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Job number 249913-00
# Document Verification

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- Prepared by: Candice De Bartolo
- Checked by: Ellie Kuitunen
- Approved by: Mark Anderson


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## Issue Document Verification with Document ✔
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<tr>
<td>AMR</td>
<td>Automated Meter Reading</td>
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<tr>
<td>AQMA</td>
<td>Air Quality Management Area</td>
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<td>ASHP</td>
<td>Air Source Heat Pump</td>
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<td>BSC</td>
<td>Balancing and Settlement Code</td>
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<td>BSUoS</td>
<td>Balancing Services Use of System</td>
</tr>
<tr>
<td>CAPEX</td>
<td>Capital expenditure</td>
</tr>
<tr>
<td>CCGT</td>
<td>Combined Cycle Gas Turbine</td>
</tr>
<tr>
<td>CCL</td>
<td>Climate Change Levy</td>
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<tr>
<td>CCS</td>
<td>Carbon Capture and Storage</td>
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<tr>
<td>CEC</td>
<td>Cheshire East Council</td>
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<tr>
<td>CEP</td>
<td>Community Energy Programme</td>
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<td>CHP</td>
<td>Combined Heat and Power</td>
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<tr>
<td>CHPQA</td>
<td>Combined Heat and Power Quality Assurance</td>
</tr>
<tr>
<td>CHPQFI</td>
<td>Combined Heat and Power Qualifying Fuel Input</td>
</tr>
<tr>
<td>CHPQHC</td>
<td>Combined Heat and Power Qualifying Heat Capacity</td>
</tr>
<tr>
<td>CHPQHO</td>
<td>Combined Heat and Power Qualifying Heat Output</td>
</tr>
<tr>
<td>CHPQPC</td>
<td>Combined Heat and Power Qualifying Power Capacity</td>
</tr>
<tr>
<td>CHPQPO</td>
<td>Combined Heat and Power Qualifying Power Output</td>
</tr>
<tr>
<td>CIBSE</td>
<td>The Chartered Institution Of Building Services Engineers</td>
</tr>
<tr>
<td>CfD</td>
<td>Contracts for Difference</td>
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<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>CoCo</td>
<td>Community Company</td>
</tr>
<tr>
<td>CRC</td>
<td>Carbon Reduction Commitment</td>
</tr>
<tr>
<td>DBEIS</td>
<td>Department for Business, Energy &amp; Industrial Strategy</td>
</tr>
<tr>
<td>DBO</td>
<td>Design, Build, Operate</td>
</tr>
<tr>
<td>DBOM</td>
<td>Design, Build, Operate, Maintain</td>
</tr>
<tr>
<td>DD</td>
<td>Degree Day</td>
</tr>
<tr>
<td>DEC</td>
<td>Display Energy Certificate</td>
</tr>
<tr>
<td>DECC</td>
<td>Department of Energy and Climate Change</td>
</tr>
<tr>
<td>DEFRA</td>
<td>Department for Environment, Food and Rural Affairs</td>
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<tr>
<td>DH</td>
<td>District Heating</td>
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<tr>
<td>DHN</td>
<td>District Heating Network</td>
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<tr>
<td>DNO</td>
<td>Distribution Network Operator</td>
</tr>
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<td>DNUoS</td>
<td>Distribution Network Use of Service</td>
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<td>EC</td>
<td>Energy Centre</td>
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<td>ECA</td>
<td>Enhanced Capital Allowance</td>
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<td>ECO</td>
<td>Energy Company Obligation</td>
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<td>EFW</td>
<td>Energy from Waste</td>
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<td>ENW</td>
<td>Electricity North West</td>
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<td>EPC</td>
<td>Energy Performance Certificate</td>
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<td>ESA</td>
<td>Energy Supply Agreement</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>ESCo</td>
<td>Energy Service Company</td>
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<tr>
<td>ESOS</td>
<td>Energy Savings Opportunity Scheme</td>
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<td>EU ETS</td>
<td>European Union Emissions Trading Scheme</td>
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<tr>
<td>FiT</td>
<td>Feed in Tariff</td>
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<tr>
<td>FM</td>
<td>Facilities Management</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<tr>
<td>GSHP</td>
<td>Ground Source Heat Pump</td>
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<tr>
<td>HH</td>
<td>Half-Hourly</td>
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<td>HIU</td>
<td>Heat Interface Unit</td>
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<td>HN</td>
<td>Heat Network</td>
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<tr>
<td>HNDU</td>
<td>Heat Network Delivery Unit</td>
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<td>HNIP</td>
<td>Heat Networks Investment Project</td>
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<tr>
<td>HV</td>
<td>High Voltage</td>
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<tr>
<td>IDNO</td>
<td>Independent Distribution Network Operator</td>
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<tr>
<td>IRM</td>
<td>Integrated Risk Model</td>
</tr>
<tr>
<td>IRR</td>
<td>Internal Rate of Return</td>
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<td>ITT</td>
<td>Invitation To Tender</td>
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<td>LDO</td>
<td>Local Development Order</td>
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<td>LECS</td>
<td>Levy Exemption Certificate</td>
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<tr>
<td>LTHW</td>
<td>Low Temperature Hot Water</td>
</tr>
<tr>
<td>LV</td>
<td>Low Voltage</td>
</tr>
<tr>
<td>MCR</td>
<td>Maximum Continuous Rating</td>
</tr>
<tr>
<td>MID</td>
<td>Measuring Instruments Directive</td>
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<tr>
<td>MoU</td>
<td>Memorandum of Understanding</td>
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<td>NHM</td>
<td>National Heat Map</td>
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<tr>
<td>NMRO</td>
<td>National Measurement &amp; Regulation Office</td>
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<tr>
<td>NPV</td>
<td>Net Present Value</td>
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<td>NOx</td>
<td>Nitrogen Oxides</td>
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<tr>
<td>OBC</td>
<td>Outline Business Case</td>
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<tr>
<td>OPEX</td>
<td>Operational expenditure</td>
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<tr>
<td>ORC</td>
<td>Organic Rankine Cycle</td>
</tr>
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<td>PIN</td>
<td>Prior Information Notice</td>
</tr>
<tr>
<td>PPA</td>
<td>Power Purchase Agreement</td>
</tr>
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<td>PQQ</td>
<td>Pre-Qualification Questionnaire</td>
</tr>
<tr>
<td>PW</td>
<td>Private Wire</td>
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<tr>
<td>QI</td>
<td>Quality Index</td>
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<td>RHI</td>
<td>Renewable Heat Incentive</td>
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<td>RMU</td>
<td>Ring Main Unit</td>
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<tr>
<td>SBC</td>
<td>Strategic Business Case</td>
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<td>STOR</td>
<td>Short Term Operating Reserve</td>
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<tr>
<td>TRV</td>
<td>Thermostatic Radiator Valve</td>
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<td>TNUsS</td>
<td>Transmission Network Use of Service</td>
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<td>VPN</td>
<td>Virtual Private Network</td>
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<td>WSHP</td>
<td>Water Source Heat Pump</td>
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Executive Summary

Arup was commissioned by Cheshire East Council (CEC) in 2016 to undertake a detailed feasibility study of a possible heat network in Macclesfield town centre. Macclesfield town centre had been identified as a heat network opportunity area within a previous study completed by Aecom in 2015. The study was managed for CEC by The Skills and Growth Company (SAGC).

Methodology

Stakeholder engagement with possible town centre area consumers was undertaken to identify current and future heat demand clusters and consumer interest. Concurrently, workshops were carried out with CEC and SAGC personnel from planning, highways, energy, environmental and regeneration teams to identify opportunities and constraints for the heat network development. This engagement and detailed modelling identified the most advantageous heat generation technologies, anchor building connections and network routes. The resulting recommendation is to develop an initial heat network centred around the Town Hall as the basis for establishing a potential heat network across the town centre.

Recommended Networks

It is proposed that a combined heat and power (CHP) gas engine, with supplementary gas fired boilers, is located at the New Town Hall. The plant would generate heat and electricity serving an initial network of anchor load buildings.

A heat network would connect and provide heat via buried pipes to Town Hall, Police Station and Royal Mail Delivery Office, as shown in Figure 1. A private wire electricity network would connect and provide electricity to the Town Hall, Library and Police Station, as shown in Figure 2.

The current heating systems in the new part of the Town Hall, Police Station and Royal Mail Delivery Office are nearing the end of their useful lives. The implementation of the energy network now avoids the need for these systems to be replaced.

Energy Centre

The 250kWe CHP engine, along with a 35m³ (approx. 3.0m dia x 5.9m high) thermal store and other ancillary equipment would be located to the rear of the Town Hall in the location of the current bike shed. The New Town Hall plant room, on the second floor of the New Town Hall, would house the supplementary gas boilers (2No. 719kW) which would replace the existing 22-year old gas boilers. The proposed location of the energy centre is broadly shown in Figure 1 and Figure 2.

