Derbyshire County Council – Heat Mapping and Energy Masterplanning

Derbyshire County Council

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Quality information

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Table of Contents

Figures

Tables

Notation

Abbreviations	Meaning
AQMAs	Air Quality Management Area
BEIS	Department of Business, Energy and Industrial Strategy (formerly DECC – see below)
BMS	Building Mangement System
CAPEX	Capital Expenditure
CHP	Combined Heat and Power
CIBSE	Chartered Institute of Building Services Engineers
CO_2	Carbon Dioxide
CSE	Centre for Sustainable Energy
D	Diversity factor
DC	District cooling
DCC	Derbyshire County Council
DCLG	Department for Communities and Local Government
DE	District Energy
DEC	Display Energy Certificates
DECC	Department of Energy and Climate Change
DHN	District Heating network
DHW	Domestic Hot Water
DIIP	Infrastructure Investment Plan
DoT	Department of Transport
DSM	Dynamic Simulation Modelling
EC	Energy Centre
EfW	Energy from Waste
FEE	Fabric Energy Efficiency
HIU	heat interface unit
HNCoP	Heat networks Code of Practice
HNDU	Heat Networks Delivery Unit
IAG	Inter Analysts Group
IRR	Internal Rates of Return
kWe	Kilowatt electric
kWth	Kilowatt thermal
MID	Measuring Instruments Directive
MWe	Megawatt electric
MWth	Megawatt thermal
NOx	Nitrogen Dioxide
NPPF	National Planning Policy Framework
NPV	Net Present Values
OPEX	Operational Expenditure
PHEX	Plate Heat Exchange
SAP	Standard Assessment Procedure
SCR	Selective Catalytic Reduction
UKPN	UK Power Networks

Executive Summary

This study investigates the feasibility of implementing district energy in Derbyshire County. District energy provides energy (typically heating), which is generated in an Energy Centre (EC), to identified buildings in the area through the distribution of hot (or cold) water in buried pipework. Derbyshire County Council has commissioned this report with a view to:

- reducing energy prices in the county;
- complying with environmental policies, such as carbon emission reduction targets;
- providing great energy security to residents and businesses in Derbyshire;
- providing the council with a potential source of revenue that it can use to support local services; and
- improving the local economy by creating employment opportunities and enabling local businesses to be part of the supply chain.

Initially, the heating, cooling and electrical requirements of existing and planned industrial, commercial and residential buildings in the county were assessed and illustrated on maps of the area. Added to these maps were also the existing and planned heat sources in Derbyshire, including Energy from Waste (EfW) plants, rivers and industrial waste heat.

Through a client workshop and an agreed scoring methodology, the maps generated were used to identify the three best opportunities for district heating in Derbyshire, which were deemed to be:

- **Clay Cross:** with heat imported from the planned 10MWth Clay Cross Energy Recovery Facility;
- **Matlock**: with around 4MWth of heat imported from the Enthoven and Sons Ltd battery recycling facility in Darley Dale; and
- **Chesterfield**: supplying Derbyshire's largest heating load, the Chesterfield and North Derbyshire Royal Hospital, as well as a number of other buildings in the town centre, with heat generated specifically for use in the district heating network (DHN).

Each network opportunity then underwent Energy Masterplanning, which sought to:

- Identify which of the existing and planned buildings in the area would be eligible for connection to the DHN
- Recommend suitable heat generation technologies (where applicable)
- Clarify information around the heat sources (where applicable)
- Carry out physical site surveys of the areas
- Determine potential pipework routing for networks
- Assess feasibility of energy centre locations
- Summarise the phasing requirements of networks

The designs were then used to inform the technical and economic modelling of each opportunity, to allow comparison of various scenarios and to cross compare between areas. Findings and concept designs were developed in line with the recommendations and methodology set out in the CIBSE Code of Practice for District Heating, CP1.

Clay Cross

Larkfleet Group has obtained planning consent for a 10MWth EfW facility in Clay Cross. However, due to uncertainties over the security of fuel supply, it was suggested by Larkfleet at an engagement meeting that the initial installation would be smaller, in the region of 4MWth. At the meeting, it was confirmed that the energy centre for a possible new district heating scheme could be hosted on the site of the facility. This energy centre would import heat and electricity from the EfW facility and redistribute heat to buildings in the area.

A total of 17.6MW of eligible heat load was identified between Clay Cross and Wingerworth, much of which is attributable to a number of large new proposed housing developments to the north of Clay Cross. The pipework routing developed is shown in Figure 0-1.

A number of scenarios were modelled, comprising different elements of the proposed network, to test which are the most beneficial financially and environmentally. Extending the network north into Wingerworth was not found to be financially viable. The lack of undulating terrain in the area is noted as a benefit as it mitigates risks around equipment operating pressures.

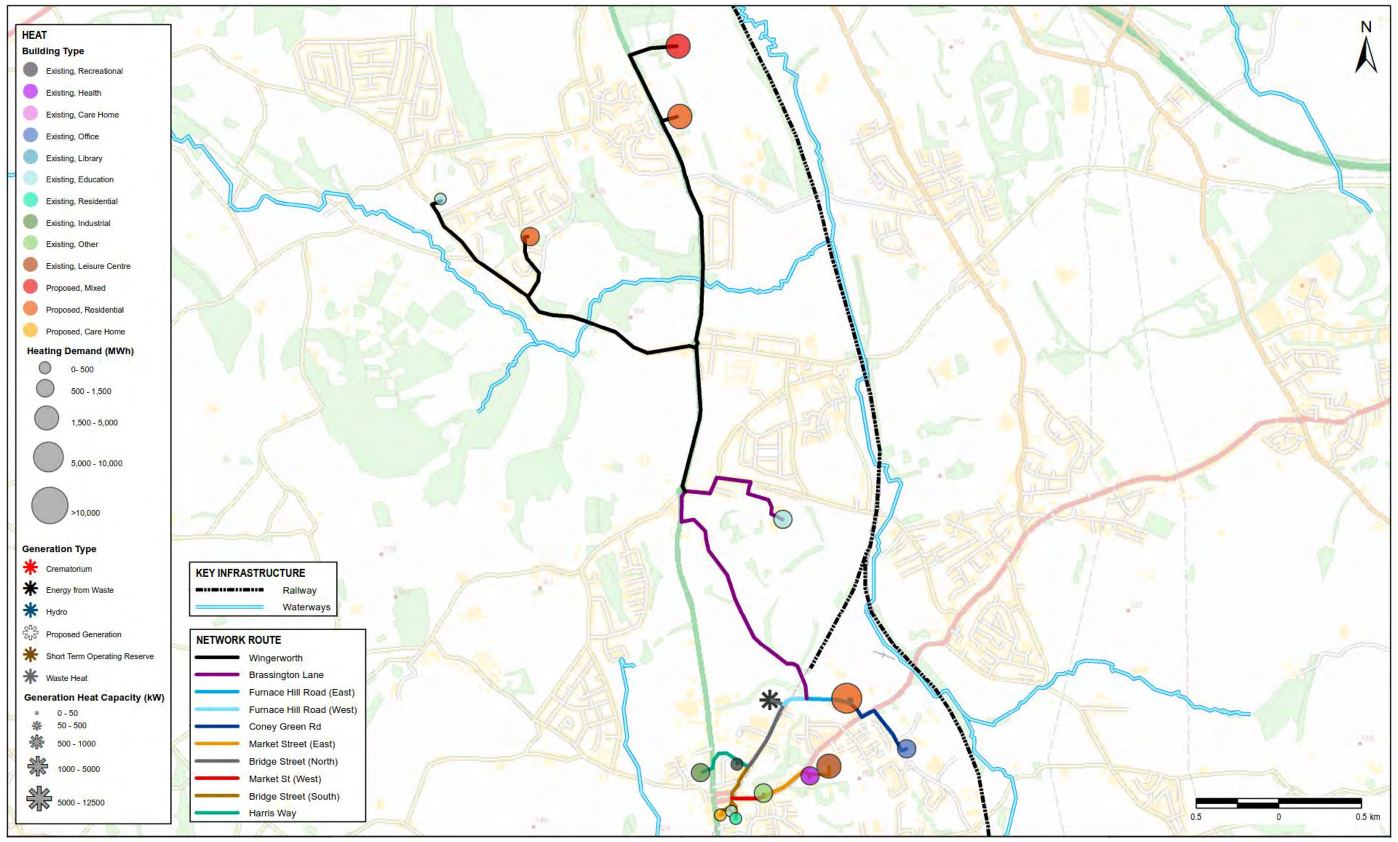


Figure 0-1 Clay Cross network

Matlock

A considerable amount of research has already been carried out into the feasibility of district heating in Matlock, specifically using low carbon waste heat that is currently being generated at the Enthoven battery recycling facility in Darley Dale. The plant operator has been working with a PhD student at Sheffield University to develop the idea. As part of this study, AECOM has engaged with Enthoven and reviewed the work done to date. A site survey of the facility was also carried out on 16th October 2017.

Around 4MW of heat at around 90°C could be recovered from the facility almost constantly – offering a significant source of zero carbon heat that would be otherwise rejected into the atmosphere. Matlock is around 4.5km from the Enthoven site, where around 11.2MW of heat loads eligible for connection to a DHN were identified. Figure 0-2 shows the proposed network routing for the Matlock opportunity. It is suggested that pipework is routed along the road in an attempt to mitigate the risks associated with crossing the railway. There may also be risks associated with the height difference between points around the network. Both these risks require further study. Enthoven expressed a willingness to host the energy centre on their site.

Of the scenarios tested in Matlock, those that present the greatest heating load overall were shown to perform best, due to the significant costs associated with the pipework run between Darley Dale and Matlock.

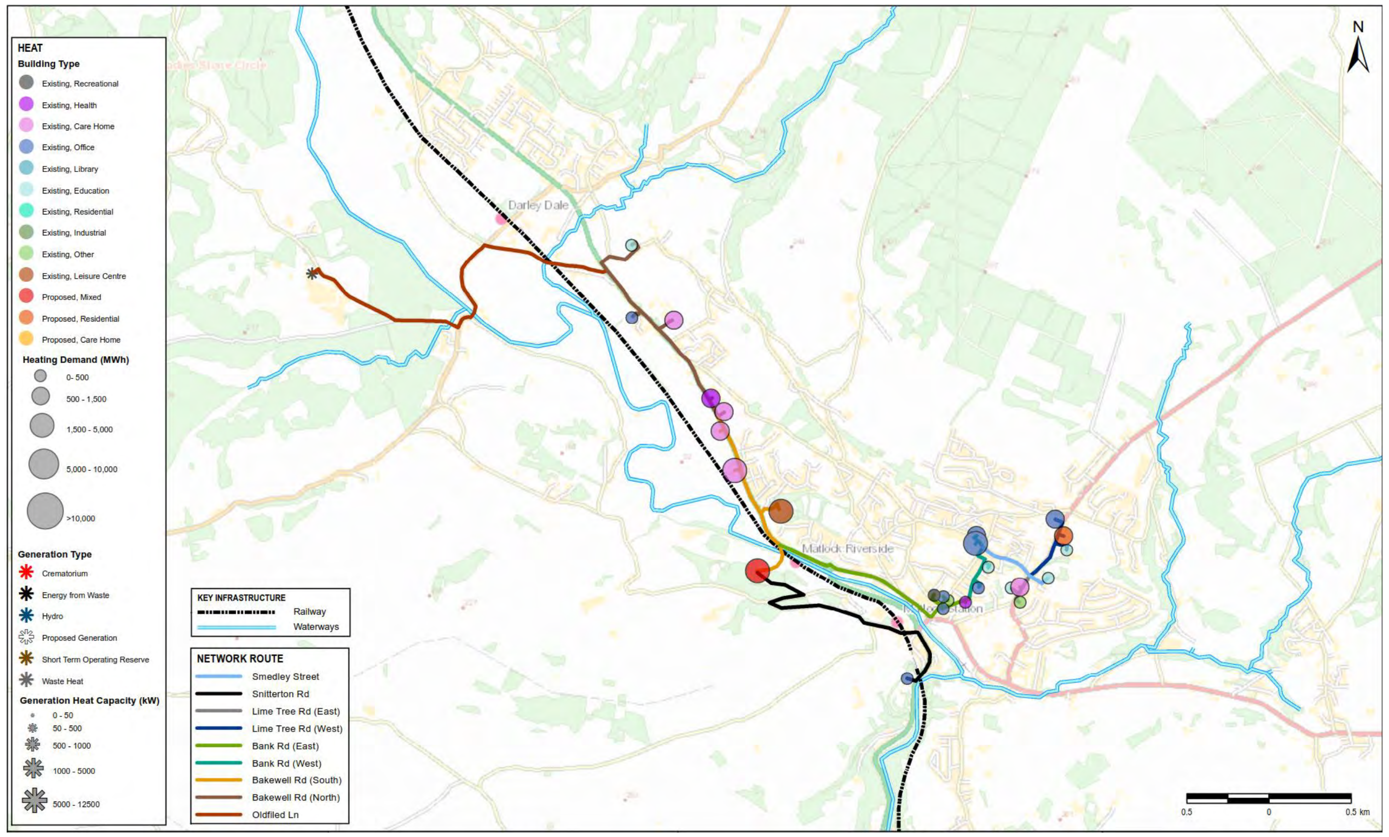


Figure 0-2 Matlock network

Chesterfield

No existing or planned sources of heat were identified in Chesterfield; instead heat must be generated on site. Using a multi-criteria scoring approach, gas combined heat and power (CHP) was identified as the most suitable heat generation technology currently. Considering the future projected decarbonisation of the UK's electricity grid and the associated policy and regulatory pressure to move away from combustion based technologies, a path to low carbon heat generation for Chesterfield is likely to include water source heat pumps and heat recovered from industry.

The network in Chesterfield contains Derbyshire's largest heat load, the Chesterfield and North Derbyshire Royal Hospital. No engagement was possible with the hospital as part of this study – a key risk area that should be addressed if DCC pursue this opportunity. It was postulated that the EC be located in close proximity to the hospital; no exact location was identified. Figure 0-3 shows the indicative network routing.

Whilst the scenario that contained only the hospital was shown to perform best financially, it also delivers the least carbon emission savings and benefits to public buildings over the other scenarios that include the town centre. Other scenarios considered for the Chesterfield should therefore be considered.

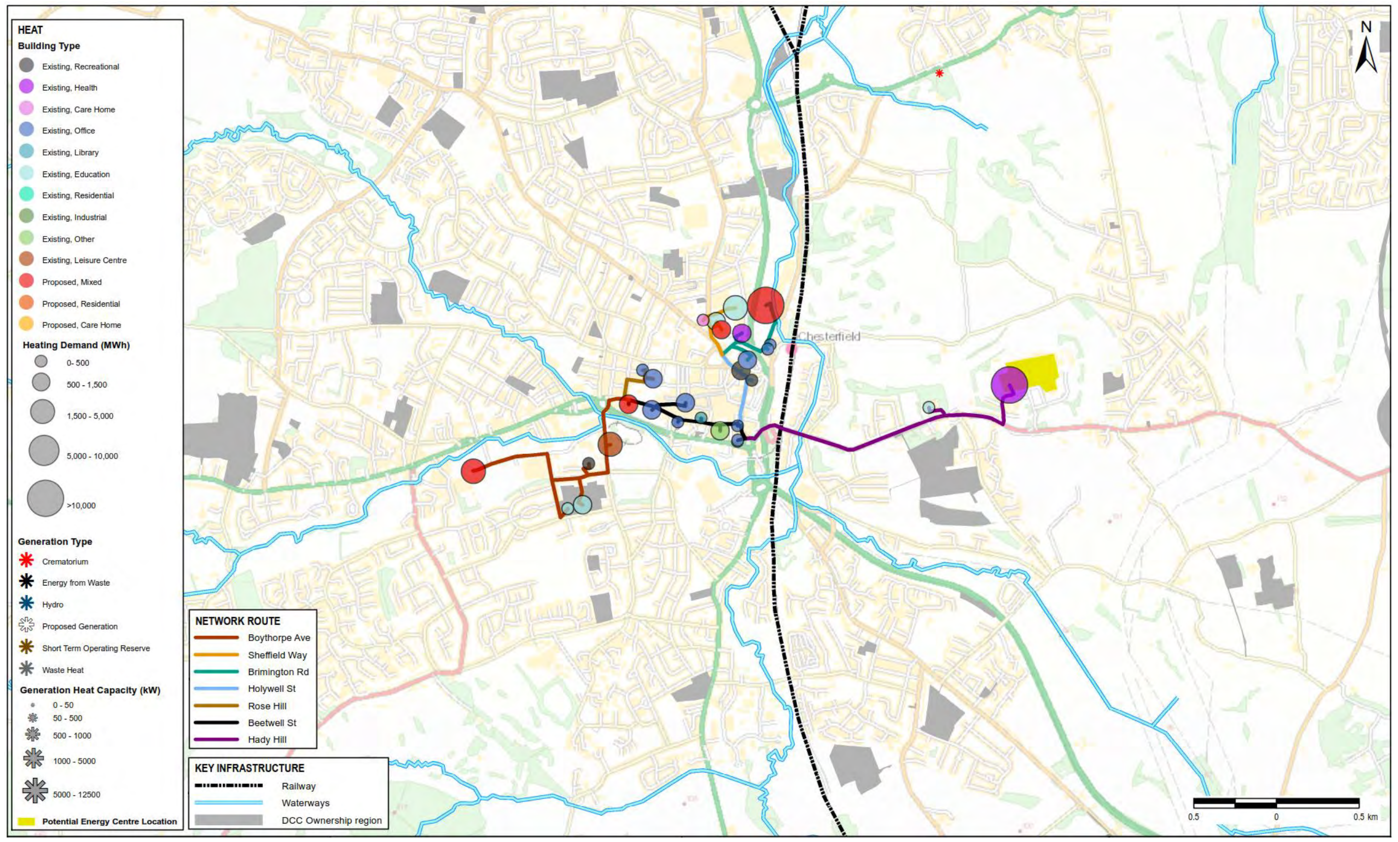


Figure 0-3 Chesterfield network

Results

Network scenarios for each opportunity were modelled in a bespoke techno-economic model, which allows users to select various key parameters in the installation and operation of a network, such as:

- Buildings to be connected
- Plant sizing and network distribution losses
- Heat, gas and electricity sale/purchase prices
- Customer network connection costs and standing charges
- Discount rate

Derbyshire would benefit from implementing many of the network scenarios investigated as part of this study. Some opportunities represent good value for money, whilst others deliver good carbon emissions savings or other environmental benefits such as improving air quality. In all cases, networks have been financially modelled to ensure that savings would be realised by a customer who connects to the network.

Table 0-1 shows the high level results summary of the best scenarios[1] found in each of the three network opportunities modelled. In Clay Cross, the CAPEX values are associated with the network and energy centre only, including a plate heat exchanger that allows for heat import. All EfW plant costs are assumed to be borne by Larkfleet Energy. In Matlock, Enthoven plant upgrade costs are assumed to be borne by the network operator, in order to reduce the cost of heat and maximise financial returns.

Table 0-1: Overall results summary

Network	Scenario	EC thermal output capacity, MW	Total pipework length, m	CAPEX, £	40 yr cumulative carbon savings, tCO_2e	40 yr IRR, %	40 yr NPV, £
Clay Cross	4	8	1,660	8.6m	64,900	8.9	6.7m
Matlock	6	10	9,021	17.9m	154,200	3.8	1.0m
Chesterfield	6	23	5,891	31.9m	70,200	11.2	31.5m

Clay Cross is the smallest network, making it the least risky in terms of ensuring customers connect and that pipework routes are possible. It delivers good carbon savings for the investment of only £8.6M, a fraction of the cost of the Chesterfield network. With a 40 year IRR of 8.9% it represents an investment opportunity that may begin to attract private investment. There are risks around the EfW facility and the actual installed capacity. At the time of writing Larkfleet group were intending to install 4MWth initially; continued engagement will be necessary to ensure the risk of this being reduced or abandoned is managed.

Whilst Matlock offers the greatest savings to carbon emissions, it is the poorest performer financially. This is largely due to the large capital costs associated with the 9km of pipework necessary to serve the network. The network only includes 10MW of thermal generation plant, but is costed at £17.9m. However, the sensitivity analysis showed that IRRs of 7.0% would be achievable with a capital grant of 30% of the CAPEX. Schemes such as the UK Government's HNIP funding stream (where capital grants are made available for heat networks that meet certain requirements) could be investigated.

Chesterfield shows the best rates of return on investment, but with the highest capital expenditure at £31.9M. Engagement with the hospital is necessary to mitigate the risks around this network. There are a number of public buildings located in Chesterfield, meaning this option would provide the most financial benefit to the council and other public bodies. The carbon emissions savings offered in Chesterfield are under half that of the Matlock network.

[1] In Chesterfield, the chosen 'best' scenario is not the scenario that provides the highest IRR and NPV, rather it is a scenario that provides good financial returns *as well as* additional benefits such as a reduction in operating costs for public buildings and significant carbon emissions savings.

Recommendations and Next Steps

In summary, all three networks identified present viable opportunities for district heating in Derbyshire:

- **Clay Cross:** Reliant on the Clay Cross Energy Recovery Facility going ahead, and with the same installed generation capacity as detailed in this report.
- **Matlock:** If DCC can secure a capital grant of c. £6m to support the costs of implementation.
- **Chesterfield:** Particularly if the Chesterfield and North Derbyshire Royal hospital is found to be interested in switching its heating supply and is positive about hosting an energy centre on or near the site.

It is recommended that Derbyshire County Council pursues the above key uncertainties as it decides which of the networks to pursue further. Continued engagement with Lark Energy, the HNDU and the hospital would help inform the council whether the individual scenarios for each network are achievable.

Table 0-2 shows the project development process for HNDU funded projects. This study has incorporated Stages 1, 2 and parts of 3, up to the end of detailed techno-economic modelling. Should DCC choose to proceed with any of the network opportunities identified herein, further funding for the stages below can be applied for with the HNDU to develop those opportunities. Proceeding to the next phase of project development would not commit DCC to implementing district heating in Derbyshire, rather it would provide the council with better certainty of the feasibility of DH in the county.

Table 0-2: HNDU Stages of work[2]

HNDU Stage	Detail
1. Heat Mapping	Area-wide exploration, identification and prioritisation of heat network project opportunities.
2. Energy Masterplanning	Area-wide exploration, identification and prioritisation of heat network project opportunities.
3. Feasibility Study	Technical feasibility and options appraisal; scheme definition and concept design; detailed techno-economic modelling; development of financial model; initial scheme specific business model/commercial structures options identification & evaluation; delivery programme.
4. Detailed project development	Development of business/commercial model and financing options; development of business case; further development of detailed financial model; development of procurement strategy; further scheme design including development of proposed network route, network sizes, and customer connections, development of proposed energy centre solution and location; costing reviews to improve cost certainty; initial scoping and development of commercial agreements; soft market testing.
5. Commercialisation	Reasonable legal costs such as in relation to developing customer commercial agreements, heat supply contracts, necessary land purchase, land access arrangements, etc.; further development of tariff structure for customer contracts; further development of financial model and business case and associated commercial advice costs where necessary.

[2] HNDU Round 7: Overview https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/645081/R7_HNDU_overview__1_.pdf

1. Introduction

AECOM has been commissioned by the Derbyshire County Council (DCC) to undertake an energy mapping and energy master planning study to identify key opportunities for decentralised heat and power schemes within Derbyshire County. As part of this work, network opportunities have been technically and commercially assessed with a view to identifying the most viable solution.

1.1 Background to Study

The area of study is Derbyshire, a county in the East Midlands. This extends across a number of districts: High Peak; Derbyshire Dales; South Derbyshire; Erewash; Amber Valley; North East Derbyshire; Chesterfield; and Bolsover. The total population of the county is circa 786,000 people and it is a key area for housing, employment, retail and community services and supports opportunities for further sustainable development and economic growth.

Derbyshire County red-line boundary is illustrated within Figure 1-1 below.

