	9	6	3
Total	**154**	**118**	**177**	**165**	**139**	**102**	**84**	**118**	**72**

6.3 Cluster shortlist

A description of the characteristics of each cluster is provided below. The opportunities and barriers associated with each of the shortlisted clusters are shown in Table 6—3. Further details of the buildings in these clusters is given in the consumer review in Appendix A. A summary of the buildings and heat loads considered for the cluster shortlist is given in Table 6—4.

The demand density differs across all clusters, This is illustrated in Figure 6—1.

Lower Bristol Road:

- The core scheme connects the Roseberry Place and Bath Press Enterprise Area development sites
- There is a connection to the existing BWR energy centre to sell renewable heat to allow BWR heat. For the purpose of this feasibility study it has been assumed that this connection provides 130kW of heat as a baseload between the hours of 6am and 11pm. This was discussed with E.ON (the operators of the BWR scheme) and they indicated that they would consider purchasing heat on this basis.
- The network also connects to the existing Charlton Court Unite Student Residence and the Oldfield Park Infant School.

South Bank:

- The scheme consists of the South Bank and South Quay Enterprise Area development sites. There is limit opportunity to connect to existing buildings due to the challenges with installing pipework in Lower Bristol Road and that nearby existing buildings are generally small offices or individual houses, which will have limited heat demand.
- The energy centre is located at the west of the scheme to give the potential for future expansion to the Green Park West Enterprise Area development site without having to significantly oversize initial pipework.
- South Quay (at the east of the site) will be constructed before South Bank therefore these buildings would be served by local plant or a temporary gas fired energy centre.

North Quay and expansions:

- The North Quay scheme consists of the North Quay Enterprise Area development site and a connection to the existing City of Bath College energy centre. The expansions options extend the initial network to serve existing buildings and new development to the east and north. A major load in the expansion schemes is Thermae Bath Spa.
- It is assumed that energy centre is integrated into a new building on the North Quay site.

The opportunities and barriers associated with each of the shortlisted clusters are shown in Table 6—3. Further details of the buildings in these clusters is given in the consumer review in Appendix A. A summary of the buildings and heat loads considered for the cluster shortlist is given in Table 6—4.

The demand density differs across all clusters, which is illustrated in Figure 6—1. The North Quay options have the highest density.

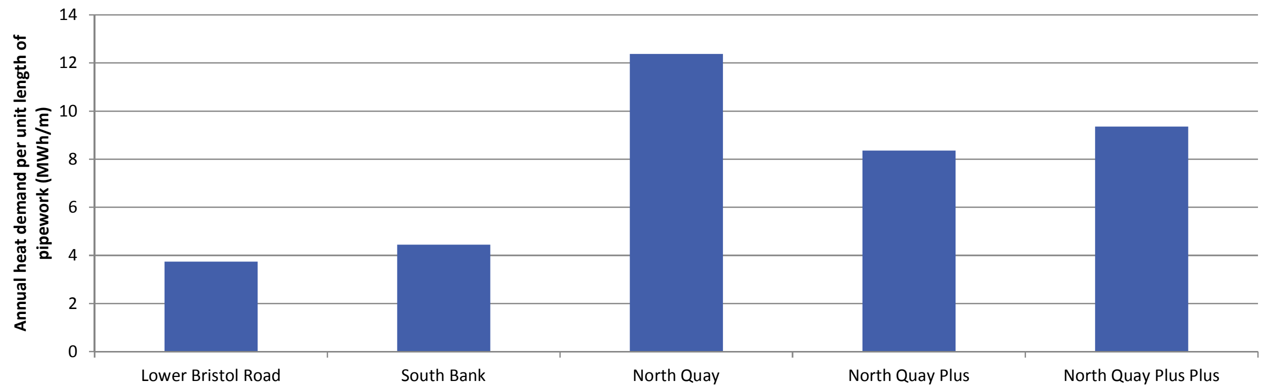


Figure 6—1 Linear heat demand density

Table 6—3 Shortlisted clusters opportunities and barriers

Cluster	Opportunities	Barriers
Lower Bristol Road	• Large amount of residential buildings so good summer baseload • Potential to sell heat to Bath Western Riverside as they require renewable energy to meet planning obligations	• Bath Press developers have submitted a planning application, which states district heating is not viable for the site • Placing pipework in Lower Bristol Road would be disruptive and expensive so a longer route through Bath Western Riverside is recommended (requires agreement from Crest Nicholson) • Requires coordination of a number of different developers
South Bank	• Entire site to be redeveloped so potential to install district heating as part of the infrastructure works to reduce cost and disruption • Potential to include space in the energy centre to allow expansion to Green Park West in the future	• Limited heat demand as primarily office buildings • Most remote part of the site is the first part to be built
North Quay	• Large amount of site to be redeveloped so potential to install district heating as part of the infrastructure works to reduce cost and disruption • North Quay site owned by B&NES • North Quay development brief has challenging sustainability targets • City of Bath College has a large heat demand with a single connection point • Potential to expand	• Little opportunity to connect to other Enterprise Area sites • Land value at a premium due to city centre location
North Quay Plus	• Connection of existing buildings with minimal additional energy centre costs • University of Bath have a positive attitude towards connection • Potential for future expansion	• Private sector organisations may not be willing to connect
North Quay Plus Plus	• Connection of existing buildings with minimal additional energy centre costs • Thermae Bath Spa has a significant year round load • Potential for future expansion e.g Gainsborough Hotel	• Private sector organisations may not be willing to connect • Vaults surrounding Thermae Bath Spa • Disruption to James Street West

Table 6—4 Cluster shortlist heating demand

Site	Modelling typology	Total heating demand (MWh/yr.)					*Heating demand calculation notes*
		Lower Bristol Road	South Bank	North Quay	North Quay Plus	North Quay Plus Plus	
1-3 James Street West	Student residence					102	*Planning application 14/01896/FUL and BH benchmarks*
Allen building	Office					45	*Future use unknown, assumed office with same floor area as existing, floor area from City of Bath College data*
Bath Press	Residential	1009					*Pre-app residential and old masterplan non-residential floor areas and BH benchmarks*
Charlton Court	Student residence	237					*BH benchmarks for DHW for 316 student flats*
Oldfield Park Infant School	Education	102					*B&NES gas metering*
Roseberry Place	Residential	816					*2015 planning statement and BH benchmarks*
BWR heat export	Bulk supply	855					*Data from Crest floor area schedule and BH benchmarks, checked against EON survey*
City of Bath College existing buildings	Education			2036	2036	2036	*Main campus building excluding the forge, pro-rated from energy centre gas data*
Forum	Arts				221	221	*Metered gas data*
Innovation Centre	Office				453	453	*University metered gas data (office/ residential split assumed)*
	Student				272	272	
John Wood Building	Student residence				233	233	*University metered gas data*
North Quay	Mixed Use			2392	2392	2392	*BH benchmarks, FCB masterplan floor areas (option 2 rev 03)*
Quay House	Office				287	450	*VOA floor area and CIBSE good practice benchmarks*
South Bank	Mixed		1195				*BH benchmarks, FCB masterplan floor areas (old masterplan)*
South Quay	Office		895				*BH benchmarks, FCB masterplan floor areas (old masterplan)*
St Johns Hospital	Residential					586	*NHM data*
Thermae Bath Spa	Spa					3101	*DEC database 2010 actual consumption, 20% demand reduction assume.*
Total heating demand (MWh/yr.)		**3000**	**2100**	**4400**	**5900**	**9900**	
Total number of connections		**5**	**11**	**7**	**12**	**16**	
Peak heating demand (kW)		**2300**	**2900**	**3900**	**5000**	**7100**	

6.4 Heat Sources

Three heat technologies were selected for modelling as these were identified as the most viable district heating technologies for the Enterprise Area in the energy supply options review:

- Gas CHP
- Water Source Heat Pumps
- Biomass boiler

Two technologies were modelled for each cluster. A water source heat pump and biomass boiler were modelled for Lower Bristol Road as a renewable source of heat is required for a connection to the Bath Western Riverside site to be viable. The other clusters were modelled with water source heat pumps and gas CHP as they were closer to the city centre, therefore it was felt that the space and delivery requirements of a biomass boiler made the option less viable. There may also be air quality challenges with a biomass boiler in these locations.

Table 6—5 Clusters and technology options

Cluster	Technology Option 1	Technology Option 2
Lower Bristol Road	Water Source Heat Pump	Biomass boiler
South Bank	Water Source Heat Pump	Gas CHP
North Quay	Water Source Heat Pump	Gas CHP
North Quay Plus	Water Source Heat Pump	Gas CHP
North Quay Plus Plus	Water Source Heat Pump	Gas CHP

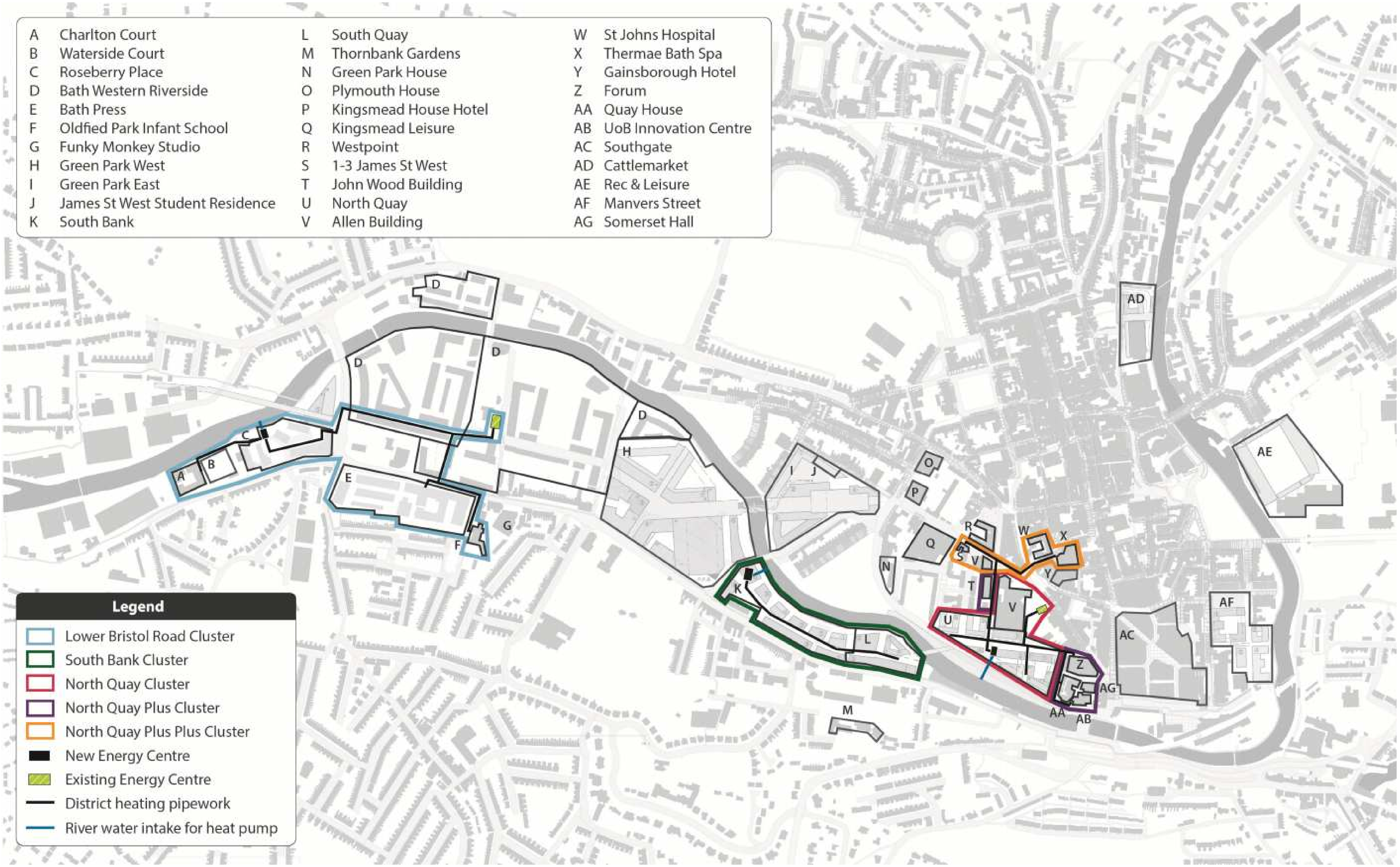


Figure 6—2 Cluster shortlist details

7 Options Assessment

7.1 Techno-economic assessment

Techno-economic assessment has been carried out for each of the 5 shortlisted clusters. The heat demands in each cluster were matched with appropriate hourly profiles, depending on the type of building, and inputted to EnergyPro[8] software in order to develop an annual heat demand profile for each cluster. EnergyPro was used to assess an appropriate size for the low carbon baseload plant and thermal store.

Technical design for each option was carried out based upon this and the peak load assessment. A full list of technical assumptions can be found in Appendix C.

The technical design was used to develop capital costs for each option. A full breakdown of capital costs is in Appendix E.

These capital costs and operating data from EnergyPro were inputted to a financial model, which was used to assess the financial viability of the options. This financial model considered:

- Connection charges
- Heat sales
- Electricity sales
- Renewable Heat Incentive
- Fuel costs
- Plant replacement sinking fund
- Staff costs
- Business rates
- Insurance
- Operation and maintenance of central plant, network, heat meters and hydraulic interface units

The financial modelling was carried out on a before interest and tax basis so does not cover finance costs or corporation tax. All energy prices and sales were at today's prices. A full list of commercial assumptions can be found in Appendix D.

7.1.1 Techno-economic results

The technical analysis results are presented in Table 7—1 and the results of the economic analysis are presented in Table 7—2. Figure 7—1 to Figure 7—4 present a number of these results graphically.

There are a number of key points to note regarding the results of the techno-economic analysis:

1. NPV - None of the schemes achieve a positive NPV after 25 years at a 3.5% discount rate. A decrease in net capital costs (i.e. through increased developer contributions) or increase in revenue (i.e. through increased heat sales prices) would be required to make the schemes achieve a positive NPV. It should be noted that this assessment is based upon the base input assumptions used; Section 7.5 explores the sensitivity of these assumptions and how the viability could be improved.
2. Carbon saving - The CO_2 savings of the heat pump and CHP options will alter significantly within the lifetime of the plant as the grid decarbonises, as shown in Figure 7—2. Based upon DECC grid decarbonisation projects CHP led schemes achieve strong CO_2 savings compared to local gas boilers today (>30%) but will have higher CO_2 emissions than local gas boilers within the next 10 years. Conversely, the CO_2 emissions savings from heat pumps will increase from 15% to 60% in the same period.
3. Capital cost - The river source heat pump options have a capital cost approximately 10% higher than alternative options with CHP/biomass boilers due to the cost the water intake/outfall.
4. Energy sales and subsidy income -
   - Heat pump led schemes rely heavily on the RHI to make an operating margin, as shown in Figure 7—5 . A 20% reduction in the RHI results in an operating loss.
   - CHP led schemes make an operating loss if typical grid export electricity sales prices are used, as shown in Figure 7—5. Higher electricity sales prices are needed for the scheme to make an operating margin.
   - Biomass boiler led schemes rely on the RHI to make an operating margin, as shown in Figure 7—5. A 60% reduction in the RHI results in an operating loss.

[8] http://www.emd.dk/energypro/

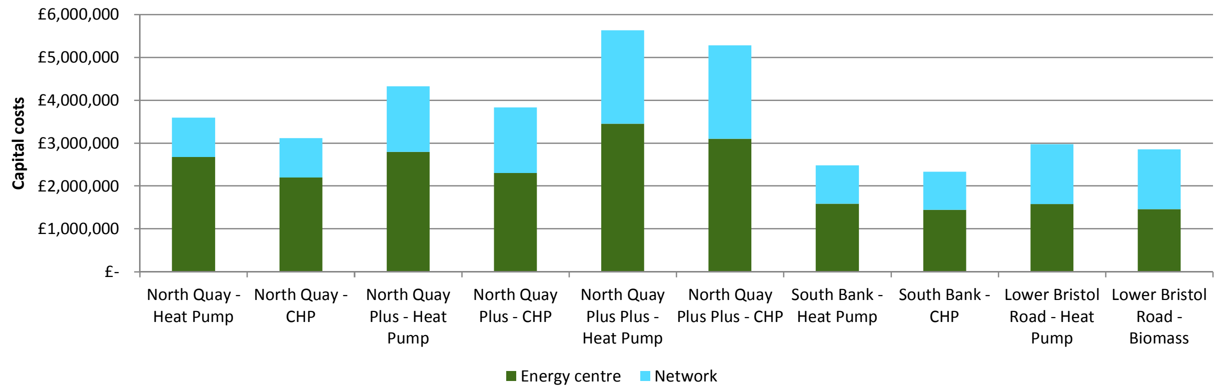


Figure 7—1 Options capital cost comparison

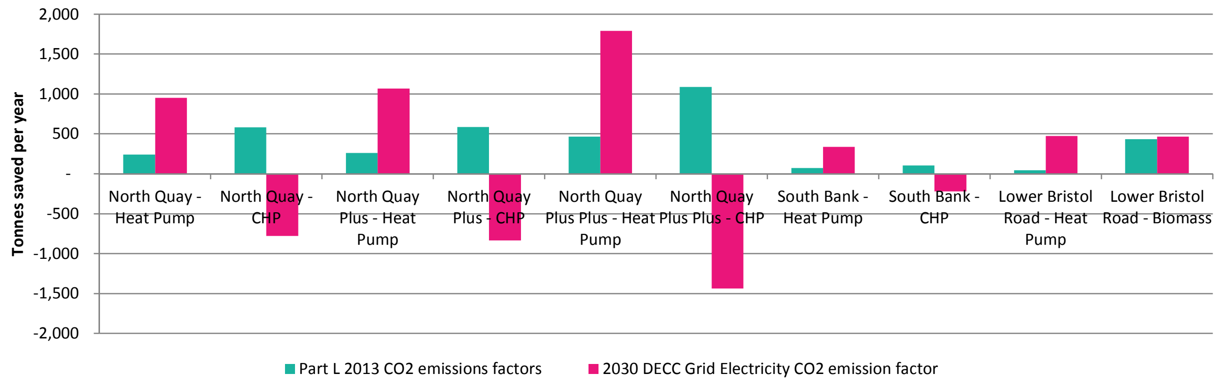


Figure 7—2 Comparison of CO_2 savings today and in 2035

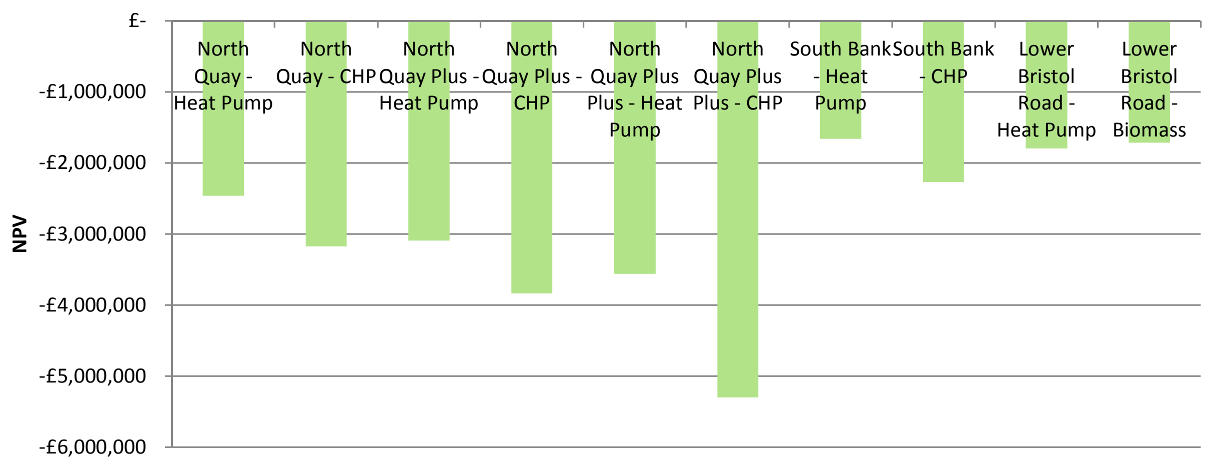


Figure 7—3 Net present value comparison (25 years – 3.5% discount factor)

