WARWICK DISTRICT HEAT MAPPING AND ENERGY MASTERPLANNING

REPORT

Prepared by :	Hannah James	Checked by :	Tom Lelyveld	Approved by :	Andrew Turton
	Senior Consultant		Associate Director		Regional Director

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5th Floor, 2 City Walk, Leeds, LS11 9AR

Telephone: 0113 391 6800 Website: http://www.aecom.com

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EXECUTIVE SUMMARY

Background

This report has been prepared by AECOM for Warwick District Council (WDC), using funding from the Department of Energy and Climate Change (DECC) Heat Networks Delivery Unit (HNDU). WDC are investigating the potential for district heat in Warwick District, with a view to applying for government funding for further studies and to set up a network, if opportunities exist.

This study (*Warwick District Heat Mapping and Masterplanning*) considers the potential for district heat networks (DHNs) in the district, and identifies five areas which may be particularly suitable. Indicative heat network designs have been tested for each of the five areas, to give an indication of the potential scale of capital costs, financial returns and carbon savings that they could deliver.

District Heat Networks

The standard approach to providing energy to buildings in the UK is relatively inefficient. Heat is usually generated at a building scale which means that only small scale technologies such as gas boilers can be used: limiting the use of other forms of low carbon heat technologies. Electricity meanwhile is generated at remote power stations where there are significant inefficiencies from the waste of the heat generated and losses in transmission.

District heating (DH) offers an alternative to this arrangement, generating and distributing heat at a larger scale to a number of buildings, and using a wider range of heat sources including waste heat and combined heat and power plants that bring the generation of energy closer to the point of use and in so doing provide significant carbon and cost savings.

District heat networks (DHNs) consist of a system of insulated pipes which distribute hot water from a centralised heat generation plant to a number of different buildings to provide space heating and hot water. Instead of individual boilers, each building has a heat interface unit which performs the same function. Schemes can range in size from a simple connection between two buildings to a network connecting entire cities.

The development of district heat networks in Warwick District offers many potential benefits to the district, including:

- Reductions in energy prices for businesses, individuals or organisations connected to the network;
- Reduced environmental taxes for businesses and public organisations;
- Increased security of energy supply;
- Protection against energy price fluctuations;
- Creation of employment opportunities and opportunities for local businesses to be involved in the supply chain;
- CO_2 emissions reductions.

Assessing the potential for district heating in Warwick District

Using Geographical Information Systems (GIS) mapping software and energy use data for buildings in Warwick District, areas of the district likely to be particularly suitable for district heat were identified. The following factors were taken into account:

- Total heat demand;
- Heat density;
- Presence of key anchor loads;
- Building ownership (e.g. public or private);
- Building energy demand profiles;
- Proximity to key opportunities and constraints;

- Potential for expansion;
- Social benefits; and
- Financial and practical viability.

A shortlist of clusters with particular potential for DH was identified. The clusters are shown in Figure 1 and are in the following areas:

1a and 1b) Warwick town centre (two areas)

2) Myton

3) Whitnash

4) Leamington Spa riverside area

5) Lillington

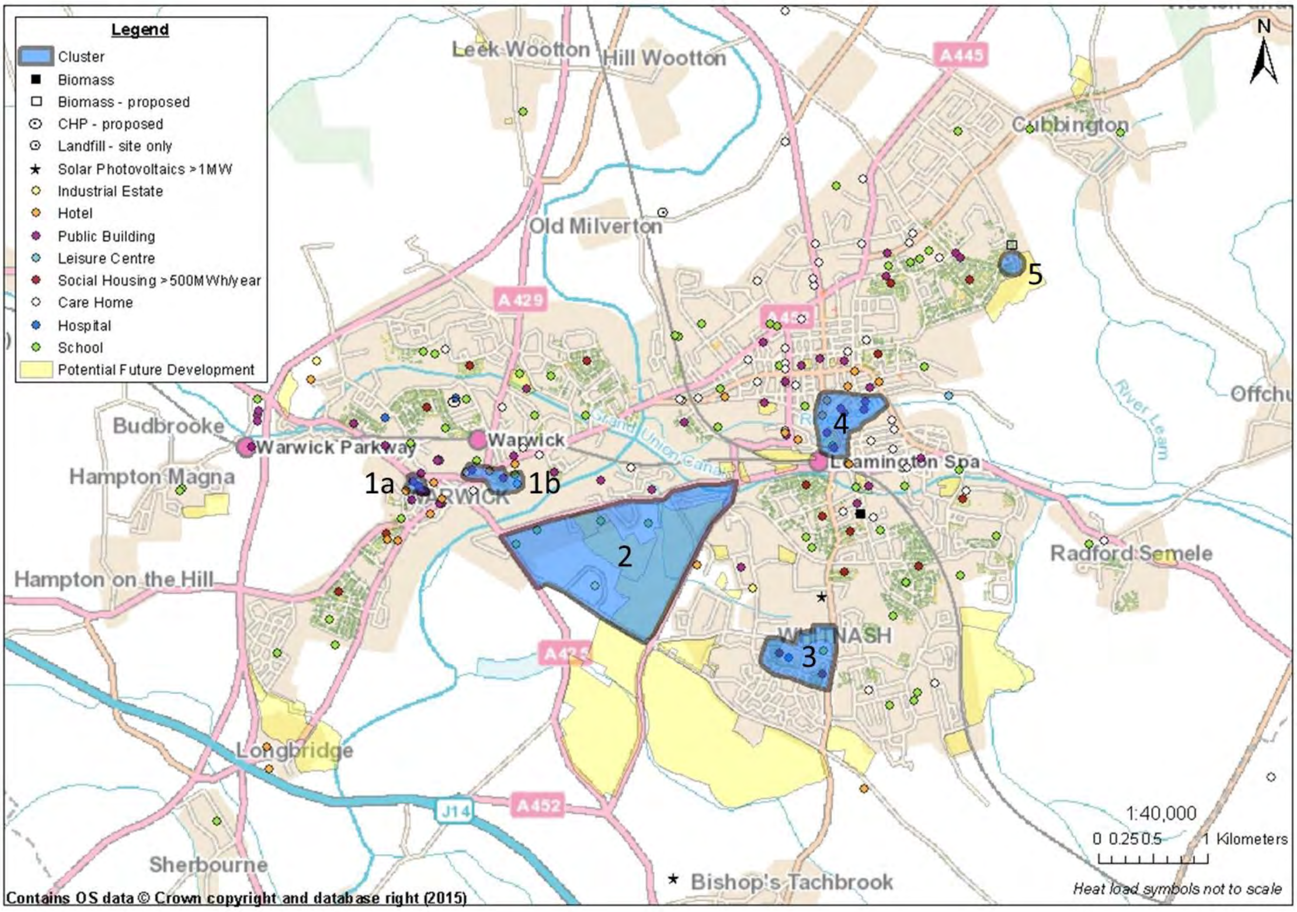

Figure 1. Potential opportunity areas for district heating in Leamington Spa and Warwick town.

Technoeconomic analysis of network opportunities

An indicative heat network outline was produced for each cluster, based on the maps produced and information gathered during the short listing phase. Potential carbon savings, capital costs, IRR[1] and NPV[2] for each network were modelled to give a preliminary idea of feasibility.

A summary of the tested network proposals with the results of the indicative technical and financial assessments is shown in Table 1. Network scenarios for Warwick Town Centre, Myton and Whitnash achieved 25 or 40 year IRRs of over 6%, the level at which a scheme may be expected to attract public funding. A scenario using gas CHP (with private wire) for Whitnash achieved an IRR of over 10%, the level at which a scheme may be expected to attract private funding. Network concepts for Whitnash were developed based on benchmarked assumptions around the energy demand from future developments, whereas those for Myton and Warwick Town Centre were based around existing buildings.

The results show that there are some potential options for developing heat networks in Warwick District that could warrant further exploration. The Leamington Spa riverside area is recommended as particularly suitable for a more detailed feasibility study. While the projected IRRs achieved are currently lower than those for other areas, the technoeconomic assessment of the network concepts in that cluster were based on existing buildings, and many of the anchor loads are buildings owned or run by WDC. This may therefore represent a good opportunity for the Council to drive the development of a network in this area.

The Warwick Town Centre scenarios are based around several Warwickshire County Council buildings, and some WDC buildings, and may also therefore represent a good opportunity for local authorities to drive forward the development of district heat networks.

The Myton network scenarios were based largely around either commercial properties or schools, none of which fall under the Council's control. If engagement with potential network customers in this area indicates good levels of interest in connection to a DHN, a full feasibility study would be beneficial.

The network scenarios in Whitnash are based on assumptions regarding developments at Tachbrook Park and around Harbury Lane. While the technoeconomic analyses here suggest that there is the potential to develop a profitable DHN, greater certainty around the nature of the developments will be required to move to a detailed feasibility study.

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[1] IRR = Internal Rate of Return: the discount rate at which an initial investment breaks even (i.e. for an NPV of £0: see below).

[2] NPV = Net Present Value: the present net worth of a scheme taking into account future inflation and returns. The NPV in this report is calculated using a discount rate of 6%.

Technology option	Capital cost	25 year IRR	25 year NPV	25 year average CO_2 savings	40 year IRR	40 year NPV	40 year average CO_2 savings
Warwick Town Centre							
Gas CHP	£3,585,700	-	-£2,154,418	30	-	-£2,014,891	-19
Gas CHP with private wire	£3,585,700	4.2%	-£403,200	30	6.1%	£80,200	-19
Biomass	£3,551,900	-	-£1,837,500	711	-	-£1,946,700	695
Biomass with Gas CHP and private wire	£3,810,700	-	-£1,718,300	644	-	-£1,765,100	617
Myton							
Gas CHP without private wire	£13,415,200	3.7%	-£1,840,600	719	5.6%	-£352,200	383
Gas CHP with private wire	£13,415,200	6.8%	£1,151,100	719	8.3%	£3,265,400	383
Biomass	£15,360,100	-	-£4,780,600	5098	-	-£5,033,200	4987
WSHP	£13,560,600	9.5%	£2,423,500	3036	9.4%	£2,665,700	2938
Leamington Spa Riverside							
Gas CHP (excl. new Council offices)	£3,847,700	0.8%	-£1,248,400	175	3.3%	-£939,300	97
Biomass (excl. new Council offices)	£3,929,300	-	-£1,099,200	1098	-	-£1,164,400	1072
Gas CHP (incl. new Council offices with private wire)	£4,484,700	-	-£2,084,400	132	1.2%	-£1,834,400	49
Biomass and gas CHP (incl. new Council offices with private wire)	£4,953,100	-	-£1,557,900	917	-	-£1,575,300	818
Whitnash							
Gas CHP	£5,709,700	0.4%	-£2,048,200	89	3.2%	-£1,542,900	21
Gas CHP with private wire	£5,709,700	10.0%	£2,055,500	89	11.1%	£3,367,500	21
Biomass with gas CHP and private wire	£6,122,900	-	-£2,522,500	587	0.3%	-£2,383,100	422
Lillington							
Biomass tower blocks only	£1,865,500	1.5%	-£405,000	561	1.6%	-£421,300	552
Biomass tower blocks and Red House Farm	£2,048,700	2.8%	-£337,100	706	3.4%	-£322,200	693

Table 1. Summary of economic analysis results.

Funding and delivering heat networks

In addition to the financial benefits, the social, environmental, and indirect economic benefits of district heat networks can help to strengthen the case for their development:

- Reduced public and private spending on carbon taxes;
- Reductions in fuel poverty and improved energy affordability;
- Development of local skills, job creation and wider economic regeneration;
- Facilitating the delivery of development sites by providing low carbon energy infrastructure;
- Health benefits: reducing the risks of illness associated with living in inadequately heated homes; and
- Investment in local infrastructure improvements.

External funding can also reduce the rate of return required for a project to attract investment. Funding for projects in Warwick District could potentially be sought from the following:

- HNDU
- The Renewable Heat Incentive
- Enhanced Capital Allowances
- Local Authority prudential borrowing
- Community Infrastructure Levy
- Coventry and Warwickshire Local Enterprise Partnership European Funds
- Coventry and Warwickshire's Growth Hub

Under the National Planning Policy Framework, Local Authorities have a responsibility to contribute to the UK's emissions reduction targets and to facilitate local action. WDC has opportunities to drive delivery in the county by:

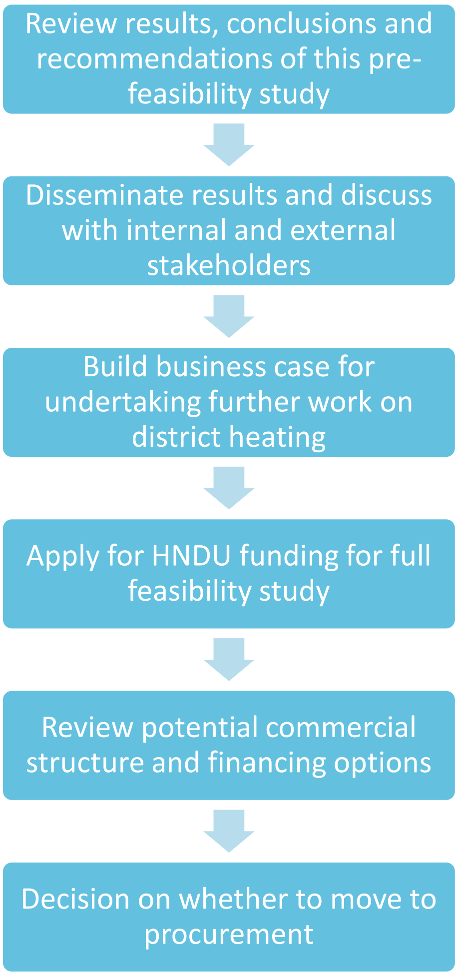
- Using planning policy to require new developments to contribute and/or connect to DHNs;
- Using Local Development Orders to extend permitted development rights across whole local authority areas or to grant permission for certain types of development.
- Committing to connect their own buildings to a network in order to provide the anchor load for any scheme, and enter into a long-term energy contract to reduce levels of risk and help to attract investment from third-parties.
- Investigating opportunities for establishing an SPV and/or ESCO to deliver and manage DHNs.
- Nominating Council members, staff and/or other stakeholders to act as 'champions' and drive delivery of planned schemes.

Conclusions and next steps

If WDC wished to pursue the heat network opportunities identified in this study then we would recommend that a detailed feasibility study be undertaken. Part funding for such studies is currently being offered by DECC through HNDU.

The detailed feasibility studies would need to include more detailed analysis of measured heat loads, detailed network design, different technology options and configurations and scheme governance. The accuracy of these and other key variables will be of critical importance to provide confidence in the commercial and environmental viability of district heating schemes. Further studies should begin to engage with potential customers and other stakeholders, and include market testing of potential network customers.

If the results of the detailed feasibility studies were to define a viable scheme and funding could be allocated to deliver the project then it would be possible to move the project to detailed design and procurement. Like other large infrastructure projects, heat networks are long-term projects and generally take around 3 to 5 years from initial concept to operation. The diagram below suggests a possible workflow for taking forward one or more district heating projects in Warwick District.



INTRODUCTION

01

INTRODUCTION

Background to this study

As part of its 'Fit for the Future' programme, Warwick District Council is working to devise cross-cutting solutions which increase economic equality for the district's residents, minimise the district's impact on the environment, improve quality of life, engage and strengthen communities and improve rural communities. There are ambitious plans for growth in the district. 16,876 additional homes will be needed by 2029[3], and the Council is committed to ensuring that they support the delivery of sustainable communities.

The goals of the 'Fit for the Future' programme must be met while the Council reduces its operational costs, in response to decreasing financial support from central government. One possible solution is the development of district heat networks, which have the potential to reduce energy costs and carbon emissions, while attracting investment and creating jobs in the area. Published in January 2015, *Warwick District Council's Strategic approach to sustainability and climate change* sets out an action plan to 2016, which includes a resolution to carry out heat mapping and energy masterplanning to identify opportunities for district heating networks. Warwick District Council has secured grant funding from the Department of Energy and Climate Change (DECC) Heat Network Development Unit (HNDU) for this study, which explores the potential for district heat networks within the existing and planned future urban areas of the District. This study focuses on the key planned growth areas in Warwick District which are the towns of Warwick, Leamington Spa, Whitnash and Kenilworth.

Benefits of district heat networks

The standard approach to providing energy to buildings in the UK is relatively inefficient. Heat is usually generated at a building scale which means that only small scale technologies such as gas boilers can be used: limiting the use of other forms of low carbon heat technologies. Electricity meanwhile is generated at remote power stations where there are significant inefficiencies from the waste of the heat generated and losses in transmission from the remote power station to point of use.

District heating (DH) offers an alternative to this arrangement, generating and distributing heat at a larger scale to a number of buildings and, depending on the generation equipment, also producing electricity locally.

District heat networks (DHNs) consist of a system of insulated pipes which distribute hot water from centralised heat generation plant to a number of different buildings to provide space heating and hot water. Instead of individual boilers, each building has a heat interface unit which supplies heat from the network to the local building distribution system performing the same function as a boiler. Schemes can range in size from a simple connection between two buildings to a network connecting entire cities. In some continental European countries the use of district heating is widespread – in Denmark around 60% of the country's homes are connected to heat networks including a scheme which supplies the whole of Copenhagen.

Generating and distributing heat at a district scale allows alternative and more efficient forms of heat generation to be used which would not be viable at a building scale, including the capture and delivery of waste heat from power generation, energy from waste plants and industry, or the transition to technologies such as combined heat and power engines and heat pumps.

The development of district heat networks within Warwick District offers many potential benefits to the area, including:

- **Reductions in energy prices** – increased efficiencies can lead to reduced energy costs for customers. This can mean improved competitiveness for local businesses and reduced energy bills and the alleviation of fuel poverty for households.
- **Local dividends** – profits from the sale of energy from district heating networks accrue to local authorities, communities, and/or businesses when they are stakeholders; rather than to national or international businesses.
- **Local economy** – the construction and operation of a network can create employment opportunities and opportunities for local businesses to be involved in the supply chain.
- **Increased security of energy supply** – the higher efficiencies combined with the ability to provide alternative forms of heat generation means that district heating can increase energy security and reduce reliance on fossil fuels.

[3] Warwick District Council Five Year Supply of Housing Land 2014-2019

- **CO_2 emissions reductions** – the combination of more efficient generation and the ability to use alternative technologies and fuels means that district heat networks can provide significant CO_2 reductions.
- **Emissions reductions in hard-to-treat buildings** – where retrofit of existing stock is challenging (e.g. for listed buildings), district heat provides an alternative method by which to reduce CO_2 emissions.
- **Reduced environmental taxes** – policies such as the Carbon Reduction Commitment (CRC) and the EU Emissions Trading Scheme place a value on CO_2 emissions (effectively a carbon tax) and it is expected that the effect of such policies may increase in the future as the pressure to reduce emissions increases and the cost of emitting CO_2 rises.
- **Opportunity to deliver CO_2 reductions in partnership with the private sector** – revenue opportunities from the sale of energy attract investment from the private sector, transferring some or all of the financial risk of projects from the public sector.

Overview of Warwick District

Warwick District is one of five local authority areas in the county of Warwickshire, and has an area of 28,288ha[4] and a population of approximately 140,000[5] which is projected to increase to nearly 160,000 by 2037[6]. It has a strong and diverse local economy, established by financial and business services, education, technology, advanced manufacturing and engineering. The District comprises of a mix of rural and urban areas and includes the towns of Warwick, Royal Leamington Spa, Kenilworth and Whitnash. It is bordered by the City of Coventry and rural areas of Solihull to the north, Stratford-Upon-Avon to the south and Rugby to the east. Figure 2 below shows the boundaries of Warwick District.

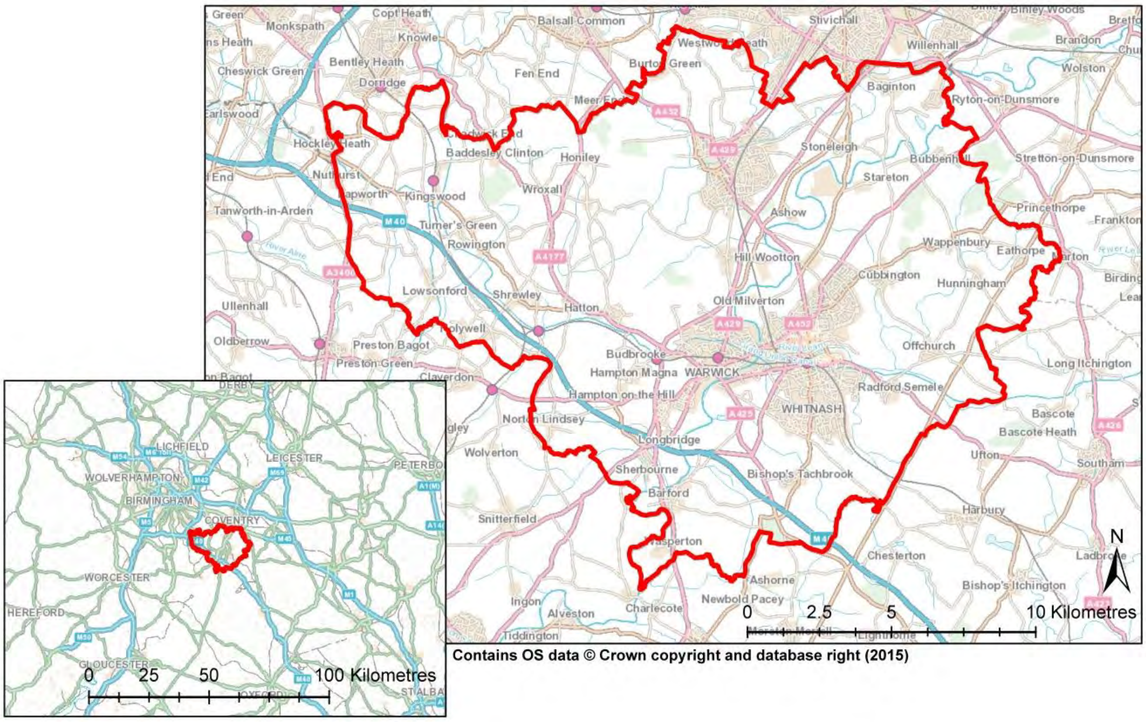


Figure 2. Location and boundary of Warwick District

In 2013, final energy consumption in Warwick District was 3,549GWh, with the majority of consumption from the transport sector, followed by the domestic and commercial sectors, as shown in Figure 3. Petroleum, gas, and electricity are the dominant fuel sources, as illustrated in Figure 4[7]. CO_2 emissions are similarly split between the three sectors, and have been falling over the last decade, as shown in Figure 5. The largest emissions reductions have been from the industry and commercial sector.

[4] Office for National Statistics (ONS), Standard area measurement for 2012 local authority districts (UK)
[5] Office for National Statistics (ONS), National and Local Authority Level Population Estimates
[6] Office for National Statistics (ONS), Subnational Population Projections 2012-based projections
[7] DECC Statistics, Sub-national total final energy consumption data 2005-2013

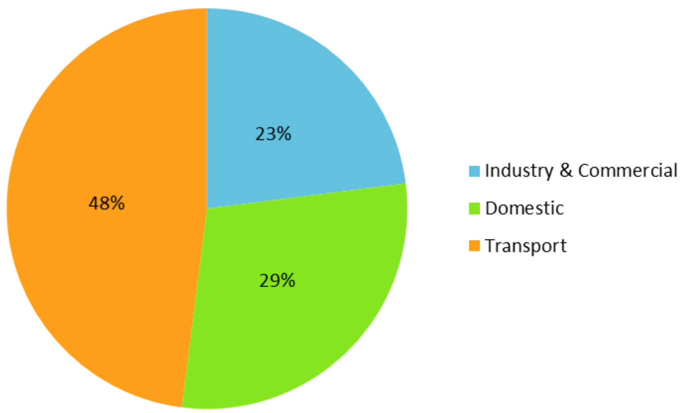


Figure 3: Final Energy Consumption (GWh) in Warwick District by Sector, 2013

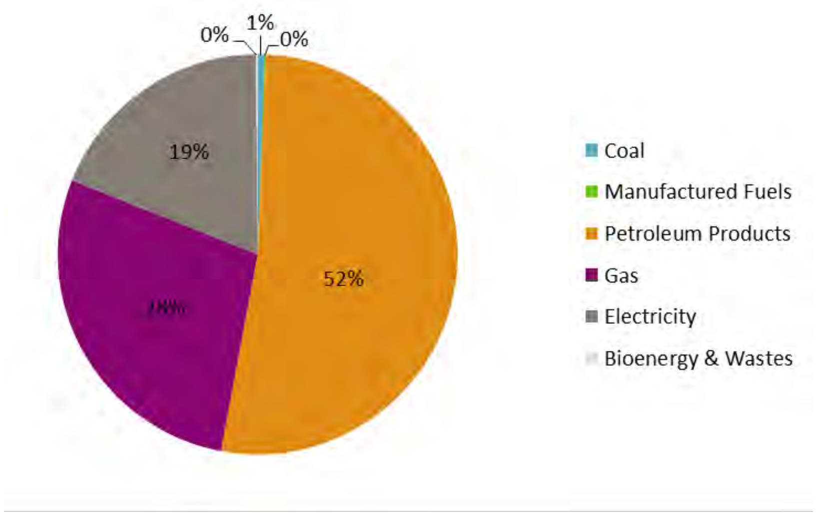


Figure 4: Final Energy Consumption (GWh) in Warwick District by Fuel Type, 2013

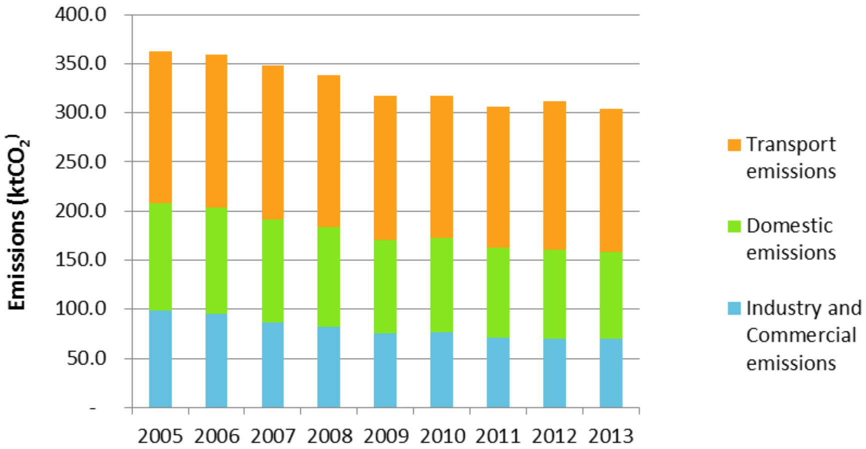


Figure 5: CO_2 emissions in Warwick District by Sector, 2005 to 2013

Policy context

This section sets out the key policies which drive energy efficiency and CO_2 emissions reductions and support the development of district heat networks in Warwick District.

International and National Policy

The key international and national policies relating to reductions in CO_2 emissions and the development of heat networks are summarised below:

The Kyoto Protocol is a legally binding agreement signed in 1997 mandating industrialised nations to collectively limit CO_2 emissions to 8% below a 1990 baseline between 2008 and 2012. In the absence of a legally binding international agreement to supersede Kyoto, the 1997 Protocol was extended to 2017 under the 2011 Durban Platform for Enhanced Allowance, which also allowed for a new legally binding agreement to be drafted before 2015 and enacted by 2020. The 2012 Doha Amendment established the second commitment period of the Kyoto Protocol, which began on 1st January 2013 and will end on 31st December 2020. The United Kingdom has not ratified the Doha Amendment.

EU CO_2 reduction targets. The UK is committed to meeting targets agreed between the European Commission and the Member States to reduce CO_2 emissions by 20% on 1990 levels by 2020.

The UK Climate Change Act (2008) established a legally binding target for the UK to cut CO_2 emissions by 80% by 2050 (against a 1990 baseline), with interim targets of 34% by 2020 and 60% by 2030. It is this primary legislation that is driving national regional and local policy on climate change.

The UK Heat Strategy (2013) sets out pathways for the transition to a low carbon heat supply. It sets out DECC's commitments to support local authorities in the development of heat networks in their areas through the establishment of a Heat Networks Delivery Unit, support for technological innovation, provision of funding for feasibility work, exploration of potential additional financial incentives and government funding for heat networks, and provision of a consumer protection scheme. Initial modelling undertaken by DECC suggests that heat networks could form an important part of the least cost mix of technologies by 2050, with the potential to serve 14% of domestic heating and hot water demand (41TWh) and 9% of non-domestic heating and hot water demand (11TWh) by 2050. It suggests that in the period to 2030 heat networks will predominantly be fuelled by gas Combined Heat and Power (CHP).

The National Planning Policy Framework (NPPF) sets out the Government's planning policies for England and stipulates how they should be applied through local planning policies. Local planning authorities are required to design policies which increase the use and supply of low carbon energy, have a positive strategy to promote energy from renewable and low carbon sources, support community-led initiatives for low carbon energy and identify suitable areas for low carbon energy sources.

The CIBSE Heat Networks: Code of Practice for the UK was produced in collaboration between the Association for Decentralised Energy (ADE), the Chartered Institution of Building Services Engineers (CIBSE) and industry partners to establish common standards for the development of district heating. Its aim was to establish minimum standards to ensure the conception, design, build and operation of efficient, cost effective district heating for all users. A public consultation on the draft Code of Practice (CoP) was issued in Autumn 2014 and the final version was published in July 2015. While the guidance in the CoP is not legally binding, many local authorities use it as a reference standard in design, procurement and implementation of heat networks in their areas, and it is frequently referenced in tender documentation.

Local Policy

The Draft Warwick District Local Plan will form the statutory development plan for the District, setting out the Council's policies which will be used to shape development of the District through to 2029. The draft plan stipulates that the Council will promote sustainable development and secure development that improves the economic, social and environmental conditions in the area, following the National Planning Policy Framework (**Policy DS5**). It calls for new development proposals to supply energy through efficient means and shows support for new low carbon and renewable energy technologies (**Policy DS3, SC0, CC2 and CC3**). Reference is specifically given to district heating systems as a means to increase efficiency and maximise opportunities to address the energy needs of neighbouring uses (**Policy CC2 and CC3**). Furthermore, the draft plan stipulates that proposals should ensure development is adaptable to climate change (**Policy SC0**).

METHODOLOGY

02

METHODOLOGY

Overview

The methodology used to identify areas of potential for district heating networks in Warwick District is summarised in Figure 6, and described in more detail below.

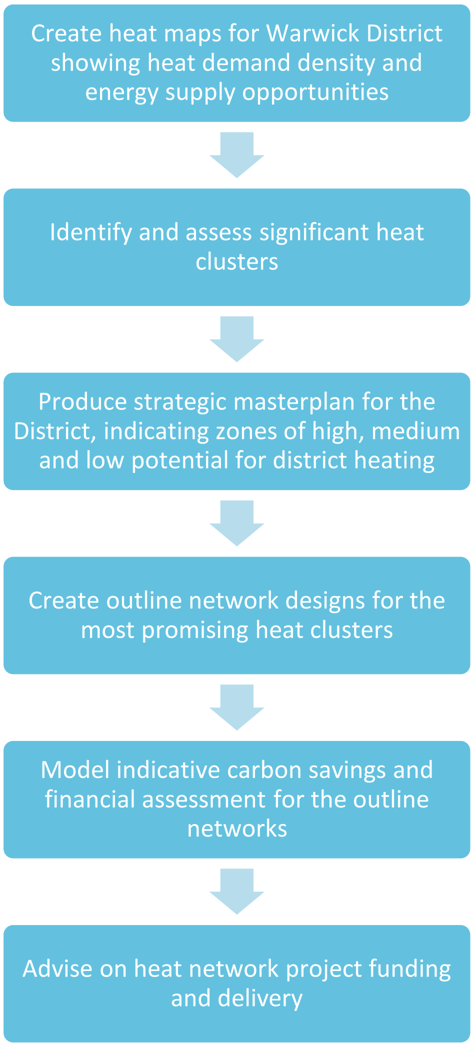


Figure 6. Overview of study methodology.

Heat mapping and zoning

Digital heat maps of Warwick District have been produced in GIS. The maps are intended to provide Warwick District Council with an overview of the opportunities for the development of heat networks in the District, and to provide the evidence base to support the next stages of the project: defining, assessing and prioritising potential heat network project opportunities within the district. Images of the heat maps can be seen in Section 3 of this report.

Information relating to the scale, location and type of energy demands or opportunities was collected from a range of sources, including the Council's energy management database and energy and regeneration managers. For key buildings not on the Council database, contact was made with the relevant organisation to request information. Where metered energy data was not available for a site we have used industry benchmarks such as CIBSE TM46 and Guide F to estimate annual energy demand. A detailed explanation of information sources, benchmarking techniques, calculations and assumptions for the heat mapping is provided in Appendix 1.

In reviewing the potential for heat networks in Warwick District this study has sought to identify locations that scored highly when assessed against the following criteria:

High heat density

Using energy consumption statistics available from DECC we calculated heat density within Warwick District at the Lower-Layer Super Output Area (LLSOA) level. Heat density is a good indication of the financial viability of a district heating network as it indicates the potential to supply a large amount of heat with minimal infrastructure.

High heat demand

We assessed the heat demand from the buildings in Warwick District based on energy consumption data from the Council's energy management database, data from the DECC National Heat Map, and metered or benchmarked data from other sources where available. Heat demand provides an indication of the potential environmental and financial benefits that could be derived from the creation of a heat network served by a low carbon energy technology.

The 'anchor' heat loads shown on the maps were selected for one or more of the following reasons:

- They have, or are considered likely to have, a high level of year-round heat demand (e.g. hospitals and care homes)
- They have, or are considered likely to have, a stable, constant and predictable level of year round heat demand (e.g. swimming pools)
- They are buildings for which the Council has a high level of control or influence to support the connection to a heat network (e.g. Council buildings)

We reviewed building ownership to gain an understanding of the likely ease with which a network might be created. It is easier to secure customers for a DHN if there is one point of contact to coordinate with, rather than many individual customers. For example, a block of 50 social housing dwellings could be connected more easily under one agreement with the Housing Association, rather than 50 individual private homeowners. Local Authorities are also usually more able to enter into long term energy supply contracts than private customers.

Cooling

Like district heating, district cooling is only viable in an area with a high cooling demand and density. In the UK most buildings require less cooling than heating, particularly outside of large cities and the south of England. The benchmark data in CIBSE Guide F shows that a typical, standard air conditioned office annually uses 178kWh/m² for heating and hot water, in comparison to 31kWh/m² for cooling.

In cases where district cooling is provided, the cooling energy is normally generated by an absorption chiller. Absorption chillers run on heat and have CoPs in the range of 0.7 to 1.6 which is much less than the efficiencies of modern electrically-driven chillers. This low efficiency means that the economic and CO_2 benefits of using absorption chillers are generally only realised where the heat used to drive them is waste heat that can be accessed cheaply; this does not include the heat output of CHP systems.

This study has not identified any significant sources of cooling demand in proximity to the potential anchor loads identified, so it is not anticipated that absorption cooling will achieve economic or environmental benefits at this time.

For these reasons it is our view that district cooling is not currently a viable option for Warwick District.

Development sites

As well as reviewing the existing heat demands and densities we looked at future development plans in Warwick District and assessed the potential for using these to facilitate the delivery of district heating networks. In addition to providing further heat loads, new developments can offer potential locations for energy centres or routes for delivering heat distribution pipe installations.

The potential future development sites shown on the maps are based on information from the Draft Local Plan for Warwick District, and details of planning applications from the Government's Planning Portal. Since the Draft Local Plan is currently under review, and planning applications may be granted, refused or withdrawn, these sites are subject to change. Where possible, updated information has been added to the maps throughout the project, but it should be noted that development on the sites shown on the maps is subject to uncertainty.

Energy supply opportunities

We mapped opportunities such as existing decentralised energy generation plant and sources of waste heat, and locations where supply infrastructure has been proposed or planned. Such infrastructure could potentially make the creation of a wider district heating network more deliverable and viable.

Other opportunities and constraints

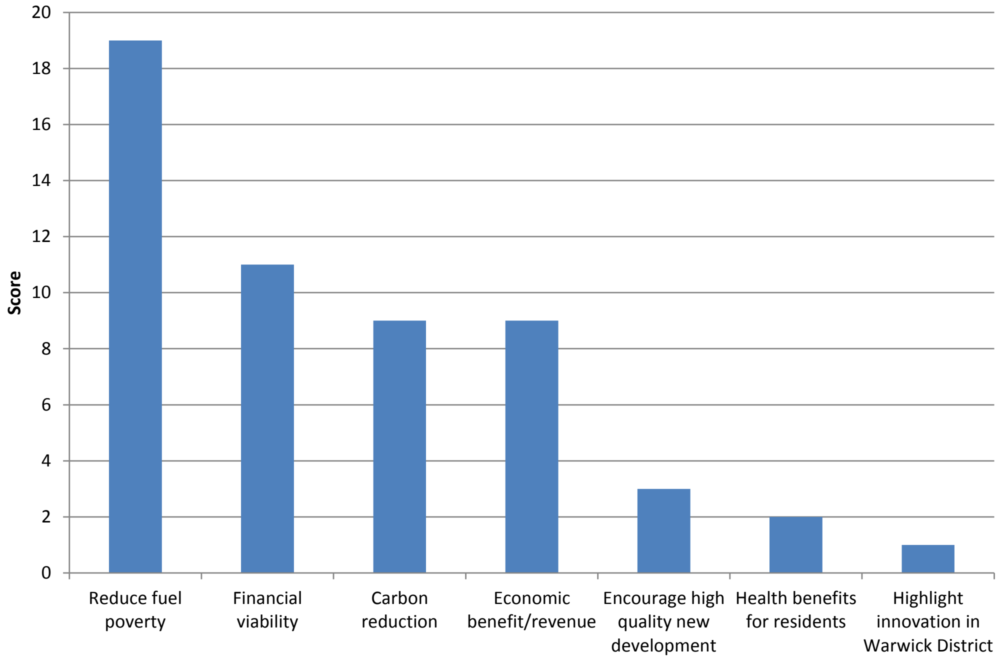
Fuel poverty in the district has been mapped to provide an outline indication of the potential social benefits of developing DHNs in particular areas. Also mapped are physical opportunities such as areas of soft dig where laying network pipework is likely to be cheaper, and constraints that could adversely impact on the potential for establishing district heating in a particular location such as air quality restrictions, listed buildings and physical barriers such as railway tracks.

Identifying opportunity areas

At a workshop with Warwick District Council, the heat maps were reviewed and the Council's key motivations for seeking to develop heat networks were discussed. In attendance were:

Mark Perkins	WDC Energy Manager
Duncan Elliott	WDC Senior Projects Co-ordinator
Andy Thompson	WDC Head of Housing and Property Services
Ken Bruno	WDC Housing Strategy and Development Officer
Grahame Helm	WDC Environmental Sustainability
Richard Hall	WDC Head of Health and Community Protection
Joe Baconnet	WDC Economic Development & Regeneration
Mark Barnes	WDC GIS Manager
Susan Smith	WDC Sustainability and Climate Change Officer
George Dobson	DECC HNDU representative

Each WDC workshop participant listed their ranked top three priorities when considering the development of district heat networks (DECC and AECOM representatives did not participate at this stage). The priorities were categorised and scored, with the highest ranked assigned a score of three, and the lowest ranked assigned a score of one. The results of this exercise are presented below:



The most important criteria in identifying and assessing clusters were therefore judged to be:

1. Potential for reductions in fuel poverty

2. Financial viability of a network

=3. Potential for carbon reductions

=3. Economic benefit/revenue

Using the heat maps, which were reviewed in the context of Warwick District Council's priorities and the criteria discussed above, the study area was divided into zones. Five key heat clusters considered to have high potential for the development of heat networks were identified for further analysis and masterplanning. Two of the clusters around Warwick Town Centre were later merged and considered as one cluster, due to their proximity to each other. The remaining areas were classed as having medium, low or very low current potential for the development of heat networks.

Outline network masterplanning

Information gathered has been used to identify the specific buildings to include within a network in each key cluster. The general approach taken was to include as many of the buildings identified as possible. However, in some cases buildings were not included where they were relatively isolated, because of the effect that this might have on the scheme viability (from the extra capital costs of connection outweighing the extra revenue generated). Further work to refine a project opportunity in any of the clusters would need to critically review the buildings proposed for inclusion and the efficiency and practicality of the network routes.

Based on the buildings selected for inclusion, high level network options designs based on indicative network routes and energy centre locations were developed. Using the defined network layout and information on the heat demand from the buildings connected, the lengths and sizes of the pipework and trenches for the network were calculated. Using the details of the sizes and lengths of pipework and trenches we applied recent prices that have been sourced from a range of suppliers to calculate high level cost estimates for the networks.

We have identified potential energy centre locations. There are a number of factors that may constrain the location of an energy centre, including:

- Proximity to tall buildings;
- Air Quality Management;
- Land value;
- Access;
- Land ownership;
- Noise;
- Visual impact/ aesthetic design and conservation;
- Integration with proposed new development;
- Location on network;
- Environmental risks such as flooding;
- Pipework routing; including pinch-points, hard and soft dig, and existing utilities provision.

These points are discussed in more detail in the following sections. The potential energy centre locations are indicative only, and may change in the future as network concepts and designs develop.

Proximity to Tall Buildings

One of the key factors in determining the required flue height for an energy centre is the height of surrounding buildings. General guidance used when determining the appropriate flue height is that the flue should terminate 3m above any building within a distance of five times the chimney height.

For example, assuming that the minimum chimney height, based on the energy centre height and plant output, is 15m; it would be necessary to evaluate the height of any building within 75m (5 x chimney height, 15m) of the proposed location. If any building within this zone is greater than 15m tall, it will be necessary to increase the flue height so that it is 3m taller than the tallest building within that zone.

Although the key consideration of stack height is to ensure the adequate dispersal of pollutants associated with combustion; consideration of the visual impact of the chimney should be made. Constraints associated with the visual impact of the energy centre are discussed in a subsequent section.

Air Quality Management

There are two key methods by which the air quality of an area can be maintained, and managed: Smoke Control Areas and Air Quality Management Areas (AQMAs).

Within a Smoke Control Area it is an offence to emit visible smoke from a chimney, either serving a building or the furnace of a fixed boiler or industrial plant. The requirements of a Smoke Control Area can be met through the careful specification of plant to ensure that smoke is not emitted.

Air Quality Management Areas are implemented by Local Authorities for areas where they believe the relevant national air quality objectives may not be met by the relevant deadlines. Areas are identified by monitoring air pollution levels, and predictions are made as to whether the air quality objectives can be met. Upon identifying an area where the objectives are not likely to be achieved, the Local Authority must declare an Air Quality Management Area (AQMA) there and put a Local Air Quality Action Plan in place. AQMAs are declared for particular pollutant(s), depending on the objective that has been identified.

AQMAs are most often located along roads, with the majority of AQMAs declared for transport-related pollution sources. Of the current 498 AQMAs in England, 473 relate to transport sources. Therefore, in the majority of cases where an AQMA is associated with a road, much of the impact of a new energy centre is mitigated by the fact that the flue will disperse pollutants outside of the road corridor. Consideration of the AQMA should be made during the design of the energy centre, to ensure that the new energy centre does not impact the performance of the AQMA.