Techno-Economic Assessment

The scheme has an initial capital cost of £1,017,000, on-going running costs (including O&M) of £64,000, and generates revenue through the sale of heat and electricity. Annual electricity and heat sale revenues are estimated to be £100,000 and £46,000 respectively. The analysis assumes that the costs of heat and electricity remain at the current level for all the connections. The economic analysis of the proposed scheme estimates a 25-year IRR of 4.8%. Grant funding of £392,000 would be required to increase the IRR to 11%.
Figure 1  Proposed heat network (HN).
Figure 2  Proposed electricity (private wire) network.
Environmental and Planning Considerations

The scheme is estimated to result in an average annual greenhouse gas saving of 149tCO₂e compared to the current heat and electricity sources of the connected buildings. The energy centre location, size and operational strategy have been optimised by:

- Locating the energy centre in an area which minimises visual impact to nearby residences and avoids blocking views of the Town Hall from lower parts of the town centre
- Avoiding the loss of car parking spaces
- Utilising a containerised CHP, with the supplementary boilers located in an existing plant room, thus accounting for the limited space available at the Town Hall
- Reducing environmental impact by maximising energy efficiency and minimising heat rejection
- Recommending an operational strategy which minimises noise to nearby residences at night time

Delivery

The most suitable delivery vehicles for the scheme are considered to be either a public sector led or a public-private shared leadership. It is envisaged that the Council will take on the role of project development whether it falls to Planning, Major Projects or Estates departments. While it has not been agreed as yet, the Strategic Business Case (SBC) and the draft Outline Business Case (OBC) is leading the decision to a delivery model that will be a publicly owned vehicle with a private sector partner procured to undertake developer agent activities. CEC will need to carry out the creation/specification of the Statement of Requirements (SOR) against which a design, build, operate and/or maintain (DBO or DBOM) contract can be let.

A high level delivery programme is shown below.

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<thead>
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<th>2017</th>
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<th>2019</th>
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<td>Customer preliminary negotiations</td>
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<td>Outline planning permissions</td>
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<td>Develop business case</td>
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<td>Secure funding</td>
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<td>Secure Energy Supply Agreements (ESAs)</td>
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<td>Investment decision</td>
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<td>DBOM tender</td>
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<tr>
<td>Operation</td>
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Expansion Potential

The scheme is designed as the first step towards a wider Macclesfield heat network, with expansion potential:

- In its immediate vicinity if suitable buildings are identified in the future (e.g. critical regeneration projects such as the Old Police Station)
- Within the wider town centre to connect to, for example, future social housing, commercial properties and other areas of high heat demand
- To other areas of high heat and power demand / production such as Hurdsfield Industrial Estate

Key Risks

Stakeholder interest and buy-in is key to the project. In particular, contact with Cheshire Constabulary should be established as early as possible to obtain actual consumption data and information about the current plant and heating system.
1 Introduction

Arup has been commissioned by Cheshire East Council (CEC) to undertake a feasibility study of a possible heat network in Macclesfield town centre. The study was managed for CEC by The Skills and Growth Company (SAGC). This work builds on a number of earlier outline assessments that have highlighted opportunities for low carbon infrastructure in Macclesfield.

The opportunities were first highlighted in the Climate Change and Energy Report, produced by LDA Design in 2011. This study identified Macclesfield as a ‘second priority cluster’ with potential for heat networks, defined by major developments such as AstraZeneca which could link to other anchor loads and energy sources (including on the Hurdsfield industrial estate), other existing developments with high heat density and proposed new developments.

In 2012, LDA Design was commissioned by Macclesfield’s Transition Town group, a community-led group, to identify renewable and low carbon energy projects in Macclesfield. This led to the identification of a possible district heating network in the Macclesfield town centre which would connect the Town Hall, Cheshire Constabulary Police Station, Library and St Michael & All Angels Church. LDA Design also investigated the potential for utilising biomass and for developing a local supply chain for it.

In 2015, AECOM, on behalf of Cheshire East Council, widened the search for district heating opportunities around Macclesfield, identifying three potential opportunity areas:

- Macclesfield town centre
- Area around Macclesfield District General Hospital
- Area north of Prestbury Road

Of these, a potential network in Macclesfield town centre was deemed most feasible and deliverable and is, therefore, the subject of this detailed feasibility study.

1.1 Aims and Objectives

The critical outcome of this project is to identify an implementable and investable heat network opportunity to connect existing and new, primarily public, buildings in Macclesfield town centre. The approximate study area is shown in Figure 3.

The objectives of the project are:

1. Build on the heat mapping and masterplanning study undertaken on behalf of the Council by Aecom in 2015.
2. Analyse energy demand and supply nodes around the town centre, taking account of recent announcements around future regeneration and redevelopment opportunities.
3. Review key anchor loads and refine previously benchmarked data where possible in consultation with key stakeholders, through the review of heat demand and supply.
4. Plan, review, hydraulically model, and optimise possible networking routings and sizes, based on key anchor loads from local authority buildings and taking account of technical risks and constraints.
5. Identify a preferred network option and clearly set out the technical specification for the preferred network for use by the Council in tender documentation as required, including the technical requirements for connecting to heat loads and existing utilities.
6. Undertake detailed technical and financial analysis of the preferred option, including outline systems design and a detailed development plan.

7. Undertake detailed financial modelling of the preferred network using discounted cash flow analysis, and including financial risk, sensitivity analysis, and optimism bias, utilising current HNDU guidance.

8. Provide the necessary level of detail and evidence in the form of a draft outline 5 case business case to enable the Council to engage in meaningful and informed discussions regarding potential investment and scheme delivery. Collation of information will be turned into a draft outline business case in compliance with government guidance on the 5 case model but will not be a full-fledged business case.

Figure 3 Outline of initial study area boundary.

1.2 National Drivers

1.2.1 The scale of the opportunity

Heat is a significant challenge to the UK commitment to combat climate change that is attributable to emissions of CO₂ from energy consumption.

Estimates show that approximately 14% of UK heat demand could be met by heat networks by 2030 and around 43% by 2050, making a cost effective contribution to the UK’s
Decarbonisation targets\(^1\). There are approximately 2,000 heat networks in the UK currently, supplying heat to 21,000 dwellings and 1,700 commercial and public buildings\(^2\).

As part of the Government’s decarbonisation strategy, the Heat Networks Delivery Unit (HNDU) was established in 2013 to support local authorities exploring heat network opportunities.

The market potential of heat networks is growing. The increased investment potential in heat networks was signalled by the government publishing guidance on heat network investment. The guide sets out the scale of the opportunity which amounts to over 280 heat network projects at varying stages of development across the UK. However, despite this, the UK has a very small industry with heat networks currently providing just around 2% of total heat demand\(^3\). By contrast, in Denmark, Combined Heat and Power (CHP) based heat networks provide heat to 63% of households.

The government’s long-term investment includes investment in an innovation programme which includes a remit to deliver commitments on seed funding for promising new renewable energy technologies and smart grids. This focuses on improved energy efficiency of public buildings and heat networks. For heat networks alone, the 2015 Autumn Statement with capital grant funding totalling £320 million over 5 years of funding for up to 200 heat networks will generate enough heat to support the equivalent of over 400,000 homes and leverage up to £2 billion of private capital investment\(^4\). This amount is six times larger than the government’s last district heating funding initiative ‘Community Energy Programme’ (CEP) launched in 2002. The CEP offered grants of up to 40% of capital costs, however, with a spend timeline of three years, just £29 million was spent due to the difficulties project sponsors experienced in mobilising projects in the relatively short timeframe\(^5\).

### District heat network

District heat network means the distribution of thermal energy in the form of steam, hot water or chilled liquids from a central source of production through a network to multiple buildings or sites for the use of space heating or process heating, cooling or hot water.

The minimum criteria for an installation to be considered a district heat network are two buildings being supplied with heat and at least one final customer. A heat supplier cannot be their own final customer. Therefore, where a heat supplier is using the heat for their own use and is also supplying heat to a second party in another building then this is sufficient to meet the criteria of a district heat network.

Where a remote source is supplying multiple buildings and each building has multiple occupants, this is still considered a district heat network.

### Communal heating

Communal heating means the distribution of thermal energy in the form of steam, hot water, or chilled liquids from a central source in a building which is occupied by more than one final customer, for the use of space heating, process heating, cooling or hot water. It is not necessary for the heat supply to be within the building, only that a single building is making use of the heat.

All communal heating serves only one building. The minimum size for communal heating is two final customers. Where a remote source is supplying a single building with multiple occupants this is also communal heating.


\(^1\) DECC (2015). Heat Networks Delivery Unit. HNDU Round 5: Overview. October 2015


1.2.2 Heat networks and carbon

Heat networks serve districts at scale and in so doing present lower carbon emissions than most conventional heat technologies can provide at the equivalent scale. However, this carbon saving is not evident in the usual ways of heat and energy pricing. Added to this, consumer operational and avoided capital cost are similarly often not factored into the benefit of heat networks heat supply over the alternative conventional supplies. This means that, without policy interventions, heat networks uptake is difficult to achieve, as heat networks are compared with conventional heat technologies that are perceived to provide apparently competitive, reliable and better understood alternatives.

The 5th Carbon Budget prioritises the effective deployment of low cost approaches to drive a shift towards low-carbon forms of heating through heat pumps and heat networks to supply businesses and households, alongside energy efficiency. Technically, there has been significant focus on understanding the role heat pumps can play in district heating. Recent research shows that alongside decarbonisation of the grid, integrating heat pumps to district heating offers large CO₂ reduction, with low or medium temperature networks based entirely on heat pumps providing greatest potential CO₂ savings (compared to conventional heat networks).

Despite the emissions reduction benefits, it is predicted that the use and integration of heat pumps in district heat schemes will lead to high heat prices. At present heat pumps represent a crossroads of balancing cost and environmental objectives, with schemes integrating heat pumps needing continuation of financial support for renewable heat and in parallel progress with intervention to ensure high carbon price.