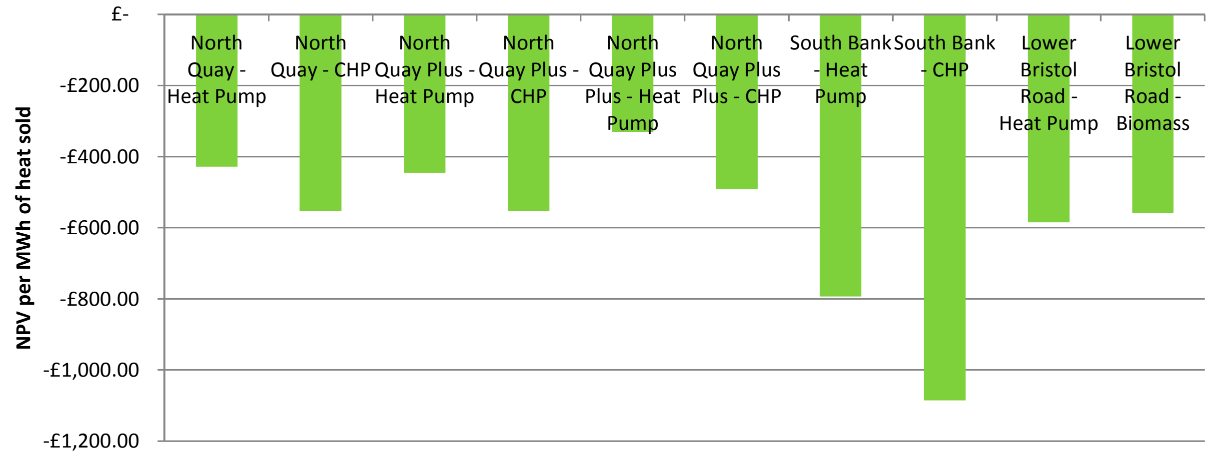


Figure 7—4 Net present value normalised by heat sales (25 years – 3.5% discount factor)

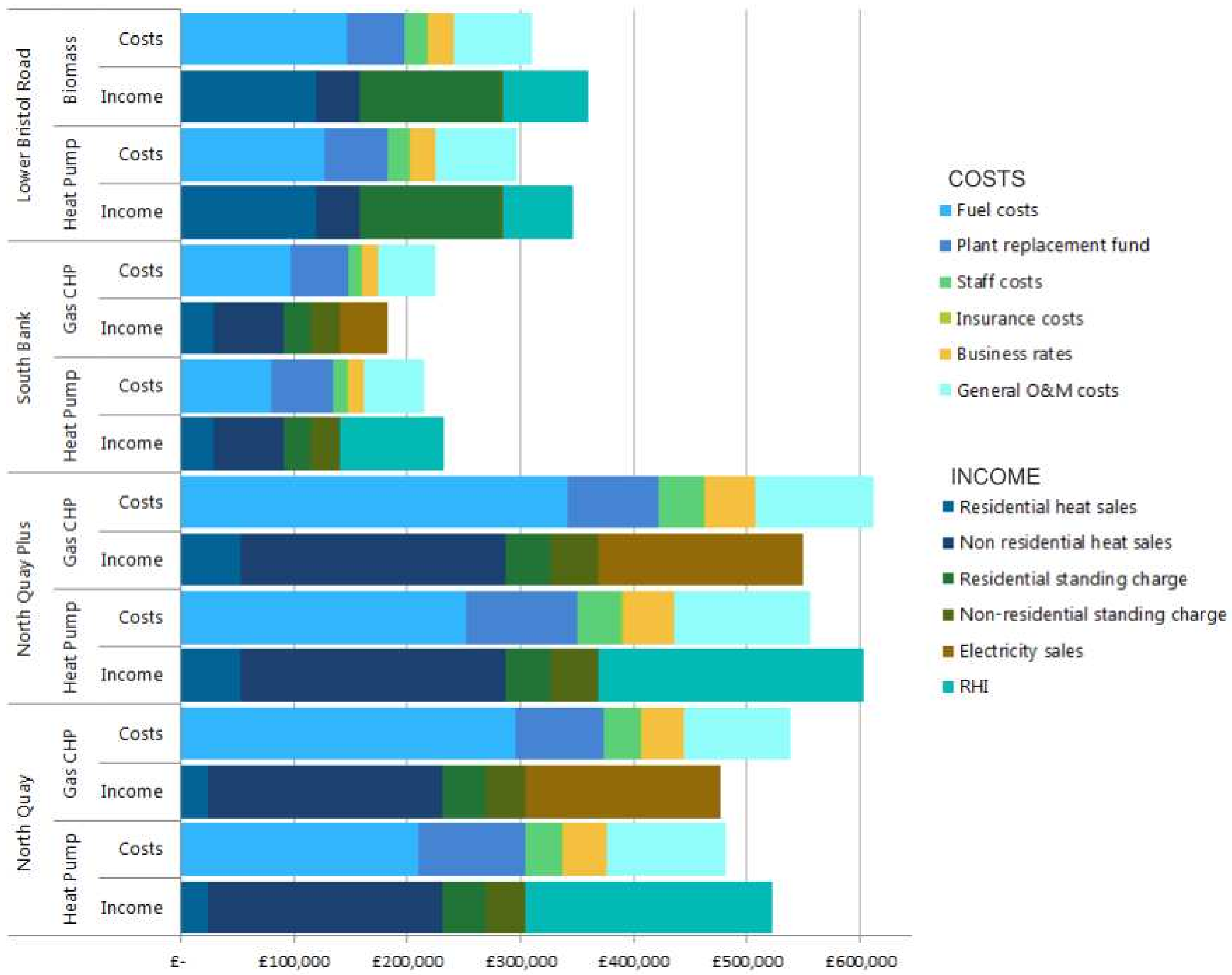


Figure 7—5 Revenue balance

Table 7—1 Technical analysis results

Option	Number of connections	Network length (m)	Heat demand (MWh/year)	Peak boiler capacity (kWth)	CHP capacity (kWth)	Heat pump capacity (kWth)	Biomass boiler capacity (kWth)	Thermal store size (m^3)	Linear heat density (MWh/y/m)	CO_2 savings – 2015 (tonnes/year)	CO_2 savings – 2035 (tonnes/year)
North Quay - Heat Pump	7	505	6,200	6,000	-	1,200	-	30	12.4	241	952
North Quay - CHP	7	505	6,200	6,000	915	-	-	100	12.4	580	-778
North Quay Plus - Heat Pump	12	900	7,500	8,000	-	1,200	-	30	8.4	263	1,070
North Quay Plus - CHP	12	900	7,500	8,000	915	-	-	100	8.4	585	-835
North Quay Plus Plus - Heat Pump	16	1,245	11,600	10,000	-	1,800	-	40	9.4	465	1,791
North Quay Plus Plus - CHP	16	1,245	11,600	10,000	915 690	-	-	175	9.4	1,087	-1,438
South Bank - Heat Pump	11	531	2,400	4,200	-	600	-	20	4.4	71	340
South Bank - CHP	11	531	2,400	4,200	236	-	-	36	4.4	105	-222
Lower Bristol Road - Heat Pump	5	1,010	3,800	3,600	-	600	-	20	3.7	45	474
Lower Bristol Road - Biomass	5	1,010	3,800	3,600	-	-	600	75	3.7	433	464

Table 7—2 Economic analysis results

Option	Capital cost – Energy centre (£)	Capital cost – Network (£)	Gross capital cost (£)	Connection charges[9] (£)	Net capital cost [gross capital cost minus connection charges] (£)	Year 1 net revenue (£)	Year 1 operating margin (%)	25 year NPV at 3.5% discount factor (£)	IRR
North Quay - Heat Pump	£2,700,000	£900,000	£3,600,000	£850,000	£2,750,000	£40,800	8%	-£2,450,000	N/A – due to –ve NPV
North Quay - CHP	£2,200,000	£900,000	£3,100,000	£850,000	£2,250,000	-£62,700	-12%	-£3,150,000	N/A – due to –ve NPV
North Quay Plus - Heat Pump	£2,800,000	£1,550,000	£4,350,000	£850,000	£3,500,000	£47,800	9%	-£3,100,000	N/A – due to –ve NPV
North Quay Plus - CHP	£2,300,000	£1,550,000	£3,850,000	£850,000	£3,000,000	-£60,900	-10%	-£3,850,000	N/A – due to –ve NPV
North Quay Plus Plus - Heat Pump	£3,450,000	£2,200,000	£5,650,000	£900,000	£4,750,000	£114,300	14%	-£3,550,000	N/A – due to –ve NPV
North Quay Plus Plus - CHP	£3,100,000	£2,200,000	£5,300,000	£900,000	£4,400,000	-£67,600	-7%	-£5,300,000	N/A – due to –ve NPV
South Bank - Heat Pump	£1,600,000	£900,000	£2,500,000	£700,000	£1,800,000	£18,100	8%	-£1,650,000	N/A – due to –ve NPV
South Bank - CHP	£1,450,000	£900,000	£2,350,000	£700,000	£1,650,000	-£41,700	-19%	-£2,250,000	N/A – due to –ve NPV
Lower Bristol Road - Heat Pump	£1,600,000	£1,400,000	£3,000,000	£450,000	£2,550,000	£49,600	17%	-£1,800,000	N/A – due to –ve NPV
Lower Bristol Road - Biomass	£1,450,000	£1,400,000	£2,850,000	£450,000	£2,400,000	£49,200	16%	-£1,700,000	N/A – due to –ve NPV

[9] Connection charges are the cost a building owner pays to the district heating operator to connect to the network. They represent the avoided costs of connection (e.g. boiler costs). For details of the charges refer to Appendix D.

7.2 Alternatives

The capital cost per tonne of CO_2 saved per year (at today's emission factors) for each option is compared to alternative methods of CO_2 reduction in Figure 7—6. The cost of PV is based upon a roof mounted array on a commercial building or large scale residential scheme as assessed in the Solar PV Energy Assessment: Placemaking Plan Development Sites report. The cost of retrofit is based upon studies carried out by the Zero Carbon Hub for Allowable Solutions. The capital cost per amount of CO_2 saved is similar to solar PV for the best performing district heating options and is significantly more expensive than retrofit measures. However, it should be noted that it may not be possible to achieve the same scale of CO_2 reduction at the particular development sites considered through solar PV or retrofit.

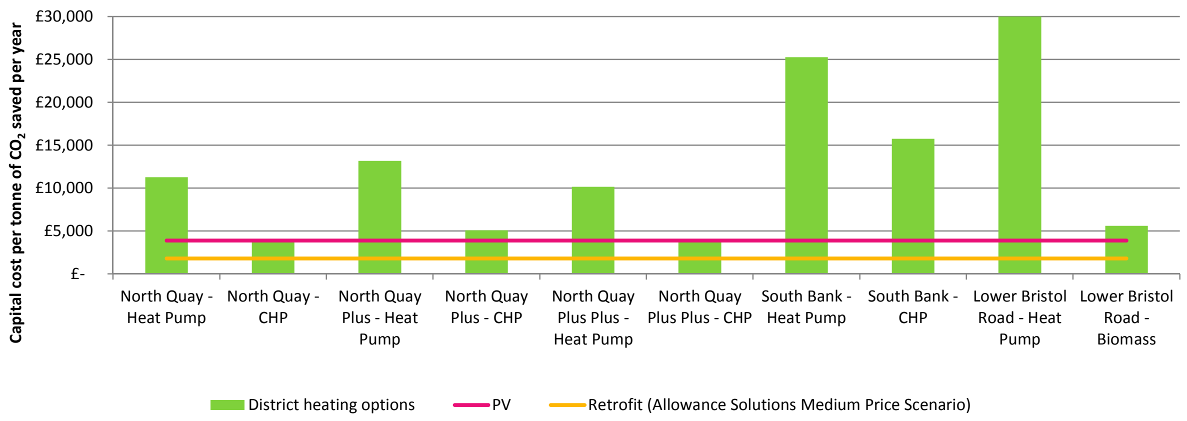


Figure 7—6 Capital cost per tonne of CO_2 saved per year comparison

7.3 Options appraisal

In addition to the quantitative results of the techno-economic assessment, there are issues that need to be considered qualitatively when selecting the preferred district heating scheme option. A list of criteria and a scoring guide is shown inAppendix G. The scheme options are appraised using a method called 'swing weighting'. In this method a weighting is applied to each criterion based upon the difference between the worst and best performing score. The weighting is applied after each criterion is scored. This means that the results of the appraisal are not skewed by criterion that are seen as having a high importance prior to the scoring but have a small range of scores. The qualitative assessment under each of the criteria for each option is presented in Appendix G. A qualitative summary of the unweighted scoring for each category is shown in Table 7—3.

Attribute (refer to Appendix G for full description)	Option									
	North Quay - Heat Pump	North Quay - CHP	North Quay Plus - Heat Pump	North Quay Plus - CHP	North Quay Plus Plus - Heat Pump	North Quay Plus Plus - CHP	South Bank - Heat Pump	South Bank - CHP	Lower Bristol Road - Heat Pump	Lower Bristol Road - Biomass
NPV per heat sold [£/MWh]	-446	-558	-330	-497	-793	-1,081	-585	-559	-446	-558
CO_2 savings per heat sold (today) [kg/year/MWh]	38	84	43	101	34	50	15	141	38	84
CO_2 savings per heat sold (2030) [kg/year/MWh]	154	-120	166	-133	163	-106	154	151	154	-120
Deliverability	6	7	5	6	4	6	4	6	6	7
Potential for expansion	6	6	6	6	8	8	1	1	6	6
Potential for community or other public sector involvement in ESCo	6	6	6	6	3	3	1	1	6	6
Potential for private sector led ESCo	4	4	3	3	4	4	7	7	4	4
Local environmental impacts	5	6	5	6	5	6	6	5	5	6
Risk	7	5	8	6	6	4	8	6	7	5

Table 7—3 Cluster prioritisation matrix - unweighted scoring

These weightings have been based upon the range of scores in each criterion and BuroHappold's understanding of B&NES Council's priorities. The two most important criteria are the financial viability (measured via NPV) and deliverability. CO_2 savings today are prioritised slightly higher than CO_2 savings in 2030 as the attractiveness of connecting to the network for new development is strongly related to the CO_2 emissions savings at the time of construction.

Figure 7—7 presents the overall scoring with weighting applied for each option, where a score of 100% would represent a maximum score in all categories. From this it can be seen that North Quay and North Quay Plus network clusters with a CHP heat source are the best of the assessed options. The Lower Bristol Road biomass option is the next most viable.

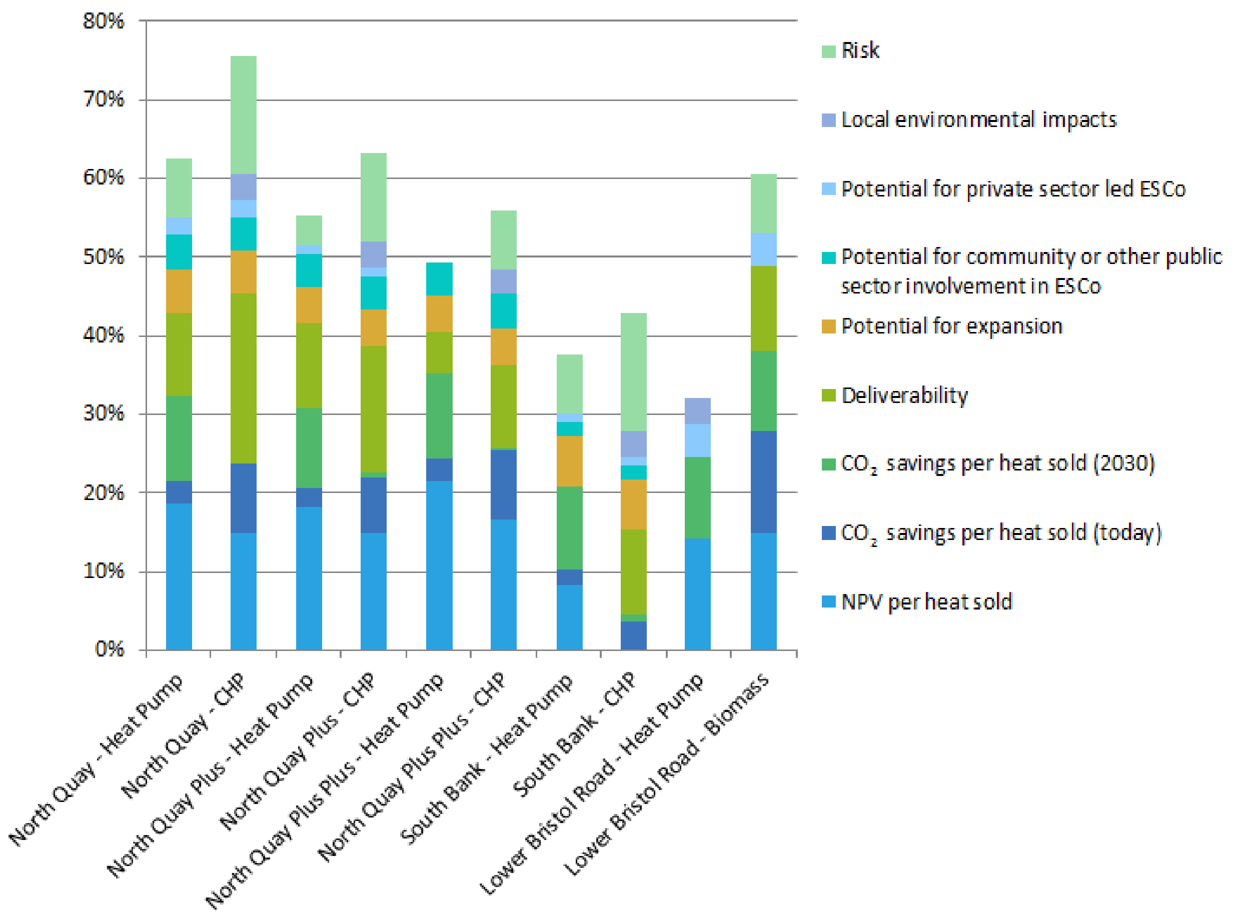


Figure 7—7 Cluster prioritisation matrix - weighted scoring

7.5 Sensitivity analysis of North Quay cluster

It should be noted that none of the options achieve a positive NPV after 25 years at a 3.5% discount factor based upon the financial assumptions used in the techno-economic model. High level sensitivity testing was undertaken on the North Quay CHP option in order to establish what might be needed to achieve an acceptable financial return.

A number of input variables were tested in order to understand the impact on financial viability:

1. Increasing heat variable price by 20%
2. Increasing electricity sales price to £90/MWh (i.e. private wire price levels)
3. + 20% on annual heat demand
4. - 20% on annual heat demand
5. A capital grant of £1.25 million
6. Extending the project life to 40 years
7. A capital grant plus high power price (2 plus 5)
8. A capital grant plus high power price and 40 year project life (2 plus 5 and 6)
9. A high heat sales price plus power price (1 plus 2)

Figure 7—8 shows the impact of these sensitivity scenarios on the NPV of the option. A higher electricity sales price than assumed in the base case is required for the scheme to make an operating profit. This combined with a capital grant allows the scheme to achieve a positive NPV. A high electricity sales price and heat sales price has a small negative NPV at a 3.5% discount factor. Table 7—4 shows that these scenarios achieve IRRs varying from 1% to 7%,

In order for the North Quay scheme to be viable the following must occur:

- A reduction in net capital costs borne by the scheme, options include:
  - Value engineering, such as removing low value building connections
  - Increase connection charges to new building, such as charging a higher price for the value of CO2 savings
  - Introduce connection charges for existing buildings, such as the avoid cost for boiler replacement
  - A capital grant – there are limited available sources for a capital grant. The most viable source is the Community Infrastructure Levy.
- Increase revenue, options include:
  - Increase electricity sales price, such as through private wire connections
  - Increase heat sales prices
  - TRIAD payments through an aggregator, such as Flexitricity

It is not felt that a significant reduction in operating costs can be considered given the level of detail of this feasibility study.

Table 7—4 IRR summary

Sensitivity scenario	25 years IRR
7 - capital grant plus high power price	6%
8 - capital grant plus high power price and 40 year project life	7%
9 - high heat sales price plus power price	2%

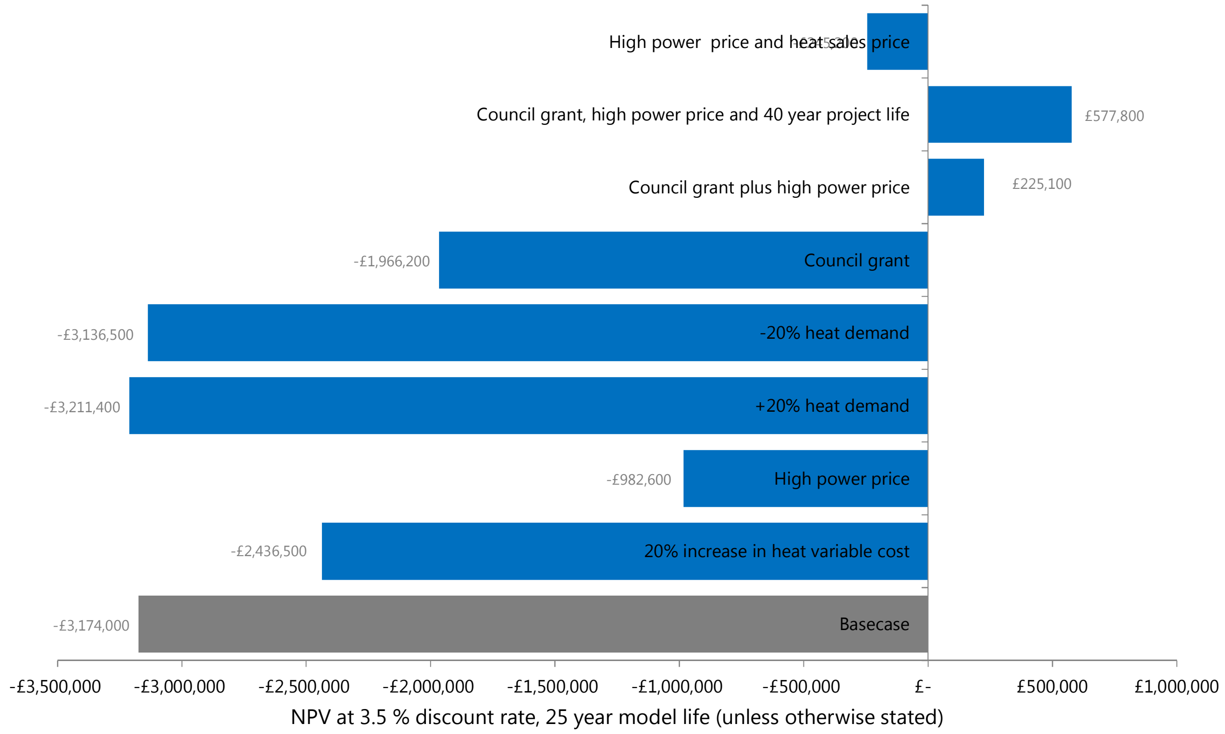


Figure 7—8 Summary of sensitivity testing

8 Governance and the Council's Role

8.1 B&NES Energy Services Review

A separate review of governance structures suitable for taking forward a range of low carbon energy options has been undertaken by the Council, and has explored three core models for local energy service delivery:

1. '**Go it alone'**: B&NES Council develops its own arms-length energy company.

