District Heating Opportunity Assessment Study

Bath and North East Somerset Council

Prepared by: .... Raphael Sibille Consultant

Matthew Turner Principal Consultant

Checked by: .... Abena Poku-Awuah Senior Consultant

Paul Woods Technical Director

District Heating Opportunity Assessment Study

Rev No	Comments	Prepared by	Checked by	Date
0	Preview draft issued for discussion	RS&MT	APA	30.09.10
1	Working draft report issued for comments	RS&MT	APA	08.10.10
2	Final report	RS&MT	PW	05.11.10
3	Final report with amendments	RS&MT	APA	22.11.10

The Johnson Building, 77 Hatton Garden, London, EC1N 8JS
Telephone: 020 7645 2000 Website: http://www.aecom.com

Job No 60161375 Reference: B&NES District Heating Study Date Created 22nd November 2010

This study investigates the technical options and feasibility of developing district heating networks with CHP in Bath and North East Somerset, based on plans and information available at the time of writing. Before implementation of any of the options further detailed study, design and costing, based on ground surveys, structural analysis etc will be necessary.

f:\sdg\jobs\sdg - bath and ne somerset district heating feasibility study\06 reports\issued 221110\221110-mjt&rs-banes district heating report (final issued).docx

Table of Contents

Capabilities on project:
Building Engineering

Non Technical Summary

1. Background

What is district heating?

Heat is supplied from a central energy centre to multiple buildings. The hot water is distributed using a network of insulated pipes. Individual boilers are replaced with heat exchangers in each of the buildings. These heat exchangers then deliver the heat to the properties using the normal wet system.

There are already a number of district heating schemes within B&NES, located at the University, Royal United Hospital and a social housing scheme in Bath.

Why is district heating being encouraged?

The primary reason for assessing the potential for district heating is to deliver a reduction in CO_2 emissions. The Bath and North East Somerset Sustainable Community Strategy has set the goal of delivering a 45% reduction in carbon emissions across the district by 2026. Achieving this target will require concerted action to be taken.

As part of the evidence base for the Core Strategy of the Local Development Framework a study was undertaken to look at the capacity to deliver renewable energy within the district. This study indicates that the delivery of low carbon heat could help to deliver significant CO_2 savings. District heating offers a way of delivering low carbon heat to existing and new buildings. Large central energy centers can incorporate new and alternative technologies that are difficult to implement at smaller scales. Technologies such as combined heat and power and alternative fuels such as biomass can deliver significant CO_2 reductions. In addition, district heating systems provide the flexibility to connect new technologies as they come forward or to link to sources of waste heat such as industrial sites, waste processing facilities or power stations.

This study follows on from this work has assessed the potential for delivering district heating systems within Bath and North East Somerset. The two main aims of the study are:

i. To provide an evidence base to support planning policy within the Core Strategy promoting district heating

ii. To identify potential opportunities for district heating projects in the district and undertake initial technical and commercial analysis

2. Assessing the potential for District Heating in B&NES

In order to assess the potential for district heating systems within Bath and North East Somerset data was collected to allow the heat demands and other specific opportunities to be mapped.

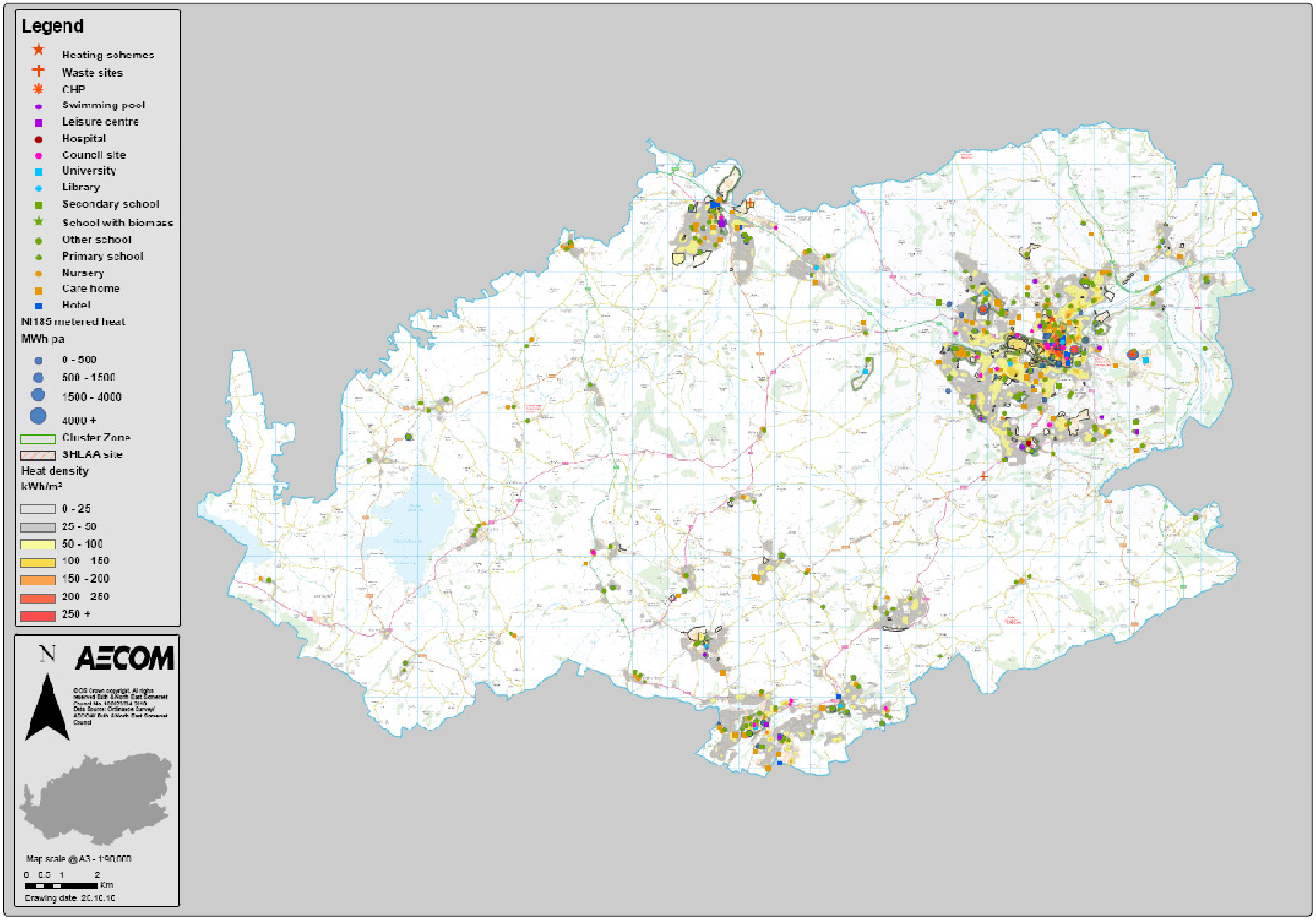
Data was obtained from the recently released South West Heat Map, which shows the density of heat (total heat demand per square meter) across the region. This is based on an understanding of the number, size and types of properties and the average heat demand from each. Heat demands from new developments have also been included based on the Council's assessment of development sites across the district and the likely types of development that will take place between now and 2026.

In addition to this we have collected data on the known metered energy consumption from public buildings, location of existing communal heating infrastructure and the location of existing low carbon heating systems.

Two of the maps created in this process are shown in the following pages (the full suite of maps is presented in the full report).