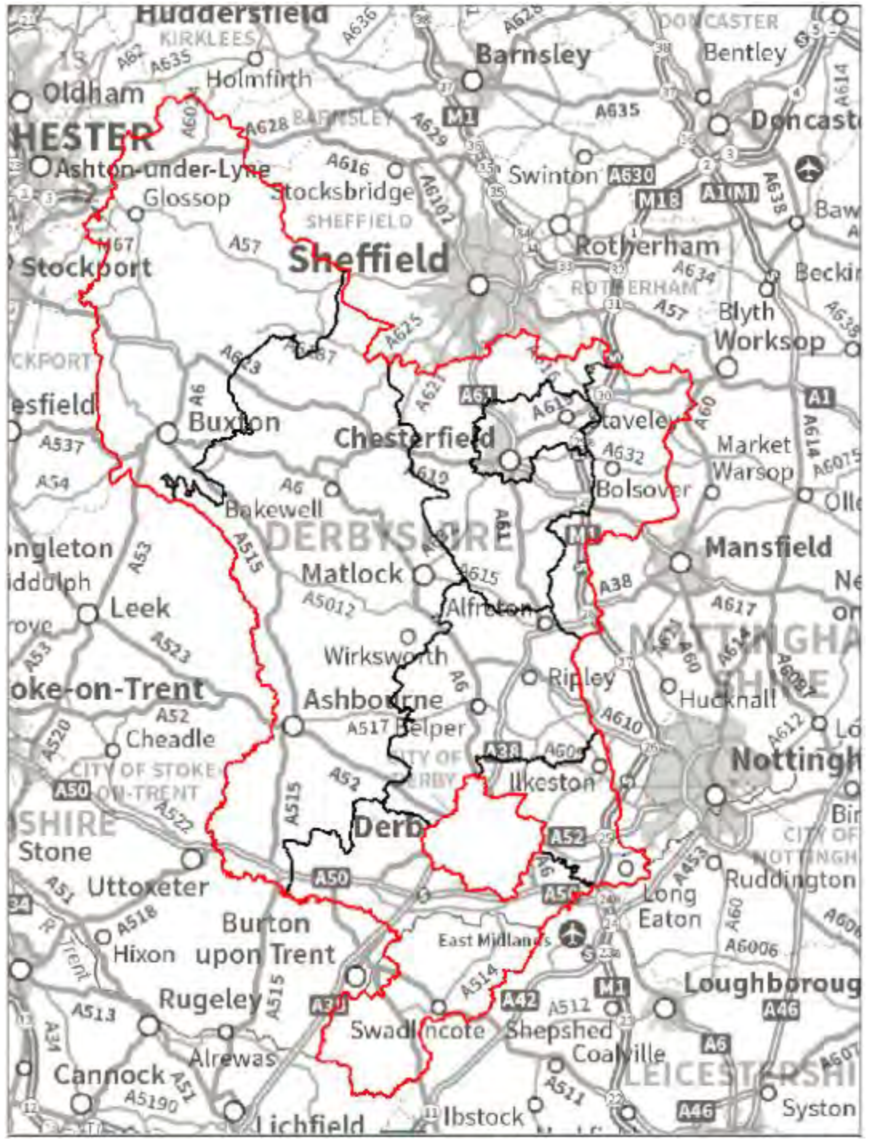


Figure 1-1 Red-line boundary[3]

1.2 Aim

The purpose of this study is to assess the technical and commercial feasibility of district energy networks in Derbyshire County. By developing local heat networks, DCC will have the opportunity to deliver greener solutions to heating buildings, tackle fuel poverty and mitigate the impact of climate change through the reduction of carbon emissions.

The benefits from such heating networks, as detailed below, also align with the pledges of the Derbyshire County Council Plan 2014-2017[4].

- **Reduction in energy prices –** increased efficiencies and economies of scale can lead to reduced energy costs for customers. This can mean improved competitiveness for local businesses, reduced energy bills and subsequent alleviation of fuel poverty in households. Reduced energy prices will particularly help the more vulnerable members of communities, supporting the pledge of **'a Derbyshire that cares'**.
- **Compliance with environmental policies –** heat networks have the potential to deliver CO_2 reductions, especially when they use alternative forms of energy generation. This could be an opportunity for the Council to meet its environmental policies whilst improving the health of their citizens, promoting **'a healthy Derbyshire'.**
- **Energy security –** the higher plant efficiencies and Energy Centre resilience, combined with alternative forms of energy generation increases energy security and reduces reliance on fossil fuels, helping to deliver **'a safer Derbyshire'.**
- **Local dividends –** profits from the sale of energy from district heating networks can accrue to local authorities, communities, and/or businesses, rather than to national or international businesses. This enables the profit to remain within the county, supporting **'a local Derbyshire'** outlook.
- **Local economy –** the construction and operation of a network can create employment and opportunities for local businesses to be involved in the supply chain, driving growth in the area and fulfilling **'a Derbyshire that works'**.

1.3 Methodology

The methodology developed to undertake this study is summarised below. This is in line with CIBSE/ADE CP1 Heat Networks: Code of Practice for the UK. A visual presentation of the methodology of the study herein is presented in Figure 1-2. A more detailed methodology will be presented in the relevant sections of this report.

1. **Data Collection:** Data collection was undertaken to identify the heating, cooling and power requirements of the existing and planned buildings within the red-line boundary. This built upon Local Planning Area heat maps previously commissioned by East Midlands Council and used a number of sources to establish load quanta, including collecting energy consumption data, based either on industry recognised benchmarks or record data provided by DCC. A heat consumption threshold was applied in order to omit smaller buildings, leaving only the most suitable for connection to a district energy network for further analysis.
2. **Energy Mapping:** Using this annual load analysis, energy maps were produced, illustrating the size and location of the key heating, cooling and power loads with Derbyshire County.
3. **Energy Masterplanning:** Heat maps enabled the buildings and the associated areas deemed to be particularly suitable for an energy network to be identified, by considering a number of criteria (e.g. heat demand density, annual heat consumption, the presence of anchor loads, physical constraints, etc.).
4. **Identify Network Opportunities**: Optioneering of potential network opportunities was carried out, taking into account the main barriers and load priorities, in addition to considering coordination with existing energy utilities.
5. **Analysis of Technology Opportunities:** A high level review of potential low carbon technologies was carried out by assessing their suitability for use against deliverability, environmental, financial and technical criteria.

[3] Appendix B Specification: CTP 847 Heat Mapping and Energy Masterplanning, Derbyshire County Council

[4] http://www.derbyshire.gov.uk/images/DCC%20Council%20Plan%202014-2017_tcm44-247338.pdf

6. **Network Development-Technical Evaluation:** A high-level technical evaluation was undertaken for the network options identified, in order to make initial technical recommendations based on cost, energy and carbon performance metrics.

7. **Network Development-Economic Assessment:** A high-level financial analysis was further undertaken providing a discounted cash flow analysis, Net Present Values (NPV) and Internal Rates of Return (IRR) for each network option over 25 and 40 year project lifetimes.

8. **Recommendations:** Recommendations for the most technically and commercially viable network options were made.

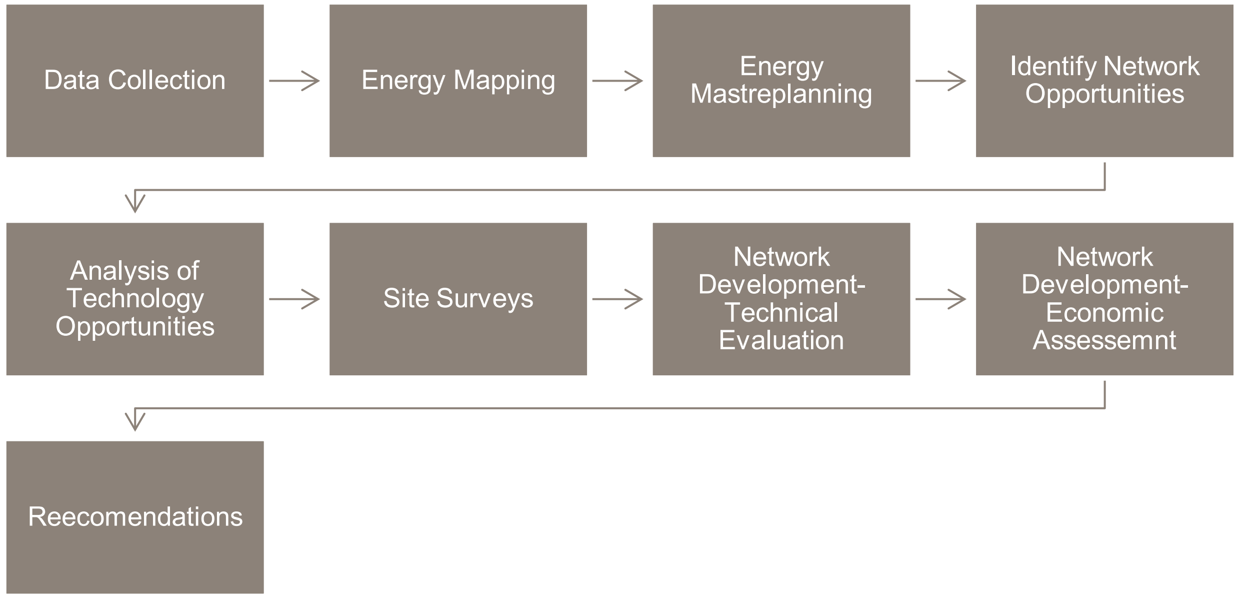


Figure 1-2 Methodology

2. Policy Context

The key policies relating to reductions in CO_2 emissions and the development of district heat networks are summarised below. This discussion is intended to provide an overview of relevant legislation and policies, thereby providing a contextual background to the study.

2.1 National Policy

Below illustrates a timeline of policies that have been implemented by the Government with respect to improving the efficiency of the built environment in order to combat global warming and climate change.

Our Energy Future – Creating a Low Carbon Economy, 2003 sets a target for 10% of electricity to be produced from renewable sources nationally by 2010 and twice this by 2020, with a 60% reduction in CO_2 emissions by 2050.

Climate Change and Sustainable Energy Act, 2006 enhances the contribution of the UK to combating climate change, alleviating fuel poverty and securing a diverse and viable long-term energy supply. The Climate Change and Sustainable Energy Act 2006 supports schemes whose purpose or effect is the promotion of community energy projects.

The Department for Communities and Local Government (DCLG)'s 'Building A Greener Future - Towards Zero Carbon Development', 2006 demonstrates the step change required in the Building Regulations to achieve zero carbon housing. District heating is recognised as a means to provide low or zero carbon energy to a development.

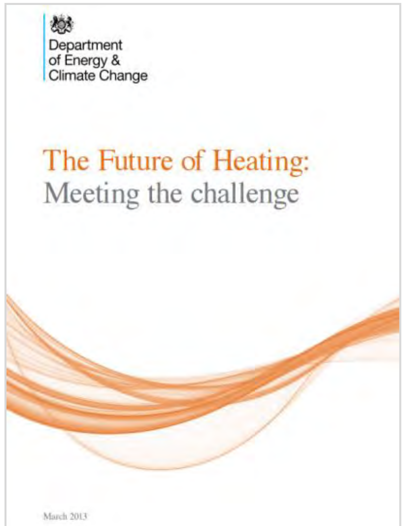
The Department of Transport (DoT) and Industry White Paper entitled 'Meeting the Energy Challenge', 2007 sets out UK energy strategy, recognising the need to tackle climate change and energy security by encouraging energy savings and supporting low carbon technologies.

The Climate Change Act, 2008 sets up a framework for the UK to achieve its long-term goals of reducing greenhouse gas emissions by 34% over the 1990s baseline by 2020 and by 80% by 2050 and to ensure steps are taken towards adapting to the impact of climate change. The Act introduces a market system of carbon budgeting which constrains the total amount of emissions in a given time period, and sets out a procedure for assessing the risks of the impact of climate change for the UK, and a requirement for the Government to develop an adaptation programme.

The Planning and Energy Act, 2008 enables local planning authorities to set requirements and targets for energy use and energy efficiency in local plans.

The Carbon Plan, 2011 sets out the Government's plans for achieving the emissions reductions committed to in the Climate Change Act, 2008, on a pathway consistent with meeting the 2050 target. This publication brings together the Government's strategy to curb greenhouse gas emissions and deliver on climate change targets, as well as updating actions and milestones for the following five years.

The National Planning Policy Framework (NPPF), 2012 sets out the Government's planning policies for England and how these are expected to be applied. The NPPF must be taken into account in the preparation of local and neighbourhood plans, and is a material consideration in planning decisions. 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 Energy Act, 2013 makes a provision for the setting of a decarbonisation target range and duties in relation to it, and for the reforming of the electricity market for purposes of encouraging low carbon electricity generation and ensuring security of supply.

The Future of Heating: Meeting the challenge, 2013 sets out pathways for the transition to a low carbon heat supply. It sets out Department of Energy and Climate Change (DECC)[5] commitments to support local authorities in the development of heat networks in their areas through the establishment of a Heat Networks Delivery Unit (HNDU), 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% (or more) 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-fired Combined Heat and Power (CHP).

The Deregulation Act, 2015 reduces the legislative and regulatory burdens and repeals legislation that no longer has practical use. With regard to energy, the Deregulation Act 2015 states that local planning authorities can no longer require that developments in their area meet higher energy efficiency standards than are required by building regulations. At the time of writing, this legislation has not yet been enacted.

The Productivity Plan, Fixing the Foundations: Creating a More Prosperous Nation, 2015 indicates that the Government does not intend to precede with the zero carbon Allowable Solutions carbon offsetting scheme, or the proposed 2016 increase in on-site energy efficiency standards via the Building Regulations. It will, however, keep energy efficiency standards under review, recognising that existing measures to increase energy efficiency of new buildings should be allowed time to become established.

2.2 Local Policy

At a local level, all authorities within Derbyshire County are committed to combatting climate change and protecting the environment though carbon reduction efforts in both new and existing developments. This includes requirements for quality, energy efficient design, generation from renewable energy sources and the implementation of community heating networks. Related policies can be found in the following documents:

- Derbyshire County Council Plan (adopted in 2014)
- Erewash Core strategy (adopted in 2014)
- Matlock Town Centre Supplementary Planning Document (adopted November 2008)
- High Peak Local Plan (adopted in 2016)
- Chesterfield Local plan (adopted in 2013) and Emerging Chesterfield Local plan
- Emerging Amber Valley Borough Local Plan.
- Emerging Bolsover District Council Local Plan
- Emerging Derbyshire Dales Local Plan 2017-2033
- Emerging North East Derbyshire Local Plan 2011-2033
- Emerging South Derbyshire Local Plan

[5] From July 2016, Department of Energy & Climate Change became part of Department for Business, Energy & Industrial Strategy

3. Stakeholder Engagement

AECOM engaged frequently with both DCC and other relevant stakeholders to obtain detailed information on development opportunities for District Heating in Derbyshire. The following hierarchy of communication was used for stakeholder engagement:

1. Meetings (where applicable)
2. Phone calls
3. Emails

Proper engagement is essential to ensure stakeholders:

- are aware of the project the council is running
- understand the implications (benefits or otherwise) of having a district energy network in the area
- understand the implications to their plant/facilities if the district network is being supplied heat via a third party supplier (e.g. an Energy from Waste (EfW) plant)
- understand the benefits a district energy network can bring to the environment, potential heat suppliers and customers
- are made aware of construction and phasing implications in their area

Table 3-1 provides a summary of the engagement and outcome of these various discussions.

Table 3-1: Engagement Schedule

Meeting	Summary of engagement	AECOM attendees	DCC attendees	Other attendees
Client Inception (12/07/2017)	Data and information gathering, reviewing DCC aims and objectives, setting the project boundary and agreeing timescales.	[redacted]	[redacted]	[redacted] - BEIS
Mapping Workshop (01/09/2017)	Presenting the findings of the energy mapping phase of the study. Shortlisting the identified building clusters that may be viable for district heating for further investigation.	[redacted]	[redacted]	
Enthoven Battery Overview (28/09/2017)	Ian Brocklebank is currently undertaking a PhD at the University of Sheffield, looking at the application of heat recovery for district heating at the Enthoven site. This meeting was arranged to review his work to date.	[redacted]		[redacted] – PhD student, University of Sheffield
Enthoven Site Visit (16/10/2017)	Meeting with Enthoven process engineers. Assessing Enthoven requirements, aims and drivers. Site tour of facility, survey of the heat rejection plant. Providing overview of study.	[redacted]		[redacted] Process Engineer, Enthoven
Clay Cross EfW (16/10/2017)	Meeting with the Clay Cross EfW developers. Establishing timescales, understanding plant parameters and developer's drivers and aims. Providing overview of study.	[redacted]	[redacted]	[redacted] – Lark Energy [redacted]– Lark energy
Final project presentation (30/01/2018)	Present the final findings of the study to DCC. Collate comments from both the HNDU and DCC in order to inform necessary changes to draft report for inclusion in final.	[redacted]	[redacted]	

4. District Energy Overview

The standard approach to providing energy to buildings in the UK is relatively inefficient. Heat and cooling is usually generated at a building scale typically with gas boilers for heating and chillers or air conditioners for cooling, limiting the use of low and zero carbon technologies. Electricity is usually generated at power stations that are remote from the point of use, leading to inefficiencies from wasted heat produced in the generation process and the losses associated with transmission.

District Energy (DE) offers an alternative to this arrangement, generating and distributing heat and /or cooling to a number of buildings in an area and, depending on the generation equipment, also producing electricity locally. Generation plant, which is located in a centralised location, generates hot water and /or chilled water which is then distributed via underground pipework to the connected buildings.

DE schemes range in size from simply linking two buildings together, to spanning entire cities. Benefits include:

- **Emissions reductions in hard-to-treat buildings –** where retrofitting fabric improvements to existing stock is challenging (e.g. for listed or critical buildings), DE provides an alternative method by which to reduce CO_2 emissions.
- **Reduced environmental taxes –** certain policies place a financial value on CO_2 emissions, meaning a reduction in emissions also provides financial benefit. It is expected that the effect of such policies may increase in future as the pressure to reduce emissions increases.
- **Reduction in energy prices –** increased efficiencies and economies of scale 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 in households.
- **Energy security –** the higher plant efficiencies and in-built resilience, combined with alternative forms of energy generation increases energy security and reduces reliance on fossil fuels.
- **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 energy projects from the public sector.
- **Local dividends –** profits from the sale of energy from DE networks can accrue to local authorities, communities, and/or businesses, rather than to national or international businesses.
- **Local economy –** the construction and operation of a network can create employment and opportunities for local businesses to be involved in the supply chain.

4.1 District Heating

District heating (DH) is the distribution of thermal energy (Low Temperature Hot Water (LTHW)) from a central source to a number of different buildings where it is used to provide space heating and hot water.

Where buildings have conventional wet heating systems, connection to district heating can be straightforward. Potentially only minor changes to the building’s secondary side distribution systems are necessary; the existing boiler could be removed or decommissioned and replaced with a heat interface unit (HIU) which transfers heat from the DH network (DHN) to the local building distribution system. Compatible temperatures and operating regimes however do need to be established.

The following heat generation technologies can be applicable to district heating, depending on the location in question:

- Gas fired combined heat and power (CHP)
- Biomass or biofuel fired CHP
- Energy from waste
- Anaerobic digestion
- Biomass and biofuel boilers
- Deep geothermal
- Air, water and ground source heat pumps
- Solar thermal

The choice of heat generating technology that is employed in a network depends on a number of technical, financial, environmental and deliverability factors, as described in Section 7.

Areas with large concentrated heat loads present significant opportunities for the installation of a DHN. High heat density areas are made up by groups of buildings and/or a single, or collection of anchor load(s). ‘Anchor’ heat loads are deemed to be buildings (or a group of buildings in an estate, e.g. hospital) that comply with one or more of the following criteria:

- Buildings with a high level of heat consumption (e.g. hospitals and care homes);
- Buildings with a stable, constant and predictable level of year-round heat consumption (e.g. swimming pools); and
- Buildings over which the Council has a high degree of control or influence to support the connection to a DHN (e.g. the County Hall in Matlock), since it is often easier to secure customers for a DHN if there is consent from related institutions.

Initial heat mapping exercises and feasibility studies can reveal particularly dense areas of heat demand which may be considered as heat network strategic development areas.

4.2 District Cooling

District cooling (DC) is distributed in the form of chilled water through a network of insulated pipes to different buildings to supply demand for cooling. Chilled water (typically 6°C flow/12°C return) is used in central cooling units such as air handling units, or in local units such as fan coil units or chilled beams. Chilled water can be generated in different ways: through conventional electrically-driven vapour compression chillers; or via absorption (i.e. heat-driven) chillers. Both of these could be utilised in providing DC services.

5. Energy Mapping

5.1 Energy Demand Mapping

Initially, a high level analysis was undertaken to determine the key existing and future buildings in Derbyshire that could be considered suitable for a DE scheme. In order to incorporate the most appropriate energy data for the study, a number of sources were considered. These sources and assumptions made have been briefly described in the sections to follow.

5.1.1 Existing Developments

Data on the quantum and type of existing developments was acquired from the following sources:

- A list of public buildings provided by Derbyshire County Council
- A list of social housing addresses provided by Derbyshire County Council
- National Heat Map data provided by the Centre for Sustainable Energy (CSE)

A list of sites was compiled including all developments identified from the above sources. The list was narrowed down to only include buildings with a thermal demand higher than 100MWh, since AECOM experience shows that only larger developments are viable for connection to DE networks. These buildings typically fall in the following categories:

- Large residential schemes
- Offices
- Hospitals
- Hotels
- Schools, colleges and universities
- Industrial sites
- Community centre
- Leisure centre/Health clubs
- Libraries
- Museums

Heating, cooling and electrical energy consumption figures were estimated using the following source hierarchy:

- Actual metered energy data for existing sites (half hourly, monthly, annually);
- Fiscal data for existing sites (monthly, quarterly, annually);
- Display Energy Certificates (DEC) (annual data);
- Benchmarks:
    - CIBSE Guide F ‘Energy Efficiency in Buildings’ (Third Edition, May 2012); and
    - Building Regulations approved software modelling experience from AECOM projects.

Depending on the nature, class and condition of the building, a combination of the above methodologies may be suitable. CIBSE Guide F[6] is a widely recognised industry standard document on energy efficiency in buildings which includes energy consumption benchmarks for fossil fuel and electricity uses. Although the benchmarks are considered outdated and tend to overestimate energy consumption in new buildings, they still form the most extensively accepted benchmarks in the industry and are more applicable to existing buildings. Fossil fuel uses were converted to heating consumption using an assumed boiler efficiency of 86% and removing any gas uses attributed to cooking (which is not an appropriate end use for district heating).

Cooling and electricity consumption was also estimated from CIBSE Guide F. Following the review of a wide range of industry standards including Energy Consumption Guides, CIBSE TM22[7] and BSRIA Rules of Thumb[8], it was found that cooling benchmarks only exist for Offices and Retail building types. It is assumed that other building types do not have a demand for cooling in Derbyshire.

5.1.2 Future Developments

A thorough investigation was carried out in order to identify developments currently in planning. The Derbyshire Infrastructure Investment Plan (DIIP) list was used to identify new developments offering over 100MWh of heat consumption annually. A list of planning applications in each district/borough council was also provided; AECOM engaged with the council to determine which of them were to be included in the study.

For new developments in Planning, it is expected that the use of CIBSE Guide F is unlikely to be representative of the energy requirements, due to the significant improvements to energy efficiency in buildings made in recent years. Therefore, current Building Regulations standards are likely to be more appropriate. These are derived from government-approved Dynamic Simulation Modelling (DSM) software and Standard Assessment Procedure (SAP) calculations.

Data from previous AECOM projects was used for this purpose. Building Regulations compliant calculations identify those energy uses which are ‘regulated’ (including for heating, cooling, ventilation, lighting and hot water) and ‘unregulated’ (including for appliances, cooking, external lighting, etc.). It is important to note that for the baseline calculation exercise, the unregulated energy demand will also be taken into consideration in order to fully account for the electricity requirements in buildings.

In the absence of specific modelling data, it is considered appropriate to assume that the ‘Good practice’ standards included in CIBSE Guide F most accurately estimates fuel consumption for future developments.

For residential schemes, the Building Regulations Fabric Energy Efficiency (FEE) standard from SAP models will inform the space heating demand. For the Domestic Hot Water (DHW) demand, a similar principle will be followed and the average DHW demand per unit floor area from various previous projects will be applied.

5.2 Energy Supply Mapping

In order to identify good opportunities for district energy schemes in the county, available sources of energy (both heat and electricity) were also mapped. Through engagement with the council and other relevant companies operating in the county, the following sources of energy were investigated:

- Industrial waste heat including distilleries and crematoriums
- Water source heat potential from rivers, mines and lakes (Derbyshire is landlocked, so the sea was omitted)
- Anaerobic digestion plants
- Energy from Waste plants
- Large scale solar PV installations
- Hydroelectricity installations

[6] http://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q20000008I7oTAAS
[7] http://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q20000008I7eWAAS
[8] https://www.bsria.co.uk/download/product/?file=zxrulZgWBrY%3D

The capacity and location of each supply opportunity was ascertained or estimated through the following hierarchical approach:

- Direct engagement with the plant operator
- From information provided by the council
- Data from the Renewable Energy Map[9]
- Estimation from AECOM experience

Further investigation as to the technical viability of utilising energy sources was carried out only if sources were found to be in close proximity to high density areas of energy demand. A list of energy supply opportunities in Derbyshire is provided in Appendix C.

5.3 Energy Mapping

The energy consumption analysis described above was used to produce maps illustrating the annual heat demand, cooling demand and total electricity demand for the most appropriate buildings in Derbyshire (see overleaf for Figure 5-1, Figure 5-2 and Figure 5-3). In addition to the demand maps, a layer showing the energy supplies in the county was also added so that opportunities for matching supplies and demands could be easily identified. These maps form the backbone to the energy masterplanning phase of the study.