2. '**Joint Venture':** B&NES Council establishes a Joint venture with a third party (such as Bath & West Community Energy, another local authority, a commercial ESCO or another public sector body.

3. '**Enabler'**: B&NES Council continues to act primarily as an enabler for others to deliver services, either through concessions or as an investor

The study concluded the most appropriate route forward was for B&NES Council to continue to play an enabling role in energy services development, taking a proactive approach that looks at opportunities strategically in collaboration with local stakeholders and identifies activities based on the case for both financial viability and local additionality (alongside ability to support the Council's wider strategic objectives)..

Applying this 'enabler' approach to district heating would suggest a potential business model as described in Figure 8.1. Activities which it might be appropriate for the Council to lead on include the following:

- Pre-development feasibility study
- Convening of key stakeholders and anchor loads
- Procurement of design and build of the district heat network
- Procurement of operation and management of the network, or development of capacity to carry out this work in house.

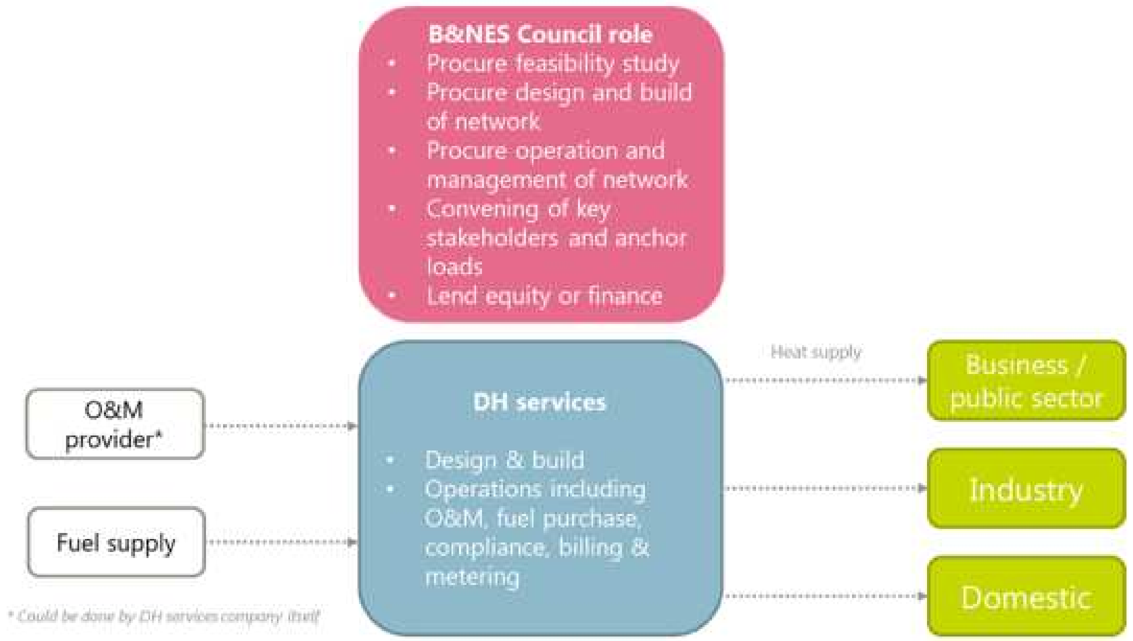


Figure 8—1 Business model for district heating

8.2 Challenges of district heating

This report builds on this earlier work and explores governance structures for district heating schemes in more depth. There are a number of challenges particular to these schemes that need to be addressed by the governance structure. These include:

- Monopoly pricing: customers on a district heating system will have only one supplier – transparency and accountability over pricing is important to gain customer trust, particularly with consumers unfamiliar with the concept
- Need for sufficient long term sales contracts to ensure viability – upfront costs of district heating networks are significant thus some security over revenues in the long term are necessary to unlock investment finance
- Multiple parties required to collaborate in order to effectively deliver a scheme – leadership is important

The most common response to these challenges where the public sector has been involved has been a partnership arrangement, examples of which are presented in Table 8—1.

Table 8—1 Examples of district heating schemes involving the public sector

Governance option	Description	District heating precedents
'Joint venture'	Special Purpose Vehicle (SPV) established to run energy company. B&NES and other party(s) jointly own SPV.	No JVs between a council and third party identified, nearest equivalent seems to be Thameswey Energy = 90% owned by Woking Borough Council.
'Enabler'	B&NES acts primarily as an enabler for others to deliver services. Key gaps or barriers to energy service provision are identified in collaboration with stakeholders and addressed accordingly. B&NES may or may not provide some funding. Can involve different types of partners and collaboration agreements, and/or can use concession approach.	Most common approach used in UK. Several examples with different features eg. • Southampton City Council which developed its scheme based on a **co-operation agreement** (legal document) with Cofely (formerly Utilicom) which wholly owns the energy company. There is a 'joint co-operation' team with representatives from both parties. Worked together to encourage connections / expand the scheme. • Coventry 'Heatline' project – Council provided a **25 year concession** to Cofely to design, build and operate a heat network connecting to an EfW plant and supplying to buildings in the city including those owned by Coventry Council. Cofely effectively acting as 'heat shipper'. NB originally partnered with University but they subsequently pulled out of the scheme. • Birmingham City Council signed a **25 year heat supply agreement** with Birmingham District Energy Company, a subsidiary of Cofely set up for the scheme. Other partners include Aston University & Birmingham Children's Hospital.

The 'enabler' role is the most common approach, with a number of examples of LAs offering concessions to private sector operators. Those included in Table 8—1 suggest three alternative contractual structures:

- A co-operation agreement
- A concession agreement
- A heat supply agreement

All are long term in nature and were developed in accordance with the specifics of the scheme, important factors being: council buildings taking heat from the scheme, a commitment to joint working and long term scheme expansion, innovation around business models.

A further option explored in this study is a consumer / community led approach that uses some form of mutual association. This would address the key challenges of transparency and trust that arise from monopoly pricing arrangements that are a feature of district heating schemes.

This section builds on the findings of the B&NES Energy Services Review in the specific context of delivering district heating networks in the Bath Enterprise Area. In particular it takes into account project specific factors of:

- Geography / spatial characteristics (size, location, constraints, new build / existing etc)
- Stakeholders
- Potential to expand
- Viability
- Timescale

The section also considers alternative governance structures not fully covered in the B&NES Energy Services Review, namely community ownership models for district heating and Multi-Service Utility Companies (MUSCo's).

8.3 Preferred governance approach for Enterprise Area schemes

The proposed schemes for the Enterprise Area were mapped against the preferred governance approaches identified in B&NES Energy Services Review in the context of the following factors:

- Geography / spatial characteristics (size, location, constraints, new build / existing etc)
- Stakeholders
- Potential to expand
- Viability
- Timescale

Each scheme is discussed below. Conclusions are high level at this stage pending further discussion with stakeholders to understand their objectives and requirements.

8.3.1 Lower Bristol Road

Key features of the Lower Bristol Road development are outlined in Table 8—2 leading to an assessment of the different governance options for the scheme in Table 8—3.

Important factors for this scheme are its proximity to the Bath Western Riverside district heating network run by E.ON on the adjacent Crest Nicolson site, combined with its marginal viability. If the scheme is to progress it would appear that B&NES' role would be as an enabler, ensuring the relevant parties come together to establish early on whether objectives can be aligned sufficiently to get the scheme delivered. As well as Crest Nicolson and E.ON, other parties to be involved would be the new site developers, Spenhill Developments and Deeley Freed Estates.

The marginal viability of the scheme suggests some requirement for B&NES to take a proactive approach to de-risking and potentially to providing / channelling funding.

It would appear that there would be limited opportunities / benefits for B&NES to become involved in any kind of partnership agreement as there are no council buildings nearby to be supplied and limited potential for the scheme to expand (other than linking to the existing E.ON network). However, B&NES involvement could be beneficial in the context of a longer term vision for the development of district heating in the city. Some direct involvement / working relationship beyond that of planning and early stakeholder engagement could be of value in promoting and coordinating schemes more generally and ensuring shared learning and collaboration.

An alternative approach to district heating for the Lower Bristol Road sites that could be considered is an expansion of Crest Nicholson/E.ON existing scheme building on the existing energy centre to serve the new developments. In this case, the Council could play a proactive coordinator/enabler role.

Table 8—2 Lower Bristol Road key features relevant to governance

Factor	Site characteristics	Implications
Scale and geography	• Peak load – 2.5MW • c. 500 residences, primarily new build • Adjacent to existing scheme (with approximately 1,200 unbuilt apartments to connect) • One small council building is part of the scheme (Oldfield Park Infant School) but with a negligible heat load in the overall scale	Location lends itself to coordination with existing scheme – should lead to more efficient, low cost operations. Residential led although all new build, potential for community scheme but only in the longer term. No nearby council buildings reduces incentive for B&NES to be directly involved.
Key stakeholders	• Crest Nicolson – requirement for permission to cross land; adjacent developer / land owner; requirement for low carbon heat to meet planning; built and owns network on site • E.ON – operates DH network on adjacent site • Spenhill Developments – Bath Press developer • Deeley Freed Estates – Roseberry Place developer	Complex relationships with differing objectives. Likely that B&NES involvement will be a necessary precondition to getting the scheme delivered. Role would be to coordinate and help to align stakeholder objectives.
Potential to expand	Limited – constrained by the river to the north and existing buildings to the south are too low density to make district heating viable	Limited potential to expand reduces the incentive for B&NES to intervene. However, there is the potential to link to the existing neighbouring scheme.
Viability	Marginal	Marginal nature of scheme makes it harder to deliver and attract private sector; limited expansion potential means that the scheme has to stand alone. Likely to require B&NES support either in form of direct funding or significant de-risking.
Timescale	Planning applications submitted 2015 Likely delivery unknown	

Table 8—3 Assessment of the suitability of different governance options for the scheme

Component 1 Governance option	RAG *	Comments
Joint venture with BWCE	Amber	Potentially; JV could still engage private sector expertise to develop and operate the scheme – possibly E.ON? Could be a hybrid JV/enabler option?
Joint venture with other local authorities	Amber	Bristol CC potentially? Depends on political appetite, could just make it more complex without adding any particular value?
Joint venture with commercial ESCO	Amber	Need to understand commercial relationships in place for BWR between CN and E.ON. Potentially JV (with Eon and BWCE as partners?) could develop the new network and contract with E.On to operate it – as was done with CN. Coordination with existing BWR scheme could introduce efficiencies and hence cost savings.
Joint venture with other public sector bodies	Amber	No other public sector bodies with buildings that would connect, hence less likely
Enabler - investor	Green	Support from B&NES in coordinating project between relevant parties is likely to be critical. Viability is marginal making it likely some support from B&NES is likely. De-risking could help to unlock private sector funds.
Enabler - investor / community group	Amber	Potentially large number of residential customers; transitional period required while community group set up and role for B&NES in this? Would need cooperation from site developers.
Enabler - concession	Red	Not within B&NES remit to offer concession. Other forms of partnership agreement also hard to imagine – single small public sector buildings adjacent to scheme to take heat and limited expansion opportunities so limited incentive for B&NES to enter a long term agreement. Depends on B&NES longer term vision for involvement in district heating in the city and whether it sees the potential to coordinate all schemes and thus have some direct involvement / working relationship beyond that of planning and early stakeholder engagement.

** RAG rating: Red implies unlikely, Amber some potential and Green, significant potential*

8.3.2 South Bank

Key features of the South Bank development are outlined in Table 8—4 leading to an assessment of the different governance options for the scheme in Table 8—4.

This is the least financially attractive of the options reviewed in this study and is unlikely therefore to be a priority at this stage. Were it to be taken forward, the most likely role for B&NES would be as an enabler, bringing together stakeholders and exploring ways to optimise the scheme. Although there is some potential for expansion to the Green Park West development site, the plans for this are highly uncertain. This, combined with the lack of nearby council buildings, suggests a longer term role for the council is unlikely.

Table 8—4 South Bank key features relevant to governance

Factor	Site characteristics	Implications
Scale and geography	• Peak load – 2.9 MW • c. 90 apartments • Primarily new build + major refurbishment of existing structures • No council buildings in proximity of scheme	
Key stakeholders	New developers not yet identified; no obvious public sector partners	
Potential to expand	• Energy centre in west would favour expansion to Green Park developments (reduced pipe diameter to South Quay) • Connection across bridge to North Quay not considered due to cost and aesthetic impact • Expansion potential hard to factor in to initial build until Green Park plot layouts developed further	Limited potential to expand reduces the incentive for B&NES to intervene.
Viability	Least financially attractive of all schemes	Limited incentive to take forward
Timescale	South Quay –2017 South Bank – 2025 onwards	

Table 8—5 Assessment of the suitability of different governance options for the scheme

Component 1 Governance option	RAG *	Comments
Joint venture with BWCE	Amber	Potentially; JV could still engage private sector expertise to develop and operate the scheme. Could be a hybrid JV/enabler option? See below.
Joint venture with other local authorities	Amber	Bristol CC potentially? Depends on political appetite, could just make it more complex without adding any particular value?
Joint venture with commercial ESCO	Amber	Depends on viability of scheme and hence ability to attract private sector to participate.
Joint venture with other public sector bodies	Amber	No other public sector bodies with buildings that would connect, hence less likely
Enabler - investor	Green	Support from B&NES in coordinating project between relevant parties. Some de-risking useful to help private sector unlock funds.
Enabler - investor / community group	Amber	Fewer residential customers and more offices; transitional period required while community group set up? Ie bigger role for B&NES early on?
Enabler - concession	Red	Not within B&NES remit to offer concession. Other forms of partnership agreement also hard to imagine – no public sector buildings adjacent to scheme to take heat and uncertain expansion opportunities so limited incentive for B&NES to enter a long term agreement. Depends on B&NES longer term vision for involvement in district heating in the city and whether it sees the potential to coordinate all schemes and thus have some direct involvement / working relationship beyond that of planning and early stakeholder engagement.

** RAG rating: Red implies unlikely, Amber some potential and Green, significant potential*

8.3.3 North Quay

Key features of the North Quay development are outlined in Table 8—6. The initial assessment of viability of this scheme suggests it is marginal however it is more positive than the other schemes, largely as a consequence of its greater density. There could be potential to optimise it further. This opens up a wider range of governance options and a greater potential to attract the private sector.

Important factors for this scheme are the involvement of B&NES directly in the development process owning and potentially managing the site in the long term, and the potential to partner with other public sector bodies. There could be potential to establish a JV to take forward the scheme involving these partners however this will only work if objectives can be suitably aligned. Although initially it may appear that they are, precedent studies (e.g. Coventry) suggest it can be challenging to maintain this as the scheme progresses.

There is also potential for other forms of partnership agreement such as a concession let to a private sector ESCo. The benefits of this are that a higher share of risk can be transferred from the council, however, as indicated in Component 1, this would be at the expense of control.

The location of this scheme is lends it to expansion. This suggests it would be beneficial for the council to take a longer term role to enable this to happen and ensure it develops in line with the council vision for district heating in the area leading to an assessment of the different governance options for the scheme in Table 8—7.

Table 8—6 North Quay key features relevant to governance

Factor	Site characteristics	Implications
Scale and geography	• Peak load – 7MW • c. 160 apartments • Mixture of new build and existing • No council buildings but the development is likely to be owned by the Council long term through a wholly owned subsidiary • Other public sector buildings could connect to scheme	At full build out North Quay would be largest scheme and would also have a mixed load (ie not dominated by a single load type)
Key stakeholders	• City of Bath College • University of Bath (as occupant of Carpenter House and John Wood Building) • B&NES (as landowner / site operator)	B&NES likely to take on ownership and operation / management of development giving it a major opportunity for heat network delivery. Range of potential partners supportive of low carbon scheme.
Potential to expand	Expansion plans explored as part of this study; could go wider	Strong incentive for B&NES to be involved longer term to support expansion and connection of new customers
Viability	Low returns but more potential than other schemes explored	Potential to further optimise the scheme; incentive for B&NES to be involved longer term.
Timescale	North Quay Enterprise Area site – 2017 – 2021	

Table 8—7 Assessment of the suitability of different governance options for the scheme

Component 1 Governance option	RAG *	Comments
Joint venture with BWCE		Mixture of existing and new properties - potential to get existing building owners / customers involved and then expand to new as and when? Could have wider ownership eg with other public sector bodies – see below
Joint venture with other local authorities		Bristol CC potentially? Depends on political appetite, could just make it more complex without adding any particular value?
Joint venture with commercial ESCO		Depends on viability of scheme and hence ability to attract private sector to participate. Early stage analysis suggests some council / other funding would be required to make proposal attractive.
Joint venture with other public sector bodies		Could link up with City of Bath College and University of Bath but depends on their objectives and existing heat supply arrangements. Could have wider ownership e.g .with BWCE – see above
Enabler - investor		Likely that support from B&NES in coordinating project between relevant parties will be required; also additional funding. Some funds could be generated from building developer (connection fees) but further analysis required to confirm extent of this. Currently no connection fees from existing buildings assumed. Some de-risking by B&NES would be useful to help private sector unlock funds.
Enabler - investor / community group		Mix of residential, student, hotel, offices new and existing, but mostly commercial. Formation of community group (including commercial) possible but if so only in the long term.
Enabler - concession		Whether B&NES would be in a position to offer a concession is to be determined, depending on role of B&NES in development of scheme. Terms would depend on viability and ability to attract private sector to participate.

** RAG rating: Red implies unlikely, Amber some potential and Green, significant potential*

8.3.4 Summary

The North Quay option lends itself to a more direct governance role for B&NES, either through a JV with the universities that could connect to the scheme, or a long term partnership agreement such as a concession with a private sector operator. A hybrid approach is also possible. The potential for a mutual association / consumer co-operative is discussed in the next section.

Involvement of B&NES in Lower Bristol Road as an enabler in bringing stakeholders together at an early stage is important. There is less potential for longer term partnering although it could be valuable to have some longer term arrangement in the context of the vision of the council for developing heat networks in the Enterprise Area.

South Bank is not considered a viable option at this stage however, if it were to progress, it would most likely benefit from input from B&NES as an enabler, supporting early stakeholder engagement.

8.4 Community led schemes

Whatever the governance option selected for B&NES, the energy entity itself could involve other parties, in particular the community. This section provides an overview of community led schemes in the UK and elsewhere in Europe.

The term 'community' can be widely interpreted. In some instances it is used to refer to a physical geographic community whereas in others it could refer to a community of interests. In the context of district heating, where there are particular challenges around consumer acceptance and monopoly pricing, a customer focused community – including users and building owners both as individuals and as organisations – that forms some kind of mutual association could be envisaged.

Community projects in the UK have traditionally been formed around the installation of renewables, typically solar PV or wind, such that a community will benefit directly from the exploitation of local resources. Sustainable business models have been developed that can provide a reasonable return to investors based on government incentives plus the sale of electricity.

District heating differs from renewable generation in that it is more complex to construct and operate, and is likely to have more direct consumers meaning that there are issues over acceptability, service delivery, billing and metering etc. Heat is an unregulated market which provides some advantages in that there is more flexibility over heat pricing, but disadvantages in that it can lead to a lack of transparency and making it harder to ensure consumers are treated fairly[10]. A summary of differences is provided in Table 8—8.