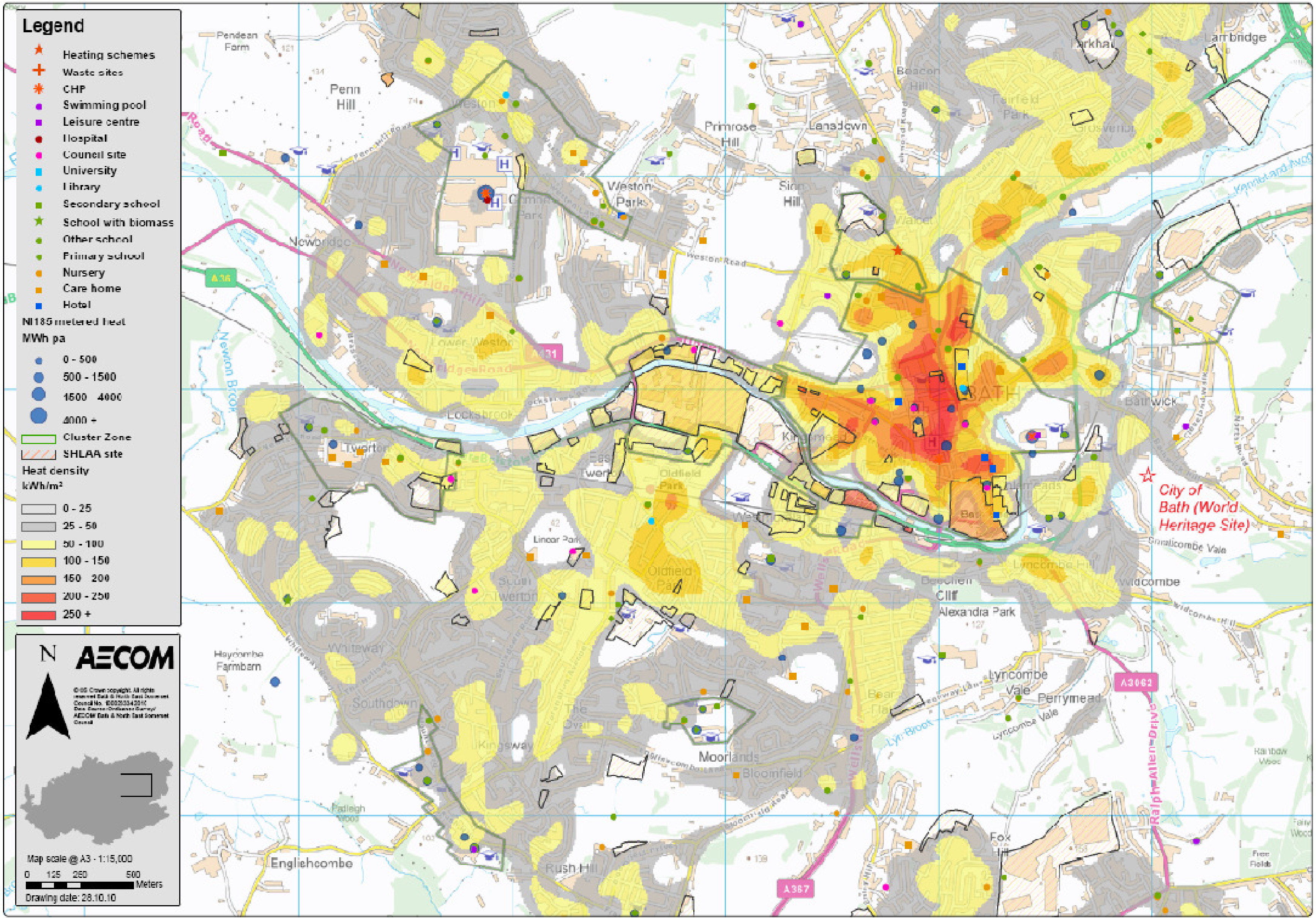
Capabilities on project:
Building Engineering

District Heating Opportunity Map for Bath and North East Somerset



Capabilities on project:
Building Engineering

District Heating Opportunity Map for Bath



3. Identifying opportunity areas

The maps were reviewed in detail to identify locations with the most potential in the following areas:

- High heat density (high heat demands in a small area)
- High total heat demand
- Presence of public buildings with large heat demands
- A range of building types
- Future development plans
- Potential for linking lots of buildings and expanding over time

By reviewing the maps we identified a long-list of 15 clusters for further analysis (See Map 6). The long-list included:

Clusters	Key buildings & opportunities
Midsomer Norton	Pool, school, library, retail and new development
Keynsham	Leisure centre, fire, multi-residential and a new town hall
Paulton	New developments
Radstock	College, commercial properties and new developments
Odd Down	Hospital, residential, schools
Kingsway	School and leisure centre with pool
Twerton	School, multi-tenanted properties, new developments
Weston	Close proximity to RUH including school and dense residential
Bath Riverside Corridor	New development expansion to other new plus existing
Bath Spa University	Development of new campus buildings
Bath City Centre	Dense mix of buildings, various local authority properties and a number of development sites
Lansdown	Balance Street, lots of Georgian housing
Moorlands	Schools and multi-residential buildings
Bathwick	Hotel with pool, schools
Somerdale	New mixed-use development

A stakeholder workshop was held to get additional feedback on the maps and 'long-list' of clusters to assist in our analysis. The information was added to the cluster datasheets that are presented in the main report and which collate the opportunities and constraints associated with each location

The clusters were then assessed and ranked based on the following criteria:

- Technical potential: A relative assessment of the total heat demands and density of demand as well as the phasing of new development, future expansion potential, likely scale of CO_2 savings and the direct benefit to the Council.
- Financial potential: A very broad assessment, based on relative size and density of the key heat loads, of the relative commercial viability of each of the clusters.
- Deliverability potential; An assessment of the opportunities and constraints to the practical deliver of a potential network.

Based on this assessment the most promising opportunities in B&NES were deemed to be:

- Bath Centre;
- Bath Riverside Corridor; and
- Keynsham.

4. Technical and commercial assessment

The three identified 'opportunity areas' were assessed in more detail to understand the technical and commercial viability of delivering a district heating scheme in these locations.

The information collected for each of the three priority clusters was used to identify the existing and proposed building with the highest heat loads. This was then used produce high level network designs. For each of the key locations we have developed three network options: a small network, a large network and a small network with capacity for expansion.

In locating the energy centre we have made an assumption on a possible location within each priority cluster based on the information we have managed to collect from the Council, key stakeholders and desktop research. In the case of Bath River Corridor and Keynsham this is located within a potential development site. In Bath city centre it is located on the site of an existing energy centre.

For each network we reviewed the potential for incorporating gas-fired CHP and biomass boilers. Our modelling enables us to understand the heat and electricity output from the different plant, which allow us to calculate heat and electricity sales and the potential reductions in CO_2 emissions relative to a ‘business as usual’ case.

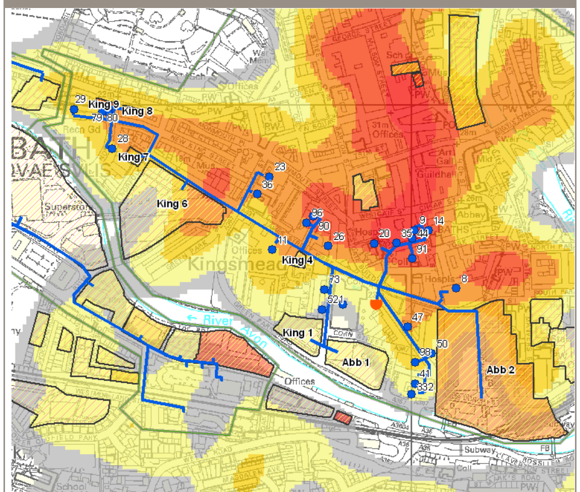
To assess the commercial viability of the district heating networks identified we have estimated the total capital costs associated with the system, the costs associated with operation and maintenance and the revenue from the sales of heat and electricity. We have assumed that a financial contribution would be able to be obtained from developers of sites connecting to a network based on the reduced costs of meeting planning policy and building regulations requirements compared to alternative strategies.

The costs have been run over a 25 year period to determine the cash flows and calculate annual costs and revenue. The resulting analysis allows us to assess the Net Present Value (NPV) which is the yield of the investment based on the capital investment and the costs and returns over time together with the discount factor. We have reviewed the NPV for two discount rates, 3.5% and 6%. The former equates to the standard value used for public sector valuations and the latter reflects the rate required for some private sector involvement. In reality commercial organisations would seek to apply a higher discount factor but these two values give an indication of viability. The NPV is a useful indicator as it shows, for any given discount factor and length of contract, how much gap funding may be required (if any) in order to make a project viable.