In all cases, buildings are represented by coloured circles, where the colour represents the building usage, and the size of the circle is scaled to the amount of energy consumed by the building. Energy sources are also scaled as to their output capacity, with different symbols attributed to the various source types. See the map key for further information.

Note that the scale of the heat and electricity consumption circles are the same, whilst the cooling consumption circles are shown with a different scale, such that the smaller scale cooling loads are visible. The heating and cooling maps show buildings with thermal energy consumption of greater than 100MWh only.

As shown in Figure 5-3, the cooling demands in Derbyshire are significantly lower than the county's heating demands. Due to the lack of significant clusters of high density cooling, it is expected that district cooling networks would not pose an attractive investment both in terms of financial return and carbon savings offered. Furthermore, cooling can be delivered very effectively and easily at an individual building level. As such, cooling will not be progressed to the further masterplanning stages of this study.

The list of buildings and associated heating, electrical and cooling loads is provided in Excel format in addition to this report – see Appendix J.

[9] http://renewables-map.co.uk/

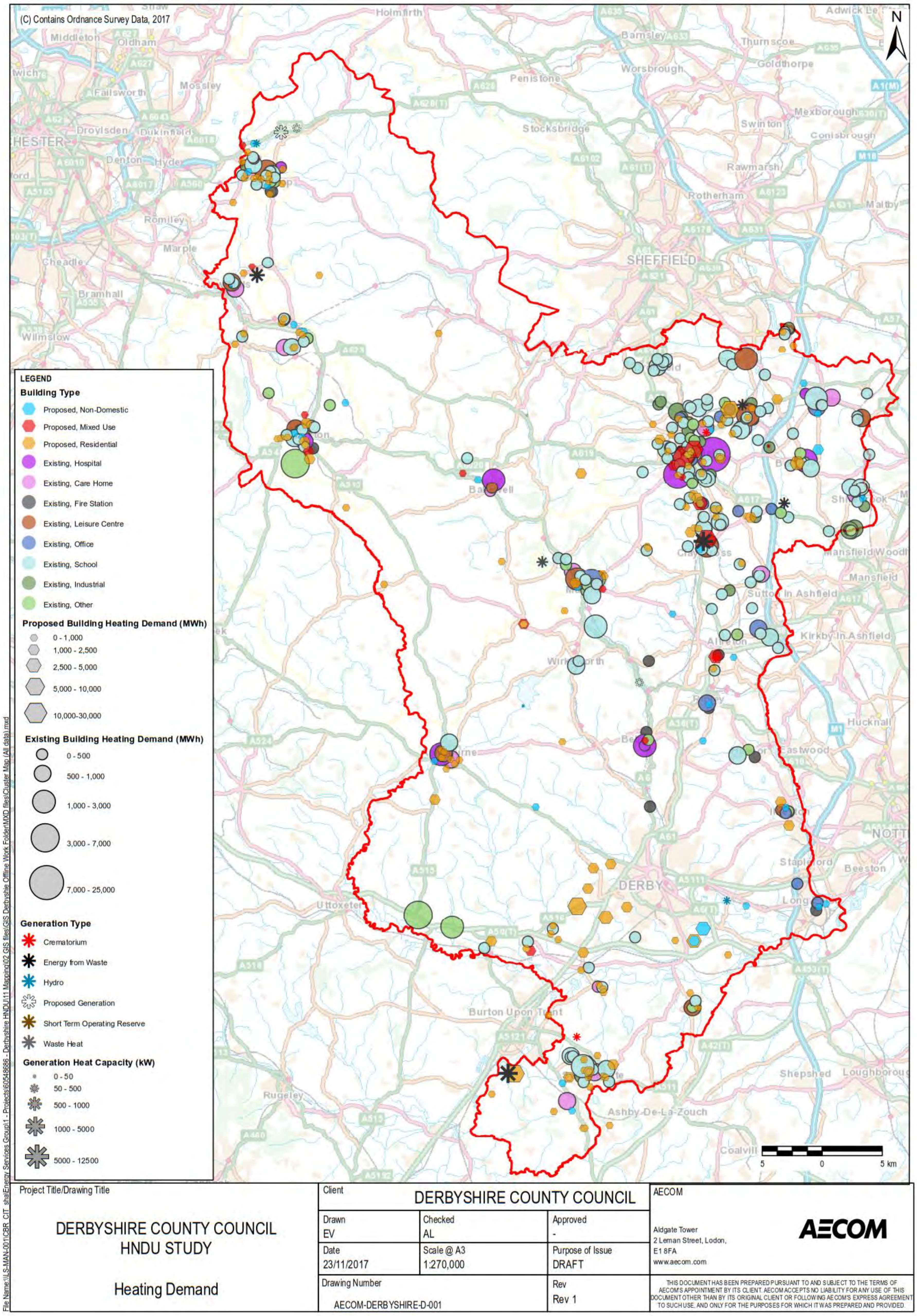


Figure 5-1 Derbyshire Heat Demand Map

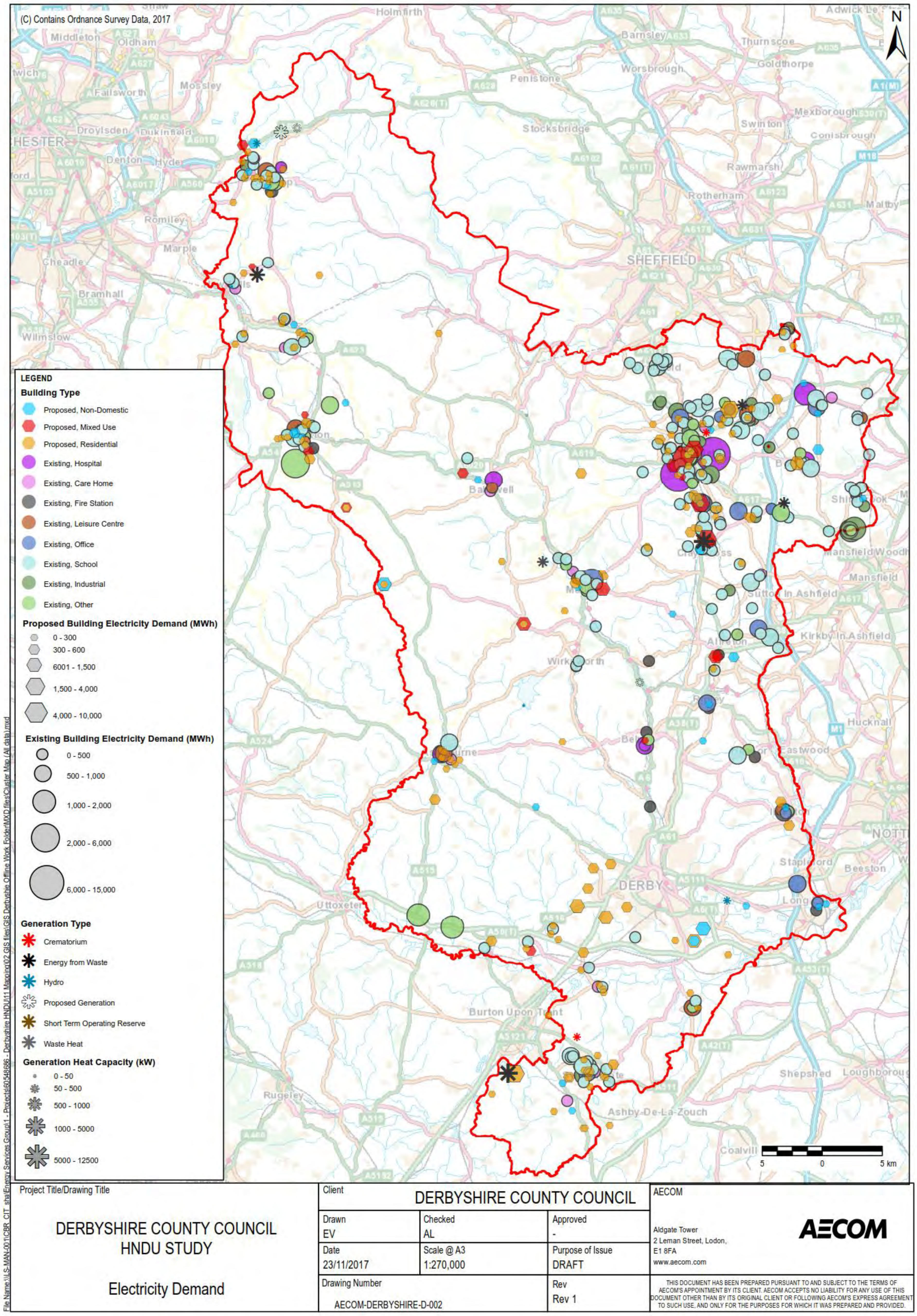


Figure 5-2 Derbyshire Electricity Demand Map

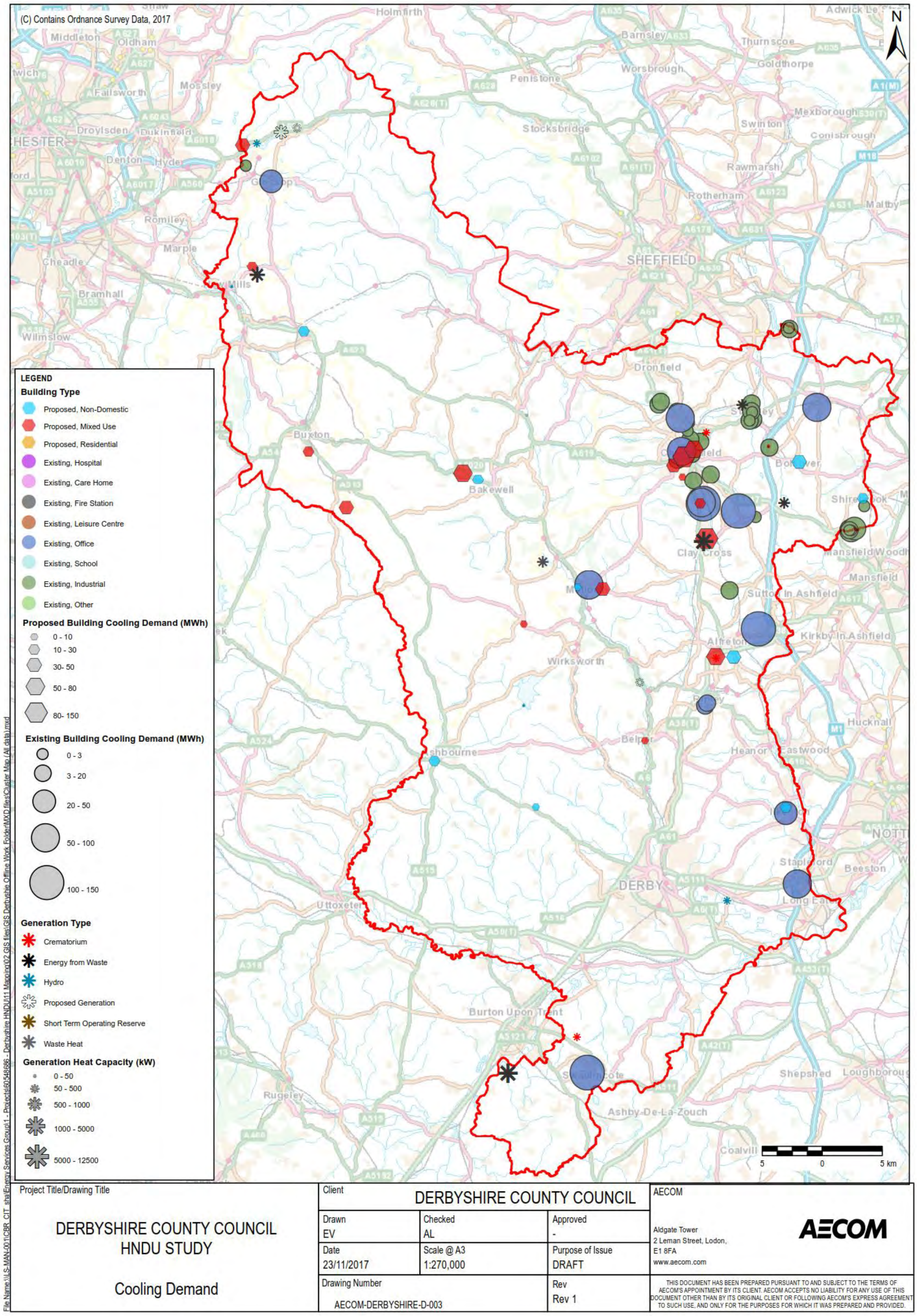


Figure 5-3 Derbyshire Cooling Demand Map

6. Identifying district heating opportunities

A number of areas of high heat consumption density have been identified as a result of the energy mapping exercise. These 'clusters' are of particular interest where they are in close proximity to existing sources of energy, reducing the requirements for heat generation technologies to supply the network.

In light of the scope of this study to assess the three best heat network solutions in Derbyshire, analysis was undertaken to narrow down the initially identified clusters to three. The methodologies employed to reduce the wider list are given in this section. The process followed is summarised below:

- Heat mapping workshop with the client to reduce the list of the identified clusters. The workshop narrowed the opportunities down to seven by assessing each opportunity's advantages and constraints (section 6.2);
- Further assessment of the seven opportunities identified by the heat mapping workshop in order to narrow them down to three, as indicated by the scope of this study (section 6.3). The design of these three opportunities will then be further developed and their financial performance scrutinised.

6.1 Cluster Identification

Nineteen cluster areas of high heat demand density were identified and presented at the heat mapping workshop on 1 September 2017. Existing heat sources in proximity to these areas were reviewed, along with any key barriers to network construction. The findings are shown in Figure 6-1 and Table 6-1.

At this stage in the study, the information gathered around heat supplies and heat demands is high level only. As the list is narrowed down, further detail is added. A full list of the buildings captured by the heat mapping is provided in Appendix J.

6.2 Cluster initial shortlisting

To narrow down the 19 cluster options an initial shortlisting exercise took place. This involved a client heat mapping workshop to examine each area in light of local knowledge and client specific aims and drivers. At the client workshop, AECOM presented the heat mapping approach and opportunity areas under consideration. A discussion was then had concerning the pros and cons of each opportunity. From this a qualitative judgement on the most appealing heat network opportunities was made, resulting in selection of seven cluster areas for further study.

The seven shortlisted clusters were:

- Staveley
- The combination of Clay Cross and Wingerworth
- Ilkeston
- The combination of Drakelow and Swadlincote
- Matlock
- Buxton
- Chesterfield

These areas were chosen based on discussions around heat density, the local area, barriers to construction as well as the type, location and relevance of existing sources of heat supply in the vicinity. In particular, the Staveley, Clay Cross, Drakelow and Matlock networks were chosen due to the proximity of high densities of heat demand to significant sources of heat supply. These sources are as follows:

- Staveley: Existing 1MW EfW facility approximately 1km from demands.
- Clay Cross and Wingerworth: the Clay Cross Energy Recovery Facility, a 10MW EfW plant with planning permission granted on the outskirts of the town. Less than 500m from significant existing and future heat demands.
- Drakelow and Swadlicote: the Drakelow Renewable Energy Facility[10], a 15MWe EfW plant with planning consent, located around 7km from Swadlincote.
- Matlock: the Enthoven and Sons Ltd battery recycling facility located in Darley Dale, around 4.5km from Matlock town centre. Significant research has already been carried out by Enthoven engineers and a PhD student at the Univerisyt of Sheffield into this option.

6.3 Cluster final shortlisting

As this study intends to develop the design of three heat network solutions, a final shortlisting was implemented. To select the three best options from the seven clusters listed above, areas were scored against the following key criteria:

- **Source to demand ratio:** Ratio of how much of the heat demand is met by local waste or renewable heat
- **Density**: Ratio of cluster heat demand to the distance between two farthest loads (as connected by EC)
- **Demand compatibility**: Qualitative assessment of the buildings in the cluster and their viability for connection (hospitals score high, industrial and buildings likely to have CHP score lower)
- **Deliverability**: Qualitative assessment of the physical and geographical barriers to pipework installation (e.g. railways, hills and rivers)
- **Carbon savings:** Proportion of the cluster demand that would have to be met by combustion technologies, with associated higher carbon emissions

The seven cluster areas were assigned a score between 1 and 5 for each of these categories. The categories themselves where weighted out of a hundred to reflect their relative importance. This allowed a single total score (with a maximum of 500) to be awarded to each cluster (i.e. the sum of the scores multiplied by their respective weights).

Table 6-2 shows the outcome of the matrix scoring. It can be seen that Clay Cross and Wingerworth came out with the highest score by a considerable margin, followed by Matlock. Drakelow/Swadlincote and Chesterfield tied on the next highest total.

Due to the lack of distinction between Drakelow/Swadlincote and Chesterfield, a further high level assessment of the two clusters was undertaken. This involved indicative network costing, a financial performance assessment, including simple payback calculations, as well as a qualitative comparison of the two heat network opportunities. Consequently, it was advised that the Chesterfield opportunity be pursued due to a smaller payback period and the availability of a larger anchor load, along with other comparative advantages. The full assessment can be viewed in Appendix D.

Note that the numbers contained in the high level assessment in Appendix D were developed prior to the design and energy masterplanning of networks. As such they are indicative only and are not representative of the figures included in the later stages of this report.

Based on the assessment detailed in this chapter and Appendix D, the following network opportunities will be advanced to the energy masterplanning phase of the study, in line with DCC's requirements to study three network opportunities:

- **Clay Cross**: where heat will be supplied from the proposed Clay Cross EfW facility
- **Matlock**: utilising waste heat from the Enthoven battery recycling facility
- **Chesterfield:** with heat generated on site (see Section 7.4.1 for the heat generation technology assessment)

[10] https://www.derbyshire.gov.uk/planningdocuments/CW9-0615-48/sup-Design%20and%20Access%20Statement.pdf

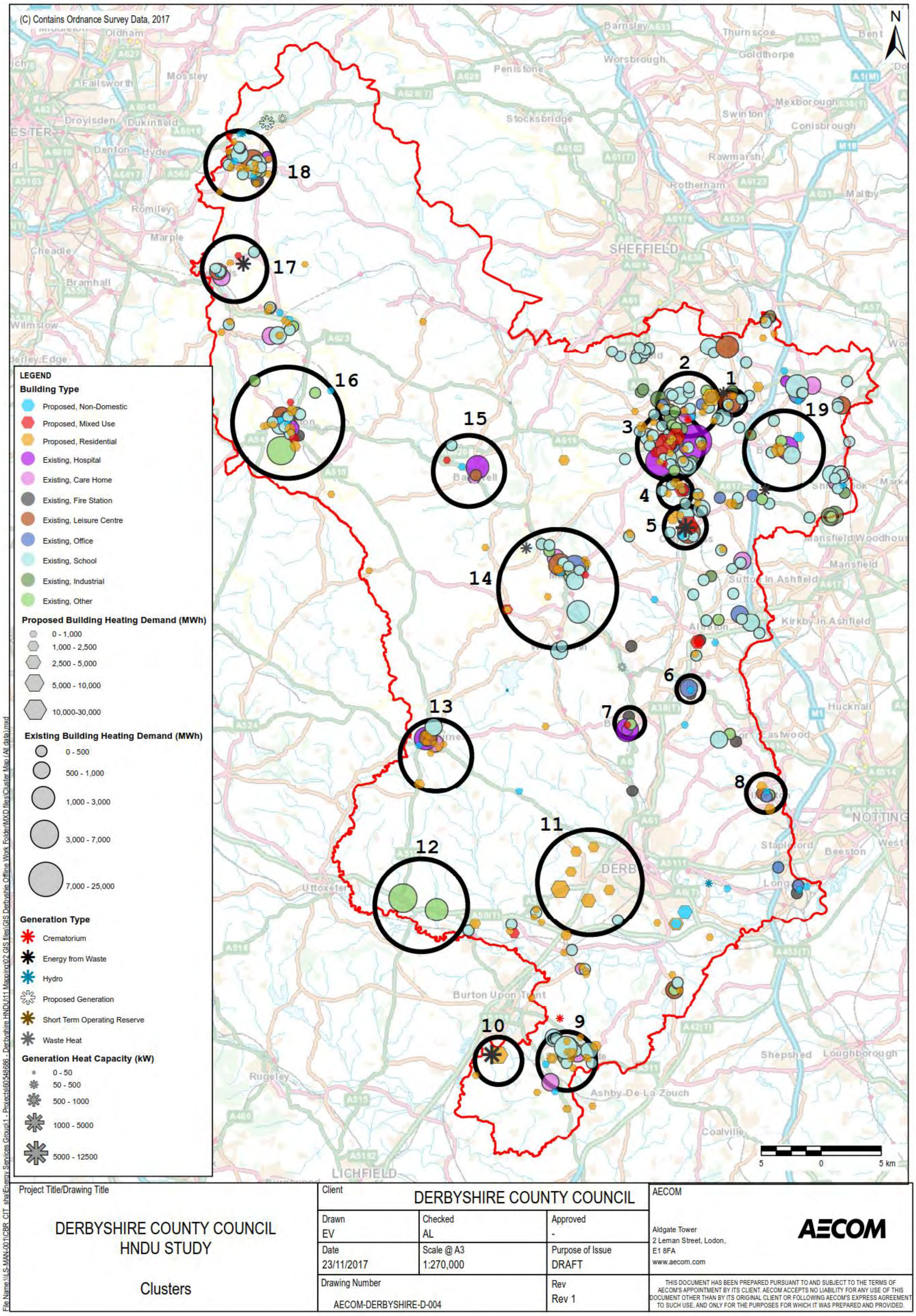


Figure 6-1 Derbyshire Heat Clusters (initial cluster identification). Reference Table 6-1.

Table 6-1 Initial heat cluster identification

Number	Cluster name	Existing Buildings	Future developments	Heat sources	Key barriers to construction
1	Staveley	Healthy Living Centre; Fire Station Industrial; Leisure; Schools	600 homes Mixed use development incl 2000 homes	Stavely EfW ~1km away, 1MW heat River	Lots of rail infrastructure in the area
2	Chesterfield North	Industrial; Schools	125 homes	-	-
3	Chesterfield Central	Chesterfield Royal Hospital (24GWh) Walton Hospital (5GWh) Schools Social Housing	1500 homes to North 500 homes to West	-	Busy town centre
4	Wingerworth	Public offices Schools	250 homes 400 homes 1100 homes over 2 phases	River	-
5	Clay Cross	Clay Cross Hospital Sharley Park Leisure Centre Schools, incl Tupton Hall (1GWh)	Biwater: Mixed use incl 1000 homes	Clay Cross EfW	-
6	Ripley	Council Offices Social Housing ~ 50 homes	-	-	-
7	Belper	Hospital; Social Housing; Job Centre	-	-	Railway through town centre
8	Ilkeston	Health Centre Public Offices	350 homes to North of town 450 homes to South of town	Crematorium	-
9	Swadlincote	Schools Public Buildings Industrial	New residential development	Bretby EfW, 1MW (source: renewable energy map - needs confirmation)	-
10	Drakelow	Near Swadlincote	2250 homes	Drakelow EfW	6km from Swadlincote
11	West Derby	-	1600 homes 1200 homes + more housing	-	-
12	Sudbury and Foston Hall	2no. Large prisons		Marchington EfW, 1MW	3 - 4km from EfW plant
13	Ashbourne	Hospital, schools	A few small housing developments, largest 220 homes	River	-
14	Matlock	Public Buildings A range of other buildings	Some smaller new developments, mainly existing	Enthoven Battery Recycling River	-
15	Bakewell	Hospital, Schools	-	River	-
16	Buxton	Public buildings	Mixed use and residential	Rivers	-
17	New Mills	Leisure, Schools	-	Arden Quarry EfW: 3MW	-
18	Glossop	Hospital Schools Public Buildings	50 unit new development Some mixed use	Rivers	Railways
19	Bolsover	Schools, Hospital	795 homes	-	-

Table 6-2 Matrix scores for heat cluster shortlist

Cluster Summary									Cluster Score					
Cluster name	Existing Buildings	Future developments	Heat sources	Total average heat source available, MWth	Total Heat Demand within Cluster, GWh	Proportion of demand met by available heat	Approximate Heat load density (MWh/m)	Key barriers to construction	Ratio of Source to Demand	Demand Density	Demand Compatibility	Deliverability Score	Carbon Savings	Total
									25	25	15	15	20	500
Staveley	Healthy Living Centre Fire Station Industrial Leisure Schools	600 homes Mixed use development incl 2000 homes	Stavely EfW ~1km away River Rother 2.7MW River Doe Lea 0.25MW Potential Chesterfiled Canal	1.0	16.6	53%	3.5	Rail infrastructure surrounding EfW site. Multiple water courses within cluster area.	3	3	2	1	3	255
Clay Cross and Wingerworth	Clay Cross Hospital Sharley Park Leisure Centre Schools, incl Tupton Hall (1GWh) Public offices	Biwater: Mixed use incl 1000 homes 250 homes 400 homes 1100 homes over 2 phases	Clay Cross EfW site	12.5	23.7	462%	4.3	Rail line (with road underpass) Road Network - Major Road River crossing between CC and Wingerworth	5	4	4	4	5	445
Ilkeston	Health Centre Public Offices	350 homes to North of town 450 homes to South of town	Crematorium 0.25MW Nutbrooke Canal 0.25MW Possibly new plant for drying of Incinerator Bottom Ash	0.5	15.3	29%	3.1	Dense Urban environment Canal between town centre and Stanton Ironworks	2	2	2	3	2	215
Drakelow / Swadlincote	Schools Public Buildings Industrial	2250 homes Other resi developments in Woodville - unknown quantum	Drakelow EfW 8MW Bretby EfW 1MW (source: renewable energy map - needs confirmation)	9.0	23.1	341%	2.6	6km from Swadlincote Rail Line and River between Drakelow EfW and Swadlincote	5	1	2	1	4	275
Matlock	Public Buildings A range of other buildings	Some smaller new developments, mainly existing	Enthoven Battery Recycling River Derwent 10MW	1.8	17.1	92%	2.9	River and Railway between Battery Plant and Matlock Centre Hilly Terrain	4	2	3	2	3	285
Buxton	Public buildings	Mixed use and residential	River Wye 3.8MW	0.0	18.5	0%	4.6	River and Railway to the north east	1	5	3	2	1	245
Chesterfield	Public buildings A range of other buildings Very large hospital (Derbyshire's largest heat load)	Mixed use and residential	None	0.0	51.8	0%	7.4	Railways and major roads between town centre and hospital site Major gradients	1	5	4	3	1	275

7. Energy Masterplanning

7.1 Introduction

A detailed methodology providing the background to the energy masterplanning phases of this study is provided in Appendix E. In short, this section develops the design of district heating networks in the three key focus areas, specifically:

- Prioritising buildings for connection
- Carrying out physical site surveys of the areas and buildings
- Assessing the pipework routing aspects of networks
- Determining the best location for the Energy Centre (EC) of each network
- Developing the phasing of loads and plant over the installation of the network

Thereafter, network scenarios are developed and their financial and carbon saving performance modelled in a techno-economic model. See Appendix F and Sections 8, 9 and 10. Findings and concept designs were developed in line with the recommendations and methodology set out in the CIBSE Code of Practice for District Heating, CP1.