Land Value

Variations in land prices across a city or town can be a key factor in determining the most appropriate location for a new energy centre. Typically, town- or city- centre locations demand the highest values, being a desirable location for prime retail or commercial office space, with land value typically diminishing further from the centre.

Consideration of the potential loss of earnings by siting an energy centre in a prime, central, location should be made; along with consideration of the impact on neighbouring buildings. Generally, in locations with higher land values, neighbours are likely to be sensitive to the impact of a new energy centre; including any acoustic and visual impact, and so careful consideration of these factors should be made.

Access

Site access for large vehicles is needed during construction, and during later refurbishment of the energy centre, in order to deliver large items of plant. If biomass is chosen as the fuel source, then frequent access for delivery of fuel will be required during the operation of the energy centre.

It will be necessary to identify route(s) to site that can accommodate the large vehicles, and whether there are any existing constraints that may make access unfeasible. For example, it may be acceptable to access a site via a pedestrianised street if access is only required occasionally; although, street furniture would need to be positioned such that sufficient space is maintained. In cases where regular site access is required by large vehicles, such as would be required for a biomass-fuelled plant, access via a pedestrianised street is unlikely to be acceptable.

Other constraints to access such as tight bends on access roads, narrow roads, and volume of traffic should be considered.

Land Ownership

When a potential energy centre location is identified, it will be necessary to identify who owns the land. If it is already owned by the Local Authority (or other body) which is developing the District Heating network, securing the land for the construction of the energy centre should be straightforward.

In cases where a site is identified that is not owned by the Local Authority, it will be necessary to secure the land ownership, or come to another agreement, so that the energy centre can be constructed there. This can add time and cost to the delivery of the energy centre.

Noise

The National Planning Policy Framework (NPPF) was introduced in March 2012. The document sets out the Government's planning policies for England and how these are expected to be applied. The Framework supersedes the previous guidance document PPG 24 'Planning and Noise'. The planning system is required to contribute to and enhance the natural and local environment. Consequently, the aim is to prevent both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of noise pollution.

The NPPF states that planning policies and decisions should aim to:

- ‘avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;
- mitigate and reduce to a minimum other adverse impacts on quality of life arising from noise from new development, including through the use of conditions;
- recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established [subject to the provisions of the Environmental Protect Act 1990 and other relevant law]; and
- identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.’

In order to ensure that any proposed energy centre does not have a significant adverse impact on any existing buildings, a detailed study should be undertaken once the most appropriate site(s) have been chosen. This study should identify whether any mitigation measures will be required, and what form these should take.

Visual Impact/ Aesthetic Design and Conservation

The visual impact of an energy centre should be considered during the design process, to ensure that the proposals are appropriate for the area. Minimising the visual impact of a new energy centre may go some way to mitigating local resistance to the new development; although there are some aspects, for example the flue, which may present a particular challenge.

Some areas are designated as Conservation Areas, for their special architectural and historic interest; and may, or may not, include Listed Buildings. Within a Conservation Area, stricter controls over demolition, new development, works to trees and some alterations apply. In such areas, the design of an energy centre will require extra care, such that it enhances and preserves the area’s character.

Many energy centres are designed to aesthetically enhance their surroundings, for example the recently completed Leeds Recycling and Energy Recovery Facility (RERF) is designed with the aim of “creat[ing] a positive landmark for the Aire Valley region of Leeds” and includes an innovative design based upon the use of glass and timber framing and a green ‘living’ wall one of the largest of its type in the country.

Integration with Proposed New Development

There are several benefits offered by integrating an energy centre within a proposed, new development, including:

- The opportunity to have construction activities on the energy centre and development running concurrently;
- The opportunity to integrate the energy centre within the design of new building(s);
- The potential to favourably locate the energy centre within the site;
- The potential to co-locate the energy centre with a heat load.

One of the benefits of locating an energy centre within a proposed new development is the opportunity to run construction activities on the energy centre concurrently to the rest of the development. If this is possible, one of the key benefits is that it will minimise the disruption associated with the construction of the energy centre. This in turn may help to mitigate local resistance to the construction of the energy centre. Another benefit offered by running the construction of the energy centre concurrently to other aspects of the development is the opportunity for cost savings associated with operating a construction site, especially if time savings can be made.

A further benefit of integrating an energy centre within a proposed development is the opportunity to incorporate the design of the energy centre within the overall scheme, which offers a number of key benefits.

One of the primary benefits is the opportunity to visually integrate the energy centre with the design of the new development, which may assist in reducing any local resistance.

Another benefit is the opportunity to favourably locate the energy centre within the site, taking account of any constraints; both in and around the proposed development site. For example, it may be possible to locate the energy centre such that the distance to any sensitive neighbours, within or surrounding the new development, is maximised. Other constraints that could be mitigated through the careful positioning of the energy centre include minimising the impact of surrounding tall buildings by maximising the distance between them and the energy centre, and enhancing the ease of site access.

A further benefit that may be realised by siting an energy centre within a proposed development is the opportunity for the energy centre to be co-located with a heat load on the network. Depending on the nature of the development, it may become the anchor load for the network and so, by collocating the energy centre with it, capital and operational costs savings can be made, by minimising the length of distribution pipework needed and therefore reducing heat losses during operation.

Conversely, locating an energy centre within a proposed development presents a constraint if the proposed development does not occur. This risk could be mitigated by earmarking part of the site for the energy centre, so that it may be constructed even if the remainder of the development does not go ahead. This approach would require careful consideration of the design of the energy centre, to ensure that it could easily be integrated with a future development, with consideration taken of any potential changes that may be made to the development, for example changes in use. Another factor to consider in this situation would be if the new development was to form one of the key heat loads in the network; if the development did not go ahead as planned, then the economic viability of the network may be affected. In such cases the choice of energy centre location should be revisited.

Location on Network

Of key importance when locating the energy centre on the network is to consider the proximity of the site to the heat loads. Ideally, the energy centre would be located centrally within the cluster, so that the distance to the loads is minimised, which offers benefits in terms of reducing the both the capital costs, associated with the installation of distribution pipework, and operational costs, associated with pipework heat losses.

However, it may be appropriate to co-locate the energy centre with a particularly large, or anchor, heat load; especially if such a location offers other benefits, such as those identified in the previous section.

Depending on the nature of the network, it may be appropriate to consider the location of the energy centre in conjunction with making future connections to other heat loads in the area.

Technoeconomic assessments

To assess the commercial viability of the network options we have estimated the total capital costs associated with the network, plant and thermal storage, the costs associated with operation and maintenance and the revenue from the sales of heat and electricity; based on recent quotes from suppliers and AECOM's previous experience of delivering district heating projects. The costs have been run over 25 and 40 year periods to determine the cash flows and calculate the following:

- Total capital cost.
- Simple payback period – the time taken to return the initial capital expenditure.
- Net Present Value (NPV) – this 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 a 6% discount rate, based on an estimate of the standard value used for public sector borrowing. 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.
- Internal Rate of Return (IRR) – this shows the rate of return on the investment.

Some network options use 'private wire'. The term 'private wire' is used to represent higher electricity sales values for electricity from CHP generation. This could be achieved through the use of a separate 'private wire' electricity network or infrastructure, or through negotiation on a power purchase agreement with a licensed electricity supplier. Given the high level nature of this study and the range of options available for setting up a private wire agreement, additional capital costs for private wire have not been estimated at this stage. In general, the complexities of licensing mean that selling electricity over a privately owned network to other customers is not viable due to the requirements to allow competition for electricity supply. Therefore privately owned networks are generally used on single customer sites, such as a University campus or hospital.

We conducted a sensitivity analysis on a number of the key financial variables to demonstrate the implications of variation in the IRR outputs of the schemes assessed. The key factors that will affect the commercial viability of a scheme are:

- Discount rate
- Average heat sales price
- Gas costs
- Annual heat volume
- Average electricity sales price
- Plant efficiency
- Capital cost.

To test the sensitivity of the IRR to each factor, a graph of the variation in IRR with the variation of that particular (holding all other inputs constant) was plotted. These graphs are shown alongside the technoeconomic analysis for each network.

Further financial analysis will be required to more accurately understand the feasibility of the network options if they are to be pursued. The accuracy of these key variables will be of critical importance to provide confidence in the commercial viability of a scheme.

Social impact assessments

For each network option, we have estimated the average annual change in CO_2 emissions arising from the network compared with 'business as usual' - distributed gas boilers and (in the case of CHP) electricity from the National Grid. The averages are given over 25 years and 40 years.

The carbon savings associated with CHP systems is strongly affected by the carbon intensity of the National Grid. The carbon intensity of the grid is normally expressed as a carbon factor equating to the mass of CO_2 emitted on average for every unit of electrical energy delivered to end users; for example in $kgCO_2/kWh$. When the grid carbon intensity is high then the carbon savings from CHP are enhanced as the carbon benefit of the electrical output of the CHP is enhanced. Conversely when the grid's carbon intensity is below around $0.25kgCO_2/kWh$ the use of a gas-fired CHP may result in higher carbon emissions than a business as usual scenario.

The UK Government has set out its ambitions to reduce the carbon intensity of UK electricity by increasing the amount of low carbon technologies on the National Grid. There is a wide range of forecasts of how quickly the carbon factor will fall over the next few decades. The Interdepartmental Analysts' Group (IAG) on Energy and Climate Change publish predictions of future carbon emission factors for both grid average and marginal use. DECC (who have part-funded this study) recommend the use of IAG data and this has been used for the technoeconomic analyses conducted for the clusters in this study.

To illustrate the sensitivity of carbon savings to changes in the carbon emission factors our analysis includes a comparison of carbon emissions of the proposed scheme based on the IAG data and an alternative forecast based on a DECC report titled *Modelling the impacts of additional Gas CHP capacity in the GB electricity market (December 2014)*[8]. This approach was referred to by analysts from DECC's Heat Network Delivery Unit (HNDU) as the emissions factors HNDU have used in their predictions for future uptake of CHP. The DECC forecast is based on the assumption that the operators of a large CHP system will be economically incentivised to operate the CHP at times when the instantaneous electricity price is high; this is generally at times when the output of large scale renewables is low. Conversely at times when national renewable output is high (e.g. on windy days) the instantaneous price of electricity will fall and the CHP operators will be incentivised to reduce their power export. On this basis it is calculated that the carbon intensity of the electricity that is being displaced by large CHP systems will remain higher than the grid average carbon intensity.

These two carbon emission factor projections are shown in Figure 7. This shows that the prediction of how CHP will operate as part of the UK generating mix has a large impact on the predicted level of carbon saving to be gained from the installation of CHP. The effect of this is that the projected carbon savings from CHP systems will be greater under the DECC forecast.

[8] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/389070/LCP_Modelling.pdf

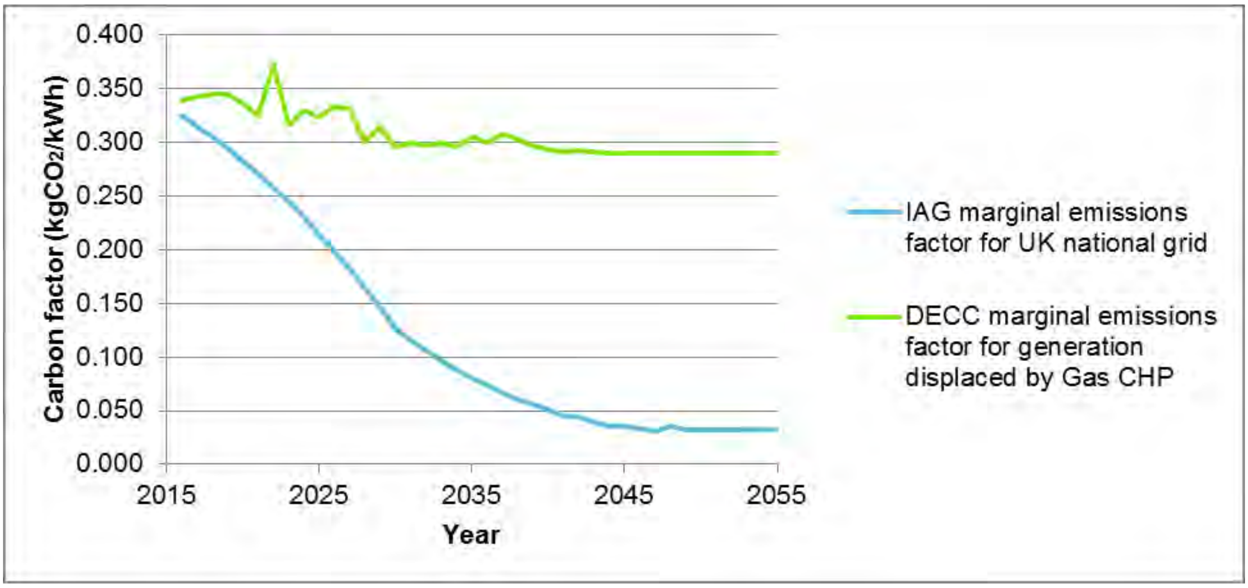


Figure 7: Comparison of IAG marginal emissions factor for UK grid with DECC marginal emissions factor for generation displaced by gas CHP.

It is important to note that whilst the decarbonisation of the grid reduces the carbon benefits of gas-CHP, it increases the carbon benefits of other technologies, in particular that of heat pumps. Taking this further it could be argued that operators of heat pumps would be economically incentivised to operate generate and store heat at times when the instantaneous electricity price is low; this is generally at times when the output of large scale renewables is high (e.g. on windy days). On this basis it could be suggested that the carbon intensity of the electricity used by large heat pumps will be lower than the grid average carbon intensity. This presents the opportunity for combined heat pump/CHP plant rooms to be developed which operate heat pumps when the price and carbon content of power is low and switch to CHP when the price and carbon content of electricity is high.

Qualitative discussions of other social impacts such as reductions in fuel prices and fuel poverty, and benefits for the local economy, are included in the network assessments and the advice on district heating network delivery.

DISTRICT ENERGY OPPORTUNITIES IN WARWICK DISTRICT

03

HEAT MAPS FOR WARWICK DISTRICT

Overview

The following heat maps provide a high level view of the opportunities for district heating networks in Warwick District. The maps provide an overview of the opportunities for the development of heat networks in Warwick, and form an evidence base to support the next stages of the project, in which potential networks are designed and assessed.

Heat maps

Map 1: Warwick District Overview of Heat Loads

This map provides an overview of the Warwick District and its immediate surroundings, showing the dispersal of significant heat loads (as defined above) currently in existence, sites of potential new developments, and locations where low carbon energy generation is occurring or proposed. For this overview map the heat load symbols are not scaled, in order to make their locations clearer and provide an indication of their dispersal throughout the district.

The map indicates that the majority of significant heat loads (and nearly all public buildings) are clustered in the urban areas of Warwick town, Leamington Spa, and Kenilworth. Areas where there are significant numbers of potential new development sites are around Whitnash and east of Kenilworth. Existing and proposed low carbon energy generation sites are not clustered, but several are situated in or close to Leamington Spa and Kenilworth.

Map 2: Warwick District Overview of Domestic Heat Demand

This map provides an overview of annual domestic heat demand density in Warwick District by LSOA. The highest demand densities are clustered in the urban areas of Kenilworth, Warwick town and Leamington Spa. For this reason, mapping and modelling of anchor load energy demands was subsequently focused in these areas.

Map 3: Warwick District Overview of Non-Domestic Heat Demand

This map provides an overview of annual non-domestic heat demand density in Warwick District by MSOA. The highest demand densities are clustered in Warwick town and Leamington Spa. This provided an additional rationale for focusing mapping and modelling of anchor load energy demands in Warwick District's urban areas.

Map 4: Energy Generation and Opportunities in Warwick District

This map focuses on the locations of existing and proposed low carbon energy generation sites, and areas of significant predicted shallow geothermal potential (indicating the potential for ground source heat pump use), in Warwick District. Of particular note are the biomass boilers serving social housing in Kenilworth and Leamington Spa, and the proposal (currently early stage) to replace the redundant micro-CHP systems at Warwick Hospital with a single 530kWe CHP plant. There is also a swathe of soil predicted to have high shallow geothermal potential running north to south across the district, which covers most of Kenilworth, and some of the west of Warwick town.

Map 5: Fuel Poverty in Warwick District

This map shows the percentage of households in fuel poverty at LSOA level in Warwick. This map will help to assess the potential social benefits provided by the development of district heating in the town. Across much of the district levels of fuel poverty at the LSOA level are comparable with or above the national average (10.6%) and the average for Warwickshire (10.9%). The highest level of fuel poverty (26.3%, compared with an average of 11.1% for Warwick District) is recorded in and around the centre of Leamington Spa.

Map 6: Existing Heat Loads and Potential Developments in Warwick Town

This map provides an overview of the town of Warwick and its immediate surroundings, showing the significant heat loads (as defined above) currently in existence, and the potential developments proposed for the area. The heat load symbols are scaled (by area) in proportion to the relative size of the heat demands.

The map indicates that, based on the data currently collected or benchmarked, Warwick School (benchmarked), Warwick Hospital (metered data) and IBM (benchmarked) are the three largest single-point heat loads in the town. There is a large cluster of heat loads around the town centre, including several public buildings, the St Nicholas Park leisure centre, and several clusters of social housing. There are also some clusters of social housing with particularly high and dense benchmarked energy demand in the northeast of the town.

A number of attempts were made to contact IBM and the Warwick School to obtain metered energy data, but neither provided information within the project programme.

Map 7: Existing Heat Loads and Potential Developments in Leamington Spa

This map provides an overview of the town of Leamington Spa and its immediate surroundings, showing the significant heat loads (as defined above) currently in existence, and the potential developments proposed for the area. The heat load symbols are scaled (by area) in proportion to the relative size of the heat demands.

The map indicates that, based on the data currently collected, Warwickshire College, the Livery Street Travel Lodge and the Premier Inn on the Parade are the three largest single-point heat loads in the town. There is a large cluster of heat loads around the town centre, including several public buildings and care homes; and several clusters of social housing, including some with particularly high and dense benchmarked energy demand south of the river and northeast of the town centre. The map also indicates the proximity of the industrial estate at Tachbrook Park to the heat loads in the south of the town, and the scale of developments planned for Whitnash and Myton, including the Myton Garden suburb for which planning permission has been granted.

Map 8: Leamington Spa Town Centre

This map focuses on the centre of Leamington Spa, to provide a higher resolution view of the heat loads and development plans clustered around the town centre. Heat load symbols are scaled (by area) in proportion to the relative size of the heat demands.

The map indicates the locations of planned developments including the Creative Quarter regeneration project and the relocation of the Warwick District Council offices. Of particular note is the cluster of public buildings, hotels and dense social housing north of the river, with the Newbold Comyn leisure centre less than 1km to the east: an area where the Council may be able to have significant influence in the development of a district heating network.

Map 9: Existing Heat Loads and Potential Developments in Kenilworth

This map provides an overview of Kenilworth, showing the significant heat loads (as defined above) currently in existence, and the potential developments proposed for the area. The heat load symbols are scaled (by area) in proportion to the relative size of the heat demands.

The map indicates that, based on the data currently collected, the heat loads in Kenilworth are relatively small compared with those in Warwick town and Leamington Spa and are geographically dispersed. If the development allocations around Thickthorn are retained, associated demand could be over 5GWh per year (estimated based on CIBSE TM46 benchmarks), although the density of the development must be considered (e.g. if low density it may not be suitable for district heating). The highest single point heat demands are predicted to come from the Holiday Inn and The Kenilworth hotel on Warwick Road, and there is a dense cluster of social housing near Bulkington. The Abbey Fields leisure centre has an annual heat demand of approximately 700MWh (based on metered data) and is likely to have stable heat demand due to the presence of a swimming pool, however this is situated in the protected area of Abbey Fields, and its continued presence may be dependent upon development or relocation plans for Kenilworth School.