1.2.3 Awareness and engagement

Awareness of heat networks is relatively low, and even where there is project activity and engagement, there is often a lack of interest. There is lack of trust in the reliability of the technology, perceptions that connecting to a heat network is difficult and disruptive, and service provision is poor quality. This culminates to provide a very challenging environment for heat network project development.

1.2.4 Policy and regulatory change

There is a high level of policy interventions in the heating sector, with multiple aims. Policy uncertainty has a direct impact on investor risk as heat networks are capital intensive with a long lifecycle, meaning such asset investments are exposed to changes in heat policy. As such, local authority involvement is critical to making heat networks succeed. The local authority should be tasked with leading projects development, supporting private networks through the planning system, owning or operating heat networks or being a heat customer.

Energy policy is often siloed with different policies having specific aims depending on the technology (e.g. renewable energy, nuclear) and sector (e.g. ESOS, CRC, EU ETS) and this can reduce investment interest. Regulatory frameworks can also be a barrier, for example the planning system making it difficult to gain planning consent for network installation or future connections from new development proposals.

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The 2015 Autumn Statement identified that the Energy Company Obligation (ECO) would continue replaced from April 2017 with a new cheaper domestic energy efficiency supplier obligation which will run for 5 years with a revised annual spend of £640m per year. ECO has been a barrier to district energy; however the consultation process for this new five year programme provides an opportunity for the district heating sector to be represented and promote the case for inclusion in the programme. Further encouragement can be drawn from the situation with the Renewable Heat Incentive (RHI).

Despite a risk that the RHI would be scrapped, the government announced it would in fact receive an increase to £1.15 billion in 2021. The scheme is to be redesigned following consultation on what is to be funded, presenting an opportunity to ensure that RHI mechanisms is integrated more closely with Government’s district heating ambitions.

The 2014 Heat Network Regulations apply to individuals and businesses that supply and charge for heating, cooling or hot water via a liquid distribution system. The regulations require all affected organisations to complete a notification and data collection exercise for the heat networks they operate for the National Measurement & Regulation Office (NMRO). Where heat meters are deemed necessary, they must be installed by 31 December 2016. Compliance is mandatory for all communal or district heating networks in a commercial or residential setting. The process must be repeated every four years and organisations who fail to meet the deadline will be subject to a heavy fine.

1.2.5 Finance

Heat networks are natural monopolies due to their high capital expenditure and fixed costs requiring a single operator to serve the local market. This often means that customers are required to enter into long-term agreements to purchase heat in order to achieve the tariff rate needed to make the investment to construct, commission, operate and maintain the network viable. Customers wanting the lowest tariffs possible indefinitely, with the flexibility to change contracts, can be a barrier to the deliverability of schemes.

1.2.6  Guidance

Two key documents that signal a shift in the importance of heat networks are the CIBSE and ADE’s published heat Networks Code of Practice and the government’s investment guide ‘Investing in the UK’s Heat Infrastructure: Heat Networks’.

Further recognition of the market shift in heat network project development has been the publishing of the CIBSE and the ADE Heat Networks Code of Practice (hereafter referred to as the Code). The Code covers all stages of the project development cycle, from feasibility through design, construction, commissioning and operation. The core of the Code is structured as follows:

- The typical sequence of a project by stage from initial brief and feasibility through to operation and maintenance.
- For each project stage, a number of objectives are set.
- For each objective a number of minimum requirements are defined to achieve the objectives.

All of these minimum requirements will need to be met if the project is to comply fully with the Code.

![Figure 4](image)

Figure 4  Two key documents that signal a shift in the importance of heat networks are the CIBSE and ADE’s published heat Networks Code of Practice and the government’s investment guide ‘Investing in the UK’s Heat Infrastructure: Heat Networks’.

1.2.7  Capital Support and Guidance for Commercialisation and Delivery

The Heat Networks Investment Project (HNIP), funded by the Department for Business, Energy and Industrial Strategy (DBEIS), aims to provide the £320m of capital support over the next 5 years, as originally announced in the 2015 Autumn Statement, to increase the volume of heat networks being built, deliver carbon savings, and help create the conditions...
necessary for a self-sustaining heat network market to develop\textsuperscript{11}. Figure 6 shows the scopes of HNDU and HNIP funding.

At the same time, HNDU has published draft guidance\textsuperscript{12} to support the development of heat network projects from the feasibility stage to business case stage. The guidance has come at a crucial time, as many local authorities and heat network developers are bringing their project opportunities forwards for investment and procurement decisions.

![Figure 6: Heat Network Investment Project scope\textsuperscript{13}](image)

HNIP has launched their Pilot Scheme, with applications having closed in autumn 2016 and first payments to be made by 3\textsuperscript{1st} March 2017. The budget available for the Pilot Scheme is up to £39m\textsuperscript{14}, split across two financial years (2016/17 and 2017/18). The Pilot Scheme consists of one single competitive funding round and it is designed to inform the Main Scheme which is expected to open in 2017 and run for four years.

The Pilot Scheme is open to local authorities and other public sector bodies excluding central Government Departments, noting that there are some restrictions on the type of finance that some public sector organisations can accept. Applicants can apply for grants or loans. Any efficient heating and cooling networks in England and Wales – including those that also generate electricity – are eligible for support. Eligible costs include the construction, expansion, refurbishment and interconnection of heat networks, including works to access recoverable heat and upgrade of heating systems inside some existing properties as well as commercialisation phase costs (where they are capitalised). Multiple criteria will be used to score and rank applications with respect to their carbon savings, customer impact and social net present value. More information about HNIP criteria is given in Section 5.5.

\textsuperscript{11} https://hnip.salixfinance.co.uk. [Accessed 8\textsuperscript{th} March 2017].


\textsuperscript{13} http://www.heatandthecity.org.uk.

\textsuperscript{14} http://salixfinance.co.uk/system/public_files/hnip_pilot_pre-qualification_applicant_guidance.pdf.
1.3  **Local Drivers**

A new Local Plan is currently being prepared by Cheshire East. It has been reviewed to understand key objectives and priorities of the plan and to ensure that the project outputs are aligned with local policies. This section captures some aspects of the Local Plan with relevance to a Macclesfield town centre heat network. Current issues faced, as well as the priorities and objectives defined by the new Local Plan will help to identify the best solutions for the project. The Local Plan strategy aims for the revitalisation of town centres. In accordance with the Local Plan objectives, a Macclesfield town centre heat network would develop local skills, create jobs and most generally help with wider economic regeneration. The following section describes the characteristics, issues and needs of the Borough.

1.3.1  **Key issues currently faced in the Borough**

The Borough is facing a certain number of issues which could be addressed while developing the project:

- **Population growth:** The Borough’s population is expected to grow by around 40,000 people by 2030. Thus the plan aims to create sustainable homes and job-led growth. Residential connections would balance heat demand profile and known developments in the town centre will be investigated as potential future connections.

- **Urban sprawling:** The Borough has a strong rural nature that needs to be preserved against rapid population growth.

- **The centre of Macclesfield has a medieval street pattern, partly overlaid by later phases of the town’s growth. This could be a potential constraints for pipework routes.**

- **A great part of the town centre is designated as a conservation area and potential constraints for heat network development will be investigated.**

- **Unemployment:** Its unemployment rate is higher than the Borough average. Potential social housing connections in the town centre will be studied.

- **Further development in the Borough may compromise the environmental qualities of the area.**

There is an obvious need to balance economic prosperity and demands for development against the growing concerns for the environment and protection of the Borough’s character and identity. Heat networks can help address environmental aspects together with economic development and make some areas of the town centre more desirable for future development.

1.3.2  **Local Plan priorities**

Particular focus is given to the local development pressure on the Green Belt and the strategic location of new housing and employment sites. As a result, the strategic priorities of the Local Development Plan are as follows:

**Economic prosperity by creating opportunities for business growth**

- Provide employment opportunities and income.

- Development sites for economic growth (key sites should be investigated as potential future connections).
• Promote the viability and accessibility of town centres.

• Support major town centre regeneration schemes to improve environmental quality (heat network can provide support to this).

• Provide quality employment land and premises.

One of the main advantages of district heating is the ability to use lower carbon technologies which can provide significant carbon savings, provide reputational benefits and reduce environmental taxes for businesses and public organisations, and thus help attract new businesses in town. District heating schemes can also create employment opportunities and provide opportunities for local businesses to become involved in the supply chain in a sustainable way, and so increase the economic prosperity of the town.

**Sustainable communities with member’s engagement**

• Provide the opportunity for healthier lifestyles through provision of high quality green infrastructure.

• Ensure that all infrastructure is provided to communities.

• Ensure that all new development is well designed, sustainable and energy-efficient.

A district heating schemes could provide the opportunity to involve local communities and local stakeholders to build local expertise and hence to guide the project in a way that maximises local benefits. It could allow for the reduction of energy prices for businesses, individuals and public organisations which are part of the network as well as protecting against energy price fluctuations. Also, developing a sustainable and reliable energy network could reduce fuel poverty and increase security of energy supply.

**Environmental quality protection and enhancement**

• Maintain the distinctiveness of places, buildings and landscapes.

• Conserve and enhance the natural and historic environment.

• Reduce waste and manage it in a sustainable way.

• Reduce the Borough’s impact on climate change (by promoting renewable energy, reducing energy use and improving energy efficiency).

Macclesfield has amongst the highest carbon footprints in the country with 14 tonnes CO₂ per capita and has also a high level of greenhouse gas emissions, well above the regional and UK average\(^\text{15}\). This is mainly due to larger houses, more cars per household, lower public transport use and higher overall consumption levels. As a result, reducing its impact on climate change is one of the biggest priorities. District heating schemes could lead to carbon and energy consumption reduction. They would demonstrate the town’s commitment to mitigating climate change and enhance the reputation of the town.