A summary of the results for the large network options is presented below. For more details, including the buildings indicated as connected (the numbered circles) please refer to the full report.

Capabilities on project:
Building Engineering

Bath Central – Large network



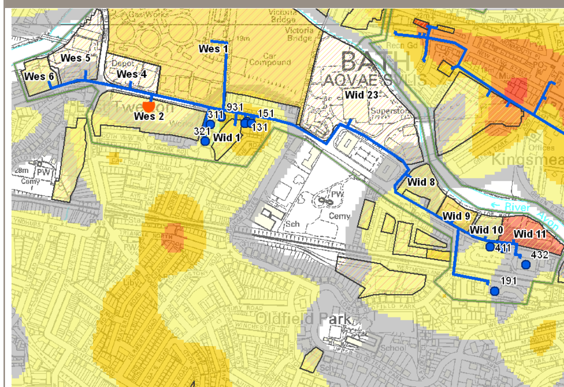
Description

The Bath Centre network could be based around the City College site, where there is an existing energy centre which could house an initial heat source. We have taken the decision to avoid the centre of the city which, despite the high heat density, has a number of constraints associated with the underground vaults.

Key results from gas-CHP analysis	
Heat capacity	3200 kW
Heat generation	15048 MWh
CO_2 emissions saved	3097 tCO_2 pa
Capital costs (in brackets without developer contributions)	£4,182,224 (£5,010,224)
NPV @ 3.5%	£231,206
NPV @ 6%	-£835,263

Key results from biomass boiler analysis	
Heat capacity	2529 kW
Heat generation	15244 MWh
CO_2 emissions saved	2451 - 2785 tCO_2 pa
Capital costs	£2,373,996 (£3,201,996)
NPV @ 3.5%	£-1,355,759
NPV @ 6%	£-1,609,872

Bath Riverside South – Large network



Description

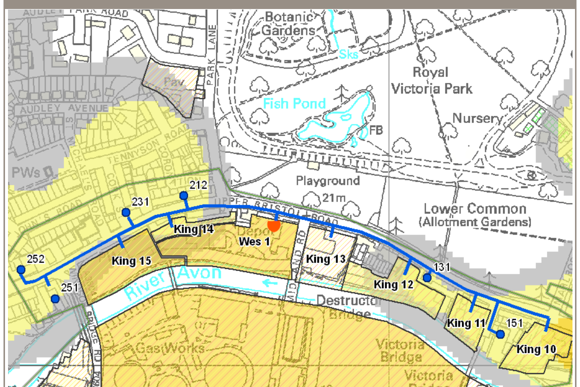
The Bath Riverside South network would be based around the string of development sites along the Avon. The concept behind this network is to deliver co-ordinated low carbon energy infrastructure that could serve all new developments in this area, rather than to leave each developer to meet their energy targets separately.

Key results from gas-CHP analysis	
Heat capacity	3300 kW
Heat generation	16591 MWh
CO_2 emissions saved	3401 tCO_2 pa
Capital costs (in brackets without developer contributions)	£3,701,996 (£5,448,996)
NPV @ 3.5%	£1,625,318
NPV @ 6%	£335,456

Key results from biomass boiler analysis	
Heat capacity	2731 kW
Heat generation	17232 MWh
CO_2 emissions saved	2771 - 3148 tCO_2 pa
Capital costs	£2,373,996 (£3,201,996)
NPV @ 3.5%	£-1,355,759
NPV @ 6%	£-1,609,872

Capabilities on project:
Building Engineering

Bath Riverside North – Large network



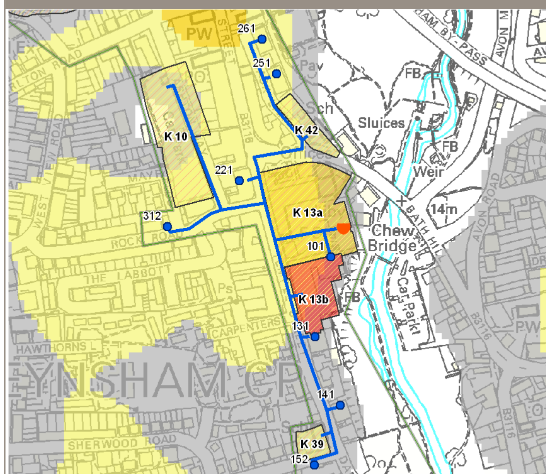
Description

As with the Bath Riverside South development the concept would be to create a network that linked all the development sites on the north of the river. Feedback from key stakeholders suggests that creating a link across the river could be difficult.

Key results from gas-CHP analysis	
Heat capacity	501 kW
Heat generation	2790 MWh
CO_2 emissions saved	401 tCO_2 pa
Capital costs (in brackets without developer contributions)	£154,185 (£1,163,105)
NPV @ 3.5%	£12,903
NPV @ 6%	-£37,593

Key results from biomass boiler analysis	
Heat capacity	428 kW
Heat generation	2870 MWh
CO_2 emissions saved	462 - 524 tCO_2 pa
Capital costs	£-184,380 (£824,539)
NPV @ 3.5%	£227,943
NPV @ 6%	£213,345

Keynsham – Large network



Description

The Keynsham Network could be based around the development of the new Town Hall network and extend to connect to other key buildings in the town centre.

Key results from gas-CHP analysis	
Heat capacity	800 kW
Heat generation	5797 MWh
CO_2 emissions saved	848 tCO_2 pa
Capital costs (in brackets without developer contributions)	£712,575 (£1,577,075)
NPV @ 3.5%	£1,672,126
NPV @ 6%	£1,092,229

Key results from biomass boiler analysis	
Heat capacity	973 kW
Heat generation	5935 MWh
CO_2 emissions saved	954 - 1084 tCO_2 pa
Capital costs	£147,526 (£1,012,026)
NPV @ 3.5%	£248,926
NPV @ 6%	£149,987

A summary of the key findings from the technical and commercial viability analysis is presented below:

- All the schemes identified have the potential to deliver significant CO_2 emissions reductions, although the commercial viability varies considerably depending on the size of the system, the type of technology and the potential levels of funding that could be obtained from new developments.
- Gas fired combined heat and power has the potential to deliver high CO_2 savings because it can generate electricity that has a much lower CO_2 emissions than electricity from the national grid. However, the government plans to reduce the CO_2 emissions associated with electricity from the national grid and as this happens the CO_2 savings will reduce. Biomass boilers can also deliver high CO_2 savings, which are more likely to remain high over the lifetime of the system.
- The capital costs associated with biomass boilers is much lower than the gas CHP engines but they generate lower profits compared to gas-CHP which is able to achieve high revenues from the sale of electricity. However, the government is planning to introduce a financial incentive for the generation of heat from renewable energy which could have a significant impact on the profitability of using biomass.
- The use of wood chips results in higher CO_2 emissions savings compared to the use of wood pellets. Wood chips are also significantly cheaper; however they have higher storage requirements and need to be of a good quality to ensure efficient operation. If a biomass option is taken forward the Council will need to investigate a suitable source of fuel.
- The Keynsham networks looks to have a high level of commercial viability although the scale of the scheme is relatively small.
- The Bath Central scheme has the potential to deliver significant reductions in CO_2 emissions but the capital costs are high and the rates of return are low.
- The Bath Riverside South network also has the potential to deliver high CO_2 emissions reductions and the presence of a large number of development sites means that the commercial viability can be significantly improved if contributions could be secured from developers.
- The Bath Riverside North network looks to have a high level of commercial viability but this is primarily a result of the potential to offset a large proportion of the capital costs with developer contributions.

5. Recommendations and Conclusions

On the basis of the results of this study, the following recommendations have been proposed to promoted district heating opportunities within B&NES and to take forward the projects identified.

- Obtaining financial contributions from developers will improve the commercial viability of all schemes. These ‘developer contributions’ would essentially be substituting for the costs that would be occurred in meeting building regulations through alternative means
- The commercial viability of using biomass boilers is likely to depend upon the introduction of the Renewable Heat Incentive.
- The commercial viability of delivering a district heating network served by gas-CHP will depend on the ability to site an energy centre such that it is possible to sell a

significant proportion of the electricity directly to a major consumer.