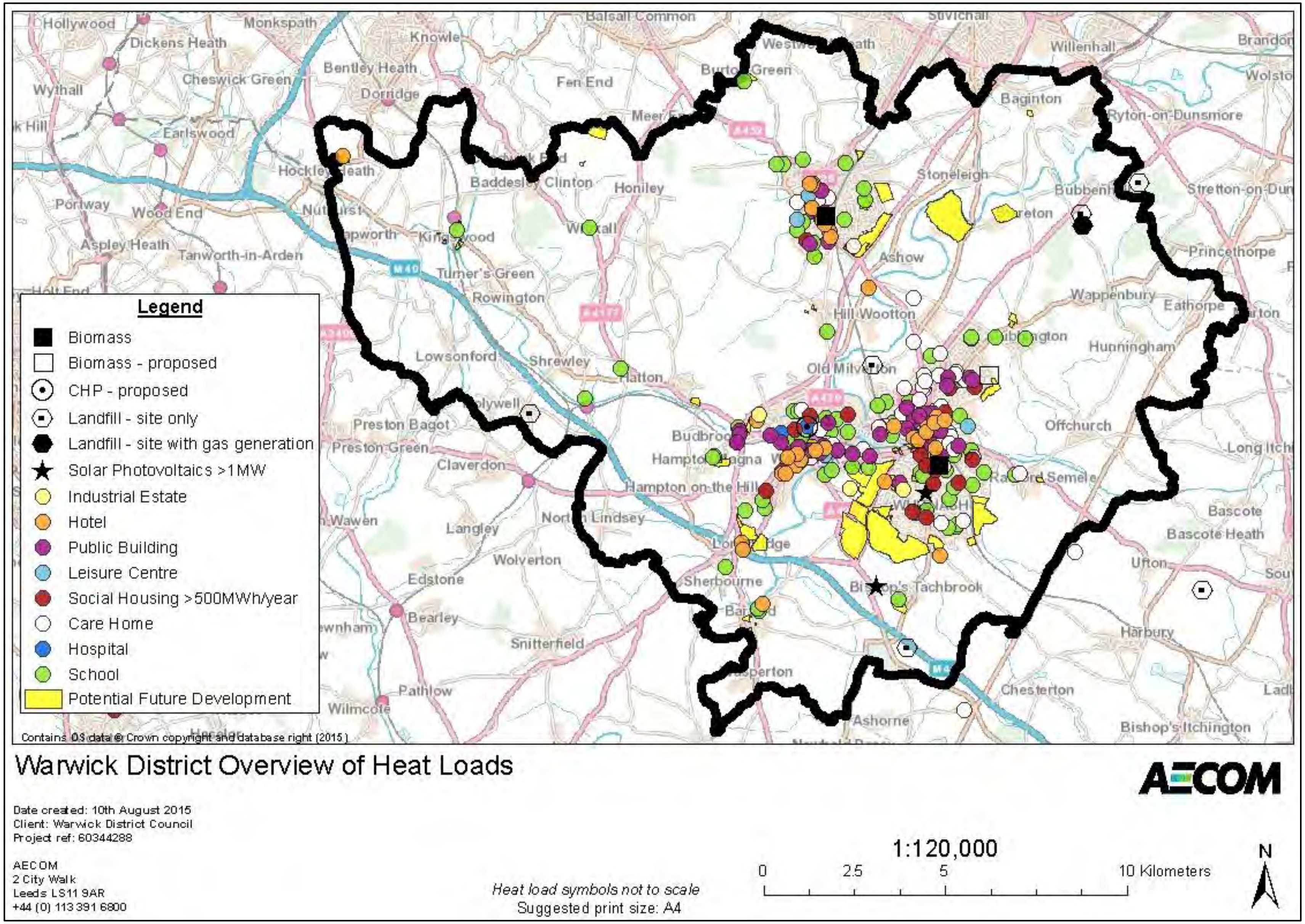


Figure 8. Map 1 Warwick District Overview of Heat Loads

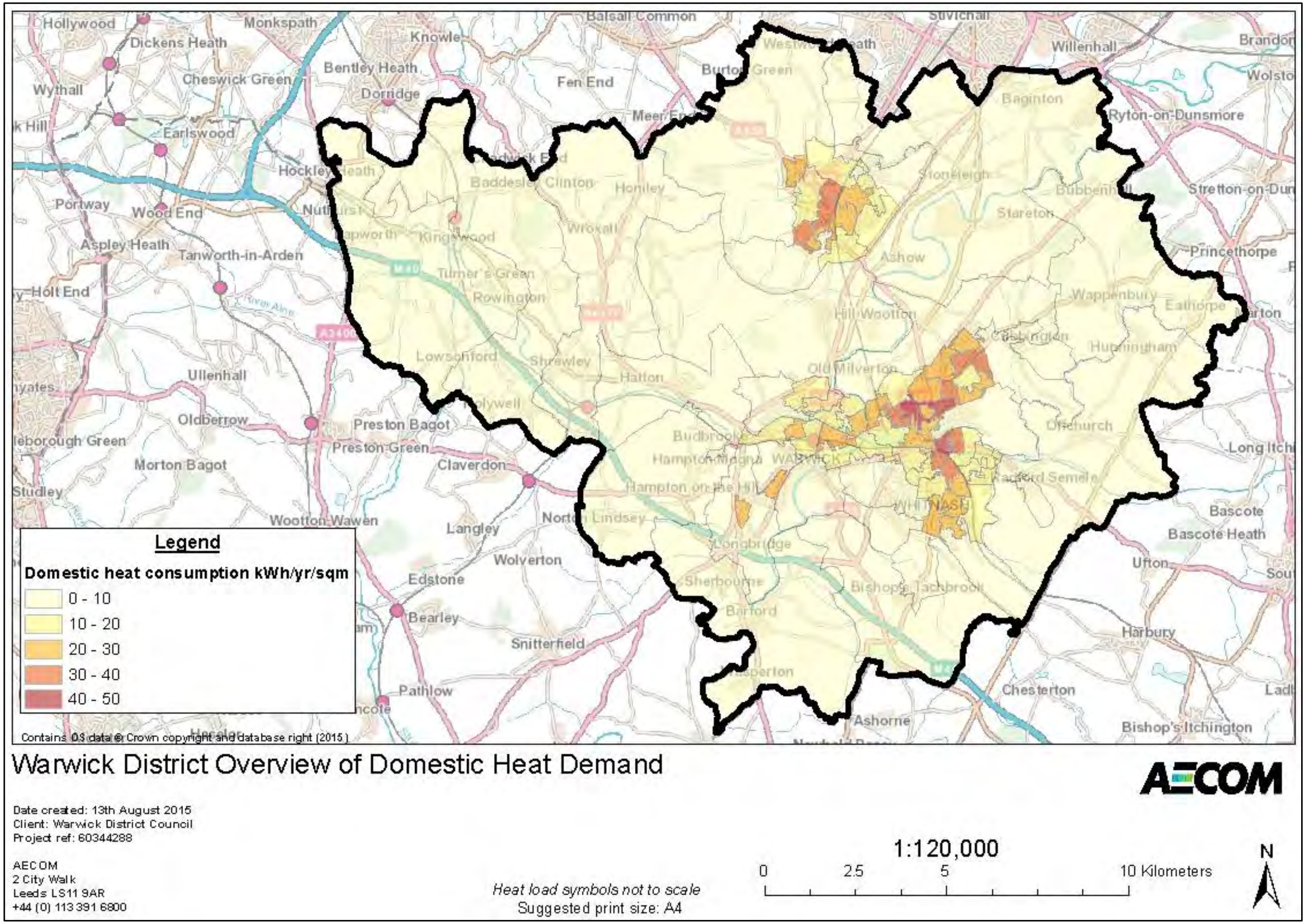


Figure 9. Map 2: Warwick District Overview of Domestic Heat Demand

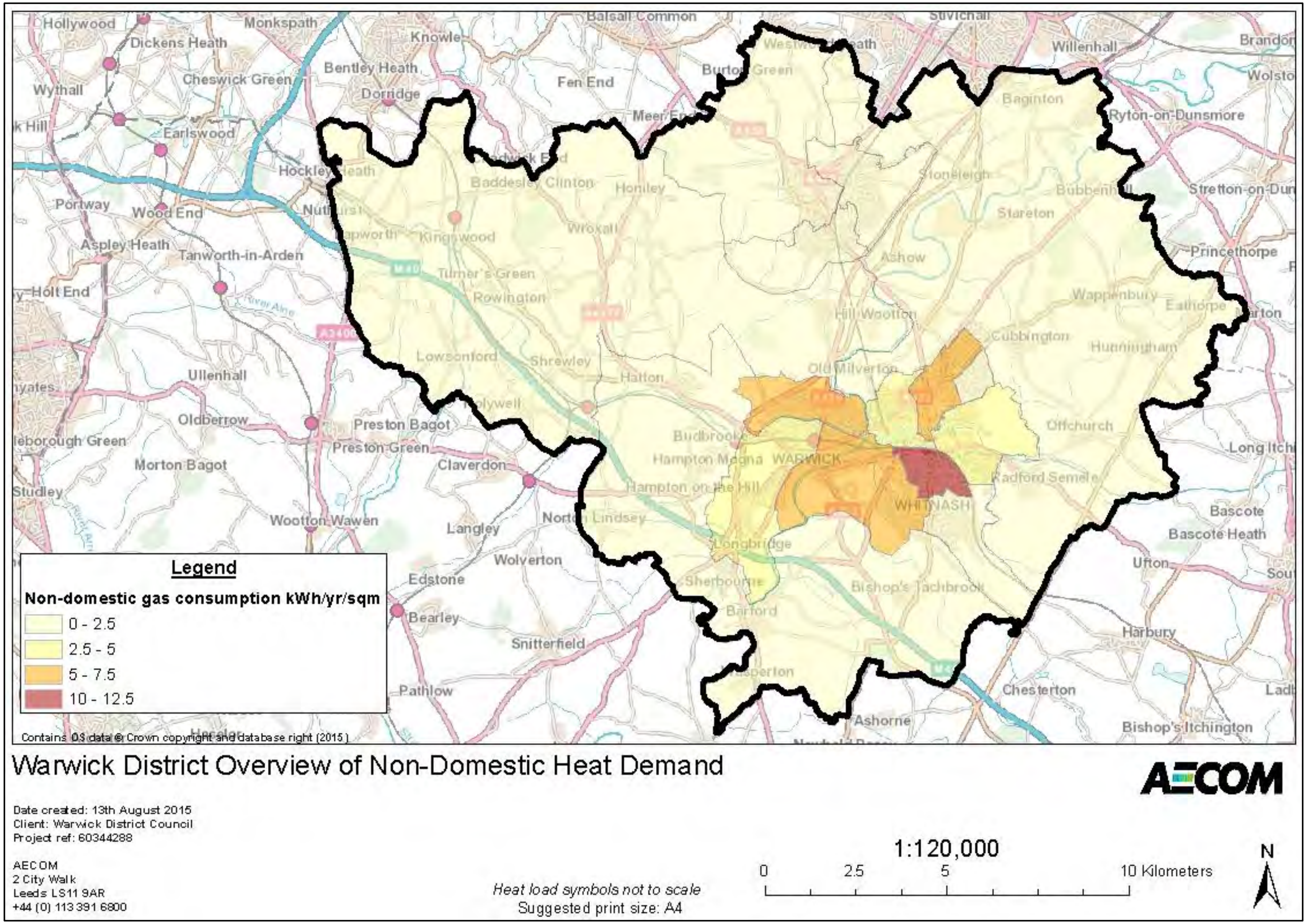


Figure 10. Map 3: Warwick District Overview of Non-Domestic Heat Demand

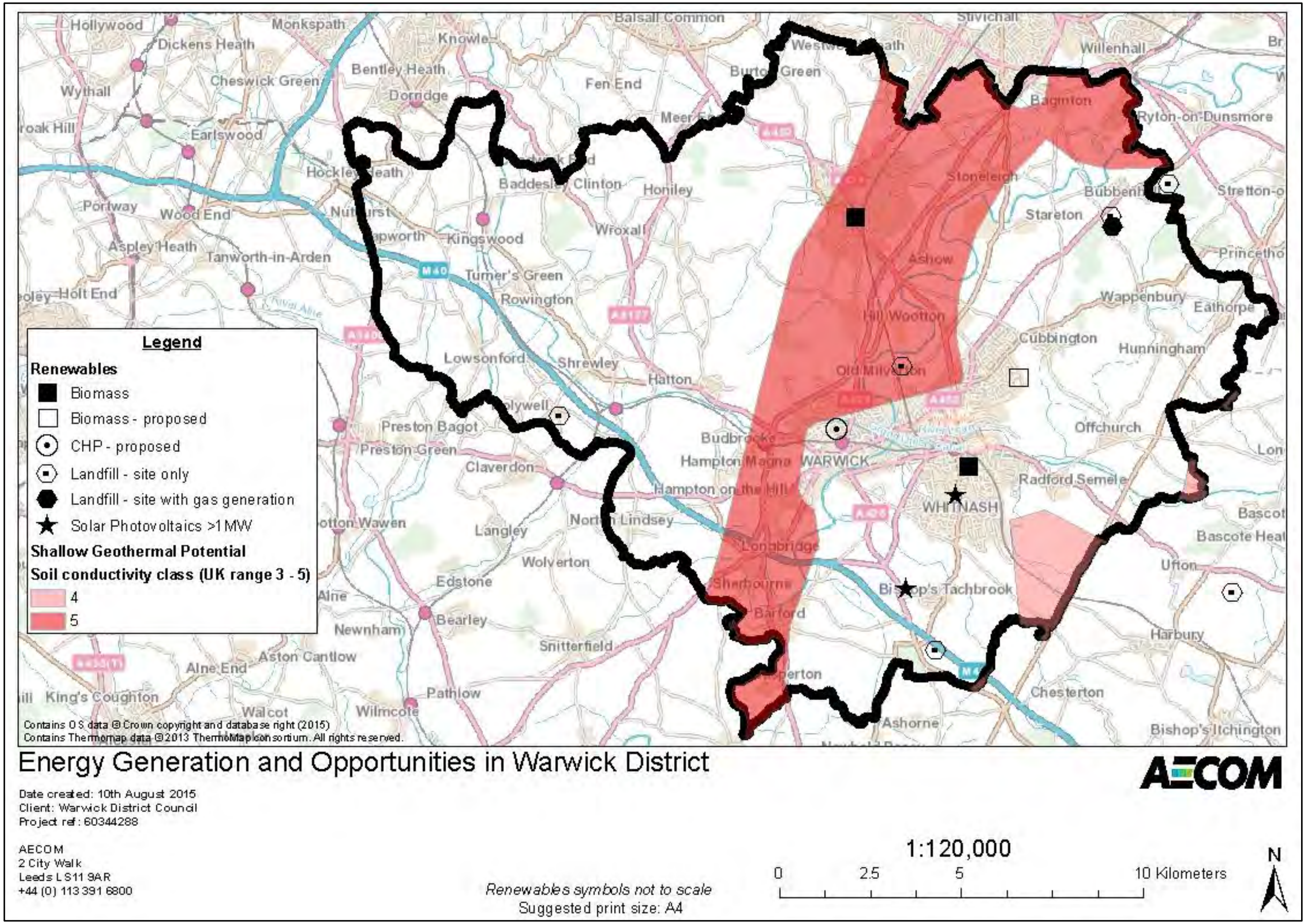


Figure 11. Map 4: Energy Generation and Opportunities in Warwick District

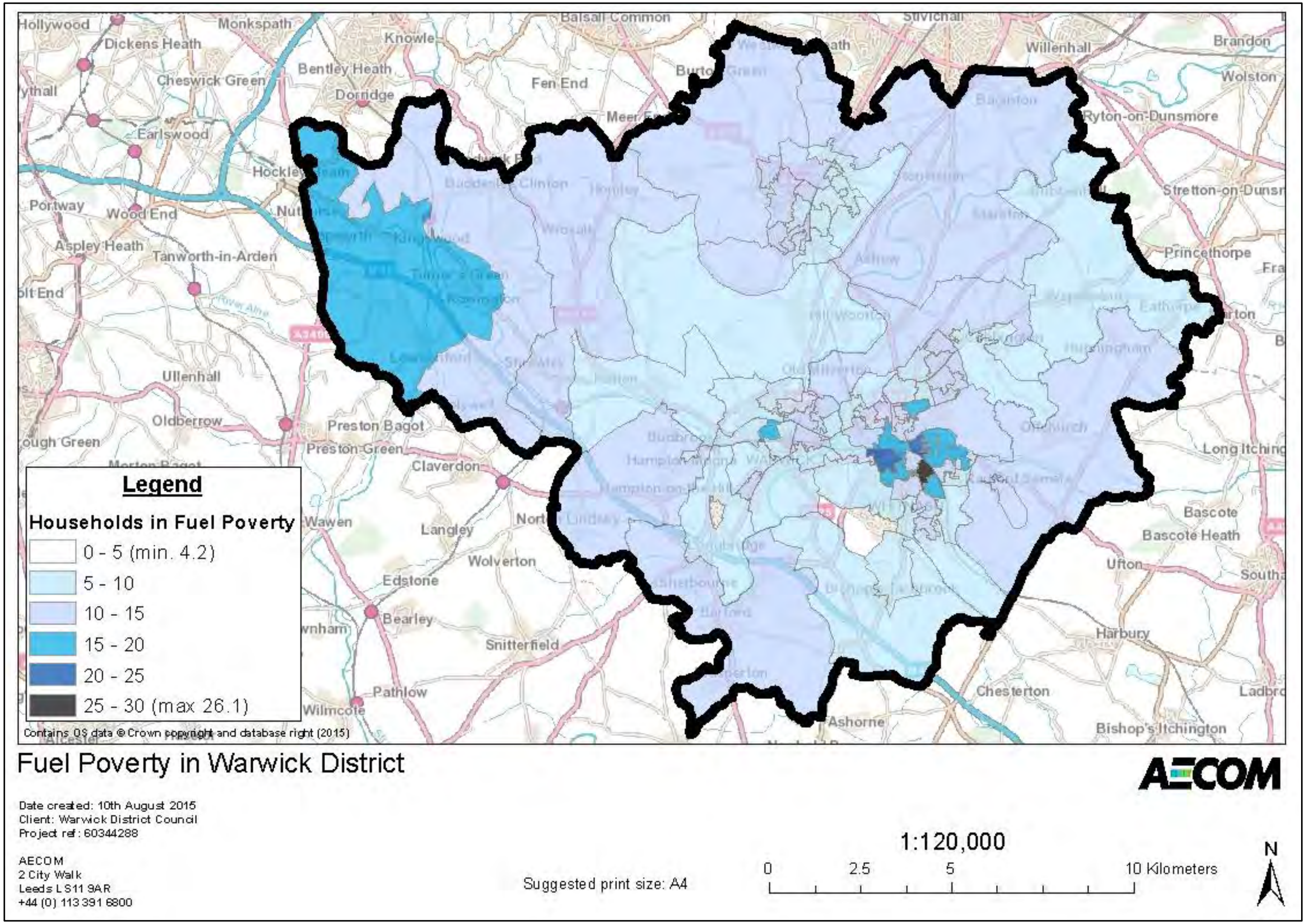


Figure 12. Map 5: Fuel Poverty in Warwick District

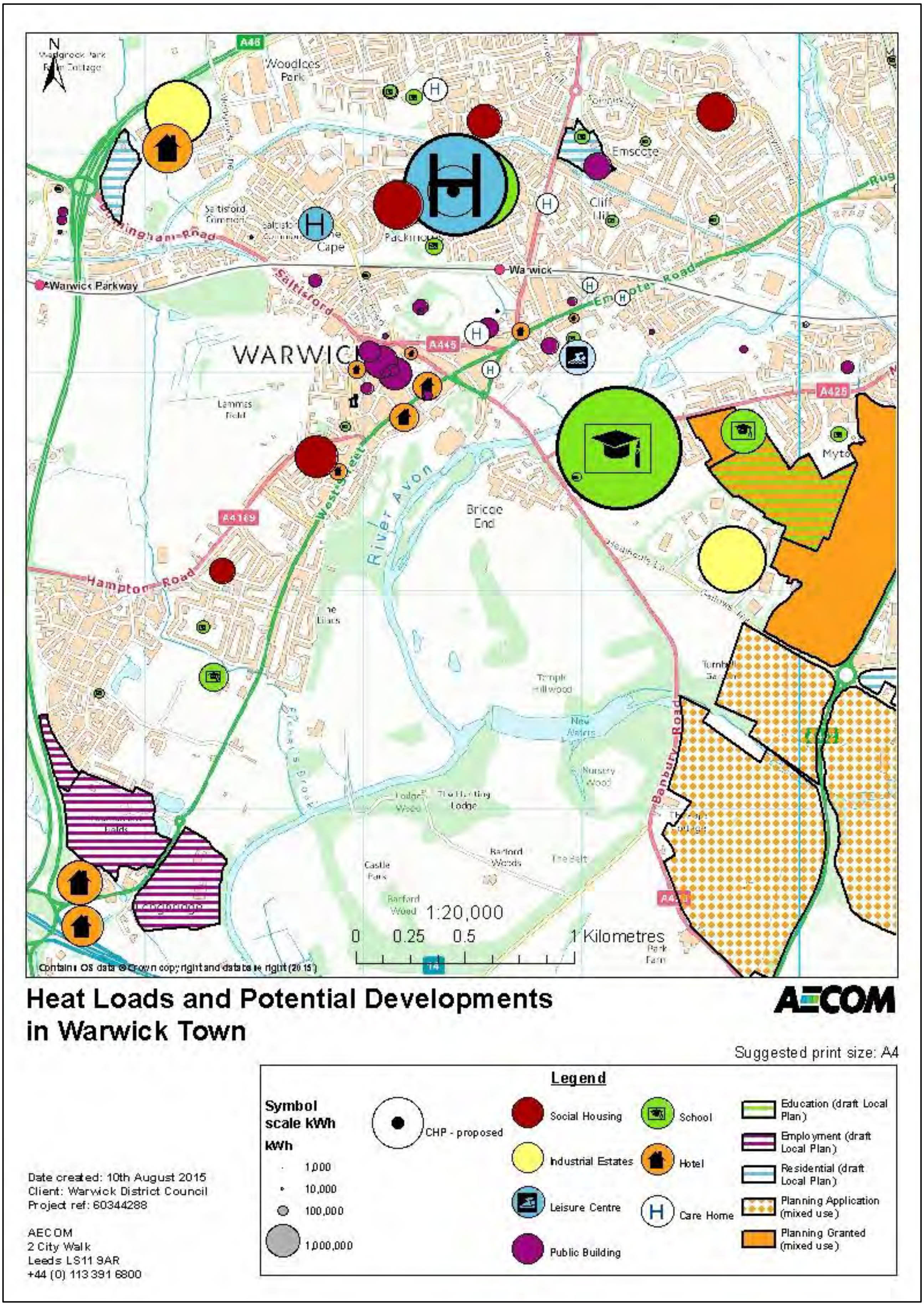


Figure 13. Map 6: Heat Loads and Potential Developments in Warwick Town

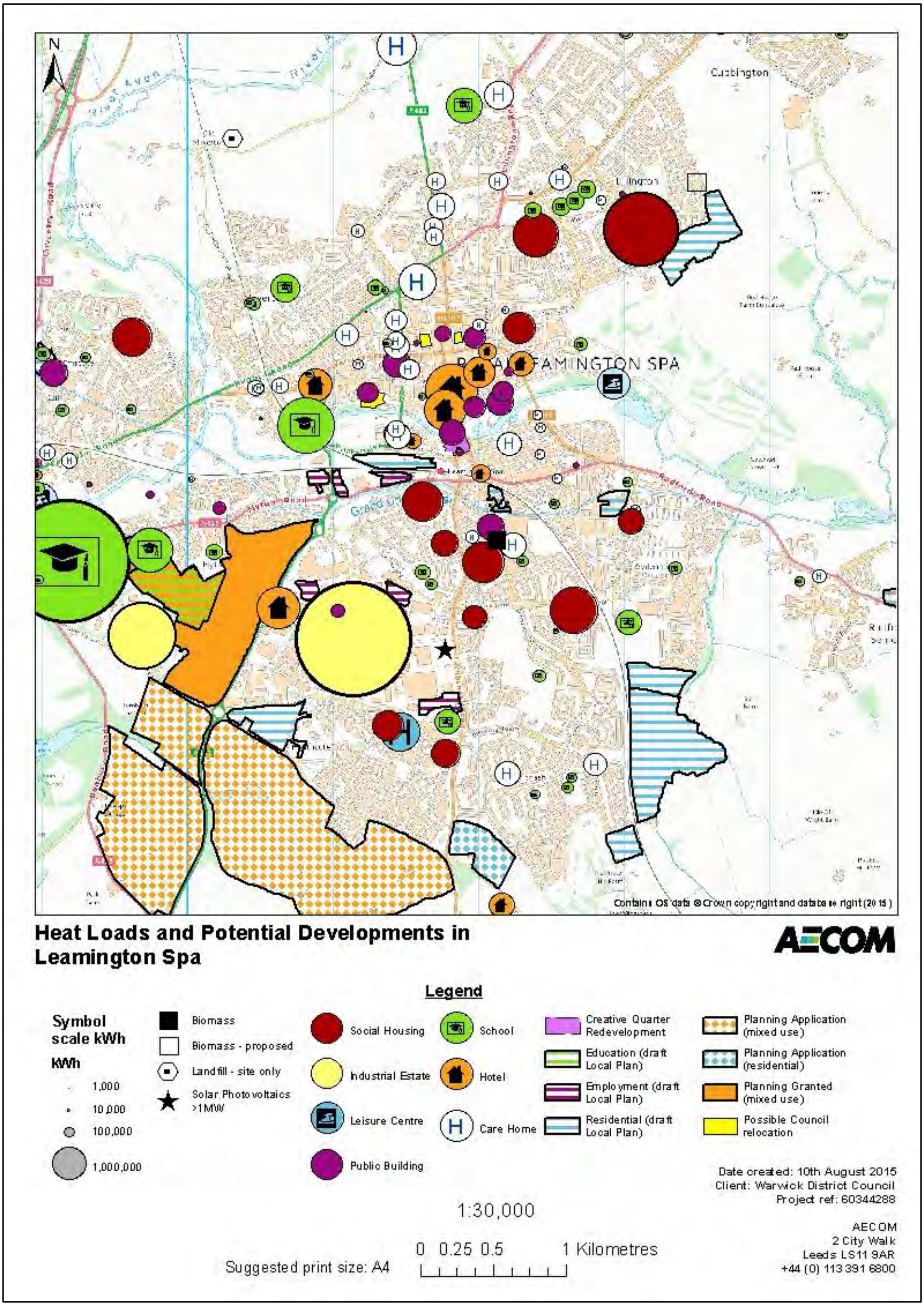


Figure 14. Map 7: Heat Loads and Potential Developments in Leamington Spa

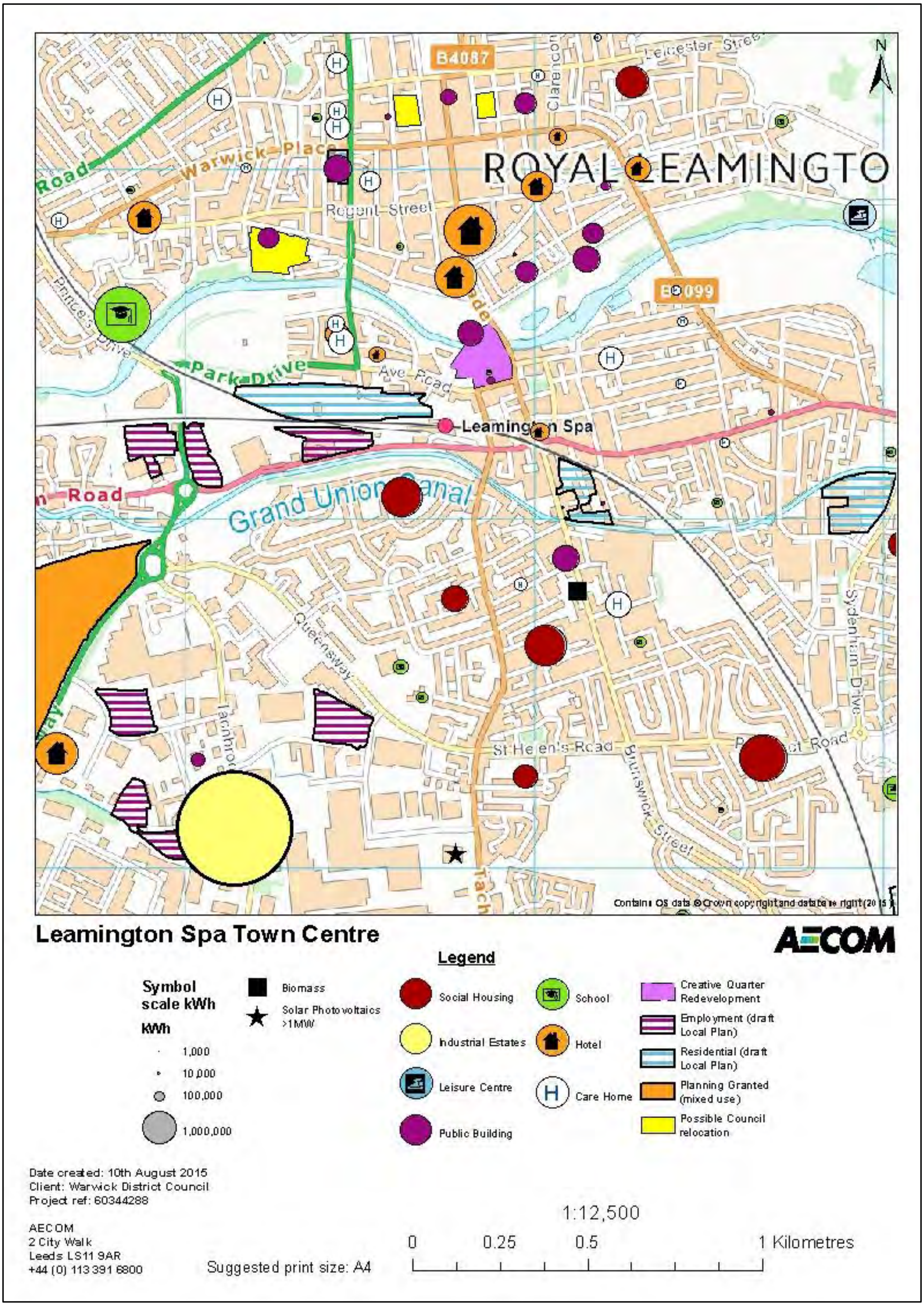


Figure 15. Map 8: Leamington Spa Town Centre

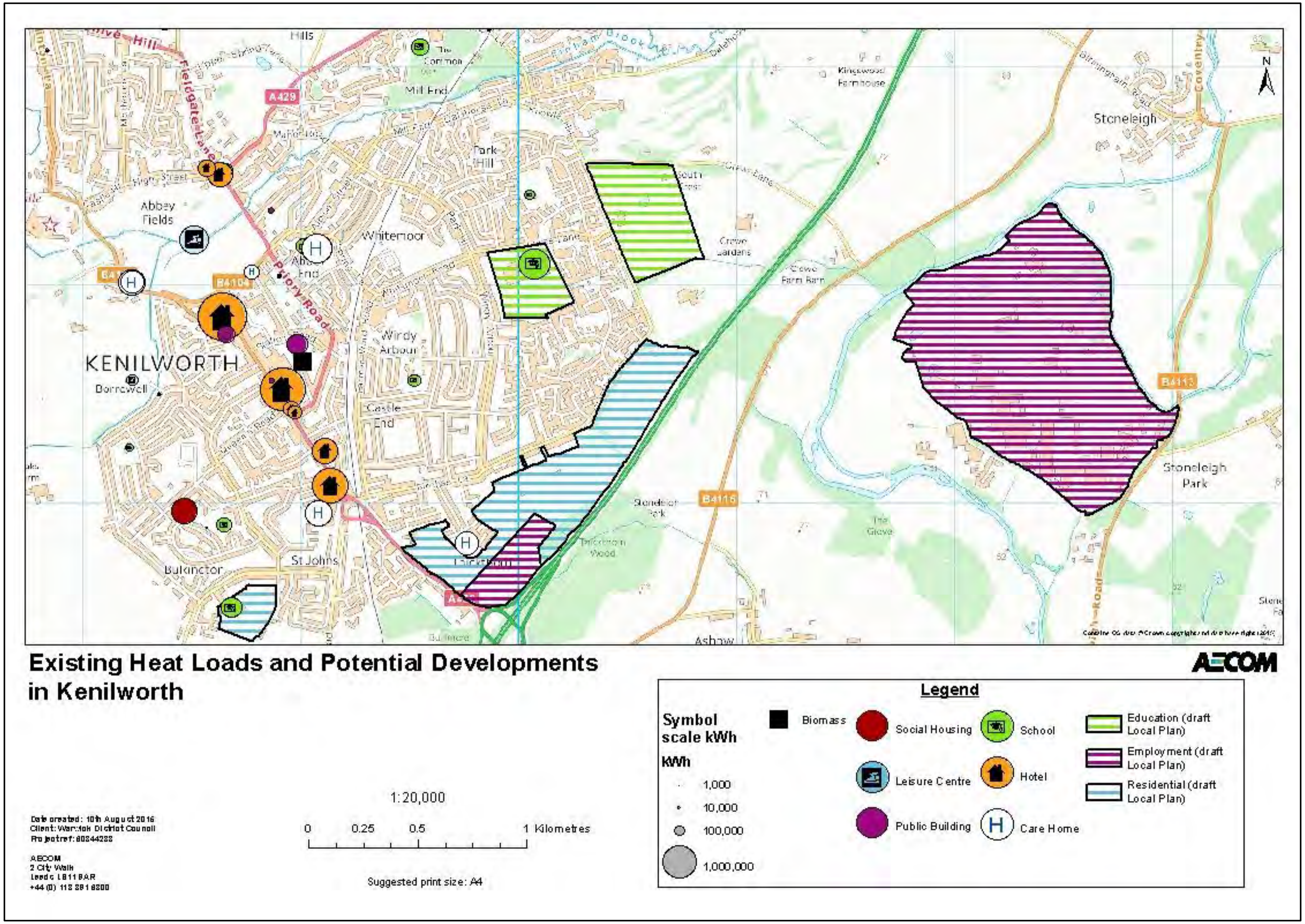


Figure 16. Map 9: Existing Heat Loads and Potential Developments in Kenilworth

OPPORTUNITIES FOR HEAT NETWORKS IN WARWICK DISTRICT

Heat Network Opportunity Areas in Warwick District

By reviewing the heat maps using the criteria described in the methodology, and the Council's priorities identified above, five key heat clusters were identified. These areas are those judged most likely to have the potential for the development of heat networks in the near future. The urban areas of Warwick District are characterised by low density, low rise buildings, and as a result relatively few areas are likely to present significant opportunities for the development of heat networks at present. In some cases however, planned new developments may present opportunities to incorporate or extend district heat networks, and this has been taken into account in cluster identification and selection. A map showing the locations of the six clusters identified is presented in Figure 17, with further details discussed in the following sections of the report.

As discussed in the introduction to this report, the areas of focus for this study are Warwick town, Leamington Spa, Whitnash and Kenilworth. Although Kenilworth does contain some heat loads and future development areas (shown in Figure 16), the opportunities for developing a network there are considered low at present. While the Abbey Fields leisure centre may provide a stable baseload of demand, development plans for Kenilworth School may lead to its removal. These plans, and the others in the area, are currently subject to change as the draft Local Plan is under review. The other key heat loads in Kenilworth are privately owned hotels, which would likely present challenges in terms of network development as the Council would have little influence over decisions regarding whether to connect. As a result, none of the five identified clusters is in Kenilworth.

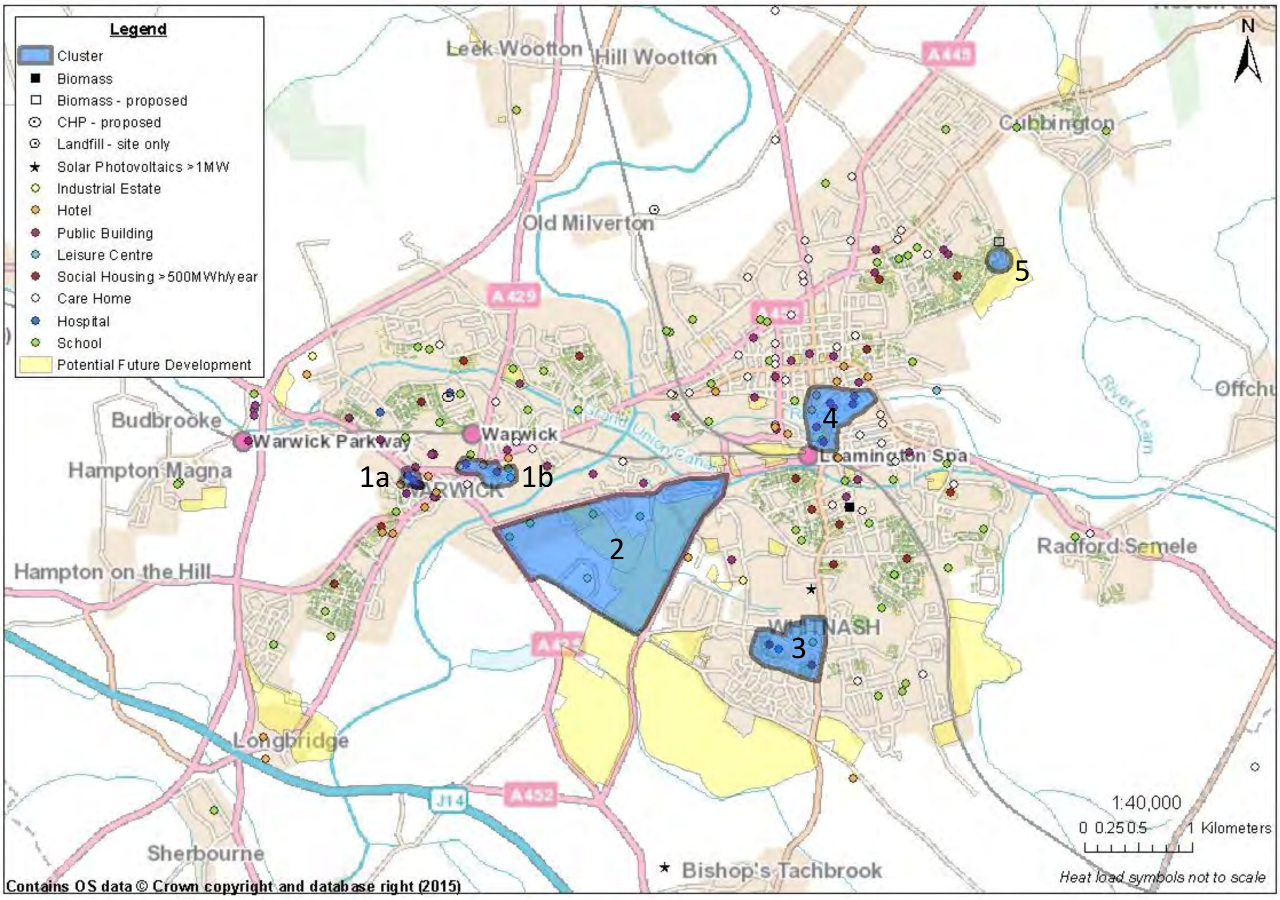


Figure 17. Potential opportunity areas for district heating in Leamington Spa and Warwick town.

Clusters 1-5

- **Clusters 1a and 1b, Warwick town centre**

Two opportunity areas have been identified in Warwick town centre: one compact cluster of County Council buildings (cluster 1), and one containing sheltered housing and a care home, a school and the St Nicholas leisure centre (cluster 2). Consisting exclusively of public buildings, cluster 1 may represent a good opportunity for the County Council to drive forward the development of a heat network in the area, which could be extended to cluster 2 in a later phase.

- **Cluster 2, Myton**

This opportunity area includes one of the largest benchmarked anchor loads in Warwick District – the Warwick School – as well as several key commercial buildings and the site of the planned Myton Garden Suburb.

- **Cluster 3, Whitnash**

The key existing heat load in this area is Leamington Spa Rehabilitation Hospital, which is close to Warwick Trident College and three areas of potential new development. Although there are few existing heat loads in this area, it may represent an opportunity to deliver a small scale heat network which has the potential to expand in the future as additional sites are developed nearby. Hospitals are often particularly suitable for CHP and heat networks as they tend to have high and constant heat demand.

- **Cluster 4, Leamington Spa Riverside**

A key opportunity in this area is the cluster of public buildings which could act as anchor loads for the development of a heat network. The cluster is also in proximity to two Council-led future developments: the new Creative Quarter, and the relocation of the District Council offices to Tavistock Square (Covent Garden). Redevelopment or new construction at these sites may present opportunities for siting energy centre(s) for a heat network.

- **Cluster 5, Lillington**

The opportunity identified here is a cluster of three social housing tower blocks in Lillington, which are scheduled for either refurbishment (including a biomass heating system), or demolition and redevelopment of the site. In either case, the redevelopment may present an opportunity to design in an energy centre and pipework for a heat network. The relatively high density of social housing in the area may mean that a heat network could provide social benefits by reducing heat prices for local residents.

Expansion zones A and B

Having identified the six clusters where heat networks may be most easily delivered in the near future, the areas surrounding them were considered qualitatively with respect to the potential for network expansion, and the possible timescales for that expansion. All heat mapping layers were overlaid and examined in order to identify further zones of network expansion:

- **Expansion Zone A**: where overall heat demand may be sufficient, or become sufficient if planned developments are built out, to justify the development or extension of a heat network beyond the original cluster area in the near to mid-term. There are likely to be challenges such as retrofitting existing buildings, and connecting private commercial and residential customers.
- **Expansion Zone B**: where there may be potential to develop or extend heat networks in the mid- to long-term, subject to uncertainties such as whether networks expand into zone A, the realisation and nature of future development allocations, and the cost and capacity of network infrastructure as the technology develops.

The location of the expansion zones is shown in Figure 18 overleaf. The criteria considered to identify the boundaries of the zones were:

- **Cost** of network development and connection: size of heat loads relative to the length of pipe required, the opportunities for ‘soft dig’ (less costly pipe-laying in non-tarmacked areas), the need to cross rivers or railway lines, and the likely disruption to local businesses, traffic and residents during construction.

- **Proximity** to initial clusters: where networks could be expanded outwards rather than establishing new ones from scratch.
- **Opportunities to connect** to existing energy generation (e.g. CHP at Warwick hospital or biomass boilers in social housing blocks) or to develop energy supply opportunities (e.g. the high water source heat potential along the River Avon).
- **Heat demand density** (shown in Figure 9 and Figure 10): although connecting existing non-public buildings to heat networks presents a number of logistical and contractual challenges (particularly for residential areas), areas of high heat demand are more technically suitable for the development of networks. These areas may present viable connection opportunities if the technology becomes more mainstream/desirable in future (e.g. if the price of centrally generated energy rises, or successful networks are established nearby).
- **Physical constraints:** crossing water bodies or railway lines may increase the cost of network route development, and in some areas (e.g. SSSIs or heritage areas) network development may not be permitted.
- **Level of council influence**: the presence of public buildings allows the Council to drive forward heat network development by connecting their own assets.
- **Proximity to planned new developments**: designing in district energy supply to a new development is usually easier than retrofitting to existing buildings. For larger sites where planning applications have not yet been made, the Council may be able to encourage the development of district heat by making it a condition of planning.

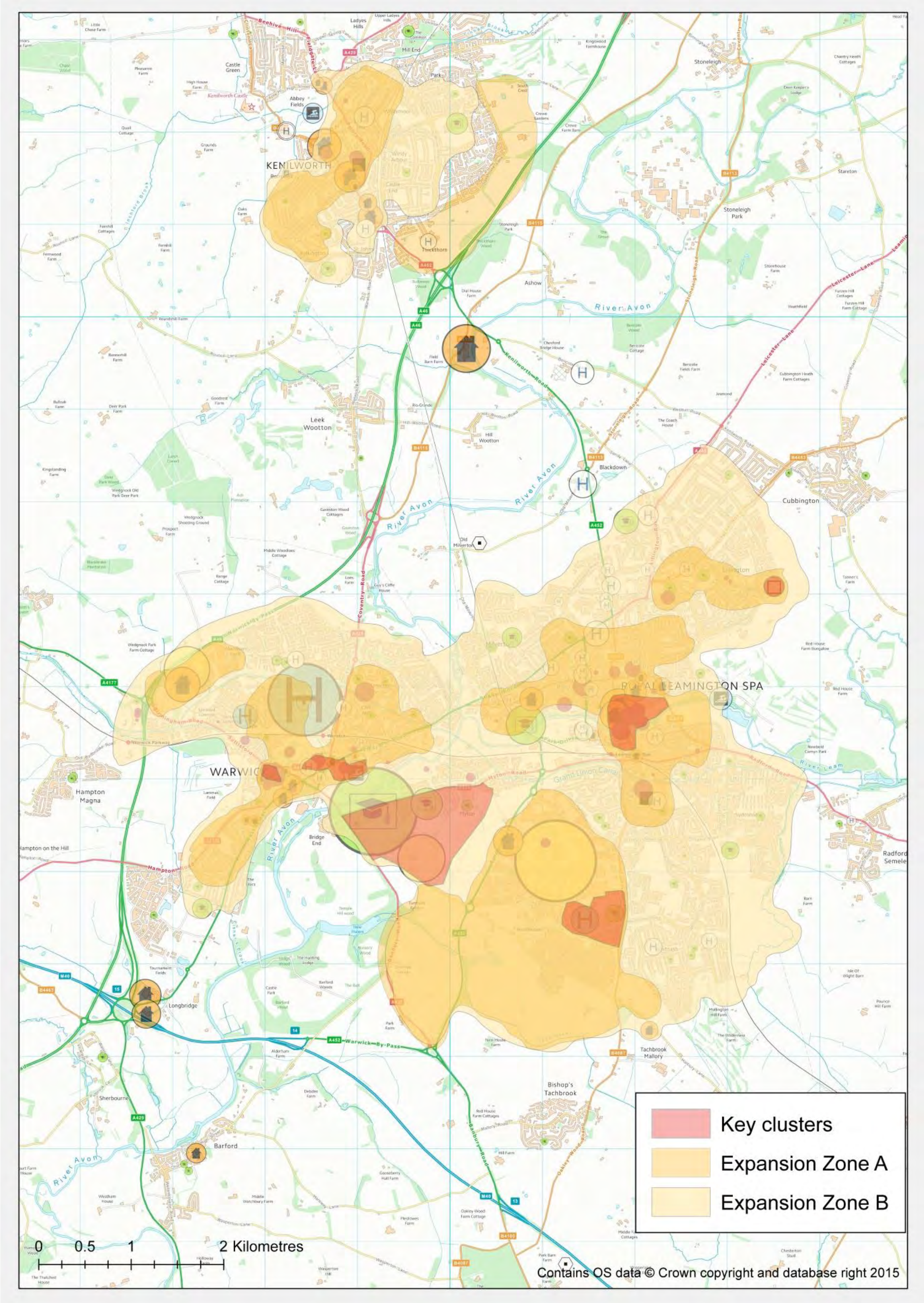


Figure 18. Expansion zones in Kenilworth, Leamington Spa and Warwick Town

Strategic masterplans

Having identified the zones, indicative network masterplans were produced for the study area, to show how networks could be developed and extended over time. Using the same criteria as those used to identify the clusters and expansion zones, four classes of potential network route were designed:

- **Class I**: networks which are judged to have the highest potential for development in the near future. These routes connect mostly existing anchor loads with high and stable heat demands, often public buildings where the Council may be able to positively influence network development.
- **Class II**: networks which may develop from networks in the key clusters in the near future. These routes connect mostly existing anchor loads, and some new developments for which planning permission has been granted, or which are likely to be built out in the near future.
- **Class III and IV**: networks which may develop from further extensions to networks in the key clusters, or as a result of new development. These potential network routes are unlikely to be suitable as the basis for new networks in the near future due to their locations in low heat demand density areas, but indicate a long term vision: where future feasibility studies and masterplanning may be beneficial if networks have already developed within the key cluster areas. Class IV networks would develop after class III (if at all).

Given the increasing uncertainty regarding the building mix present and the nature of developments in Warwick District as projections are made further into the future, the suggested network routes are less precise for classes III and IV than for classes I and II. In all cases, more detailed feasibility studies (including for example utilities searches and market testing) would be required prior to network delivery. The strategic masterplan for Leamington Spa and Warwick town is shown in Figure 19, and the masterplan for Kenilworth in Figure 20.

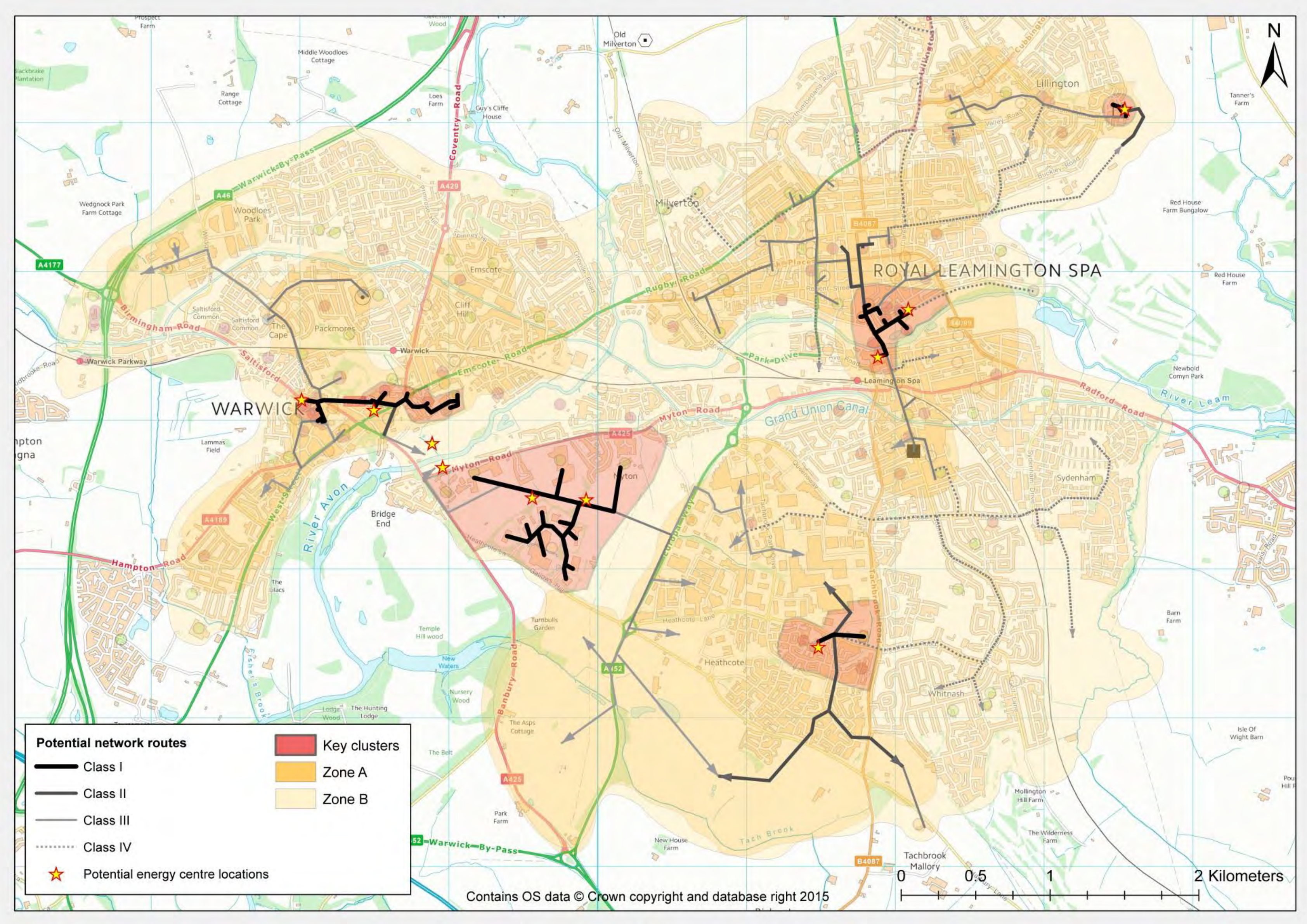


Figure 19. Strategic masterplan for Warwick town and Leamington Spa

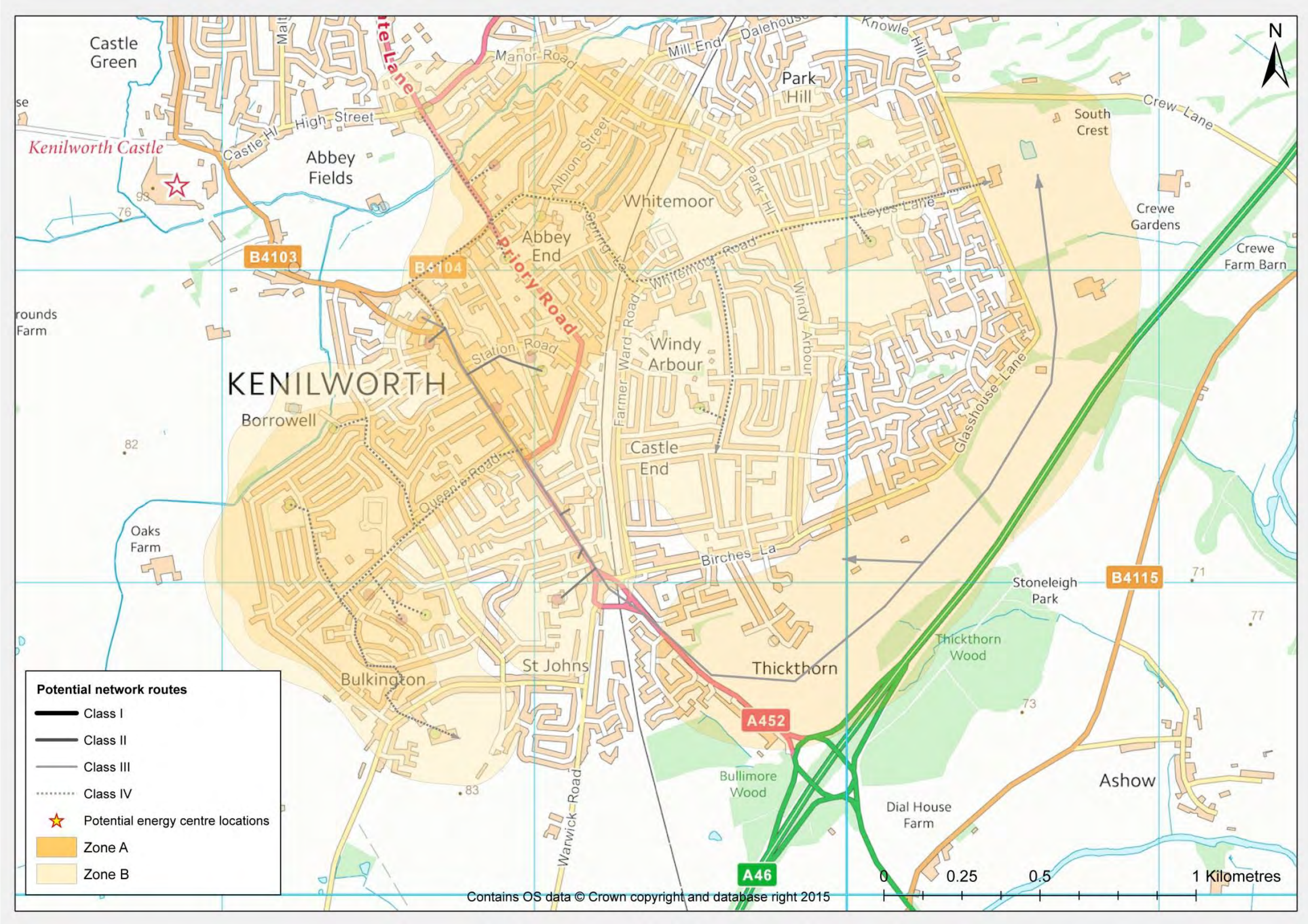


Figure 20. Strategic masterplan for Kenilworth

TECHNOLOGY OPTIONS FOR DISTRICT HEAT NETWORKS

04

TECHNOLOGY OPTIONS REVIEW

In this section, the energy supply options for generating heat for district heat networks (DHNs) have been reviewed to identify their suitability in terms of providing a cost effective and reliable heat supply that will also deliver environmental benefits in an urban environment.

Community Boilers

The first option considered is community boiler plant acting as a prime heat generator for supplying heat, distributed via a DHN.

Community Gas Boilers

The use of gas-fired boilers supplying community heating can be ruled out almost immediately as a replacement for existing locally sited gas boilers. New large boilers are likely to be a few percent more efficient than existing boilers in individual buildings (dependent on the age of existing plant), however this advantage is normally negated by heat losses from the DHN and the additional running costs of the energy centre and billing systems.

Therefore this option has not been considered further for primary heat supply.

Community Biomass / Biogas Boilers

Biomass refers to the use of a wide variety of organic material such as wood, straw, dedicated energy crops (e.g. specific types of grasses), sewage sludge and animal litter for the generation of heat, electricity or motive power. Biomass is regarded as a low carbon fuel because the CO_2 released when it is converted to energy by combustion is largely offset by that absorbed by the organic material during its growth.

With the appropriate management this emitted CO_2 can be recaptured, provided new growth of the same amount of biomass is achieved. However an overall carbon balance may not be achieved as a result of energy expended to harvest, process and transport biomass to its point of use. With this in mind, it is important to identify a source of fuel that is sourced from sustainably managed crops/woodland that does not need to be transported over long distances.

Biomass heating plant is available in a wide range of sizes from a few kilowatts to many megawatts. For smaller scale installations, fuel is usually supplied as wood pellets; whilst at the larger scales, wood chip is presently one of the most common fuels. In some cases other specific local sources of biomass fuel may exist, such as industrial by-products.

The advantages of supplying a DHN from communal biomass boilers include:

- Environmental benefits as a result of the low $kgCO_2$ per kWh for biomass compared to gas;
- The eligibility of the technology for the Renewable Heat Incentive (RHI);
- Ease of future heat source substitution.

However, any such biomass community boiler scheme would require:

- An energy centre large enough to incorporate the biomass boilers, in addition to the fuel store and thermal store (to avoid operating the boilers at low loads), plus gas-fired top-up / back-up boilers;
- Measures to ensure air quality standards are met;
- A suitable access route to the fuel store for large delivery lorries;
- A management company, typically an ESCo which also has responsibilities for sourcing fuel;
- A secure source of biomass fuel over a significant period, typically 20 to 25 years;
- A suitable source of biomass fuel that is near to its point of use, and has a low moisture content; dried for at least two years.

Figure 21 illustrates the biofuel suppliers in the vicinity of Warwick. It is not known whether the suppliers identified would be able to supply sufficient fuel to support the delivery of a biomass-fuelled DHN. However, the presence of biomass boilers serving social housing in Kenilworth and Leamington Spa suggests that a fuel supply network is already in place, which may be able to extend to other installations in the area.

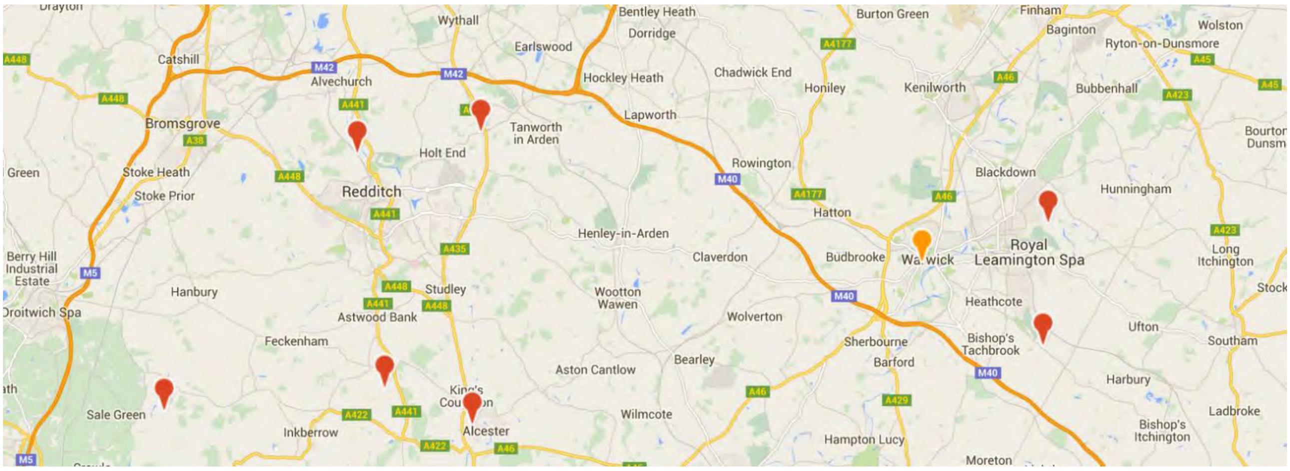


Figure 21. Extract from the National Biofuel Supply Database[9] showing Biomass Fuel Suppliers (Orange denotes a Supplier of Chips, Red indicates a Mixed Fuel Type Supplier).

In general, biomass boilers are only economic compared with gas boilers when RHI payments are obtained. Although the higher biomass fuel costs compared to gas could be offset by RHI payments, the longevity of the RHI scheme is not certain. However, if these constraints could be overcome, a biomass-fuelled district heating network could provide a low carbon heating solution for Warwick District.

Large Power Station Heat Take-Off

A significant amount of low grade heat energy is produced in the generation of electricity, which is normally rejected to the atmosphere, rivers or sea. When suitable heat demand is located nearby, the waste heat can be extracted to supply this demand via a DHN.

A typical heat offtake temperature for power station heat rejection is 35ºC, although it can be much higher[10]. Low grade heat (up to around 95ºC) can be extracted from most gas and steam turbines with minimal loss of electrical output; however, if higher grade heat (above 95 ºC) is required, then this can only be extracted at the cost of reduced electrical output. In such cases, the heat is no longer considered to be ‘waste heat’.

There are both economic and environmental advantages to the use of waste heat from power generation, if the cost to install the network and connections is less than the cost of producing the heat (related to the value of the electricity reduction), over a prescribed period.

Since there are no large power stations near to the study area, this heat source has not been considered any further for Warwick District.

Industrial / Commercial Waste Heat

Another potential source of heat for a DHN is waste industrial or commercial heat. The principle is the same as that for waste heat from power stations: an organisation is generating heat, in this case as a result of a process, which is surplus to requirements and therefore rejected to atmosphere or water.

No potential sources of waste heat have been identified within the opportunity areas, therefore this option has not been considered further.

[9] National Biofuel Supply Database. http://www.woodfueldirectory.org/

[10] London’s Zero Carbon Energy Resource – Secondary Heat Summary Report (July 2013) http://www.london.gov.uk/sites/default/files/031250%20GLA%20Secondary%20Heat%20-%20Summary%20Report_0.pdf

Combined Heat and Power

In general, the economic and environmental benefits of using an energy centre to supply heat via a DHN to a number of buildings are greater when the heat is provided by a Combined Heat and Power (CHP) plant which generates electricity in addition to heat, than when a standard gas boiler is used. For efficiency reasons, the CHP scheme should be designed to be heat-led so that all of the 'waste' heat produced as a by-product of electricity generation is utilised. The electricity is either used on site (directly supplying customers and displacing purchased grid supplied electricity), or it is exported to the grid (and sold for a wholesale value). Ideally, a large proportion or all of the electricity would be used on site to maximise the income from electricity generation. This requires a suitable host site with a large electrical demand, and/or the construction of a private wire network to sell electricity directly to customers (which has many licensing implications that may render the scheme unviable). Any CHP scheme will typically include a top-up and back-up energy supply, typically gas-fired boilers.

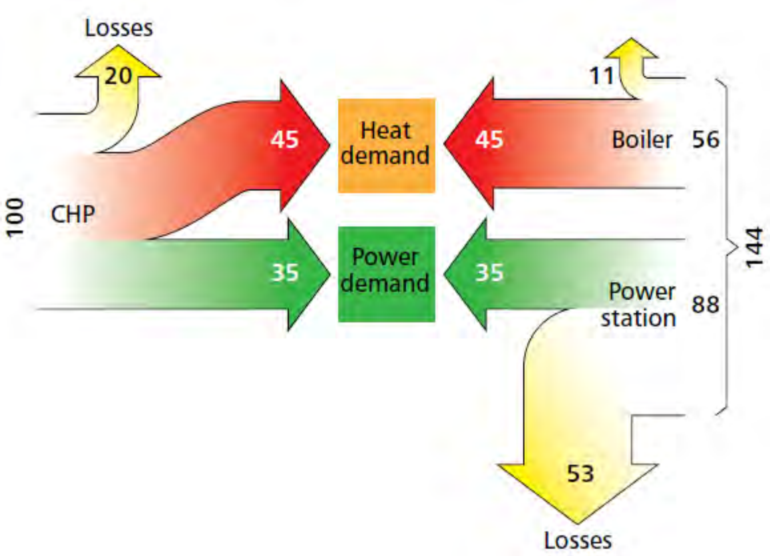


Figure 22: The efficiency benefits of CHP over conventional power generation and boilers (Source: CIBSE AM12[11])

Gas-Fired Combined Heat and Power (CHP) – Gas Reciprocating Engine

This technology has been widely used for many years and is considered mature and economically viable. The most noticeable advancement over the years is higher shaft efficiency and lower emissions. The normal system configuration is that an electrical generator is connected to the engine mechanically and a heat exchanger is used to extract the heat from the engine jacket, oil cooler and exhaust gas. Some gas engines have been developed to run on fuels other than natural gas, which have lower heating values and higher contents of impurities: such as anaerobic digestion gas (biomethane), landfill gas and syngas.

A CHP plant based on a gas engine can produce heat from three main sources: the engine jacket cooling system, the oil cooler, and the exhaust gases. Typically two-thirds of the heat is available in the engine jacket/oil cooler with the remaining one-third in the exhaust. A gas-engine CHP is normally used in low temperature hot water applications due to the maximum temperature in the engine jacket circuit (typically 95°C).