Table 8—8 Overview of differences between renewable energy and district heating projects

Issue	Renewable electricity / generation	District heating
Capital cost and financing	High capital costs. Financing for community schemes through public share offers reasonably common model whereby organisation offers return based on relatively secure business model. Otherwise some debt financing possible again due to relatively secure income streams.	High capital costs. Financing generally from a range of sources depending on stakeholders. In a new development, may get connection charges from developer (based on avoided costs of alternative heating systems). Some grant funding may be available. Private sector ESCo can raise and provide finance if given some security over returns (eg. some assurance over build out and connections for a new development)
Design & construction	Relatively straightforward once site selected	A large number of options to consider particularly around location and type of energy centre (generation) and network routes (distribution)
Geography / site	Constrained by availability of land / space and renewable resource (sun / wind)	Constrained by density of buildings to serve (if too spread out, network costs outweigh benefits); also issues of network routing within potentially congested urban areas
Expansion	Generally constrained by site conditions; potential to 're-power' wind sites as technology improves to enable larger turbines to be installed	Networks can expand to link proximate buildings; need to allow space in energy centre (or be able to link in additional centres) to be able to serve increased demand
Revenue risk	Output is generally sold direct a single offtaker, however depending on location, can supply direct to end users (eg solar rooftop PV). Revenue aligned to weather events – but whatever is generated can be sold. Long term power purchase agreement with single off taker can be negotiated to reduce price. uncertainty. Incentives for renewable generation vary with scale	All heat sales retail to end users under a supply agreement. CHP schemes can also supply electricity – potentially through long term power purchase agreement. Heat revenues linked to demand / occupant behaviour, building type / efficiency. High heat revenue risk particularly in the early stages as demand patterns develop and are

[10] See Which? report '*Turning up the heat: Getting a fair deal for District Heating users*', March 2015

Issue	Renewable electricity / generation	District heating
	– under severe political scrutiny	understood. Long term heat supply agreements can be negotiated with commercial customers; more challenging with multiple domestic users. Incentives only available for renewable fuels and where heat and power and generated together (CHP)
Operating cost / maintenance	Relatively low ongoing costs of maintenance	Higher ongoing costs and also requirement to purchase fuel
Business model	Relatively straightforward, no fuel purchases and limited billing / metering (unless installation is supplying direct to end users). Admin around gov't incentives.	More complex operations as need to purchase fuel, ensure reliable heat / HW supply to end users, maintain and operate energy centre and networks. Billing and metering. Higher risk. Can split into more than one business eg separate generation from distribution / supply. Relatively common on the Continent; used by Cofely in Coventry where it acts as a 'heat shipper'
Regulation	Highly regulated, requirement for licence or licence exemption.	Heat supply is currently unregulated; gas as fuel is regulated but that doesn't have a big impact
Planning	Engagement with community required hence benefit of making it a community scheme. Can be local opposition depending on site.	Generally supported by planners as long as scheme is well designed.

Despite these difficulties, a handful of schemes have been developed by communities in the UK with a wider variety and larger scale schemes successfully operating elsewhere in Europe. These are summarised in Table 8—9.

In the UK, success factors for community led district heating schemes delivered to date include:

- Leadership / commitment by leaders to push the scheme through
- Scheme is not an end in itself, other contributory / driving factors (eg regeneration)

In terms of partnering with the public sector, community groups show a range of approaches from independence / no partnering through to JV/part ownership.

Table 8—9 Community-led district heating schemes

Case study	Country	Description	Council role	Funding
Douglas Community Ecoheat	UK (Scotland)	Not for profit trading subsidiary of St Bride's Community centre; supplies heat to 3 customers including community centre. Developed as part of major refurbishment programme; relies on volunteers.	Council provided some of the funding	Council, Community Energy Scotland
Springbok Sustainable Wood Heat Co-Operative	UK (England)	Not for profit co-operative, built, owns and manages district heating system to serve local care home and associated buildings. Supported by Energy4All.	None	Share offer raised c£475k, aim for a return of 6-7%, EIS tax relief for investors. Business model dependent on RHI. Shareholders are members of co-op.
Kielder Community Enterprise Ltd (KCEL)	England	Community owned ESCo. Uses local wood chip, serves local attractions (eg Kielder Castle), school plus new dwellings in the village.	Council worked with Kielder Regeneration Initiative and KCEL to develop scheme. Did fundraising and let contract, then handed over to KCEL to run once operational.	Northumberland National Park, £50k; Northumberland Strategic Partnership £250,000; the European Regional Development Fund, £310,000, Northumberland County Council, £20,000, and Tynedale Council, £11,200. The Forestry Commission also provided in-kind support to the scheme.
Buchkirchen	Austria	Set up, owned and managed by 4 farmers; 25 customers including municipality buildings	Customer	Mix of government incentive, loans and farmers' own investment
Gjern Varmevaerk	Denmark	Well established, 490 customers including school and swimming pool. Customer owned co-operative	None	High connection fees
Mullsjø	Sweden	160 district heating customers in 5,000 resident town; converted oil fired system to wood pellet; modular system, total 9MW	Wholly owned subsidiary of the municipality; municipality provided security for loans to district energy company	Debt from local bank secured by municipality; customers subsidised to connect
Hållanders Sawmill & Village of Dalstorp	Sweden	Sawmill built system for its own needs and exports surplus heat to 150 customers locally. 5MW plant, 60% used on site.	Council built and owns network and does all customer billing. Council is a customer of the saw mill which provides the heat.	

Although the complexity and high upfront costs of district heating schemes make them more suitable for public sector / commercial development, there could be some potential to refinance a scheme once operational and then transfer it to community ownership at that time. This longer term transitional approach would appear to be more suited to the Enterprise Area options explored in this study, where the preconditions for the emergence of a community group at the outset would not appear to be present. It would be particularly difficult to develop where the majority of buildings connected are new and thus owners / tenants unknown.

The exception to this could be North Quay where a mutual association of existing users – including the council and universities – could potentially be established from the outset.

The stages/process could be as follows:

1. DH network developed by B&NES council (potentially in partnership with BWCE), with involvement of any customers that can be identified at this stage
2. The governance structure could have different classes of consumer: domestic, large commercial, SME
3. Once a number of consumers from each class have been connected, a consumers' cooperative could be formed. This could be structured such that the board of directors includes representatives of every class of customer, from the beginning.
4. B&NES council and BWCE could provide information about a set of options for tariffs, from which the members of the co-operative could select
5. Once the system is running, ownership could be transferred to the consumer co-operative. This could be financed through a community share offer, or through a gradual repayment arrangement, commercial refinancing (which should be cheap as there will be very low risk since it is already built), or some hybrid of these.
6. B&NES council and BWCE could continue to support/advise the cooperative until it has built the capacity to operate independently.

7. B&NES council representation on the board to play a coordinating and strategic role in relation to other district heating networks. Or alternatively the council could have some other form of role in governance of the co-operative.

8.5 Discussion of opportunities for MUSCo approach

The council has expressed interest in the multi-utility approach to infrastructure management and delivery. This section provides a high level overview of the current status of this approach in the UK.

Research suggests that infrastructure delivery and management through a Multi-Utility Service Company is still in its infancy. Although generally considered a 'good thing' there are no examples of a scheme having been successfully delivered in the UK. In addition, there are different understandings of exactly what a MUSCo is and how it would be structured.

The most widely known example is probably that of Southwark Borough Council where the council went out to competitive tender for a MUSCo which it described as "…. a company proposed to be set up **to create and operate** infrastructure at the Elephant & Castle". The particular drivers for the council were environmental – a reduction in GHG emissions and in water demand. They sought to establish "a public/private joint venture vehicle (MUSCo) as a special purpose vehicle whose core business is the provision of low carbon heating, cooling, power, non-potable water and data services at district level."

Through the tender process, the council appointed a consortium led by Dalkia. The services to be provided by the MUSCo were:

- A comprehensive district network delivering heat and electricity to the development.
- A non-potable water network.
- An open access fibre optic communications network.
- The scope to explore the feasibility of the inclusion of other services such as mechanised waste removal and cooling.
- Delivered as a services concession over thirty-five years.
- The Council granting leases and way leaves to facilitate the scheme.

The technical scheme involved putting all utilities in a shared trench to minimise disruption.

The concept was however abandoned in 2011[11] . There were a number of reasons for this, most related to delays and changes in the construction programme such that the business offer made by Dalkia had to change significantly – particularly in relation to provision of the district heating network – to the extent that the council no longer felt it was value for money.

More recently, East Hampshire District Council is looking to establish a MUSCo in relation to the delivery of infrastructure for the proposed Whitehill Bordon development (a large brownfield site development on ex Ministry of Defence land). Their interpretation of a MUSCo differs from that of Southwark and is described as "a special purpose vehicle set up to act as an **umbrella organisation** for one or more utilities, which can **work in partnership** with the utilities providers." This would appear to be a looser interpretation than that of Southwark in that the individual utilities would retain their role in delivering in the infrastructure but the EHDC MUSCo would coordinate their activities leading to efficiency savings and benefits that could be fed back into the local community. An example structure is illustrated in Figure 8—2.

[11] http://moderngov.southwark.gov.uk/mgConvert2PDF.aspx?ID=16241

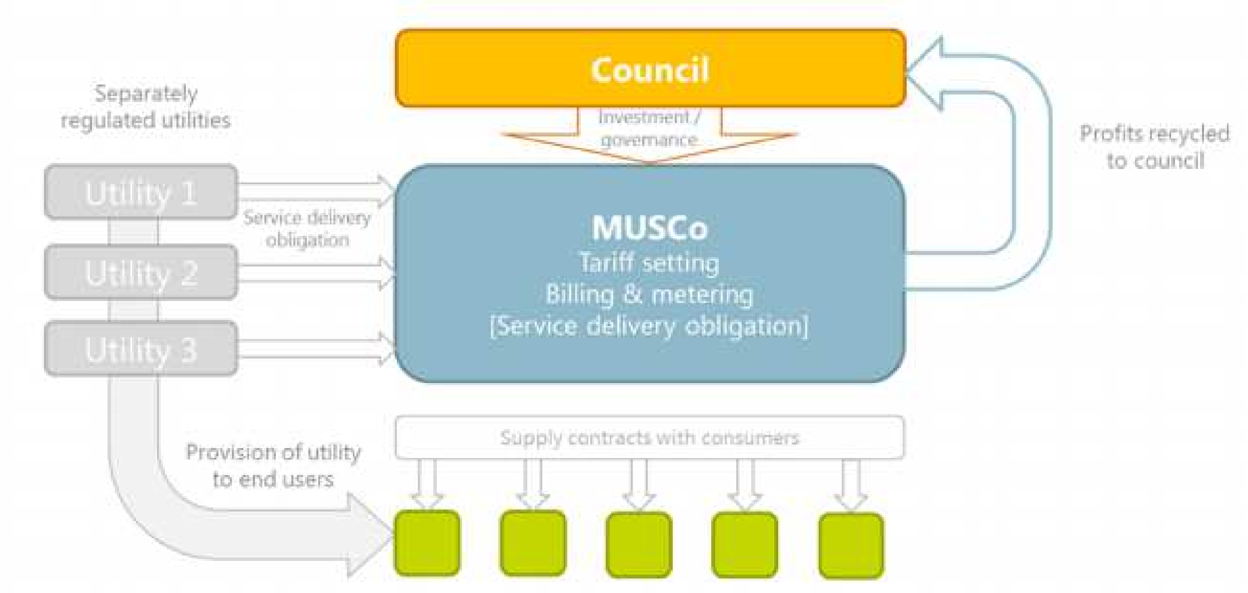


Figure 8—2 Example MUSCo structure

There is some academic research being undertaken in relation to joined up infrastructure delivery[12]. Research undertaken at University of Leeds defines the characteristics of a MUSCo as "(1) the **single point of service** to multiple utilities; and (2) profiting from **service delivery**, not selling physical products….The lower the energy and water consumption of its clients, the higher the MUSCo's profit – as long as the MUSCo maintains the requested level of service provision."

Obstacles identified by the research include:

- "A widespread and deeply ingrained reliance on mainstream technologies and modes of operation, but the high costs associated with creating and monitoring service performance contracts are also an important factor.
- The existing regulatory framework. The whole emphasis of UK regulation is wrong for the development of MUSCos: it enshrines the freedom to change providers and the requirement for short term contracts; it forbids the sharing of information between utilities – preventing joint utility solutions; and it excludes local groups of providers and users from being more actively involved in infrastructure operation."

Again, it would appear that innovation, leadership and commitment are required for MUSCo delivery . The current UK legislative framework and behaviour of incumbents suggest that delivery is challenging, however some are seeking to address this and develop new business models that could work.

[12] http://www.see.leeds.ac.uk/research/sri/specialisms/economics-and-policy-for-sustainability/current-research/the-land-of-the-muscos-multiple-utility-service-companies/

9 Conclusions and Recommendations

9.1 District heating technologies

Three low carbon technologies providing baseload heat supply were considered as part of district heating options assessment. Although the viability of each network and technology combination has been considered separately there are a number of broad conclusions that can be drawn regarding the heat supply technologies.

River source heat pump

- A heat pump led system delivers limited CO_2 savings compared to using local gas boilers based upon the carbon emission factors used in 2015. These savings are in the region of 5% to 15%. These limited savings may make connecting to a district heating system unattractive to developers as they provide little benefit to compliance with Part L or BREEAM requirements.
- However, as the grid decarbonises, a heat pump led solution delivers large CO_2 savings compared to local gas boilers with approximately a 60% improvement in 2030 (assuming that the grid decarbonises in line with DECC projections).
- The input fuel for a heat pump is electricity and heat sales prices are generally pegged to gas prices. The price of electricity and the efficiency of large scale water source heat pumps means that cost of heat generated offers little or no cost saving compared to a gas boiler. Consequently the operational margin for a heat pump led scheme (at today's capital costs) relies heavily on subsidy (such as the RHI). A 20% reduction in the RHI tariff would result in an operating loss, largely due to the difference in cost of gas and electricity..
- Key risks with the technology are:
  - o The Environment Agency may object to the placement of intake pipes in the River Avon due to the impact on flood risk
  - o The Canals and Rivers Trust may require a charge for use of river water at a level that may make the technology unviable
- There is potential that heat pumps could be combined with gas CHP or solar PV in order to increase CO_2 savings during the period the grid decarbonises and reduce the overall running costs. This could be explored in Phase 2.
- A heat pump led scheme is currently a high risk option for initial district heating development, however, it could be considered as a future replacement technology for other plant.

Gas CHP

- A gas CHP led system delivers good CO_2 savings associated with supplied heat compared to using local gas boilers based upon the carbon emission factors used in 2015. These savings are in the region of 20% to 40%. This makes connecting to a district heating system attractive to developers as it provides a benefit to compliance with Part L or BREEAM requirements.
- However, as the grid decarbonises, the CO_2 savings reduce and in 2030 a gas CHP led system has higher CO2 emissions than a local gas boiler.
- The operational margin for a CHP led scheme relies on it being possible to sell electricity at close to retail prices, i.e higher than £80/MWh. Sales at £50/MWh resulting in an operating loss. There is less risk of the relative prices of gas and electricity altering than changes to the RHI.
- Gas CHP could be used as a transition technology in order to establish the infrastructure that allows a change to a future lower carbon technology, such as a heat pump.

Biomass boiler

- A biomass led system delivers good CO_2 emissions savings compared to local gas boilers both now and in the future (as it is not significantly affected by grid decarbonisation).
- Fuel delivery access and air quality are important considerations when installing biomass boilers and therefore it is recommended that they are not used for the city centre clusters.
- The operating margin relies on the RHI. A 60% reduction in RHI results in an operating loss. The cost of biomass for a system of the sizes proposed for the options is generally similar to or slightly more expensive than gas.

Hot springs options

- It is not viable to drill boreholes directly into the hot aquifer as this may affect the heat and flow balance between the aquifer. The hot springs are a vital part of Bath's tourism experience and on this basis the Council is not willing to permit additional boreholes for this purpose.
- It may be viable to use shallow boreholes (potentially with piled foundations) to make use of the raised ground temperature in Bath without disturbing the aquifer. However, this is more suited to being used to supply individual buildings as, to avoid issues with multiple heat source ownership, a district heating scheme would require a larger open area in which to install a borehole field. To provide heat to North Quay approximately a 25,000m^2 area would be required.

9.2 Options appraisal for the shortlisted heat network clusters

North Quay and wider options

- 'North Quay', 'North Quay Plus' and 'North Quay Plus Plus' have the highest line heat density of all options.
- These schemes have the most opportunity for expansion due to the location adjacent to the city centre, which means there is a higher chance of redevelopment and refurbishment of surrounding buildings.
- The Council has the ability to influence the scheme due to the ownership and development of the North Quay (Avon Street Car Park) site and the public sector ownership of adjacent buildings.
- The optimal initial scheme is likely to be a mixture of the buildings considered as part of the North Quay and North Quay Plus options.
- The river source heat pump option is less attractive than CHP based upon today's energy prices and grid electricity CO_2 emissions factor, but could be a good long term replacement opportunity.
- In order for a CHP led scheme to make a reasonable operating margin an electricity sales price of close to £90/MWh is required.
- Based upon current assumptions a capital grant of some kind is needed in order to make the scheme financially viable as a standalone project or SPV.
- There is potential for B&NES Council to establish a joint venture to take forward the scheme, potentially involving City of Bath College or the University of Bath. There is also potential for other forms of partnership agreement, such as a concession let to a private sector ESCo, which would allow greater risk to be transferred from the Council but at the expense of control.
- The North Quay scheme saves approximately 600 tonnes/year of CO_2 based upon current grid electricity emissions. If the scheme is not developed then other CO_2 reduction methods will be required to meet the same level of CO_2 reduction, such as solar PV or retrofit energy efficiency improvements.

South Bank

- The scheme is too small to support a viable heat network. The majority of the site is office buildings, which have a limited heat demand.
- It is recommended that policy CP4 is used to ensure that the buildings are future-proofed for district heating connections as the development of the Green Park area could lead to heat network connections being viable as part of a larger scheme.

Lower Bristol Road

- There is too much pipework compared to the annual heat demand for the scheme to be viable as a standalone network (as opposed to being fully integrated with the existing BWR network).
- There is limited value in connecting Oldfield Park Infant School and Charlton Court to the network due to the size of the annual heat demand and the large amounts of additional pipework required.
- There minimal opportunity for significant future expansion of the network due the constraints of the river, Bath Western Riverside, Lower Bristol Road and the low density of existing development to the west and south.
- There could be potential for an expansion of the Bath Western Riverside scheme with an extended energy centre and the Bath Western Riverside Phase 2 pipework being used to distribute heat to Roseberry Place and Bath Press. However, there may be practical and legal issues with option. The commercial sensitivity of E.ON's business model means that it has not been possible to explore the financial viability of this option in this work.
- B&NES Council could act as an enabler and coordinate discussions between E.ON, Crest Nicholson, Spenhill and Deeley Freed.

9.3 Other Enterprise Area sites

It has not been possible to include the Green Park Enterprise Area development sites in this study due to uncertainty about the development plans. It is recommended that when plans for this site start to be developed the feasibility of district heating in this area is reviewed again.

9.4 Next steps

The following next steps are recommended:

- Further investigation of the North Quay cluster to establish what conditions would be required in order to make the scheme viable. This would include:
  - Refinement of the technical design
  - Exploration of options to reduce net capital costs borne by the scheme
  - Exploration of options to increase revenue, such as private wire supply
- Investigation of options for the expansion of the Bath Western Riverside network to serve Bath Press and Roseberry Place to allow B&NES to act as a facilitator for the private sector to make the decision of whether to develop the scheme.

These will be taken forward in Phase 2.