- Planners should ensure that all development in close proximity to the suggested networks is compatible with connection.
- Planners should explore the option of establishing an local development orders in order to add certainty to the development process and potentially speed up delivery.
- The Council should commit to connecting its own buildings to the network in order to provide the 'anchor load' for any scheme.
- The Council will need to use its influence both in terms of planning policy (for new developments) and as a major landowner (for existing buildings) in order to encourage others to connect to the network.
- Bath Centre Network

  The Bath Central cluster is likely to require greater involvement and investment from B&NES to take it forward. The Council will need to use its influence as a major landowner in the city to act as a long-term customer, supporting a critical mass of heat demands which make establishing the network viable.

  The low rates of return suggest that private investment interest is unlikely to be high and therefore B&NES would need to find the majority of the capital to fund the scheme. This money could potentially be sought from low interest loans that could be paid back using the profits generated, funding from the community energy fund or government/European funds aimed at promoting low carbon energy infrastructure.

  The likely delivery model would require a vehicle which would involve the local authority working in partnership with a private ESCo. Potential links with community groups should also be explored, particularly Bath Community Energy Ltd who could be well placed to provide a mechanism for developing the client base.

  Crucial to the technical viability of this scheme will be understanding more about the constraints relating to the vaults and other historical and archaeological sites in this location.

- Bath Riverside Network(s)

  These network options are based on the creation of an energy solution for the whole area, as opposed to requiring each of the developers to delivery their own strategies in isolation. In theory this approach benefits all parties since it should prove to be more cost effective for the developer and provides a holistic solution for the local authority with the potential for addressing emissions from existing buildings as well

  The assessment suggests that, if developer contributions can be secured, that the scheme could achieve a level of viability that would be attractive to investment. However, the technical and commercial viability will depend heavily on the timing of the different sites coming forwards and the ability to obtain and co-ordinate funding contributions from developers. The Council's role in taking forward this opportunity would be to ensure that a wider view is taken on the masterplanning of this area in regards to energy infrastructure. This would help the development sites to meet the stringent energy standards of forthcoming building regulations in a cost effective way as well as providing the infrastructure to help to address CO_2 emissions from existing buildings.

- Keynsham Network

  The Keynsham network has a high level of commercial viability and if incorporated into the Town Hall redevelopment offers a good return on the capital investment although the scale of the scheme is smaller than the other networks and therefore the reductions in CO_2 emissions are smaller.

The Council is in a strong position to lead on the implementation of a relatively small-scale district heating network linking the new Town Hall to the Riverside Centre and enable potential expansion which could be facilitated by the proposed redevelopment of the High Street

The delivery model for this scheme could have a much greater level of Council involvement. This would give the Council greater control over the system and would enable the financial benefits to be taken by the authority.

Introduction, Background and Context to this study

1 Introduction, Background and Context to this Study

This study has been commissioned to support Bath and North East Somerset Council in assessing the potential for district heating within the district. It supports local planning policy and identifies potential projects that could be investigated further.

Bath and North East Somerset Council (B&NES) have commissioned AECOM to identify locations within the district where district heating could potentially be both technically feasible and commercially viable. Opportunities based around both existing buildings and potential future developments have been considered.

1.1 The need for a district heating feasibility study

The challenge of climate change, and the need to reduce greenhouse gases and stabilise carbon dioxide (CO_2) in the atmosphere has intensified. There is now a comprehensive range of legislation and policy at all levels of government which supports the development and implementation of decentralised, low carbon and renewable energy policy and targets.

Planning Policy Statement 1: Delivering Sustainable Development (PPS1) (2005) places an emphasis on promoting more sustainable development. The PPS1 Supplement expects local authorities to provide a framework through their local development planning documents to encourage the uptake of decentralised, low carbon and renewable energy generation.

The Council has already undertaken a high level capacity study looking at renewable energy and decentralised energy technologies in the district.[1] District heating is identified as a potentially effective means of providing low carbon energy in the district, however further evidence is needed to justify a policy approach within the Core Strategy of the Local Development Framework.

An initial feasibility assessment and identification of the most promising opportunities is also required to give the Council a basis on which to consider undertaking more detailed investigations into district heating projects. It can also provide the impetus for capacity building within the Council and with other key stakeholders.

1.2 Overview of district heating

District Heating Networks (DHN) (also sometimes referred to as Community Heating) supply heat via hot water via a network of insulated pipes. Systems are also often referred to as District Energy Networks, as they often also involve the delivery of electricity and/or cooling within separate networks of pipes and wires.

The network of hot water pipes is linked to one or more energy centres, typically containing a combination of energy generating technologies. Heat (and potentially cooling) from the network is transferred to individual properties through a heat exchanger, or Heat Interface Unit (HIU), and then used in a separate conventional heating (or cooling) system, controllable from within the property. Heat meters are usually used to measure the amount of energy that is taken from the network for billing purposes.

[1] Bath & North East Somerset Council Renewable Energy Research and Planning, Camco Advisory Services, June 2009 and update 2010

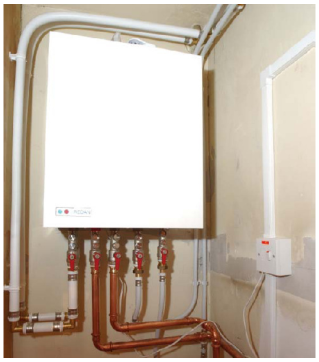


Figure 1: A heat exchanger inside one of the flats connected to the Aberdeen district heating network (Source: Aberdeen City Council: a case study of community heating CE65, Energy Saving Trust, 2003)

There is currently no system of regulation for heat networks so the generation, distribution and supply of the heat is usually owned either by the building owner or a private Energy Services Company (ESCo). More information on the structure of an ESCo and different types of models is provided in Section 5.

District heating networks can be applied at a variety of scales from a few buildings to whole cities. In the UK there are numerous examples, including various schemes across Council housing estates, university campuses, hospitals as well as city-wide schemes such as those in Birmingham, Southampton, Pimlico, Sheffield and Nottingham. Even larger schemes exist outside the UK. For example the Copenhagen district heating network has the heat generating plant located up to 40km outside the city centre. Within Bath itself there are two existing district heating networks, located at Bath University and Royal United Hospital, as well as smaller scale system at a Somer Housing owned site in Balance Street.

District heating generally helps to deliver energy more efficiently because the system can run at relatively constant levels, smoothing out the demands of the various buildings, although to some extent this is mitigated by losses across the network. Similarly the ability to consolidate heat supply, together with the ability to bulk buy fuel, means that district heating can often provide cheaper energy, although the savings are to some extent offset by operational and maintenance costs. An example of a system that provides reduced fuel costs is the scheme in Birmingham which is able to offer customers a 10% reduction in utility bills.

Reduction in CO_2 emissions can be achieved more easily with district heating schemes because of the ability to incorporate low or zero carbon technologies which are often not efficient or effective at smaller scales. It also enables strategic connection to waste heat from industrial or other sources and/or connection to energy from waste systems. The following table shows the CO_2 emissions associated with different fuels, taken from SAP 2009[2]:

Fuel	CO_2 emissions ($kgCO_2/kWh$ delivered)
Gas	0.198
LPG	0.245
Heating Oil	0.274
Grid Supplied Electricity*	0.517
Wood Chips	0.009
Wood Pellets	0.028

**These figures are projected to reduce over time in line with the Government's plans to decarbonise the generation and supply of electricity from the National Grid*

The actual CO_2 and cost savings from using a DHN compared to individual systems are dependent on the type of system, the fuel used and the scale of energy generation. To maximise both the CO_2 reductions and cost savings the system needs to be efficient, minimising the extent of the network but delivering as much energy as possible. This therefore favours location where the density of heat demand is high.

---

[2] The Government's Standard Assessment Procedure for Energy Rating of Dwellings (2009, with corrections May 2010)

1.3 The benefits of district heating

District heating can potentially offer a number of benefits to Bath and North East Somerset, these are outlined below:

1.3.1 Delivering reductions in CO_2 emissions from the public and private sectors

District heating can deliver significant reductions in CO_2 emissions compared to individual heating systems. The scale of the CO_2 reductions will depend on a number of factors, primarily the technology used on the network and the systems that it replaces. This is discussed further in section 1.4.