[11] Combined Heat and Power for Buildings. CIBSE AM12. 2012.

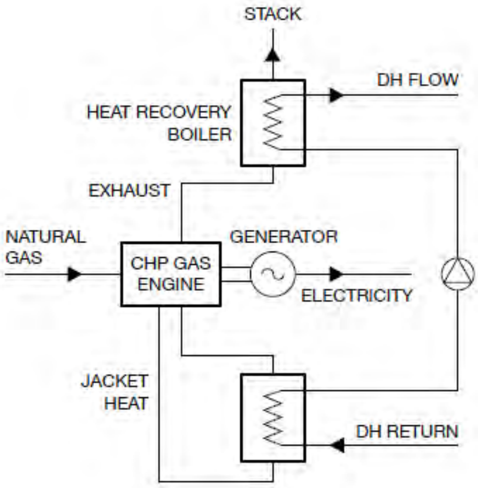


Figure 23: Typical DH connection to a gas reciprocating engine CHP system (Source: District Heating Manual for London[12])

Biomass-fuelled CHP
Biomass CHP can be based around gasification or combustion.

Gasification systems turn biomass material into a fuel known as syngas through a high temperature process (in excess of 800°C) where the fuel is reacted with oxygen and/or steam under high pressure, without combustion. This process produces a syngas which contains carbon monoxide, hydrogen and methane and can be burned in a modified gas engine to produce electricity and heat.

Gasification brings higher electrical efficiencies due to gas engine technology having advantages over steam based systems. Biomass gasification has been trialled at a number of sites in the UK for smaller scale CHP with varying degrees of success. There have been some instances of poor performance and it is generally considered that this technology is pre-commercial and immature. In Europe there are several wood gasifiers of less than 1 MW capacity that have been running successfully for some years, and this technology is now starting to become available in the UK.

Due to the use of steam turbine technology, small scale biomass CHP (in the order of 100s of kilowatts or tens of megawatts) is relatively low in efficiency. Electrical efficiency is often 20% or less, meaning that when operated in heat led mode, small scale systems are required due to the large heat outputs, resulting in the use of smaller, less efficient and more costly systems.

At a larger-scale, typically over 10MWe, combustion systems are well established and are usually fuelled by straw, forest residues (e.g. wood-chips), or waste wood (which is usually classed as a waste product and therefore is required to comply with the Waste Incineration Directive). Such biomass plants tend to be large in physical space terms, because they require space for fuel handling, storage and potentially processing, in addition to the need for relatively large boilers.

A biomass-fuelled CHP system requires a source of biomass fuel which is secure for a significant time period (20 to 25 years); near to its point of use; and has low moisture content.

Biogas-fuelled CHP
Biogas is produced from the decomposition of organic matter in an oxygen-free environment, and more specifically from anaerobic digestion systems designed for treating organic products, for example during the sewage treatment process. Biogas can be utilised in biogas engines to generate renewable power via cogeneration in the form of electricity and heat.

The Campion Hills water treatment works may provide a source of biogas suitable for use in a CHP system in Warwick District. However, biogas generated in sewage treatment works is typically used entirely to provide heat and power for the sewage treatment process.

Fuel cell CHP
A fuel cell is an electrochemical device that converts the chemical energy contained in fuels into electrical energy and heat. It is typically composed of a fuel electrode (anode) and an oxidant electrode (cathode) separated by an ion-conducting membrane. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat.

[12] District Heating Manual for London (DRAFT). GLA. 2013.

There are five main types of fuel cell classified by the electrolyte used in the cells. Three of these five types, the Phosphoric Acid Fuel Cell PAFC (150-200°C), the Molten Carbonate Fuel Cell MCFC (600-700°C), and the Solid Oxide Fuel Cell SOFC (700-1000°C) are suitable for district heating applications due to their operating temperature range.

As there is no combustion, the pollutants arising from fuel cells are relatively low compared with a gas-engine or gas turbine. Fuel cells can operate continuously as long as the necessary reactant and oxidant flows are maintained. High temperature systems cannot modulate and therefore need a constant baseload heat demand. However, although fuel cells are commercially available, they are generally considered to be an immature technology and significantly more expensive than conventional gas CHP engine alternatives.

In general at present, the efficiency advantages of fuel cells do not justify the additional costs over gas engine CHP. If the cost of fuel cells reduces significantly, then they may become more viable in the future, although due to the expected reduction in the electricity grid CO_2 intensity, this maturity may not happen in a timeframe which allows natural gas fuel cells to remain effective at saving CO_2.

Energy from Waste

Incineration

Energy from Waste systems are typically based around the incineration of waste in boilers to generate steam for a steam turbine. There are no Energy from Waste plants in the immediate locality of the opportunity area considered in this study. Therefore, heat from waste incineration is not considered further in this study.

Anaerobic Digestion

Anaerobic digestion (AD) produces biogas through the decomposition of organic waste in an oxygen-free environment. Feedstock for AD plants can be from a range of organic sources including animal waste, food waste, and purpose grown feedstocks (such as maize). A wet AD system typically processes feedstock using shredding and pulping systems before digesting in an air-tight reactor (usually batch processed). The biogas produced is taken off for energy generation (usually in a gas CHP engine, but also potentially for export), with some of the CHP heat used within the process. The resultant digestate is removed for use as a fertiliser. An alternative dry-batch system is also used for green waste where the feedstock is digested in air tight bunkers using a watering system to aid the process.

At present Warwick District Council collect garden and food waste from households and processes it at treatment plants in Ufton or Daventry, resulting in the production of compost. Assuming each home produces around 0.29 tonnes of food waste per year, and there are circa 60,000 homes in Warwick, the total annual food waste generation is around 17,400 tonnes per year[13 14]. This is an upper limit and assumes that food waste generation in Warwick is the same as the UK average, that all food waste is collected, and that all food waste is suitable for AD. It would be necessary to change from a combined collection of food and garden waste, to collect these waste streams separately. The actual figure is likely to be lower to account for collection uptake and suitability. Additional sources of food waste may be available from commercial premises or food processing.

A typical AD scheme operating on food waste will require around 40,000 tonnes per year of food waste feedstock for a 1 MWe output unit – this is around the minimum size considered to be commercially viable. It can therefore be seen that even with significant increases in food waste availability, the contribution that AD can make from the Warwick household resource alone is likely to be limited, and will be relatively small if it is part of a DE scheme.

Whilst other feedstocks could be imported for use in Warwick, the significant volumes of feedstock required, and the corresponding transportation, means that AD systems are best located near to the source of feedstock, often a rural location. In addition the significant transportation of digestate from the scheme also needs to be considered, which also benefits from a rural location.

For this reason, AD is not considered as a key heat generation option in this study. However if future organic waste treatment using AD is proposed in Warwick, the location of plant should allow for connection to a current or future DHN to allow export of heat.

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13 A figure of 0.29 tonnes per year per household is based on WRAP estimates of 7.2 million tonnes of food waste per year from UK homes. There are assumed to be 25 million homes in the UK. (New estimates for household food and drink waste in the UK, WRAP, 2011).

14 The actual number of homes in Warwick in 2011 was 60,427. Source – Neighbourhood Statistics Dataset Dwellings (QS418EW).

Large Scale Heat Pumps: Air, Water and Ground Sourced

Heat pumps take heat from the ambient surroundings (air, ground, or water) and deliver this heat at a higher temperature through a closed process; either involving a compressor (using electricity) or absorption (using heat; e.g. steam, hot water or flue gas).Of these heat sources, air is a diffuse source and so is less suitable for a centralised heating plant for DH. In order to absorb enough energy from the air the collector coil will need to be very large. This size can be reduced somewhat by blowing air across the collector with a fan, however if noise is to be minimised then this fan speed will be limited and the size of the collector increases.

Closed loop ground source systems are similarly limited in capacity as a large ground area is required. A closed loop system extracts heat through the use of a secondary medium. A glycol mix is circulated around the borehole array, and this is connected to the evaporator side of the heat pump. In general, closed loop, borehole ground energy systems are best suited to individual building systems, rather than wide area heat networks as the energy source is diffuse. Each borehole provides around 5-8kW of heat output (3.7-6.4MWh/yr).

In the case of open loop ground source heat pumps, water is extracted from the ground, passed through a heat exchanger and returned to a separate borehole. The heat extracted is available through a water to water heat exchanger. Boreholes are typically arranged at 100m centres. Open loop ground water systems could produce water at higher temperatures than typically achieved by closed loop systems. The flow rate from a single well is still limited though so a number of such installations would be needed across the area considered. A typical open loop borehole pairing can only provide around 380kW of heat energy. The amount of energy available from open loop schemes is subject to regulatory constraints imposed by the Environment Agency (EA). To avoid long term cooling of the ground, preference is given to balanced schemes which both extract and reject heat to aquifers on an annual cycle.

With water source heat pumps (e.g. river source), heat is extracted by passing a proportion of the water flow through a plate heat exchanger system (water to water). The water is then returned to the source, with no net abstraction and no changes in chemical composition but at a lower temperature. Robust water intake arrangements are required, along with measures to deal with biological fouling and to protect fish from being entrained within the intake pump suction.

The heat output is restricted to the allowable temperature difference and the minimum water return temperature, both of which are regulated by the EA. The heat available is directly proportional to the volume of water abstracted and to the temperature difference allowed. There is a significant degree of temperature variation, roughly corresponding to variations in average monthly air temperature.

An extract from the DECC Water Source Heat Potential layer of the National Heat Map shown in *Figure 24* indicates that the section of the River Avon running between Warwick (town) and Leamington Spa has some potential for water source heat.

Figure 24. Extract from DECC National Heat Map showing the River Heat Capacity (in kW) in Warwick and Leamington Spa.

Summary

The analysis of possible energy sources is summarised in the table below. Those in green have been examined further where appropriate in the technoeconomic analyses carried out for this study.

Technology	Suitability	Comments
Community gas boilers	Not suitable	Whilst technically viable, this is not expected to lead to financial savings which can justify the costs of the distribution network, and are also unlikely to be of any environmental benefits.
Community biomass/biogas boilers	Potentially Suitable	Technically suitable for connection to a DH network and will result in environmental benefits. Requires significant plant space for the biomass boilers, fuel storage, thermal store and gas-fired top-up/back-up boilers. Biogas requires particular consideration of the source of fuel, no local sources have been identified. Also requires consideration of air quality. Not expected to lead to financial savings which can justify the costs of the distribution network, although the RHI may partially offset this. There are risks surrounding future availability and cost of fuel, but the costs could be partially offset by the RHI.
Large power station heat take-off	Not suitable	No suitable power stations have been identified within the study area.
Industrial/commercial waste heat	Not suitable	No local potential heat sources have been identified.
Gas-fired CHP	Potentially Suitable	Gas CHP combines a mature, economic, technology with significant CO_2 reductions. There are no fuel constraints.
Biomass-fired CHP	Not suitable	Biomass CHP can deliver large CO_2 reductions and air quality issues can be addressed where plants are sufficiently large. There are significant concerns over the availability and future cost of fuel as for biomass boilers. The area required for an energy centre would be relatively large to allow for fuel delivery, storage, and processing.
Biogas-fired CHP	Not suitable	No local sources of biogas have been identified for use in a CHP system. Biogas generated in sewage treatment works is typically used entirely for the sewage treatment process.
Fuel cell CHP	Not suitable	This is currently considered an immature technology, and uneconomic compared with gas CHP engines. Whilst the electrical efficiency can be higher than for engines, the significant additional capital and operation costs outweigh this benefit.
Energy from waste - incineration	Not suitable	There are no EfW plants within the study area.
Energy from waste - Anaerobic Digestion	Not suitable	No current schemes using food waste exist in the area. AD requires a significant land take, and is unsuitable for a town centre location.
Heat pumps - Water source	Potentially Suitable	The River Avon between the towns of Warwick and Leamington Spa may provide a suitable heat source for a Water Source Heat Pump.
Heat pumps - Ground and air source	Not suitable	The limitations of capturing secondary heat from the ground or air at the scale required for DHNs means these systems are not suitable.

Table 2. Summary of Technology Options Review, Identifying which Technologies may be appropriate for the Opportunity Areas.

PRE-FEASIBILITY ANALYSIS: WARWICK TOWN CENTRE

05

PRE-FEASIBILITY ANALYSIS: WARWICK TOWN CENTRE

Overview

Two opportunity areas have been identified in Warwick town centre: one compact cluster of County Council buildings (cluster 1a), and one containing sheltered housing and a care home, a school and the St Nicholas leisure centre (cluster 1b).

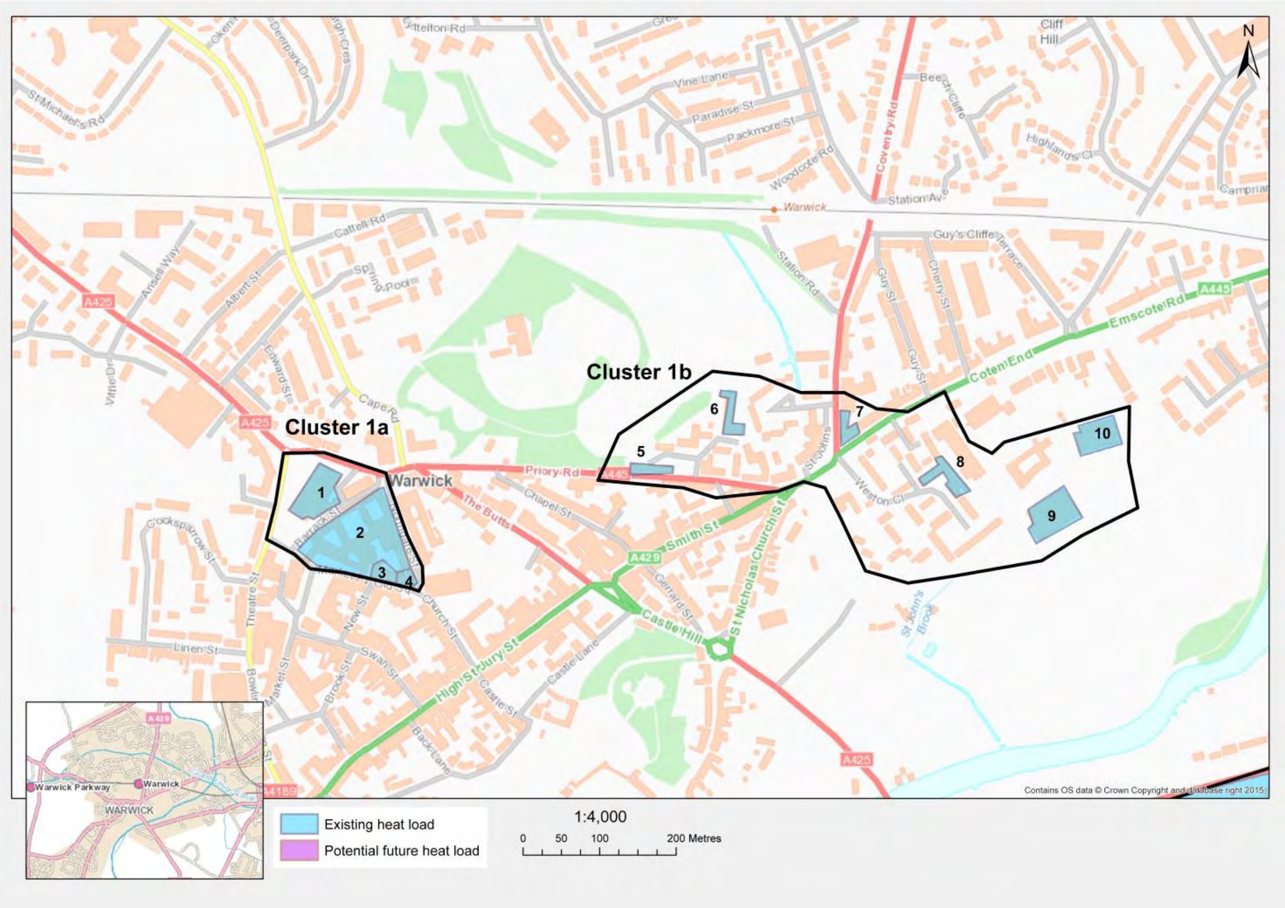


Figure 25. Warwick town centre clusters 1a and 1b.

Total heat demand Cluster 1a: 1,589 MWh/year Cluster 1b: 2,650 MWh/year				
Number	**Name**	**Heat demand**	**Data source**	**Notes**
1	Barrack Street Complex	415 MWh/year	Metered data from WCC energy management database	County Council offices.
2	Shire Hall	945 MWh/year	Metered data from WCC energy management database	County Council offices and court. Grade 1 listed.
3	Children and Family Services	99 MWh/year	Metered data from WCC energy management database	County Council offices.
4	Judge's House	130 MWh/year	Metered data from WCC energy management database	County Council offices. Grade 2 listed.
5	Park View Residential Home	540 MWh/year	Benchmarked from floor area and CIBSE TM46	
6	Yeomanry Court	370 MWh/year	Metered data from WDC energy management database	Sheltered housing.
7	Castle Limes Hotel	260 MWh/year	DEC	
8	James Court	255 MWh/year	Metered data from WCC energy management database	Sheltered housing.
9	St Nicholas Park Leisure Centre	1070 MWh/year	Metered data from WDC energy management database	
10	Coten End Primary School	155 MWh/year	Metered data from WCC energy management database	

Table 3 . Clusters 1a and 1b heat demand

Consisting exclusively of public buildings, cluster 1a may represent a good opportunity for the County Council to drive forward the development of a heat network in the area, which could be extended to cluster 1b in a later phase, as indicated in Figure 28. Shire Hall and Judge's House are listed buildings, which limits the opportunities for redevelopment and would require energy plant to be located in existing service spaces (if available), or outside the buildings. There is also an air quality management area (AQMA) along the roads which border the area (shown in Figure 26) which may place some restrictions on the placement of biomass plant.

Cluster 1b contains two sheltered housing schemes, a care home, and the St Nicholas leisure centre; all of which are predicted to have relatively stable heat demands. The leisure centre is predicted to have reasonably high heat demands due to the presence of a swimming pool. The proximity of these buildings to cluster 1a may present an opportunity to extend an established Council-led heat network (cluster 1a) to them; or to develop a network serving both clusters from the outset. Figure 27 shows the AQMAs and areas of flood risk in cluster 1b which may affect the placement of energy generation plant.

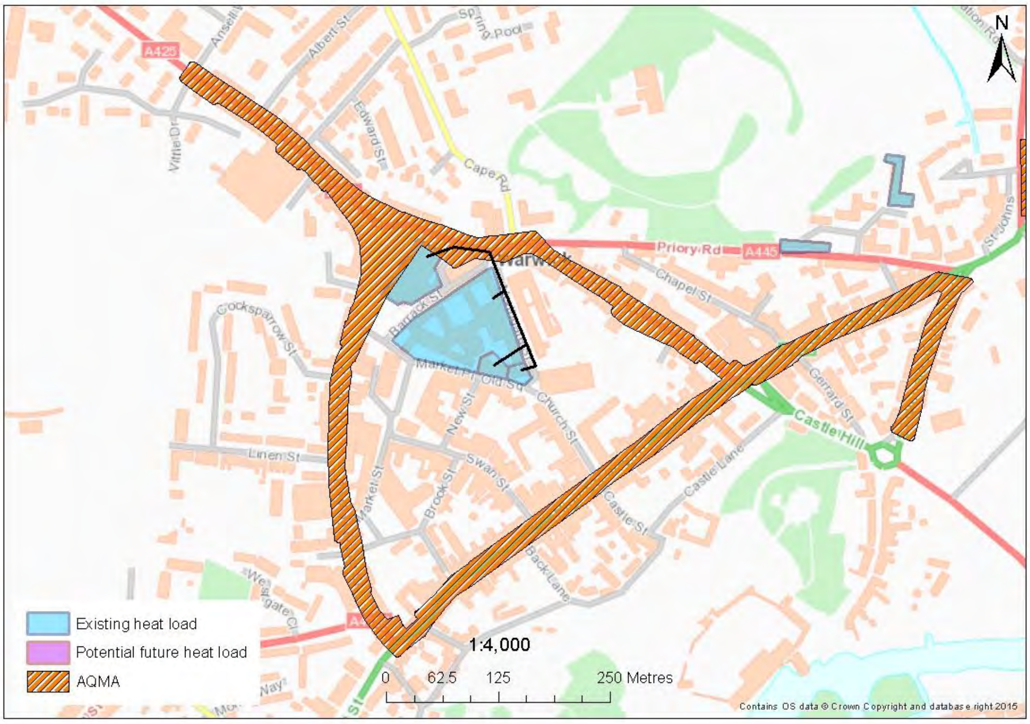


Figure 26. Network route option for Warwick town centre cluster 1a

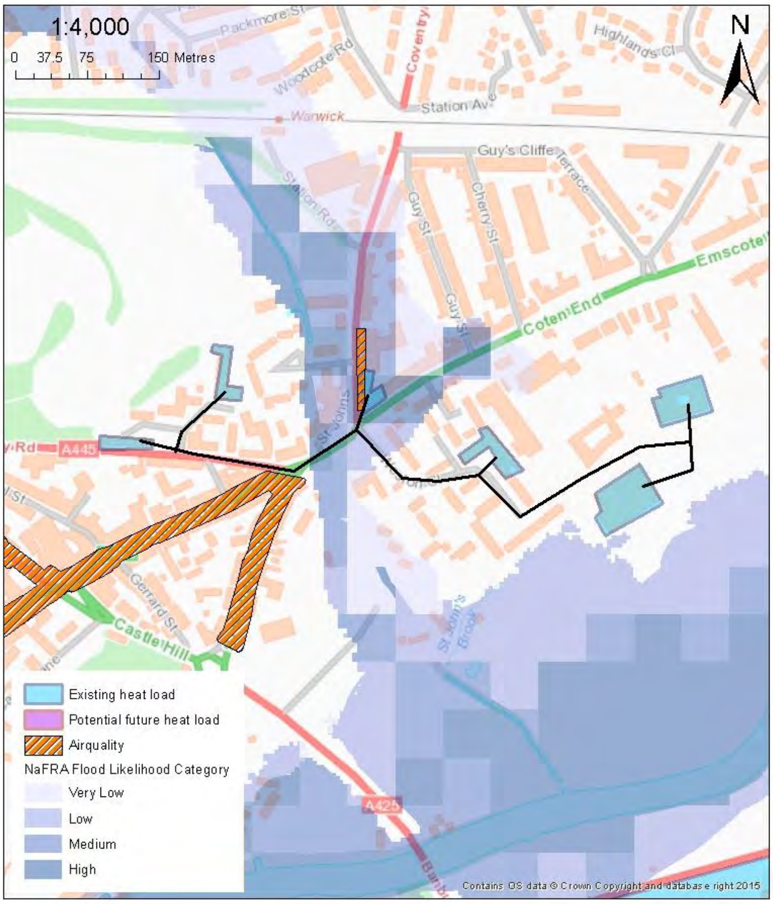


Figure 27. Network route option for Warwick town centre cluster 1b

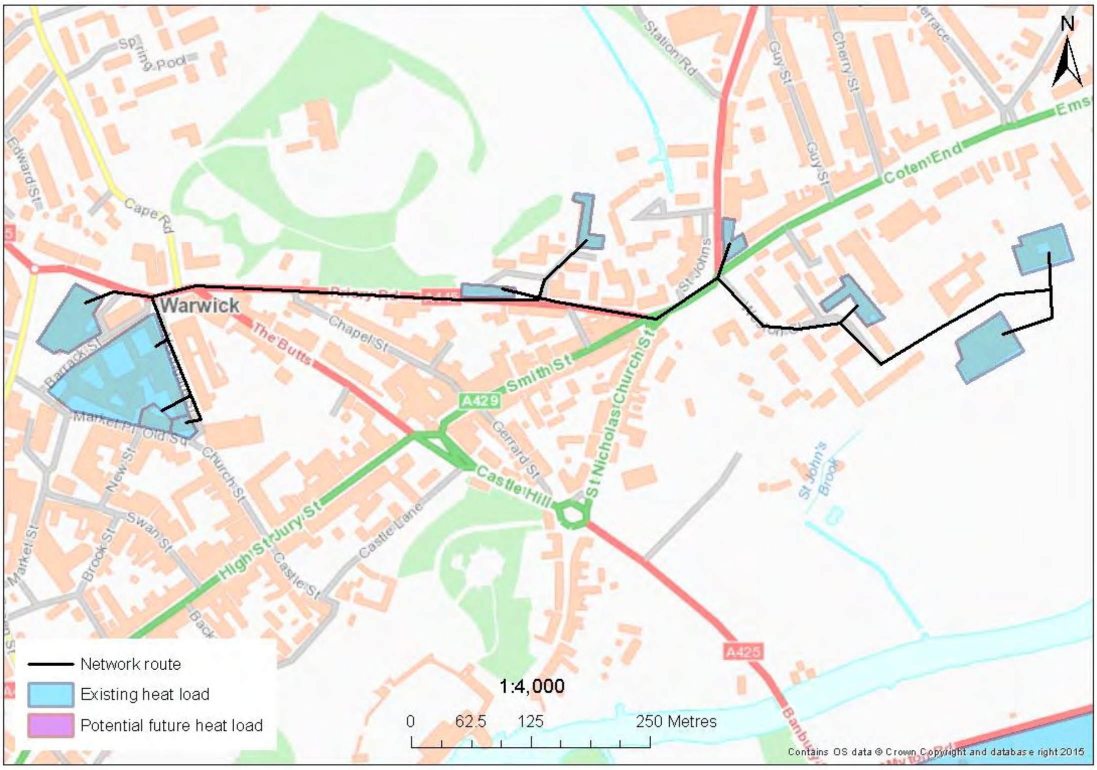


Figure 28. Network route option linking Warwick town centre clusters 1a and 1b

Energy Centre Location

General Constraints

The town centre locations of clusters 1a and 1b present a number of challenges to the appropriate siting of an energy centre, including:

- Much of the town centre lies within the Warwick Conservation Area. Figure 29 shows the extent of the area covered;
- There is an Air Quality Management Area (AQMA) along roads which border cluster 1a;
- There is little apparently vacant land.

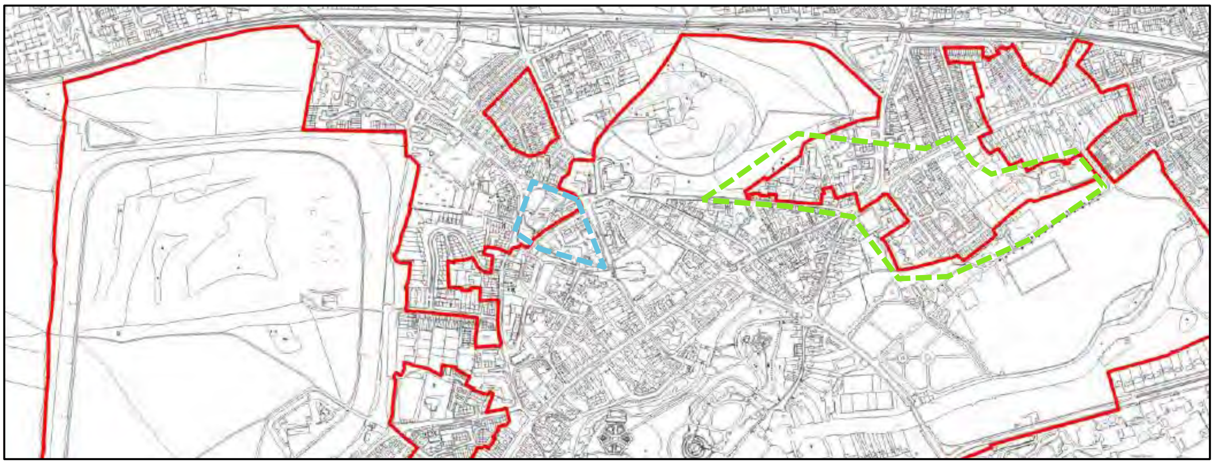


Figure 29. Extract from Revised Warwick Conservation Area (April 2010) Map, showing Conservation Area Boundary in Red and approximate locations of Cluster 1 (in Blue) and Cluster 2 (in Green).

Appraisal

The below Figure 30, illustrates the sites that have been identified as potentially viable for the siting of a new energy centre.

Figure 30. Potential Energy Centre Locations for Warwick Town Centre (potential sites for Cluster 1a denoted by numbers in blue circles, potential sites for Cluster 1b denoted by letters in orange circles).

The following table presents the initial appraisal of energy centre sites for the Warwick Town Centre clusters 1a and 1b.

Site Name and Reference	Opportunities	Constraints	Site Image
(1) St Mary's Area 4 Surface Car Park	• Warwick District Council car park. • No tall (greater than 2 storeys) buildings within immediate vicinity.	• Site lies within the Warwick Conservation Area. • Located to the extreme West of Cluster 1, making pipework runs very long and difficult to connect Clusters 1 and 2. • Close proximity to Warwick Racecourse, Warwick Golf Centre and residential buildings.	
(2) Vacant Land Adjacent to Warwick Racecourse	• No tall (greater than 2 storeys) buildings in immediate vicinity.	• Unknown site ownership • Very close proximity to residential buildings. • Site lies within the Warwick Conservation Area. • Close proximity to Warwick Racecourse, Warwick Golf Centre, residential buildings and the Hill Close Gardens (Victorian leisure gardens with Grade II listed summer houses).	
(3) Land adjacent to the Barrack Street Complex	• Outside of (but immediately adjacent to) the Warwick conservation area.	• Overlooked by residential buildings. • 3-storey Barrack Street office building in close proximity may require increased flue height. • Site bordered by the Air Quality Management Area (AQMA) on Saltisford and Theatre Street.	
(4) West Rock Surface Car Park	• Existing Warwick District Council car park.	• Site lies within Warwick conservation area. • 3-storey flat/apartment buildings in close proximity to the site. Other residential buildings (2 storey houses) in close proximity. • Close to the Air Quality Management Area.	
(A) St Nicholas Park Surface Car Park	• Existing Warwick District Council car park.	• Site lies within Warwick conservation area. • 3-storey flat/apartment buildings in close proximity to the North East of the site. • Close to St Nicholas Park. • Outside of cluster area.	
(B) St Nicholas Park Leisure Centre	• Close to largest heat load. • No tall buildings in immediate vicinity. • Warwick District Council leisure centre.	• Unknown existing plant space capacity, or whether a new stand-alone energy centre could be built. • Close proximity to Coten End Primary School. • Potentially difficult access. • Site lies within Warwick conservation area.	

The technoeconomic analyses for the Warwick Town Centre cluster have assumed energy centres sited adjacent to the Barrack Street complex (option 3) and/or at the St Nicholas Park leisure centre (option B). Both sites were chosen due to their relative proximity to the heat loads compared with the other options, and in the case of the Barrack Street site, its position outside the Warwick Conservation area.

Technology options review

The technology options review in Section 5 has identified that the following technologies may be appropriate for the Warwick Town Centre opportunity area. These are discussed in more detail below.

Community Biomass/Biogas Boilers

A biomass-fuelled DHN may be a viable option for Warwick town centre if a suitable fuel supplier can be found. Careful consideration of the location of the energy centre will be required, to ensure that access for fuel deliveries can be made, along with a suitable flue arrangement to address air quality issues.

Gas Fired CHP

As gas-fired CHP is a mature technology, this technology is considered to be suitable for connection to a district heating network in Warwick town centre.

Town centre network options: technoeconomic assessment

Different generating technology and network scenarios for the town centre clusters were modelled to produce indicative IRR and NPV figures. Where a private wire arrangement was included, it was assumed that electricity could be sold directly on the network to the Barrack Street complex, Shire Hall, Children and Family Services and the Judge's House; since they are publically owned and are in close proximity to the energy centre and each other.

The export tariff for the private wire option was calculated as follows:

Building	Proportion of total electricity demand on the network
Barrack St Complex	3%
Shire Hall	69%
Children and Family Services	3%
Judge's House	2%
Total	**77%**

Lowest assumed retail tariff paid by buildings connected with private wire[15]: 10.08p/kWh

Assumed standard export tariff: 5.50p/kWh

Export tariff for Warwick Town Centre network concept = (0.77*10.08) + (0.23*5.50)

= 9.03p/kWh

Network concepts connecting only the buildings in cluster 1a (shown in Figure 31) and only the buildings in 1b (shown in Figure 32) were tested first. The concepts failed to achieve a positive IRR and NPVs were very negative. Network concepts connecting the buildings in both clusters, as shown in Figure 33, achieved positive IRRs, and the results are discussed further below.

15 From: DECC 2015: Prices of fuels purchased by non-domestic consumers in the UK

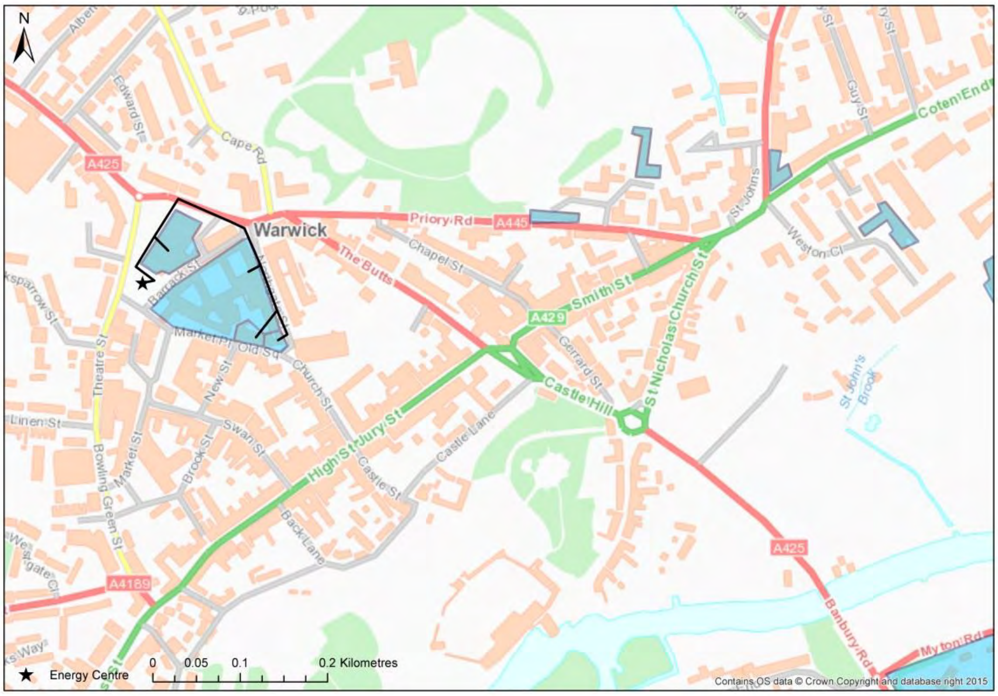


Figure 31. Network concept for cluster 1a.

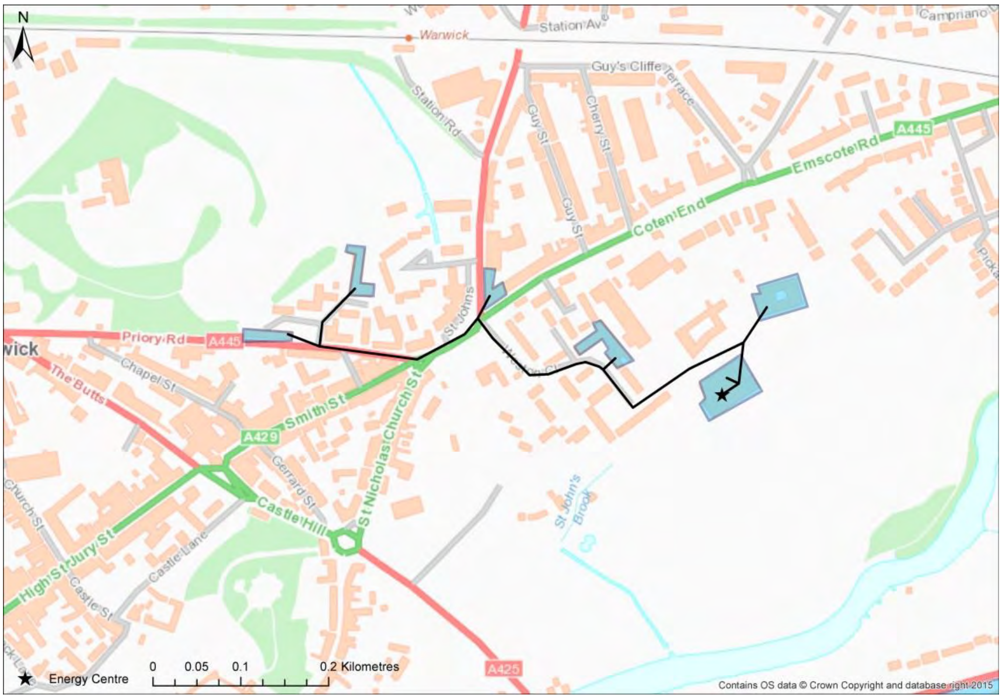


Figure 32. Network concept for cluster 1b.

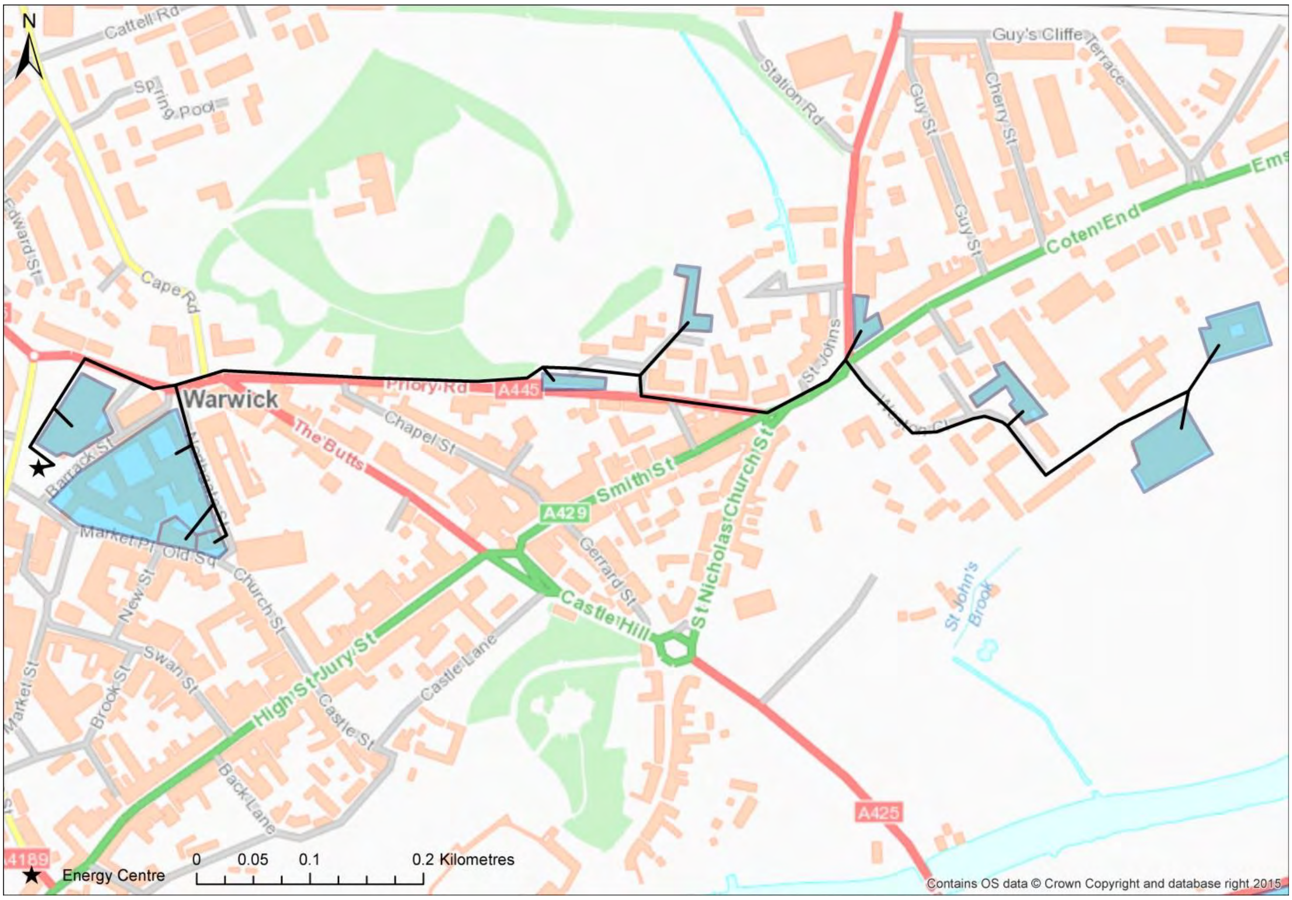


Figure 33. Network concept for cluster 1a and 1b.

<u>*Clusters 1a and 1b: Gas CHP*</u>

		Capital cost: £3,858,700 1 x 428 kW + 1 x 645 kW Gas CHP + 230kW top-up Gas Boiler Electricity export tariff: 5.50p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[c]
Emissions 1[a]	25 year	-509	-	-£2,154,400
	40 year	-684	-	-£2,014,900
Emissions 2[b]	25 year	30	-	-£2,154,400
	40 year	-19	-	-£2,014,900

[a] IAG emissions projections for average and marginal electricity use
[b] Emissions projections for electricity use from *Modelling the impacts of additional Gas CHP capacity in the GB electricity market (December 2014)*
[c] Using discount rate of 6%

Table 4. Results of techno-economic modelling for clusters 1a and 1b: Gas CHP. See Appendix 2 for a summary of the assumptions used.

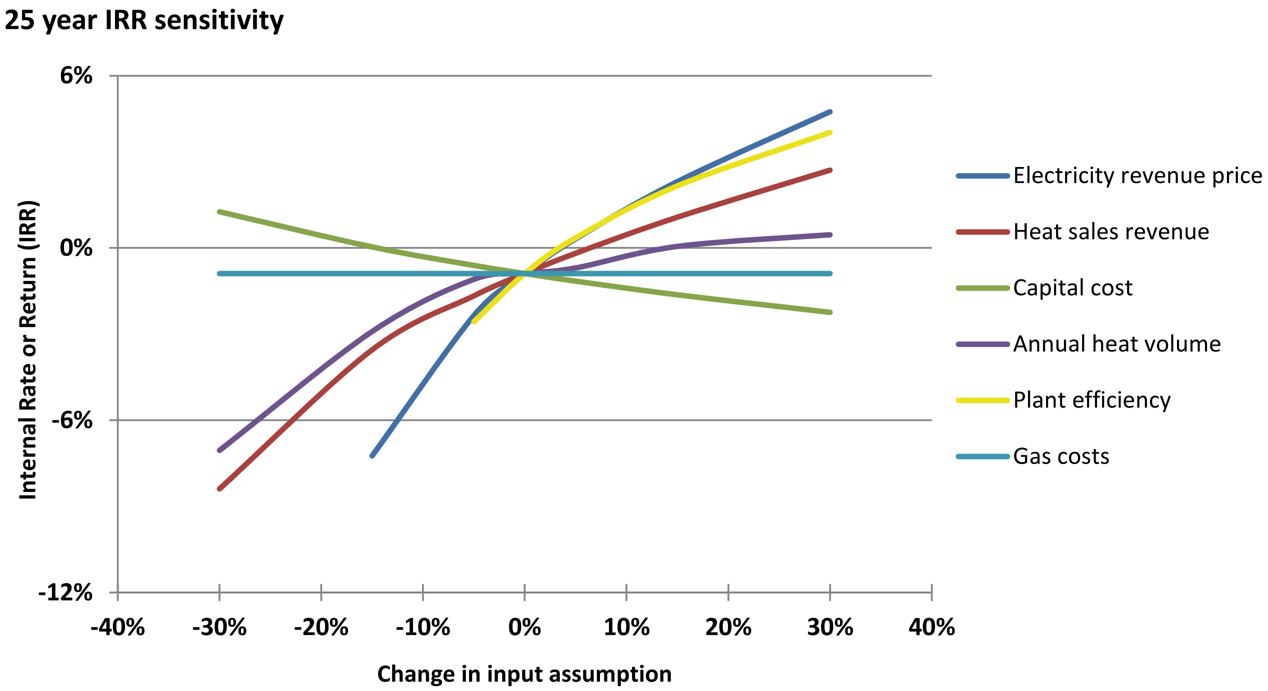


Figure 34. Sensitivity of 25 year IRR to changes in inputs, for clusters 1a and 1b: Gas CHP.