**Sustainable transport**

• Improve road network by building new roads close to people.

• Reduce the need to travel.

• Improve connectivity by additional transport infrastructure.

• Promote sustainable modes of travel to reduce congestion.

\(^{15}\) Macclesfield town’s history & legacy, Regional Intelligence Unit by the NWDA Research Team
The development and remodelling of the current transport infrastructure is an opportunity for improving road junctions, addressing existing congestion and building heat networks. Indeed, the works required to install pipes could take place at the same time and disruption from burying pipes would be minimised. Appropriate car parking should be identified and unused space could help determine potential energy centre locations and minimise the use of greenfield sites.

Macclesfield is the second largest town in Cheshire East and one of the two Principal Towns. In order to sustain the town's performance as one of the most successful in the regional economy, significant development is encouraged in order to support its role as one of the most important settlements in the Borough.

1.3.3 Heat network drivers

Heat networks are central to the Council’s energy agenda and will be a key factor in achieving CEC’s targets set out in the Independent Energy key objective of the Cheshire East Energy Framework. In January 2015, the Council endorsed the Energy Vision with one of the three objectives being to create local heat distributions utilising geothermal and low carbon heat sources.

Through engagement with Cheshire East Council, a number of local drivers have been identified to help shape the project. Drivers for the heat network include:

- To deliver a heat network that supports and enhances the regeneration and growth of the town centre and can be integrated with the wider development programmes being planned and delivered.
- Public and private sector energy costs are reduced and revenues created. The solutions and business case developed reflect the Council’s appetite for risk and will be sensitive to the Council’s ongoing work, and the needs for communities and local business.
- Help support and enhance economic regeneration by ensuring the identification and analysis of heat network opportunities is integrated with established and emerging plans, policies and programmes.
- Help support the local push for sustainability and low carbon energy.

1.4 Structure of the Report

The report is divided into ten sections as follows:

Section 1: This section introduces the project and its background and discusses local drivers and priorities.

Section 2: The section outlines the study methodology and tools and software used.

Section 3: The section introduces the heat network opportunity areas within the town centre area. A promising area is identified and described in detail.

Section 4: Potential technologies for supplying heat to the town centre heat network are considered and short listed.

Section 5: An energy centre site is identified. The energy centre is then described in detail, including the selection and sizing of the preferred technologies and the configuration of the proposed system.
Section 6: The section introduces the proposed heat network, including pipe routes and information about building connections.

Section 7: The section introduces the proposed private wire network.

Section 8: The section considers the feasibility of a cooling network.

Section 9: The Economic performance of the proposed scheme is discussed, including its capital costs, revenues, operational costs, NPV and IRR.

Section 10: Considers the future expansion potential of the proposed network.

Section 11: The section considers the environmental and social impacts of the proposed scheme.

Section 12: The section concludes the report by giving recommendations and a delivery plan for implementing a heat network in Macclesfield town centre.
2 Study Methodology

The study methodology has been designed to fulfil the objectives and minimum requirements of the CIBSE and ADE Code of Practice\(^\text{16}\). Figure 7 illustrates this.

![Diagram](image)

**Figure 7** Methodology.

### 2.1 Step 1: Understanding Study Area and Demand

![Graphs](image)

**Figure 8** Hourly and seasonal demand profiling for heat, power and cooling is undertaken for each suitable building in the opportunity area.

The study commenced with a stakeholder engagement exercise to understand heat demands within the study area. The aim of this exercise was to identify clusters of heat demand with the potential to be served by a heat network. This involved creating a heat map from information made available through stakeholder engagement and that in the public domain. When actual data was not available, estimated data was used. The heat map is a dynamic tool updatable according to the following data hierarchy whenever additional information is sourced or received:

1. Billing data
2. Display Energy Certificate (DEC) data
3. National Heat Map (NHM) data
4. Renewable Energy Statement data (Future Builds)
5. Energy Performance Certificate (EPC) data for floor area and benchmark heat consumption
6. Estimated floor area and benchmark heat consumption

Benchmark heat consumption data has been gathered using references identified in Section 2.1.5 of the Heat Networks Code of Practice. For new and planned buildings, benchmarks were used to develop anticipated heat demand.

Similarly, electricity and cooling demands were also considered.

2.2 Step 2: Options Appraisal

Throughout the project an Arup-developed options appraisal tool IRM was used to assess options, opportunities and constraints. The tool was developed in collaboration with Cheshire East Council in two workshops: the first one on 25th November 2016 where criteria for assessing options were identified and given weightings and the second one on 1st February 2017 where the results of the IRM analyses were presented and discussed. The full list of assessment criteria is available in Appendix B. The categories and weightings suggested by the Council and agreed to are as follows:

- Economic (45%)
- Strategic (5%)
- Legislative/Legal (5%)
- Technological/Technical (20%)
- Environmental (15%)
- Social (10%)

Economic and Technological criteria account for 65% of the total available score, with all other categories given a lower weighting. Each criterion within a category was then allocated an importance number varying from 1 to 10 to prioritise the criteria against each other.

2.3 Step 3: Modelling

Figure 9 Technical analysis is completed using EnergyPro.
The heat demand clusters and constraints from Step 1 were then used to develop a potential heat network along with the size and configuration of the energy conversion plant and heat network.

EnergyPro modelling was carried out to illustrate overall heat demand profiles and to determine the most appropriate energy conversion plant capacities and thus informed the spatial layout of the energy centre. For heat network sizing, NetSim nodal modelling was used. This modelling allowed a variety of routes serving clusters of demands to be assessed and scenarios of optimum network sized in a phased and expandable manner. Location for the energy centre was also considered taking into account factors such as proximity to demands centres, space and access requirements as well as visual and air quality impacts. Site visits were organised to identify local constraints and potential planning issues which were factored to determine the preferred energy centre location.

Figure 10  Vitec’s NetSim software is used to undertake network simulation for district heating and cooling, providing accurate values for various parameters including pressure, flow, velocity and temperature.

The technical modelling identified, for example:

- Heat and electricity demand in the opportunity area(s)
- Energy centre size and configuration
- Plant capacities and operational strategies
- Heat/electricity produced
- Heat network pipe sizes, lengths and pressure drops

2.4  Step 4: Feasibility Analysis

Figure 11  A bespoke economic model is developed to perform life cycle cost analysis that results in robust business cases.

The analysis considered the technical and economic feasibility of the proposed scheme, including:

- Location of the energy centre
- Capital and operational costs
- Annual revenues (heat and electricity sales)
- Net Present Value (NPV) and Internal Rate Return (IRR)
- Greenhouse gas emissions

Based on engagement with stakeholders (both potential customers and council representatives) and the Steps 1 to 3, potential risks and opportunities were identified in terms of heat demand, network location, scheme deliverability and potential opportunities for expansion. HNIP requirements were also considered.

A site visit was undertaken on 6th February to narrow the range of Energy Centre options from potentially feasible to practically feasible. Local constraints were thoroughly identified to determine the preferred energy centre location as well as feasible configurations, connections and operational strategies.

### 2.5 Step 5: 5 Case Business Case and Recommendations

Finally, conclusions of the study were drawn and recommendations were given in terms of next steps. The information obtained through the modelling and analysis was used to populate a draft outline business case based on the Five Case Model, utilising HM Treasury guidance. The key aspects of the OBC not addressed in this report, and which therefore need further consideration before the completion of the OBC and application to capital funding, include:

- Confirmation of the delivery vehicle and role(s) assumed by CEC. This impacts on several aspects of the OBC, including in particular the Commercial Case.
- Consideration of funding sources and further costs such as VAT, inflation and depreciation and capital charges. This will lead to the completion of the financial model and the Financial Case.
- Completion of the Management Case, including for example CEC governance arrangements.
3 Town Centre Opportunity Areas

3.1 Key Stakeholders

The key stakeholders of this study include potential anchor connections to the heat network and members of Cheshire East Council who provided information, contacts and advice throughout the study.

Figure 12 shows a map of the study area labelled with potential anchor connections. These were identified in several ways: from the Aecom study (2015), through a desk study and through communication with stakeholders at a ‘Make it Macclesfield’ public event on 2nd December 2016.

A full record of communication with all the stakeholders is provided in Appendix A. The potential anchor loads considered for this study are shown in Figure 12 and detailed in Table 1.

![Figure 12: Potential anchor loads.](image-url)
Table 1 Potential anchor loads.