There are a number of key drivers pushing Bath and North East Somerset Council to address CO_2 emissions from their own activities and across the district as a whole. The key driver is the Bath and North east Somerset Sustainable Community Strategy, which has set the goal of delivering a 45% reduction in carbon emissions across the district by 2026.

Another key driver is the CRC Energy Efficiency Scheme (EES), a mandatory carbon trading scheme designed to encourage large organisations to manage energy consumption and emissions. The scheme is designed to create a shift in awareness, behaviour and infrastructure. Participating organisations will be ranked in a league table for their sector, depending on their performance in reducing carbon emissions. They will also receive either a financial penalty or reward depending on where they are ranked in the table.

Connection to the network may also help other businesses to meet their own commitments to CO_2 emissions reductions. In particular it could enable colleges and universities to meet future Higher Education Funding Council for England (HEFCE) targets required to secure capital investment funding.

1.3.2 Enabling new development to meet forthcoming energy requirements

Connection to district heating networks would provide developers with a more straightforward and potentially cheaper solution for meeting the increasingly stringent energy performance standards of the current (and forthcoming revisions) of the Building Regulations as well as higher standards of the Code for Sustainable Homes (CSH) and BREEAM.

Building Regulations targets for energy consumption and CO_2 emissions associated with new buildings are being tightened, with the government set to require all new dwellings to be ‘zero-carbon’ by 2016 and for all new non-domestic building to achieve this standard from 2019.

These increasingly difficult targets are likely to have a significant cost impact as they will require buildings to optimise additional fabric and energy efficiency measures as well as install decentralised, low and zero carbon (LZC) technologies in order to achieve compliance. In this context connection to a district heating network could be a much more cost effective option of achieving compliance than an alternative strategy involving extensive on-site LZC technologies.

Building Regulations 2010 will come into force on the 1st October 2010 and will require new buildings to achieve a 25% improvement in CO_2 emissions compared to the 2006 baseline. For residential buildings this will be a flat rate (i.e. all building will have the same target) but for new non-residential buildings it will be an aggregate target (i.e. the target will vary depending on the building type but on aggregate a 25% improvement across all types is expected).

In 2013, another revision of Building Regulations is planned which will further reduce in the CO_2 emissions rate from new buildings with a 44% improvement on the 2006 baseline required. This will place a greater emphasis on improving fabric and energy efficiency standards but it will also force the use of high proportions of LZC technologies.

The revisions of Building Regulations in 2016 (for dwellings) and 2019 (for non-domestic buildings) are expected to require a ‘zero carbon’ standard to be achieved. The proposed approach suggests that this should be achieved through three steps, Energy Efficiency (covering the building fabric), Carbon Compliance and Allowable Solutions.

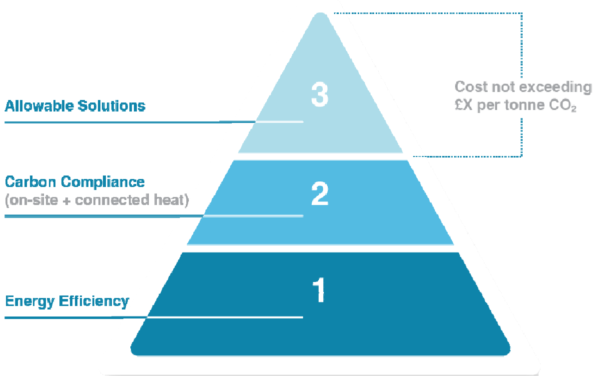


Figure 2: Proposed Zero Carbon Methodology

The mandatory Energy Efficiency requirements are not yet finalised but a Task Group from the Zero Carbon Hub has proposed that this cover only space heating and cooling from building fabric elements using an energy consumption metric (kWh/m^2/year).

The Carbon Compliance requirement has been set so that, in combination with the Energy Efficiency improvements it will deliver a set target reduction (still to be decided) compared to the 2006 Building Regulations Target Emission Rate (TER). This will require either more fabric or other energy efficiency measures, onsite low or zero carbon energy technologies or connection to low carbon sources of heat or electricity.

Allowable Solutions will cover the remaining carbon emitted from home for 30 years (including unregulated emissions not previously covered by Building Regulations). Exactly what mechanisms will be allowed is still to be defined but could include:

- Additional Carbon Compliance
- Use of energy efficient appliances
- Advanced building control systems
- Exports of low carbon or renewable heat
- Investments in community heat infrastructure

The final option potentially opens the possibility for the Local Authority to create a fund to capture the payments under the allowable solutions requirement to use on low carbon energy infrastructure in their area. This money could therefore potentially be used to fund district heating networks.

1.3.3 Providing energy security

A decentralised energy system can provide greater security over both the price and supply of energy.

The increased buying power of an ESCo purchasing energy for multiple customers affords better protection against price fluctuations in the marketplace and is better placed to get better deals on energy prices.

The flexibility of a decentralised energy network enables additional and different energy generating technologies to be added and the proportion of heat delivered by each to be varied. This offers the potential to alternate between different fuels, such as gas and biomass, to get the best fuel prices and financial returns as prices and financial incentives change over time.

In a similar vein, the flexibility of the system and the ability to switch between fuels will provide an element of security of supply and greater control to energy delivery. Given future predictions on energy supply and demand this could be an attractive proposition to both the Council and other key energy users in the District.

1.3.4 Delivering practical benefits

District heating systems offer a number of practical benefits to buildings that are connected. By offsetting the need for plant rooms they can potentially free up space. For new buildings it will reduce the area required for plant within each building, thereby increasing the potential lettable/usable floorspace.

By replacing or offsetting the need for individual plant, connection to a district heating network means that flues are also not required for each building. This is of particular interest in Bath because it means that the facades of existing buildings, or new buildings within conservation areas, do not need intervention.

1.3.5 Deliver reputational benefits for the Council and the District

The deployment of a low carbon energy infrastructure network within the district could be the catalyst to attract investment to the area. The improved performance of buildings on the network may help to increase values or rental rates in these areas.

As well as reducing costs and CO_2 emissions, connecting Council buildings to a district heating network served by LZC technologies would have a significant impact on the Energy Performance Certificates and Display Energy Certificates for those buildings.

1.4 Low and Zero Carbon Energy Technologies

As noted above, the level of CO_2 savings that can be realised from a district heating system will depend upon the technology that is used to provide the heat. Most DHN schemes in the UK using low and zero carbon energy technologies (LZCs) use either gas-fired Combined Heat and Power (CHP) or Biomass Boilers. However there are other schemes that use waste heat from power stations or incinerators (Nottingham), geothermal energy (Southampton) or biomass or biofuel CHP (proposed at the Hanham Hall development near Bristol). The inherent flexibility of a district heating network allows additional technologies to be added, either as additional plant within the energy centre(s) or in new energy centres connected to the network at a different point.

1.4.1 Combined Heat and Power (CHP)

CHP technology is an efficient way to deliver energy. Fuel is used to generate electricity but the heat from the process is also captured to generate hot water. Electricity that is produced and used locally is much more efficient than electricity supplied from power stations, which do not normally utilise the waste heat generated and have high losses associated with transmission of power over the national grid.

Predominantly CHP systems use gas and are therefore classified as a 'low carbon technology' rather than a 'renewable technology', however some systems are now available that use biomass or biofuel, thus qualifying as renewable. The following diagram demonstrates the benefits of CHP (right side) over standard energy services delivered from individual boilers and the national grid (left side):

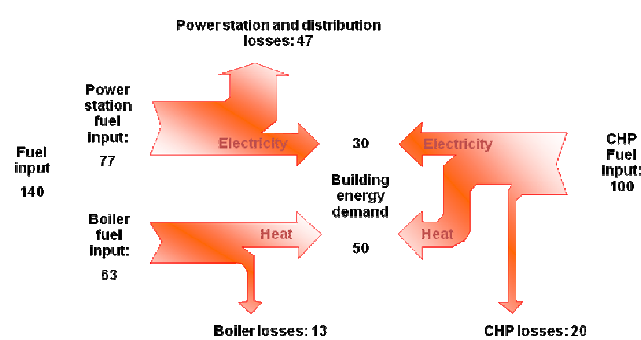


Figure 3: Energy flows from the use of CHP relative to standard utility provision

With CHP systems, the CO_2 savings and financial benefits are primarily derived from the production of electricity. However, the production of electricity by the systems is linked to the production of heat and the limiting factor for most systems will be the level of heat demand on the network. Systems should be sized to meet the base heat demands and avoid overproducing and dumping excess heat in order to generate more electricity.