Clusters 1a and 1b: Gas CHP with private wire to public buildings

		Capital cost: £3,858,700 1 x 428 kW + 1 x 645 kW Gas CHP + 230kW top-up Gas Boiler Electricity export tariff: 9.03p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[c]
Emissions 1[a]	25 year	-509	4.2%	-£403,200
	40 year	-684	6.1%	£80,200
Emissions 2[b]	25 year	30	4.2%	-£403,200
	40 year	-19	6.1%	£80,200

[a] IAG emissions projections for average and marginal electricity use

[b] Emissions projections for electricity use from *Modelling the impacts of additional Gas CHP capacity in the GB electricity market (December 2014)*

[c] Using discount rate of 6%

Table 5. Results of techno-economic modelling for clusters 1a and 1b: Gas CHP with private wire to Council buildings. See Appendix 2 for a summary of the assumptions used.

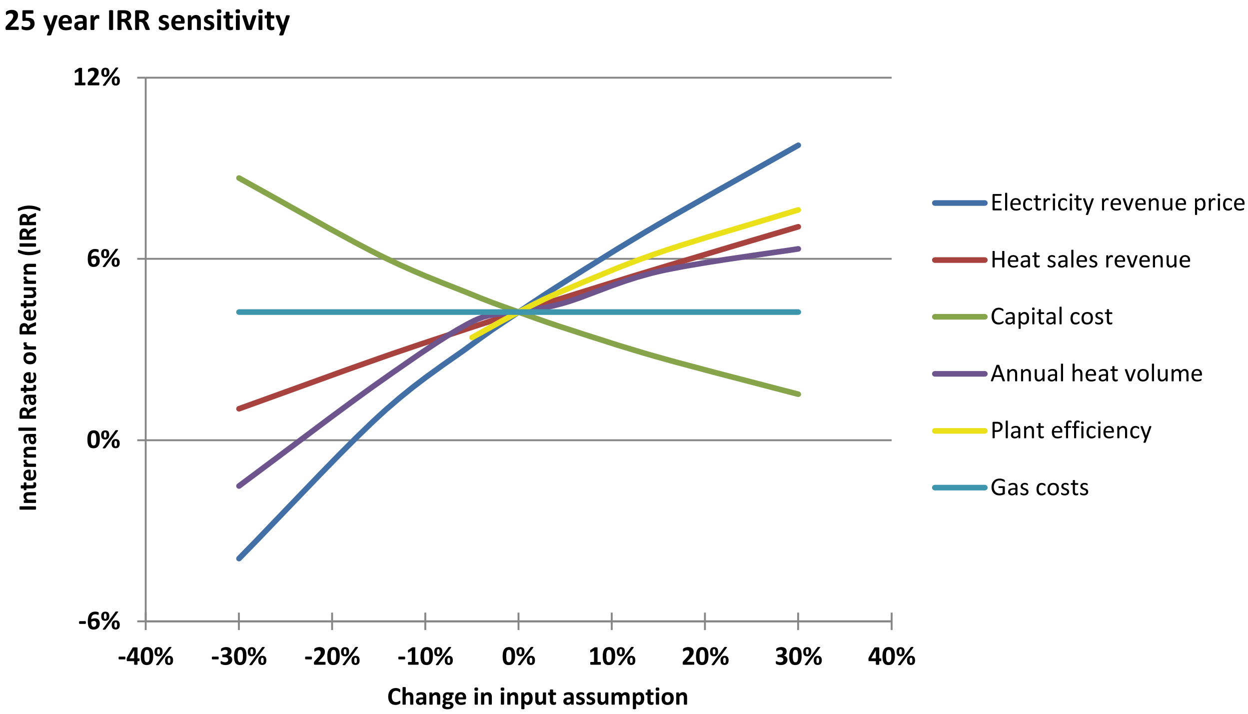


Figure 35. Sensitivity of 25 year IRR to changes in inputs, for clusters 1a and 1b: Gas CHP with private wire to Council buildings.

The sensitivity analyses for gas CHP-led network concepts demonstrate the importance of the price achieved for electricity sales from CHP, either directly on the network or exported to the grid. Achieving a high enough price without disadvantaging network customers will require careful negotiation and contract design. Capital cost is also a significant factor: this analysis indicates that reducing capital cost by approximately 20% (e.g. through value engineering or grant funding) could allow the network concept which includes private wire to achieve an IRR of 6% within 25 years.

Clusters 1a and 1b: Biomass

		Capital cost: £3,551,900 750kW biomass + 430kW top-up gas boiler Electricity export tariff: n/a		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	711	-	-£1,837,500
	40 year	695	-	-£1,946,700

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 6. Results of techno-economic modelling for clusters 1a and 1b: biomass. See Appendix 2 for a summary of the assumptions used.

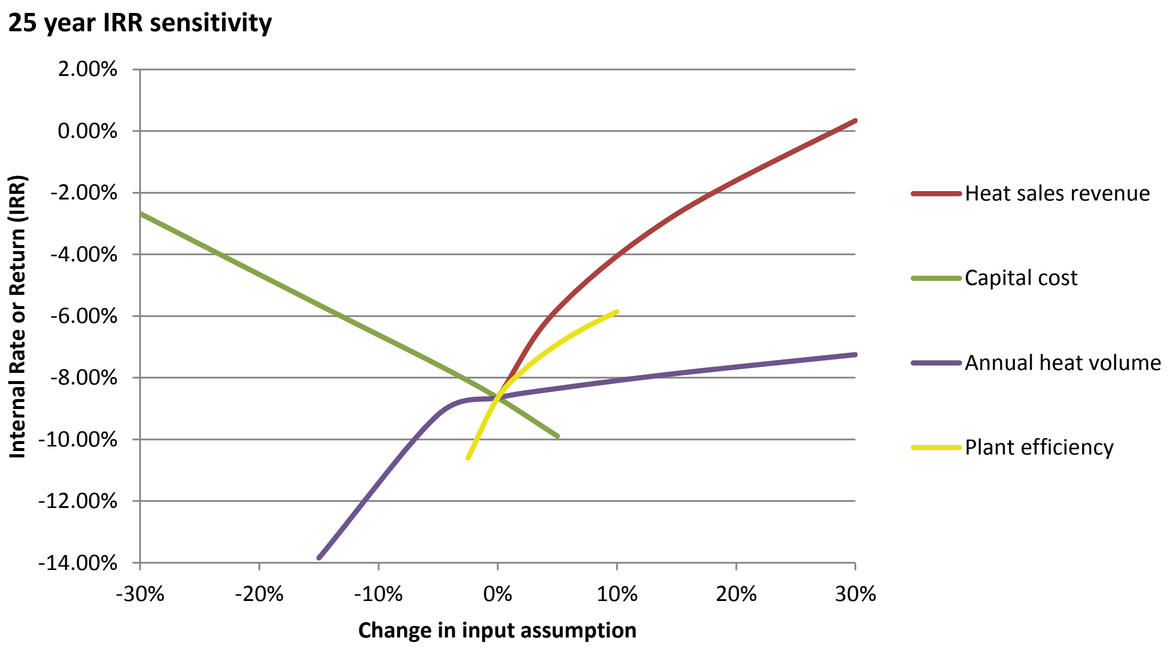


Figure 36. Sensitivity of 25 year IRR to changes in inputs, for clusters 1a and 1b: Biomass.

Clusters 1a and 1b: Biomass boiler and Gas CHP, with private wire to Council buildings

		Capital cost: £3,810,700 600kW biomass + 650kW CHP + 160kW top-up Gas Boiler Electricity export tariff: 9.03p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	644	0.4%	-£1,166,200
	40 year	617	1.6%	-£1,104,400

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 7. Results of techno-economic modelling for clusters 1a and 1b: Gas CHP and biomass with private wire to Council buildings. See Appendix 2 for a summary of the assumptions used.

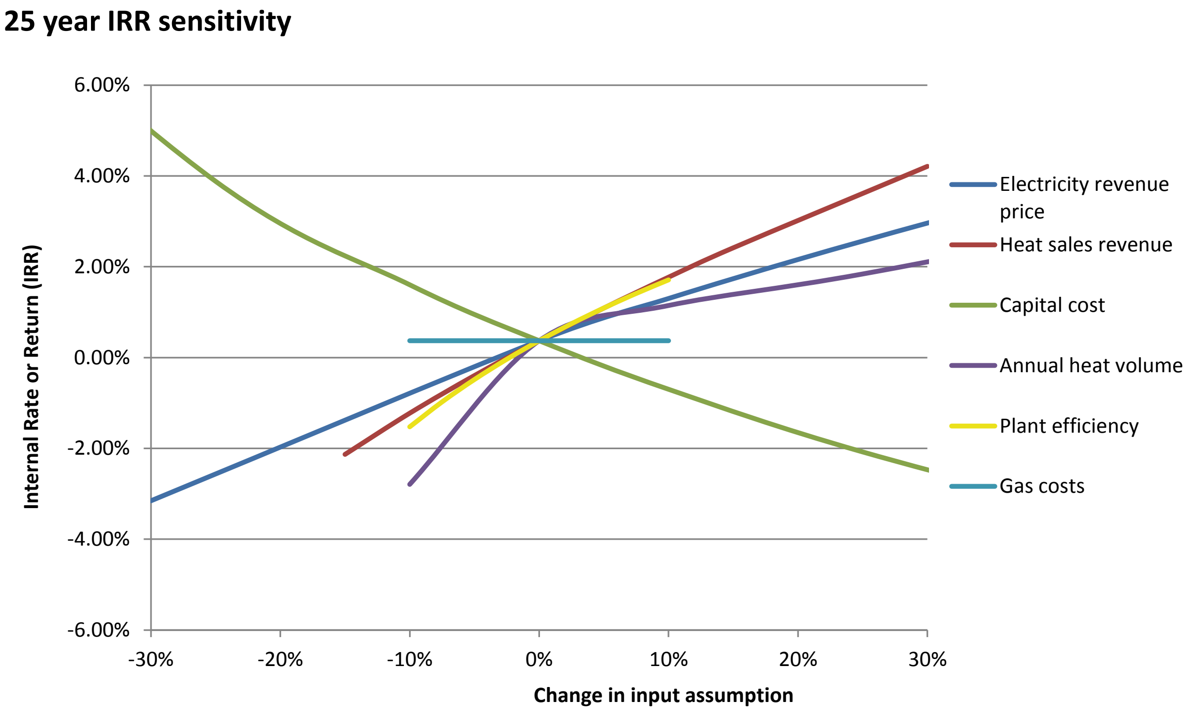


Figure 37. Sensitivity of 25 year IRR to changes in inputs, for clusters 1a and 1b: Biomass Boiler and Gas CHP, with private wire to Council buildings.

CHP was included in addition to the biomass in this network concept to increase the potential energy sale revenue by generating electricity (which usually achieves higher sale prices than heat). The use of biomass to generate heat is prioritised over CHP in order to maximise the amount of generation eligible for RHI payments.

The sensitivity analysis demonstrates that capital cost is likely to be the most significant factor affecting the economic feasibility of this network concept, although achieving an IRR of 6% within 25 years would require a reduction in capital cost of over 30%. It also demonstrates the importance of the price achieved for heat on the network (more important than electricity in this case since the scheme is biomass-led). Achieving a high enough price without disadvantaging network customers will require careful negotiation and contract design.

Summary and conclusions

Technology option	Capital cost	25 year IRR	25 year NPV	25 year average CO_2 savings[16]	40 year IRR	40 year NPV	40 year average CO_2 savings[17]
Gas CHP	£3,585,700	-	-£2,154,418	30	-	-£2,014,891	-19
Gas CHP with private wire	£3,585,700	4.2%	-£403,200	30	6.1%	£80,200	-19
Biomass	£3,551,900	-	-£1,837,500	711	-	-£1,946,700	695
Biomass with Gas CHP and private wire	£3,810,700	-	-£1,718,300	644	-	-£1,765,100	617

Table 8. Summary of results for Warwick Town Centre

16 Under the 'Emissions 2' scenario
17 Under the 'Emissions 2' scenario

The analysis suggests that a network connecting the public buildings only would not be economically viable at present unless it also extended east to other buildings in the cluster. Engaging with potential customers for a network here will therefore be essential for any detailed feasibility study undertaken for this area.

A gas CHP-led network linking the two clusters identified in Warwick Town Centre and with private wire to Council buildings achieves a 40 year predicted IRR of 6.1%, a rate which may be expected to attract public funding. A significant advantage of developing a network here is the opportunity for Warwickshire County Council to lead and drive development by connecting their buildings to a network. Attracting additional commercial network customers to a new or extended network may be easier when a network (or plans for a network) is already in place, rather than at the concept design stage.

PRE-FEASIBILITY ANALYSIS: MYTON

06

PRE-FEASIBILITY ANALYSIS: MYTON

Overview

This opportunity area includes one of the largest benchmarked anchor loads in Warwick District – the Warwick School – as well as several key commercial buildings and the site of the planned Myton Garden Suburb. Although developing a heat network for commercial buildings can be more challenging than developing one around public buildings due to the diversity of stakeholders involved, Myton Garden Suburb may present opportunities to establish a network linked to the new development which may be extended to commercial customers.

Outline planning permission has already been granted for sections of the site, which may preclude the development of a network in those areas. The new school provision planned for the suburb has not yet been masterplanned, and may still represent an opportunity to incorporate a district heat network. Due to this uncertainty, neither has been included in the technoeconomic analysis for this network.

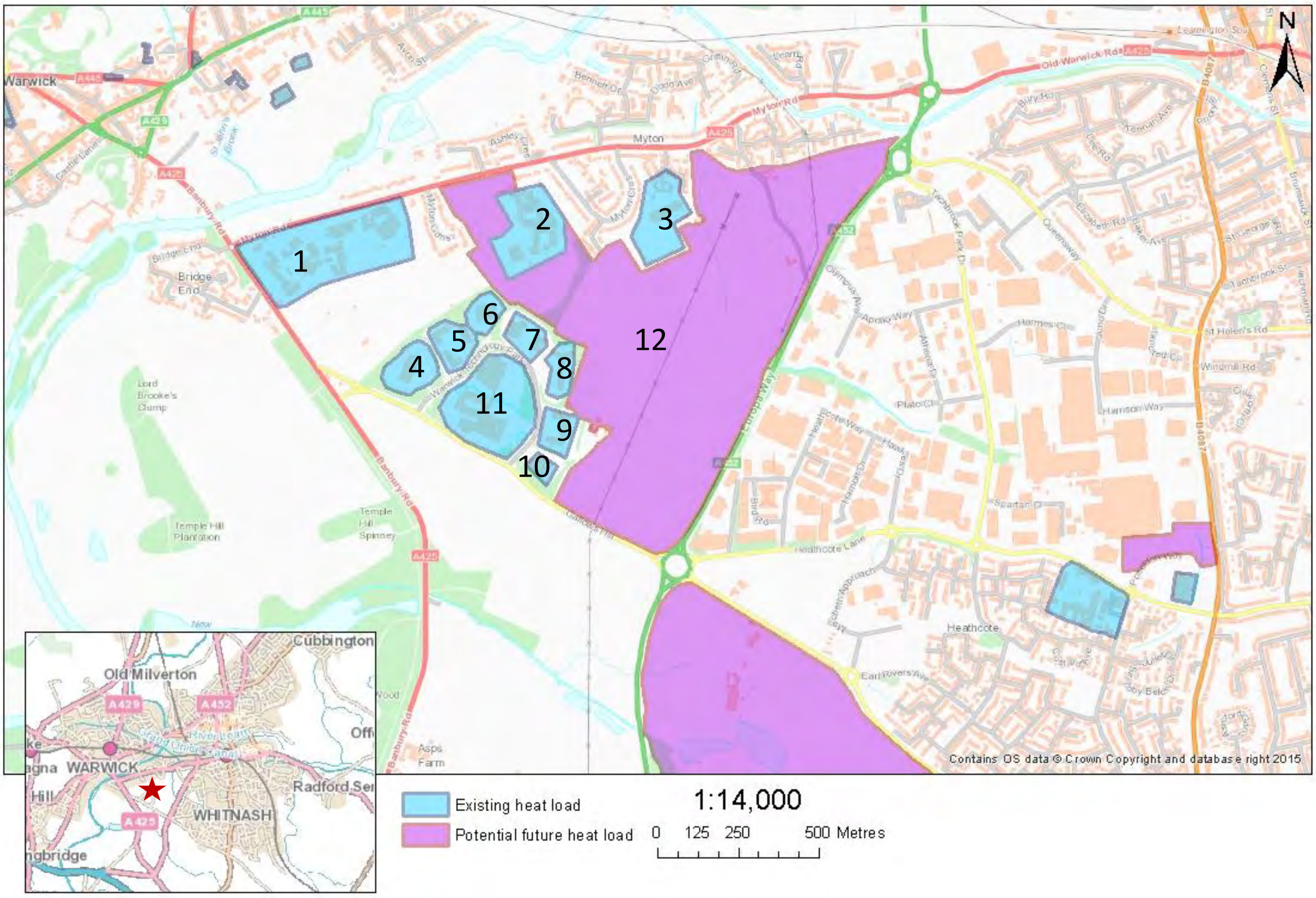


Figure 38. Myton opportunity area

Total heat demand: 43,175 MWh/year				
Number	**Name**	**Heat demand**	**Data source**	**Notes**
1	Warwick School	13500 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	Boarding school with campus including residential dorms, sports centre and theatre.
2	Myton School	2400 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	
3	Round Oak School	190 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	
4	Wireless House	480 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	Occupied by National Grid.
5	IRESS/Phillips 66	820 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	
6	Mid Counties Co-op	415 MWh/year	Benchmarked from map measurements and CIBSE TM46	
7	Tulip	415 MWh/year	Benchmarked from map measurements and CIBSE TM46	
8	University of Warwick Science Park/Warwick Innovation Centre	450 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	
9	ICENI Centre	1595 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	
10	McKesson	810 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	
11	National Grid Headquarters	8200 MWh/year	DEC	
12	Myton Garden Suburb	5700 MWh/year	Benchmarked from details within planning applications, CIBSE TM46 and AECOM models for new dwellings	Part of Southern Urban Extension, owned by the Europa Way Consortium. Planning permission granted for construction of up to 735 dwellings, and a mixed-use neighbourhood centre to include retail development and/or community and health uses.

Figure 39 illustrates an option for development of a network including the entire Myton Garden Suburb, while Figure 40 demonstrates how a network could be developed around the commercial customers and the new school provision only.

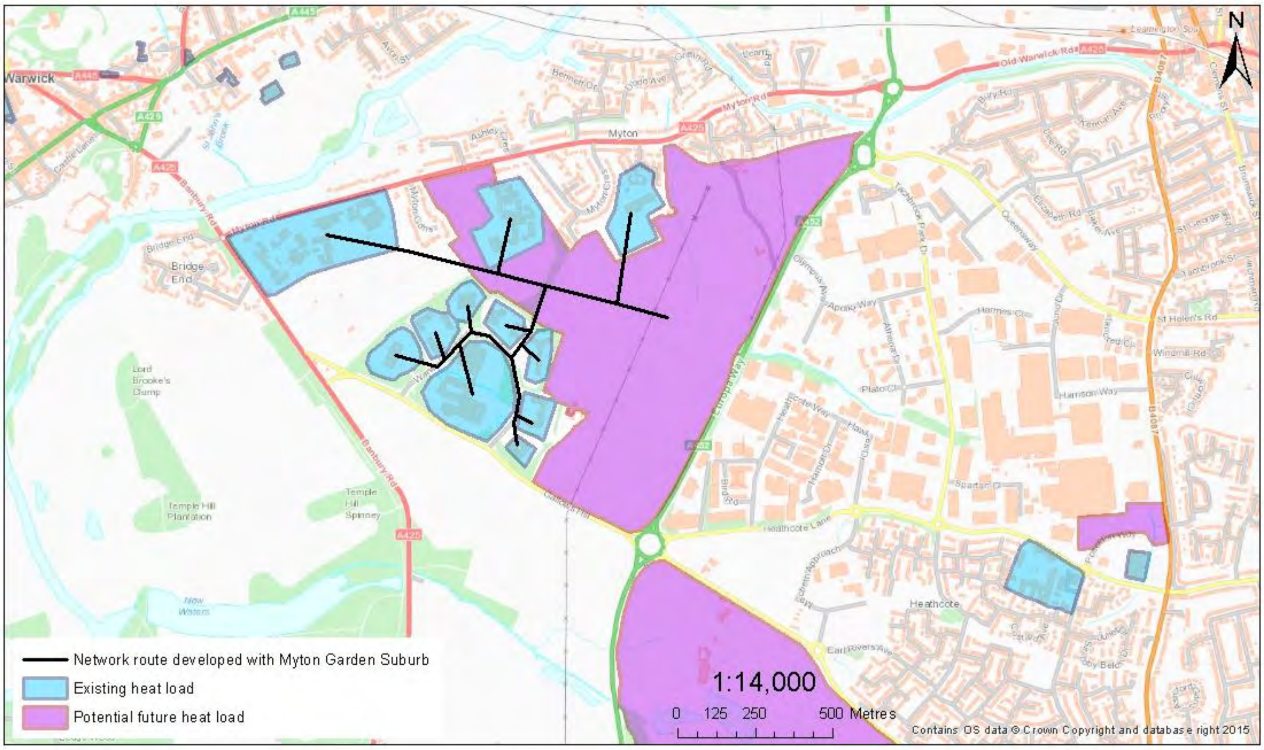


Figure 39. Network route option developed with Myton Garden Suburb

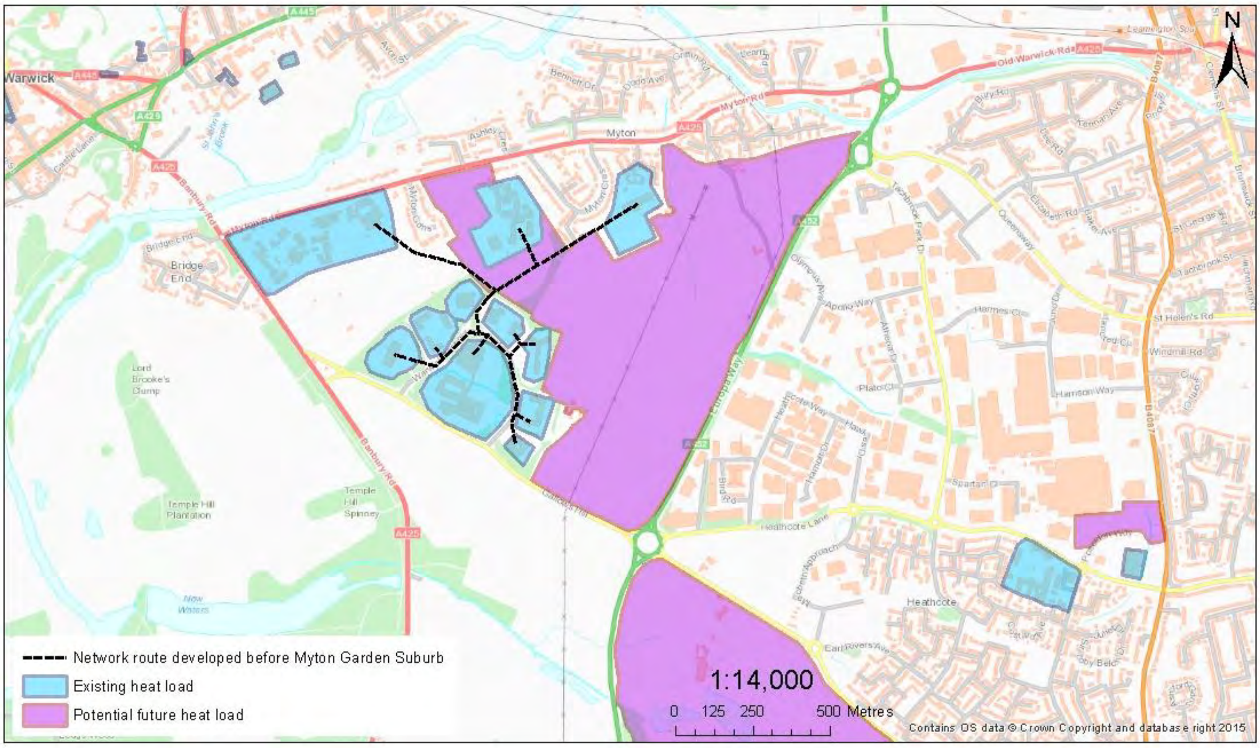


Figure 40. Network route option developed around commercial customers and education allocation

Energy Centre Location

Appraisal

The following sites, as illustrated in Figure 41, have been identified as potentially viable for the siting of a new energy centre.

Figure 41. Potential Energy Centre Locations for the Myton Opportunity Area.

The following table presents the initial appraisal of energy centre sites for the Myton opportunity area.

Site Name and Reference	Opportunities	Constraints	Site Image
(1) Myton Fields Surface Car Park	• Close proximity to River Avon for water source heat pumps. • No tall buildings in close proximity. • Access via A425. • Existing Warwick District Council car park.	• On the extreme Northern side of the Cluster. • Site is in close proximity to residential buildings. • Visual impact on river bank, although base for comparison is current car park. • Disturbance to wildlife. • Possible flood risk to energy centre from River Avon • Difficult connection to heat loads, including crossing the A425. • Site lies within Warwick conservation area.	
(2) National Grid Office Car Park	• Site is central to Myton cluster. • Site is next to one of the largest heat loads in the cluster.	• Land ownership may be an issue. • Significant structural impacts to integrate a new energy centre with existing multi-storey car park. • Several large offices in close proximity; careful consideration of noise and visual impacts.	

Site Name and Reference	Opportunities	Constraints	Site Image
(3) Unused Land Around Office Park	• Close proximity to large heat loads, minimising distribution losses.	• Several large offices in close proximity; careful consideration of noise and visual impacts. • Loss of green space. • Large disruption during construction. • Land ownership may be an issue.	
(4) Existing Farmhouse	• Potential for redevelopment after the construction of the Myton Garden suburb. • Site in close proximity to planned Garden Suburb.	• Land ownership may be an issue. • Future plans for farm house are currently unknown.	
(5) Within Myton Garden Suburb	• Potential to locate energy centre within School; proposed to be located in the centre of the Myton Garden Suburb. • Potential to be close to large heat loads.	• Majority of the Myton Garden Suburb is at “Reserved Matters” stage, and so unlikely to be able to locate a new energy centre within. • Land ownership may be an issue.	

Due to the size of the site at Myton Fields car park, the likely level of influence held by Warwick District Council over this site, and the potential for the use of water source heat presented by the River Avon, the technoeconomic analyses for this network have assumed an energy centre sited at Myton Fields (option 1).

Technology options review

The technology options review in Section 5 has identified that the following technologies may be appropriate for the Myton opportunity area and are discussed in more detail below.

Community Biomass/Biogas Boilers

A Biomass-fuelled District Heating network may be a viable option for Myton, if a suitable fuel supplier can be found. Careful consideration of the location of the energy centre will be required, to ensure that access for fuel deliveries can be made, along with a suitable flue arrangement to address air quality issues.

Gas Fired CHP

As Gas-fired CHP is a mature technology, this technology is considered to be suitable for connection to a district heating network in Myton.

Heat Pumps – Water Source Heat Pumps

Figure 42 and Figure 43, below, illustrate the river and canal heat capacity, respectively, as taken from the DECC National Heat Map.

The River Avon has a relatively high potential heat capacity of approximately and therefore, may be a suitable heat source for a Water Source Heat Pump.

Figure 42. Extract from DECC National Heat Map showing the River Heat Capacity (in kW) near Warwick.

Figure 43. Extract from DECC National Heat Map showing the Canal Heat Capacity (in kW) near Warwick.

Myton network options: technoeconomic assessment

Different generating technology and network scenarios for the Myton cluster were modelled to produce indicative IRR and NPV figures. Where a private wire arrangement was included, it was assumed that electricity could be sold directly on the network to the National Grid HQ building to meet 100% of its electricity demand. National Grid HQ is the largest electricity consumer for this network concept. At this stage it was not assumed that electricity would be sold via private wire to any other network customers, due to the technical and contractual issues involved in supplying multiple customers. It should be noted however that this is an assumption made due to the high level scope of this study. If further studies are conducted in this area, soft market testing should be carried out to investigate opportunities to connect to different and/or additional customers.

The export tariff for the private wire option was calculated as follows:

Proportion of total electricity generated predicted to be consumed by National Grid HQ = 48%

Lowest assumed retail tariff paid by buildings connected with private wire[18]= 10.08p/kWh

Assumed standard export tariff= 5.50p/kWh

Export tariff for Warwick Town Centre network concept = (0.48*10.08) + (0.52*5.50) **= 7.70p/kWh**

In general, network concepts in this cluster show good rates of return, due to the high levels of heat demand on the network and the short distances between the buildings included.

Gas CHP without private wire

		Capital cost: £13,415,200 2 x 3.2MW gas CHP + 1.8MW top-up Gas Boiler Electricity export tariff: 5.50p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[c]
Emissions 1[a]	25 year	-2999	3.7%	-£1,840,600
	40 year	-4207	5.6%	-£352,200
Emissions 2[b]	25 year	719	3.7%	-£1,840,600
	40 year	383	5.6%	-£352,200

[a] IAG emissions projections for average and marginal electricity use
[b] Emissions projections for electricity use from *Modelling the impacts of additional Gas CHP capacity in the GB electricity market (December 2014)*
[c] Using discount rate of 6%

Table 9. Results of techno-economic modelling for Myton: Gas CHP. See Appendix 2 for a summary of the assumptions used.

[18] From: DECC 2015: Prices of fuels purchased by non-domestic consumers in the UK

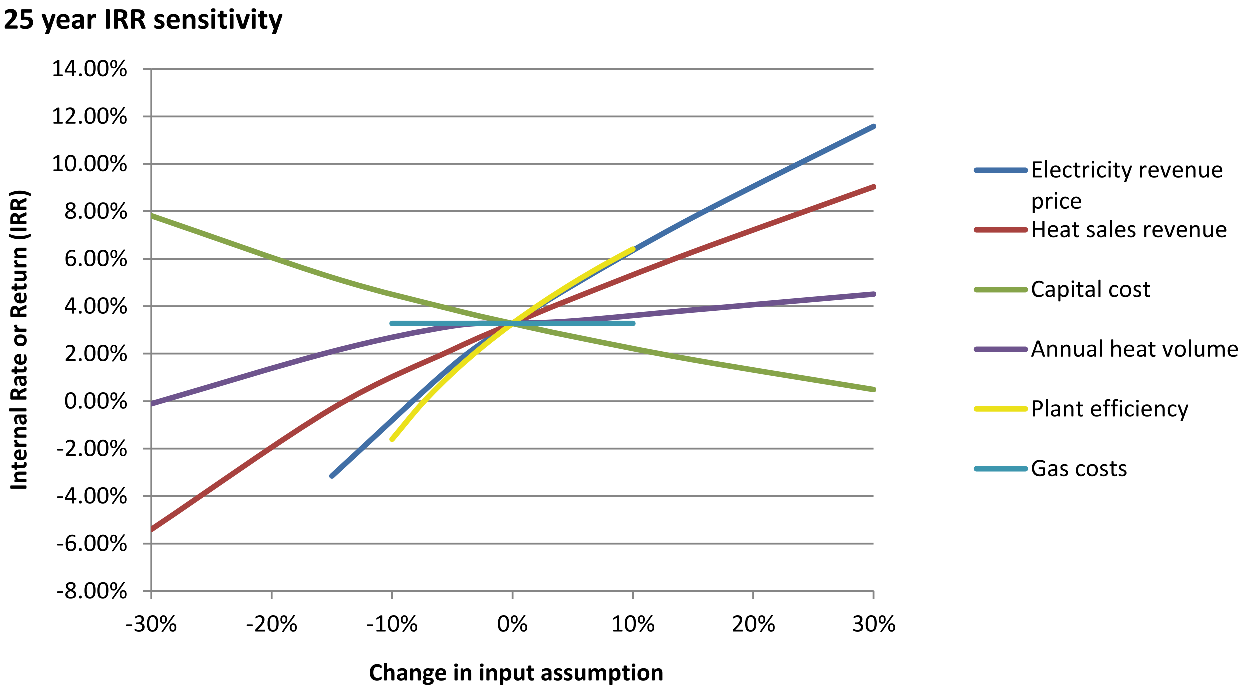


Figure 44. Sensitivity of 25 year IRR to changes in inputs, for Myton: Gas CHP.

Gas CHP with private wire

		Capital cost: £13,415,200 2 x 3.2MW gas CHP + 1.8MW top-up Gas Boiler Electricity export tariff: 7.70p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[c]
Emissions 1[a]	25 year	-2999	6.8%	£1,151,100
	40 year	-4207	8.3%	£3,265,400
Emissions 2[b]	25 year	719	6.8%	£1,151,100
	40 year	383	8.3%	£3,265,400

[a] IAG emissions projections for average and marginal electricity use
[b] Emissions projections for electricity use from *Modelling the impacts of additional Gas CHP capacity in the GB electricity market (December 2014)*
[c] Using discount rate of 6%

Table 10. Results of techno-economic modelling for Myton: Gas CHP with private wire. See Appendix 2 for a summary of the assumptions used.

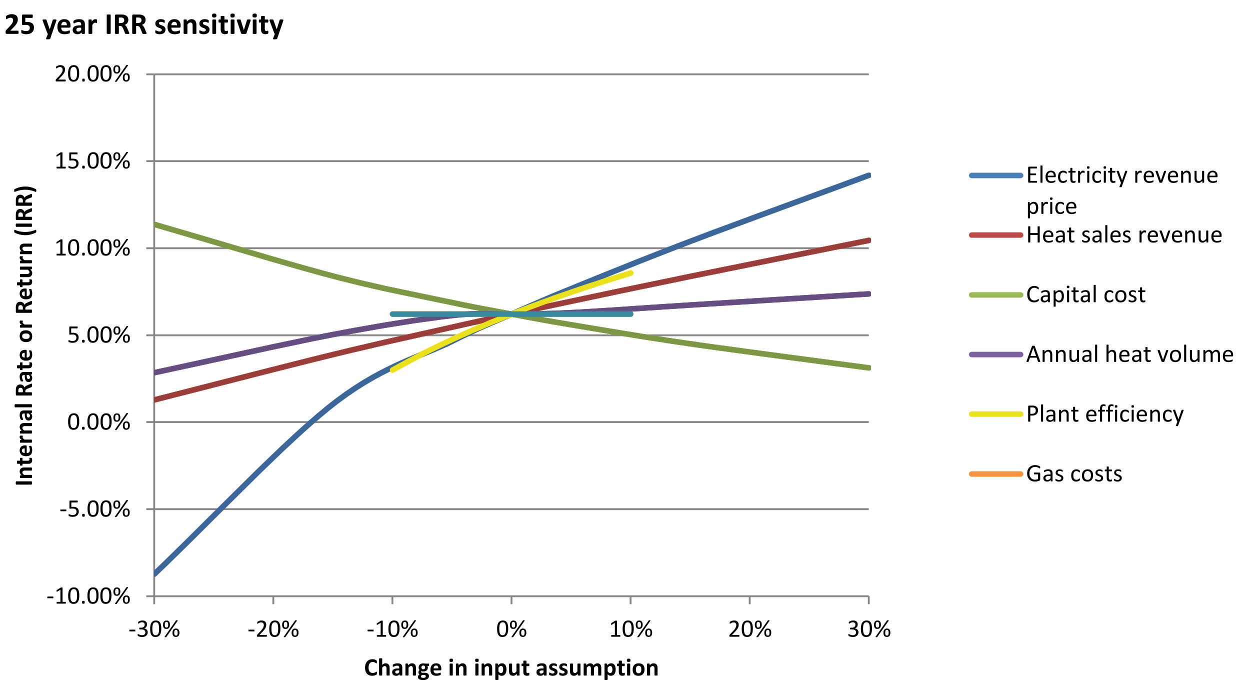


Figure 45. Sensitivity of 25 year IRR to changes in inputs, for Myton: Gas CHP with private wire.

The sensitivity analyses demonstrate the importance of the price achieved for electricity sales from CHP, either directly on the network or exported to the grid. Although reasonable IRRs are achieved for the scenario without private wire, the private wire scenario is more likely to yield higher IRRs, and opportunities to sell electricity directly to customers on the network will therefore be important. Achieving a high enough price without disadvantaging network customers will require careful negotiation and contract design. Capital cost is also a significant factor: this analysis indicates that reducing capital cost by approximately 25% (e.g. through value engineering or grant funding) could allow the private wire network concept to achieve an IRR of 10% within 25 years.

Biomass

		Capital cost: £15,360,100 5MW Biomass + 2.3MW top-up gas boiler Electricity export tariff: n/a		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	5098	-	-£4,780,600
	40 year	4987	-	-£5,033,200

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 11. Results of techno-economic modelling for Myton: Biomass. See Appendix 2 for a summary of the assumptions used.

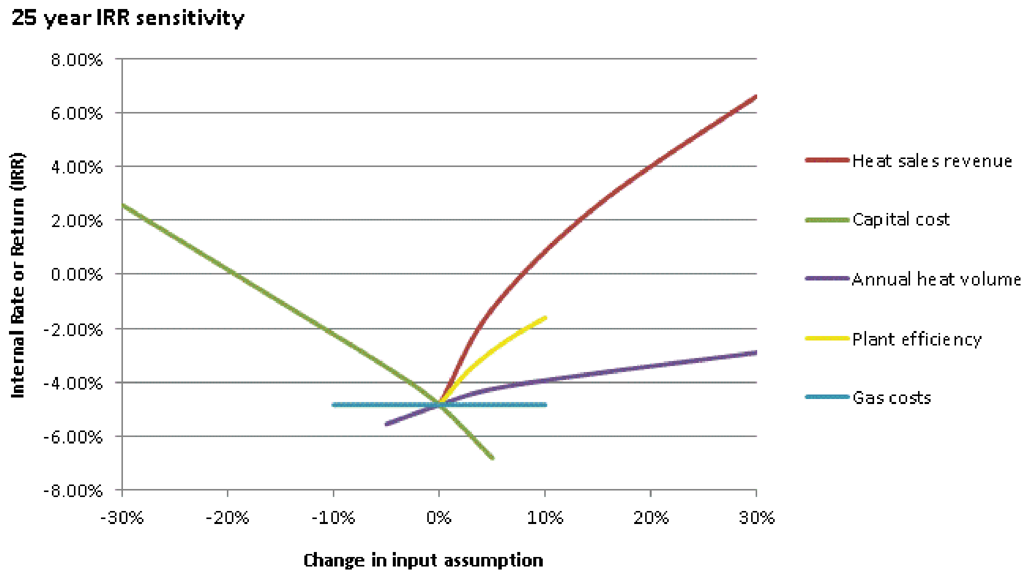


Figure 46. Sensitivity of 25 year IRR to changes in inputs, for Myton: Biomass.

This analysis suggests that a biomass only network in Myton is unlikely to be profitable using this network scenario, likely due to the distances between buildings and the larger size of plant required, which qualifies for lower RHI payments.

WSHP

		Capital cost: £13,560,600 4MW WSHP + 2MW gas CHP + 2.1MW top-up gas boiler		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	3036	9.5%	£2,423,500
	40 year	2938	9.4%	£2,665,700

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 12. Results of techno-economic modelling for Myton: WSHP. See Appendix 2 for a summary of the assumptions used.

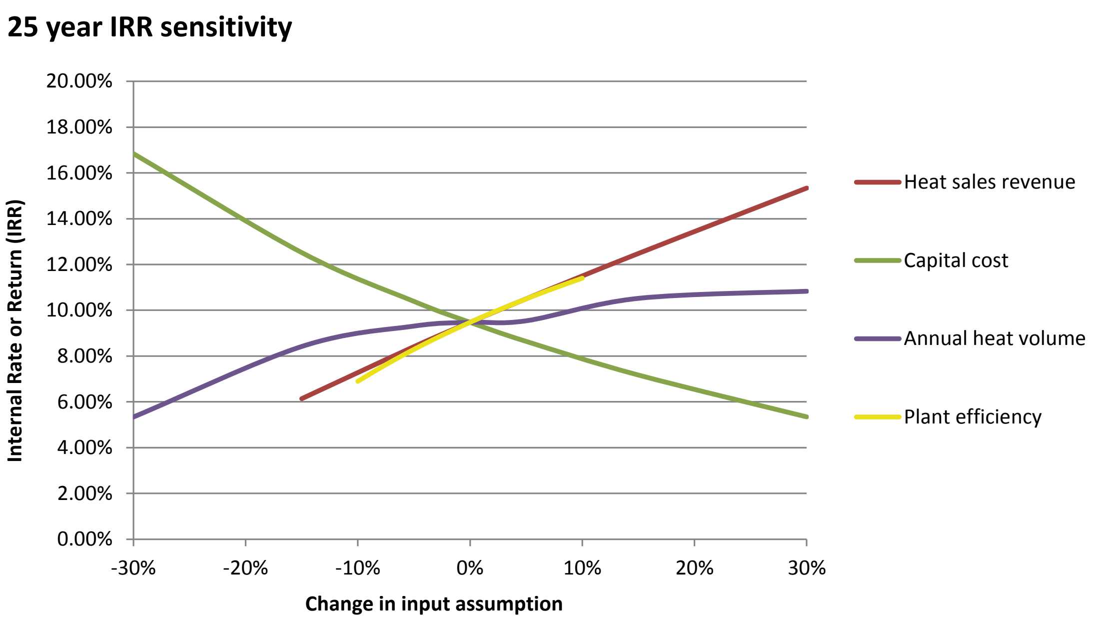


Figure 47. Sensitivity of 25 year IRR to changes in inputs, for Myton: Biomass.

CHP has been included in this network scenario in addition to the WSHP to increase the proportion of heat demand that could be met by the DHN (minimising the use of gas boilers). Meeting the entirety of the demand using WSHP would require an extremely high capacity heat pump, which would incur very high capital costs and may not be feasible given the size and heat capacity of the river in this location.