Appendix A Consumer review

Table 9—1 Potential consumer review details

Ref.	Name	Status	Building Type	Owner/ Developer	Space heating type	Hot water system	Age of plant / year of connection	Demand benchmarking notes	Contact details	Floor area (m^2)	Resi. units	Annual space heating (MWh)	Annual hot water (MWh)	Total heat demand (MWh)	Peak heat load (kW)	Annual elec. load (MWh)	Peak elec. load (kW
B001	City of Bath College existing buildings	Existing	Education	City of Bath College	Central boilers in energy centre	Central boilers in energy centre		Main campus building excluding the forge, pro rated from energy centre gas data	Leon Hosaka			1,629	407	2,036			
B002	Allen building	Proposed	Office	City of Bath College				To be sold off as either residential or office	Leon Hosaka			26	6	45	59		
B003	John Wood Court	Existing	Student residence	University of Bath	Combi boilers in each flat (48no.)	Combi boilers in each flat (48no.)	2 years	176 student bedrooms with communal bathrooms (Metered data from Uni.)	Peter Phelps								
B004	John Wood Building	Existing	Student residence	University of Bath	Central gas boilers (4no.)	Calorifiers off main boilers	5 years	Metered data from Uni. Peak load assumed from annual data and other UoB buildings	Peter Phelps			70	163	233	215		
B005	Southgate	Existing	Retail	Lendlease													
B006	Somerset Hall	Existing	Office					2010 AECOM report – SWHM. Now for sale						373			
B007	SACO Apartments	Existing	Serviced apartments	SACO	Electric panel heaters	Electric		2010 AECOM report - SWHM						351			
B008	40 Southgate Street	Existing	Retail/F&B					Several tenanted units. (2010 AECOM report - SWHM)						324			
B009	Forum	Existing	Arts	Bath Christian Trust				Metered gas data				177	44	221			
B010	St Johns Hospital	Existing	Residential	The Hospital of St John the Baptist				Sheltered housing, currently in the process of modernisation. (NHM data)	Steve Harrup			720	180	586			
B011	Kingsmead Leisure Complex	Existing	Mixed use					Gym, restaurants, hotel, cinema (2010 AECOM report - SWHM)						888			
B012	Plymouth House	Existing	Office					To let. Access constrained by vaults. (2010 AECOM report - SWHM)						494			
B013	Westpoint Bath	Existing	Office					2010 AECOM report - SWHM		2,100				469			
B014	Carpenter House	Existing	Student residence	University of Bath	Central gas boilers	Calorifiers off main boilers	20+ years	133 student bedrooms with communal bathrooms. Metered data from Uni. (4no. 100kW boilers)	Peter Phelps						400		
B015	Innovation Centre - office	Existing	Office	University of Bath	Central gas boilers	Calorifiers off main boilers	20+ years	Metered data from Uni. (office reaction assumed based on 131 flats). Part of Carpenter House	Peter Phelps			146	35	181			
B016	Innovation Centre - student	Existing	Student residence	University of Bath	Central gas boilers	Calorifiers off main boilers	20+ years	Metered data from Uni. (office reaction assumed based on 131 flats). Part of Carpenter House	Peter Phelps			82	190	272			
B017	Quay House	Existing	Office					Mechanically ventilated. Tenant is Future Publishing. VOA floor area and CIBSE good practice benchmarks	Robert Dark			231	56	287			
B018	Quasar Building	Existing	Student residence						J Aland Lettings								
B019	Thermae Bath Spa	Existing	Spa	Thermae Bath Spa				DEC database 2010 actual consumption, 20% demand reduction assumed. (225kWe CHP so 320kWth and assumed to meet 20% of peak load)	Mike Davis – Technical Manager			659	2,442	3,101	1600		
B020	Gainsborough Hotel	Under constructi on	Hotel	YTL													
B021	Kingsmead House Hotel	Under constructi on	Hotel	Apex Hotels				180 bedroom hotel and conference centre									

Ref.	Name	Status	Building Type	Owner/ Developer	Space heating type	Hot water system	Age of plant / year of connection	Demand benchmarking notes	Contact details	Floor area (m^2)	Resi. units	Annual space heating (MWh)	Annual hot water (MWh)	Total heat demand (MWh)	Peak heat load (kW)	Annual elec. load (MWh)	Peak elec. load (kW
B022	1-3 James Street West	Proposed	Student residence	IJSW Ltd				115 bedrooms in 21 flats			21	34	69	102	123		
B023	James Street West Student Residences	Proposed	Student residence	The Johnsons Group Ltd				169 bedrooms in flats									
B024	Green Park House	Under constructi on	Student residence	Bath Spa University	Electric	Electric		461 bed rooms - completion in summer 2016. DH connection not possible. Private wire may be possible.	Julian Greaves								
B025	North Quay Block 1	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		15,125		363	88	450	983	766	719
B026	North Quay Block 2	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		8,404		530	231	761	546	765	573
B027	North Quay Block 3	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		4,628		96	23	119	301	328	277
B028	North Quay Block 3	Proposed	Hotel		New TBC	New TBC	N/A	BH benchmarks		3,776		434	208	642	378	65	109
B029	North Quay Block 4	Proposed	A3		New TBC	New TBC	N/A	BH benchmarks		314		44	35	79	176	121	193
B030	North Quay Block 5	Proposed	Residential		New TBC	New TBC	N/A	BH benchmarks		3,884	64	78	117	194	233	122	194
B031	North Quay Block 6	Proposed	Residential		New TBC	New TBC	N/A	BH benchmarks		4,520	75	90	136	226	258	122	194
B032	South Quay Block 1	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks, FCB masterplan floor areas		6,785		244	91	336	441	435	427
B033	South Quay Block 2	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks, FCB masterplan floor areas		4,667		135	33	168	303	303	257
B034	South Quay Block 3	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks, FCB masterplan floor areas		8,985		326	66	392	584	613	519
B035	South Bank New Building A	Proposed	Residential		New TBC	New TBC	N/A	BH benchmarks		3,406	49	134	146	281	209	128	228
B036	South Bank New Building B	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		2,642		77	18	95	172	172	145
B037	South Bank New Building C	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		2,305		67	16	83	150	150	127
B038	South Bank New Building D	Proposed	Residential		New TBC	New TBC	N/A	BH benchmarks		2,839	41	106	118	224	174	106	183
B039	South Bank New Building E	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		2,676		78	19	96	174	174	147
B040	South Bank New Building F	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		3,573		104	25	129	232	232	197
B041	South Bank New Building H	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		4,719		137	33	170	307	307	260
B042	South Bank New Building J	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		3,252		94	23	117	211	211	179
B043	Green Park West Building 1	Proposed	Residential		New TBC	New TBC	N/A	BH benchmarks		19,844				1,028	995	764	1,156
B044	Green Park West Building 2	Proposed	Residential		New TBC	New TBC	N/A	BH benchmarks		23,067				1,104	1,143	877	1,267
B045	Green Park West Building 3	Proposed	Retail and library		New TBC	New TBC	N/A	BH benchmarks		12,383				310	557	726	1,417
B046	Green Park West Building 4	Proposed	Retail		New TBC	New TBC	N/A	BH benchmarks		27,735				693	1,248	1,941	4,438
B047	Green Park West Building 5	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		4,767				172	310	310	262
B048	Green Park East Building 1	Proposed	Residential		New TBC	New TBC	N/A	BH benchmarks		8,918				446	446	312	401
B049	Green Park East Building 2	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		5,054				163	329	337	455
B050	Green Park East Building 3	Proposed	Office		New TBC	New TBC	N/A	BH benchmarks		10,258				353	667	674	718
B051	Pinesgate East Offices	Proposed	Office	Pinesgate Investment Company				Refused planning permission. BANES gas metering		16,000							

Ref.	Name	Status	Building Type	Owner/ Developer	Space heating type	Hot water system	Age of plant / year of connection	Demand benchmarking notes	Contact details	Floor area (m^2)	Resi. units	Annual space heating (MWh)	Annual hot water (MWh)	Total heat demand (MWh)	Peak heat load (kW)	Annual elec. load (MWh)	Peak elec. load (kW
B052	Oldfield Park Infant School	Existing	Education	B&NES								82	20	102			
B053	Funky Monkey Studio	Existing	Sports					2010 AECOM report - SWHM						930			
B054	St James House	Existing	Office					2010 AECOM report - SWHM						233			
B055	Thornbank Gardens	Existing	Student residence	University of Bath	Boilers per 8-10 person flat (26no. In total)	Calorifiers off main boilers	3 years	217 bedroom post graduate accommodation	Peter Phelps								
B056	Bath Press (resi)	Proposed	Residential		New DH compatible	New DH compatible	N/A	AECOM Energy Statement & BH benchmarks		17,080	244	416	593	1,009	769	769	
B057	Roseberry Place	Proposed	Residential		New DH compatible	New DH compatible	N/A	BH benchmarks		14,000	200	414	402	816	630	630	
B058	Charlton Court	Existing	Student residence	Unite	Electric panel heaters	Central gas calorifier		316 bed student accommodation	James Tiernan, Unite		316		237	237			
B059	Waterside Court	Existing	Student residence	Unite	Electric panel heaters	Local electric		294 bed student accommodation	James Tiernan, Unite								
B060	Holiday Inn Express	Existing	Hotel	Holiday Inn				126 bedroom hotel									
B061	Site 1 - Crest DPA	Existing	Residential	Crest Nicholson	DH	DH	2015	Data from Crest floor area schedule and BH benchmarks	Neil Dawtrey	18,159	227	363	545	872	817	817	
B062	Site 1 - Crest	Existing	Residential	Crest Nicholson	DH	DH	2016	Data from Crest floor area schedule and BH benchmarks	Neil Dawtrey	34,645	433	693	1,039	1647	1,559	1,559	
B063	Site 2 - Wessex Water	Proposed	Residential	Crest Nicholson	New DH compatible	New DH compatible	2019	Data from Crest floor area schedule and BH benchmarks	Neil Dawtrey	7,858	98	157	236	362	354	354	
B064	Site 3 - Gas Works Second Site	Proposed	Residential	Crest Nicholson	New DH compatible	New DH compatible	2025	Data from Crest floor area schedule and BH benchmarks	Neil Dawtrey	64,402	805	1,288	1,932	3064	2,898	2,898	
B065	Site 4 - Kingsmead (Stewart) & Hills (S & P Hse)	Proposed	Mixed Use	Crest Nicholson	New DH compatible	New DH compatible	2025	Data from Crest floor area schedule and BH benchmarks	Neil Dawtrey	5,772	72	129	117	246	248	248	
B066	Site 5 - Stones/Cuff	Proposed	Student	Crest Nicholson	New DH compatible	New DH compatible	2025	Data from Crest floor area schedule and BH benchmarks	Neil Dawtrey	9,055	226	181	371	412	550	550	
B067	Site 6 - Council Depot	Proposed	Residential	Crest Nicholson	New DH compatible	New DH compatible	2026	Data from Crest floor area schedule and BH benchmarks	Neil Dawtrey	11,720	147	234	352	552	527	527	
B068	BWR heat export		Bulk supply					20% assumption of total site 3-6 demand. Used tocover baseload and supply 10% total energy savigns of new build				367	554	855			

Appendix B Stakeholder Engagement Record

Table 9—2 Stakeholder list and engagement record

Stakeholder	Description	Key contact	Consultation held	Comments	Next steps in engagement of stakeholders
Crest Nicholson	Developer for Bath Western Riverside site	Neil Dawtrey	Teleconference 14/05/15 Email	Crest Nicholson have been carrying out a high level review of the energy strategy for BWR to establish if district heating is still the correct strategy for Phase 2. No decision has been made but district heating remains the base strategy as residents are generally happy with the operation (although some find it expensive). There is a requirement for onsite renewable energy to meet 10% of the development's energy demand and for all homes to achieve CfSH Level 4. Additional renewable energy provision will be needed to meet the targets for the entire site. 350 homes are currently built, with the balance of Phase 1 adding a further 790 homes. Phase 2 will start construction in 2016.	Arrange meeting between E.ON, Bath Press and Roseberry Place developers and Crest Nicholson to discuss district heating opportunities
E.ON Community Energy	ESCo. Incumbent operator for Bath Western Riverside heat network.	Kate Jenkins – Key Account Manager	Meeting 15/05/15 Email	E.ON are the incumbent ESCo for BWR with a that concession runs until 2036. E.ON Community Energy operate both a Design and Build contractor and an Energy Services Company. For BWR E.ON constructed the energy centre, heat network and building HIUs with the capital cost paid for by Crest Nicholson. E.ON then pay Crest Nicholson for each customer that connects to the scheme. Crest Nicholson own the energy centre building. E.ON are interested in potentially expanding their operations to serve adjacent new development although it would require discussion with Crest Nicholson as utility constraints on Midland Road would necessitate routing pipes through their land. There is only sufficient space in the energy centre to serve BWR and the existing pipework has no spare capacity. Adjacent developments would have to be served by a new transmission main and either an extension to the existing energy centre or a separate new energy centre.	Establish appetite for supplying Bath Press and Roseberry Place Arrange meeting between E.ON, Bath Press and Roseberry Place developers and Crest Nicholson to discuss district heating opportunities
City of Bath College	Public sector landowner adjacent to North Quay site with existing campus. Currently masterplanning redevelopment of campus, potentially with new buildings.	Matt Atkinson - Principal	Meeting with facilities team – 22/04/15 Meeting with principal – 20/05/15	City of Bath College has an existing energy centre with gas boiler (8-9 years old that serves a number of their buildings). The building on site are: • MAPA Building, Herschel Building and Macaulay Building – served with heat from energy centre. • The Forge – served by local gas burners in AHUs. May be refurbished as part of masterplan. • Roper Building – new building completed in 2012. Systems are not compatible with district heating. • Allen Building – served by gas boiler separate to energy centre. May be sold and redeveloped as part of the masterplan (likely office or residential use). The College are open to the concept of connecting to a district heating network and the potential use of their existing energy centre building to house new plant (although they would be concerned about constraints on the future development of the site). They currently buy their energy through a consortium. The updated estates strategy is being presented to the College board in July and this will make recommendations about any land sales and redevelopment.	Review updated estates strategy Discuss potential for private wire electricity connection as well as district heating
Thermae Bath Spa	Spa building with a number of bathing pools supplied with hot spring water by B&NES. Freehold for site is owned by B&NES with leasehold by the operator.	Mike Davis – Technical Manager	Meeting 19/05/15	The building has a significant heat load due to the number of bathing pools. There is an existing CHP unit with a capacity of approximately 225kW. The plant within the building is approximately 10 years old. There are vaults in the streets surrounding the building, which are not owned by Thermae Bath Spa. These vaults are used to supply hot spring water so B&NES have access to them. The organisation is potentially interested in connected to a district heating network if it offers costs savings over the current situation. An energy efficiency study was carried out in 2013 but none of the measures have been implemented yet. Due to the final construction works of the adjacent Gainsborough Hotel by the same organisation, the Technical Manager was not able to supply detailed information on the building's plant.	Get up to date information on plant capacities and energy consumption
University of Bath	Main university within Bath. Main campus is located outside of the city centre but they own a number of buildings within the study area.	Peter Phelps - Energy and Environment Manager	Email	The University owns five buildings within the study area: • Manvers Street ex Police Station – used as office type space - served by 2no. 15 years old boilers • Carpenter House/Innovation Centre – used as student residences and office type space – served by 4no. 20 years old boilers • John Wood Court – used as student accommodation – 48no. 2 years old combi boilers (one per flat) • John Wood Building – used as student accommodation and education space – served by 4no. 5 years old gas boilers • Thornbank Gardens – used as student accommodation – served by 26no. 3 years old boilers (one per flat) The University is open to the idea of district heating connections to their buildings but a number of buildings are on long term leases so the commercial elements of connection may be complicated.	Establish lease issues with key buildings Review plant room locations in key buildings Discuss potential for private wire electricity connection as well as district heating

Stakeholder	Description	Key contact	Consultation held	Comments	Next steps in engagement of stakeholders
Bath Spa University	Main campus is located outside of Bath near Newton St Loe but they own a student residence building that is currently under construction within the study area.	Julian Greaves – Sustainability Manager	Email	Green Park House student residence is currently under construction by Berkley Homes and has been bought by Bath Spa University. The student residence has all electric heating and hot water and so is not suitable to connection to a district heating system. Julian Greaves has indicated that Bath Spa would be open to discussions regarding a private wire connection to the building.	Discuss potential for private wire electricity connection to Green Park House
Future Publishing	Occupy Quay house adjacent to North Quay site.	Robert Dark – Facilities Manager	No response to attempts to contact	The office building has a floor area of approximately 3,500m^2. It was initially constructed in the 1970s and extensively refurbished in the 2000s.	Make further attempts to contact
The Forum	Entertainment and conference venue adjacent to North Quay site.	Peter Wells – Facilities Manager	Meeting 20/05/15	The building has a number of different pieces of plant for providing heating and hot water. The main boiler serves the auditorium, other systems are unlikely to be viable to connect. The peak loads on this boiler are in the afternoon and evening. The Forum are open to the idea of connecting to a district heating network.	Continued engagement
Western Power Distribution	Local electricity district network operator	Michael Kaveney – High Voltage Design Engineer	Telephone – 16/04/15 Email	Discussion on substations and cabling (locations and capacity – details confidential). Capacity for gas CHP generation and heat pump steady state operation. Heat pump start up current may need some consideration but no show stoppers. Western Power happy to meet for further discussions once project reaches detailed design stage.	Contact regarding cost of connection
Wales and West Utilities	Local gas network operator	-	None at this stage	Local gas network operator	Contact regarding gas supply capacity
Rivers and Canals Trust	Charitable trust with responsibility for waterways in England and Wales, including parts of the Avon.		None at this stage	RCT has responsibility for the Avon towpaths and the northern half of the River Avon. Likely to impose capital and revenue costs on the scheme if a River Source Heat Pump option is used.	Engage through River Avon Working Group
Environment Agency	Non-departmental public body responsibility for flood protection of Bath and parts of the River Avon.		None at this stage	The EA has responsibility for flood protection of Bath. They may be against a River Source Heat Pump option on these grounds due to requirement to place obstructions in the river channel. Also, responsible for the southern half of the River Avon and likely to be less commercial regarding permissions than the Rivers and Canals Trust.	Engage through River Avon Working Group
St John's Hospital	Almshouse in a number of buildings, some listed, to the North of North Quay.	Steve Harrup – Building Supervisor	Meeting 22/04/15 Email	Charity offers sheltered accommodation for the elderly. Potential interest in connecting if it provides cost savings. Also concerned about heating resilience. Occupies six buildings all of which have Grade 1 or Grade 2 Listed elements. Four buildings have separate boiler plant and two buildings share a boiler. All space heating and majority of hot water is provided by boilers. All but one building is served by radiators, Combe Park is served by underfloor heating. One boiler is over 20 years old. Two were installed in the early 2000s and three were installed in 2011.	Gather further data on heat energy consumption
Future Enterprise Area developers	Developers for Enterprise Area sites	N/A	-	Primary motivation for connection to a district heating network will be meeting Policy CP4 when in the District Heating Priority Area and assisting compliance with Part L/BREEAM requirements (where applicable).	Engage through planning process
Bath and West Community Energy	Community Benefit Society set up to deliver community owned renewable energy, energy efficiency and energy supply projects.	Peter Capener	None specifically regarding district heating	Strong relationship with Council through Wilmington Solar Farm project, in which the Council invested. Potential involvement with DH systems through part community ownership/funding.	Engage if community governance is deemed viable
Southgate	Shopping centre operator with approximately 50 retail units and 100 homes.	Nigel Poulsom	Meeting – 22/05/15	Development heating and cooling is provided with tenant fitted-out systems, which are generally reversible heat pumps. All public realm areas with the development with the exception of Southgate Street and the areas outside of the colonnades on Dorchester Street are privately owned. It was the opinion of Nigel Poulsom that Southgate would not allow district heating pipes to run through their site due to the finish build up and the basement car park beneath the site.	No further action needed
Curo	Primary social housing provider in Bath	Richard Horn	Email	No large scale housing sites within study area. Information regarding sites has been request but not received.	Keep informed of project development

Appendix C Technical assumptions

Table 9—3 Technical assumptions

Input	Unit	Value	Reference
Gas boiler efficiency	%	85%	Project team assumption
Biomass boiler efficiency	%	80%	Project team assumption
Water source heat pump efficiency	%	310%	Manufacturer information for heat pump. Project team assumption for river extraction pump efficiency.
CHP efficiency	Varies		Manufacturer data. Depends on size of CHP selected.
Energy centre electrical parasitic load	% of heat production	2%	CIBSE Heat Networks Code of Practice for the UK 2015
DH apartment building in building losses	% of building demand	22%	Project team assumption
DH in ground network losses	% of network demand	7%	Project team assumption
PV output for counterfactual CO_2 emissions saving costs	$kWh/m^2/year$	150	Project team assumption

Table 9—4 CO_2 emission factor assumptions

Input	Unit	Value	Reference
Gas	$tonneCO_2/MWh$	0.216	Part L of the Building Regulations 2013
Biomass	$tonneCO_2/MWh$	0.031	Part L of the Building Regulations 2013
Electricity imported from grid 2015	$tonneCO_2/MWh$	0.519	Part L of the Building Regulations 2013
Electricity displaced from grid 2015	$tonneCO_2/MWh$	0.519	Part L of the Building Regulations 2013
Electricity imported from grid 2030	$tonneCO_2/MWh$	0.109	DECC projection
Electricity displaced from grid 2030	$tonneCO_2/MWh$	0.109	DECC projection

Table 9—5 Technology sizing design criteria

Technology	Sizing design criteria
Gas CHP	Over 5,000 run hours per year
Heat pumps	Capable of meeting over 80% of the annual heat demand
Biomass	Capable of meeting over 80% of the annual heat demand