CHP systems can adjust their output to follow the heat demand, but it is preferable for them to operate against a relatively stable demand. This is achieved by both sizing the CHP correctly and ensuring it has a sufficient base heat load to operate against by combining buildings on a heating network with different energy profiles. A CHP system can be an expensive item of plant so it is necessary to run the unit for as long as possible in order to maximise the financial (and emission reduction) benefits. Additional ways of using heat (such as absorptive cooling) and ways of storing the heat (using thermal storage vessels) can all help to increase and stabilise the heat demand thus increasing the electricity generation and therefore the CO_2 savings and financial benefits.

Large communal systems are usually able to provide cheaper utility costs arising from the large scale delivery of CHP across a range of buildings with varying energy profiles which combine to create a good base load for the CHP. Savings are further enhanced by the ability to bulk buy fuel, although there are additional costs for management, operation and billing which offset a proportion of these savings.

Ideally, a system would have at least 4,500 run hours per year for a reasonable return on investment. This equates to around 17.5 hours per day five days per week, or 12.5 hours per day every day of the year. CHP is therefore most effective when serving a mixture of uses, which guarantees a relatively constant heat load throughout the day and night.

Figure 4 Energ100kWth, 70kWe gas-fired CHP plant, installed at Highbury Stadium redevelopment, London.

Another contributory factor to the economic viability of CHP is the difference between the cost of electricity and gas, referred to as the “spark gap”. The greater the cost of electricity over gas is, the more likely a CHP installation is to be viable.

The potential for district heating powered by CHP can be assessed at a high level by setting a threshold heat density above which schemes become viable. Previous research into the economics of district heating and CHP has suggested that a threshold of 3,000 kW/km^2 can give financial returns of 6%, which is below typical commercial rates of return but greater than the discount rate applied to public sector financial appraisal.

A standard, gas-fired CHP typically achieves a 35% reduction in energy usage compared with conventional power stations and gas boilers. CHP can also be run using biomass or biogas to provide reductions in CO_2 emissions nearing 100% and in this setup can therefore be counted towards renewable energy targets.

It is worth noting that the benefits of gas-fired CHP with regards to reducing CO_2 emissions will reduce over time as the CO_2 emissions associated with grid electricity fall. The Department for Energy and Climate Change (DECC) have set out the projected emissions from different fuel sources including electricity from the national grid up to 2050[3]. This shows a substantial drop in the predicted CO_2 emissions from grid electricity over the next 40 years, as power generation changes to cleaner and greener forms of electricity generation.

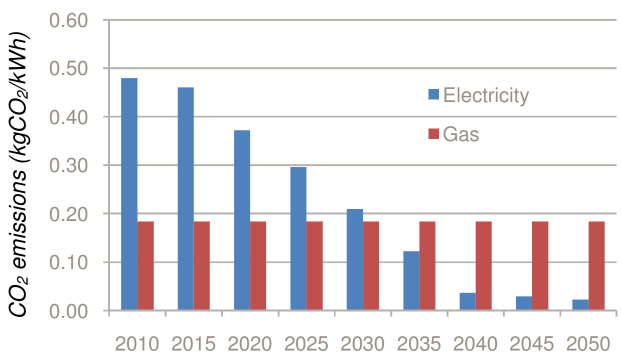


Figure 5 Graph showing the projected CO_2 emissions ($kgCO_2/kWh$) from gas and grid electricity to 2050 (DECC)

If these reductions are realised then the CO_2 emissions savings from the use of gas-CHP will decrease over time and become negligible around 2030. This issue could be addressed using one of the alternative fuels/technologies discussed below.

1.4.2 Biomass heating

Biomass heating is based on the use of a boiler just as standard heating technologies; however it uses wood fuel instead of fossil fuel as the source of energy. Wood fuel comes in a number of different forms, each with different characteristics. Chips can be obtained from arboriculture waste or other wood waste streams and are often cheap and locally available but can often be of variable size, shape and moisture content. This can affect the efficiency of the heat produced. Pellets made from compressed saw dust usually have much lower moisture contents and higher calorific value than chips but tend to have higher processing and transportation requirements. Logs can also be used but are very rarely used for systems larger than stoves serving individual domestic dwellings.

[3] Valuation of energy use and greenhouse gas emissions for appraisal and evaluation (DECC, June 2010)

Biomass boilers come in a variety of capacities (rated in kW). The main difference between biomass boilers and conventional gas boilers is their considerably larger physical size and thermal inertia. Because of this they are normally designed to meet the base heat load for space and hot water with gas back-up to cover the peak loads. This arrangement means that the majority (around 80%) of energy use for heating and hot water can be met using biomass. Although wood fuels do have a CO_2 emission factor (0.09 - 0.028$kgCO_2/kWh$ depending on the type of fuel) to account for processing and transportation, this is much lower than the factor associated with gas (0.198$kgCO_2/kWh$) and therefore the use of biomass can result in considerable CO_2 savings.

The use of biomass can have air quality implications which are associated with its higher nitrogen oxides (NO_x) and particulate matter (PM_{10}) compared to conventional gas boilers. Biomass boilers also have significant space requirements for plant and fuel storage. Access is needed for fuel delivery. A large fuel demand can require regular HGV deliveries, with impacts on roads and sensitive receptors nearby. The fuel costs can also be higher than for a gas system depending on the fuel used.

The following list of biomass suppliers within 30 miles of Bath has been taken from the South West Woodshed website[4].

Supplier	Detail	Fuel	Distance to Bath
Admiral Tree Services	13 Larkhall Terrace, Larkhall, Bath, BA1 6RZ www.treesurgerybath.co.uk 01225 338864	Chips	Within Bath
Branch Walkers	29 St Edyth Road, Sea Mills, Bristol, BS9 2EP www.branchwalkers.co.uk 01179682361	Chips	17 miles

[4] http://www.southwestwoodshed.co.uk/index.php/search

Forever Fuels	Nationwide but have a supply base in Avonmouth. Quote £180/tonne ex del www.forever-fuels.com	Pellets	20 miles
Boomeco Limited,	Unit 1, Q Park, Bath Road, Woodchester, Glos, GL5 5HT www.boomeco.co.uk 01453 873773	Chips	25 miles

Table 1: List of local biomass suppliers

A study commissioned by B&NES, The Renewable Energy & Planning Research - Update (CAMCO, 2010), proposes setting targets for the amount of energy generated annually by biomass heating and by biomass CHP with linked targets for the amount of installed capacity within the district.

The report indicates that the current biomass resource in B&NES will be able to supply the fuel to meet the majority of projected fuel demands through the LDF plan period. The report makes recommendations regarding the promotion of wood-fuel supply chains locally and making the most of the available resources.

The use of biomass may also qualify for the proposed Renewable Heat Incentive (RHI). The consultation document proposed that large-scale Biomass systems of 500kW or more (which would be the likely size of systems used on a DHN) would be eligible for a generation-linked payment of between 1.6-2.5p/kWh. However, although the proposals to introduce the scheme were retained in the recent Spending Review (October 2010), there is still uncertainty on the levels of the tariff and the technologies that will be supported.

1.4.3 Other technologies

The flexibility of a district heating network allows additional technologies to be added to the system over time if it makes technical and commercial sense to do so. These could include:

<u>Geothermal energy</u>

This is of particular relevance to Bath, which has a number of hot springs within the city. We understand that previous studies have looked at the potential to extract the heat from the springs and indeed this has been implemented in the past at the Guildhall and the baths. However we understand that the success has been hampered by high mineral content of the water, which has had a significant effect on the lifespan of the heat exchangers used.