<table>
<thead>
<tr>
<th>Stakeholder Name</th>
<th>Building Use</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldi</td>
<td>Grocery store</td>
<td>Queen Victoria St, Macclesfield, SK11 6LP, Macclesfield</td>
</tr>
<tr>
<td>Ask Real Estate</td>
<td>Redevelopment of the Churchill Way Car Park to a six screen cinema, restaurants and a retail unit</td>
<td>Ask Real Estate, 3rd Floor, Clarence House, Clarence Street, Manchester M2 4DW</td>
</tr>
<tr>
<td>AstraZeneca</td>
<td>Large manufacturing, packing and research site to the north of the town centre employing 1,800 people</td>
<td>Charter Way, Silk Road Business Park, Macclesfield, SK10 2NA</td>
</tr>
<tr>
<td>BT</td>
<td>Operational telephone exchange but operations have been reduced recently and limited personnel on site</td>
<td>Hibel Road, Macclesfield, SK10 2EE</td>
</tr>
<tr>
<td>Cheshire Constabulary</td>
<td>Police station</td>
<td>Brunswick Street, Macclesfield SK10 1HQ</td>
</tr>
<tr>
<td>Christ Church</td>
<td>Currently unused church, waiting for refurbishment</td>
<td>Bridge Street, Macclesfield, SK11 6EG</td>
</tr>
<tr>
<td>DW Sports Fitness</td>
<td>Gym and spa</td>
<td>Pickford Street, The Silk Works, Macclesfield SK11 6JD</td>
</tr>
<tr>
<td>Grosvenor Shopping Centre</td>
<td>Shopping centre and car park</td>
<td>Grosvenor Shopping Centre, 27-29 Market Place, Macclesfield, SK10 1DY</td>
</tr>
<tr>
<td>Grosvenor shopping centre extension</td>
<td>Re-development of the Stanley Street / Castle Street area into offices and shopping area</td>
<td></td>
</tr>
<tr>
<td>Heritage Centre</td>
<td>Museum, including a café, shop and cinema</td>
<td>Roe Street, Macclesfield SK11 6UT</td>
</tr>
<tr>
<td>Jordangate Car Park</td>
<td>Car park</td>
<td>Jordangate, Macclesfield, SK10 1EW</td>
</tr>
<tr>
<td>Library</td>
<td>Library</td>
<td>Jordangate, Macclesfield, SK10 1EE</td>
</tr>
<tr>
<td>Marks and Spencer’s</td>
<td>Clothing and food store including café</td>
<td>33 Mill Street, Macclesfield, SK11 6NE</td>
</tr>
<tr>
<td>Merchant Exchange</td>
<td>Former mill adjacent to Travelodge, converted to 930m² of office space</td>
<td>Gas Road, Macclesfield, SK11 6NY</td>
</tr>
<tr>
<td>Peaks &amp; Plains Housing Trust</td>
<td>Social housing provider operating in the area</td>
<td>Peaks &amp; Plains Housing Trust, Ropewalks, Newton Street, Macclesfield, SK11 6QJ</td>
</tr>
<tr>
<td>Ropewalks</td>
<td>Peaks &amp; Plains head office with 150 personnel on two floors (the remaining two floors are let out)</td>
<td>Newton Street, Macclesfield, SK11 6QJ</td>
</tr>
<tr>
<td>Royal Mail</td>
<td>Delivery office</td>
<td>Jordangate, Macclesfield, SK10 1EJ</td>
</tr>
<tr>
<td>Salvation Army</td>
<td>Salvation Army worship hall, café and community space</td>
<td>Roe Street, Macclesfield SK11 6UT</td>
</tr>
<tr>
<td>Silk Museum</td>
<td>Exhibition space and café</td>
<td>Park Lane, Macclesfield, SK11 6TJ</td>
</tr>
<tr>
<td>St Michael &amp; All Angels Church</td>
<td>Church (400 person capacity), including a kitchen, youth centre, two meeting rooms and chapel (all 30 - 50 person capacity)</td>
<td>Market Place, Macclesfield, SK10 1HG</td>
</tr>
<tr>
<td>Symphony Housing Group</td>
<td>Social housing provider operating in the area</td>
<td>2 Christie Way, Manchester, M21 7QY</td>
</tr>
<tr>
<td>Tesco</td>
<td>Grocery store</td>
<td>Tesco metro, Exchange Street, Macclesfield, SK11 6UZ</td>
</tr>
<tr>
<td>Tesco</td>
<td>Large supermarket</td>
<td>Hibel Road, Macclesfield SK10 2AB</td>
</tr>
<tr>
<td>Town Hall</td>
<td>Town Hall comprising an old part (hall and assembly rooms) and new part (office block)</td>
<td>Unicorn Gateway, Macclesfield, SK10 1EA</td>
</tr>
<tr>
<td>Travelodge</td>
<td>Hotel</td>
<td>Castle House, Gas Road, Macclesfield, SK11 6JS</td>
</tr>
<tr>
<td>Waters Green Medical Centre</td>
<td>Medical centre consisting of 6 GP surgeries on the 2nd floor and some general services on the 1st floor</td>
<td>Sunderland St, Macclesfield, SK11 6J</td>
</tr>
</tbody>
</table>
3.2 Identification of Opportunity Clusters

Given the significant number of potential stakeholders, they have been classified by geographical location in clusters. Four heat demand clusters have been identified in the study area, as shown in Figure 13 and discussed below.

3.2.1 Cluster 1

Cluster 1 consists of primarily public buildings (Town Hall, Library, Cheshire Constabulary’s police station and St Michael & All Angels Church), together with a Royal Mail Delivery Office, BT Telephone Exchange, Travelodge, Merchant Exchange, Grosvenor Market and its extension. The buildings are located close to each other and on a fairly even level, with only Travelodge and Merchant Exchange located further away down a hill. There is good buy-in from the stakeholders in this Cluster, with all of them except Cheshire Constabulary and Merchant Exchange having expressed an interest in the study and provided heat and electricity demand information for the modelling. It is recommended that a full techno-economic model is developed for this Cluster.

Library and BT Telephone Exchange have electricity demand only and could form a potential private wire, instead of heat network, connection, should the chosen energy conversion technology involve electricity generation. Additionally, BT has indicated that it has signed up to a pledge to have a 100% renewable energy supply by 2020, potentially impacting its role in this project.

Whilst it is recommended that Cheshire Constabulary is included in the Cluster 1 modelling due to its central location and public ownership, Merchant Exchange is excluded due to Arup not being able to establish any contact with the building owner or estate agent. Travelodge has a low heat and electricity demand due to electric heaters being used in its energy efficient rooms, with gas being used for hot water only. Additionally, St Michael & All Angels Church is excluded from the modelling due to its estimated low heat demand and three separate heating systems serving different parts of the building. Grosvenor Market has also been excluded due to the shops being electrically heated, with each shop being responsible for its own arrangements and energy provision.

3.2.2 Cluster 2

Cluster 2 consists of several developments and future renovations, as well as established retailers, a museum and those with an interest in public well-being (such as Peaks & Plains Housing Trust and the Salvation Army). This is a well-sized cluster which was already considered for a heat network connection in the Aecom pre-feasibility study. However, there has been a significant lack of interest from the stakeholders in this area to engage with the current study. Due to the lack of actual consumption data and the uncertainty surrounding new developments such as Ask Development and the renovation of the Christ Church, it is recommended that this Cluster is investigated as a potential future extension to the Cluster 1 heat network. Consumption data is currently available for the Heritage Centre only. No detailed modelling will be carried out for this cluster as it is
unlikely that the accuracy of the modelling could be significantly improved from the Aecom study.

3.2.3  Cluster 3

The existing anchor loads in Cluster 3 include Waters Green Medical Centre, DW Sports Fitness and Aldi. DW Sports Fitness operate a small swimming pool/spa and have expressed an interest in the study and provided consumption data. Aldi, however, have said they would not like to be part of the study, and no communication has been established with the medical centre. This area, is however, interesting, due to the social benefits provided due to the connection of the medical centre, and the large heat demand of DW Sports Fitness. Additionally, Peaks & Plains Housing Trust has indicated that it has plans to develop up to 100 new social housing units to the south of this area (see Section 3.3 for more information).

3.2.4  Cluster 4

Cluster 4 forms a further opportunity for extension, should Cluster 2 and/or 3 become attractive for connection. This area contains a current car park which is considered as being difficult to develop due to a shallow sewage pipe which divides the site into two through the middle. The car park is located across the road from the Arighi Bianchi warehouse which is set to relocate in the near future (timescale for this is not known by Arup), thus creating a large area ready for development but with some constraints. A heat network could help make the site more desirable to developers. There are also plans to locate a Lidl store in the area, adding to the potential heat demand.
Figure 13  Four heat demand clusters identified within the study area.

3.3  Potential Residential Connections

A mix of building types, including public and residential buildings, creates a smooth energy demand profile and, therefore, the basis for an efficient heat network.

Arup investigated the possibility of including residential buildings as connections to the Macclesfield heat network. The following sections present a summary of the relevant information from the stakeholder engagement carried out with possible residential connections to the town centre heat network. Where a distance from the town centre is indicated, this is taken to be the distance from the Town Hall in Cluster 1.

3.3.1  Social housing

In order to determine possible residential heat network consumers in the town centre, the Council provided information about organisations that could have potential properties to be connected to the heat network. Arup attempted to
contact five social housing providers operating in the study area. The results of the engagement are provided in Table 2.

Table 2  Potential connections owned by social housing providers.