Appendix D Commercial assumptions and disclaimer

Table 9—6 Commercial assumptions

Input	Unit	Value	Reference
Heat sale revenues			
Variable - resi	£/MWh	56.8	Assessment of the Costs, Performance, and Characteristics of UK Heat Networks (DECC 2015)
Variable - non-resi	£/MWh	39.0	DECC Quarterly Energy Prices 2014 average for small consumer. Assumes 85% efficient boiler.
Fixed - resi	£/kW/year	7.7	Assessment of the Costs, Performance, and Characteristics of UK Heat Networks (DECC 2015)
Fixed - non resi	£/kW/year	10	Boiler replacement - £60kW every 15 years. O&M cost of 6/kW/year.
Electricity sale revenues			
Grid spill average	£/MWh	50	Base case assumes all grid spill
Private wire average	£/MWh	90	Assumes 10% discount on current B&NES price to make connection attractive
Connection charges			
New build boiler avoided cost	£/kW	60	Applies to new buildings only
Low carbon technology avoided cost	£/MWh of heat supplied	140	Applies to new buildings only Based on PV to achieve a 25% CO_2 saving over a gas boiler heat supply with a 30% discount on cost to make district heating more attractive
Value of plant room space saved	£/kW	70	Applies to new buildings only Applies to offices, residential and hotels only, i.e. where there is a benefit in increase in lettable/saleable space
Operational & maintenance costs			
Fuel cost - gas at energy centre	£/MWh	25	B&NES current gas cost lower bound
Fuel cost - electricity (for pumping energy)	£/MWh	99.8	B&NES Email 25/03/15 Average Estate Electricity Price
Biomass fuel cost	£/MWh	31	Woodchip: http://www.biomassenergycentre.org.uk/
Plant replacement fund	%	70%	% of energy centre capex that will need replacing within below period
Plant lifetime	years	20	Replacement period for energy centre capex
Staff costs	£/MWh	5.2	BH experience from previous DH projects
Business rates	£/MWh	6	Assessment of the Costs, Performance, and Characteristics of UK Heat Networks (DECC 2015)
Insurance costs	£/kW/year	1.7	Based upon baseload plant size Electricity Generation Cost Model - 2011 Update (DECC) – for CHP
Heat network maintenance cost	£/MWh	0.6	Assessment of the Costs, Performance, and Characteristics of UK Heat Networks (DECC 2015)
HIUs maintenance cost	£/MW/year	8.2	Assessment of the Costs, Performance, and Characteristics of UK Heat Networks (DECC 2015)
Heat meter maintenance cost	£/MWh	3.4	Assessment of the Costs, Performance, and Characteristics of UK Heat Networks (DECC 2015)
Baseload plant OPEX	£/MWh	8 to 13	Supplier data. Depends on unit size.
Other energy centre O&M costs	1% of total energy centre CAPEX per year		Previous BH DH project experience
Funding assumptions			
Model lifetime	Years	25	
Discount rate	%	3.5%	HM Treasury Green Book
Gas price indexing	Not indexed		
Heat sales	Not indexed		
Electricity sales	Not indexed		
Electricity purchase	Not indexed		
Funding streams and charges			
ECO/ STOR / TRIAD / CPS		n/a	Excluded from simplified modelling,
Biomass RHI Tier 1	£/MWh	51.8	
Biomass RHI Tier 2	£/MWh	22.4	

Input	Unit	Value	Reference
Water Source Heat Pump RHI Tier 1	£/MWh	88.4	
Water Source Heat Pump RHI Tier 2	£/MWh	26.4	
RHI Lifetime	years	20	

Appendix E Capital cost schedules

The capital cost for each option are presented on the following pages. The costs are based on the following assumptions and exclusions:

- It has been assumed that the energy centre building is delivered as part of the construction of the Enterprise Area development sites (e.g. in a basement). Energy centre building costs are for fit-out only.
- Costs are at 2015 levels and no allowance has been made for inflation.
- Design, planning and project development costs (including legal costs) are excluded.
- Land purchase is excluded.
- Land purchase costs are excluded.
- Road closures and traffic management costs are excluded.
- Extraction licence costs are excluded.

Lower Bristol Road costing CHP scheme Energy Centre		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Enabling works	Prepare site	50,000		1 no.	n/a	£ 50,000	*Allowance*
Natural gas boilers	Natural gas boilers incl. gas train	30	£/kW	3 no.	1,200	£ 108,000	*Spons*
	Installation + pressurisation unit	5,000	each	2 no.		£ 10,000	*Allowance*
Flues	600 mm diameter flue + Bends and connections	25,000	each	4 no.		£ 100,000	*Quote from Airtherm*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	3 no.		£ 15,000	*Spons*
	Main pumps - variable speed controlled pumps N+1 operation: 25kg/s @ 420kPa including valves and controls	5,000	each	2 no.		£ 10,000	*Spons+ Electrical work*
	Low flow pumps - variable speed controlled pumps N+1 operation: 7kg/s @ 420kPa including valves and controls	3,500	each	2 no.		£ 7,000	*Spons*
	Thermal store shunt pumps	8,000	each	1 no.		£ 8,000	*Allowance*
Biomass boiler	Biomass boilers including fuel storage hopper	350	£/kW	2 no.	300	£ 210,000	*Spons*
	Engine controls and ancillaries	15,000	each	2 no.		£ 30,000	*Allowance*
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	75	£ 112,500	*Quote from McDonald Engineers*
Water treatment	Water dosing	10,000	each	1 no.		£ 10,000	*Allowance*
Dirt Separator	100mm diameter	4,000	each	1 no.		£ 4,000	*Spons(doubled- industry quote £18.5k)*
Deaerator	100mm diameter	2,500	each	1 no.		£ 2,500	*Spons*
Balance of plant	Mechanical Installations; including Public health	150,000	each	1 no.		£ 150,000	*Allowance*
Expansion/Pressurisation	Twin-pressurisation pumps and spill unit	40,000	each	1 no.		£ 40,000	*Quote from Spirotech*
Utility connections	Gas	30,000	each	2 no.		£ 60,000	*Allowance*
	Sewer	15,000	each	1 no.		£ 15,000	*Allowance*
	Electrical connection including incoming LV connection	25,000	each	1 no.		£ 25,000	*Allowance*
Energy centre substation	Transformer	15,000	each	1 no.		£ 15,000	*Allowance*
	HV switchgear	15,000	each	1 no.		£ 15,000	*Allowance*
Controls		50,000	each	1 no.		£ 50,000	*Allowance*
Energy centre fit-out and finishes	Energy Centre fitout	350	£/m^2	1 no.	500	£ 175,000	*Allowance*
Testing and commissioning		2.0%	%			£ 24,440	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 213,850	
TOTAL CAPEX						**£ 1,460,290**	
Exclusions	*Plantroom modifications, purpose built plantroom assumed built*						
TOTAL ENERGY CENTRE CAPEX						**£ 1,460,290**	

Network and Connection Included: Pipe, Trenching, Connections		Rate £/unit	Unit	m		Subtotal	Refernece
Lower Bristol Road	Network costs					£ 950,738	*BH project quote averages for installed DH pipe*
	Connection costs					£ 124,392	*Spons*
Testing and commissioning		2.0%	%			£ 21,503	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 295,661	
TOTAL NETWORK CAPEX						**£ 1,392,294**	
Exclusions	*Utilities clashes in trenches and movement of existing routes*						
	Any trenching in public highways, soft landscaping assumed for all trenching. No						
Notes	Including buiding connections, PXE and pumps. Excluding buidling system alterations						

TOTAL PLANT AND NETWORK CAPEX	**£ 2,852,584**

Lower Bristol Road costing HP scheme Energy Centre		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Enabling works	Prepare site	50,000		1 no.	n/a	£ 50,000	*Allowance*
Natural gas boilers	Natural gas boilers incl. gas train	30	£/kW	3 no.	1,200	£ 108,000	*Spons*
	Installation + pressurisation unit	5,000	each	2 no.		£ 10,000	*Allowance*
Flues	600 mm diameter flue + Bends and connections	25,000	each	2 no.		£ 50,000	*Quote from Airtherm*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	3 no.		£ 15,000	*Spons*
	Main pumps - variable speed controlled pumps N+1 operation: 25kg/s @ 420kPa including valves and controls	5,000	each	2 no.		£ 10,000	*Spons+ Electrical work*
	Low flow pumps - variable speed controlled pumps N+1 operation: 7kg/s @ 420kPa including valves and controls	3,500	each	2 no.		£ 7,000	*Spons*
	Thermal store shunt pumps	8,000	each	1 no.		£ 8,000	*Allowance*
Heat Pumps	Star 500kW Heat Pump package + acoustic attenuation package	400,000	each	1 no.		£ 400,000	*Star HeatPumps Quote*
	Abstraction pump 70l/s @ 250kPa	5,000	each	2 no.		£ 10,000	
	Intake/Discharge chamber	10,000	each	2 no.		£ 20,000	
	Connection pipework	500	£/m	1 no.	60	£ 30,000	
	Filter	10,000	each	1 no.		£ 10,000	
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	20	£ 30,000	*Quote from McDonald Engineers*
Water treatment	Water dosing	10,000	each	1 no.		£ 10,000	*Allowance*
Dirt Separator	100mm diameter	4,000	each	1 no.		£ 4,000	*Spons(doubled- industry quote £18.5k)*
Deaerator	100mm diameter	2,500	each	1 no.		£ 2,500	*Spons*
Balance of plant	Mechanical Installations; including Public health	150,000	each	1 no.		£ 150,000	*Allowance*
Expansion/Pressurisation	Twin-pressurisation pumps and spill unit	40,000	each	1 no.		£ 40,000	*Quote from Spirotech*
Utility connections	Gas	30,000	each	2 no.		£ 60,000	*Allowance*
	Sewer	15,000	each	1 no.		£ 15,000	*Allowance*
	Electrical connection including incoming LV connection	25,000	each	1 no.		£ 25,000	*Allowance*
Energy centre substation	Transformer	20,000	each	1 no.		£ 20,000	*Allowance*
	HV switchgear	15,000	each	1 no.		£ 15,000	*Allowance*
Controls		50,000	each	1 no.		£ 50,000	*Allowance*
Energy centre fit-out and finishes	Energy Centre fitout	350	£/m^2	1 no.	500	£ 175,000	*Allowance*
Testing and commissioning		2.0%	%			£ 26,490	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 231,788	
TOTAL CAPEX						**£ 1,582,778**	
Exclusions	*Plantroom modifications, purpose built plantroom assumed built*						
TOTAL ENERGY CENTRE CAPEX						**£ 1,582,778**	

Network and Connection Included: Pipe, Trenching, Connections		Rate £/unit	Unit	m		Subtotal	Refernece
Lower Bristol Road	Network costs					£ 950,738	*BH project quote averages for installed DH pipe*
	Connection costs					£ 124,392	*Spons*
Testing and commissioning		2.0%	%			£ 21,503	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 295,661	
TOTAL NETWORK CAPEX						**£ 1,392,294**	
Exclusions	*Utilities clashes in trenches and movement of existing routes*						
	Any trenching in public highways, soft landscaping assumed for all trenching. No						
Notes	Including buiding connections, PXE and pumps. Excluding buidling system alterations						

TOTAL PLANT AND NETWORK CAPEX **£ 2,975,071**

North Quay costing CHP scheme Energy Centre		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Enabling works	Prepare site	50,000		1 no.	n/a	£ 50,000	*Allowance*
Natural gas boilers	Natural gas boilers incl. gas train	30	£/kW	3 no.	2,000	£ 180,000	*Spons*
	Installation + pressurisation unit	5,000	each	2 no.		£ 10,000	*Allowance*
Flues	600 mm diameter flue + Bends and connections	25,000	each	4 no.		£ 100,000	*Quote from Airtherm*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	3 no.		£ 15,000	*Spons*
	Main pumps - variable speed controlled pumps N+1 operation: 40kg/s @ 310kPa including valves and controls	7,500	each	2 no.		£ 15,000	*Spons+ Electrical work*
	Low flow pumps - variable speed controlled pumps N+1 operation: 14.5kg/s @ 310kPa including valves and controls	4,000	each	2 no.		£ 8,000	*Spons*
	Thermal store shunt pumps	10,000	each	1 no.		£ 10,000	*Allowance*
Gas engines	Gas Engine 1 - 800 kWe TCG 2016 V16 Edina engine. incl engine cell	460,000	each	1 no.		£ 460,000	*Edina range*
	Engine controls and ancillaries	25,000	each	1 no.		£ 25,000	*Allowance*
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	100	£ 150,000	*Quote from McDonald Engineers*
Water treatment	Water dosing	10,000	each	1 no.		£ 10,000	*Allowance*
Dirt Separator	250mm diameter	10,000	each	1 no.		£ 10,000	*Spons(doubled- industry quote £18.5k)*
Deaerator	250mm diameter	6,000	each	1 no.		£ 6,000	*Spons*
Balance of plant	Mechanical Installations; including Public health	200,000	each	1 no.		£ 200,000	*Allowance*
Expansion/Pressurisation	Twin-pressurisation pumps and spill unit	60,000	each	1 no.		£ 60,000	*Quote from Spirotech*
Utility connections	Gas	30,000	each	2 no.		£ 60,000	*Allowance*
	Sewer	15,000	each	1 no.		£ 15,000	*Allowance*
	Electrical connection including 1.4MW export capability and 310kVA incoming LV	75,000	each	1 no.		£ 75,000	*Allowance*
Energy centre substation	Transformer 1600kVA,	54,000	each	1 no.		£ 54,000	*Spons*
	HV switchgear	30,000	each	1 no.		£ 30,000	*Spons*
Controls		50,000	each	1 no.		£ 50,000	*Allowance*
Energy centre fit-out and finishes	Energy Centre fitout	500	£/m^2	1 no.	500	£ 250,000	*Allowance*
Testing and commissioning		2.0%	%			£ 36,860	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 322,525	
TOTAL CAPEX						**£ 2,202,385**	
Exclusions							

North Quay Plus		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Flues	Main flue already installed - connection	5,000		1 no.		£ 5,000	*Allowance*
Natural gas boilers	Natural gas boilers incl. gas train	30	£/kW	1 no.	2,000	£ 60,000	*Spons*
	Installation + pressurisation unit	5,000		1 no.		£ 5,000	*Quote from Spirotech*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	1 no.		£ 5,000	*Allowance*
	Main pumps - variable speed controlled pumps N+1 operation: 40kg/s @ 75kPa including valves and controls	7,500	each	1 no.		£ 7,500	*Spons+ Electrical work*
Balance of plant and controls		5,000	each	1 no.		£ 5,000	*Allowance*
Testing and commissioning		2.0%	%			£ 1,750	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 15,313	
TOTAL CAPEX						**£ 104,563**	
Exclusions	*Plantroom modifications, purpose built plantroom assumed built*						

North Quay costing CHP scheme							
North Quay Plus Plus		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Gas engines	Gas Engine 2 - 600 kWe Edina TCG 2016 V12	435,000	each	1 no.		£ 435,000	*Edina quote*
	Engine controls and ancillaries	25,000	each	1 no.		£ 25,000	*Allowance*
Flues	Main flue already installed - connection	10,000		1 no.		£ 10,000	*Allowance*
Natural gas boilers	Natural gas boilers incl. gas train	30	2,000	1 no.	n/a	£ 60,000	*Spons*
	Installation + pressurisation unit	5,000		1 no.		£ 5,000	*Allowance*
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	75	£ 112,500	*Quote from McDonald Engineers*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	1 no.		£ 5,000	*Allowance*
	Main pumps - variable speed controlled pumps N+1 operation: 70kg/s @ 75kPa including valves and controls	7,500	each	1 no.		£ 7,500	*Spons+ Electrical work*
Balance of plant and controls		5,000	each	1 no.		£ 5,000	*Allowance*
Testing and commissioning		2.0%	%			£ 13,300	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 116,375	
TOTAL CAPEX						**£ 794,675**	
Exclusions	*Plantroom modifications, purpose built plantroom assumed built*						
TOTAL ENERGY CENTRE CAPEX						**£ 3,101,623**	

Network and Connection Included: Pipe, Trenching, Connections		Rate £/unit	Unit	m		Subtotal	Refernece
North Quay	Network costs					£ 563,143	*BH project quote averages for installed DH pipe*
	Connection costs					£ 147,078	*Spons*
Testing and commissioning		2.0%	%			£ 14,204	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 195,311	
SUBTOTAL CAPEX						**£ 919,737**	
North Quay Plus	Network costs					£ 405,591	*BH project quote averages for installed DH pipe*
	Connection costs					£ 65,389	*Spons*
Testing and commissioning		2.0%	%			£ 9,420	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 129,519	
SUBTOTAL CAPEX						**£ 609,919**	
North Quay Plus Plus	Network costs					£ 438,391	*BH project quote averages for installed DH pipe*
	Connection costs					£ 66,580	*Spons*
Testing and commissioning		2.0%	%			£ 10,099	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 138,867	
SUBTOTAL CAPEX						**£ 653,938**	
TOTAL NETWORK CAPEX						**£ 2,183,593**	
Exclusions	*Utilities clashes in trenches and movement of existing routes*						
	Any trenching in public highways, soft landscaping assumed for all trenching. No						
Notes	Including buiding connections, PXE and pumps. Excluding buidling system alterations						

North Quay costing CHP scheme

TOTAL PLANT AND NETWORK CAPEX	**£ 5,285,216**

Total Capex

	EC	Network	
North Quay	£ 2,202,385	£ 919,737	£ 3,122,122
North Quay Plus	£ 104,563	£ 609,919	£ 714,481
North Quay Plus Plus	£ 794,675	£ 653,938	£ 1,448,613
Total			£ 5,285,216

North Quay costing Heat Pump scheme **Energy Centre**		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Enabling works	Prepare site	50,000		1 no.	n/a	£ 50,000	*Allowance*
Natural gas boilers	Natural gas boilers incl. gas train	30	£/kW	3 no.	2,000	£ 180,000	*Spons*
	Installation + pressurisation unit	5,000	each	2 no.		£ 10,000	*Allowance*
Flues	600 mm diameter flue + Bends and connections	25,000	each	3 no.		£ 75,000	*Quote from Airtherm*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	3 no.		£ 15,000	*Spons+ Electrical work*
	Main pumps - variable speed controlled pumps N+1 operation: 40kg/s @ 310kPa including valves and controls	7,500	each	2 no.		£ 15,000	*Spons*
	Low flow pumps - variable speed controlled pumps N+1 operation: 14.5kg/s @ 310kPa including valves and controls	4,000	each	2 no.		£ 8,000	*Allowance*
	Thermal store shunt pumps	10,000	each	1 no.		£ 10,000	*allowance*
Heat Pumps	Star 600kW Heat Pump package + acoustic attenuation package	440,000	each	2 no.		£ 880,000	*Star HeatPumps Quote*
	Abstraction pump 70l/s @ 250kPa	5,000	each	4 no.		£ 20,000	
	Intake/Discharge chamber	10,000	each	2 no.		£ 20,000	
	Connection pipework	500	£/m	1 no.	120	£ 60,000	
	Filter	10,000	each	1 no.		£ 10,000	
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	20	£ 30,000	*Quote from McDonald Engineers*
Water treatment	Water dosing	10,000	each	1 no.		£ 10,000	*Allowance*
Dirt Separator	250mm diameter	10,000	each	1 no.		£ 10,000	*Spons(doubled- industry quote £18.5k)*
Deaerator	250mm diameter	6,000	each	1 no.		£ 6,000	*Spons*
Balance of plant	Mechanical Installations; including Public health	200,000	each	1 no.		£ 200,000	*Allowance*
Expansion/Pressurisation	Twin-pressurisation pumps and spill unit	60,000	each	1 no.		£ 60,000	*Quote from Spirotech*
Utility connections	Gas	30,000	each	2 no.		£ 60,000	*Allowance*
	Sewer	15,000	each	1 no.		£ 15,000	*Allowance*
	Electrical connection including uprating to serve 1.8MW of heat pumps	100,000	each	1 no.		£ 100,000	*Allowance*
Energy centre substation	Transformer 2500kVA,	65,000	each	1 no.		£ 65,000	*Spons*
	HV switchgear	30,000	each	1 no.		£ 30,000	*Spons*
Controls		50,000	each	1 no.		£ 50,000	*Allowance*
Energy centre fit-out and finishes	Energy Centre fitout	500		500 no.	m2	£ 250,000	*Allowance*
Testing and commissioning		2.0%	%			£ 44,780	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 391,825	
TOTAL CAPEX						**£ 2,675,605**	
Exclusions							

North Quay Plus		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Flues	Main flue already installed - connection	5,000		1 no.		£ 5,000	*allowance*
Natural gas boilers	Natural gas boilers - 2.0MW Cochran	30	£/kW	1 no.	2,000	£ 60,000	*Spons*
	Installation + pressurisation unit	5,000		1 no.		£ 5,000	*allowance*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	1 no.		£ 5,000	*allowance*
	Main pumps - variable speed controlled pumps N+1 operation: 70kg/s @ 75kPa including valves and controls	7,500	each	1 no.		£ 7,500	*Spons+ Electrical work*
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	10	£ 15,000	*Quote from McDonald Engineers*
Balance of plant and controls		5,000	each	1 no.		£ 5,000	*Allowance*
Testing and commissioning		2.0%	%			£ 2,050	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 17,938	