7.2 Clay Cross Energy Masterplanning

Derbyshire County Council granted planning permission for the construction and operation of an energy recovery facility at Clay Cross in 2016. This facility will use biomass gasification technology to produce both electrical and thermal energy, and will be sufficient to supply much of the required heat to the Clay Cross district heating network investigated here. Due to the low carbon emission intensity of heat produced from waste, use of this energy recovery facility was deemed the most appropriate solution for district heat in the Clay Cross area. A summary of the other heat generation technologies considered for Clay Cross can be found in Section 7.2.1..

7.2.1 Heat Generation Appraisal

Table 7-1 and Table 7-2 present the results of the Clay Cross technology appraisal for years 0-15 and years 15+, with rank 1 representing the most viable technology. The assessment presented here seeks to identify constraints and advantages associated with the use of different technologies in Clay Cross. The methodology behind the assessment is provided in Appendix E.

In both assessment periods, the Clay Cross Energy Recovery Facility scores highest, due to its proximity to the heat loads, the scale of the heat source available and the relevance to the area (i.e. there is a EfW facility being proposed in Clay Cross).

In the event that the EfW facility does not go forward, the next best scoring technology in the 0-15 year assessment period was found to be CHP. CHP is a mature technology that has been used successfully in other similar projects; it does not usually involve a requirement for additional space, nor any reliance on third parties. Some practical issues, including the air quality implications will need to be addressed but early investigations suggest that there are no major barriers that would prevent the use of this technology.

Due to the exceptionally high costs of drilling to the required depths, deep geothermal heat recovery is not considered viable. There were no existing deep wells identified in the area.

Previous studies have deemed that minewater heat extraction is only viable if the coal authority is already pumping out water. There are considerable costs and uncertainties over water volumes associated if this is not the case. There were no active pumped coal mines identified within close proximity to Clay Cross.

Similarly, no anaerobic digestion plants exist in the local vicinity, so this technology is not deemed a viable solution for heat generation in Clay Cross.

Biomass or biofuel CHP engines and boilers are generally considered to be good substitute technologies for gas CHP, with good applicability to heat networks and technology maturity levels. The reliance on third parties (for fuel security), high fuel costs (relative to gas) and air quality implications (high levels of NO_x and particulate emissions) are particular risks, however. In this case, these issues make biomass and biofuel technology unsuitable.

Heat pumps scored reasonably well due to their environmental benefits and security of supply. However older buildings require higher heating supply temperatures which significantly reduce the efficiencies of heat pumps. As such, the operating costs and CO_2 emissions savings of such systems are not as favourable as other technologies. Whilst building secondary side systems could be changed for lower temperature heat emitters, this would entail significant site disruption and associated costs that would not likely be favoured by customers. On the other hand, large new developments lend themselves well to heat pump technologies, as the design of their heating distribution systems can allow for lower heating supply temperatures, giving higher efficiencies.

Heat pump based technologies score better in the 15+ year assessment period as it is predicted that the electricity grid in the UK will decarbonise in the future, improving the environmental performance of the technology. Furthermore, future buildings are expected to have lower supply temperatures, enhancing the competitiveness of heat pump technologies.

Figure 7-1 Clay Cross WSHP potential

Figure 7-1 shows two rivers in the Clay Cross area. Neither are particularly close to the heat demands, nor do they provide much heat capacity. The higher capacity of the two, the Rother, can only supply around 220kW of heating at this point. As such WSHP are not recommended for use in Clay Cross.

Solar thermal systems score relatively low due to the additional space requirements of the thermal collectors. It was not considered likely that enough land (or roof space) would be secured near to a central energy centre to support the system.

Heat recovery from industry scores well in the assessment; it is a low carbon and often cheap method of generating heat for heat networks, since heat would otherwise be rejected into the atmosphere. No significant emitters of waste heat were identified in Clay Cross, however, so its current suitability in this case is low.

Table 7-1 Clay Cross Technology Appraisal Matrix (0-15 years)

		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10	Option 11	Option 12	Option 13
Category	**Name Ref**	**Gas Fired CHP**	**Biomass Fired CHP**	**Biofuel Fired CHP**	**Energy From Waste**	**Biomass Boiler**	**Biofuel Boiler**	**Geothermal**	**Anaerobic digestion**	**Air Source Heat Pumps**	**Water Source Heat Pump**	**Ground Source Heat Pump**	**Heat recovery from industry**	**Solar Thermal**
Technical	Technology maturity and availability	5	4	4	4	4	4	1	4	4	4	4	4	3
	Suitability for scale and profile of heat demand	4	4	4	5	4	4	3	2	3	1	3	3	1
	Security of supply	4	2	2	4	2	2	3	4	5	4	4	3	3
	Suitability for required supply temperatures	5	5	5	5	5	5	3	5	2	2	2	4	3
	Proximity to heat demands	5	5	5	5	3	3	1	1	4	1	4	1	3
Environmental	Level of CO2 emission savings	3	4	4	5	4	4	5	5	3	3	3	5	5
	Air quality implications	2	1	1	4	1	1	5	4	5	5	5	5	5
	Wider environmental impacts	3	3	3	4	3	3	3	4	3	3	3	5	3
Financial	Technology cost	4	3	3	4	4	4	1	4	4	4	3	4	3
	Impact on scheme financial viability	4	3	3	3	3	3	1	3	3	3	3	4	3
	Long term financial risks	3	3	3	2	3	3	2	2	3	3	3	3	4
Deliverability	Suitability to Clay Cross	5	5	5	5	4	4	1	1	3	1	3	2	2
	Implications for energy centre size/design	4	3	3	4	3	3	5	4	4	4	4	4	4
	Implications for additional space requirements	5	3	3	5	3	3	5	5	1	4	1	5	2
	Reliance on third parties	5	2	2	1	3	3	5	1	5	5	5	1	4
	Total score (%)	79.60	66.80	66.80	80.80	65.60	65.60	57.20	68.80	70.00	64.00	67.60	74.40	67.20
	Rank	2	8	8	1	10	10	13	5	4	12	6	3	7

Table 7-2 Clay Cross Technology Appraisal Matrix (15+ years)

		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10	Option 11	Option 12	Option 13
Category	**Name Ref**	Gas Fired CHP	Biomass Fired CHP	Biofuel Fired CHP	Energy From Waste	Biomass Boiler	Biofuel Boiler	Geothermal	Anaerobic digestion	Air Source Heat Pumps	Water Source Heat Pump	Ground Source Heat Pump	Heat recovery from industry	Solar Thermal
Technical	Technology maturity and availability	5	5	5	4	4	4	2	4	4	4	4	4	4
	Suitability for scale and profile of heat demand	4	4	4	3	4	4	3	2	3	3	4	3	1
	Security of supply	4	3	3	4	2	2	3	4	5	4	4	3	3
	Suitability for required supply temperatures	5	5	5	5	5	5	3	5	4	4	4	4	3
	Proximity to heat demands	5	5	5	5	3	3	1	1	4	3	4	1	3
Environmental	Level of CO_2 emission savings	2	4	4	5	3	3	5	5	5	5	5	5	5
	Air quality implications	1	1	1	4	1	1	5	4	5	5	5	5	5
	Wider environmental impacts	2	2	2	4	2	2	3	4	3	3	3	5	3
Financial	Technology cost	4	4	4	4	4	4	2	4	4	4	3	4	3
	Impact on scheme financial viability	4	3	3	3	3	3	1	3	3	3	3	4	3
	Long term financial risks	3	3	3	2	3	3	2	2	3	3	3	3	4
Deliverability	Suitability to Clay Cross	5	5	5	5	4	4	1	2	3	3	1	2	2
	Implications for energy centre size/design	4	3	3	4	3	3	5	4	4	4	4	4	4
	Implications for additional space requirements	5	3	3	5	3	3	5	5	1	4	1	5	2
	Reliance on third parties	5	2	2	1	3	3	5	1	5	5	5	1	4
	Total score (%)	**74.80**	**70.40**	**70.40**	**79.20**	**62.80**	**62.80**	**60.40**	**70.40**	**77.20**	**74.40**	**75.60**	**74.40**	**69.20**
	Rank	**4**	**7**	**7**	**1**	**11**	**11**	**13**	**7**	**2**	**5**	**3**	**6**	**10**

7.2.2 Building Prioritisation

The Clay Cross and Wingerworth area contains a number of proposed new developments as shown in the table. The assumptions made on the phasing of construction and dwelling areas are provided in Table 7-3.

The shortlist of buildings considered for connection to the Clay Cross heating network is given in Table 7-4.

7.2.3 Surveys

A site visit to Clay Cross took place on the 1 November 2017. Some particular points of note include:

- The local junior school located in the Bridge Street area is currently not in use
- Marx Court retirement housing complex – regeneration project undertaken in 2014 to fit a new energy efficient heating system, including 3 central boiler systems
- Uncertainty over whether Clay Cross retail centre is still in use
- No evidence of GBL International Ltd on Furnace Hill Road and Coney Green Road
- Uncertainty over use of 185-187 Coney Green

A list of new developments in Clay Cross commencing within the next few years is shown in Table 7-3.

Table 7-3: Clay Cross new developments

Development name	Phasing details	Source	Number of residential units	Dwelling and area breakdown	Source
Biwater	Construction over 3 phases, 10 year to full build out, construction starting 2020	Assumed	1,000	10% 2 bed, 80m^2 60% 3 bed, 120m^2 30% 4 bed, 160m^2 Average area 128m^2	Planning application[11] Full breakdown is assumed, based on similar developments in the county
Deerlands Road	Single phase construction, occupied 2020	Assumed	180	Average area 128m^2	Planning application[12] Average area is assumed, based on similar developments in the county
Hanging Banks	Two phase construction, 5 years to full build out, construction starting 2020	Assumed	240	Average area 125m^2	Planning application[13]
The Avenue Coking Plant	Two phase construction, 5 years to full build out, construction starting 2020	Assumed	469	Average area 128m^2	Planning application[14] Average area is assumed, based on similar developments in the county

[11] http://planapps-online.ne-derbyshire.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=ORJ55FLIK7700
[12] http://planapps-online.ne-derbyshire.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=OMA6AGLIJ8700
[13] http://planapps-online.ne-derbyshire.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=N9S41FLIIE000&documentOrdering.orderBy=documentType&documentOrdering.orderDirection=ascending
[14] http://planapps-online.ne-derbyshire.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=MLT6CGLI2Z000

Table 7-4: Clay Cross building list

Building Name	Building Type	Building Age	Number of units	Area Used	Heat Demand used			Peak Demand
			no.	m^2	MWh	Source	Ref.	kW
Chuckles Bridge Street	Recreational	Existing		417	115	Estimated	CSE	29
Units 1 to 4 Tower Business Park	Industrial	Existing		3,276	762	Estimated	CSE	262
Smithybrook View	Residential	Existing	90	-	340	Benchmark	DCC	408
Adult Community Education Centre /Clay Cross Youth Centre	Other Education	Existing		1,339	258	Actual	CSE	116
Market Street (Care Home)	Care Home	Proposed	200	-	295	Benchmark	DCC	384
Fire Station	Emergency services	Existing		310	581	Estimated	CSE	27
Clay Cross Community Hospital	Health	Existing		3,094	1,092	DEC	DCC	269
Sharley Park Leisure Centre	Leisure Centre	Existing		3,601	1,963	Actual	CSE	313
Biwater (2020)	Residential	Proposed	320	-	2,212	Benchmark	DCC	2,107
Biwater (2025)	Residential	Proposed	320	-	2,212	Benchmark	DCC	2,107
Biwater (2030)	Residential	Proposed	360	-	2,488	Benchmark	DCC	2,339
Coney Green Business Centre	Offices	Existing		4,970	561	Estimated	CSE	348
Tupton Hall School	School	Existing		14,000	1,092	Actual	CSE	1,218
Deerlands Road (2020)	Residential	Proposed	180	-	1,244	Benchmark	DCC	1,279
Deer Park Primary School	School	Existing		1,095	129	DEC	DCC	95
Hanging Banks, Derby Road (2020)	Residential	Proposed	111	-	749	Benchmark	DCC	837
Hanging Banks, Derby Road (2025)	Residential	Proposed	139	-	938	Benchmark	DCC	1,008
The Avenue coking plant (2020)	Mixed	Proposed	239	-	2,177	Benchmark	DCC	2,279
The Avenue coking plant (2025)	Mixed	Proposed	230	-	2,115	Benchmark	DCC	2,225
		Totals:	**2,189**	**48,102**	**21,324**			**17,650**

7.2.4 Network Routing

The topology of the area is shown in Figure 7-2. It can be seen that the proposed pipework routes do not traverse severe gradients.

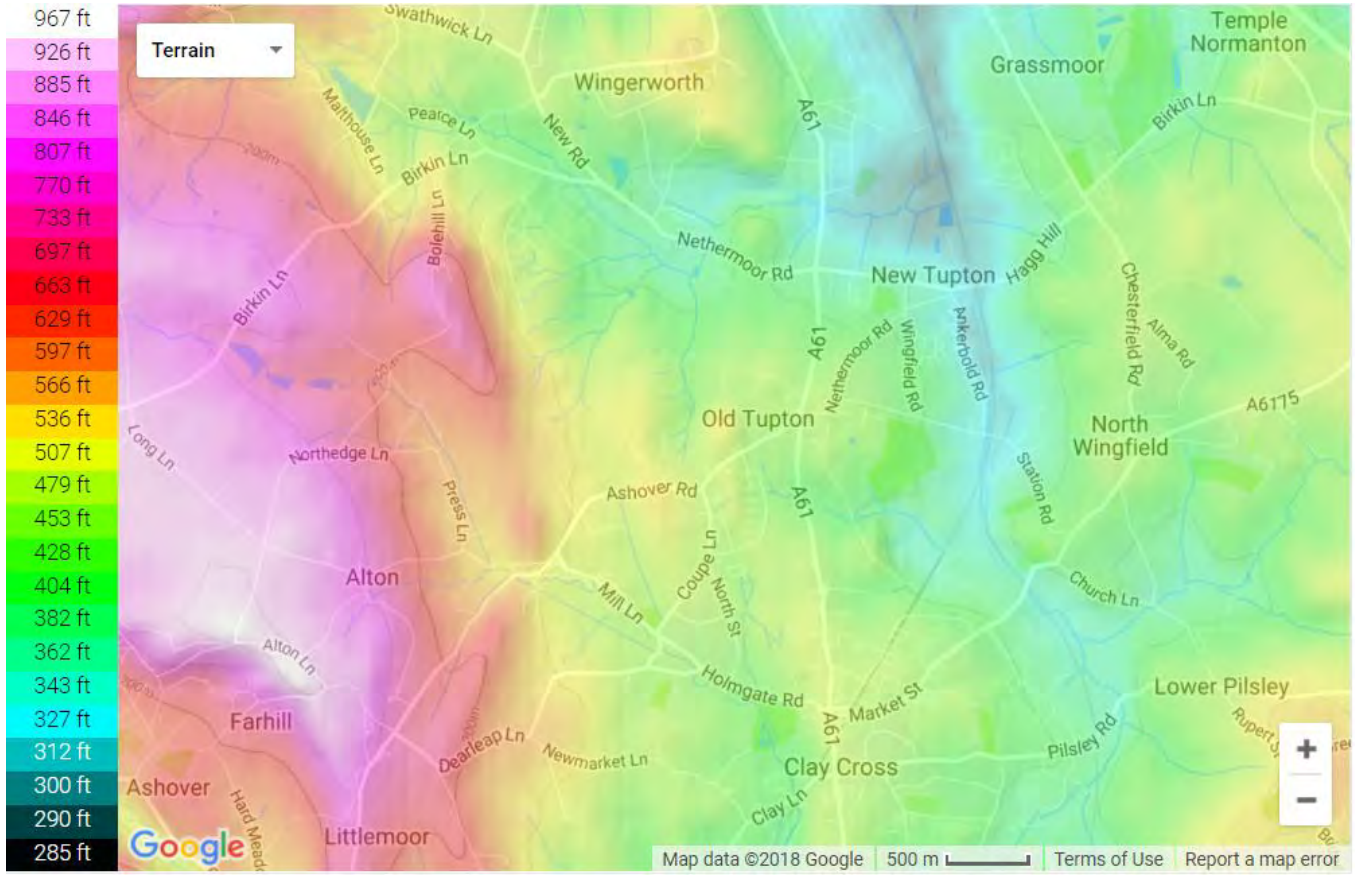


Figure 7-2 Clay Cross topology

Indicative pipework routes for the Clay Cross network are shown in Figure 7-3. No soft dig opportunities were identified for the network.

7.2.4.1 Key pipework barriers

Where crossing of the railway and local waterways were necessary, existing crossings (i.e. road bridges or underpasses) were used to limit additional costs. The key pipework barriers and proposed mitigation strategies are given in Table 7-5.

Table 7-5: Clay Cross pipework barriers (see Figure 7-3 for barrier referral numbers)

Barrier no.	Description	Risk level	Mitigation strategy
1	Redleadmill Brook 1. Small brook crossing via road	Low	Crossing requirement is very short. Assessment of bridge depth necessary to ensure adequate depth for pipework is provided.
2	Redleadmill Brook 2. Small brook crossing via road	Low	Crossing requirement is very short. Assessment of bridge depth necessary to ensure adequate depth for pipework is provided.
3	Railway crossing	Low	At the point where pipework is proposed to cross the railway, the tracks are underground in a tunnel. Assessment of the cover height above the tunnel is necessary to ensure adequate depth for pipework is present

7.2.5 Energy Centre Considerations

The proposed Clay Cross Energy from Waste facility will be installed and operated by Larkfleet Group, a sustainable development company based in Lincolnshire. The initial (granted) planning application was for 10MW electrical output capacity. At the engagement meeting in Matlock on 16 October 2017, Larkfleet stated that due to uncertainties over the security of fuel supply, they would reduce the installed capacity to 4MW (initially, with an intention to increase if there was demand and security of fuel supply). It is their intentions to begin supply in 2018.

Lark Energy confirmed that the district heating network energy centre could be located on the same site as the EfW facility.

Lark Energy also confirmed that they would consider selling electricity privately. Such an arrangement could be used to supply the ancillary electrical requirements of the energy centre. This would provide Lark Energy with a comparatively higher rate for privately sold electricity as opposed to exporting to grid. Furthermore, it would provide the DHN operator with a lower cost of power than if it was purchased from the grid directly. The assumption that the EC imports its electricity from the EfW plant is adopted in the modelling detailed in this report. No assumption is made on additional private wire networks in the vicinity that Lark Energy may want to explore.

Due to the differences in construction and implementation times of the Clay Cross Energy Recovery Facility and any subsequent district heating network in Clay Cross, Lark Energy will need to secure Power Purchase Agreements (PPA) ahead of the installation of the network. As such there is a risk that Lark Energy would be unable to provide the network in the future if they have signed a PPA for the export of its power elsewhere. This risk should be mitigated through engagement with Lark Energy. The presence of a large electricity consumer adjacent to the EfW facility (i.e. the Energy Centre) may however promote the case for expansion of the EfW plant above the initial planned 4MW installation (planning has been granted for 10MW).

Based on the peak demand and diversity assessment for the Clay Cross network, together with other key considerations such as boiler resilience and heat exchanger provision, the appropriate composition of EC plant is presented in Table 7-6. The numbers given represent the requirements for the whole network; further granularity on various network scenarios is provided in Section 8.

Table 7-6: Proposed network technical parameters - Clay Cross

	Parameter	Value
Demand	Network peak heating demand (assuming full build out), MW	12.3
EfW	EfW thermal output capacity, MW	4.0
	EfW electrical output capacity, MW	4.0
	EfW power/heat availability	90%
Boiler plant	Phase 1 (2020) boiler capacity, MW	8.0
	Phase 2 (2025) boiler capacity, MW	7.0
	Assumed boiler efficiency	86%
Thermal storage	Thermal storage (30l per kW), m^3	450
	Thermal storage delta T, K	30
Ancillaries	Ancillary equipment electrical demand (as % of thermal output)	5%
Space	Energy centre footprint, m^2	225
Utilities	Gas main extension required (assumed), m	200

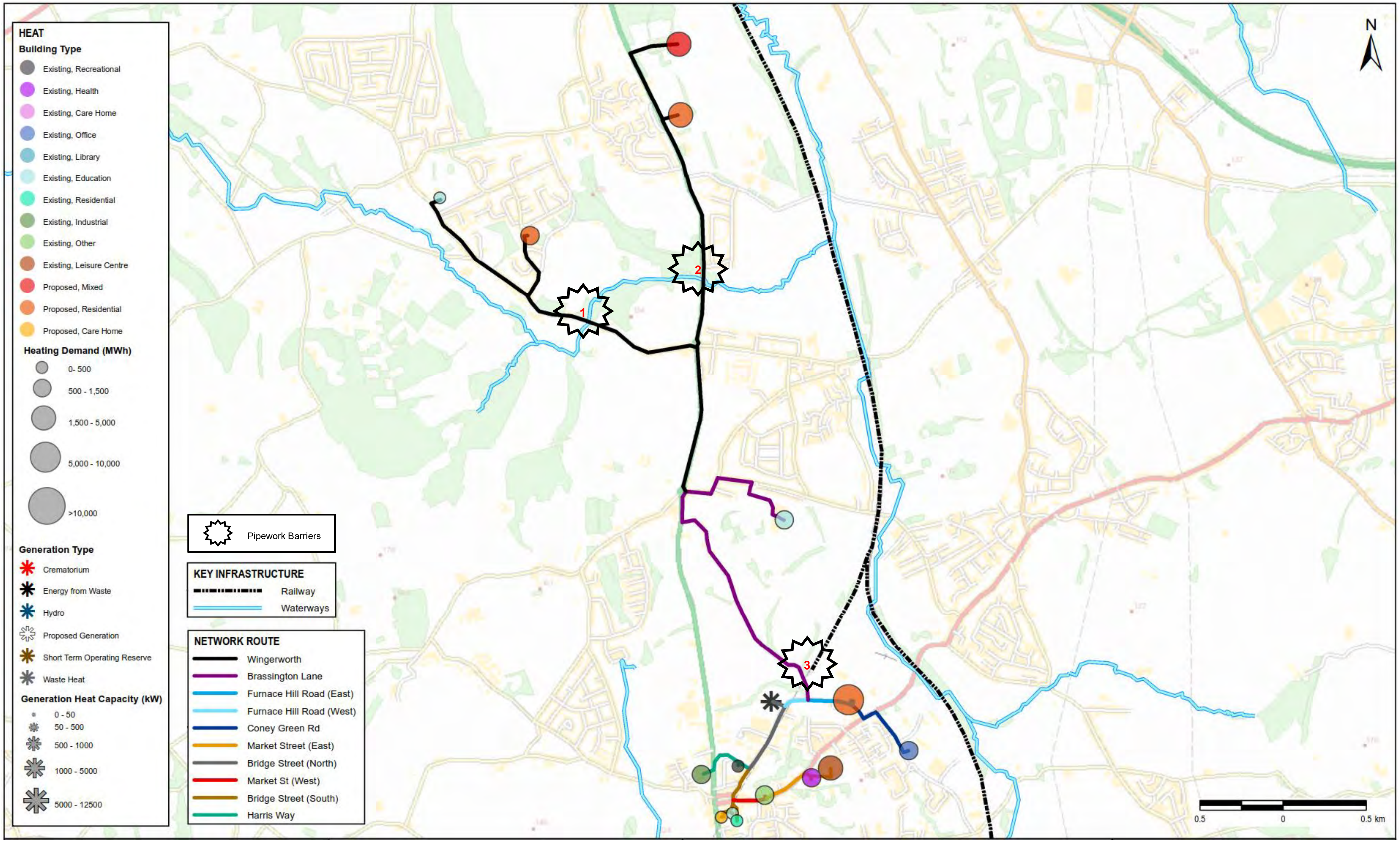


Figure 7-3 Indicative Clay Cross network routing, with identified key network routing barriers (see also Table 7-5). EC located at EfW site.