<table>
<thead>
<tr>
<th>Name of Organisation</th>
<th>Contact Name and Details</th>
<th>Existing Properties in the Town Centre</th>
<th>Future Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity Housing Group Limited</td>
<td>Angela Garrard, <a href="mailto:angelaG@equityhousing.co.uk">angelaG@equityhousing.co.uk</a></td>
<td>Equity Housing Group Limited owns three developments in the town centre: The Old Ribbon Mill, Pitt Street, located 0.8 mile from the town centre. The property is a 3-storey building with mixed tenure neighbourhoods and semi-detached properties or flats. Simpsons Court, Great King Street, located 0.4 mile from the town centre. This sheltered housing comprises 21 2-bedroom flats built in 1989. Consumption data for Simpsons Court was unavailable for this study.</td>
<td>None identified</td>
</tr>
<tr>
<td>Peaks &amp; Plains Housing Trust</td>
<td>Tim Pinder, Chief Executive (contact for new development)</td>
<td>Three existing locations with potential to be connected to the heat network were identified: The Old Ribbon Mill, Pitt Street, located 0.3 mile from the town centre. The property is made of 12 flats, 6 bungalows and a new build apartment block consisting of 8 2-bedroom apartments with central heating and a boiler replacement date due in 2040. Throwsters Court, Maydews Passage, located 0.6 mile from the town centre. This new development of 36 modern open plan apartments consists of 24 2-bedroom apartments and 12 1-bedroom apartments with central heating and a boiler replacement date due in 2045. The Ropewalks, Newton Street, located 0.5 mile from the town centre. This is the headquarters of Peaks &amp; Plains Housing Trust. The building comprises 4 floors of offices, 2 floors occupied by Peaks &amp; Plains head office and the 2 others let out. Consumption data has been requested and the office has been added to the stakeholder list. However, no data has been received for the study.</td>
<td>Plans to build up to 100 new units in the Park Green / Sunderland Street area which could have a significant heat demand and be of interest as a future heat network connection.</td>
</tr>
<tr>
<td>Places for People</td>
<td>John Wright, <a href="mailto:John.Wright@placesforpeople.co.uk">John.Wright@placesforpeople.co.uk</a></td>
<td>The Council mentioned that the organisation owns at least one property on Cumberland Street. Information request was sent to the contact but no communication was established.</td>
<td></td>
</tr>
</tbody>
</table>
### Plus Dane

This social housing provider could potentially own some properties in Macclesfield town centre and a request for information was sent via their website but no reply was received.

### Symphony Housing Group

Victoria Young  
Victoria.Young@contourhomes.co.uk  
0161 875 8000

This social housing provider could potentially own some properties in Macclesfield town centre and a request for information was sent to the contact person provided by the council but no reply was received.

Arup’s Council contact informed that they are currently developing flats on Chestergate but no communication was established.

#### 3.3.2 Private housing

Arup engaged with the Planning Team of the Council to obtain information about Local Development Orders for residential development. The Council provided the commitments list as at 31st March 2016 with pipeline residential scheme details. Strategic sites with planning permission in the Macclesfield area include:

- **Moss Lane, Macclesfield.** This housing scheme comprises 150 dwellings located 1.7 miles from the town centre.
- **Congleton Road, Macclesfield, SK11 7UP.** This housing scheme comprises 220 dwellings located 1.7 miles from the town centre.

Both sites are greenfield sites.

Strategic sites awaiting planning permission were also reviewed and only one scheme with potentially significant heat demand (gross total dwellings superior to 50) was identified: Former Territorial Army Centre (TA), Chester Road, located 0.6 mile from the town centre. The former TA centre was empty for a long period of time and has since been demolished and the site cleared to make way for its redevelopment. The planning application proposes 3.52ha housing development of 75 new homes including a combination of traditional family homes, apartments and an element of affordable housing.

#### 3.3.3 Residential connections included in the study

Figure 14 shows the locations of the residential buildings. The headquarters of Peaks & Plains Housing Trust is not shown in the figure, as it is an office rather than a residential building, but will be included as a recommended connection for Cluster 2.

It can be seen from Figure 14 that the future housing schemes in Moss Lane, Congleton Road and Chester Road and the existing properties in Old Ribbon Mill do not qualify for the study as they are located significantly further from the heat clusters.
Simpsons Court seems to be in good location and looks promising for a connection to Cluster 2. Equity Housing has shown interest in the heat network connection should Cluster 2 go ahead. However, Simpsons Court is a sheltered housing comprising only 21 flats and the heat demand should be further assessed to balance connection costs with the benefits.

Crockatt House is located relatively close to the town centre even if it is the only stakeholder in the North West part of the town along A537. This is a relatively new building with a seven year old heating system. It is recommended that the potential for connecting Crockatt House to the heat network is re-assessed in the future, to coincide with the boiler replacement programme.

Throwsters Court appears to be in a good location for a heat network connection to Cluster 4. However, it is a brand new small-scale housing scheme which does not make it suitable for the current study, as changing the new heating system would be unlikely to be considered as cost-efficient.

The future development of Peaks & Plains Housing Trust could be a potential opportunity for Cluster 4. As Cluster 4 is a future potential opportunity cluster, the heat network expansion could match the timescale of the future development of the Peaks & Plains social housing scheme. We recommend that this connection opportunity is further investigated if the heat network is extended beyond Cluster 1, as it would also increase the benefits of the scheme to local communities and have potential to alleviate fuel poverty.

In conclusion, the existing residential connection with most potential to be connected to the heat network is Simpsons Court located in Cluster 2. In addition to usual benefits of a heat network, the benefits of connecting to social housing buildings include affordable heat to consumers, help to bring people out of fuel poverty as well as awareness about fossil fuel issues and promotion of renewable energy. Additionally, future development of Peaks & Plains Housing Trust in Park Street / Sunderland Street area should be considered for Cluster 4, if this Cluster is taken forward in the future. The potential to connect Crockatt House and Throwsters Court could be considered in the future to coincide with the boiler replacement programmes at these locations. However, this is assumed to be some time away and there are likely to be further social housing developments in the town centre, the details of which are currently unknown, before then.
3.4 Constraints

3.4.1 Historic setting

Macclesfield is originally a market town with a population of 52,000. Known as the ‘Silk Town’, the place once thrived of the fast growing silk industry. During the 1830s there were 71 silk mills operating there; many remain and four of them are still used as museums dedicated to the industry. The town centre has a medieval street pattern, partly overlaid by later phases of the town’s growth. The historic character of Macclesfield is visible through its spatial organisation and distinctive features such as the Churchside area with streets made of cobblestone (Figure 15) and the Market Place (Figure 16).
Figure 15  Cobblestone street on Churchside.

Figure 16  Market Place.

Macclesfield is located on a hill with a gentle descent to the west towards the Cheshire plain but a very steep descent to the north and the east to the valley of Bollin. Connection from this side with the low part of the town can be made by pedestrians up Bunker Hill using ‘Step Hill’ which is made of 108 historic steps and is shown in Figure 17. Cheshire East Council recently completed retaining wall improvement works at this location to address historic structural stability issues.
As the history of the town is reflected in its buildings, much of the town is designated as conservation area with listed buildings of Grade II (buildings of national importance and special interest) and Grade II* (Particularly important buildings of more than special interest). Indeed, as of 2014 there are 218 buildings recorded in the National Heritage List for England as designated listed buildings. Of these, 18 are listed as Grade II*. There are no buildings listed as Grade I (buildings of exceptional interest).

Figure 18 to Figure 22 depict some of the iconic listed buildings in Macclesfield which are also stakeholders for the heat network study. They are the Town Hall, St Michaels’ Church and the Library in Cluster 1 and the Heritage Centre and the Salvation Army in Cluster 2. There are no listed buildings in Cluster 3.

Figure 18 The Town Hall west façade.
Figure 19  St Michael's Church east façade.

Figure 20  Library entrance.
Macclesfield is located 20 miles South of Manchester in East Cheshire and has an elevation of 160m above the sea level. Transport links and roads have been investigated as they can act as physical obstacles for the development of district heating schemes. Some physical constraints around the main study area include:

- The railway line (east of the site) is located to the east of A523. It is crossed by A537 to the north east of Cluster 1. There are bridges with height limitation (3.35m) to allow for the connection of the town centre to the east of the town as shown in Figure 23. There is currently no constraint as the proposed network does not cross the railway. The only constraint is on the ability of the network to expand to the east but there are no immediate proposals to do this.

- The River Bollin (located to the east of the town centre) is a major tributary of the River Mersey in the north-west of England. It rises in Macclesfield Forest at the western end of the Peak District, and can be seen in spring form, from the Buxton to Macclesfield road. The river is...
located down the hill along the railway line and is not a current constraint. Also, should the network be extended to the East and cross the river, it is unlikely to be a significant constraint to network development / expansion as there are already multiple crossing points.

- The Macclesfield Canal (further to the east of the railway and River Bollin) is one of the six canals that make up the Cheshire Ring. The canal runs 26 miles from Marple Junction at Marple, where it joins the Upper Peak Forest Canal, 16 miles, southwards through Bollington and Macclesfield, before arriving at Bosley. The use of the canal started declining in 1845 after the arrival of the railway line. The canal is located further away from the town centre and there is no current proposal to cross the canal for heat network connections. Also, it is unlikely to form a constraint to the heat network development.

- Macclesfield is served by good road links from the north, south and west, but has fewer roads going east due to the proximity of the Peak District. From the south, access from Congleton and the Potteries is from the A536, and via the A523 from Leek. The main west–east road is the A537 Knutsford to Buxton Road. The A538 provides access to Prestbury, Wilmslow and Manchester Airport, with the B5470 being the only other eastbound route from the town. The town centre is accessed primarily by car, and according to the Council’s website, there are 22 car parks in Macclesfield which is a relatively high number given the size of the town. Figure 24 shows A537 which is the busiest road in the study area and is located to the north of the town centre.

Most of the physical constraints are located on the east side of the town centre. Crossing rivers with a heat network can incur considerable additional cost. Similarly, crossing major roads adds constraints to the location and programme of heat network development and crossing the railway line from the town centre to the east could incur considerable additional cost. Consequently, the study area focuses on buildings to the west of the railway line and the river and to the south of A537.