It is not within the scope of this study to review the technical or financial potential to use energy from the springs. Further information on the potential of this resource is contained in the CAMCO report.

<u>Waste incineration</u>

Incineration is a means of releasing the energy in waste through combustion at high temperatures. This can reduce the amount of municipal solid waste sent to landfill by 90% and generates useful amounts of heat and electricity. With current technology, around 100,000 tonnes of municipal solid waste can provide 7MW of electricity. Incinerators produce large amounts of waste heat. This can be a resource when it is exported to nearby buildings/consumers. Energy from Waste schemes with CHP are now eligible for Renewable Obligation Certificates (ROCs), providing additional financial incentive.

Incineration plants typically operate on large scales and require large plant resulting in significant land take. Incinerators are also normally accompanied by tall stacks which may constitute a significant impact on both landscape character and visual amenity. Incineration plants are regulated by the EU Waste Incineration Directive which sets emissions limits for many substances. Air quality is a material planning consideration and can be an issue of great public concern. Detailed emissions studies will be required along with careful stack design and management. Incineration plants can handle large amounts of waste requiring regular delivery access. Good transport links are important although site traffic should be constrained to operations during only daytime hours, where possible.

Because of the quantity of waste handled, incinerators are good candidates for integration with rail and water transport networks.

Pyrolysis and gasification:

Pyrolysis and gasification are novel methods for extracting energy from municipal solid waste. Both operate at high temperature in a reduced oxygen environment turning waste into useful resources.

Pyrolysis produces syngas which can be used to generate electricity while other chemical compounds are bound in a char. The binding of these chemicals helps reduce emissions and leaching to the environment and the char can be used as a fertiliser. Gasification operates at higher temperatures with some oxygen. It produces a gas along with an ash residue with little calorific value.

These thermal treatments currently have a small market penetration but are becoming increasingly common, partly due to the EU landfill tax. Costs remain high but are expected to reduce as their development continues. Pyrolysis and gasification have similar site constraints to waste incineration but may be able to run at slightly smaller scale, meaning land take may not be as great.

Anaerobic digestion

Anaerobic digestion is a biological process for the treatment of organic waste. It requires separation of the biodegradable (or putrescible) waste stream. The process produces a gas which is methane rich and can be used for energy production. It also has a liquid by-product that can be used as a fertilizer and the solid, fibrous fragment can be used as a soil conditioner

Anaerobic digestion has been applied on a small scale in the UK, processing sludge, agricultural and industrial waste. Larger scale facilities are active across Europe and North America accepting a greater range of organic feedstocks including parks waste. A few of these types of facilities are now operational in the UK (e.g. Greenfinch, Shropshire) and others are being planned. Many existing Waste Plans refer to anaerobic digestion as a future waste treatment option.

Anaerobic digestion is thought to be generally viable at smaller scales than some of the thermal waste treatment processes but would still result in significant land take due to requirements for waste storage, vehicle turning etc. Odours from decomposing waste can become a nuisance so typically as part of an anaerobic digestion facility there would be a requirement for enclosed waste storage. The digestion process itself is also enclosed and emissions to the atmosphere are controlled.

Fuel Cells

Like CHP engines fuel cells produce heat and power and can be linked to district or communal heat networks. They are similar to batteries in that they produce electricity from a chemical reaction. However, whereas a battery delivers power from a finite amount of stored energy, fuel cells can operate indefinitely provided that a fuel source is continuously supplied. Most fuel cells operating today use natural gas which is reformed to produce hydrogen.

There is debate as to whether electricity generation from hydrogen is better than generating electricity directly from renewable sources such as PV and wind. The virtue of fuel cells is that they guarantee continuity of supply and clean, quiet and very efficient electricity generation. The ratio of electricity production versus heat is also better than from CHP engines meaning fuel cells can deliver better levels of carbon reduction.

The capital cost of fuel cells is currently much higher than most other competing low and zero carbon technologies. Commercial models currently available cost approximately £3,000/kW. Fuel cell prices are expected to drop in the next decade with further advancements and increased manufacturing volumes.

1.5 Bath and North East Somerset in context

There are over 74,500 dwellings within the district and a non-residential buildings ground floor area of over 500,000m^2. Around 48% of the population live in the city of Bath and the other major conurbations are Keynsham, Midsomer Norton and Radstock. The majority of the remainder of the district is rural and has a dispersed population.

The city of Bath is of considerable historic and archaeological importance. The city is a designated World Heritage Site and is therefore protected by UNESCO. It also has a significant number of conservation areas, listed buildings, scheduled ancient monuments and other historical designations.

New growth within the district is planned to take place predominantly within the existing urban areas, as outlined in the B&NES Draft Core Strategy. The Strategic Housing Land Availability Assessment (SHLAA) identifies future potential development sites which are primarily brownfield or urban infill. Within Bath there are a number of key developments planned along the river corridor extending west from the city. Within Keynsham there are plans to redevelop the Town Hall and Riverside Centre and masterplans have also been prepared for the potential redevelopment of the High Street and the Cadbury's factory at Somerdale. A masterplan has also been prepared for the potential redevelopment of the centre of Midsomer Norton.

More detailed local context is incorporated into the assessment of each of the potential clusters that are identified and reviewed in Sections 3 and 4.

1.6 Outputs and objectives of the study

The outputs of this study are as follows:

a) District Heating Opportunity Maps to assess the potential across the district;

b) Identification and analysis of 'Opportunity Areas' to assess and rank the relative potential of each;

c) High level technical feasibility assessment of potential projects within the key opportunity areas identified;

d) High level commercial viability assessment of potential projects within the key opportunity areas.

These outputs have two major objectives:

1. Support planning policy within the Local Development Framework to promote implementation of district heating within new developments as well as supporting strategic project opportunities to develop energy networks
2. Identify strategic opportunities that could potentially be taken forward to deliver district heating projects within the district.

1.7 Structure of the report

The remainder of the report is structured as follows:

Section 2 outlines our approach and methodology to producing the heat opportunity maps

Section 3 outlines our approach to identifying a 'long-list' of potential clusters within the district, our methodology and our results from analysing and ranking the clusters.

Section 4 presents the results of our technical and financial assessment of potential district heating network projects in each of the three key opportunity areas.

Section 5 outlines potential considerations and strategic actions for the implementation and delivery of district heating networks.

Section 6 presents the key district heating opportunity maps produced as part of the study

The appendices contain details of the stakeholder workshop, the assumptions that have been used in our calculations and modelling, a list of key contacts approached during the study and further details of sources of funding.

Reviewing the potential for district heating in Bath and North East Somerset

2 Reviewing the potential for district heating in Bath and North East Somerset

2.1 Introduction

In order to understand the potential for district heating systems within Bath and North East Somerset the first stage of the work focussed on mapping the heating demands and specific opportunities within the district to enable identification of those areas with the most potential for district heating.

2.2 Data collection

Data relating to heat demands and specific heating systems was collected from the Council, key stakeholders and from a desktop study.

The key data and sources used in the mapping exercise are shown in the following table:

Data	Source
South West Heat Map	RenewSW/CSE
Energy demands from public buildings (NI185 data)	B&NES
Energy demands from proposed buildings	AECOM
Locations of Hotels	AECOM desktop study
Metered data from key buildings	Various sources
Locations of Strategic Waste sites	B&NES
Locations of existing CHP systems	B&NES and AECOM desktop study
Locations of Public Buildings	B&NES
Location of biomass boilers (in schools)	B&NES

Table 2: Examples of some of the data collected and sources

2.3 Mapping heat demands

The primary factor that affects the viability of a district heating is size and proximity of the heating demands (please refer to Section 1 for more details). Mapping heat demands in terms of heat density (kWh/m^2) and presenting these as a density surface using graduated colours allows the areas with the largest heat demands in the closest proximity to be easily identified.

A study to develop a heat map for the South West region has recently been undertaken by CSE for RegenSW[5].