7.2.1 Phasing

The network development has been phased to capture phasing in the future developments. It has been assumed that the boiler installation will be split into two phases held in 2020 and 2025 respectively. The peak demand and plant installation for the full build out over these two phases is illustrated in Figure 7-4.

The installed operational capacity (18MW in 2025) is much higher than the required network peak demand at the time of around 12MW because the back-up boiler provision is sized to meet the full load without any heat recovery. This is to ensure that demands can be met during plant downtimes. Boiler plant is sized to meet N+1 resiliency requirements.

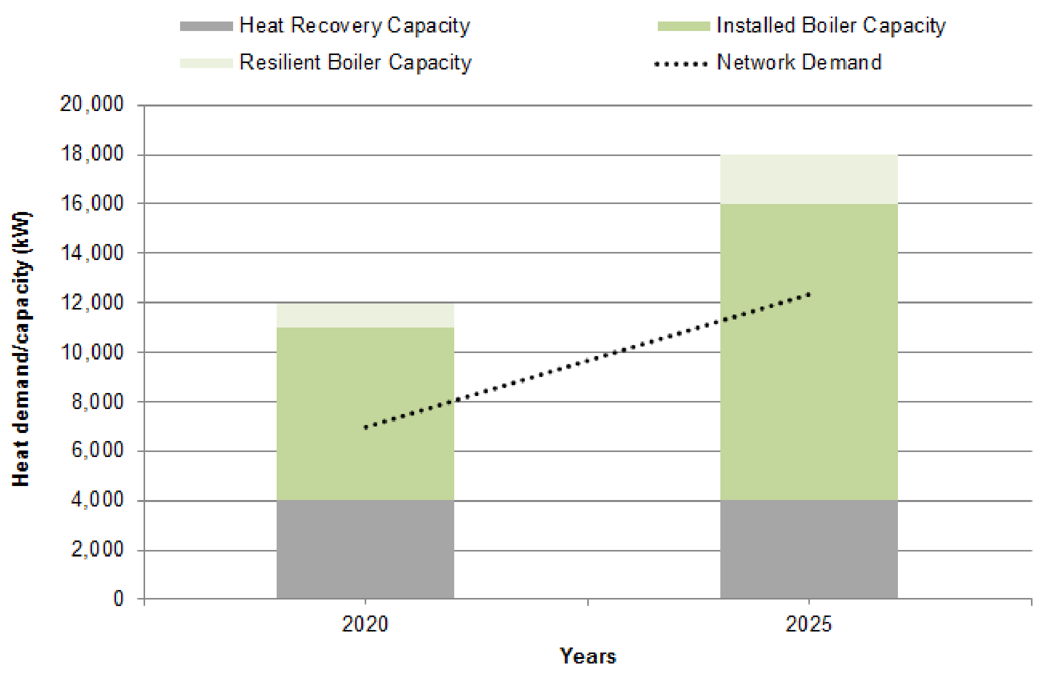


Figure 7-4 Clay Cross phasing in heat demand and plant installation

7.3 Matlock Energy Masterplanning

The Enthoven battery recycling facility is proposed to supply heat to the Matlock network. Due to the very low carbon content of recovered waste heat, and the work done to date on using this waste heat, it is the most appropriate heat generation technology for the area. A full appraisal of the heat generation options considered can be found in Section 7.3.1.

The masterplanning aspects of the study have included engagement with Enthoven to review work done to date, and with Ian Brocklebank, who is carrying out a PhD on the topic at Sheffield University. See Section 7.3.5 for more details.

7.3.1 Heat Generation Appraisal

Table 7-7 and Table 7-8 present the results of the Matlock technology appraisal for years 0-15 and years 15+, with rank 1 representing the most viable technology. The assessment presented here seeks to identify constraints and advantages associated with the use of different technologies in Matlock. The methodology behind the assessment is provided in Appendix E.

The analysis shows that a heat recovery from industry, such as from the Enthoven battery recycling facility, is the most viable option for a DH network in Matlock. This is partly due to the existence of a third party supplier already established in the area. This option also provides a relatively favourable environmental impact and low financial cost compared to alternative technologies. Heat recovery from industry is a reasonably mature technology that in this case can provide suitable supply temperatures to a local network.

Like Clay Cross, gas fired CHP, score well and would be highly suitable for the Matlock area if the Enthoven Recycling facility was found to be unviable. Due to the fuel requirements for gas CHP, however, it is less favourable than the purely renewable recovery of heat that would otherwise be emitted into the atmosphere.

Biomass and biofuel CHP and boilers are seen as unfavourable for Matlock due to a lack of third party fuel suppliers, affecting confidence in the security of supply. Furthermore these technologies score poorly for air quality due to high emission levels of NOx and particulates.

Geothermal is currently an expensive and relatively immature technology in the UK. As Matlock has no existing wells it is not a viable option for the area. There were also no Anaerobic digestion of EfW plants in the vicinity and as such these score low in the assessment.

Water and air source heat pumps both scored well for Matlock due to their air quality benefits and security of supply in the area. Particularly, water source heat pumps would be relatively easy and intrusive to install along the River Derwent. The national heat map suggests that as much as 10.9MW of heat could be delivered from the river (see Figure 7-5). However there are salmonid constraints that present a risk to this technology; the EA would have to be engaged with to provide insight on whether this would be viable. Furthermore, it is unlikely that the buildings in the Matlock area would support the implementation of a low temperature heat pump fed network currently.

With any heat pump solution, lower heating supply temperatures are a big benefit to performance as they significantly enhance the heat pump coefficient of performance, therefore reducing the electricity required to deliver heat. DCC should work to ensure that a strategy is in place that ensures future developments in Derbyshire are designed to allow for lower heating supply temperatures.

Ground source heat pumps are more expensive to install and consequently do not score as well.

The assessment shows that for both periods, heat recovery from the existing Enthoven battery recycling facility is the best opportunity for supplying a heat network in Matlock. See Section 7.2.1 for more discussion around the heat generation appraisal.

Figure 7-5 Matlock WSHP potential

Table 7-7 Matlock Technology Appraisal Matrix (0-15 years)

		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10	Option 11	Option 12	Option 13
Category	Name Ref	Gas Fired CHP	Biomass Fired CHP	Biofuel Fired CHP	Energy From Waste	Biomass Boiler	Biofuel Boiler	Geothermal	Anaerobic digestion	Air Source Heat Pumps	Water Source Heat Pump	Ground Source Heat Pump	Heat recovery from industry	Solar Thermal
Technical	Technology maturity and availability	5	4	4	4	4	4	1	4	4	4	4	4	3
	Suitability for scale and profile of heat demand	4	4	4	3	4	4	3	2	3	3	3	3	1
	Security of supply	4	2	2	4	2	2	3	4	5	4	4	3	3
	Suitability for required supply temperatures	5	5	5	5	5	5	3	5	2	2	2	4	3
	Proximity to heat demands	5	5	5	1	3	3	1	1	4	3	4	3	3
Environmental	Level of CO2 emission savings	3	4	4	5	4	4	5	5	3	3	3	5	5
	Air quality implications	2	1	1	4	1	1	5	4	5	5	5	5	5
	Wider environmental impacts	3	3	3	4	3	3	3	4	3	3	3	5	3
Financial	Technology cost	4	3	3	4	4	4	1	4	4	4	3	4	3
	Impact on scheme financial viability	4	3	3	3	3	3	1	3	3	3	3	4	3
	Long term financial risks	3	3	3	2	3	3	2	2	3	3	3	3	4
Deliverability	Suitability to Matlock	5	5	5	1	4	4	1	1	3	3	3	5	2
	Implications for energy centre size/design	4	3	3	4	3	3	5	4	4	4	4	4	4
	Implications for additional space requirements	5	3	3	5	3	3	5	5	1	4	1	5	2
	Reliance on third parties	5	2	2	1	3	3	5	1	5	5	5	1	4
	Total score (%)	79.60	66.80	66.80	69.60	65.60	65.60	57.20	68.80	70.00	70.40	67.60	80.80	67.20
	Rank	2	9	9	5	11	11	13	6	4	3	7	1	8

Table 7-8 Matlock Technology Appraisal Matrix (15+ years)

		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10	Option 11	Option 12	Option 13
Category	**Name Ref**	Gas Fired CHP	Biomass Fired CHP	Biofuel Fired CHP	Energy From Waste	Biomass Boiler	Biofuel Boiler	Geothermal	Anaerobic digestion	Air Source Heat Pumps	Water Source Heat Pump	Ground Source Heat Pump	Heat recovery from industry	Solar Thermal
Technical	Technology maturity and availability	5	5	5	4	4	4	2	4	4	4	4	4	4
	Suitability for scale and profile of heat demand	4	4	4	3	4	4	3	2	3	3	4	3	1
	Security of supply	4	3	3	4	2	2	3	4	5	4	4	3	3
	Suitability for required supply temperatures	5	5	5	5	5	5	3	5	4	4	4	4	3
	Proximity to heat demands	5	5	5	1	3	3	1	1	4	3	4	3	3
Environmental	Level of CO2 emission savings	2	4	4	5	3	3	5	5	5	5	5	5	5
	Air quality implications	1	1	1	4	1	1	5	4	5	5	5	5	5
	Wider environmental impacts	2	2	2	4	2	2	3	4	3	3	3	5	3
Financial	Technology cost	4	4	4	4	4	4	2	4	4	4	3	4	3
	Impact on scheme financial viability	4	3	3	3	3	3	1	3	3	3	3	4	3
	Long term financial risks	3	3	3	2	3	3	2	2	3	3	3	3	4
Deliverability	Suitability to Matlock	5	5	5	2	4	4	1	2	3	3	3	5	2
	Implications for energy centre size/design	4	3	3	4	3	3	5	4	4	4	4	4	4
	Implications for additional space requirements	5	3	3	5	3	3	5	5	1	4	1	5	2
	Reliance on third parties	5	2	2	1	3	3	5	1	5	5	5	1	4
	Total score (%)	74.80	70.40	70.40	71.20	62.80	62.80	60.40	70.40	77.20	77.60	75.60	80.80	69.20
	Rank	5	7	7	6	11	11	13	7	3	2	4	1	10

7.3.2 Building Prioritisation

The Matlock area contains a couple of proposed new developments as shown in the table. The assumptions made on the phasing of construction and dwelling areas are provided in Table 7-9. The buildings considered for connection to the Matlock heating network are listed in Table 7-10.

Table 7-9: Matlock new developments

Development name	Phasing details	Source	Number of residential units	Dwelling and area breakdown	Source
Treetops	Single phase construction, starting in 2022	Assumed	90	Average area $239m^2$	www.richboroughestates.co.uk
Cawdor Quarry	Two phase construction, 5 years to full build out, construction starting 2023	Assumed	507	Average area $118m^2$	Planning application[15]

7.3.3 Surveys

A site visit to Matlock took place on the 1 November 2017. Some particular points of note include:

- Mackays Firs Parade – collection of shops with offices above
- Matlock Lido Swimming Baths have been demolished, replaced with a car park
- Jesters Gym potentially now Matlock Mixed Martial Arts
- St Elphins Extra Care is a significant size development, with other facilities (health club / restaurant). It is made up of a mixture of apartment buildings and cottages. Several connection points may be required.

[15] www.derbyshiredales.gov.uk/publicaccess Application number 16/00923/OUT

Table 7-10: Matlock building list

Building Name	Building Type	Building Age	Number of units	Area Used	Heat Demand used			Peak Demand
			no.	m^2	MWh	Source	Ref.	kW
Darley Dale Primary School	School	Existing		919	180	DEC	DCC	80
Shand House	Offices	Existing		1,883	146	Benchmark	-	132
St Elphins Extra Care Facility	Mixed (Care home)	Existing		8,890	510	Benchmark	-	556
Whitworth Hospital	Health	Existing		2,769	703	DEC	DCC	241
Meadow View	Care Home	Existing		3,009	796	Benchmark	-	181
Long Meadow	Care Home	Existing		2,800	992	Benchmark	-	509
Valley Lodge	Care Home	Existing		4,680	1,658	Benchmark	-	749
Arc Leisure Centre	Leisure Centre	Existing		4,192	3,471	DEC	DCC	365
Royal Mail	Offices	Existing		1,065	183	Actual	CSE	75
Matlock Town Council Imperial Rooms	Recreational	Existing		460	108	Estimated	CSE	32
22 Bank Road Police Station	Police Station	Existing		919	177	Estimated	CSE	64
Town Hall	Offices	Existing		4,169	479	Actual	CSE	292
Lime Grove Medical Centre	Health	Existing		705	133	Estimated	CSE	61
Derbyshire Record Office	Offices	Existing		2,626	228	DEC	DCC	184
Golding House	Other Education	Existing		762	216	Estimated	CSE	53
County Hall (North Complex)	Offices	Existing		5,233	743	Benchmark	DCC	366
County Hall (South Complex)	Offices	Existing		18,531	2,869	DEC	DCC	1,297
Castle View Primary School	School	Existing		1,476	177	Benchmark	DCC	128
St Joseph's Catholic Primary School	School	Existing		1,102	144	CSE	DCC	96
Treetops (2022)	Residential	Proposed	90	-	1,162	Benchmark	-	1,206
Chatsworth Hall	Offices	Existing		5,770	1,036	DEC	DCC	404
Lilybank Hamlet	Care Home	Existing		2,760	978	Benchmark	-	504
Treetops Nursery	School	Existing		439	92	Estimated	CSE	38
Derbyshire Fire And Rescue	Emergency services	Existing		646	184	DEC	DCC	56
John Hadfield House	Offices	Existing		2,348	362	DEC	DCC	164
Cawdor Quarry (2023)	Mixed	Proposed	253	-	1,643	Benchmark	DCC	1,696
Cawdor Quarry (2028)	Mixed	Proposed	254	-	1,649	Benchmark	DCC	1,701
		Totals:	**724**	**59,024**	**21,020**			**11,231**

7.3.4 Network Routing

The topology of Matlock is shown in Figure 7-6. As it can be seen, Matlock is a significantly undulating area, with the maximum height difference between points on the network being around 80m. This will add 8Bar of static pressure to the pipework, heat exchangers and pumps etc. Care should therefore be taken to ensure proper selection of hydraulic equipment. A full topological survey has not been carried out at part of this study but shall be required if this network option is pursued. See Section 11.7.

Indicative pipework routes for the Matlock network are shown in Figure 7-7. A pipework sizing schedule for Matlock is provided in Appendix H.

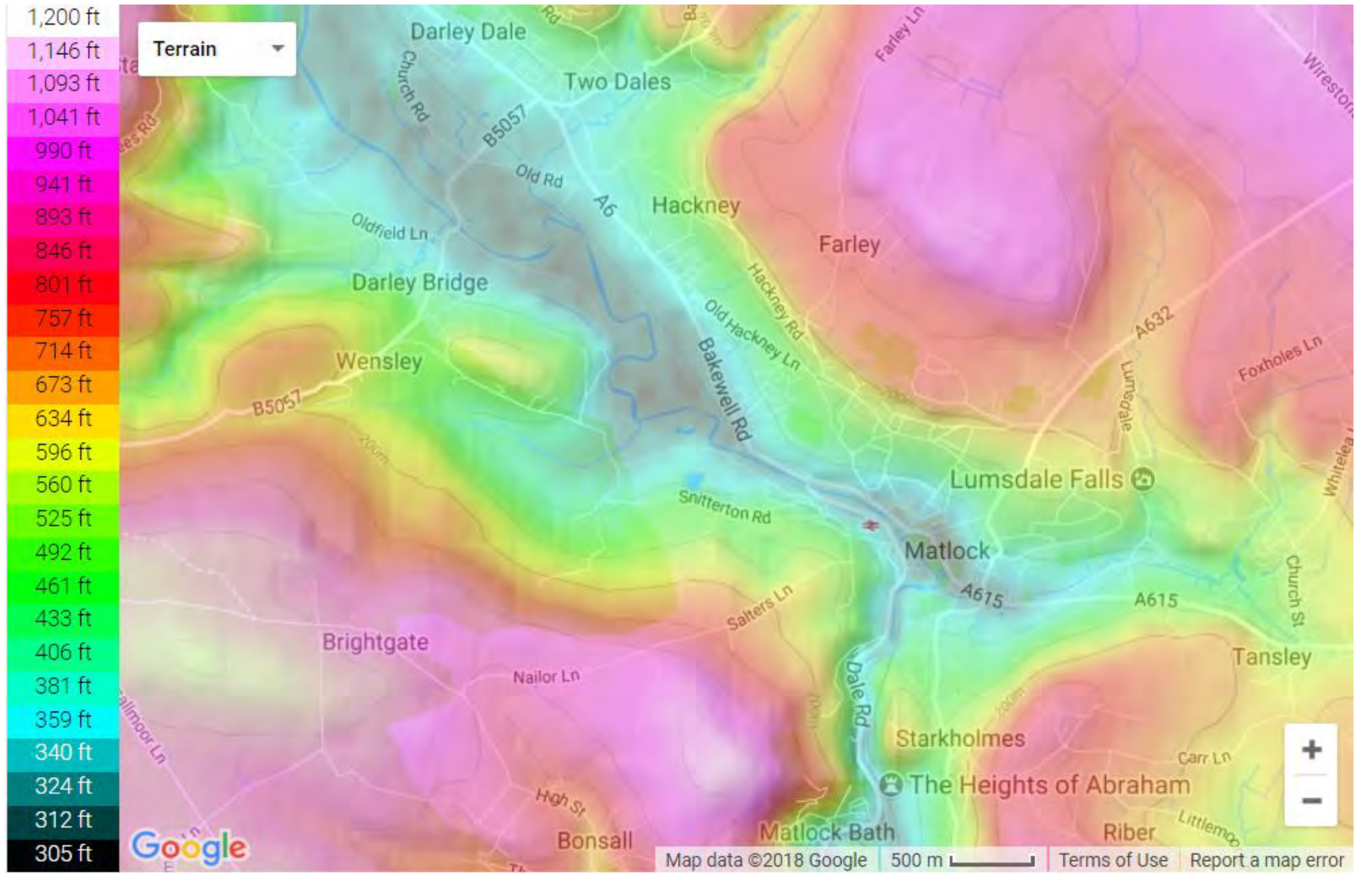


Figure 7-6: Indicative Matlock network routing

7.3.4.1 Key pipework barriers

The Enthoven facility is on the other side of a river and a railway from the wider Matlock town (highlighted in Figure 7-7 – see legend). There are also buildings to the south west of the town (such as the proposed Cawdor Quarry development) that would require crossing the railway and the river again in order to serve buildings there.

Existing crossings (i.e. road bridges or underpasses) were used to limit additional costs.

There is a bridle path that could be used to route pipework between Matlock and Darley Dale. This route would be a 'soft-dig' length of pipework. However, the requirements to cross the railway where there is currently no tunnel or bridge over it adds significant risk to this approach. As such pipework was routed along the existing road. Whilst trenching costs will be higher to lay pipework in the road, it avoids the costly crossing of the railway by using an existing crossing. The suggestion that the existing bridge could be used to support pipework needs professional verification. No other soft dig pipework opportunities were identified in Matlock.

Table 7-11: Matlock pipework barriers (see Figure 7-7 for barrier referral numbers)

Barrier no.	Description	Risk level	Mitigation strategy
1	Oldfield Lane stream crossing	Low	Ensure road cover depth over stream is sufficient to allow pipe installation. Check for other services.
2	B5057 River Derwent Crossing	High	Ensure road cover depth in bridge is sufficient to allow pipe installation. Review record drawings of bridge. Check for other services.
3	Old Road Warney Road and Peak Railway Crossing	High	Ensure road cover depth in bridge is sufficient to allow pipe installation. Review record drawings of bridge. Check for other services.
4	Peak Railway bridge over the River Derwent	High	Carry out more detailed survey of crossing. Engage with Peak Railway who operate the railway to assess their appetite for allowing pipework to be run under existing bridge.

7.3.5 Enthoven Battery Recycling Facility

The Enthoven battery recycling facility is located in South Darley DE4 2LP, around 4km from Matlock town centre. The facility has been investigating the use of its waste heat for a number of years, including through Sheffield University where a PhD student is researching the viability of a district heating network supplied by heat recovered from the plant.

As part of this study, the AECOM Energy Team attended a site visit/engagement meeting at the facility, to assess how heat is currently rejected on site. Enthoven provided the following details around the heat rejected on site that could be recovered:

- C. 2MW of heat rejected constantly at 90°C from the main furnace cooling towers
- C. 1MW of heat rejected constantly at lower temperature (exact temperature unknown) from the flue gas desulphurisation plant condenser
- C. 1MW higher temperature heat (exact temperature unknown) rejected constantly from the high temperature cooling system

Capturing the waste heat would require some upgrades to plant at the facility. The costs of these upgrades are included in the financial modelling of this network, i.e. the network operator would bear the costs of modifications at Enthoven.

Plant downtime due to maintenance was quoted at 2 – 3 days per month. As such, the model assumes 90% availability of heat from the facility.

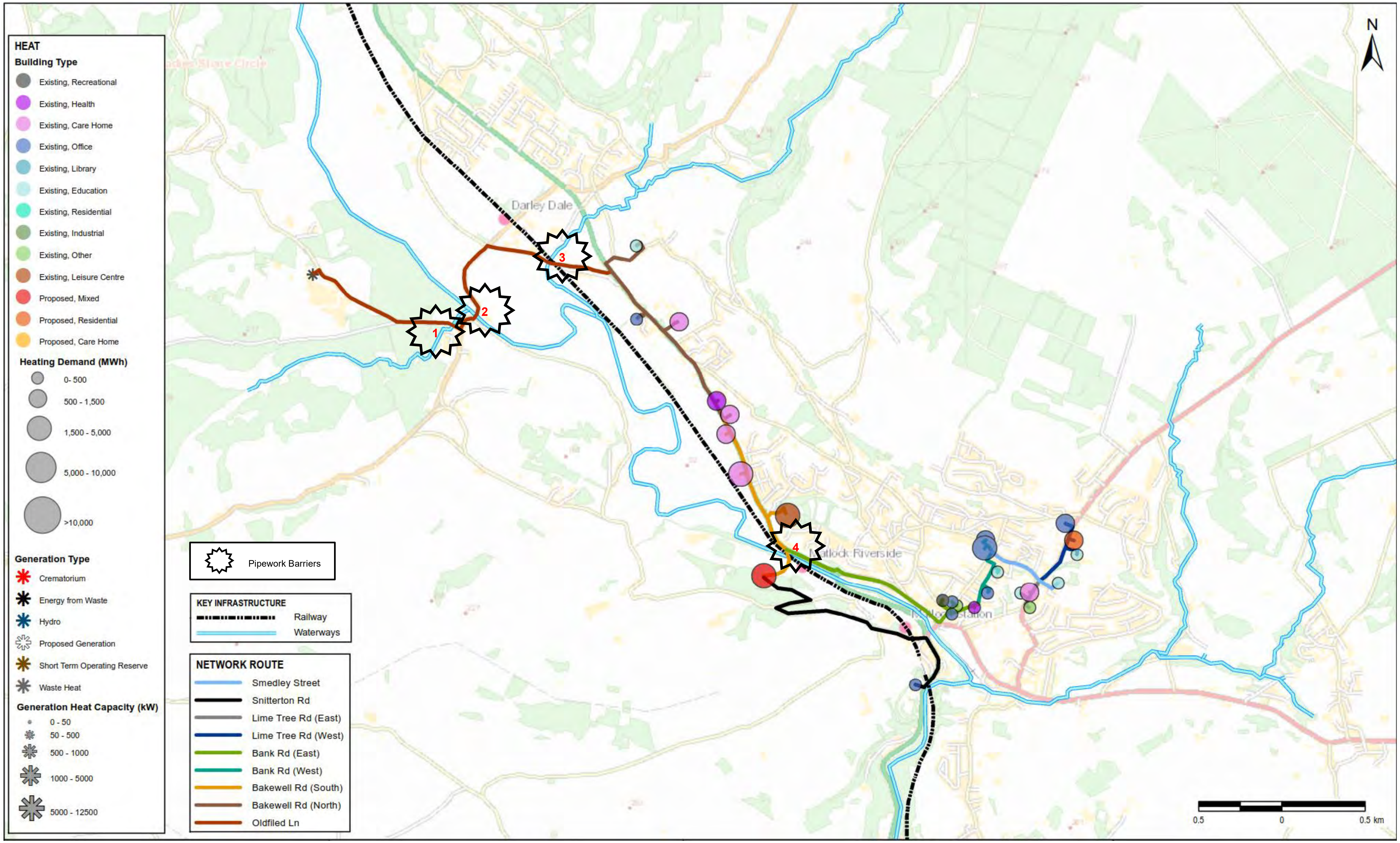


Figure 7-7: Indicative Matlock network routing with identified key network routing barriers (see also Table 7-11)

7.3.6 Energy Centre Considerations

Enthoven own significant amounts of land around the existing plant, and expressed an interest in hosting the energy centre on their site. Full boiler plant back up provision will be required for times when recovered heat is unavailable. Significant thermal storage is proposed to balance the supply of waste heat with demands.