Figure 23  Bridge crossing the railway line at Waters Green.
3.4.3 **Summary of constraints**

Table 3 shows potential constraints in the study area with the key information sourced from DEFRA’s MAGIC database. It should be noted that there are 50 listed buildings within the study area. Other than the listed buildings however, the database shows few constraints that would impact on the installation of a heat network. The main constraints are therefore the infrastructure features of the town, the river and the railway.
Table 3 Potential constraints in the study area.

<table>
<thead>
<tr>
<th>Constraint</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed Buildings</td>
<td>50</td>
</tr>
<tr>
<td>Bus Stops</td>
<td>21</td>
</tr>
<tr>
<td>Highways</td>
<td>4</td>
</tr>
<tr>
<td>Conservation Areas</td>
<td>4</td>
</tr>
<tr>
<td>Railway</td>
<td>1</td>
</tr>
<tr>
<td>River</td>
<td>1</td>
</tr>
<tr>
<td>Areas of Archaeological Potential Boundaries</td>
<td>1</td>
</tr>
<tr>
<td>Land Management Initiatives</td>
<td>0</td>
</tr>
<tr>
<td>Local Nature Reserves</td>
<td>0</td>
</tr>
<tr>
<td>Moorland Line</td>
<td>0</td>
</tr>
<tr>
<td>National Forest</td>
<td>0</td>
</tr>
<tr>
<td>National Parks</td>
<td>0</td>
</tr>
<tr>
<td>Nitrate Vulnerable Zones</td>
<td>0</td>
</tr>
<tr>
<td>Parks and Gardens</td>
<td>0</td>
</tr>
<tr>
<td>Public Rights of Way</td>
<td>0</td>
</tr>
<tr>
<td>Scheduled Monuments</td>
<td>0</td>
</tr>
<tr>
<td>Sites of Special Scientific Interest</td>
<td>0</td>
</tr>
<tr>
<td>Sites of Special Scientific Interest – impact risk zones</td>
<td>0</td>
</tr>
<tr>
<td>Special Area of Conservation</td>
<td>0</td>
</tr>
<tr>
<td>Special Protection Area</td>
<td>0</td>
</tr>
<tr>
<td>Water Management Areas</td>
<td>0</td>
</tr>
<tr>
<td>Ramsar sites</td>
<td>0</td>
</tr>
</tbody>
</table>

The town centre of Macclesfield is located within an Area of Archaeological Potential Boundaries and further study should be made in the Park Green Area which is designated as an Archaeological Potential Location, should the heat network be developed in this area.

The bus stop locations allow for the identification of bus routes. However, disruption would be temporary and would happen only during road works when the heat network is installed. Traffic management plan can be put in place and so this is not considered as a major constraint.

In order to get a better understanding of the complex historic environment of Macclesfield, the following map has been obtained from the Cheshire East Council website. It displays features relevant to planning applications, such as Conservation Areas and Listed Buildings. Major transport infrastructure is also shown.
Most of the town centre is designated as a conservation area as is often the case for the centres of historic towns. Most Conservation Areas are designated by the Council as the local planning authority. This means that any work leading to the alterations of a property in a conservation area might need planning permission from the Council before making such alterations. There are four Conservation Areas in the study area: Christ Church Conservation Area, Town Centre Conservation Area, Park Green Conservation Area and High Street Conservation Area. As result, most of the stakeholders considered in the study are located in Conversation Areas, apart from Cluster 3.

As Cluster 1 is partly within a Conservation Area, the Council has been engaged during two constraint workshops to determine potential issues related to installing a heat network but has informed not to be aware of any planning restrictions for underground pipework. Details of the Council Stakeholders and their input to the heat network project are provided in Appendix A.

Arup has been informed by the council that there are four potential new Air Management Areas in Macclesfield. Monitoring will be undertaken by the Council in these areas as they exceed the national air quality limits and an action...
plan will be produced to improve air quality. The four Air Quality Management Areas are as follows:

- **Broken Cross.** An area around the Broken Cross Roundabout including small stretches of Chester Road, Gawsworth Road and Fallibroome Road.
- **Chester Road.** A small number of properties at the junction with Cumberland Street roundabout.
- **Park Lane.** A number of properties on Park Lane between South Park Road and Hobson Street.
- **Hibel Road.** A number of properties on Hibel Road, Tunnicliffe Street, Pownall Street, Brock Street, Jordangate and Beech Lane.

Figure 26 shows the different Air Quality Management Areas (AQMAs) with red lines, apart from Broken Cross which is located 2.9km from the town centre and so is not a constraint for the study.

![Figure 26 New Air Quality Management Areas.](image)

It can be seen that the only Air Quality Management Area likely to have an impact on the town centre heat network is the Hibel Road area due to its close location to the study area. Special consideration will have to be taken in regard to fuel sources for the heat network and energy centre location which should not be placed immediately adjacent to the AQMA boundary.
As often in town centres, an important constraint for the development of a heat network is the restricted amount of land and space available. In the case of Macclesfield, another issue is the topography. The majority of Cluster 1 is located on top of a hill and any alterations to features of the upper part which would impact on the views from the lower part of the town should preserve the historical character of Macclesfield. This is likely to be of particular relevance to St Michael’s Church and the Town Hall which are listed buildings.

Any energy centre installation should be designed so that noise levels are 5db below background levels.

### 3.5 Cluster Features

This section considers the heat and electricity demand of the study area and the features of the study area that may negatively impact on the potential development of a heat network.

For this study, a total of 25 buildings/sites were initially identified as potential anchor loads for connection to a heat network. Their locations allowed for the identification of 4 clusters as presented in Section 3.2 of the report. In order to understand their suitability, an analysis was undertaken to calculate the total energy consumption in terms of heat and electricity. In addition, factors such as the locations of the buildings, the energy systems already installed in the buildings and / or uncertainty surrounding the future uses of the buildings were also assessed.

#### 3.5.1 Cluster 1 potential connections

The energy data collected for each potential anchor load in Cluster 1 is presented in Table 4. The table provides information about the existing heating system, annual heat demand, annual electricity demand and where the data was obtained from and allows the determination of the buildings’ suitability for heat network connection. The table also shows where data was missing, allowing the identification of risks and uncertainties. The Library is using electricity for heating and as the fraction of the electricity consumption used for heating is unknown, the heat demand of the Library has not been assessed. BT has currently no heating systems and so no heat demand. The Town Hall has two plant rooms with two separate heating systems: one in the Old Town Hall (3 gas boilers) and one in the New Town Hall (4 gas boilers). It can be seen that no energy data was available for either Merchant Exchange or Grosvenor Market. As Arup was unsuccessful at establishing contact with these stakeholders, annual energy demand was estimated according to the data hierarchy presented in Section 2.1.

In addition, interest in the heat network from the stakeholder engagement process, potential risks and benefits to the stakeholder if connected to the network were also assessed and are shown in Table 5.
Table 4 Cluster 1 energy data.

<table>
<thead>
<tr>
<th>Name</th>
<th>Floor Area (m²)</th>
<th>Existing Heating Systems</th>
<th>Annual Heat Demand (kWh)</th>
<th>Heat Data Source</th>
<th>Annual Electricity Demand (kWh)</th>
<th>Electricity Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT Telephone Exchange</td>
<td>Unknown</td>
<td>None</td>
<td>0</td>
<td>/</td>
<td>1,310,900</td>
<td>Bills</td>
</tr>
<tr>
<td>Royal Mail Delivery Office</td>
<td>1,673</td>
<td>3 gas-fired boilers</td>
<td>346,600</td>
<td>Bills</td>
<td>98,700</td>
<td>DEC 2013</td>
</tr>
<tr>
<td>Police Station</td>
<td>2,562</td>
<td>Oil-fired boiler to supply water central heating</td>
<td>430,200</td>
<td>DEC 2015</td>
<td>215,200</td>
<td>DEC 2015</td>
</tr>
<tr>
<td>Library</td>
<td>1,784</td>
<td>Electric panel heaters</td>
<td>/</td>
<td>/</td>
<td>227,700</td>
<td>Bills</td>
</tr>
<tr>
<td>Town Hall</td>
<td>10,109</td>
<td>Four 4 years old gas-fired boilers (Old Town Hall) and three 22 years old gas-fired boilers (New Town Hall)</td>
<td>782,200</td>
<td>Bills</td>
<td>902,300</td>
<td>HH metered</td>
</tr>
<tr>
<td>Travelodge</td>
<td>2,463</td>
<td>Electric panel used for space heating, gas for hot water only</td>
<td>92,600</td>
<td>Bills</td>
<td>212,600</td>
<td>Bills</td>
</tr>
<tr>
<td>Merchant Exchange</td>
<td>Unknown</td>
<td></td>
<td></td>
<td>Unknown</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Grosvenor Market and Ekoskin Development</td>
<td>Unknown</td>
<td>Most shops are electrically heated, only Boots is using gas</td>
<td>Unknown</td>
<td>Unknown</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>St Michael's Church</td>
<td>Unknown</td>
<td>Large gas boiler, a separate gas boiler and electric underfloor heating</td>
<td>162,00</td>
<td>LDA Design Study (2012)</td>
<td>40,200</td>
<td>LDA Design Study (2012)</td>
</tr>
</tbody>
</table>

Half-hourly (HH) electricity data from September 2015 to August 2016 was provided for the Town Hall only. The electricity demand of the library was based on average monthly consumption data from July 2014 to June 2016. Pro-rata electricity data from bills from December 2015 to November 2016 was used for BT Telephone Exchange. Pro-rata energy data from bills from September 2015 to August 2016 was used for Travelodge. Actual data from bills from May 2015 to April 2016 was used to determine the gas demand of Royal Mail. Data from DEC 2015 using actual meter readings was utilised to determine the energy demands of the Police Station. Fuel consumption data has been weather-normalised on a 20 year degree day (DD) average.