Of all eligible technologies, WSHPs receive the highest RHI tariffs: currently 8.84p/kWh (tier 1). Since this network concept assumes the use of high capacity heat pump(s), the economic viability is highly dependent on the RHI tariff for water source heat. The sensitivity analysis demonstrates that capital cost is likely to be another significant factor affecting the economic feasibility of this network concept, although under this scenario even a 30% increase does not lead to a negative IRR. It also demonstrates the importance of the price achieved for heat on the network (more important than electricity in this case since the scheme is heat pump-led). Achieving a high enough price without disadvantaging network customers will require careful negotiation and contract design.

Summary and conclusions

Technology option	Capital cost	25 year IRR	25 year NPV	25 year average CO_2 savings[19]	40 year IRR	40 year NPV	40 year average CO_2 savings[20]
Gas CHP without private wire	£13,415,200	3.7%	-£1,840,600	719	5.6%	-£352,200	383
Gas CHP with private wire	£13,415,200	6.8%	£1,151,100	719	8.3%	£3,265,400	383
Biomass	£15,360,100	-	-£4,780,600	5098	-	-£5,033,200	4987
WSHP	£13,560,600	9.5%	£2,423,500	3036	9.4%	£2,665,700	2938

Table 13. Summary of results for Myton

This analysis suggests that exploiting the heat capacity of the River Avon in the Myton area using a WSHP-led heat network could present an attractive investment proposition and result in significant CO_2 savings. The WSHP-led network concept achieves a 25 year IRR of 9.5%, which may potentially attract private funding from a joint venture partner. It should be noted however that the capital costs associated with this scenario are very high, and the profitability is highly sensitive to the RHI tariff for WSHPs. If the Council wishes to explore a WSHP-led network here therefore, it would be advisable to carry out a detailed full feasibility study which takes account of the possibility of withdrawal of the RHI prior to network development.

The analysis also suggests that a gas CHP-led network could achieve a 40 year IRR of over 6%, assuming that a private wire arrangement could be made with National Grid HQ (or other network customer(s) with equivalent electricity demand). While the carbon savings and likely returns on such a scheme are potentially lower than for a WSHP-led scheme, the financial risk would be lower since the scheme would not be reliant on RHI payments.

These network concepts are based on connections to non-Council buildings, and market testing will therefore be a key requirement for any further studies in this area.

[19] Under the 'Emissions 2' scenario
[20] Under the 'Emissions 2' scenario

PRE-FEASIBILITY ANALYSIS: LEAMINGTON SPA RIVERSIDE

07

PRE-FEASIBILITY ANALYSIS: LEAMINGTON SPA RIVERSIDE

Overview

A key opportunity in this area is the cluster of public buildings which could act as anchor loads for the development of a heat network (2-5 below). The cluster is also in proximity to two Council-led future developments: the new Creative Quarter, and the relocation of the District Council offices to Tavistock Square (Covent Garden). Redevelopment or new construction at these sites may present opportunities for siting energy centre(s) for a heat network.

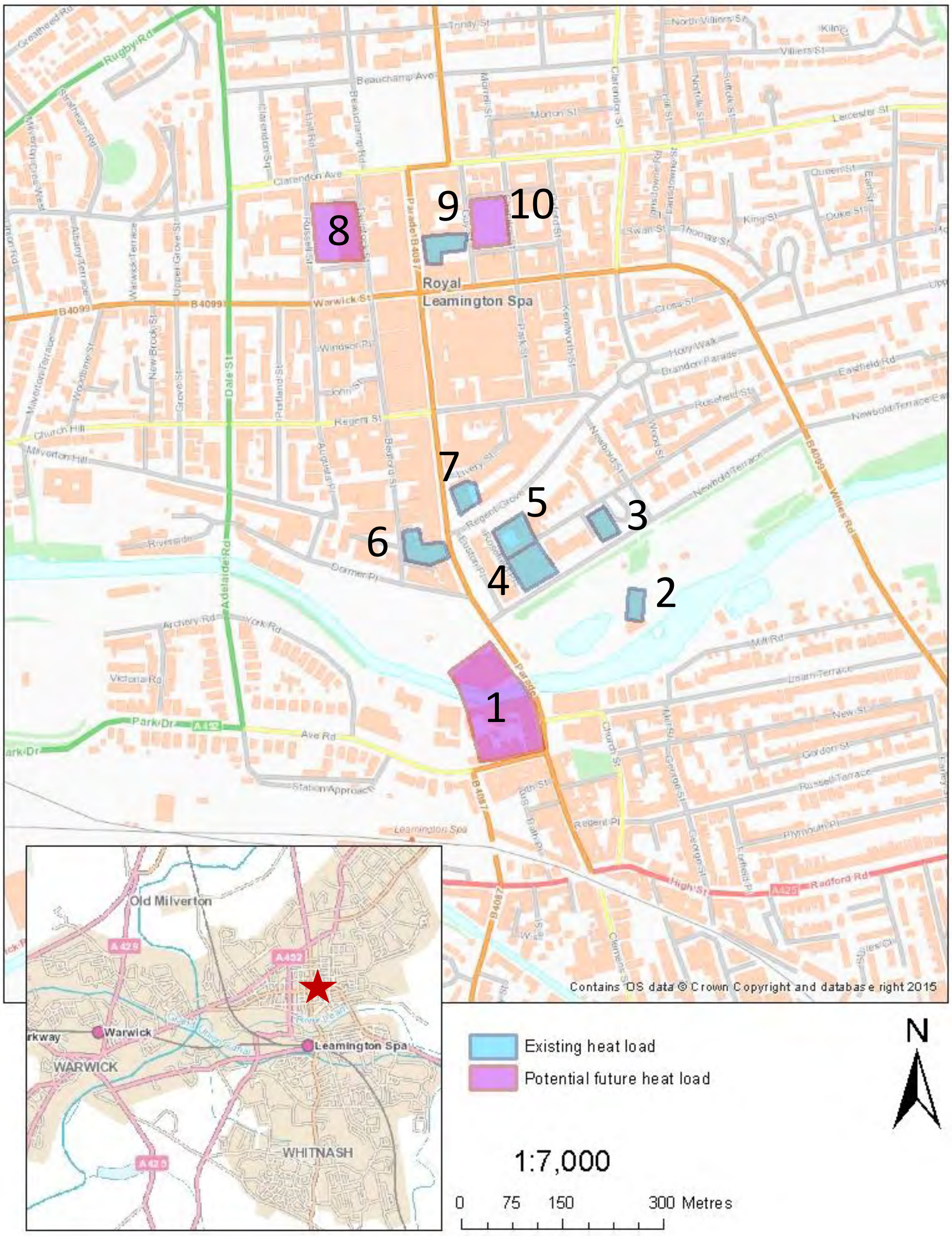


Figure 48. Leamington Spa Riverside opportunity area.

Total heat demand: 7,524 MWh (excluding Creative Quarter)				
Number	**Name**	**Heat demand**	**Data source**	**Notes**
1	New Creative Quarter	Not yet developed		A developer brief for a new Creative Quarter was drafted in May 2015. The vision is for a new town centre quarter with a focus on the creative sector, based around the redevelopment of the Royal Pump Rooms and Spencer Yard.
2	Jephson Gardens Temperate House	380 MWh/year	Metered data from WDC energy management database	
3	Royal Spa Centre	400 MWh/year	Metered data from WDC energy management database	
4	Warwickshire Justice Centre	620 MWh/year	Benchmarked from EPC floor area and CIBSE TM46	
5	Police Station	1670 MWh/year	Benchmarked from map measurements and CIBSE TM46	
6	Premier Inn	1400 MWh/year	DEC	
7	Travelodge	2300 MWh/year	DEC	
8	Tavistock Square (Covent Garden): site for WDC office relocation	519 MWh/year	Benchmarked from BCO and CIBSE Guide F Best Practice, based on 300 staff with 60% average occupancy.	Planned relocation of the WDC offices to the Tavistock Square (Covent Garden) .The new offices will house approximately 300 staff.
9	Town Hall	235 MWh/year	Benchmarked from map measurements and CIBSE TM46	
10	Chandos Street:: previously considered site for WDC office relocation	519 MWh/year	Benchmarked from BCO and CIBSE Guide F Best Practice, based on 300 staff with 60% average occupancy.	Possible future mixed use development (leisure, retail, commercial and car parking).

Figure 49 shows indicative routes for the development of a heat network with two phases in the Riverside area. Phase 1 connects the public buildings, Premier Inn and Travelodge with the new Creative Quarter development. The relatively small scale of this proposed network, along with the high level of Council influence, suggests that this is an area where an initial network phase could be delivered within a relatively short timescale. The route option for phase 2 indicates connection to the new District Council office.

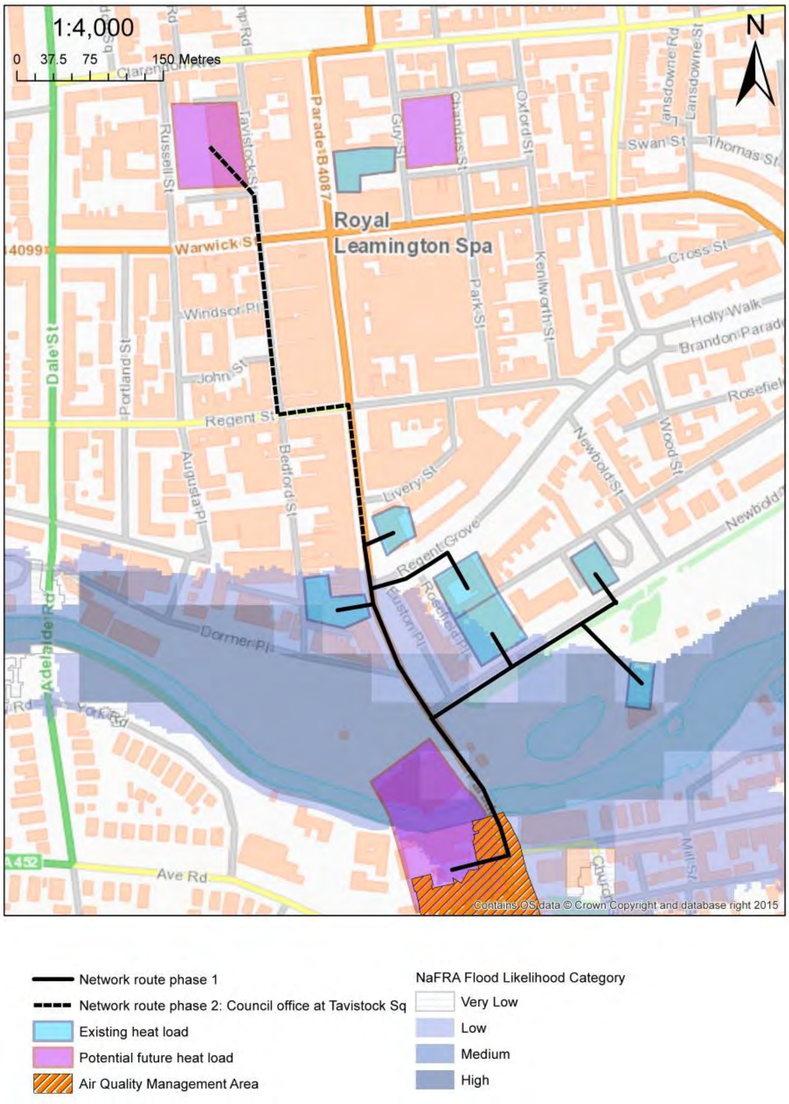


Figure 49. Network route options in the Riverside area.

Energy Centre Location

General Constraints

The town centre location of the Leamington Spa Riverside Cluster presents a number of challenges to the appropriate siting of an energy centre including:

- Much of the town centre lies within the Royal Leamington Spa Conservation Area (Figure 50);
- There is an Air Quality Management Area (AQMA) along Victoria Terrace;
- There are areas of high and medium flood risk around the river.
- There is little apparently vacant land in Royal Leamington Spa town centre.

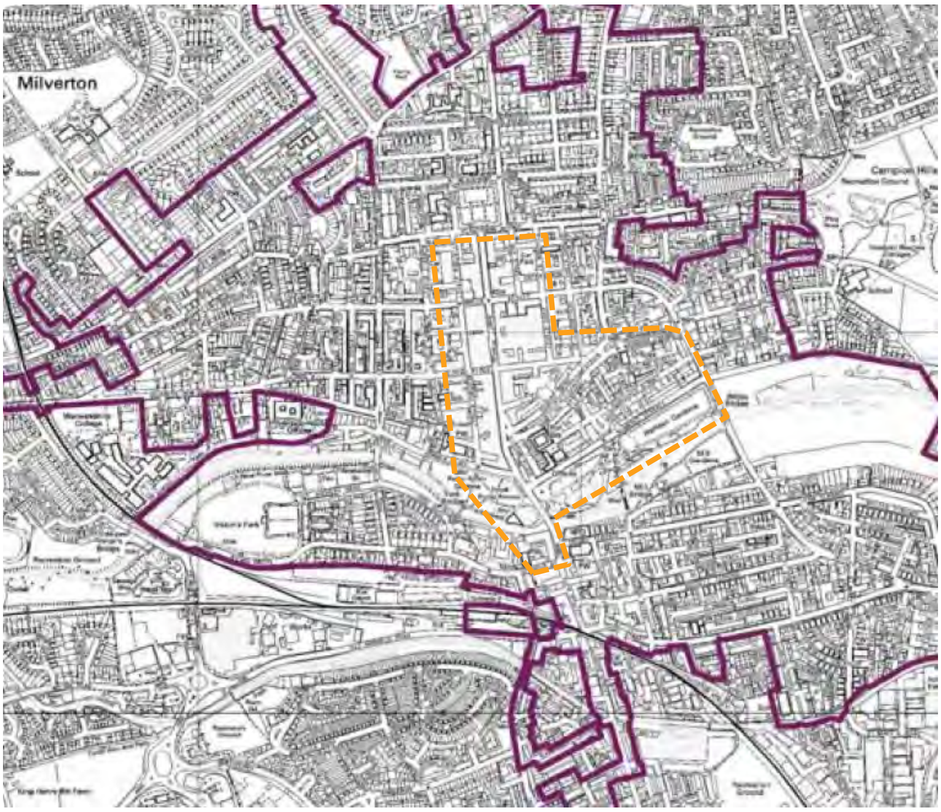


Figure 50. Extract showing Conservation Area Boundary in Purple and approximate location of the Leamington Spa Riverside Cluster (in orange).

Appraisal

The following sites, as illustrated in Figure 41, have been identified as potentially viable for the siting of a new energy centre.

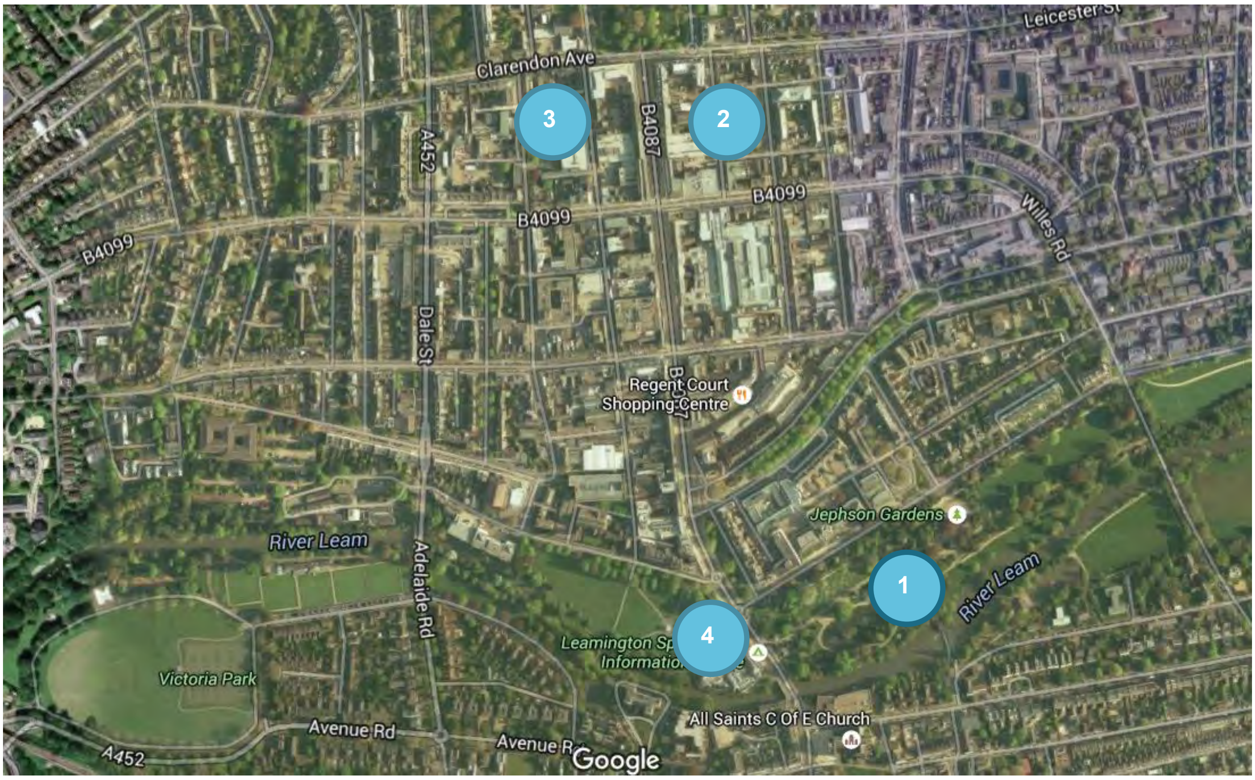


Figure 51. Potential Energy Centre Locations for the Leamington Spa Riverside Opportunity Area.

Site Name and Reference	Opportunities	Constraints	Site Image
(1) Jephson Gardens Temperate House	• Part of the existing Jephson Gardens Temperate House is unused, and therefore could be used as an energy centre.	• Difficult access. • Site is located to the extreme west of the cluster. • Digging pipework routes through gardens would be disruptive. • Site lies within Leamington Spa conservation area. • Potential flood risk.	
(2) Chandos Street Surface Car Park	• Possible site for relocation of Warwick District Council offices (although more likely to be Tavistock Square). • If offices are relocated here, potential to integrate energy centre with new development. • Close to Warwick District Council heat loads. • If offices relocate to Tavistock Square, could use car park as site for energy centre.	• Sheltered housing development overlooking site. • Potential for loss of income, if car parking spaces lost. Or, additional investment required to build multi-storey car park to maintain parking provision. • Located at the extreme north of cluster. • Potential disruption to local businesses. • Site lies within Royal Leamington Spa conservation area.	
(3) Tavistock Square Car Parks	• Most likely site for relocation of Warwick District Council offices (although may move to Chandos Street). • If offices are relocated here, potential to integrate energy centre with new development. • Close to Warwick District Council heat loads. • If offices relocate to Chandos Street, could use car park as site for energy centre.	• Potential for loss of income, if car parking spaces lost. Or, additional investment required to build multi-storey car park to maintain parking provision. • Located at the extreme north of cluster. • Potential disruption to local businesses. • Site lies within Royal Leamington Spa conservation area.	
(4) New Creative Quarter	• Potential to integrate energy centre with New Creative Quarter development. • Local buildings are a mixture of 2 and 3 storey buildings.	• Not yet developed, and may not go ahead. • Close to, or in (depending on location within Creative Quarter) the Air Quality Management Area. • Site lies within Royal Leamington Spa conservation area. • Residential buildings within close proximity. • Site lies within flood risk area.	

Since Tavistock Square is understood to be the site of the new Council offices, the technoeconomic analysis for this network has assumed an energy centre sited there in some cases. Where the new offices are excluded from a network scenario, it has been assumed that the energy centre is sited within the new Creative Quarter.

Technology options review

The technology options review in Section 4, has identified that the following technologies may be appropriate for the Leamington Spa Riverside opportunity area and are discussed in more detail below.

Community Biomass/Biogas Boilers

A Biomass-fuelled District Heating network may be a viable option for Leamington Spa, if a suitable fuel supplier can be found. Careful consideration of the location of the energy centre will be required, to ensure that access for fuel deliveries can be made, along with a suitable flue arrangement to address air quality issues.

Gas Fired CHP

As Gas-fired CHP is a mature technology, this technology is considered to be suitable for connection to a district heating network in Leamington Spa.

Heat Pumps – Water Source Heat Pumps

The River Leam has a potential heat capacity of approximately 590 to 950 kW, as illustrated in Figure 52, and is therefore not deemed to be a potential heat source for a Water Source Heat Pump.

Figure 52. Extract from DECC National Heat Map showing the River Heat Capacity (in kW) near Leamington Spa.

Riverside network options: technoeconomic analysis

Different generating technology and network scenarios for the Leamington Spa Riverside cluster were modelled to produce indicative IRR and NPV figures. The new Creative Quarter has been indicated on the network maps to demonstrate how it could be incorporated into a network, but has been excluded from the technoeconomic analyses since there is presently insufficient information about the nature of the proposed development to estimate energy demands.

Where a private wire arrangement was included, it was assumed that electricity could be sold directly on the network to the new Council offices, with the necessary infrastructure included at the time of construction. This assumption was made since the capital cost of installing the necessary connections and setting up contracts is likely to be significantly less for new build than for existing buildings. At this stage it was not assumed that electricity would be sold via private wire to any other network customers, due to the technical and contractual issues involved in supplying multiple customers and the relative distance of the new Council offices from the remainder of the buildings on the network. It should be noted however that this is an assumption made due to the high level scope of this study. If further studies are conducted in this area, soft market testing should be carried out to investigate opportunities to connect to different and/or additional customers.

The planned location for new WDC offices is understood to be at the Tavistock Square (Covent Garden) site. This development was benchmarked on the basis of an office serving 300 employees on a 'hotdesk' basis, with average 60% of staff on site at any one time.

Where sale of electricity via private wire was included in the economic analysis the export tariff for generated electricity was calculated as follows:

Proportion of total electricity generated predicted to be consumed by proposed WDC offices = 7%

Lowest assumed retail tariff paid by buildings connected with private wire[21] = 12.35p/kWh

Assumed standard export tariff = 5.50p/kWh

Export tariff for Warwick Town Centre network concept = (0.07*12.35) + (0.93*5.50) = **5.98p/kWh**

Excluding new Council offices: Gas CHP

		Capital cost: £3,847,700 2 x 850kW Gas CHP + 240kW top-up gas boiler Electricity export tariff: 5.50p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[c]
Emissions 1[a]	25 year	-678	0.8%	-£1,248,400
	40 year	-956	3.3%	-£939,300
Emissions 2[b]	25 year	175	0.8%	-£1,248,400
	40 year	97	3.3%	-£939,300

[a] IAG emissions projections for average and marginal electricity use
[b] Emissions projections for electricity use from *Modelling the impacts of additional Gas CHP capacity in the GB electricity market (December 2014)*
[c] Using discount rate of 6%

Table 14. Results of techno-economic modelling for Leamington Spa excluding new Council offices: Gas CHP. See Appendix 2 for a summary of the assumptions used.

[21] From: DECC 2015: *Prices of fuels purchased by non-domestic consumers in the UK*

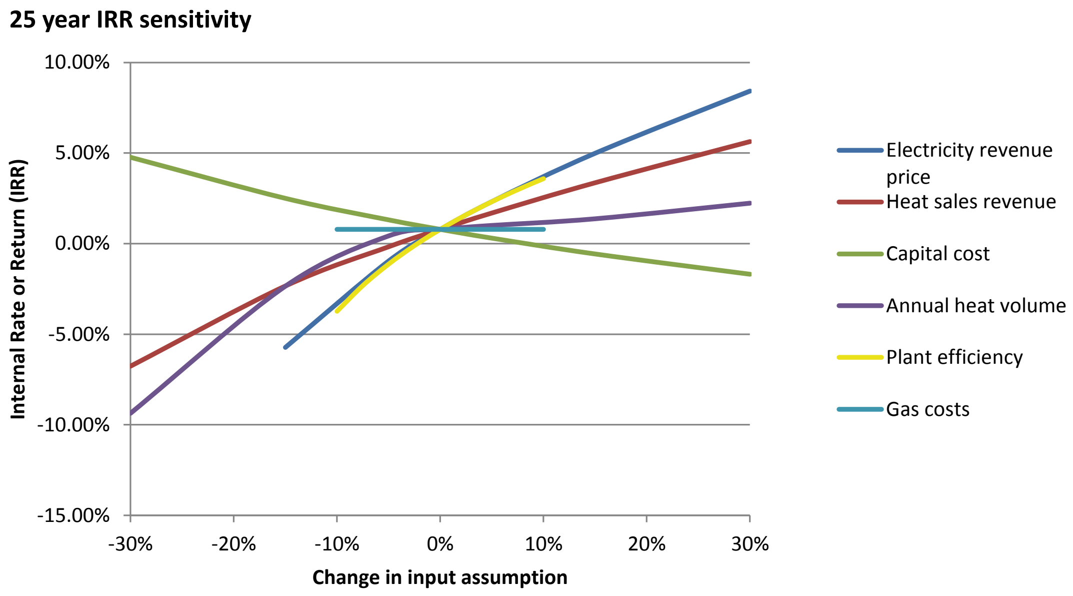


Figure 53. Sensitivity of 25 year IRR to changes in inputs, for Leamington Spa excluding new Council offices: Gas CHP.

The sensitivity analysis for the gas CHP-led network concept demonstrates the importance of the price achieved for electricity sales from CHP, suggesting that private wire arrangements may be required in this area for the network concept to be profitable. Capital cost is also a significant factor, although this analysis indicates that a substantial reduction in capital cost would be required to achieve an IRR over 6% within 25 years.

Excluding Council offices: Biomass

		Capital cost: £3,929,300 995kW biomass + 670kW top-up gas boiler Electricity export tariff: n/a		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	1099	-	-£1,099,200
	40 year	1072	1.2%	-£1,164,400

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 15. Results of techno-economic modelling for Leamington Spa excluding new Council offices: Biomass. See Appendix 2 for a summary of the assumptions used.

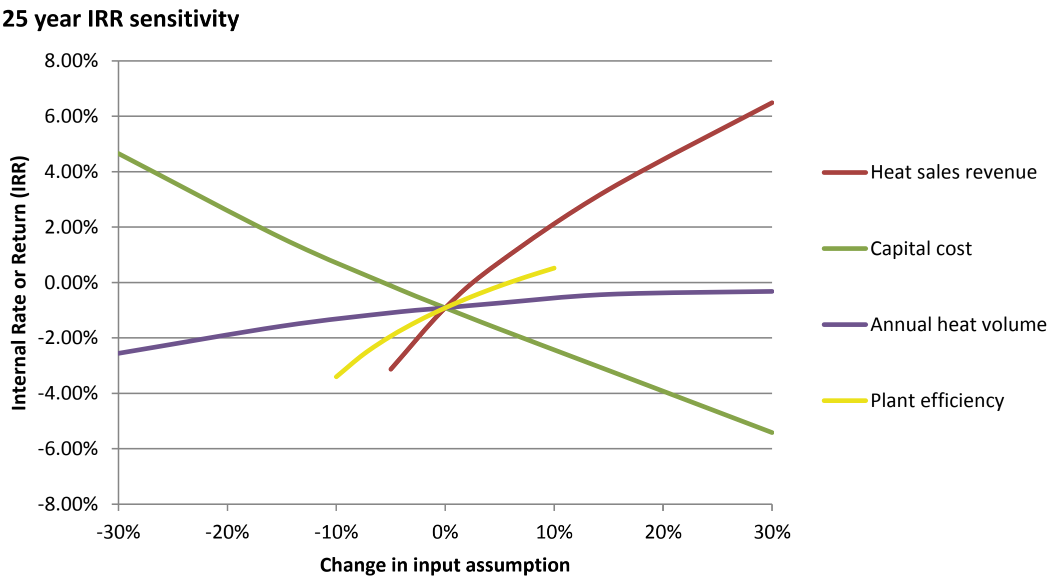


Figure 54. Sensitivity of 25 year IRR to changes in inputs, for Leamington Spa excluding new Council offices: Biomass.

Under this scenario, using biomass for heat generation leads to substantial financial losses from the network, likely due to the long pipe lengths required (relative to heat sales revenue) and the lack of revenue from electricity sales.

Including Council offices: Gas CHP with private wire

		Capital cost: £4,484,700 1 x 1.2MW + 1 x 650kW gas CHP + 430kW top-up gas boiler Electricity export tariff: 6.0p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[c]
Emissions 1[a]	25 year	-810	-	-£2,084,400
	40 year	-1113	1.2%	-£1,835,400
Emissions 2[b]	25 year	132	-	-£2,084,400
	40 year	49	1.2%	-£1,835,400

[a] IAG emissions projections for average and marginal electricity use
[b] Emissions projections for electricity use from *Modelling the impacts of additional Gas CHP capacity in the GB electricity market (December 2014)*
[c] Using discount rate of 6%

Table 16. Results of techno-economic modelling for Leamington Spa including new Council offices: CHP with private wire. See Appendix 2 for a summary of the assumptions used.

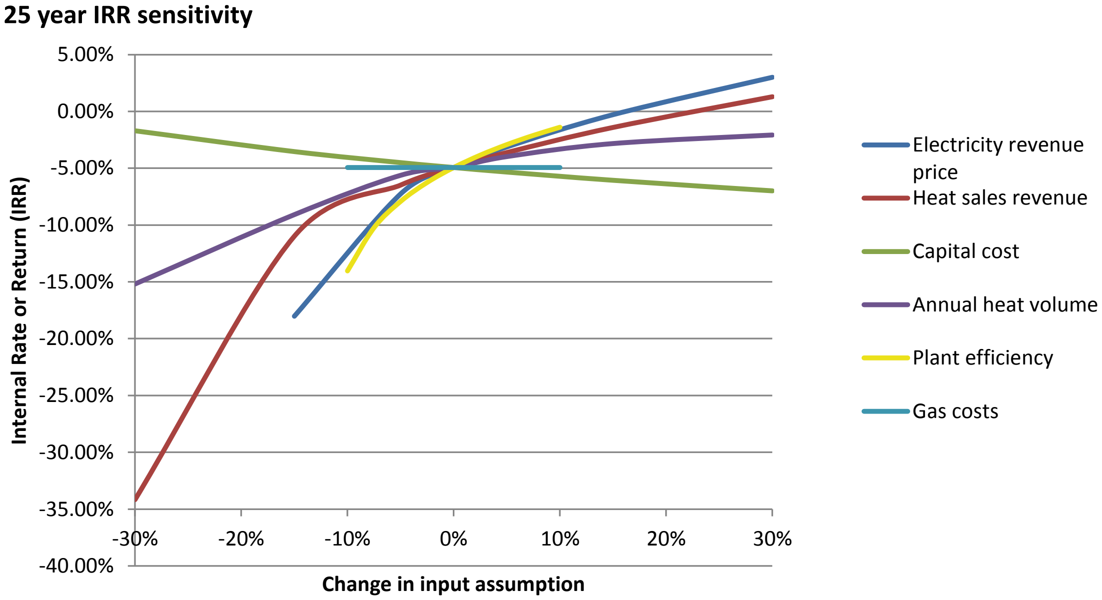


Figure 55. Sensitivity of 25 year IRR to changes in inputs, for Leamington Spa including new Council offices: Gas CHP with private wire.

Including Council offices: Biomass with CHP and private wire

		Capital cost: £4,953,100 995kW biomass + 850kW gas CHP + 300kW top-up gas boiler Electricity export tariff: 6.0p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	917	-	-£1,557,900
	40 year	818	-	-£1,575,300

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 17. Results of techno-economic modelling for Leamington Spa including new Council offices: CHP with private wire. See Appendix 2 for a summary of the assumptions used.

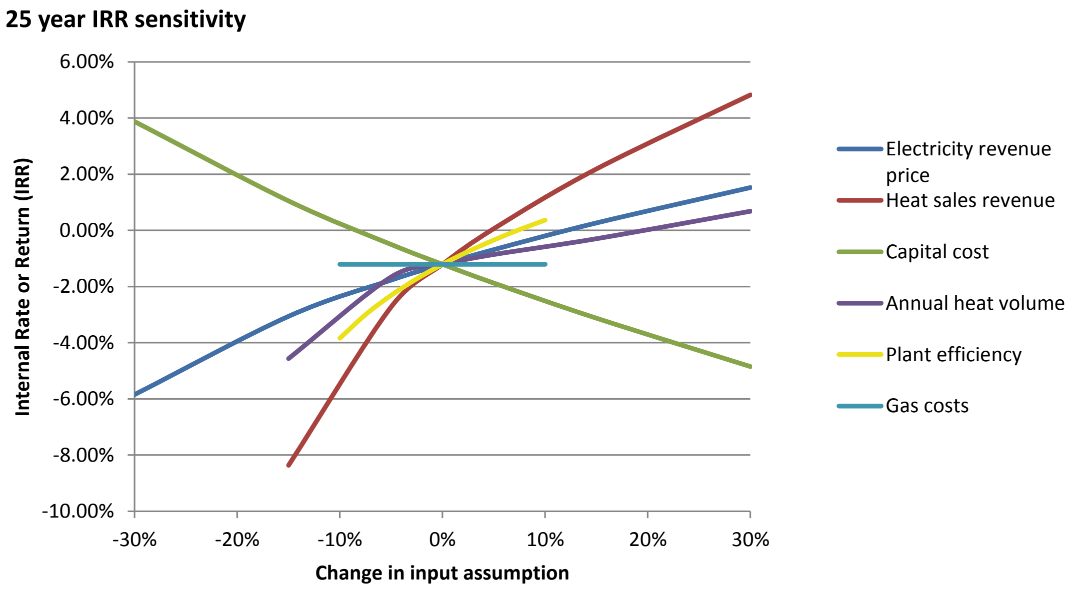


Figure 56. Sensitivity of 25 year IRR to changes in inputs, for Leamington Spa including new Council offices: Biomass and CHP with private wire.

For both CHP-only and biomass with CHP scenarios, connecting to the new Council offices does not provide sufficient increases in energy sales revenue to offset the additional cost of connection.

CHP was included in addition to the biomass in the biomass-led network concept to increase the potential energy sale revenue by generating electricity (which usually achieves higher sale prices than heat) and selling via private wire to the new Council Offices. The use of biomass to generate heat is prioritised over CHP in order to maximise the amount of generation eligible for RHI payments.

The sensitivity analysis for the biomass-led scenario demonstrates that capital cost is likely to be the most significant factor affecting the economic feasibility of this network concept: reducing capital cost by approximately 10% (e.g. through value engineering or grant funding) could allow the network concept to achieve an IRR of 6% within 25 years. It also demonstrates the importance of the price achieved for heat on the network (more important than electricity in this case since the scheme is biomass-led). Achieving a high enough price without disadvantaging network customers will require careful negotiation and contract design.

Summary and conclusions

Technology option	Capital cost	25 year IRR	25 year NPV	25 year average CO_2 savings[22]	40 year IRR	40 year NPV	40 year average CO_2 savings[23]
Gas CHP (excl. new Council offices)	£3,847,700	0.8%	-£1,248,400	175	3.3%	-£939,300	97
Biomass (excl. new Council offices)	£3,929,300	-	-£1,099,200	1098	-	-£1,164,400	1072
Gas CHP (incl. new Council offices with private wire)	£4,484,700	-	-£2,084,400	132	1.2%	-£1,834,400	49
Biomass and gas CHP (incl. new Council offices with private wire)	£4,953,100	-	-£1,557,900	917	-	-£1,575,300	818

Table 18. Summary of results for Warwick Town Centre

A compact gas CHP-led network excluding the Town Hall and the new Council Offices achieves a 40 year predicted IRR of 3.3%, below the rate which may be expected to attract public funding. It should be noted however that when additional demand from the Creative Quarter comes online the IRR may be anticipated to increase (depending on the nature of the development). Similarly, although a biomass-led network excluding the Town Hall and the new Council Offices currently fails to achieve a positive IRR under this scenario, the sensitivity analysis shows that decreasing capital cost and increasing heat revenue by approximately 30% could lead to a viable network concept.

A significant advantage of developing a network here is the opportunity for Warwick District Council to lead and drive development by connecting the public buildings in the cluster to a network. Attracting additional commercial network customers to a new or extended network may be easier when a network (or plans for a network) is already in place, rather than at the concept design stage.

Using benchmarked figures for a new Council office at Covent Garden, this analysis suggests that extending the network to this office and the Town Hall would not be economically viable at present unless additional network customers were identified. There is a great deal of uncertainty around the predicted scale of the demand from the new office since plans for it are very early stage, and this option should be re-evaluated in future studies when more information on the scheme becomes available.

[22] Under the 'Emissions 2' scenario
[23] Under the 'Emissions 2' scenario

PRE-FEASIBILITY ANALYSIS: WHITNASH

08

PRE-FEASIBILITY ANALYSIS: WHITNASH

Overview

The key existing heat load in this area is Leamington Spa Rehabilitation Hospital, which is close to Warwick Trident College and three areas of potential new development. Although there are few existing heat loads in this area, it may represent an opportunity to deliver a small scale heat network which has the potential to expand in the future as additional sites are developed nearby. Hospitals are often particularly suitable for CHP and heat networks as they tend to have high and constant heat demand.

Figure 58 indicates how a network could at first link the hospital and the college, then expand to the new developments at Tachbrook Park, Woodside Farm, and South of Harbury Lane.

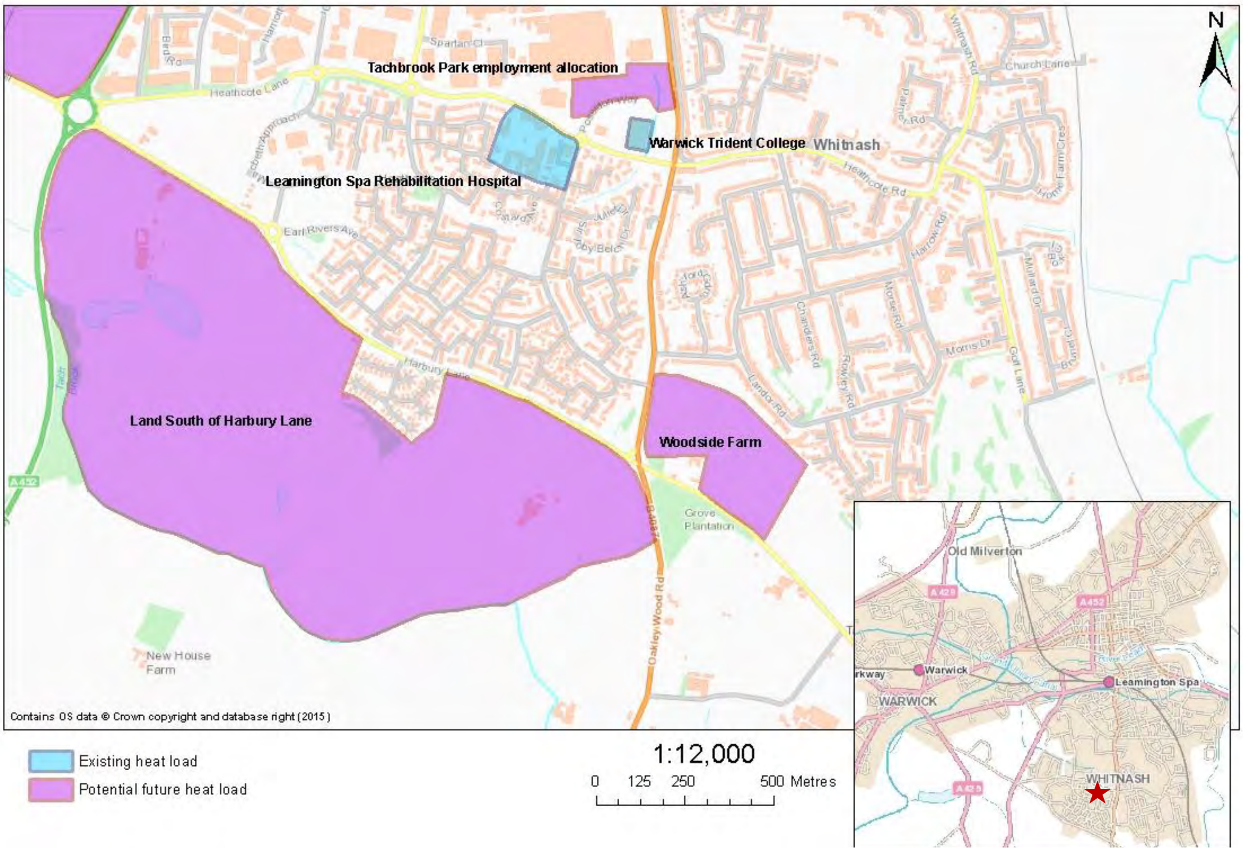


Figure 57. Whitnash opportunity area.

Total heat demand: 9,935 MWh			
Name	**Heat demand**	**Data source**	**Notes**
Tachbrook Park employment allocation	460 MWh/year	Benchmarked from details within planning applications and CIBSE TM46	Part of an allocation in draft Local Plan policy DS9 for employment uses B1 and B2 (6.1 ha total, this portion = approximately 2ha).
Warwick Trident College	545 MWh/year	DECC	
Leamington Spa Rehabilitation Hospital	1370 MWh/year	South Warwickshire NHS Trust	
Land South of Harbury Lane	6450 MWh/year	Benchmarked from details within planning applications, CIBSE TM46 and AECOM models for new dwellings	Allocated in draft Local Plan policy DS11 for approximately 1730 dwellings, two primary schools, a local centre and other local facilities.
Woodside Farm	1110 MWh/year	Benchmarked from details within planning applications, CIBSE TM46 and AECOM models for new dwellings	Planning application for approximately 235 dwellings.