Having analysed the peak annual heating demands and diversity of loads required for the indicative Matlock network, together with other key considerations such as boiler resilience and heat exchanger provision, the appropriate composition of EC plant is presented in Figure 7-8.

The numbers given represent the requirements for the whole network; further granularity on various network options is provided in Section 9

Table 7-12 Proposed network technical parameters - Matlock

	Parameter	Value
Demand	Network peak heating demand (assuming full build out), MW	7.9
EfW	Enthoven thermal output capacity, MW	4.0
	EfW heat availability	90%
Boiler plant	Phase 1 (2020) boiler capacity, MW	6.0
	Phase 2 (2025) boiler capacity, MW	4.0
	Assumed boiler efficiency	86%
Thermal storage	Thermal storage (30l per kW), m^3	300
	Thermal storage delta T, K	30
Ancillaries	Ancillary equipment electrical demand (as % of thermal output)	5%
Space	Energy centre footprint, m^2	250
Utilities	Gas main extension required (assumed), m	0

7.3.7 Phasing

The network development has been phased to capture phasing in the future developments. It has been assumed that the boiler installation will be split into two phases held in 2020 and 2023 respectively. The peak demand and plant installation for the full build out over these two phases is illustrated in Figure 7-8. Boiler plant is sized to meet the full network demand with N+1 resiliency, assuming no input from Enthoven. This ensures demand can be met if the Enthoven plant is not operational.

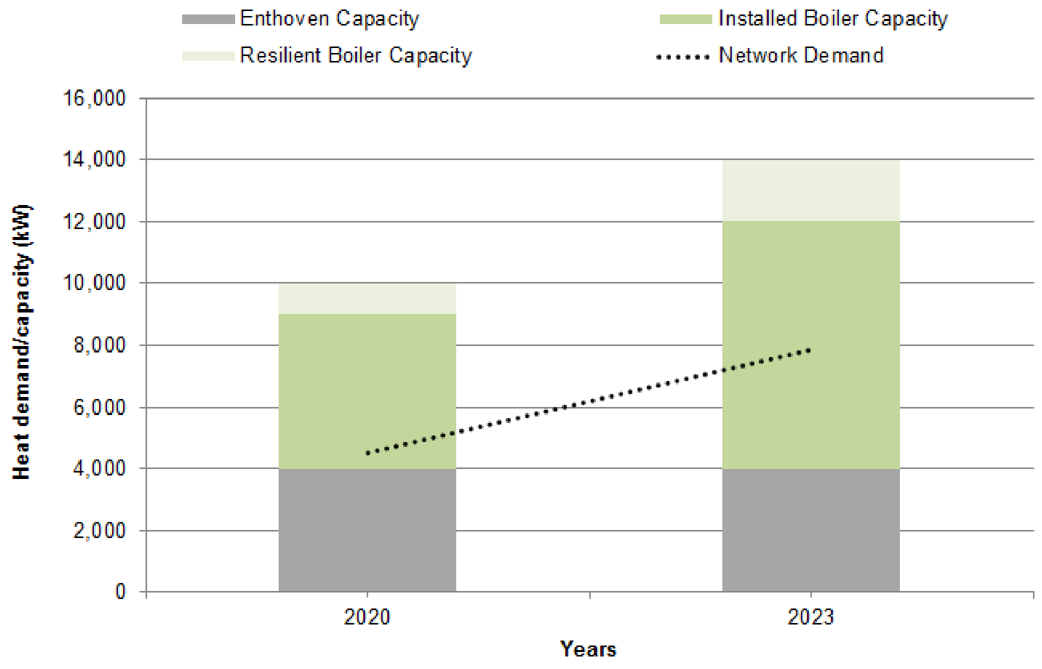


Figure 7-8 Phasing in heat demand and plant installation

7.4 Chesterfield Energy Masterplanning

As there is no adequate third party supplier of (waste) heat within the Chesterfield region, a range of heat generation technologies were appraised to identify which technologies are best suited to the area. The results of this appraisal are provided below in section 7.4.1.

7.4.1 Heat Generation Appraisal

Table 7-13 and Table 7-14 present the results of the Chesterfield technology appraisal for years 0-15 and years 15+, with rank 1 representing the most viable technology. The assessment presented here seeks to identify constraints and advantages associated with the use of different technologies in Chesterfield, providing a first indication as to which might be suitable. Their specific potential for use in Chesterfield is further discussed later in this section, taking into consideration their proximity to the site, their heat capacity to serve the heat requirements of the network and any potential risks associated with their use. See Section 7.2.1 and 7.3.1 for more discussion around heat generation technologies. The methodology behind the assessment is provided in Appendix E.

The analysis shows that among the low carbon technologies tested, gas-fired CHP is considered to be the most viable current option for serving a DH network in Chesterfield. The expected size and profiles of the heat demands that have been identified for a DHN in Chesterfield will be well suited for the use of a gas-CHP system, enabling the delivery of significant run hours of gas-CHP engines at a scale that will generate significant quantities of electricity, providing both carbon savings (in the short to medium term) and financial returns.

Both Air and Ground Source Heat Pumps require additional areas for plant. The River Rother that runs through Chesterfield is stated to have a heating capacity of 2.8MW on the national heat map[16] (see Figure 7-9). The buildings on the network are mainly existing and are likely to require conventional heating supply temperatures of 80°C or more. Such high supply temperatures make heat pumps inefficient. With the prevailing spark gap (i.e. the difference in price between gas and electricity), heat pumps must operate at high efficiencies to compete with combustion technologies; as such water source heat pumps are not recommended initially.

No significant emitters of waste heat were identified in Chesterfield, however, so its current suitability in this case is low. Currently EfW is not suitable due to no such plant currently located or planned to be in the vicinity.

In light of the decarbonisation of the grid, it is expected that gas-led technologies will not be as favourable as other options in the future (see 15+ years technology appraisal, Table 7-14). Predicting future grid decarbonisation as well as future fuel prices is inherently difficult. If the council are to pursue a gas-fired CHP network in Chesterfield, reassessing the heat generation technology throughout the project will be vital if it is to continue to deliver carbon savings cost effectively beyond the lifetime of the first engines (typically after 10-15 years).

Overall, taking into account the criteria listed above, gas-fired CHP was identified as currently the most viable low-carbon technology to provide heat for a DHN in Chesterfield. This would be topped-up by gas boilers, enabling the CHP engines to be reduced in size so that they pick up a significant proportion of the heat demand.

It is uncertain which technology (or combination of technologies) would be most suitable for replacing the gas-CHP plant, and therefore further investigation, accounting for the prevailing technical, regulatory and commercial climates, will be necessary. Most alternative low carbon technologies operate better with lower heating supply temperatures. DCC could develop a strategy to implement this. However, it is often costly and difficult in existing buildings. Whilst biomass/biofuel CHP technologies score lower in the 15+ year assessment, they have additional benefits of being able to provide operating temperatures in line with gas CHP, and would ensure the private wire electricity agreement with the hospital could be maintained. Fuel cell CHP is not included in the assessment, but may play a role in the energy mix in the future and would also be a good replacement for gas CHP. There are inherent risks involved with recommending what is appropriate in the future and it is important that Chesterfield remains flexible in the future to allow for change.

Figure 7-9 Water source heat potential in Chesterfield

[16] http://nationalheatmap.cse.org.uk/

Table 7-13: Chesterfield Technology appraisal matrix (0-15 years)

		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10	Option 11	Option 12	Option 13
Category	**Name Ref**	**Gas Fired CHP**	**Biomass Fired CHP**	**Biofuel Fired CHP**	**Energy From Waste**	**Biomass Boiler**	**Biofuel Boiler**	**Geothermal**	**Anaerobic digestion**	**Air Source Heat Pumps**	**Water Source Heat Pump**	**Ground Source Heat Pump**	**Heat recovery from industry**	**Solar Thermal**
Technical	Technology maturity and availability	5	4	4	4	4	4	1	4	4	4	4	4	3
	Suitability for scale and profile of heat demand	4	4	4	3	4	4	3	2	3	3	3	3	1
	Security of supply	4	2	2	4	2	2	3	4	5	4	4	3	3
	Suitability for required supply temperatures	5	5	5	5	5	5	3	5	2	2	2	4	3
	Proximity to heat demands	5	5	5	1	3	3	1	1	4	3	4	1	3
Environmental	Level of CO2 emission savings	4	4	4	5	4	4	5	5	3	3	3	5	5
	Air quality implications	2	1	1	4	1	1	5	4	5	5	5	5	5
	Wider environmental impacts	3	3	3	4	3	3	3	4	3	3	3	5	3
Financial	Technology cost	4	3	3	4	4	4	1	4	4	4	3	4	3
	Impact on scheme financial viability	4	3	3	3	3	3	1	3	3	3	3	4	3
	Long term financial risks	3	3	3	2	3	3	2	2	3	3	3	3	4
Deliverability	Suitability to Chesterfield	5	5	5	1	4	4	1	1	3	3	3	2	2
	Implications for energy centre size/design	4	3	3	4	3	3	5	4	4	4	4	4	4
	Implications for additional space requirements	5	3	3	5	3	3	5	5	1	4	1	5	2
	Reliance on third parties	5	2	2	1	3	3	5	1	5	5	5	1	4
	Total score (%)	81.60	66.80	66.80	69.60	65.60	65.60	57.20	68.80	70.00	70.40	67.60	74.40	67.20
	Rank	1	9	9	5	11	11	13	6	4	3	7	2	8

Table 7-14: Chesterfield Technical appraisal matrix (15+ years)

		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10	Option 11	Option 12	Option 13
Category	Name Ref	Gas Fired CHP	Biomass Fired CHP	Biofuel Fired CHP	Energy From Waste	Biomass Boiler	Biofuel Boiler	Geothermal	Anaerobic digestion	Air Source Heat Pumps	Water Source Heat Pump	Ground Source Heat Pump	Heat recovery from industry	Solar Thermal
Technical	Technology maturity and availability	5	5	5	4	4	4	2	4	4	4	4	4	4
	Suitability for scale and profile of heat demand	4	4	4	3	4	4	3	2	3	3	4	3	1
	Security of supply	4	3	3	4	2	2	3	4	5	4	4	3	3
	Suitability for required supply temperatures	5	5	5	5	5	5	3	5	4	4	4	4	3
	Proximity to heat demands	5	5	5	1	3	3	1	1	4	3	4	1	3
Environmental	Level of CO2 emission savings	2	4	4	5	3	3	5	5	5	5	5	5	5
	Air quality implications	1	1	1	4	1	1	5	4	5	5	5	5	5
	Wider environmental impacts	2	2	2	4	2	2	3	4	3	3	3	5	3
Financial	Technology cost	4	4	4	4	4	4	2	4	4	4	3	4	3
	Impact on scheme financial viability	4	3	3	3	3	3	1	3	3	3	3	4	3
	Long term financial risks	3	3	3	2	3	3	2	2	3	3	3	3	4
Deliverability	Suitability to Chesterfield	5	5	5	2	4	4	1	2	3	3	3	2	2
	Implications for energy centre size/design	4	3	3	4	3	3	5	4	4	4	4	4	4
	Implications for additional space requirements	5	3	3	5	3	3	5	5	1	4	1	5	2
	Reliance on third parties	5	2	2	1	3	3	5	1	5	5	5	1	4
	Total score (%)	74.80	70.40	70.40	71.20	62.80	62.80	60.40	70.40	77.20	77.60	75.60	77.60	69.20
	Rank	5	7	7	6	11	11	13	7	3	1	4	1	10

7.4.2 Building Prioritisation

The assumptions made on the phasing of construction and dwelling areas of new developments in Chesterfield are provided in Table 7-15.

The buildings considered for connection to the Chesterfield heating network are listed below in Table 7-17.The Chesterfield area contains a number of proposed new developments as shown in the table.

Table 7-15: Chesterfield new developments

Development name	Phasing details	Source	Number of residential units	Dwelling and area breakdown	Source
Elder Way	Single phase construction, starting in 2022	Assumed	6	Hotel, 3677 m^2 Restaurants 1910 m^2 Leisure, 1513 m^2	Chesterfield website[17]
Brimington Road (Waterside)	Construction over 3 phases, 10 year to full build out, construction starting 2021	Assumed	1,200	Average dwelling area 83m^2 16 hectare mixed use area	Chesterfield Waterside[18]
Basil Close	Single phase construction, starting in 2022	Assumed	180	10% 2 bed, 80m^2 60% 3 bed, 120m^2 30% 4 bed, 160m^2 Average area 128m^2	Planning application[19] Full breakdown is assumed, based on similar developments in the county
Brampton	Two phase construction, 5 years to full build out, construction starting 2020	Assumed	413	Average area 128m^2	Chesterfield website[20] Average area assumed is based on similar developments in the county

7.4.3 Surveys

A site visit to Chesterfield took place on the 21/11/2017. Some particular points of note include:

- Chesterfield Royal Hospital is an extensive site with many buildings and will likely need several connections
- A school is situated on Hay Hill – St Peter and St Paul school
- There is a new housing development behind House Surgery and N.E Derbyshire Council offices – Woodall Homes
- Magistrate Court is now closed and To Let
- Evidence of an area of light industrial units - Sonoco and Boythorpe Business Park
- Some existing gas infrastructure next to Boythorpe Road

[17] http://www.chesterfield.co.uk/wp-content/uploads/2015/09/chesterfield_elderway.pdf
[18] http://www.chesterfieldwaterside.com
[19] http://planapps-online.ne-derbyshire.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=OMA6AGLIJ8700
[20] http://www.chesterfield.co.uk/developments/walton-works/

7.4.4 Network Routing

The topography of Chesterfield is shown in Figure 7-10. As it can be seen, there is a 75m height difference across the network. This would add 7.5 Bar to the static pressure in the network, if no hydraulic separation is used to isolate sections of the network from one another. Careful consideration of hydraulic equipment must be ensured.

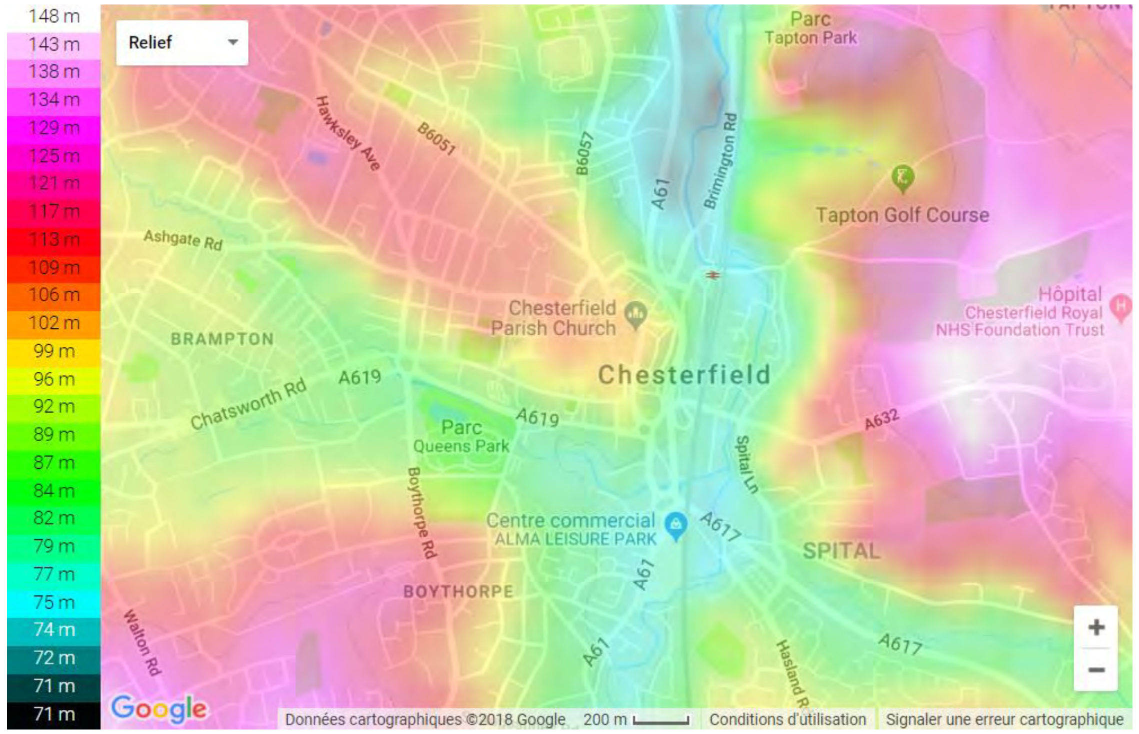


Figure 7-10 Chesterfield topography

Based on the physical barriers identified, an indicative pipework route for the Chesterfield network is shown in Figure 7-11. No soft dig opportunities were identified for the network.

7.4.4.1 Key pipework barriers

Where crossing of the railway and local waterways were necessary, existing crossings (i.e. road bridges or underpasses) were used to limit additional costs.

The pipework route between the hospital and the main town centre is proposed to be laid in the A632, which passes underneath the railway and the A52. Detailed surveys will be required to ensure that this is feasible; there is a risk that this road already contains significant existing buried infrastructure, due to its strategic routing under the busy road and railway.

Table 7-16: Clay Cross pipework barriers (see Figure 7-3 for barrier referral numbers)

Barrier no.	Description	Risk level	Mitigation strategy
1	A632 bridge crossing over River Rother	High	Assess depth of bridge and existing services
2	A632 tunnelled route under railway	Med.	Assess existing services routed under railway. Initial surveys did not flag any obvious large key services routed here, hence risk profile is Medium.
3	A632 tunnelled route under A52	Med.	Assess existing services routed under road. Initial surveys did not flag any obvious large key services routed here, hence risk profile is Medium.
4	Boythorpe Road crossing over Holme Brook	Med.	Assess depth of bridge and existing services

Table 7-17: Chesterfield building list

Building Name	Building Type	Building Age	No.of units	Area Used	Heat Demand used			Electric Demand used	Peak Demand
			no.	m^2	MWh	Source	Ref.	MWh	kW
Chesterfield and North Derbyshire Royal Hospital	Health	Existing		88,114	24,584	Actual	CSE	11,807	7,666
St Peter & St Paul School Trust	School	Existing		2,106	182	Benchmark	-	53	183
Jobcentre Plus, Markham House	Offices	Existing		2,279	283	Actual	CSE	121	160
H M Revenue & Costums, Markham House	Offices	Existing		1,505	128	Estimated	CSE	212	105
DWP, Beetwell House	Offices	Existing		3,348	475	Actual	CSE	191	234
Derbyshire Constabulary	Police station	Existing		6,825	1,003	Actual	CSE	853	478
Chesterfield Central Library	Library	Existing		4,208	467	Actual	CSE	497	366
Chesterfield & District Register Office	Offices	Existing		606	128	Estimated	CSE	33	42
Post Office, 1 Future Walk	Offices	Existing		9,970	808	Actual	CSE	1,525	698
Office 3 Market Hall	Offices	Existing		4,010	618	Actual	CSE	429	281
Elder Way (2022)	Mixed	Proposed	6	-	1,122	Benchmark	-	656	626
Town Hall	Offices	Existing		8,810	899	Actual	CSE	396	617
North Derbyshire Commmunity Drug Team, Bayheath House	Offices	Existing		993	189	Estimated	CSE	116	70
Pomegranate Theatre	Recreational	Existing		1,340	189	Actual	CSE	115	94
Winding Wheel, New Exibition Centre, 13 Holywell Street	Recreational	Existing		3,194	588	Actual	CSE	208	224
Chesterfield Magistrates Court	Offices	Existing		3,729	518	Estimated	CSE	485	261
Alexandra Private Hospital	Health	Existing		1,650	529	Benchmark	-	79	144
The Court House	Offices	Existing		475	37	Benchmark	-	61	33
National Probation Service, 3 Brimington Road	Offices	Existing		732	141	Actual	CSE	71	51
Brimington Road (Waterside) (2021)	Mixed	Proposed	310	-	2,271	Benchmark	-	930	2,071
Brimington Road (Waterside) (2026)	Mixed	Proposed	610	-	4,980	Benchmark	-	2,899	4,616
Brimington Road (Waterside) (2031)	Mixed	Proposed	611	-	4,927	Benchmark	-	2,784	4,456
Basil Close (2022)	Mixed	Proposed	180	-	1,244	Benchmark	-	300	1,279
St Helena Centre	University	Existing		3,103	794	Actual	CSE	118	270
Riverdale Care Home	Care Home	Existing		1,378	488	Benchmark	-	81	83
Chesterfield College of Technology & Arts	University	Existing		32,801	4,587	Benchmark	-	2,014	2,854
Queens Park Conference Centre	Leisure Centre	Existing		5,129	2,426	Actual	CSE	544	446
Wallis Barracks	Recreational	Existing		2,691	261	Actual	CSE	100	188
Parkside Community School	School	Existing		5,577	759	Estimated	CSE	117	485
William Rhodes Primary School	School	Existing		2,083	180	Benchmark	-	52	181
Brampton (2020)	Mixed	Proposed	37	-	312	Benchmark	-	176	505
Brampton (2025)	Mixed	Proposed	376	-	2,771	Benchmark	-	994	2,830
Totals:			**2,124**	**196,655**	**58,888**			**29,017**	**32,596**

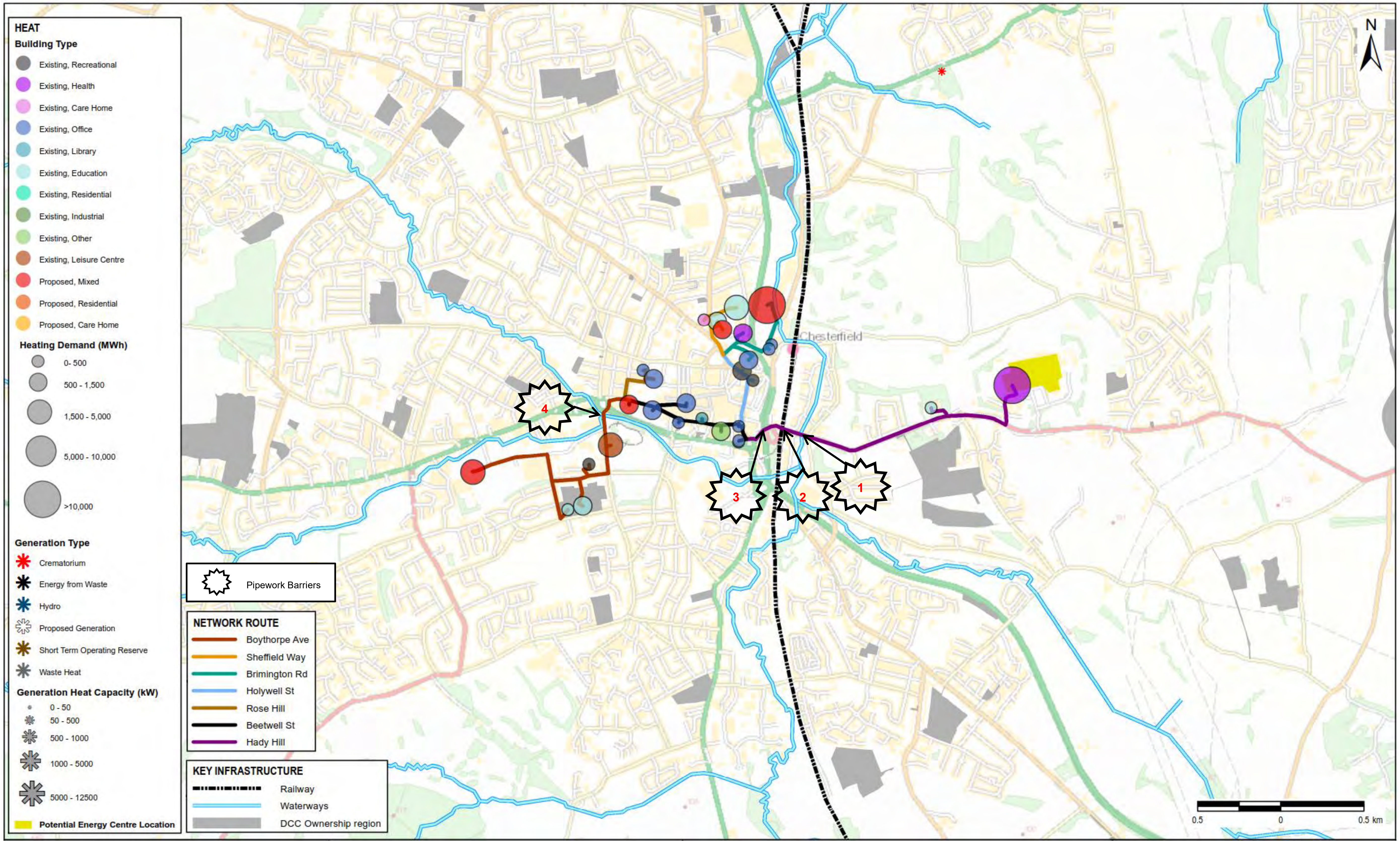


Figure 7-11 Indicative Chesterfield network routing with identified key network routing barriers (see also Table 7-16).