North Quay costing Heat Pump scheme				
TOTAL CAPEX			**£ 122,488**	

North Quay costing Heat Pump scheme							
Exclusions	*Plantroom modifications, purpose built plantroom assumed built*						
North Quay Plus Plus		**Rate £/unit**	**Unit**	**no.**	**size**	**Subtotal**	**Refernece**
Heat Pumps	Star 600kW Heat Pump package + acoustic attenuation package	440,000	each	1 no.		£ 440,000	*Star HeatPumps Quote*
	Abstraction pump 70l/s @ 250kPa		each	1 no.		£ -	
Flues	Main flue already installed - connection	10,000		1 no.		£ 10,000	*allowance*
Natural gas boilers	Natural gas boilers - 2.0MW Cochran	30	£/kW	1 no.	2,000	£ 60,000	*Spons*
	Installation + pressurisation unit	5,000		1 no.		£ 5,000	*allowance*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	1 no.		£ 5,000	*Spons*
	Main pumps - variable speed controlled pumps N+1 operation: 70kg/s @ 75kPa including valves and controls	7,500	each	1 no.		£ 7,500	*Spons+ Electrical work*
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	10	£ 15,000	*Quote from McDonald Engineers*
Balance of plant and controls		5,000	each	1 no.		£ 5,000	*Allowance*
Testing and commissioning		2.0%	%			£ 10,950	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 95,813	
TOTAL CAPEX						**£ 654,263**	
Exclusions	*Plantroom modifications, purpose built plantroom assumed built*						
TOTAL ENERGY CENTRE CAPEX						**£ 3,452,355**	

Network and Connection Included: Pipe, Trenching, Connections		Rate £/unit	Unit	m		Subtotal	Refernece
North Quay	Network costs					£ 563,143	*BH project quote averages for installed DH pipe*
	Connection costs - Substations within buildings					£ 147,078	*Spons*
Testing and commissioning		2.0%	%			£ 14,204	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 195,311	
SUBTOTAL CAPEX						**£ 919,737**	
North Quay Plus	Network costs					£ 405,591	*BH project quote averages for installed DH pipe*
	Connection costs					£ 65,389	*Spons*
Testing and commissioning		2.0%	%			£ 9,420	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 129,519	
SUBTOTAL CAPEX						**£ 609,919**	
North Quay Plus Plus	Network costs					£ 438,391	*BH project quote averages for installed DH pipe*
	Connection costs					£ 66,580	*Spons*
Testing and commissioning		2.0%	%			£ 10,099	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 138,867	
SUBTOTAL CAPEX						**£ 653,938**	
TOTAL NETWORK CAPEX						**£ 2,183,593**	

North Quay costing Heat Pump scheme			
Exclusions	*Utilities clashes in trenches and movement of existing routes*		
	Any trenching in public highways, soft landscaping assumed for all trenching. No		
Notes	Including buiding connections, PXE and pumps. Excluding buidling system		

TOTAL PLANT AND NETWORK CAPEX	**£ 5,635,948**

Total Capex

				EC	Network	
North Quay				£ 2,675,605	£ 919,737	£ 3,595,342
North Quay Plus				£ 122,488	£ 609,919	£ 732,406
North Quay Plus Plus				£ 654,263	£ 653,938	£ 1,308,200
Total						£ 5,635,948

South Bank costing CHP scheme Energy Centre		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Enabling works	Prepare site	50,000		1 no.	n/a	£ 50,000	*Allowance*
Natural gas boilers	Natural gas boilers incl. gas train	30	£/kW	3 no.	1,400	£ 126,000	*Spons*
	Installation + pressurisation unit	5,000	each	2 no.		£ 10,000	*Allowance*
Flues	600 mm diameter flue + Bends and connections	25,000	each	3 no.		£ 75,000	*Quote from Airtherm*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	3 no.		£ 15,000	*Spons*
	Main pumps - variable speed controlled pumps N+1 operation: 27kg/s @ 230kPa including valves and controls	5,000	each	3 no.		£ 15,000	*Spons+ Electrical work*
	Low flow pumps - variable speed controlled pumps N+1 operation: 8kg/s @ 230kPa including valves and controls	3,500	each	2 no.		£ 7,000	*Spons*
	Thermal store shunt pumps	8,000	each	1 no.		£ 8,000	*Allowance*
Gas engines	Gas Engine 1 - 250 kWe	280,000	each	1 no.		£ 280,000	*EnerG range*
	Engine controls and ancillaries	20,000	each	1 no.		£ 20,000	*Allowance*
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	36	£ 54,000	*Quote from McDonald Engineers*
Water treatment	Water dosing	10,000	each	1 no.		£ 10,000	*Allowance*
Dirt Separator	100mm diameter	4,000	each	1 no.		£ 4,000	*Spons(doubled- industry quote £18.5k)*
Deaerator	100mm diameter	2,500	each	1 no.		£ 2,500	*Spons*
Balance of plant	Mechanical Installations; including Public health	150,000	each	1 no.		£ 150,000	*Allowance*
Expansion/Pressurisation	Twin-pressurisation pumps and spill unit	40,000	each	1 no.		£ 40,000	*Quote from Spirotech*
Utility connections	Gas	30,000	each	2 no.		£ 60,000	*Allowance*
	Sewer	15,000	each	1 no.		£ 15,000	*Allowance*
	Electrical connection including 250kW export capability and incoming LV connecti	45,000	each	1 no.		£ 45,000	*Allowance*
Energy centre substation	Transformer 500kVA,	20,000	each	1 no.		£ 20,000	*Spons*
	HV switchgear	25,000	each	1 no.		£ 25,000	*Spons*
Controls		50,000	each	1 no.		£ 50,000	*Allowance*
Energy centre fit-out and finishes	Energy Centre fitout	250	£/m^2	1 no.	500	£ 125,000	*Allowance*
Testing and commissioning		2.0%	%			£ 24,130	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 211,138	
TOTAL CAPEX						**£ 1,441,768**	
Exclusions	*Plantroom modifications, purpose built plantroom assumed built*						

Network and Connection Included: Pipe, Trenching, Connections		Rate £/unit	Unit	m		Subtotal	Refernece
South Bank	Network costs					£ 535,451	*BH project quote averages for installed DH pipe*
	Connection costs					£ 155,457	*Spons*
Testing and commissioning		2.0%	%			£ 13,818	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 190,000	
TOTAL NETWORK CAPEX						**£ 894,725**	
Exclusions	*Utilities clashes in trenches and movement of existing routes*						
	Any trenching in public highways, soft landscaping assumed for all trenching. No						
Notes	Including buiding connections, PXE and pumps. Excluding buidling system alterations						

TOTAL PLANT AND NETWORK CAPEX	**£ 2,336,493**

South Quay costing HP scheme Energy Centre		Rate £/unit	Unit	no.	size	Subtotal	Refernece
Enabling works	Prepare site	50,000		1 no.	n/a	£ 50,000	*Allowance*
Natural gas boilers	Natural gas boilers incl. gas train	30	£/kW	3 no.	1,400	£ 126,000	*Spons*
	Installation + pressurisation unit	5,000	each	2 no.		£ 10,000	*Allowance*
Flues	600 mm diameter flue + Bends and connections	25,000	each	2 no.		£ 50,000	*Quote from Airtherm*
Pumps	Primary pump, per bolier & CHP 8.5l/s, 90kPa	5,000	each	3 no.		£ 15,000	*Spons*
	Main pumps - variable speed controlled pumps N+1 operation: 27kg/s @ 230kPa including valves and controls	5,000	each	3 no.		£ 15,000	*Spons+ Electrical work*
	Low flow pumps - variable speed controlled pumps N+1 operation: 8kg/s @ 230kPa including valves and controls	3,500	each	2 no.		£ 7,000	*Spons*
	Thermal store shunt pumps	8,000	each	1 no.		£ 8,000	*Allowance*
Heat Pumps	Star 500kW Heat Pump package + acoustic attenuation package	400,000	each	1 no.		£ 400,000	*Star HeatPumps Quote*
	Abstraction pump 70l/s @ 250kPa	5,000	each	2 no.		£ 10,000	
	Intake/Discharge chamber	10,000	each	2 no.		£ 20,000	
	Connection pipework	500	£/m	1 no.	60	£ 30,000	
	Filter	10,000	each	1 no.		£ 10,000	
Thermal store - heating	Thermal store - horizontal cylindrical, mild steel, un-pressurised	1,500	£/m^3	1 no.	20	£ 30,000	*Quote from McDonald Engineers*
Water treatment	Water dosing	10,000	each	1 no.		£ 10,000	*Allowance*
Dirt Separator	100mm diameter	4,000	each	1 no.		£ 4,000	*Spons(doubled- industry quote £18.5k)*
Deaerator	100mm diameter	2,500	each	1 no.		£ 2,500	*Spons*
Balance of plant	Mechanical Installations; including Public health	150,000	each	1 no.		£ 150,000	*Allowance*
Expansion/Pressurisation	Twin-pressurisation pumps and spill unit	40,000	each	1 no.		£ 40,000	*Quote from Spirotech*
Utility connections	Gas	30,000	each	2 no.		£ 60,000	*Allowance*
	Sewer	15,000	each	1 no.		£ 15,000	*Allowance*
	Electrical connection including 250kW export capability and incoming LV connectio	45,000	each	1 no.		£ 45,000	*Allowance*
Energy centre substation	Transformer 500kVA,	20,000	each	1 no.		£ 20,000	*Spons*
	HV switchgear	25,000	each	1 no.		£ 25,000	*Spons*
Controls		50,000	each	1 no.		£ 50,000	*Allowance*
Energy centre fit-out and finishes	Energy Centre fitout	250	£/m^2	1 no.	500	£ 125,000	*Allowance*
Testing and commissioning		2.0%	%			£ 26,550	
Engineering package prelims	Includes 10% contingency	17.5%	%			£ 232,313	
TOTAL CAPEX						**£ 1,586,363**	
Exclusions	*Plantroom modifications, purpose built plantroom assumed built*						

Network and Connection Included: Pipe, Trenching, Connections		Rate £/unit	Unit	m		Subtotal	Refernece
North Quay	Network costs					£ 535,451	*BH project quote averages for installed DH pipe*
	Connection costs					£ 155,457	*Spons*
Testing and commissioning		2.0%	%			£ 13,818	
Engineering package prelims	Includes 20% contingency	27.5%	%			£ 190,000	
TOTAL NETWORK CAPEX						**£ 894,725**	
Exclusions	*Utilities clashes in trenches and movement of existing routes*						
	Any trenching in public highways, soft landscaping assumed for all trenching. No						
Notes	Including buiding connections, PXE and pumps. Excluding buidling system alterations						

TOTAL PLANT AND NETWORK CAPEX	**£ 2,481,088**

Appendix F Low carbon energy supply matrix

Technology		Description	Site specific constraints	Typical scale	UK market maturity		CO_2 reduction		Capital costs		Funding & revenues		O&M		Planning & Environmental amenity		Land take		Community benefit		Overall assessment	
					B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D
Electricity (heating)	Water source heat pump	By leveraging ambient temperatures heat pumps are able to deliver very efficient electrical heating – typically three times more efficient than conventional electric resistive heaters. District scale heat pumps, especially air source, may require significant upgrades to the electricity grid because of the quantum of baseload electricity required.	Capacity of heat pump will be limited by environmental permitting for returning river water at higher temperatures. River modelling and discussions with Environment Agency required to determine scope. Proven technology in Europe (e.g. successful 15MW scheme in Drammen, Norway). Possibility of connecting to hot water springs for increased efficiency; current assumption that spring water capacity has been utilised. COP over 2.9 required to benefit from RHI.	>500kW																		
	Air source heat pumps		Lower efficiency than water source heat pump but more suited at a building level as do not require a site specific source. Reliant on the decarbonisation of the electricity grid. Large air source heat pumps (multi MW scale) have efficiencies up to a third higher than building scale heat pumps. Likely to require significant electricity grid reinforcement due to the high power demand. Space take low at building scale (but visual impact per unit), space comparable to gas CHP energy centre at district scale.	>4kW																		
	Ground source heat pumps		Ground source heat is of a higher grade heat than air, less seasonally dependant and with no visual impact but available at a higher cost.	>100kW																		
	Process waste heat & heat pumps		Low grade heat can be recovered from process sources such as building cooling systems or electricity substation transformers and upgraded using heat pumps. No significant scale sources have been identified in the study area.	>500kW																		
	Electric resistive heating	Uses electrical resistance in wires to generate heat e.g. in fan heaters. Resistive heating is responsive, cheap and unobtrusive, but far less efficient than heat pumps, making it more expensive.	Electric resistive heating would not currently meet B&NES carbon targets as it is reliant on the decarbonisation of the electricity grid. This is a dry heating systems and as such it is not compatible with other technologies discussed, all of which are wet heating systems. Building scale technology only.	<500kW																		
	Electric boilers	High operating cost, primarily used for providing heating and hot water where gas or oil are not available.	Also reliant on the long term decarbonisation of the electricity grid before delivering CO_2 savings.	<5MW																		
Gas	Condensing gas boilers	Gas boilers are a cheap and responsive means of generating heat. Condensing gas boilers capture some of the heat contained in flue gases and are typically 10% more efficient than non-condensing boilers in the existing building stock.	Scalable – can be used at a building or district level and to compliment other heat sources, particularly to meet peak demands and reduce plant size of CHP or heat pumps. Long term viability limited as electricity grid decarbonises. Instantaneous heat means no hot water storage tank required.	<5MW																		
	Gas CHP	Co-generation engine recovering heat from electricity generation. Well established technology delivering good CO_2 savings by offsetting grid electricity supply. As the electricity grid decarbonises these savings reduce compared to heat pumps.	Space take and NO_x emissions are less than biomass boilers. Technology is well proven and part of DECC national heating strategy and delivers good savings against building regulations targets, typically exceeding planning requirements.	<50kW																		
	Hybrid gas boiler	A hybrid heat pump system integrates an ASHP with a condensing gas boiler to create a highly efficient system, using gas boilers when ambient temperatures (and hence ASHP efficiencies) drop.	High capital cost per unit of energy. Space required both inside and outside building. New emerging technology with inherent uncertainty. Historically building scale technology only, immature (greater uptake in Europe).	<5kW																		
	Gas with CCS	Technology used in the oil and chemical sectors but not proven in district heating to date	Storage of the CO_2 is typically in deep geological formations, not suitable for city centre location and scalable	<10MW																		
Biomass	Biomass boiler	Energy can be recovered from biomass incineration from solid fuels such as wood chips, wood pellets or refuse derived fuel (RDF)	High CO_2 savings (2-3 times that of gas CHP) and mature technology. Biomass incineration has larger air quality impact than gas and so local air quality may be an issue - less suited to a city centre location. Fuel also requires frequent deliveries to site.	>50kW																		
	Biomass CHP		Even higher CO_2 savings but immature technology expensive and unreliable at a small scale owing to the high temperatures and pressures required.	>2MW																		
	Biomethane CHP	Biomethane (biomass and wastes converted to gas) has similar properties to natural gas and can be readily integrated with the existing gas grid and heating	No supply chain identified for reformation of local gas grid. Possible long term solution to decarbonisation of gas heating plant if identified in the future. Precedent for technology exists such as Becton Biofuel plant – 19MW CHP plant	>10MW																		

Technology		Description	Site specific constraints	Typical scale	UK market maturity		CO_2 reduction		Capital costs		Funding & revenues		O&M		Planning & Environmental amenity		Land take		Community benefit		Overall assessment	
					B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D
		infrastructure, with gas boilers requiring no modification.	fuelled by waste fats and oils.																			
MTHW	Deep geothermal	Low to zero carbon heat source extracting heat from hot rocks via boreholes typically 1km deep. Requires district heating network to transport heat to buildings.	Expensive unless considered at large scale (requiring large existing heat network for connections. Local geothermal gradient is lower than average for the UK (~35°C at 1,000m below ground).	>5MW																		
	Solar thermal	Solar thermal systems focusing heat from the sun to warm water. Reliable technology but seasonally variable with a reliance on hot water storage.	Proven technology, though diurnally and seasonally dependant. Issues with long term storage. Solar thermal would compete with solar PV for roof space whereas other low carbon heat sources can be installed in conjunction with solar PV. Can be used to 'recharge' ground source heating schemes.	<100kW																		
	Industrial and process heat	Waste heat recovery as a result of large industrial power generation processes. Requires district heating network to transport heat to buildings.	There are no large industrial or energy from waste plants in B&NES, as such this option has not been considered further but could in incorporated into district heating networks if forthcoming in the future, dependant on the distance required to transport heat.	>500kW																		
Hydrogen	Hydrogen fuel cell	Hydrogen fuel cells create electricity from electrolysing hydrogen, producing water as the only by product.	Hydrogen is not currently available as a fuel source; it can be created by separating hydrogen from water which currently uses more energy than is produced when the hydrogen is electrolysed in a fuel cell. Unless this process can be driven by power from renewable energy it does not result in low carbon emissions. Hydrogen as a low fuel is primarily focussed at the transport industry because of its storage properties. If this technology does come to fruition it will likely be catalysed first through the transport industry.	>1MW																		
Electricity (power)	Solar photovoltaic (PV) cells	Electricity generated from solar irradiation, offsetting the amount of grid electricity required. Can be used in conjunction to technologies for heating CO_2 savings. Either roof mounted (small scale) or ground mounted (large scale solar farm)	Technically simple to integrate roof system. Design proposals but consideration of aesthetic impacts required, may clash with planning requirements. No suitable location identified for solar farm. Aesthetic concerns greater than roof mounted scheme as more visible. A private wire connection to buildings is required to gain benefits in reporting terms (Building Regulations and Code for Sustainable Homes benefit)	>10KW																		
Wind (power)	Wind turbine	Medium scale turbine (100-50kW) is the most feasible of wind turbines at this site given the space constraints for a large turbine, lack of generation capacity at a small scale and funding available through the feed in tariff at this scale	Wind speeds in the study area is ~4.8 m/s at 45m above ground level. This is insufficient to progress a wind turbine for power generation. Typically wind speeds of 7-8 m/s at 45m above ground level are required as a minimum threshold for the viability of medium scale wind turbines. Space take and visual impact are also significant constraints.	>100kW																		
River (power)	Hydropower	Using river flow to drive turbine. Simple technology but obtrusive to river flow.	No examples of constructed precedents of micro-hydro schemes in cities in the UK have been identified. Sheffield Renewables has attempted to develop two urban sites, both of which have encountered difficulties (e.g. becoming unviable due to increased requirements for environmental protection). There are currently over 200 rural micro-hydro schemes receiving funding through the feed-in-tariff including 11 in the South-West.	>50kW																		

Appendix G Options Appraisal

Table 9—7 Options assessment criteria

Criterion	Metric	Comments	Score = 1	Score = 5	Score = 10
25 year NPV at 3.5% discount factor/annual heat sales	£/MWh	Normalised whole life cost measure (NB IRR not used as options do not achieve a return)	N/A – based upon numerical outputs from techno-economic model		
CO_2 savings (today)	kg/year/MWh	Using today's Part L carbon factors. Normalised by heat sales.	N/A – based upon numerical outputs from techno-economic model		
CO_2 savings (2030)	kg/year/MWh	Assuming grid decarbonisation. Normalised by heat sales.	N/A – based upon numerical outputs from techno-economic model		
Deliverability	Qualitative assessment on 1-10 scale	How challenging will the scheme be to deliver? Phasing, Council control over connections and new development, major constraints such as trunk road crossings/river etc.	All private sector load with no ability to compel connection. Major phasing issues. Significant infrastructure constraints.	Able to compel some connections. Phasing issue can be mitigated. Limited infrastructure constraints.	Able to compel connection of all load. No phasing issues. No major infrastructure constraints.
Potential for expansion	Qualitative assessment on 1-10 scale	Would there be opportunities for surrounding building to connect in the future?	No expansion is possible.	Some potential to expand to adjacent buildings in future	Significant potential for expansion due to proposed development and adjacent existing buildings
Potential for community or other public sector involvement in ESCo	Qualitative assessment on 1-10 scale	Does the nature of the connected buildings, surrounding community and scheme design favour public sector and/or community involvement?	No opportunity for community or public sector involvement	Some public sector buildings in scheme	Public sector/community make up majority of annual heat demand
Potential for private sector led ESCo	Qualitative assessment on 1-10 scale	Does the nature of the connected buildings, development sites and surrounding context favour a private sector led ESCo? NB does not cover economics of scheme.	No opportunity for private sector led scheme	Some Council enablement required to deliver scheme e.g. de-risking	Scheme capable of fully market led deliver with minimal Council involvement
Local environmental impacts	Qualitative assessment on 1-10 scale	Noise, air quality, visual impact etc	Local environment impact likely to significantly affect ability to deliver scheme.	Some environmental impacts/mitigation needed but unlikely to affect ability to deliver scheme.	Minimal environmental impacts/mitigation needed.
Risk	Qualitative assessment on 1-10 scale	Attribute to capture the sensitivity of all the above attributes.	All previous scores are highly variable.	Medium variance (+/-30%) in scores is likely.	Only a minimal (+/-10%) variance in scores is likely.