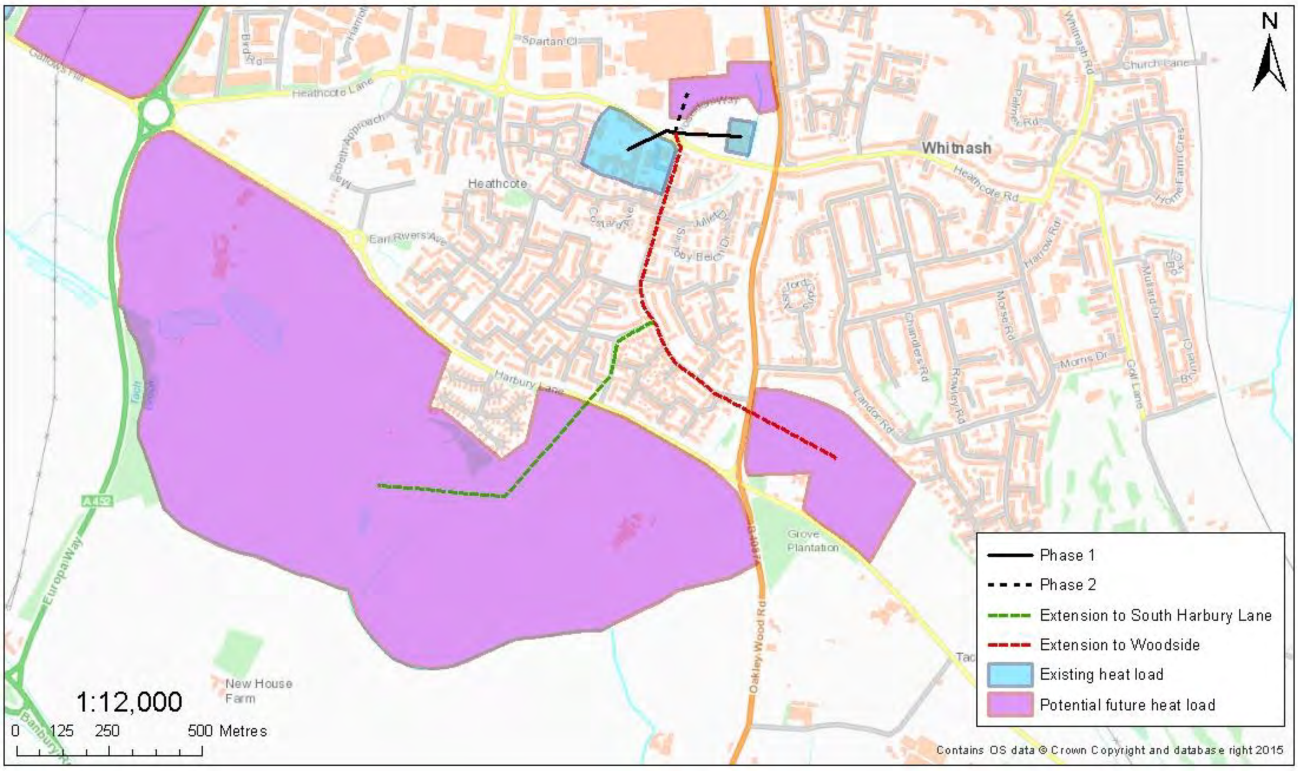


Figure 58. Indicative network routes for Whitnash.

Energy Centre Location

General Constraints

There are no local AQMAs in near to the Whitnash opportunity area. One constraint, the Whitnash conservation area, lies to the west the Whitnash opportunity area (Figure 59) and is therefore not expected to affect the siting of an energy centre.

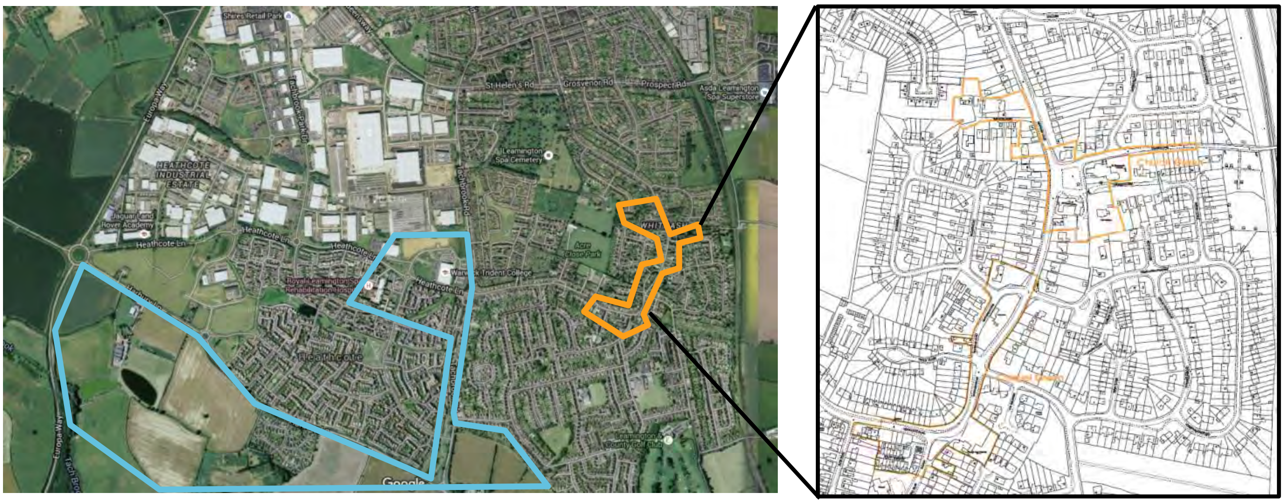


Figure 59. (Left) Aerial Image showing Approximate Position of the Whitnash Opportunity Area (in Blue), alongside the Whitnash Conservation Area (in Orange). (Right) Detailed Image showing Extent of the Whitnash Conservation Area.

Appraisal

The below Figure 60 illustrates the sites that have been identified as potentially viable for the siting of a new energy centre in Whitnash.

Figure 60. Potential Energy Centre Locations for Whitnash Opportunity Area.

The following table presents the initial appraisal of energy centre sites for the Whitnash opportunity area.

Site Name and Reference	Opportunities	Constraints	Site Image
(1) Land South of Harbury Lane	• Potential to locate energy centre within the proposed development of 1,730 dwellings, 2 primary schools, a local centre and other local facilities. • Potential to favourably locate energy centre within overall development to facilitate connection to other heat loads in the cluster. • Located within close proximity to the largest heat loads on the network. • Potential to install energy centre and pipework as part of overall construction.	• Dependent on arrangement of site, energy centre may be close to residential buildings. • There may be land ownership issues to overcome.	

Site Name and Reference	Opportunities	Constraints	Site Image
(2) Woodside Farm	• Potential to locate energy centre within the proposed development of 235 dwellings. • Potential to favourably locate energy centre within overall development to facilitate connection to other heat loads in the cluster. • Located within close proximity to the largest heat loads on the network. • Potential to install energy centre and pipework as part of overall construction.	• Energy centre likely to be close to residential buildings. • There may be land ownership issues to overcome.	
(3) Tachbrook Park Employment Allocation	• Potential to locate energy centre near “northern” heat loads of the Warwick Trident College and Leamington Spa Rehabilitation Hospital. • Buildings in close proximity are industrial, therefore potentially less sensitive to noise.	• Located some distance from the potentially large heat loads of the Woodside Farm and Land South of Harbury Lane residential developments. • Site is being developed (as part of draft Local Plan policy DS9), so there is unknown scope for inclusion of an energy centre.	
(4) Royal Leamington Spa Hospital Car Park	• Close to hospital heat load. • Access to site via Heathcote Lane, which is large enough to accommodate large HGVs. • No tall buildings in close proximity; nearby buildings are 2 storeys tall.	• There may be issues with land ownership. • There may be issues with a loss of car parking capacity; however, this could be overcome with the provision of a multi-storey car park, although incurring additional capital costs. • Very limited scope for soft dig; likely pipework route would be via Heathcote Lane. Potentially very disruptive installation. • Western side of site is flanked by houses, which will be sensitive to noise.	

Technology options review

The technology options review in Section 4, has identified that the following technologies may be appropriate for the Whitnash opportunity area and are discussed in more detail below.

Community Biomass/Biogas Boilers

A Biomass-fuelled District Heating network may be a viable option for Whitnash, if a suitable fuel supplier can be found. Careful consideration of the location of the energy centre will be required, to ensure that access for fuel deliveries can be made, along with a suitable flue arrangement to address air quality issues.

Gas Fired CHP

As gas-fired CHP is a mature technology with large potential CO_2 reductions, this technology is considered to be suitable for connection to a district heating network in Whitnash.

Heat Pumps – Water Source Heat Pumps

Figure 61, below, illustrates the river (Tach Brook) heat capacity, respectively, as taken from the DECC National Heat Map.

Tach Brook has a low potential heat capacity of approximately up to 110 kW and, therefore, is unlikely to be a suitable source for a Water Source Heat Pump.

Figure 61. Extract from DECC National Heat Map showing the River Heat Capacity (in kW) near Whitnash.

Whitnash network options: technoeconomic analysis

Different generating technology and network scenarios for the Whitnash cluster were modelled to produce indicative IRR and NPV figures. Network concepts connecting only the hospital, college and new employment developments at Tachbrook park were tested first. The concepts failed to achieve a positive IRR and NPVs were very negative. Network concepts connecting those buildings and the new developments around Harbury Lane achieved positive IRRs, and the results are discussed further below.

Where a private wire arrangement was included, it was assumed that electricity could be sold directly on the network to the new development at Harbury Lane, with the necessary infrastructure included at the time of construction. This assumption was made since the capital cost of installing the necessary connections and setting up contracts is likely to be significantly less for new build than for existing buildings. At this stage it was not assumed that electricity would be sold via private wire to any other network customers, due to the technical and contractual issues involved in supplying multiple customers and the relative distance of the new development from the remainder of the buildings on the network. It should be noted however that this is an assumption made due to the high level scope of this study. If further studies are conducted in this area, soft market testing should be carried out to investigate opportunities to connect to different and/or additional customers.

The export tariff for the private wire option was calculated as follows:

Proportion of total electricity generated predicted to be consumed by new development at Harbury Lane = 80% Lowest assumed retail tariff paid by buildings connected with private wire[24]: 10.08p/kWh

Assumed standard export tariff: 5.50p/kWh

Export tariff for Warwick Town Centre network concept = (0.80*10.08) + (0.20*5.50) = **9.16p/kWh**

[24] From: DECC 2015: Prices of fuels purchased by non-domestic consumers in the UK

Gas CHP

		Capital cost: £5,709,700 2 x 1185 kW Gas CHP + 550kW top-up gas boiler Electricity export tariff: 5.50p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[c]
Emissions 1[a]	25 year	-1232	0.4%	-£2,048,200
	40 year	-1609	3.2%	-£1,542,900
Emissions 2[b]	25 year	89	0.4%	-£2,048,200
	40 year	21	3.2%	-£1,542,900

[a] IAG emissions projections for average and marginal electricity use
[b] Emissions projections for electricity use from *Modelling the impacts of additional Gas CHP capacity in the GB electricity market (December 2014)*
[c] *Using discount rate of 6%*

Table 19. Results of techno-economic modelling for Whitnash: Gas CHP. See Appendix 2 for a summary of the assumptions used.

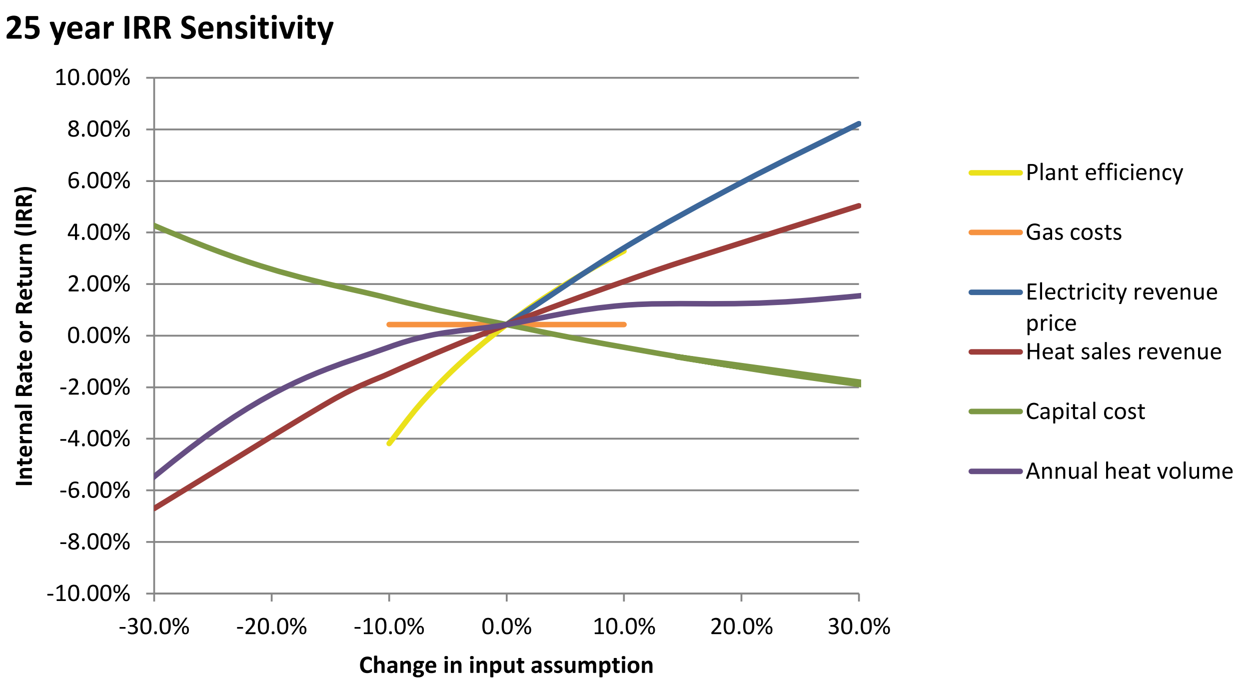


Figure 62. 25 year IRR sensitivity: Gas CHP.

Gas CHP with private wire

		Capital cost: £5,709,700 2 x 1185 kW Gas CHP + 550kW top-up gas boiler Electricity export tariff: 9.16p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[c]
Emissions 1[a]	25 year	-1232	10.0%	£2,055,500
	40 year	-1609	11.1%	£3,367,500
Emissions 2[b]	25 year	89	10.0%	£2,055,500
	40 year	21	11.1%	£3,367,500

Table 20. Results of techno-economic modelling for Whitnash: Gas CHP with private wire. See Appendix 2 for a summary of the assumptions used.

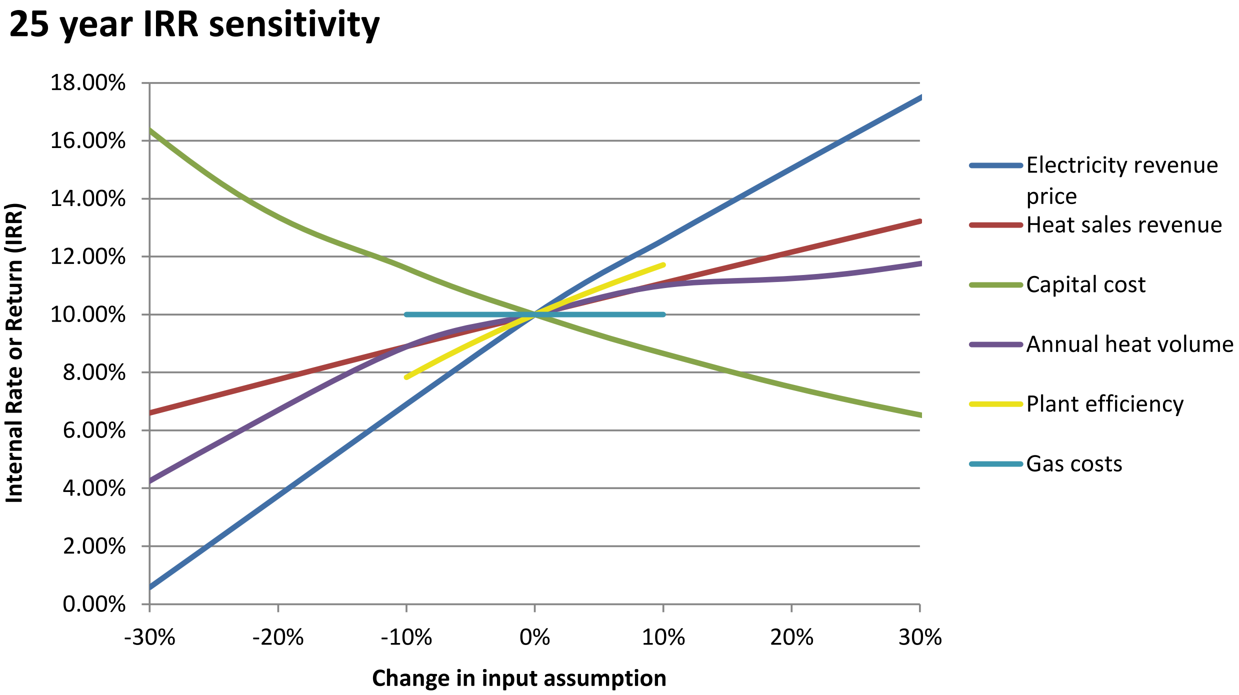


Figure 63. 25 year IRR sensitivity: Gas CHP with private wire.

Biomass with gas CHP and private wire

		Capital cost: £6,122,900 1 x 995 kW Biomass + 1185 kW Gas CHP + 428 kW Gas CHP + 400kW top-up gas boiler Electricity export tariff: 9.16p/kWh		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	587	-	-£2,522,500
	40 year	422	0.3%	-£2,383,100

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 21. Results of techno-economic modelling for Whitnash: biomass with gas CHP with private wire. See Appendix 2 for a summary of the assumptions used.

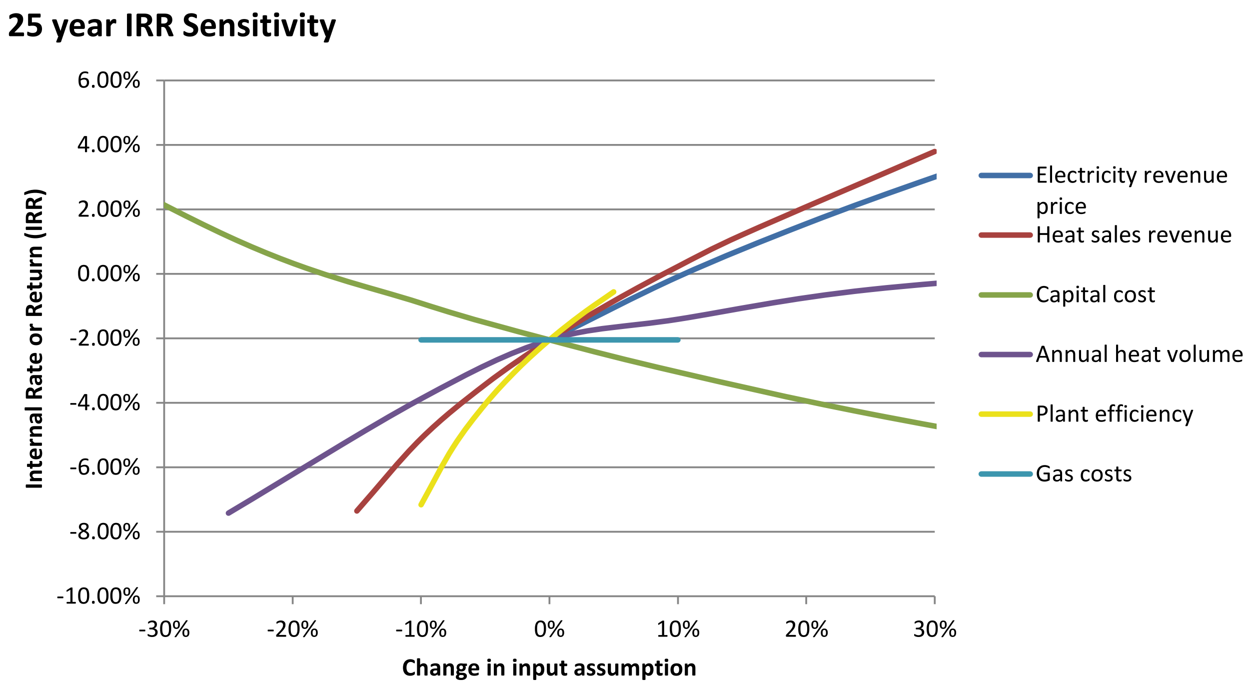


Figure 64. 25 year IRR sensitivity for Whitnash: biomass and gas CHP with private wire.

The sensitivity analysis demonstrates the importance of the price achieved for electricity sales from CHP, either directly on the network or exported to the grid. Achieving a high enough price without disadvantaging network customers will require careful negotiation and contract design. Capital cost is also a significant factor as this analysis indicates that a 10% reduction in capital cost could improve the scheme's 25 year IRR almost to zero.

Summary and conclusions

Technology option	Capital cost	25 year IRR	25 year NPV	25 year average CO_2 savings[25]	40 year IRR	40 year NPV	40 year average CO_2 savings[26]
Gas CHP	£5,709,700	0.4%	-£2,048,200	89	3.2%	-£1,542,900	21
Gas CHP with private wire	£5,709,700	10.0%	£2,055,500	89	11.1%	£3,367,500	21
Biomass with gas CHP and private wire	£6,122,900	-2.1%	-£2,522,500	587	0.3%	-£2,383,100	422

Table 22. Summary of results for Whitnash

The economic viability of this network will be heavily dependent on the nature and scale of the new developments at Woodside Farm and the land south of Harbury Lane; some of which are **already under construction**. Without connections to these developments (which, given planning has been granted and construction commenced is considered unlikely), our analysis suggests that a network is unlikely to be feasible at this time; but indicative benchmarking suggests that sufficiently high and dense energy demand on the new developments may lead to an investable proposition.

[25] Under the 'Emissions 2' scenario
[26] Under the 'Emissions 2' scenario

When planning conditions and strategies are considered for any additions to these two development areas in Whitnash, or additional information on the nature of developments is available, it is recommended that this network option be considered and if appropriate, re-evaluated using additional information.

PRE-FEASIBILITY ANALYSIS: LILLINGTON

09

PRE-FEASIBILITY ANALYSIS: LILLINGTON

Overview

The opportunity identified here is a cluster of three social housing tower blocks in Lillington, which are scheduled for either refurbishment (including a biomass heating system), or demolition and redevelopment of the site. In either case, the redevelopment may present an opportunity to design in an energy centre and pipework for a heat network. The relatively high density of social housing in the area may mean that a heat network could provide social benefits by reducing heat prices for local residents.

The three tower blocks identified are adjacent to Red House Farm: an area identified in the draft New Local Plan as an allocation for 250 new dwellings. If the site is developed, opportunities to design in a district heat network may arise. However, if the new development consists of low density housing, a heat network in the area may not be technically or economically feasible.

No immediate physical constraints to network development have been identified at this stage. Although part of the opportunity area falls within the green belt, Red House Farm has been identified in the draft New Local Plan as a green belt development.

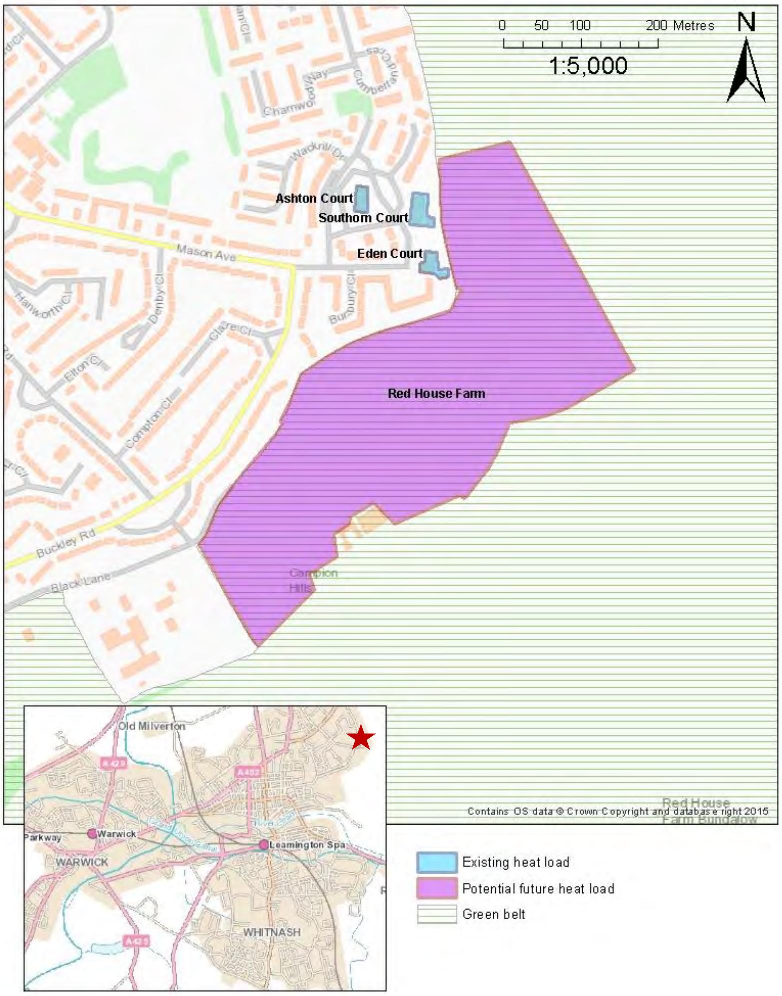


Figure 65. Lillington opportunity area.

Total heat demand: 3,700MWh/year			
Name	**Heat demand**	**Data source**	**Notes**
Ashton Court, Southorn Court and Eden Court	2500 MWh/year	Benchmarked from Ofgem typical domestic energy consumption figure.	High rise apartments (approx 90 in each block) owned by WDC. To be either demolished, or refurbished including biomass heating system.
Red House Farm	1200 MWh/year	Benchmarked from details within planning applications and AECOM models for new dwellings	Draft Local Plan policy DS11: allocated site for approximately 250 dwellings, reference H04.

Figure 66 illustrates indicative potential routes for a heat network in the Lillington area, with one option connecting the three tower blocks, and a second option connecting the tower blocks, and to the new development at Red House Farm.

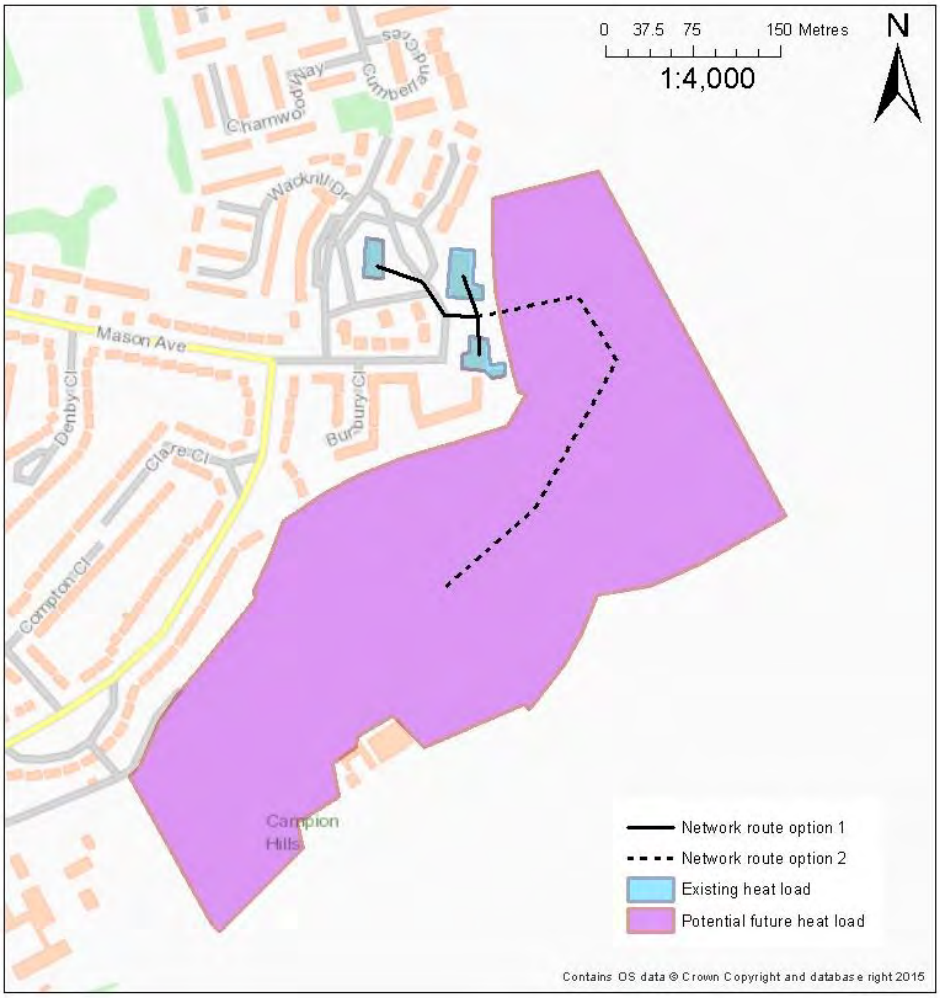


Figure 66. Indicative network route options for Lillington.

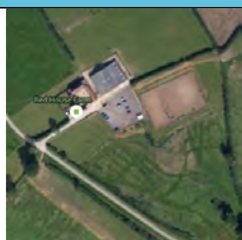
Energy Centre Location

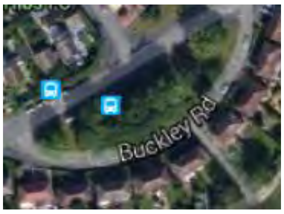
Appraisal

The below, Figure 67, illustrates the sites that have been identified as potentially viable for the siting of a new energy centre in Lillington.

Figure 67. Potential Energy Centre Locations for Lillington.

The following table presents the initial appraisal of energy centre sites for the Lillington opportunity area.

Site Name and Reference	Opportunities	Constraints	Site Image
(1) Red House Farm Development Site	• Potential to integrate new energy centre within new residential development. • Potential to locate energy centre favourably to serve all heat loads.	• Close proximity to residential buildings.	
(2) Ashton Court, Southorn Court and Eden Court	• Could locate within the existing buildings (if sufficient plant space), or construct stand-alone energy centre where garages currently stand. If buildings are demolished and rebuilt, new plant could be integrated within the building.	• Height of buildings will constrain required flue height. • Close proximity to residential buildings. • Disruption during construction, and during fuel deliveries (if biomass plant installed).	
(3) Campion Hills Allotments	• Depending on exact location on site, may be approximately 150m from nearest houses.	• Potential problems with land ownership. • Located outside of the cluster; leading to long pipework routes. • Difficult access for construction plant and fuel deliveries. • May be visually obtrusive.	

Site Name and Reference	Opportunities	Constraints	Site Image
(4) Green Space on Buckley Road/ Clare Close	• Located centrally to cluster. • No tall buildings in close proximity; nearby buildings are houses (2 or 3 storeys tall). • Potential for soft dig route to heat loads; if land ownership and access for pipework can be agreed.	• Potential problems with land ownership. • Site is overlooked by houses, which may constrain the energy centre design.	
(5) Green Space in Buckley Road (near Black Lane)	• No tall buildings in close proximity; nearby buildings are houses (2 or 3 storeys tall).	• Potential problems with land ownership. • Site is overlooked by houses, which may constrain the energy centre design. • Limited scope for soft dig. • There may be resistance to the loss of green infrastructure/trees.	

Technology options review

The technology options review in Section 5, has identified that the following technologies may be appropriate for the Lillington opportunity area and are discussed in more detail below.

Community Biomass/Biogas Boilers

A Biomass-fuelled District Heating network may be a viable option for Lillington, if a suitable fuel supplier can be found. Careful consideration of the location of the energy centre will be required, to ensure that access for fuel deliveries can be made, along with a suitable flue arrangement to address air quality issues. The Ashton Court, Southorn Court and Eden Court apartment buildings have been identified by Warwick District Council as a potential location for a biomass-fuelled heating system.

Gas Fired CHP

As Gas-fired CHP is a mature technology with large potential CO_2 reductions, this technology may be suitable for connection to a district heating network in Lillington. However, this area has been identified as an opportunity area for district heating due to the potential for the use of biomass in a district heating network, and this report will evaluate the area in this context.

Heat Pumps – Water Source Heat Pumps

There are no water sources near to the Lillington opportunity area so WSHPs are not considered to be a viable heat source for this cluster.

Lillington network options: technoeconomic analysis

Different generating technology and network scenarios for the Lillington cluster were modelled to produce indicative IRR and NPV figures. For the scenarios connecting to new development at Red House Farm, indicative energy demand figures were benchmarked based on an assumption of 250 new dwellings, as allocated in the draft Local Plan.

Biomass at tower blocks only:

		Capital cost: £1,865,500 700kW biomass + 60kW top-up gas boiler Electricity export tariff: n/a		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	561	1.5%	-£405,000
	40 year	552	1.6%	-£421,400

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 23. Results of techno-economic modelling for Lillington tower blocks only.

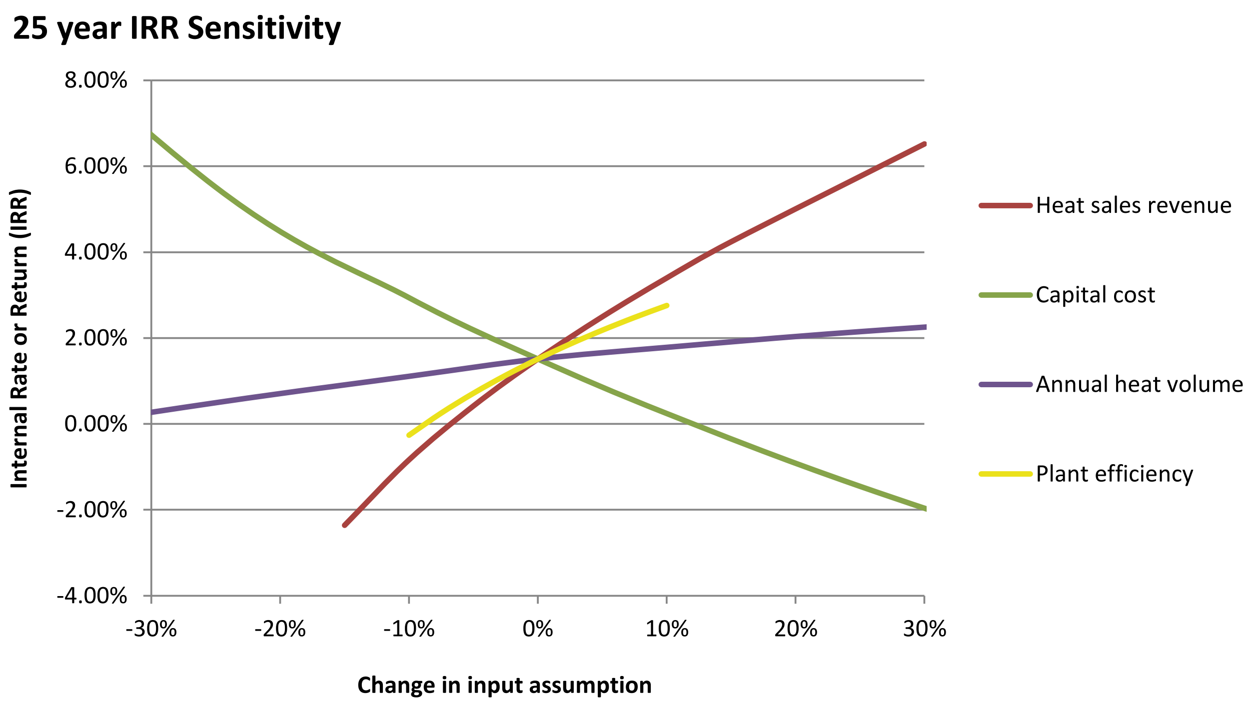


Figure 68. 25 year IRR sensitivity for Lillington: tower blocks only

Biomass at tower blocks and potential Red House Farm development:

		Capital cost: £ 2,084,700 700kW biomass + 300kW top-up gas boiler Electricity export tariff: n/a		
		Average CO_2 savings tonnes/year	IRR	NPV[b]
Emissions 1[a]	25 year	706	2.8%	-£337,100
	40 year	693	3.4%	-£322,200

[a] IAG emissions projections for average and marginal electricity use
[b] Using discount rate of 6%

Table 24. Results of techno-economic modelling for Lillington tower blocks and potential Red House Farm development.

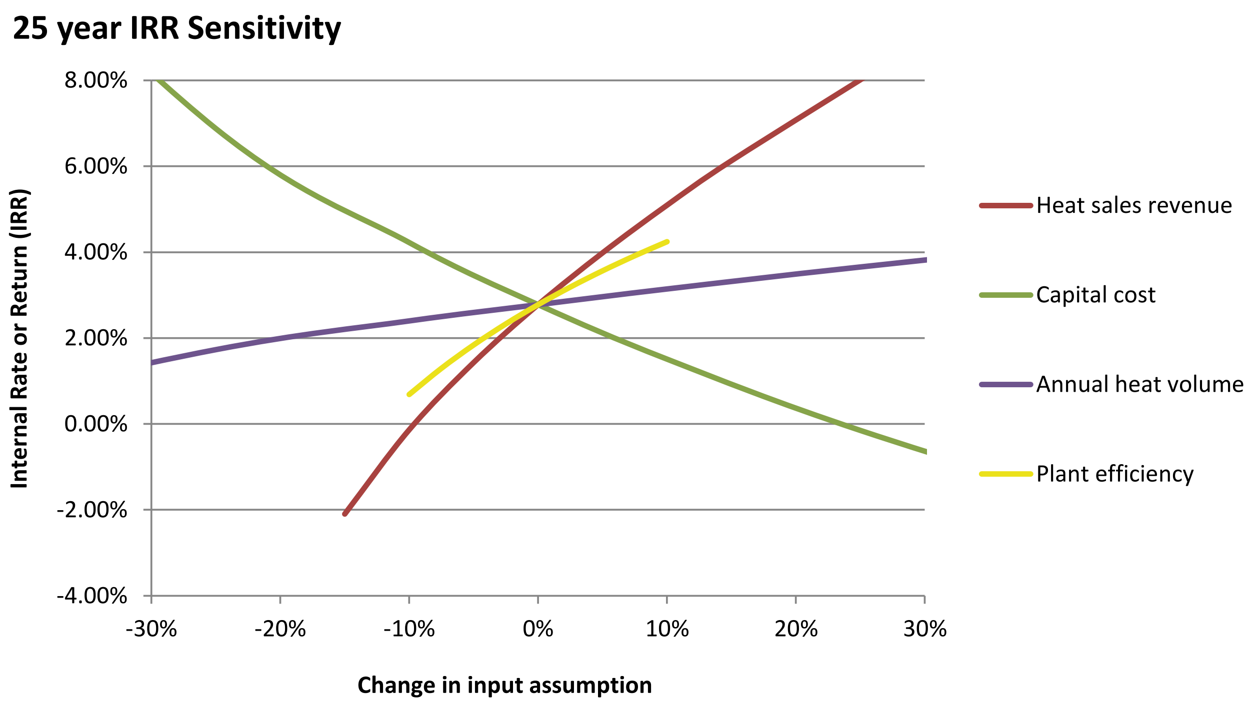


Figure 69. 25 year IRR sensitivity for Lillington: tower blocks and potential Red House Farm development

Summary and conclusions

Technology option	Capital cost	25 year IRR	25 year NPV	25 year average CO_2 savings[27]	40 year IRR	40 year NPV	40 year average CO_2 savings[28]
Biomass tower blocks only	£1,865,500	1.5%	-£405,000	561	1.6%	-£421,300	552
Biomass tower blocks and Red House Farm	£2,048,700	2.8%	-£337,100	706	3.4%	-£322,200	693

None of the network concepts tested presents an attractive investment option at present. This is likely due to the small number of anchor loads present on the networks, and the length of piping required between the tower blocks and the new development at Red House Farm, relative to the heat demand present.

Given the lack of certainty over development at Red House Farm until planning applications are received, and the absence of other key heat loads nearby, it is recommended that heat supply options in this area are considered in terms of a small scale community biomass scheme for the tower blocks, rather than as a full district heating system.

27 Under the 'Emissions 2' scenario
28 Under the 'Emissions 2' scenario

FUNDING AND DELIVERY RECOMMENDATIONS

10

FUNDING AND DELIVERY RECOMMENDATIONS

This section provides an overview of a delivery options for taking forward a district heat network in Warwick District.

Making the case for investment

The results of this pre-feasibility study provide sufficient evidence to support further detailed feasibility studies, particularly for the Warwick Town Centre, Myton and Leamington Spa Riverside clusters.

Although the potential projects outlined in this report may not be as attractive as alternative investment options on a simple business case basis, it is important to also account for the following additional benefits they can deliver when considering whether to invest in further analysis.

Consider the value of CO_2 saving

The Council is legally required to tackle CO_2 emissions and there will be a cost associated with this. Accounting for the value of CO_2 savings, with reference to carbon price mechanisms such as the carbon floor price, CRC and Carbon Levy, should enable a saving to be allocated. For projects which make financial returns that are potentially considered to be low and unattractive, the understanding that CO_2 savings are essentially being achieved for negative costs could change the view of the project's viability. As discussed in the methodology, the predicted CO_2 savings from gas CHP are very sensitive to the relative carbon intensity of gas and electricity fuels. Clarification should be sought from DECC and HNDU on the emission factors to be used for CHP in further detailed feasibility work.

Identify and account for cross sector goals

Financial, social and environmental benefits need to be taken into account to understand the wider value of investment which delivers in areas other than simple returns. Investment in low carbon energy systems often helps either directly or indirectly in areas such as fuel poverty, health, air quality and biodiversity; all of which will be considerations for Warwick District's 'Fit for the Future' programme. These other benefits should be recognised and possible financial values should be attached to them in order to deliver a more comprehensive assessment. Some of the additional benefits include:

- Reduction in fuel poverty and improved energy affordability. This releases spending power into the local economy.
- Health benefits: improved energy affordability can deliver health benefits by reducing the risks of illness associated with living in inadequately heated homes.
- Infrastructure improvements with direct economic benefits from creation of construction and operation jobs.
- Development of local skills and job creation and wider economic regeneration.
- Enabling local development by providing a low cost approach to meeting increasingly challenging standards for carbon reduction in new buildings.

Overview of funding options

The best-case indicative 40 year IRRs based on the indicative networks assessed and assumptions taken (using a 6% discount rate) were calculated at 6.14% for the Warwick Town Centre network, 8.17% for the Myton network and 7.81% for the Leamington Spa Riverside network. As a general indication, IRRs of ≥6% are normally required to attract public financing, while IRRs of ≥10% would be required to attract private investment.

There are a number of grant funding opportunities for projects like these that would reduce the level of public or private investment required, potentially making projects with lower IRRs feasible. Potential funding sources for district heat network projects include government subsidies and grants, debt financing and levies on developers. Delivery and management may be wholly privately or publically funded, or delivered through public-private partnerships.

The following general recommendations are made:

- For the Warwick Town Centre, Myton and Whitnash networks the commercial viability of delivering a district heating network served partially or fully 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 via private wire. We have highlighted potential locations within each of the clusters but further work would be required to identify the buildings that could provide a customer for the electricity.
- Strategies to maximise the revenue of the electricity generated, such as Power Purchase Agreements, could be explored.
- Obtaining financial contributions from developers is likely to be another important component of improving the commercial viability of all schemes to a level that would attract private finance. As discussed below, these contributions could be made through the Community Infrastructure Levy.
- Planners should ensure that the potential development of the heat network opportunities identified is supported by proposed development within the clusters. Key to this will be ensuring that all development in close proximity to the suggested networks is compatible with connection to a future district heating network.

Heat Networks Delivery Unit (HNDU)

DECC's Heat Networks Delivery Unit (HNDU) provides grant funding and guidance for local authorities to deliver heat networks. Since its inception in September 2013 HNDU has awarded a total of £9.7 million in grants to support 180 projects across 115 local authorities. The unit is currently scheduled to run until March 2016.

Local authorities can apply for grants to cover up to 67% of external costs of heat mapping, feasibility studies and detailed project development work (including technical design, financial modelling and exploration of commercial models and contracts). This study was part funded by the fourth round of funding applications. The fifth round of funding applications (for feasibility studies only: see Figure 70) opened on 28th September 2015 and will close on 1st November 2015. While HNDU grants do not cover capital or operational costs of heat networks, a key recommendation from this study is that Warwick District Council seeks grant funding for one or more full feasibility studies around the Myton or Leamington Spa Riverside clusters.