7.4.5 Energy Centre Considerations

Having analysed the peak annual heating demands and diversity of loads required for the indicative Chesterfield network, together with other key considerations such as boiler resilience and CHP heat provision, the appropriate composition of EC plant is presented in Table 7-18. The numbers given represent the requirements for the whole network; further granularity on various network options is provided in Sections 8, 9 and 10.

Table 7-18: Proposed network technical parameters –Chesterfield

	Parameter	Value
Demand	Diversified network peak heating demand (assuming full build out), MW	22.9
CHP	Engine Size, MW	2.5
	No. engines	3
	Turndown	50%
	Electrical efficiency	39%
	Thermal efficiency	41%
Boiler plant	Phase 1 (2020) boiler capacity, MW	14.0
	Phase 2 (2025) boiler capacity, MW	12.0
	Assumed boiler efficiency	86%
Thermal storage	Thermal storage (30l per kW), m^3	420
	Thermal storage delta T, K	30
Ancillaries	Ancillary equipment electrical demand (as % of thermal output)	5%
Space	Energy centre footprint, m^2	1,760
Utilities	Gas main extension required (assumed), m	200

The location of the energy centre is a key consideration for the Chesterfield network. No particular area was earmarked by the council prior to this study. Council owned land in Chesterfield town centre is fairly limited – especially considering the scale of the required energy centre.

It is AECOM's suggestion that the energy centre is located on the site of (or near to) the Chesterfield and North Derbyshire Royal hospital. With the hospital being a key anchor load for the network, both in terms of heat and electricity export, locating the energy centre nearby would cut pipework and cabling costs.

Engagement with the hospital is required to assess the viability of this proposal.

7.4.5.1 Electricity generation and export

The electricity generated by CHP plant in the energy centre will surpass the power consumption requirements of the energy centre itself. As such, it is proposed that power is sold privately to the adjacent hospital via a private wire arrangement. The hospital represents a good private wire electricity customer as the load requirements will be fairly constant.

It is assumed that the CHP power connection would be connected at the hospital DNO supply incomer. This would enable electricity generated by the CHP to be consumed either by the hospital or exported back to the grid via the existing connection. Enabling this solution would require significant engagement with the hospital to ensure that they are happy with the solution and that the electrical resiliency requirements are met with the proposed arrangement.

Additional power that is not consumed by the hospital shall be sold to the grid at wholesale prices (typically 50% of retail price).

Although power could also be sold to other customers on the network, this arrangement would require carrying out the complex negotiations for setting up Power Purchase Agreements (PPAs) with many individual customers. It is risky to assume that this would be possible/achievable. Furthermore, a private wire network would need to be installed that serves each customer on the network, leading to increased costs. It is recommended that DCC focus on securing the hospital as a primary customer for the purchase of power.

7.4.6 Phasing

The network development has been phased to capture phasing in the future developments. It has been assumed that the boiler installation will be split into two phases held in 2020 and 2025 respectively. The peak demand and plant installation for the full build out over these two phases is illustrated in Figure 7-12.

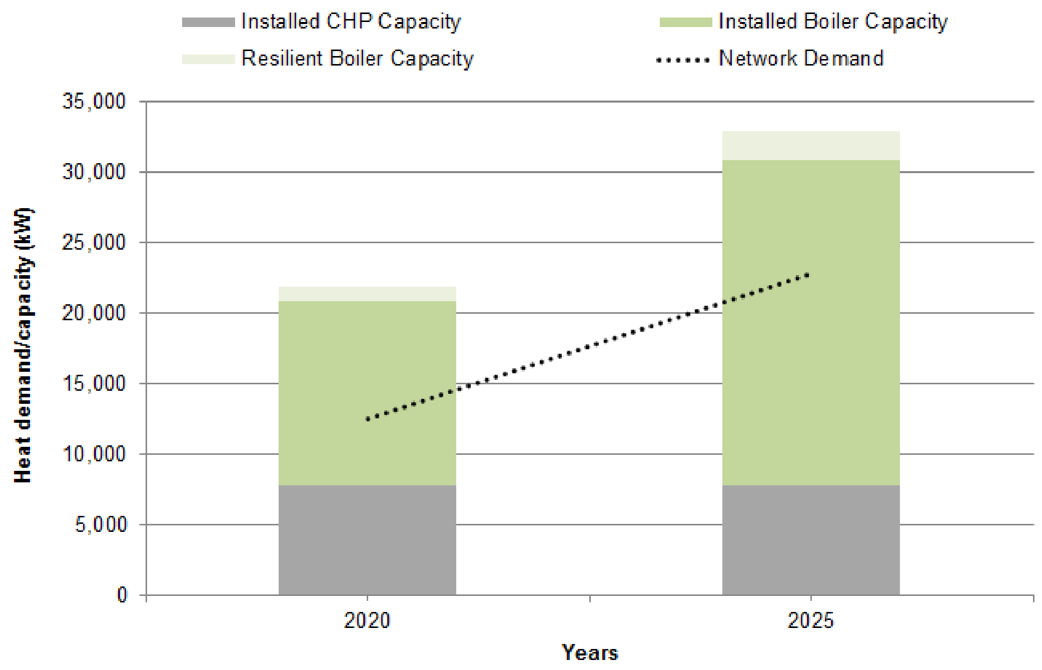


Figure 7-12: Phasing in heat demand and plant installation- Chesterfield

8. Techno-Economic Modelling Results: Clay Cross

As described in the TEM methodology and assumptions in Appendix F, various scenarios of the Clay Cross network have been investigated, as detailed in Table 8-1 and Figure 8-1. Due to the high number of user-variable parameters in the model, not all results can be presented in this report. Instead, sensible values have been chosen (as given in Appendix F) and the resultant outputs detailed in this section. Thereafter, a sensitivity analysis is carried out to identify the effects of various parameters on system feasibility.

Where results are shown against a 'counterfactual', this refers to the 'do-nothing' base case, i.e. where buildings are assumed to have their own individual boiler plant.

Table 8-1: Clay Cross modelled network scenarios

Network	Clay Cross network segment
Scenario 1	Bridge Street (North) and Harris Way
Scenario 2	Bridge Street (North & South), Harris Way, Bridge Street (South) and Market St (West)
Scenario 3	Bridge Street (North & South), Harris Way, Bridge Street (South) and Market St (West & East)
Scenario 4	Bridge Street (North & South), Harris Way, Bridge Street (South), Market St (West & East), Furnace Hill Road (East & West)
Scenario 5	Bridge Street (North & South), Harris Way, Bridge Street (South), Market St (West & East), Furnace Hill Road (East & West) and Coney Green Rd
Scenario 6	Bridge Street (North & South), Harris Way, Bridge Street (South), Market St (West & East), Furnace Hill Road (East & West) and Coney Green Rd and Brassington Lane
Scenario 7	Bridge Street (North & South), Harris Way, Bridge Street (South), Market St (West & East), Furnace Hill Road (East & West) and Coney Green Rd, Brassington Lane and Wingerworth

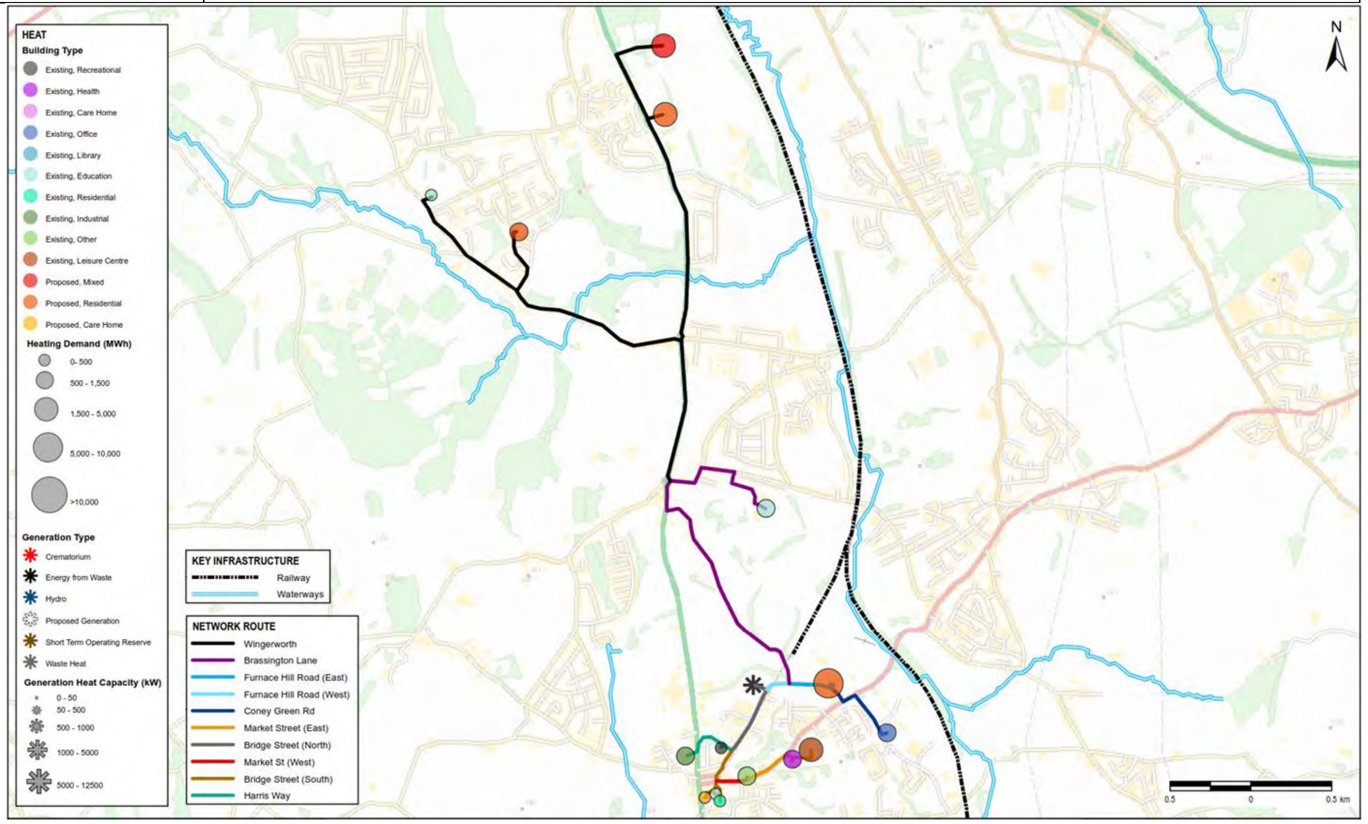


Figure 8-1 Indicative Clay Cross network routing

8.1 Technical Evaluation

The primary technical parameters that affect the resultant financial values for each network option are summarised in Table 8-1 and Table 8-2. Table 8-1 includes plant technical details and network pipework lengths whilst Table 8-2 demonstrates the energy balance being expected to occur for the network as well as for the heat recovery facility. A full breakdown of pipe sizes and flow rates is provided in Appendix H. A more detailed plant breakdown is provided in Appendix I. It is assumed that the DH network EC imports its ancillary electricity requirements from the EfW facility.

Table 8-2: Clay Cross plant technical parameters

Plant Technical Details	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Boiler plant							
Total capacity (MW_{th})	2.0	2.0	3.0	8.0	8.0	9.0	14.0
Heat recovery plant							
Heat recovery capacity (MW_{th})	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Electric capacity (MW_e)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Availability	90%	90%	90%	90%	90%	90%	90%
Energy Centre							
Footprint (m^2)	50	50	75	200	200	225	350
Distribution							
Pipework length, (m)	384	1,102	1,616	1,660	3,110	5,548	11,143
No. of new residential connections	0	90	90	1,090	1,090	1,090	1,989

Table 8-3: Clay Cross energy balance

Energy Balance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Network Thermal Energy Balance:							
Total thermal consumption (MWh_{th}/yr)	877	2,351	5,406	12,318	12,879	13,971	21,323
EfW heat import as % of total	93%	91%	91%	91%	91%	90%	88%
Total gas consumption (MWh/yr)	84	281	672	1,557	1,630	1,802	3,408
Heat recovery facility:							
Total Heat Generation (MWh_{th}/yr)	31,536	31,536	31,536	31,536	31,536	31,536	31,536
Heat export to network (MWh_{th}/yr)	937	2,463	5,641	12,831	13,413	14,522	21,598
Heat rejected (MWh_{th}/yr)	30,599	29,073	25,895	18,705	18,123	17,014	9,938
Electricity export to network (MWh_e/yr)	46	122	281	638	667	725	1,105

8.2 Economic Evaluation

A summary of the cash flows of each network scenario is provided in Table 8-4. The EfW heat and electricity costs can be viewed as revenues from the point of view of the EfW plant operator, Lark Energy. OPEX values given are for full build out of the network and will vary in the years running up to that point as the phased build out of the network progresses. Full CAPEX and OPEX breakdowns for each scenario are provided in Appendix I. Key economic outputs of the model are shown in Table 8-5, including the IRR, NPV for 25, 30 and 40 year network operation lifetimes. In line with a RIBA Stage 2 design, costs are accurate to -15%/+30%.

Table 8-4: Clay Cross cash flow summary

Financial results, £'000s	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Costs:							
CAPEX	**1,607.1**	**2,858.8**	**3,920.0**	**8,646.9**	**10,530.5**	**14,097.6**	**26,035.7**
Maintenance p.a.	22.1	45.7	60.9	140.1	175.2	237.3	444.8
Gas p.a.	6.8	14.3	34.2	79.2	82.9	91.6	152.0
EfW heat import p.a.	24.6	64.7	148.1	336.9	352.2	381.3	567.1
EfW electricity p.a.	6.3	16.8	35.8	81.4	85.1	92.4	141.0
Imported electricity p.a.	0.8	2.2	4.8	11.2	11.7	12.6	19.2
Total OPEX	**60.6**	**143.6**	**283.8**	**648.8**	**707.1**	**815.2**	**1,324.2**
Revenues:							
Residential heat p.a.	-	78.6	78.6	1,177.0	1,177.0	1,177.0	2,161.5
Commercial heat p.a.	55.5	131.8	312.1	312.1	352.5	447.6	552.5
Total connection revenues (one-off)	61.1	341.9	464.1	2,354.1	2,427.2	2,683.0	4,673.8
Simple payback	**None**	**37.7**	**32.3**	**7.5**	**9.9**	**14.1**	**15.4**

Network scenarios increase in price as more pipework is added, as well as additional loads and the associated plant required to serve them. Scenarios 4, 5, 6 and 7 include a large number of new residential developments which significantly increases the capital expenditure. Figure 8-2 shows how the CAPEX is split between the various network elements. “On-costs” refer to legal and professional fees.

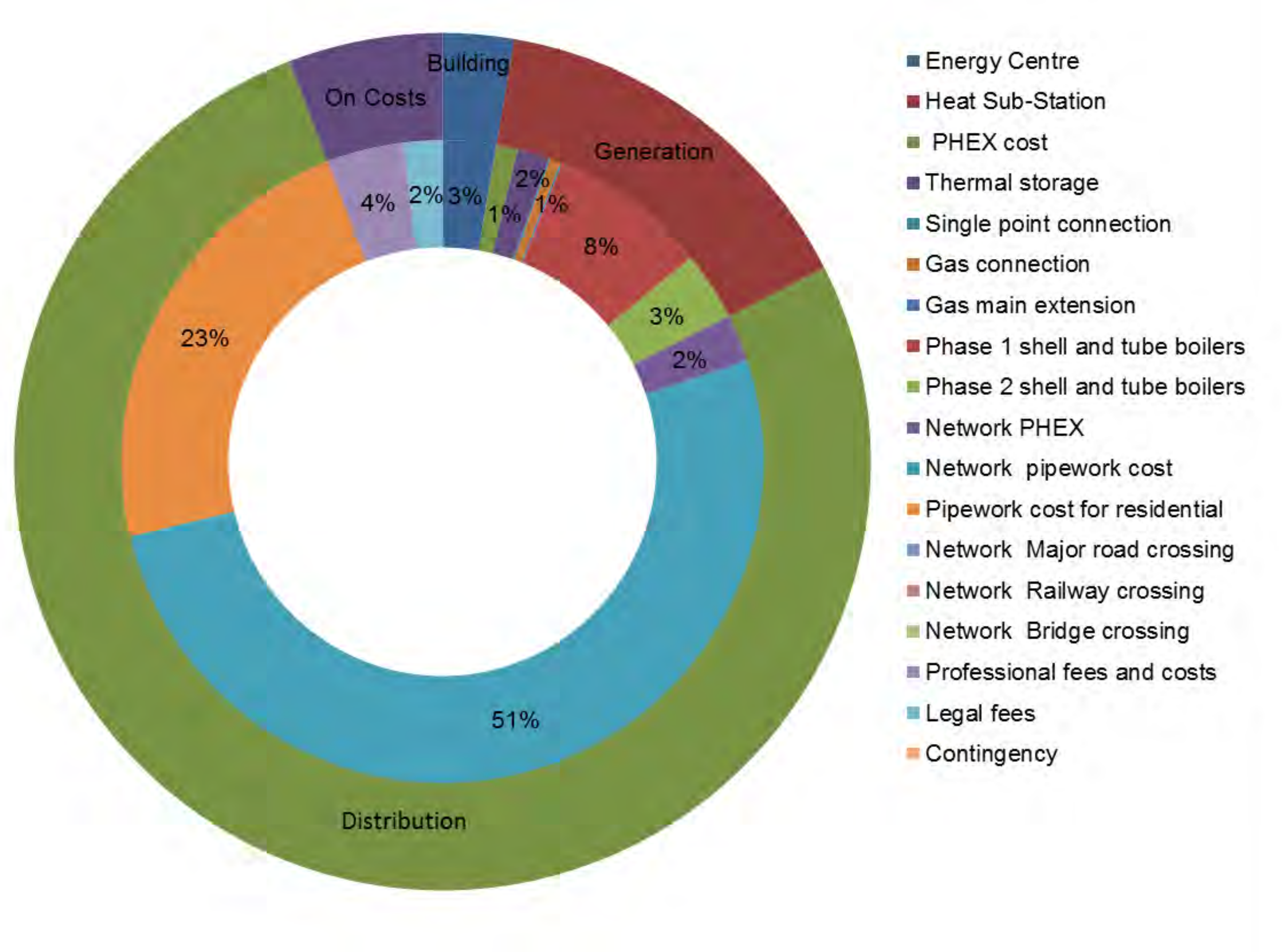


Figure 8-2: CAPEX breakdown chart – Clay Cross Scenario 7

Table 8-5: Clay Cross economic evaluation results summary

Financial assessment	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
25 Year Assessment:							
IRR (%)	-	-3.12%	-2.43%	7.54%	5.08%	2.33%	2.24%
NPV £ (000's)	-1,569	-1,429	-1,846	3,330	1,554	-1,471	-2,876
30 Year Assessment:							
IRR (%)	-	-6.96%	-4.44%	8.15%	5.83%	3.19%	3.14%
NPV £ (000's)	-1,897	-1,611	-2,054	4,446	2,665	-453	-950
40 Year Assessment:							
IRR (%)	-	-1.54%	-0.67%	8.85%	6.77%	4.45%	4.39%
NPV £ (000's)	-1,939	-1,406	-1,728	6,701	4,918	1,833	3,113

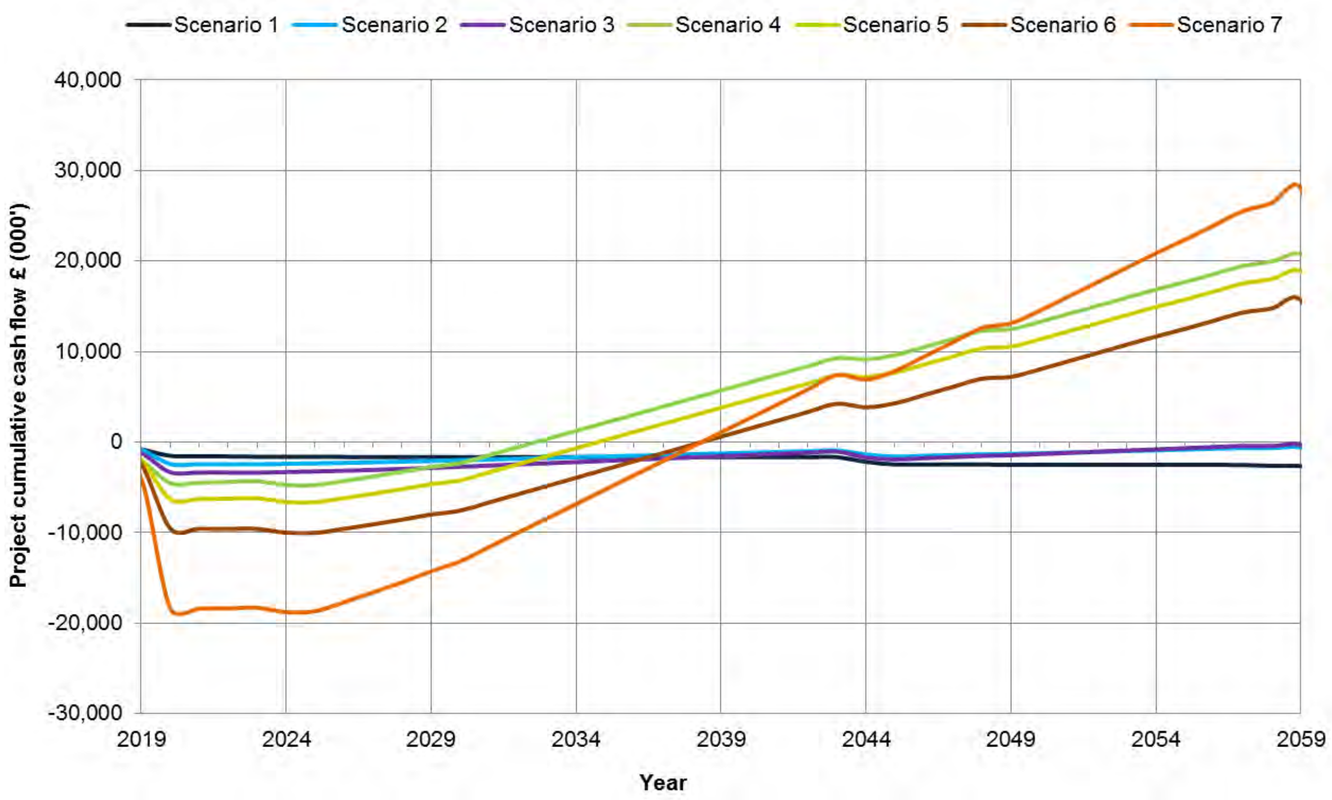


Figure 8-3 Clay Cross cumulative cash flow

Figure 8-3 shows the cumulative cash flow for network scenarios modelled over the project lifetime. The results show that among the scenarios tested, Scenario 4 presents the highest IRR and NPV. The IRR and NPV of the scheme fall when the Coney Green Rd, Brassington Lane and Wingerworth networks are connected due to increased pipework lengths necessary to service the loads in those areas. This additional pipework causes an increase in the capital cost but does not generate enough revenue to justify the additional expenditure. As such the Wingerworth and Coney Green Road connections are deemed unviable.