Table 9—8 North Quay qualitative appraisal

Criterion	North Quay – Heat Pump	North Quay - CHP
Deliverability	Able to compel connection with North Quay development site. Single developer on North Quay site. City of Bath College supportive of connection. Close to all the load can be connected in an initial phase. No significant infrastructure constraints. Environment Agency may object to intake/outfall pipes in the Avon due to impact on flood risk.	As North Quay – Heat Pump but without the Environment Agency issues regarding flood risk
Potential for expansion	Significant number of adjacent buildings that could connect. Includes University of Bath buildings plus potential development plans for City of Bath College site.	As North Quay – Heat Pump
Potential for community or other public sector involvement in ESCo	City of Bath College makes up approximately 1/3 of the total heat demand. No significant opportunity for community involvement.	As North Quay – Heat Pump
Potential for private sector led ESCo	Connection can be compelled for North Quay development site but Council involvement may be required regarding development guarantees etc.	As North Quay – Heat Pump
Local environmental impacts	Potentially a significant impact on flood risk due to place intake/outfall pipes in Avon. No significant air quality issue. No abnormal noise issues.	Adjacent to an AQMA - Air quality assessment with dispersion modelling likely to be required. Visual impact of flue. No abnormal noise issues.
Risk	Uncertainty regarding Environment Agency acceptance of river source heat pump. Changes to RHI significantly affect business case.	No abnormal risks at this stage.

Table 9—9 North Quay Plus qualitative appraisal

Criterion	North Quay Plus – Heat Pump	North Quay Plus - CHP
Deliverability	Able to compel connection with North Quay development site. Single developer on North Quay site. City of Bath College and University of Bath supportive of connection. No significant infrastructure constraints. Environment Agency may object to intake/outfall pipes in the Avon due to impact on flood risk.	As North Quay Plus – Heat Pump but without the Environment Agency issues regarding flood risk
Potential for expansion	A number of adjacent buildings that could connect. Includes potential development plans for City of Bath College site and buildings on James Street West.	As North Quay Plus – Heat Pump
Potential for community or other public sector involvement in ESCo	City of Bath College and University of Bath buildings in scheme. No significant opportunity for community involvement.	As North Quay Plus – Heat Pump
Potential for private sector led ESCo	Connection can be compelled for North Quay development site but Council involvement will be required to ensure connection of existing buildings.	As North Quay Plus – Heat Pump
Local environmental impacts	Potentially a significant impact on flood risk due to place intake/outfall pipes in Avon. No significant air quality issue. No abnormal noise issues.	Adjacent to an AQMA - Air quality assessment with dispersion modelling likely to be required. Visual impact of flue. No abnormal noise issues.
Risk	Uncertainty regarding Environment Agency acceptance of river source heat pump. Changes to RHI significantly affect business case. Risk that existing buildings may not be interested in connecting.	Risk that existing buildings may not be interested in connecting.

Table 9—10 North Quay Plus Plus qualitative appraisal

Criterion	North Quay Plus Plus – Heat Pump	North Quay Plus Plus - CHP
Deliverability	Able to compel connection with North Quay development site. Single developer on North Quay site. City of Bath College and University of Bath supportive of connection. A number of private company buildings may be more challenging to connect. Connection to Thermae Bath Spa requires a pipe route in streets with vaults. Environment Agency may object to intake/outfall pipes in the Avon due to impact on flood risk.	As North Quay Plus Plus – Heat Pump but without the Environment Agency issues regarding flood risk
Potential for expansion	A number of adjacent buildings that could connect. Includes potential development plans for City of Bath College site and buildings on James Street West.	As North Quay Plus Plus – Heat Pump
Potential for community or other public sector involvement in ESCo	City of Bath College and University of Bath buildings in scheme. No significant opportunity for community involvement.	As North Quay Plus Plus – Heat Pump
Potential for private sector led ESCo	Connection can be compelled for North Quay development site but Council involvement will be required to ensure connection of existing buildings.	As North Quay Plus Plus – Heat Pump
Local environmental impacts	Potentially a significant impact on flood risk due to place intake/outfall pipes in Avon. No significant air quality issue. No abnormal noise issues.	Adjacent to an AQMA - Air quality assessment with dispersion modelling likely to be required. Visual impact of flue. No abnormal noise issues.
Risk	Uncertainty regarding Environment Agency acceptance of river source heat pump. Changes to RHI significantly affect business case. Risk that existing buildings may not be interested in connecting.	Risk that existing buildings may not be interested in connecting.

Table 9—11 South Bank qualitative appraisal

Criterion	South Bank– Heat Pump	South Bank - CHP
Deliverability	Able to compel connection through planning process. Likely to be a number of different developers. Initial phase of construction will require temporary building level servicing. No significant infrastructure constraints. Environment Agency may object to intake/outfall pipes in the Avon due to impact on flood risk.	As South Bank – Heat Pump but without the Environment Agency issues regarding flood risk
Potential for expansion	Potential for major expansion into Green Park West development site. Some potential to connect to office buildings south of Lower Bristol Rd	As South Bank – Heat Pump
Potential for community or other public sector involvement in ESCo	All private sector development. No opportunity for community involvement.	As South Bank – Heat Pump
Potential for private sector led ESCo	Likely to be a number of different developers on site. At a minimum the Council will have to be involved with enablement and coordination between developers.	As South Bank – Heat Pump
Local environmental impacts	Potentially a significant impact on flood risk due to place intake/outfall pipes in Avon. No significant air quality issue. No abnormal noise issues.	Adjacent to an AQMA - Air quality assessment with dispersion modelling likely to be required. Visual impact of flue. No abnormal noise issues.
Risk	Uncertainty regarding Environment Agency acceptance of heat pump. Changes to RHI significantly affect business case.	No abnormal risks at this stage.

Table 9—12 Lower Bristol Road qualitative appraisal

Criterion	Lower Bristol Road– Heat Pump	Lower Bristol Road - Biomass
Deliverability	Outside of District Heating Priority Area so unable to compel connection. Phasing of development sites and interaction with phasing of Bath Western Riverside may be complicated. Excavation in Lower Bristol Road will be disruptive. Environment Agency may object to intake/outfall pipes in the Avon due to impact on flood risk.	As Lower Bristol Road - Heat Pump but without the Environment Agency issues regarding flood risk
Potential for expansion	Expansion is constrained by Avon to the north, lower density residential buildings to the south and low density development to the west.	As Lower Bristol Road - Heat Pump
Potential for community or other public sector involvement in ESCo	One public sector building but has a very limited heat demand. No significant opportunity for community involvement.	As Lower Bristol Road - Heat Pump
Potential for private sector led ESCo	Two major residential schemes, each being brought forward by a single developer. Incumbent district heating ESCo at adjacent Bath Western Riverside site.	As Lower Bristol Road - Heat Pump
Local environmental impacts	Potentially a significant impact on flood risk due to place intake/outfall pipes in Avon. No significant air quality issue. No abnormal noise issues.	Adjacent to an AQMA - Air quality assessment with dispersion modelling likely to be required. Visual impact of flue. Noise impact of delivery on residential properties needs to be considered.
Risk	Uncertainty regarding Environment Agency acceptance of river source heat pump. Changes to RHI significantly affect business case. No ability to compel new development to connect to heat networks.	No ability to compel new development to connect to heat networks.

Table 9—13 Range of scores and weighting

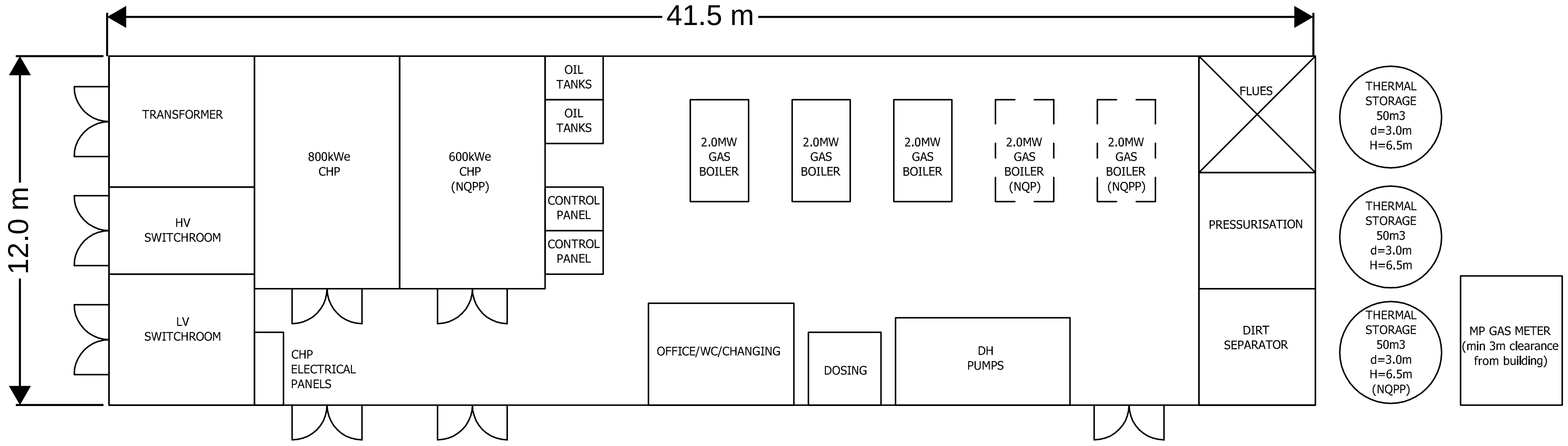
Criterion	Metric	Best	Worst	Range	Weighting (0-100)
25 year NPV at 3.5% discount factor/annual heat sales	£/MWh	-330	-1,081	751	100
CO_2 savings (today)	kg/year/MWh	141	15	126	60
CO_2 savings (2030)	kg/year/MWh	166	-135	301	50
Deliverability	Qualitative assessment on 1-10 scale	8	4	4	100
Potential for expansion	Qualitative assessment on 1-10 scale	8	1	7	30
Potential for community or other public sector involvement in ESCo	Qualitative assessment on 1-10 scale	6	1	5	20
Potential for private sector led ESCo	Qualitative assessment on 1-10 scale	7	3	4	20
Local environmental impacts	Qualitative assessment on 1-10 scale	6	5	1	15
Risk	Qualitative assessment on 1-10 scale	4	8	4	70

Appendix H North Quay Energy Centre Layouts

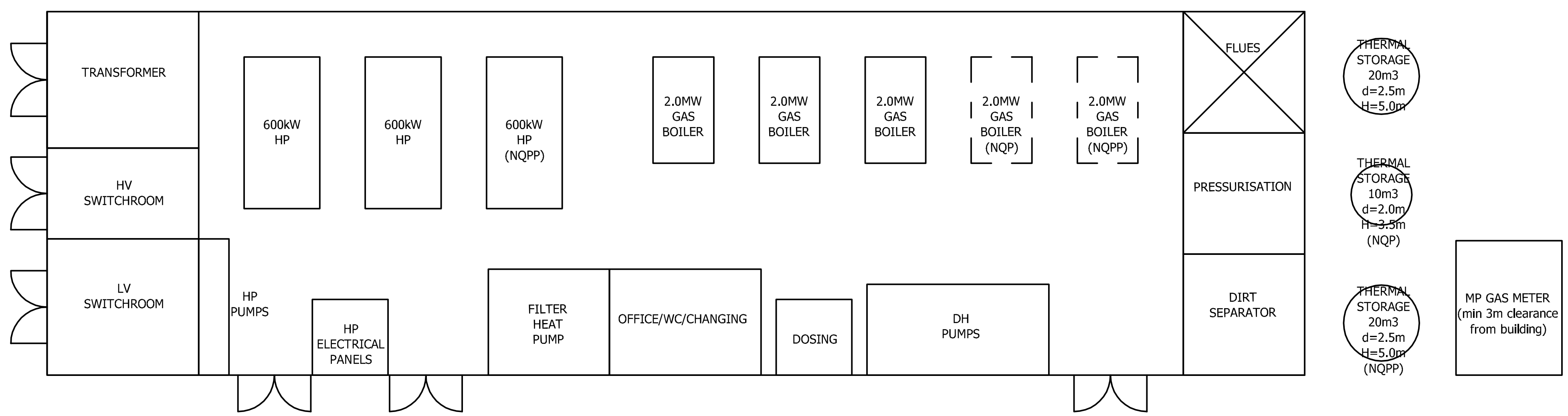
BUROHAPPOLD ENGINEERING

CHP SCHEME:

AREA ~ 500m^2



HP SCHEME:



PROJECT:
BANES DE
034004

TITLE:
NORTH QUAY
ENERGY CENTRE

PAPER: A3

SCALE: 1:200

AUTHOR: JE

DATE: 8/7/15

Appendix I Stakeholder Workshop Notes

9.5 Individual exercise responses

Question		Organisation and representative						
		Developer	*Councillor*	*Council Project Manager*	*Developer*	*Education Facilities Manager*	*Architect*	*Council officer*
1	What do you see as your organisation's role in a district energy network? For example, customer, investor, champion/enabler etc?	Developer	All of the above (examples, customer, investor, champion/enabler) and researcher Identify role of the council – facilitator? "is this something we want to do or is it too difficult to contemplate?"	Applying a consistent obligation – ensuring it not ignored Defining if Bath is right for technology Land and highways enabler ESCo	Investor, Crest has paid for all the plant and pipework. We have clearly enabled the district heating to be implemented.	Customer – End user, possible champion	Enabler – through design, understanding of implications (spatial and technical) of implementation Facilitator/Champion – helping landowners/clients to meet targets and aspirations through knowledge and experience.	Enabler Facilitator and deliverer – of infrastructure on council owned sites Promoter and facilitator on nom-council owned sites
2	What do you see as the benefits of a district energy network?	It allows us to achieve our planning obligations and Code 4	Cost savings, possible efficiency savings	Carbon commitment Private wire – reduced cost electricity supply Return on investment Tapping new source – ground and river – heat pump Community benefit – benefit locally – reduces cost	Only benefit is to comply with code 4 at BWR. Cannot be defined at present. Not considered a positive sales tool without being able to sell it to customers as a lower cost solution to them. Current analysis suggests that it is about the same.	Lower costs, reduced CO_2, removal of individual central heating source	On behalf of BANES – to enhance reputation through meeting commitments to low carbon targets, to improve efficiency and internal knowledge of ideas and strategies	Reputational – brand and image – USP? Environmental Potential financial returns (vs cost – return on investment is key) through increased asset value or revenue income Cost savings – attached to council owned assets Leading by example
3	What do you see as the challenges of a district energy network?	Cost, Reputation risk, Commercial risk	Difficulty of implementation, costs, disruption, challenge of public perception	Economics – Contractual and financial risk	Many people buying perceive low carbon to be low cost or no cost, this is strictly not the case and it can be disappointing to them. Significant capital cost which would not be recovered.	Length of time – timescale 10 to 12 years + before commencement Alterations to government priorities and funding	As an architect – integrating the infrastructure into the design proposals in a way which does not reduce the future flexibility or diminish the urban design aspirations of the scheme or plan.	Occupier/owner concerns + impact on success of council Financial – can savings/returns be generated? Is it financially efficient? Additional council cost burden? Promotion of such facilities on non-council owned sites Future proofing
4	What does your organisation need in order for a district energy network to be worthwhile for it?		Justification	Convincing Justification	The ability to justify it to our buyers as a positive cost effective solution.	Guarantee for reliability of system – initial and projected costs Assurance relating to p/downs or problems of supply Any investment required?		Demonstration of worth (in broadest sense) but, fundamentally – in financial viability. Does return justify investment?

Question	Organisation and representative

		Council officer	Councillor	Consultant to developer	University Energy Manager	Council officer	Council Divisional Director	DECC
1	What do you see as your organisation's role in a district energy network? For example, customer, investor, champion/enabler etc?	Enabler, investor? Facilitator, standard setter	Enabler Scrutineer	Consultant to Crest Nicholson	Customer	BANES as an enabler/co-ordinator. Strategic objectives Overlapping management (B&NES ownership) Mantra Risk adverse	Enabler – through policy development, is the risk a public sector risk?	Funding, facilitating and providing guidance to Local Authorities for the development of heat networks in England and wales. On wider context, governments policy to support heat networks may work as enabler for private initiatives
2	What do you see as the benefits of a district energy network?	Carbon targets, regeneration target Meeting standards (BREEAM) revenue generation?	Carbon reduction targets met Better wellbeing/reduce fuel poverty Business opportunities Opportunity to evolve energy supply	Meeting planning targets and Crest Nicholson's corporate sustainability goals.	Long-term heat cost stability Low-carbon Reduced maintenance burden	Economic Benefits Energy targets (building regulations) Links to Council overall objectives	Add to the identity of the EA "Green"	Reduce energy consumed for heat and associated emissions on a national level. University – long term low cost and cost stability Council – strategic objective Crest Nicholson – corporate sustainability targets
3	What do you see as the challenges of a district energy network?	Viability. Complexity of relationships. We can only take it so far (so needs stakeholders to buy in)	New idea in UK, possible scepticism Lack of information Disruption during installation?	Long term CO_2 savings, RHI uncertainty. Financial viability. Cost of energy to customers.	Lack of infrastructure availability during planning and development stages	Complexity Timing Managing new technology	Viability	Technology not widely understood or accepted And bad examples setting bad precedence Hard to convince developers to adopt it. Council financial viability Crest – Uncertainty long term
4	What does your organisation need in order for a district energy network to be worthwhile for it?	Carbon savings, economic viability, stakeholder appetite. Proof that it is preferable to alternatives	Proof of benefits?	Lower capital costs long term certainty on government incentives, eg RHI Cost of energy no more than for individual gas boilers for customers.	Long term cost effective confidence	Viability (Long Term)	Low risk scheme which generates level of return to make it attractive for private sector investment (10%-15%)	Private initiative University – would like to see heat price limited to price index rather than gas price

9.6 Group exercise responses

		Table 1	Table 2	Table 3
		Neil Dawtrey, Fareen Lalani, Cllr Martin Veal, Simon Martin, Jane Wildblood	*Richard Marsh, Richard Horne, Cllr Anketell-Jones, Chris Schulte, Martin Peter, Kathy Hough (Notes taken not on the specific group form and hence do not comply*	*Malcom Grainger, Julian Greaves, Dave Worthington, Lazaros Exarchakos, Derek Quilter*

				with the format of the other tables)			
		Common views of organisations/representatives	Individual views of organisations/representatives	Common views of organisations/representatives	Individual views of organisations/representatives	Common views of organisations/representatives	Individual views of organisations/representatives
1	What do you see as your organisation's role in a district energy network? For example, customer, investor, champion/enabler etc?	Enabler – B&NES • Enforcer – planning • Infrastructure – Highways • Researcher – Technology • Landsales – Property Investor – Crest Nicholson		• Important difference between Council and non-Council owned sites • Role of Curo is customer potentially – although no residences on key sites • Role of Council is enabler, scrutineer • Role of architect is enabler and facilitator • Role of City of Bath College is customer and potential champion for DH		Council – Enabler – Also a possible customer Bath Spa Uni – Customer Crest Nicholson – Customer and potential provider (EON)	DECC – Facilitator + Kickstarter
2	What do you see as the benefits of a district energy network?		<CO_2 (Good for B&NES, No value for Crest Nicholson) B&NES – ROI and Community Benefits	• Reputational (brand/image of Council / N.Quays development), environmental, financial returns (asset value + revenue / ROI), cost savings • Curo – reduce costs for residents / fuel poverty, reduced maintenance, PR • Carbon saving, health & wellbeing, business opportunity, future energy supplier		Customer (Bath Spa) – Long term heat cost stability CO_2 Savings Reduced Maintenance Council (Enabler) – Benefits strategic Carbon Reductions etc DECC – National Level Crest Nicholson – Corporate Sustainability	University (Bath Spa) can take a longer term view No economic gains for B&NES Someone needs to take on financial risk. Not council.
3	What do you see as the challenges of a district energy network?	Public Perception • Low Carbon = Low/no Cost – Not the case! • Capital Investment Risk • Financial • Reputational Cost • Infrastructure • Maintenance • Replacement		• Lots of change, time frame, timescale (will we still be here as a college?). Long term business case and gvt priorities – will gvt still be funding DH? • New idea (in UK), and lack of awareness, so will people buy into it? Need to focus on behaviours and persuasion. Also disruption (digging roads), and reinstatement (so ensure consider costs of servicing pipework). • Challenge of convincing (a) Council and (b) tenants/occupiers. Also cost (does it just add to cost?) • How do we know it will remain best value in the future? Also risk of DH taking away people's sense of control (about heating / energy use). • Investment		Listed Buildings Financial Viability Uncertainty – grid decarbonisation, right technology? Government change in legislation?	Planning decisions don't stretch far enough into the future. Infrastructure
4	What does your organisation need in order for a district energy network to be worthwhile for it?	Justification • Buyers' Benefit (Crest Nicholson) • Public Benefit • Financial Benefit (Don't be over optimistic on prices and carbon savings – could regret it)		• Price certainty, liability, insurance, consistency of delivery. • Proof of benefits • Needs to be attractive to tenants. Maybe conventional techs + better fabric is better? As occupiers tend to be nervous of new things.		Private initiative. Long term cost effective confidence Consumer price index – more stable that using a fuel – as opposed to gas Price and stability Transparency Lower overall costs	Any customers in building longer than boiler? Standardise price?

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