Phase	Detail	
Heat mapping	Area-wide exploration, identification and prioritisation of heat network project opportunities	Scope of this study
Energy master planning	Area-wide exploration, identification and prioritisation of heat network project opportunities	
Feasibility study	Project specific - An increasingly detailed investigation of the technical feasibility, design, financial modelling, business modelling, customer contractual arrangements and delivery approach, up to business case	**Funding application window open**
Detailed project development	Project specific - An increasingly detailed investigation of the technical feasibility, design, financial modelling, business modelling, customer contractual arrangements and delivery approach, up to business case	Not eligible for funding under HNDU round 5

Figure 70. Annoted extract from HNDU website[29]

In November 2015 the Government's Spending Review announced £300 million in capital funding for up to 200 heat networks. Details of how this will be administered are expected in 2016.

[29] https://www.gov.uk/guidance/heat-networks-delivery-support

Renewable Heat Incentive (RHI)

The Renewable Heat Incentive (RHI) is a subsidy scheme funded by the UK Treasury, providing payments for heat generated by eligible technologies. Payments are made for 20 years. District heating schemes qualify for the RHI, provided the heat is supplied by a qualifying technology (gas-fired CHP does not qualify). Current non-domestic tariffs for district heating technologies are shown in Table 25:

Technology	Tariff (p/kWh)
Water/ground source heat pumps	8.84
Air source heat pumps	2.54
Commercial biomass <200kWth	4.18
Commercial biomass 200kW-<1MWth	5.18
Commercial biomass ≥1MWth	2.03
Solid biomass CHP	4.17
Deep geothermal	5.08
Biogas combustion <200kWth	7.62
Biogas combustion 200kW-<1MWth	5.99
Biogas combustion ≥1MWth	2.24

Table 25: RHI tariffs for potential district heating technologies.

The technoeconomic modelling in this study has assumed that eligible technologies receive the RHI at current rates. It is currently unknown how long the RHI scheme will remain available for newly commissioned schemes, and this must be borne in mind when planning for district heating schemes commissioned in the future.

Renewable Obligation Certificates (ROCs)

The Renewables Obligation requires licensed electricity suppliers to source a specific and annually increasing proportion of the electricity they supply from renewable sources, thereby creating a market and premium for green energy. Each MWh of electricity generated from renewable sources receives a certain number of Renewables Obligation Certificates (ROCs) depending on the source used. In 2017 the scheme will be superseded by Contracts for Difference, and it is therefore unlikely to apply to any district heating schemes in Warwick District by the time they are commissioned.

Contracts for Difference (CfD)

From 2013, the ROC scheme is being phased out and replaced by Contracts for Difference (CfD), with ROCs fully superseded by 2017. Under CfD, generators are guaranteed a fixed price (the strike price) for electricity generated from renewable sources, with suppliers providing top-up payments if market electricity prices are below the strike price. Strike prices for relevant technologies are shown in Table 26.

Technology (£/MWh)	’15–‘16	’16–‘17	’17–‘18	’18–‘19
Anaerobic digestion (with or without CHP)	155	150	140	140
Dedicated biomass with CHP	125	125	125	125
Energy from waste with CHP	80	80	80	80
Geothermal (with or without CHP)	145	145	140	140
Landfill gas	55	55	55	55
Sewage gas	75	75	75	75

Table 26: Strike prices for district heating technologies.

CfD does not provide funding for Gas CHP, Biomass (without CHP) or Water Sourced Heat Pumps and so is unlikely to offer a revenue stream for any of the identified opportunities in WDC.

Enhanced Capital Allowances

Commercial organisations can benefit from Enhanced Capital Allowances (enhanced tax relief) on energy saving equipment, including CHP. Business can write off 100% of the capital costs of eligible technologies against their taxable profits in the first year after the investment is made instead of spreading this write-off.

Prudential borrowing and bond financing

The Local Government Act 2003 empowered Local Authorities to use unsupported prudential borrowing for capital investment. It simplified the former Capital Finance Regulations and allows councils flexibility in deciding their own levels of borrowing based upon its own assessment of affordability. The framework requires each authority to decide on the levels of borrowing based upon three main principles as to whether borrowing at particular levels is prudent, sustainable and affordable. The key issue is that prudential borrowing will need to be repaid from a revenue stream created by the proceeds of the development scheme, if there is an equity stake, or indeed from other Council funds (e.g. other asset sales).

Currently the majority of a council's borrowing will typically access funds via the 'Public Works Loan Board'. The Board's interest rates are determined by HM Treasury in accordance with section 5 of the National Loans Act 1968. In practice, rates are set by Debt Management Office on HM Treasury's behalf in accordance with agreed procedures and methodologies. Councils can usually easily and quickly access borrowing at less than 5%.

The most likely issue for local authorities will be whether or not to utilise Prudential Borrowing, which can be arranged at highly competitive rates, but remains 'on-balance sheet' or more expensive bond financing which is off-balance sheet and does not have recourse to the Council in the event of default.

Community Infrastructure Levy

The Community Infrastructure Levy (CIL) allows local authorities to raise funds from developers to support new or improved infrastructure in the area. The 2008 Planning Act defines infrastructure which can be funded by the CIL, which includes district heating schemes. The use of CIL funds is not geographically limited to the area of development: they may be used to fund schemes in other areas within the local authority's remit.

Opportunities in Warwick District

Some local programmes offer funding and support for new or expanding businesses, some of which may apply to district heating projects in the District, depending on the scale and type of network.

Coventry and Warwickshire Local Enterprise Partnership European Structural and Investment Funds Strategy

Coventry and Warwickshire Local Enterprise Partnership (CWLEP) European Structural and Investment Funds (ESIF) Strategy for 2014 to 2020 outlines a range of thematic objectives and strategic level activities for the region. Theme 4 is to support the shift towards a low carbon economy in all sectors, and within this theme a number of growth interventions have been identified, including "development of whole place low carbon solutions". As part of this intervention district heating, including the expansion of existing networks and the development of new renewable inputs, including biomass and biogas, has been identified as part of the solution. The funding profile for this growth intervention is indicated as £5,800,750 from the ERDF (European Regional Development Fund), £1,500,750 of Public matched funding and £4,300,00 of Private match funding, giving a total fund of £11,601,000.

Coventry and Warwickshire Growth Hub "Access to Finance" and "Business Innovation"

The Coventry and Warwickshire Growth Hub offers support to businesses of all sizes and in all sectors in Coventry and Warwickshire, with enhanced support offered to businesses who are upskilling, recruiting, expanding or changing premises, looking to conduct international trade or developing innovative new products and services.

The Coventry and Warwickshire Growth Hub "Access to Finance" scheme provides support for eligible investment projects, where it can be shown that new jobs are created by spending money on capital items including research and development. The Coventry and Warwickshire Growth Hub has its own funds to provide financial support and connects directly to the range of investment funds offered by the Coventry and Warwickshire Local Enterprise Partnership and its partners.

Through the Coventry and Warwickshire Growth Hub's "Business Innovation" initiative, grants of between £2,500 and £10,000 are available for undertaking innovation related activity, including undertaking proof of concept or proof of market activity and developing or commercialising new products, processes or services.

Transition to zero carbon

The techno-economic analyses in the preceding chapters indicated that as the UK National Grid is decarbonised in the future, CO_2 savings arising from the use of gas CHP will decline and in some cases become negative. It is important to note that whilst the decarbonisation of the grid reduces the carbon benefits of gas-CHP, it increases the carbon benefits of other technologies, in particular that of heat pumps.

Heat pumps operate on electricity and so as the grid becomes less carbon intensive, the heat provided by a heat pump also becomes less carbon intensive. Figure 71 shows the projected carbon emission rates of CHP and heat pumps (and conventional gas boilers for comparison) under the IAG and DECC alternative emissions scenarios used in this study. CHP 1 and 2, and Heat Pumps 1, 2 and 3 refer to different efficiency levels for those technologies. Under most scenarios, heat pumps are already less carbon-intensive than CHP, and become increasingly so up to 2050. Future proofing' new buildings and networks for potential connection to heat pumps upon DH plant replacement should therefore be considered in a full feasibility study.

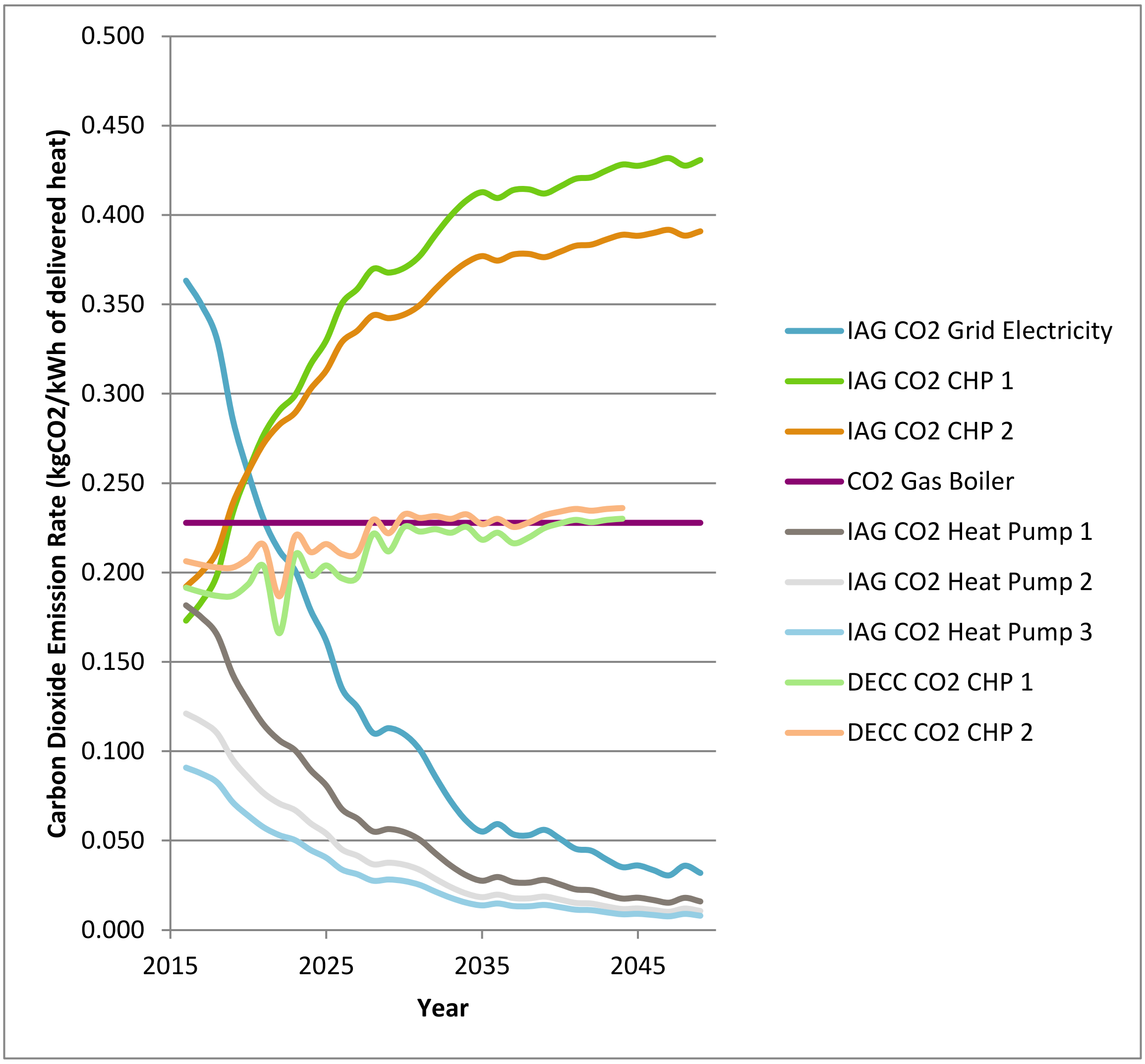


Figure 71. Carbon dioxide emissions rates under two grid electricity decarbonisation scenarios

The efficiency of heat pumps is strongly affected by the temperatures at which they operate: efficiency is highest when the flow and return temperature are low. For example some new heat pump DHNs operate at 50°C flow and 20°C return, and systems can only operate in this temperature range if the buildings they are connected to also operate at low heating system temperatures. The alternations required for existing buildings to operate at these temperatures is often prohibitive, but new buildings which may be connected to low temperature heat networks should be designed with these in mind. For example, consideration should be given as to whether the Creative Quarter and the potential new mixed use development in Leamington could be designed to operate at low temperatures or to deliver low return temperatures.

Some of the network concepts in this study use biomass as the generating technology. While biomass is sometimes referred to as 'zero carbon' since the CO_2 released upon combustion is equal to that absorbed during biomass growth; there are indirect carbon emissions associated with activities such as fertilisation, harvesting, transport and land use change. There is also a lag between the harvesting of biomass, its combustion and the subsequent take up of CO_2 in new growth. When biomass is used the fuel source must be assessed carefully to ensure that the indirect emissions do not outweigh the emissions savings arising from its use.

Warwick District Council's actions for delivery

The role of Local Authorities in delivery

Under the National Planning Policy Framework, Local Authorities have a responsibility to contribute to the UK's emissions reduction targets set out in the 2008 Climate Change Act, by using local planning policy and guidance, and by encouraging and facilitating co-ordinated local action.

In Warwick District, planning policy could be put in place that uses the outcomes of this study as the evidence base to support development of the opportunities highlighted. For the heat network concepts for which we have undertaken technoeconomic assessments and demonstrated the potential viability, the Council could require new developments to either connect to, or design for connection to, a future network in these locations. For developments in the other areas the Council would perhaps not be able to use strong wording without the more detailed evidence in place, but could encourage developers to enable future connection.

Designing non-domestic buildings for compatibility with heat networks can be achieved by the following:

- Capped-off connections on the internal heating system;
- Locating the plant room close to the planned network route;
- Providing a trench or capped plastic sleeve to allow a point of entry for the pipework to enter the energy centre and thereby minimise or avoid future intervention requirements.

For residential developments, compatibility is best achieved through the installation of communal heating systems. However, this can be expensive and may be an unattractive proposition for developers, especially in smaller schemes. An alternative position would be to require increased riser space for flow and return pipework that would make future retrofitting a possibility.

The cost of these measures is minimal and would help to support the implementation of district heating and reduce the risk of the opportunities being missed. Planning policy can also be used to safeguard potential energy centre sites or network routes.

- Local Development Orders (LDO) can potentially be applied by local authorities to extend permitted development rights across whole local authority areas or to grant permission for certain types of development. Should the Council agree to lead installation of a district heating network then it is recommended that they explore the option of establishing a LDO in order to add certainty to the development process and potentially speed up delivery.

- The Council will need to commit to connecting its own buildings to the network in order to provide the 'anchor load' for schemes where this is possible, such as those in Warwick Town Centre, Leamington Spa Riverside and Lillington. The Council will also be in a much better position to enter into a long-term energy contract and therefore reduce levels of risk and in so doing help to attract investment from third-parties.
- 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. The following incentives can be promoted:
  - **CO_2 savings** – For existing developments the CO_2 savings will be dependent on the system replaced by the district heating network, but an appropriately designed network for a new development may deliver more significant savings compared to the use of standard gas boilers. These savings should prove attractive to most major businesses wishing to address their carbon footprint, particularly those that are large enough to qualify for the CRC. For new developments, connection to the network will offer a route to delivering significant CO_2 savings that could be a cost effective option compared with on-site solutions.
  - **Space savings** – for existing buildings, connecting to a DH scheme would free up plant space for other uses. For new developments it means that additional lettable/useable floor space would be made available.
  - **Reduced operation and management risks** – the district heating network operator would take most of the risks and the management of plant away from the end user/manager of the building thus reducing operational, maintenance and management costs. Schemes are usually designed with full back-up plant. The resilience is further enhanced with additional energy generation systems being added to the network as it expands.
  - **Planning requirements** - connection to a DH scheme could help to ensure compliance with planning policies and provide a route to compliance with increasingly stringent Building Regulations standards.
- If there is clear support for the development of heat networks it could be useful to set out a clear long-term vision. This could also present a plan for the expansion and linking of networks where appropriate. Where a network is gas CHP-led, a long term technology plan is also likely to be useful to recognise that the CO_2 savings associated with the use of gas CHP are projected to fall in line with the decarbonisation of the national grid. To deliver secure and increasing CO_2 savings over time, a transition plan would need to be considered to move to alternative technologies, potentially around the time of replacing the plant. It is impossible to say with certainty what the best options will be at this time but the potential for developing the following options could be considered:
  - Incorporation of biomass boilers onto the network;
  - Replacement of gas CHP with alternative systems or fuels e.g. biomass CHP engines or fuel cells;
  - Connection to water source heat, particularly for any networks developing around the River Avon.

Special Purpose Vehicles (SPVs)

Delivering large energy projects such as district heating networks may require the creation of a Special Purpose Vehicle (SPV) that may include partners outside the authority.

If appropriate, options for setting up an SPV should be explored at the earliest opportunity once a heat network delivery project has been initiated. Although the skills required to do so may need to be developed within the Council, this should not be an insurmountable barrier and there is a growing number of local authorities engaging in similar activities both in energy and other areas. The key to success is likely to be leadership: from senior Council management or (at least initially) from committed individuals in planning or other departments.

SPV models range from fully public, through partnerships between public, private and community sectors to fully private. Broadly speaking, the greater the involvement of third parties the lower the risk to the local authority but the less control the authority will have. Whichever route is chosen, the SPV should be put in place as early on in the network development process as possible, so that its technical and financial requirements can be fed through into negotiations with potential customers.

Potential advantages and disadvantages associated with publicly led and privately led SPVs are shown in Figure 72.

	Private Sector Led	Public Sector Led
Advantages	Private sector capital Transfer of risk to private sector Commercial and technical expertise	Lower interest rates on available capital secured through Prudential Borrowing More control over strategic direction No profit needed Incremental expansion more likely Low set-up costs (internal accounting only)
Disadvantages	Loss of local authority control Most profit retained by private sector Incremental expansion more difficult High set-up costs	Greater risk to local authority Less access to private capital and expertise, though expertise can be obtained through outsourcing and specific recruitment

Figure 72. Advantages and disadvantages of publicly and privately led SPVs.

ESCOs

Local authority-led development of a DHN in Warwick District will necessitate a decision regarding Council and/or private ownership and management of the network elements, based on the risks and benefits outlined in Figure 72. Delivery is usually managed through an Energy Service Company (ESCO).

ESCOs are commercial businesses that provide and manage energy solutions. A full ESCO service involves the following elements:

1. Finance
2. Design
3. Installation
4. Operation
5. Maintenance
6. Management

The following diagrams demonstrate different ESCo models that are being used in a number of existing district heating schemes across the country. Each of these models entails a different level of risk and commercial interest, as illustrated in Figure 72.

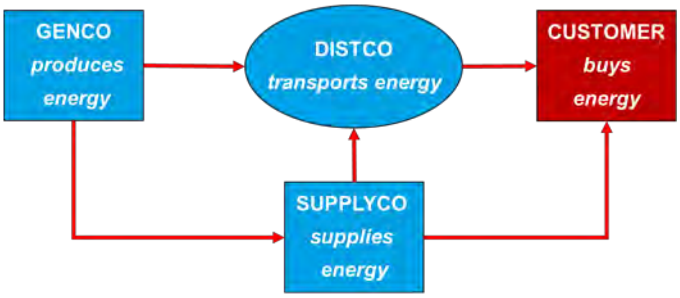
GENCO refers to the part of the organisation that owns and is responsible for the operation and maintenance of the generating plant and energy centre.

DISTCO refers to the part of the organisation that owns and is responsible for the distribution network.

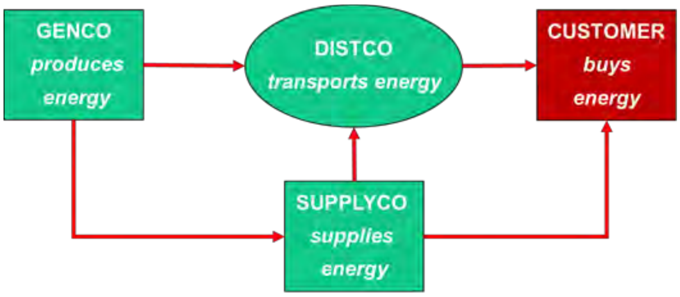
SUPPLYCO refers to the part of the organisation that is the energy supplier i.e. the interface with the customer and responsible for billing, metering etc.

BLUE BOXES represent private ownership and GREEN BOXES represent public (Council) ownership.

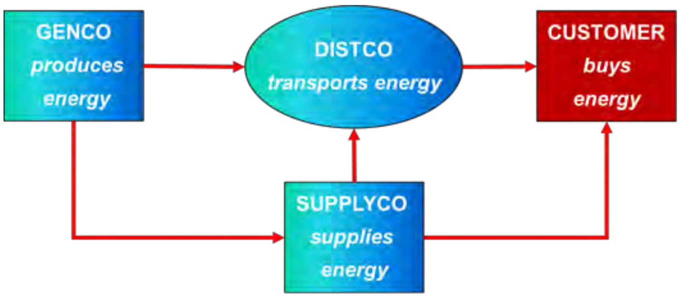
Private sector ownership e.g. Southampton, Citigen (London), Sheffield



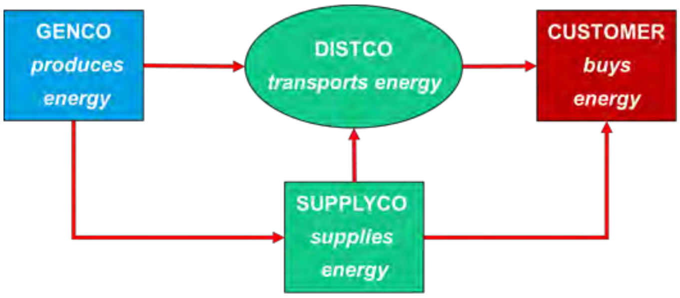
LA Ownership e.g. Islington, Pimlico, Aberdeen heat and power



Joint Ownership



LA-owned network, private sector-owned heat source, e.g. Nottingham



Risk management

The sensitivity analysis carried out as part of the economic analyses identified some areas of risk relating to the economic viability of potential district heat networks in Warwick District. Throughout the project we have identified and kept a running record of other economic, technical, social and environmental risks, which have been noted in a risk register. The register is shown below, and is also available as a supplement to this report in spreadsheet format. Risks are identified and quantified, along with recommended actions for mitigation.

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Technical viability	Insufficiently diverse load profiles for a district heating scheme.	3	5	15	Assess the viability of loads at the technical feasibility stage, including the sensitivity of the assessment to the inclusion or exclusion of each load.	1	5	5
Technical viability	Existing heating systems found to be unsuitable for connection to a DH scheme.	3	4	12	Review existing plant in buildings at the full feasibility stage to assess the high level viability of connection.	3	1	3
Technical viability	Network is not flexible enough to allow future energy supply options	3	3	9	Designs need to be future-proofed to ensure the network could allow future energy supply options. Will need to assess risks of different future supply options and interconnections at later stage.	1	3	3
Technical viability	Incorrect installation of plant or network elements leading to underperformance or failure	2	5	10	Ensure provisions in procurement/delivery contracts to protect the investors' interests in this eventuality.	1	4	4
Technical viability	Network design or incorrect installation giving rise to excessive heat losses from the network.	2	4	8	A full feasibility study will account for heat losses when considering the heat source and distribution pipework to be used. Designers should consider ways to reduce the heat losses as far as practical such as by adopting standards for insulation above the regulatory minimum.	1	4	4

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Technical viability	Inability to secure energy centre site for initial network phase(s).	4	5	20	This pre-feasibility study has identified multiple potential locations for energy centres, and has provided an outline review of the suitability of the different locations. In many areas, siting an energy centre is likely to prove challenging due to the nature of existing development. The Council, supported by a full feasibility study, will need to identify and promote their preferred option.	3	5	15
Regulatory / policy	Local political risk. Changes to council administrations results in lower priority given to DH schemes.	3	4	12	Continued engagement with the Council senior management and Executive is essential for the scheme to be given the resources and priority required. [Currently the scheme has high level support]	2	2	4
Regulatory / policy	National political risk. Changes to national administration or strategy results in move away from promotion and support for DH schemes or reduction/withdrawal of powers which allow local authorities to develop and invest in DH schemes.	3	3	9	Place a greater emphasis on schemes being economically attractive for commercial investment. Prioritise publically funded investment whilst support is strong. Engage with national government to communicate benefits.	3	2	6
Regulatory / policy	Grid electricity decarbonised more rapidly than anticipated, giving rise to negative carbon abatement from the scheme compared with counterfactual.	2	4	8	This study considers the carbon abatement arising from potential schemes using two/three different emissions scenarios. A full feasibility should conduct a similar comparison, and keep a watching brief on grid emissions factor predictions from DECC and other sources.	1	4	4

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Future strategy	Lack of integration with existing and planned works, and building activities - potentially missing opportunities and incurring extra costs, or delaying programme.	5	4	20	Design programmes for any future feasibility studies with awareness/reference to the timetable for key decision-making processes within WDC. Use evidence from this study and any feasibility studies conducted in the near future to inform revisions to the draft Local Plan for Warwick District. Maintain close communication and engagement with Warwickshire County Council.	2	4	8
Future strategy	Desired future expansion of network not achieved or limited .	3	4	12	The risk of reduction in rate or scale of network expansion can be minimised by implementing an appropriate governance and delivery structure. If the scheme is delivered with strong council control / ownership, then control will be retained. If a commercial delivery route is taken, this control may be reduced.	2	4	8
Future strategy	Opportunities to connect existing buildings and new developments to the network missed.	5	2	10	Promote the benefits of the heat network to local businesses and developers. Keep a watching brief to identify, and engage with, any new potential customers. Use planning to promote new development connection.	2	2	4

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Environmental/social risk	Flooding of energy centre. There are areas of high and medium flood risk in the Leamington Spa Riverside cluster.	2	4	8	The choice of location of the energy centre must consider flood risk. Initial feasibility review of suitable sites for the energy centres has considered flood risk. The full feasibility study should look at this issue in further detail. The design of energy centre must consider flood protection.	1	4	4
Environmental/social risk	Negative visual impact from energy centre on local residents.	3	3	9	The potential for visual impact has been discussed in the energy centre location appraisal. A full feasibility study should take into account the potential for visual impacts and seek to minimise these during the selection of a location for the energy centre. Examples of sympathetically designed energy centres in dense urban areas exist (e.g. Islington Bunhill scheme), and lessons learned from these should be considered in designing the energy centre.	1	1	1
Environmental/social risk	Energy centre - environmental impacts e.g. air quality and ecology	3	2	6	Air Quality Management Areas and/or Conservation Areas within Warwick and Leamington Spa town centres have been considered when identifying potentially appropriate locations for an energy centre. The energy centre should be designed to minimise emissions (air and noise). The full feasibility study should consider this issue in further detail.	2	1	2

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Environmental/social risk	Energy Centre and heat network do not deliver short term CO_2 saving	3	3	9	Carbon savings from CHP are dependent of relative carbon intensity of mains gas and mains electricity which are calculated by the UK Government. DECC predicts electricity grid will decarbonise which impacts on the scope for long term and potentially near term carbon savings from CHP. There is likely to be potential to secure CO_2 savings in short term with gas CHP, if the network is delivered soon. Mitigation actions: Investigate further in detailed feasibility study. Request clarity from DECC over calculation methodology when applied to CHP and district heating. Continue to review technology position as the electricity grid decarbonises.	2	3	6
Environmental/social risk	CO_2 emissions not achieved in longer term due to decarbonisation of electricity.	4	4	16	Full feasibility study to consider potential current and future potential energy supply technologies that have been assessed at pre-feasibility. Identify a strategy for longer term - e.g. replacing gas CHP with alternative generation technologies and revisit regularly as supply technology options change or improve.	2	4	8
Economic viability	Inability to secure funding for project development work.	3	5	15	Use evidence from this pre-feasibility study to support an application to HNDU for funding for a full feasibility study. The full feasibility study should be designed to support the recruitment of joint venture partners.	2	3	6

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Economic viability	Increased capital costs of network due to increases in plant or labour costs etc.	2	5	10	Include the sensitivity of scheme economic viability to capital costs as part of the economic analysis in any subsequent full feasibility studies. Review costs throughout the project lifecycle.	2	2	4
Economic viability	Increased maintenance and operational costs of network, for example, due to increases in plant or transactional costs.	2	5	10	Full feasibility study to contain an economic analysis and sensitivity analysis which considers operational costs in more detail, specific to the chosen business model.	2	2	4
Economic viability	Uncertainty over future energy prices and incentives (e.g. RHI) for development of business plan and future operation of scheme.	4	5	20	This pre-feasibility study has used DECC's energy price projections in the economic analyses. Full feasibility study should consider the suitability of these projections and where necessary compare against a range of scenarios.	4	3	9
Economic viability	Costs of metering and billing for heat sales are higher than anticipated	2	1	2	Ensure higher per customer costs of metering and billing in early phases are accounted for. Account for set up costs and 'teething' troubles in first two years. Note that initial customers may be district council and/or higher energy users and so metering and billing expected to be small proportion of heat sales revenue. Cost should be reviewed as network expands and a higher number of smaller customers join the network.	1	1	1

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Economic viability	Risk of 'sunk' costs to connect to heat network - i.e. customers may want some costs recouped where remaining life of existing plant may be good. . NB this is particularly likely in the case of the National Grid HQ, which was recently refurbished	3	4	12	Potential negotiation required with customers. Options include the delay of connection until existing plant is due for replacement and the payment to customers for the adoption of decentralised plant (e.g. to provide top up for peak loads). These options should be assessed in the full feasibility study.	2	2	4
Development and construction	Programme delays at construction stage (e.g. due to getting approval for works in roads, delivery delays etc.).	3	3	9	Undertake careful forward planning and management to manage and minimise delays. Build in contingencies to construction programme to allow for unseen delays.	2	2	4
Development and construction	Congested existing buried services impacting on the routing of the DH network and the cost of installing.	3	4	12	Carry out detailed review and survey of existing utilities during the feasibility study and the design and construction stages.	2	4	8
Development and construction	Impact on transport routes. Development of the DHN may cause disruption to key or busy routes and impact on traffic.	4	3	12	This pre-feasibility study has sought to minimise the probability of disruption by suggesting routes which, where possible, avoid transport infrastructure and/or use minor roads. Plan ahead to avoid disruption. The full feasibility study should look at this issue in further detail. As with other types of service maintenance/construction, actions may be taken to minimise the impact of disruption (such as carrying out works overnight).	3	1	3

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Development and construction	Impact on local residents, e.g. noise, visual impact	3	2	6	An acoustic survey has not been undertaken at this stage. The potential for noise impact has been discussed in the energy centre location appraisal. A full feasibility study should take into account the potential for noise impacts and seek to minimise these during the selection of a location for the energy centre.	2	1	2
Commercial	Temporary failure of plant or network elements leading to interruption of service to network customers (failure to meet contractually agreed service level).	2	3	6	Failures may result from errors in network design and errors in the assumptions made. The full feasibility study should examine and evaluate the assumptions made in this study. Procurement documentation should reflect this risk.	1	2	2
Commercial	Failure to attract a high uptake of customers willing to commit prior to or post construction and to accept long term contracts; failure to manage stakeholder expectations.	3	5	15	The potential networks identified in Warwick town centre and Leamington Spa Riverside area in this study are based around a number of public buildings, which reduces the likelihood of this risk. Where potential commercial/non-Council customers are the majority (as for the Myton network), a full feasibility study must carry out market testing and sensitivity analyses to consider the likelihood and impact of this issue.	2	2	4
Commercial	'Pull out' by investors or key customers.	2	5	10	Further studies should include sensitivity analyses showing the impact of loss of capital or key customers. Contracts should be in place prior to key development stages.	2	4	8

CONCLUSIONS

11

CONCLUSIONS AND RECOMMENDATIONS

The aim of this study was to identify and assess the key opportunities and constraints for delivering district heating across Warwick District, with a focus on the urban areas of Warwick, Leamington Spa, Whitnash and Kenilworth, in order to identify clusters of buildings that might support the development of heat networks.

Indicative network designs were developed for the heat clusters, to assess potential capital costs, financial outcomes and carbon savings from networks in those areas. A summary of the results of the economic assessments is shown in Table 27.

The best-case indicative 40 year IRRs based on the indicative networks assessed and assumptions taken (using a 6% discount rate) were calculated at 6.1% for Warwick Town Centre, 9.4% for Myton, 3.3% for Leamington Spa Riverside, 11.1% for Whitnash and 3.4% for Lillington. As a general indication, IRRs of ≥6% are normally required to attract public financing, while IRRs of ≥10% would be required to attract private investment.

Technology option	Capital cost	25 year IRR	25 year NPV	25 year average CO_2 savings	40 year IRR	40 year NPV	40 year average CO_2 savings
Warwick Town Centre							
Gas CHP	£3,585,700	-	-£2,154,418	30	-	-£2,014,891	-19
Gas CHP with private wire	£3,585,700	4.2%	-£403,200	30	6.1%	£80,200	-19
Biomass	£3,551,900	-	-£1,837,500	711	-	-£1,946,700	695
Biomass with Gas CHP and private wire	£3,810,700	-	-£1,718,300	644	-	-£1,765,100	617
Myton							
Gas CHP without private wire	£13,415,200	3.7%	-£1,840,600	719	5.6%	-£352,200	383
Gas CHP with private wire	£13,415,200	6.8%	£1,151,100	719	8.3%	£3,265,400	383
Biomass	£15,360,100	-	-£4,780,600	5098	-	-£5,033,200	4987
WSHP	£13,560,600	9.5%	£2,423,500	3036	9.4%	£2,665,700	2938
Leamington Spa Riverside							
Gas CHP (excl. new Council offices)	£3,847,700	0.8%	-£1,248,400	175	3.3%	-£939,300	97
Biomass (excl. new Council offices)	£3,929,300	-	-£1,099,200	1098	-	-£1,164,400	1072
Gas CHP (incl. new Council offices with private wire)	£4,484,700	-	-£2,084,400	132	1.2%	-£1,834,400	49
Biomass and gas CHP (incl. new Council offices with private wire)	£4,953,100	-	-£1,557,900	917	-	-£1,575,300	818

Technology option	Capital cost	25 year IRR	25 year NPV	25 year average CO_2 savings	40 year IRR	40 year NPV	40 year average CO_2 savings
Whitnash							
Gas CHP	£5,709,700	0.4%	-£2,048,200	89	3.2%	-£1,542,900	21
Gas CHP with private wire	£5,709,700	10.0%	£2,055,500	89	11.1%	£3,367,500	21
Biomass with gas CHP and private wire	£6,122,900	-2.1%	-£2,522,500	587	0.3%	-£2,383,100	422
Lillington							
Biomass tower blocks only	£1,865,500	1.5%	-£405,000	561	1.6%	-£421,300	552
Biomass tower blocks and Red House Farm	£2,048,700	2.8%	-£337,100	706	3.4%	-£322,200	693

Table 27. Summary of economic analysis results.

More detailed consideration of the potential funding and delivery options could affect the IRRs through the identification of capital funding support or reduced discount rates.

The indirect benefits of heat networks should also be considered to add value to projects. These include:

- Reduced public and private spending on carbon taxes;
- Reductions in fuel poverty and improved energy affordability;
- Increased security of energy supply;
- Health benefits: reducing the risks of illness associated with living in inadequately heated homes;
- Local infrastructure improvements;
- Development of local skills, job creation and wider economic regeneration; and
- Facilitating local development.

Conclusions

Our heat mapping work, cluster analysis and subsequent indicative technical and financial assessments have indicated specific opportunities for developing heat networks within the District. In particular the analysis has indicated that the sites identified at Warwick town centre, Myton, Leamington Spa and Whitnash could potentially lead to the development of viable networks, with the first three sites showing sufficient potential to warrant further detailed investigations. An additional opportunity was identified in Lillington, but it was concluded that this area was more likely to be suitable for a standalone biomass installation than a district heat network at present.

Recommendations

Funding

This report has described a number of potential funding options for DHNs in Warwick District. Suitable funding opportunities should be investigated at the national, regional and local levels:

National:

- Heat Networks Delivery Unit
- Renewable Heat Incentive
- Contracts for Difference
- Enhanced Capital Allowances
- ERDF/DCLG Low Carbon Plus grants

Regional:

- Coventry and Warwickshire Local Enterprise Partnership European Structural and Investment Funds Strategy Coventry and Warwickshire Growth Hub "Access to Finance" and "Business Innovation"

Local:

- Local Authority prudential borrowing
- Community Infrastructure Levy

<u>*Delivery*</u>

Local authorities can drive delivery of DHNs by:

- Using planning policy to require new developments to contribute and/or connect to DHNs;
- Using LDOs to extend permitted development rights across whole local authority areas or to grant permission for certain types of development.
- Committing to connect its own buildings to a network in order to provide the anchor load for any scheme, and enter into a long-term energy contract to reduce levels of risk and help to attract investment from third-parties.
- Investigating opportunities for establishing an SPV and/or ESCO to deliver and manage DHNs.
- Nominating Council members, staff and/or other stakeholders to act as 'champions' and drive delivery of planned schemes.

The results of the analysis in this report provide a case for undertaking detailed feasibility studies for the Warwick Town Centre, Myton and Leamington Spa Riverside network opportunities.

The detailed feasibility studies will need to include a more detailed assessment of the heat demands for the buildings identified, assess different technology options and configurations and review scheme governance. Iterations of the network layout and buildings connected will be required to define the most optimal scheme and a detailed assessment of the pipe routing and energy centre location will be required.

The detailed feasibility studies will also need to include more comprehensive financial and commercial modelling to provide a more accurate indication of the capital costs and long term financial viability of the schemes.

The accuracy of these and other key variables will be of critical importance to reduce risks and provide confidence in the commercial and environmental viability of the projects.

A possible workflow for taking forward one or more district heating projects would be:

- Review results, conclusions and recommendations of this pre-feasibility study;
- Disseminate results and discuss with internal and external stakeholders;
- Build business case for undertaking further work on district heating;
- Apply for HNDU funding for full feasibility study;
- Review potential commercial structure and financing options;
- Decision on whether to move to procurement.
- Apply for HNDU capital funding for heat network infrastructure development.

APPENDICES

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APPENDIX 1: HEAT MAP DATA SOURCES AND CALCULATIONS

Category	Data layer	Source if actual	Source if benchmarked or modelled
Heat demand	Domestic heat demand density	(Actual gas consumption) 2013 DECC statistics on domestic gas consumption by LSOA	(Modelled heat demand) AECOM assumption of 75% efficient gas boiler
	Non-domestic heat demand density	(Actual gas consumption) 2013 DECC statistics on non-domestic gas consumption by MSOA	(Modelled heat demand) AECOM assumption of 75% efficient gas boiler
	Hospitals and hospices	Abbey Morris - NHS Sustainability Manager or ERIC database	Floor areas from building footprint and AECOM building-specific assumptions of heated floor area based on real world examples and CIBSE TM46
	Care homes	DEC	Floor areas from EPC or AECOM calculation of mean area per room based on real world examples and CIBSE TM46
	Public buildings	Council energy management database or DEC register	Floor areas from EPC or Floor areas from building footprint and CIBSE TM46
	Swimming pools	Council energy management database	n/a
	Schools	Council energy management database or DEC register	Floor areas from EPC or Floor areas from building footprint and AECOM building-specific assumptions of heated floor area based on real world examples and CIBSE TM46
	Commercial/industrial properties	n/a	Floor areas from EPC or Floor areas from building footprint and AECOM building-specific modelling or CIBSE TM46

	Industrial estates	n/a	Sum of benchmarked energy demands from individual properties within the estate.
	Hotels	DEC register	AECOM calculation of mean area per room based on real world examples and CIBSE TM46
	Social housing points	n/a	Sum of individual benchmarked energy demands from properties within a cluster of social housing.
Energy opportunities	Shallow geothermal	n/a	BGS 'Thermomap' data (based on climate, geology and lithology)
	Landfill gas and landfill sites	DECC renewable energy planning database June 2015 and Environment Agency landfill sites database	n/a
	CHP	DECC renewable energy planning database June 2015 and Personal communication from Abbey Morris - NHS Sustainability Manager and Personal communication from Council officers	n/a
	Biomass	DECC renewable energy planning database June 2015 and Personal communication from Council officers	n/a
	Solar PV	DECC renewable energy planning database June 2015	n/a
Future developments	Warwick District Council relocation sites	WDC planning application database	n/a
	Creative Quarter redevelopment	Council planning meeting notes and drawings	n/a
	Draft Local Plan allocations	Draft Local Plan document	n/a
Other	Fuel poverty	DECC LIHC statistics from 2013 (most recent)	n/a

APPENDIX 2: MODELLING INPUTS AND ASSUMPTIONS

Calculating IRR and NPV

The NPV (Net Present Value) is the profit or loss accrued by the project over the calculated lifetime (in this case, 25 or 40 years), taking into account the cost of borrowing over that period. The formula used to calculate NPV is:

$$NPV = \sum_{t=0}^{N} \frac{R_t}{(1+r)^t}$$

Where *N* = the total number of time periods (years), R_t = cashflow at year *t* and *r* = the discount rate (the cost of borrowing, in this study assumed at 6%).

The IRR (Internal Rate of Return) is the percentage return on the original investment over the calculated lifetime of the project (in this case, 30 years). If the IRR exceeds the cost of borrowing, the NPV will be positive.

Modelling inputs

Category	Input	Source
Network costs	Year investment commences	Assumed 2016
	Year network becomes operational	Assumed 2017
	Cost per metre of network pipework	Averaged quotes from network installers
	Capital cost per sqm energy centre	Based on AECOM experience of previous projects
	Capex of gas CHP per kW	Averaged quotes from installers
	Opex of gas CHP	Spon's Mechanical and Electrical Services Price Book 2016
	Lifetime of gas CHP plant	
	Capex of biomass per kW	
	Opex of biomass CHP	
	Lifetime of biomass plant	
	Capex of WSHP per kW	
	Opex of WSHP	
	Lifetime of WSHP	
Technology	Gas CHP annual availability	Based on AECOM experience of previous projects
	Biomass annual availability	Based on AECOM experience of previous projects
	WSHP COP	Based on AECOM experience of previous projects
Energy prices	Retail prices of electricity and gas by sector	DECC 2015: Prices of fuels purchased by non-domestic consumers in the UK
	Export tariff for electricity sold to National Grid	Quotes from specialist energy brokers
	Tariff for heat sold on network	Assumed retail price with 10% discount
	Forward projections for retail prices of electricity and gas	DECC/IAG: 2014 energy and

		emissions projections: projections of greenhouse gas emissions and energy demand 2014 to 2030.
Carbon emissions	Grid electricity emissions factors	DECC/IAG: 2014 energy and emissions projections: projections of greenhouse gas emissions and energy demand 2014 to 2030. and DECC/LCP: Modelling the impacts of additional Gas CHP capacity in the GB electricity market
	Forward projections for grid electricity emissions factors	
	Natural gas emissions factor	