8.3 Carbon Emission Savings

Table 8-6 presents the carbon saving results for 25, 30 and 40 year network operation lifetimes. The cumulative carbon savings of the network scenarios for Clay Cross are shown in Figure 8-4.

The results show that Clay Cross network could offer significant carbon savings given that it imports a significant amount of heat and electricity from the heat recovery facility. This energy has a much lower associated carbon content and maximising its import increases the scheme's carbon savings. Depending on the scenario assessed, Clay Cross network could achieve cumulative carbon savings of 5,616 – 108,066 tCO_{2e} over 40 years.

Table 8-6: Clay Cross carbon emission summary

Carbon Assessment	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
25 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	138	356	824	1,524	1,610	1,773	2,560
Average annual CO_{2e} reduction (% on counterfactual)	72%	70%	70%	68%	68%	68%	65%
30 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	139	358	830	1,567	1,654	1,818	2,623
Average annual CO_{2e} reduction (% on counterfactual)	72%	70%	70%	68%	68%	68%	65%
40 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	140	361	837	1,622	1,709	1,875	2,702
Average annual CO_{2e} reduction (% on counterfactual)	72%	70%	70%	68%	68%	68%	65%
40 year cumulative:							
carbon emission savings (tonnes CO_{2e})	5,616	14,452	33,467	64,869	68,357	74,988	108,066

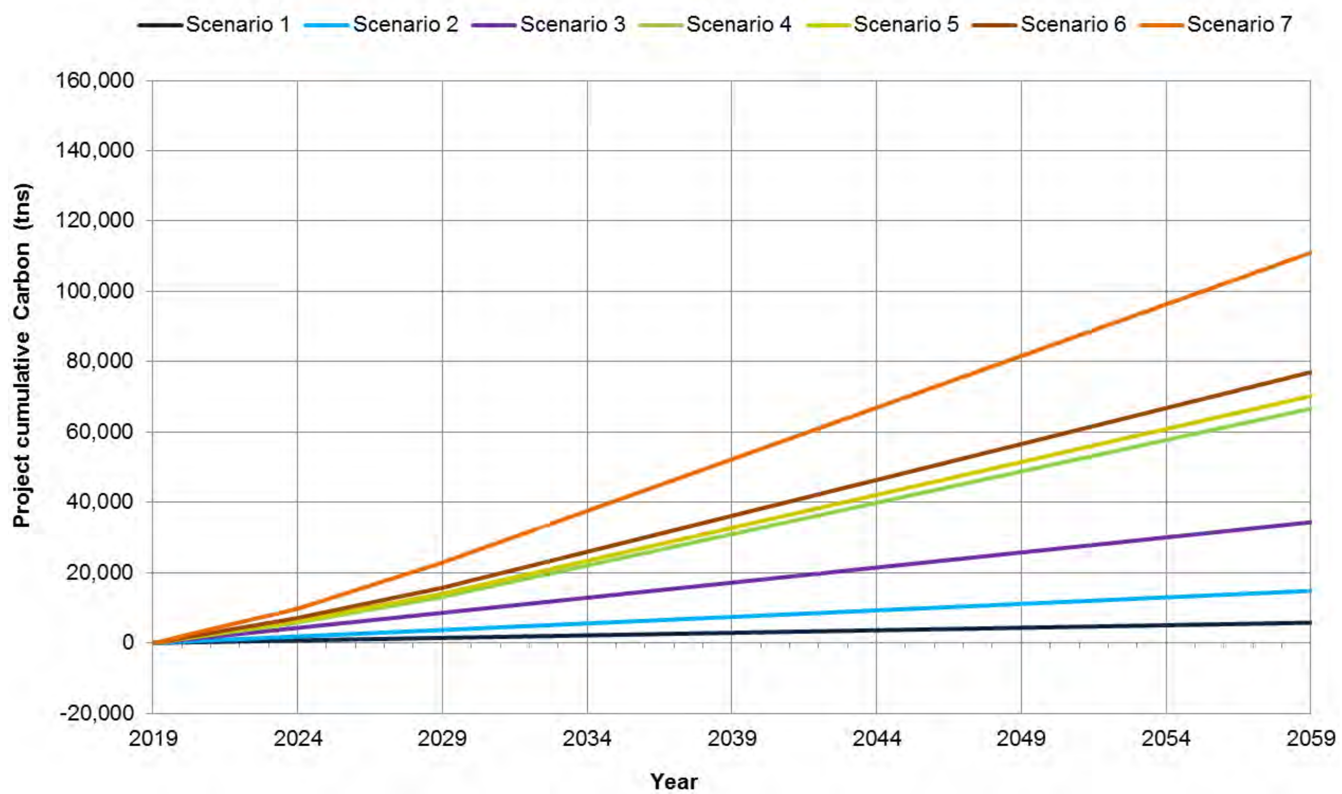


Figure 8-4 Clay Cross cumulative carbon savings

8.4 Sensitivity Analysis

Sensitivity analysis has been carried out to illustrate the effects of varying CAPEX, OPEX, heat demand, gas purchase cost, connection costs, heat purchase cost from the heat recovery facility and heat sales cost has on the IRR and NPV offered by Scenario 4. (Scenario 4 has been selected for this exercise because it is the best performing scenario for Clay Cross options.)

As can be seen in Figure 8-5 and Figure 8-6, the scheme is particularly sensitive to the cost of heat sold to the network customers, CAPEX and heat purchase cost from the heat recovery facility (see Appendix F – TEM assumptions).

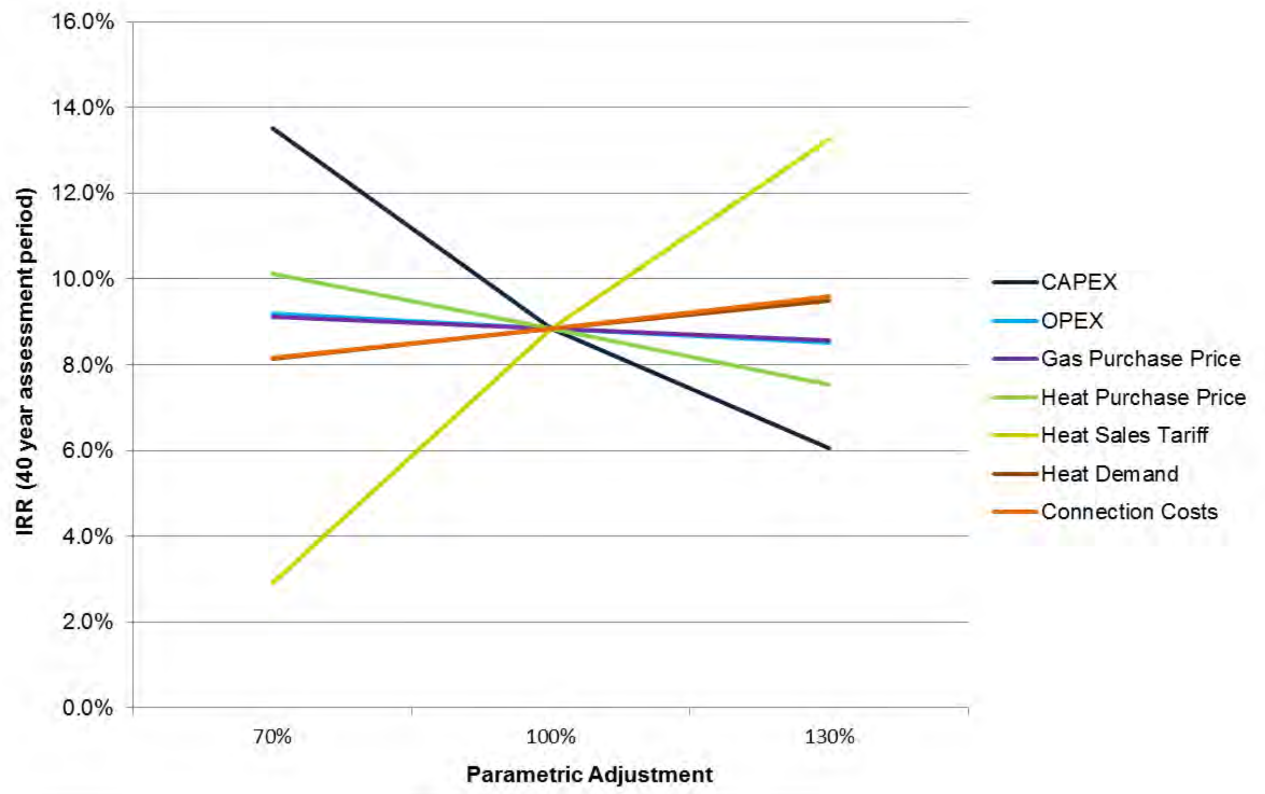


Figure 8-5 IRR sensitivity analysis for Scenario 4, showing the response to driving parameters

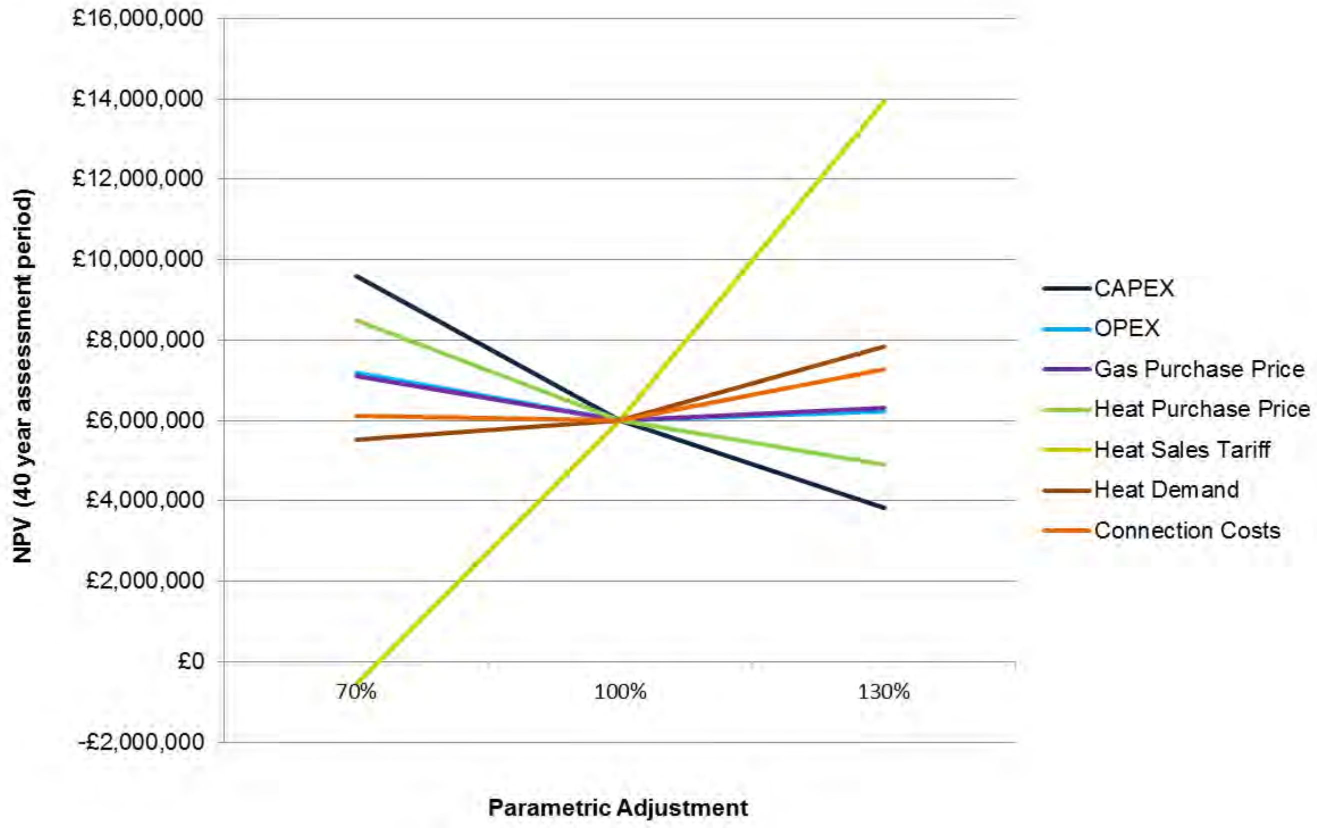


Figure 8-6 NPV sensitivity analysis for Scenario 4, showing the response to driving parameters

9. Techno-Economic Modelling Results: Matlock

This section details the results outputs from the techno-economic model for the key network scenarios identified in Appendix F and shown again in Table 9-1 and Figure 9-1 for the Matlock network. Sensible parameters for each variable have been chosen (as given in Appendix F) and the resultant outputs detailed in this section. Thereafter, a sensitivity analysis is carried out around some of the key parameters to identify the effects of various parameters on system feasibility.

Where results are shown against a 'counterfactual', this refers to the 'do-nothing' base case, i.e. where buildings are assumed to have their own individual boiler plant.

Table 9-1: Matlock modelled network scenarios

Network	Matlock network segment
Scenario 1	Oldfield Ln and Bakewell Rd (North)
Scenario 2	Oldfield Ln and Bakewell Rd (North & South)
Scenario 3	Oldfield Ln, Bakewell Rd (North & South) and Bank Rd (East)
Scenario 4	Oldfield Ln, Bakewell Rd (North & South) and Bank Rd (East & West)
Scenario 5	Oldfield Ln, Bakewell Rd (North & South), Bank Rd (East & West) and Smedley Street
Scenario 6	Oldfield Ln, Bakewell Rd (North & South), Bank Rd (East & West), Smedley Street and Lime Tree Rd (East & West)
Scenario 7	Oldfield Ln, Bakewell Rd (North & South), Bank Rd (East & West), Smedley Street, Lime Tree Rd (East & West) and Snitterton Rd

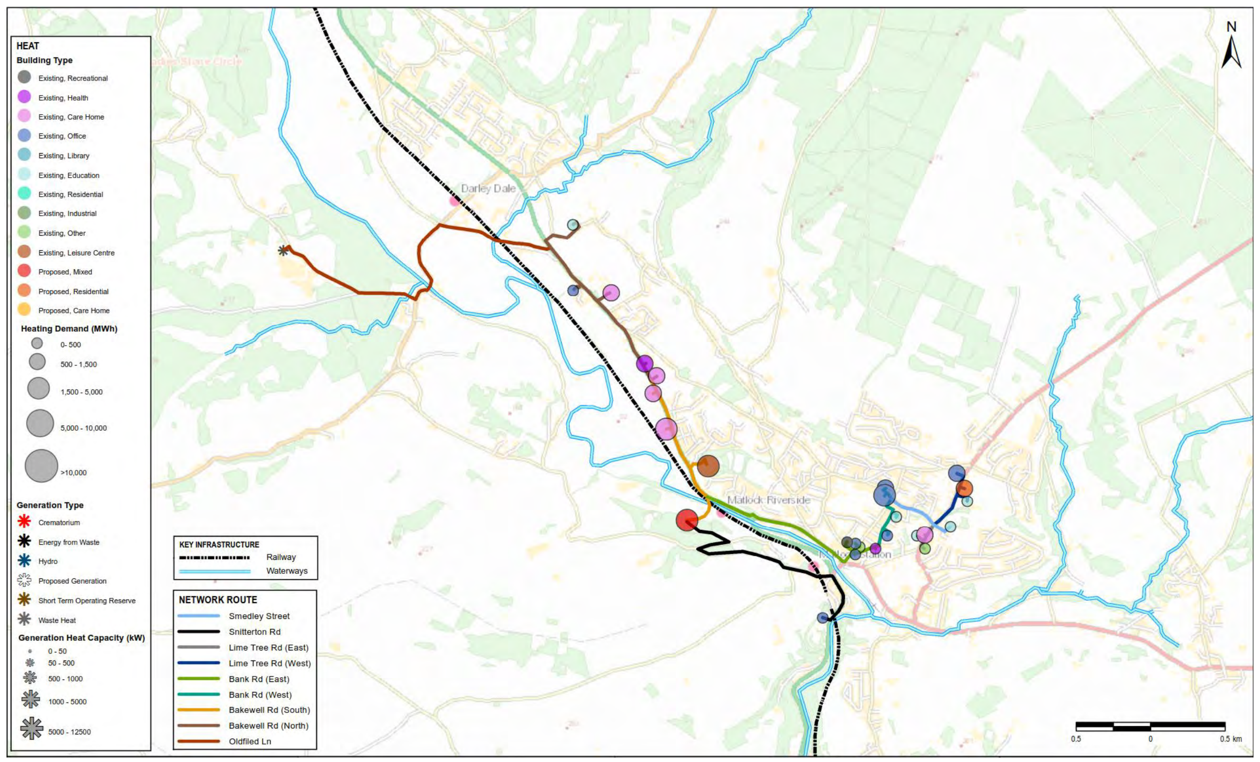


Figure 9-1 Indicative Matlock network routing

9.1 Technical Evaluation

The primary technical parameters that affect the resultant financial values for each network option are summarised in Table 9-2 and Table 9-3. Table 9-2 includes plant technical details and network pipework lengths whilst Table 9-3 demonstrates the energy balance being expected to occur for the network as well as for the heat recovery facility.

Table 9-2: Matlock plant technical parameters

Plant Technical Details	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Boiler plant							
Total capacity (MW_{th})	2.0	6.0	7.0	7.0	8.0	10.0	10.0
Heat recovery plant							
Heat recovery capacity (MW_{th})	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Availability	90%	90%	90%	90%	90%	90%	90%
Energy Centre							
Footprint (m^2)	50	150	175	175	200	250	250
Distribution							
Pipework length, (m)	4,182	5,296	7,039	7,410	8,143	9,021	10,900
No. of new residential connections	0	507	507	507	507	597	597

Table 9-3: Matlock energy balance

Energy Balance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Thermal Energy Balance:							
Total thermal consumption (MWh_{th} p.a.)	2,335	11,748	12,828	13,272	17,061	20,657	21,019
Enthoven heat import as % of total	91%	90%	90%	90%	90%	89%	88%
Total gas consumption (MWh/year)	291	1,514	1,647	1,705	2,316	3,173	3,308
Enthoven heat recovery facility:							
Heat Generation (MWh_{th} p.a.)	31,536	31,536	31,536	31,536	31,536	31,536	31,536
Heat export to Matlock network (MWh_{th} p.a.)	2,436	12,211	13,339	13,800	17,633	21,032	21,332
Heat rejected (MWh_{th} p.a.)	29,100	19,325	18,197	17,736	13,903	10,504	10,204

9.2 Economic Evaluation

A summary of the cash flows of each network scenario is provided in Table 9-4. The Enthoven heat costs can be viewed as revenues from their point of view. OPEX values given are for full build out of the network and will vary in the years running up to that point as the phased build out of the network progresses. Full CAPEX and OPEX breakdowns for each scenario are provided in Appendix I. Key economic outputs of the model are shown in Table 9-5, including the IRR, NPV for 25, 30 and 40 year network operation lifetimes. In line with a RIBA Stage 2 design, costs are accurate to -15%/+30%.

Table 9-4: Matlock cash flow summary

Financial results, £'000s	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Costs:							
CAPEX	7,457	13,420	16,064	16,552	17,941	20,085	22,555
Maintenance (at full build out)	116	188	232	241	263	297	342
Gas costs p.a. (at full build out)	15	77	84	87	118	141	148
Enthoven heat import costs	16	80	88	91	116	138	140
Imported electricity costs p.a. (at full build out)	21	97	105	109	140	170	173
Total OPEX	168	441	509	528	637	746	802
Revenues:							
Residential heat sale revenue p.a.	-	537.3	537.3	537.3	537.3	674.8	674.8
Commercial heat sale revenue p.a.	160.4	544.6	617.9	648.8	904.8	1,067.6	1,091.9
Total connection revenues (one-off revenue)	249.9	1,590.1	1,700.2	1,749.9	2,126.0	2,526.7	2,561.2
Simple payback	**None**	**18.5**	**22.2**	**22.5**	**19.6**	**17.6**	**20.7**

Figure 9-2 shows the breakdown of CAPEX between the various network elements.

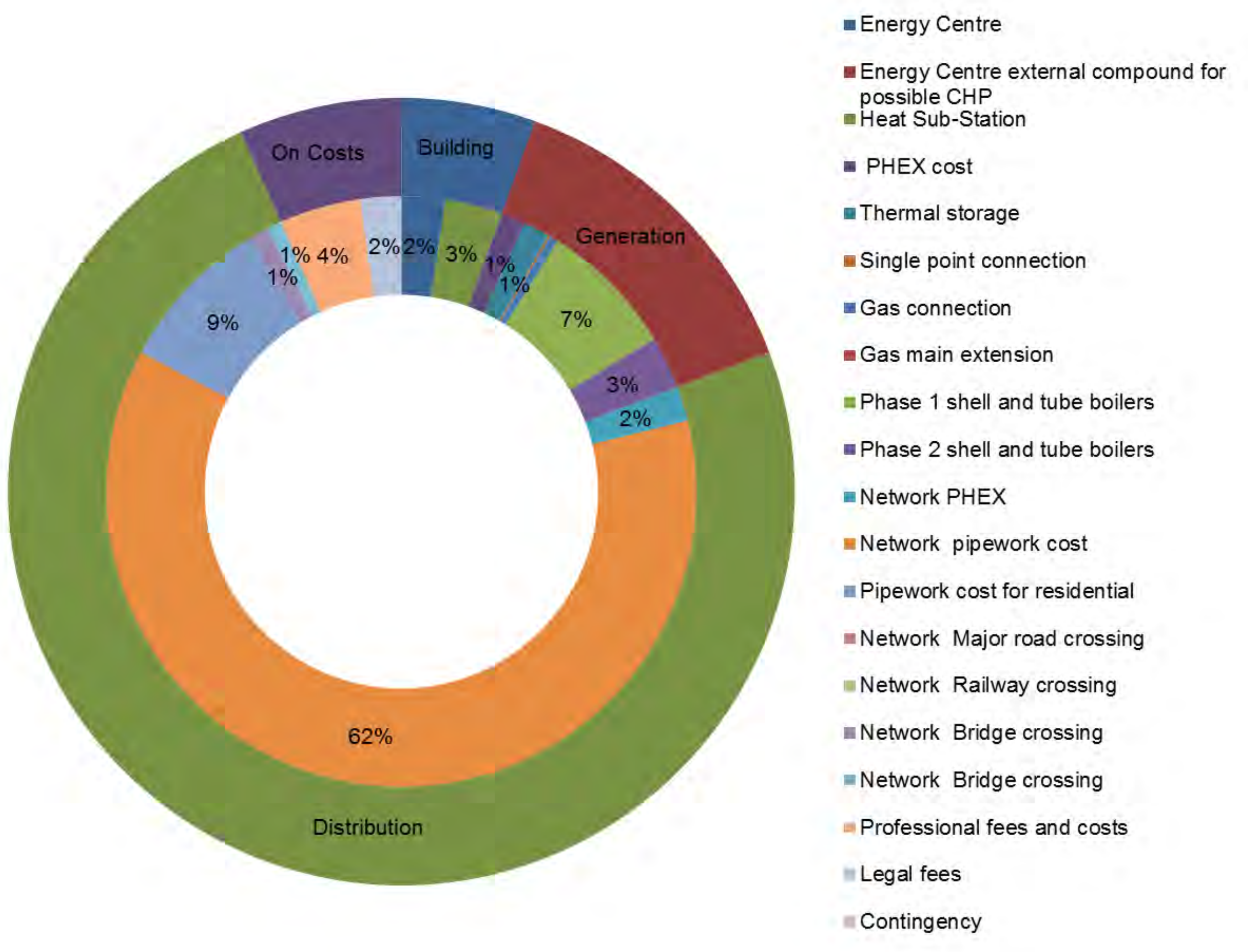


Figure 9-2 CAPEX breakdown chart – Matlock scenario 7

Table 9-5: Matlock economic evaluation results summary

Financial assessment	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
25 Year Assessment:							
IRR (%)	-12.93%	0.89%	-0.30%	-0.34%	0.73%	1.66%	0.56%
NPV (£'000s)	-£6,452	-£3,048	-£5,153	-£5,356	-£4,273	-£3,230	-£5,470
30 Year Assessment:							
IRR (%)	-	1.73%	0.54%	0.51%	1.52%	2.39%	1.38%
NPV (£'000s)	-£6,711	-£2,329	-£4,497	-£4,672	-£3,423	-£2,180	-£4,441
40 Year Assessment:							
IRR (%)	-10.74%	3.33%	2.34%	2.31%	3.14%	3.86%	3.04%
NPV (£'000s)	-£6,618	-£312	-£2,418	-£2,544	-£849	£968	-£1,321