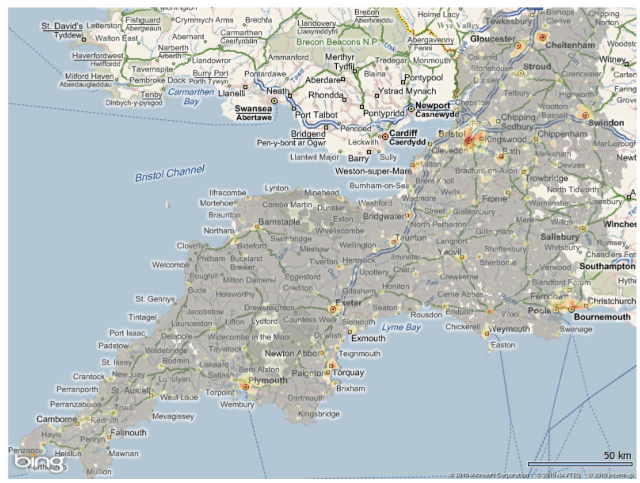


Figure 6 Image of the South West Heat Map (Image taken from the South West Heat Map website)

GIS layers have been obtained from RegenSW/CSE and overlaid onto base layers of the district provided by B&NES Council. The scale of the graduated colour system has been adjusted so that it more clearly presents areas of interest and excludes areas where the heat density is too low to be of any interest.

The locations of public buildings, from nursing homes to hospitals, have also been incorporated. Where available we have incorporated metered data obtained from B&NES Council and other sources. These have been presented as point sources on the map, with the icon sized relative to the scale of the demand.

[5] http://www.southwestheatmap.co.uk

2.4 Mapping other opportunities

Additional information was collected to identify the location of specific opportunities that could improve the potential to create district heating networks.

This includes existing infrastructure such as installed and forthcoming CHP systems, existing DH and communal heating schemes and biomass boilers. We have also indicated the location of specific key building types that tend to have high heat demands such as public buildings, hotels and leisure centres. These are often referred to as ‘anchor loads’ because, either by themselves or in combination, they provide a high and consistent demand for heat which can be crucial for getting a scheme up and running.

2.5 Proposed developments

In order to understand and map the heat demands from proposed new development within B&NES we undertook a modelling exercise.

The SHLAA was used to define the potential number of residential units and the size and type on non-domestic buildings. Using benchmarks and models we were then able to calculate the anticipated energy consumption and heat demands from these future buildings. These heat demands were then converted to a heat density for the proposed development site and added to the overall opportunity map.

Further details of the assumptions and methodology for this modelling are presented in Appendix B.

2.6 District heating opportunity maps

The following District Heating Opportunity Maps are presented in the Maps section of the report.

Map 1: District-wide DH Opportunity Map

Map 2: Bath City DH Opportunity Map

Map 3: Keynsham DH Opportunity Map

Map 4: Midsommer-Norton/Radstock Area DH Opportunity Map

The areas of highest heat demand are concentrated within the centre of Bath and to a lesser extent the market towns of Keynsham and Midsomer Norton.

2.7 Specific opportunities and constraint

To accompany the district heating opportunity maps we have collected data and maps to understand related opportunities and constraints in the local area. These are discussed below:

2.7.1 Air Quality

Bath has declared two air quality management areas (AQMAs), one of which covers a number of major roads within the city of Bath and the other is located in Keynsham.

This could potentially act as a constraint on the implementation of a district heating network because an air quality assessment would be required to demonstrate that the proposed scheme did not adversely affect local air quality. A large gas-fired CHP would have a greater concentration of emissions than lots of separate gas boilers over a wider area. Also since more gas is burnt in order to generate electricity as well as heat the total emissions are naturally higher.

The combustion of biomass has much higher emissions of NO_x and PM_{10} than gas. This is more pronounced with wood chips than pellets since they have a greater proportion of bark and the combustion is less efficient.

The use of biomass boilers or gas-fired CHP is likely to require air quality assessments, particularly in sensitive locations to demonstrate that the impact on local air quality does not result in breaches of the required concentrations.

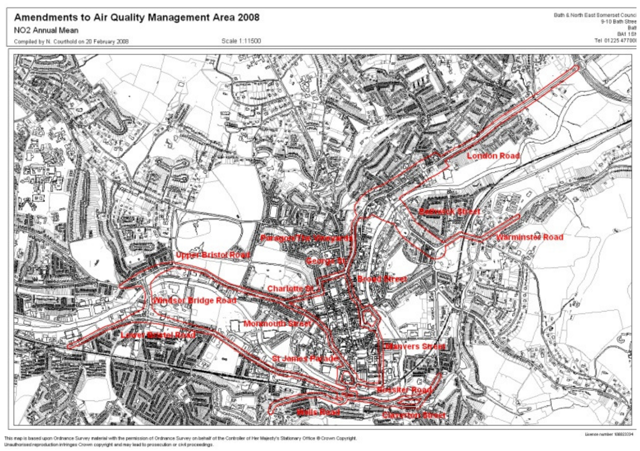


Figure 7 Map showing the extent of the AQMA declared for NO_2 in Bath (B&NES, 2008)

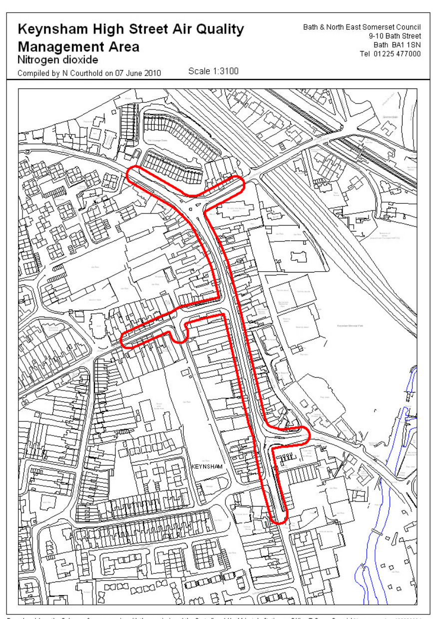


Figure 8 Map showing the extent of the AQMA declared for NO_2 in Keynsham (B&NES, 2010)

2.7.2 Avon Act

The Avon Act was passed in 1982 and was designed to protect the hot springs from development that could affect its flow. Our understanding is that developments within the area of the hot springs and which excavate below a specified depth can only take place if the flow of the springs is monitored. The effect of this requirement is that only one development can take place at a time to ensure that any impacts on the spring can be easily understood.

The location and depths of any network proposed in the springs will therefore need to be passed to the Avon Act officer at B&NES for assessment.

2.7.3 Historic Vaults

The centre of Bath has a significant number of vaults underneath the streets of varying ages. In many areas they will act as a constraint because the depth of excavation will be limited. We understand that in many places the utilities are located very close to the street surface already due to the limited available space. However, in other instances small underground vaults could be used to house the pipework, as is currently the case for the hot water pipes to the Thermae Baths.

The vaults are mainly located in the centre of the city around the baths and guildhall but also expand south and west. B&NES Property Services have build up a picture of the subsurface conditions and this information will be critical to informing the development of district heating networks.

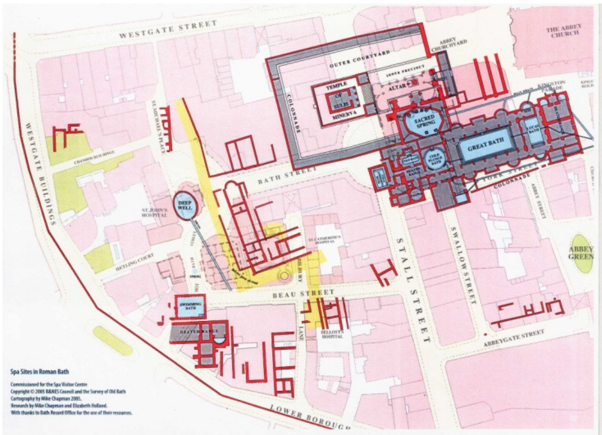


Figure 9 Image of the subsurface vaults and buildings below the Roman Baths

2.7.4 Archaeology and Scheduled Monuments

Bath also has a significant number of historical and archaeological designations, which could also potentially restrict the development of a network. Discussion with the archaeological officer at B&NES has suggested that by utilising existing utility corridors and other interventions, these constraints could be mitigated.