Table 5 Cluster 1 potential risks and benefits of connecting to a heat network.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Interest</th>
<th>Identified Risks</th>
<th>Benefits to the Stakeholder</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT Telephone Exchange</td>
<td>Expessed interest in the heat network connection</td>
<td>The electricity supplied has to be 100% renewable</td>
<td>Lower electricity costs</td>
</tr>
<tr>
<td>Royal Mail Delivery Office</td>
<td>Expessed interest in the heat network connection</td>
<td>Risk that the stakeholder has low appetite in the heat network connection because of connection costs</td>
<td>Avoidance of replacement CAPEX for heat generating plant. Lower heat costs</td>
</tr>
<tr>
<td>Cheshire Constabulary</td>
<td>Unknown</td>
<td>Risk that the stakeholder has low appetite in the heat network connection</td>
<td>Avoidance of replacement CAPEX for heat generating plant. Use of cleaner fuel than oil</td>
</tr>
<tr>
<td>Library</td>
<td>Expessed interest in the heat network connection</td>
<td>/</td>
<td>Lower electricity costs</td>
</tr>
<tr>
<td>Town Hall</td>
<td>Expessed interest in the heat network connection</td>
<td>/</td>
<td>Avoidance of replacement CAPEX for heat generating plant in the New Town Hall. Lower heat and electricity costs</td>
</tr>
<tr>
<td>Travelodge</td>
<td>Expessed interest in the heat network connection</td>
<td>/</td>
<td>Lower energy costs</td>
</tr>
<tr>
<td>Merchant Exchange</td>
<td>Unknown</td>
<td>No data available, risk of low heat demand and no appetite for connection</td>
<td>/</td>
</tr>
<tr>
<td>Grosvenor Market and Ekoskin Development</td>
<td>Unknown as there is no centralised management but many independent shops</td>
<td>Each tenant is responsible for his own shop and the malls are unheated. The important number of individual and independent shops would make network connections complex. Probably very low gas consumption as there is only one gas consumer. No space to accommodate additional plant or equipment.</td>
<td>/</td>
</tr>
<tr>
<td>St Michael's Church</td>
<td>Unknown</td>
<td>Risk that the stakeholder has low appetite in the heat network connection because of the retrofitting and connecting cost. There separate heating systems requiring connection. Risk that the heat demand is lower than the estimate.</td>
<td>Avoidance of replacement CAPEX for heat generating plant and new heating system for the entire building</td>
</tr>
</tbody>
</table>
Based on the above data, the Cluster 1 buildings were assessed for their suitability for a heat network connection. Of the nine stakeholders within Cluster 1, the following buildings did not meet the criteria and so are not considered further in the analysis:

- **Grosvenor Market and Eskimur Development**: Most shops do not have a wet heating system and it is unknown if their current electric systems are near end of life. It is likely that retrofitting them will not make connection financially viable, especially given the great number of connections that would be required as each shop has its individual heating system.

- **St Michael’s Church**: A previous LDA Design study concluded that the church has multiple heating systems of different ages and that the historical character of the church would make connection difficult and probably not economically viable.

- **Merchant Exchange**: This stakeholder has been excluded from the study as Arup has not been able to establish any contact and no information was available from previous studies. Considering this building further for the study would result in a great number of assumptions and would not make the modelling accurate.

- **Travelodge**: has a very low gas demand as gas is only used for hot water. This would not make a connection to the heat network viable as the heating system installed is likely to be efficient and the building owner is unlikely to be receptive to undergoing a conversion to a wet heating system at this point in the building’s life. Private wire could be considered but the relatively low electricity demand associated with the challenging location of the building is unlikely to make the connection financially viable.

Further observations are as follows:

- **BT Telephone Exchange**: has no heat demand as the staff was relocated last year but the electrical equipment onsite still consumes electricity. Due to its high electricity demand, BT can be considered for a private wire connection but only if the power can be claimed as renewable. Indeed, BT informed that their policy, having signed up to RE100, is to have all supplies 100% renewable by 2020 and that they are unlikely to buy electricity if not from 100% renewable sources. They have plans to meet their 2020 renewable target through the grid supply from nPower which is currently REGO backed renewable. As a result, private wire to BT is not considered for the study.

- **The library**: is using electricity for heating and so has been discounted as a heat network connection, as retrofitting the current heating system would likely have prohibitively high costs. The building should be considered for connection when the electric heating system reaches end of life, or when an alternative use for the building is chosen in which the current system is not optimal. However, a private wire connection to this building should be considered, particularly also as this is a council-owned building.
The Town Hall: The heat demand and the electricity demand of the building represent 47% of the total heat demand and 30% of the total electricity demand identified for Cluster 1, respectively. Thus, both a heat network and a private wire connection should be considered in this strategic location in the town centre.

Following this analysis, the modelling of Cluster 1 was reduced to the following buildings:

- Royal Mail Delivery Office
- Cheshire Constabulary
- The Town Hall (including private wire)
- The Library (private wire only)

All the energy data for these buildings is actual consumption data, either from actual meter readings, bills, actual metered data or DECs, which increases the accuracy of the modelling.

### 3.5.2 Cluster 2 potential connections

The energy data collected for each key building in Cluster 2 is presented in Table 6, with the stakeholder interest, risks and benefits outlined in Table 7.

#### Table 6 Cluster 2 energy data.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Floor Area (m²)</th>
<th>Existing Heating systems</th>
<th>Annual Fuel Demand (kWh)</th>
<th>Heat Data Source</th>
<th>Annual Electricity Demand (kWh)</th>
<th>Electricity Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>M&amp;S</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>/</td>
<td>Unknown</td>
<td>/</td>
</tr>
<tr>
<td>Salvation Army</td>
<td>500</td>
<td>Unknown</td>
<td>44,600</td>
<td>CIBSE TM46:2008 Benchmark (Google maps)</td>
<td>10,000</td>
<td>CIBSE TM46:2008 Benchmark (Google maps)</td>
</tr>
<tr>
<td>Heritage Centre</td>
<td>1,155</td>
<td>Two 34 years-old gas-fired boilers</td>
<td>213,900</td>
<td>Metered data</td>
<td>73,300</td>
<td>Metered data</td>
</tr>
<tr>
<td>Christ Church</td>
<td>1,200</td>
<td>None</td>
<td>204,000</td>
<td>CIBSE TM46:2008 Benchmark (Google maps)</td>
<td>84,000</td>
<td>CIBSE TM46:2008 Benchmark (Google maps)</td>
</tr>
<tr>
<td>Simpsons Court</td>
<td>1,500</td>
<td>Unknown</td>
<td>535,500</td>
<td>CIBSE TM46:2008 Benchmark (Google maps)</td>
<td>97,500</td>
<td>CIBSE TM46:2008 Benchmark (Google maps)</td>
</tr>
<tr>
<td>Ropewalks</td>
<td>2,980</td>
<td>Unknown</td>
<td>384,000</td>
<td>CIBSE TM46:2008 Benchmark (Google maps)</td>
<td>283,100</td>
<td>CIBSE TM46:2008 Benchmark (Google maps)</td>
</tr>
<tr>
<td>Ask Development</td>
<td>Unknown</td>
<td>Unknown</td>
<td>656,000</td>
<td>AECOM study</td>
<td>Unknown</td>
<td>/</td>
</tr>
</tbody>
</table>
Table 7 Cluster 2 potential risks and benefits of connecting to a heat network.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Interest</th>
<th>Identified Risks</th>
<th>Benefits to the stakeholder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesco Exchange St</td>
<td>Unknown</td>
<td>Risk that the stakeholder has low appetite in the heat network connection, risk that the heat demand is lower than the estimate</td>
<td>Lower energy costs</td>
</tr>
<tr>
<td>M&amp;S</td>
<td>Unknown</td>
<td>Removed from the study as we list in the list of the M&amp;S shop closure</td>
<td>/</td>
</tr>
<tr>
<td>Salvation Army</td>
<td>Expessed interest in the heat network connection</td>
<td>Risk that the stakeholder has low appetite in the heat network connection</td>
<td>Lower energy costs</td>
</tr>
<tr>
<td>Heritage Centre</td>
<td>Expessed interest in the heat network connection</td>
<td>Risk that the plant is replaced before the heat network comes online</td>
<td>Lower energy costs, avoidance of replacement CAPEX for heat generating plant and liabilities</td>
</tr>
<tr>
<td>Christ Church</td>
<td>Expessed interest in the heat network connection</td>
<td>The Church is currently very rarely used, very poorly-energy efficient and is very expensive to be heated. Current energy data will not be representative as occupancy is very low. Benchmark will probably have to be used and there is a risk that the estimate will be over-estimated.</td>
<td>Refurbishment should be conducted in 3-5 year time and could match the development of the heat network. Lower energy costs, avoidance of replacement CAPEX for heat generating plant and liabilities.</td>
</tr>
<tr>
<td>Simpsons Court</td>
<td>Expessed interest in the heat network connection</td>
<td>Risk that the building is using electricity for heating or that the heat demand is lower than the estimate</td>
<td>Lower energy costs and social benefits to local communities</td>
</tr>
<tr>
<td>Ropewalks</td>
<td>Expessed interest in the heat network connection</td>
<td>Risk that the building is using electricity for heating or that the heat demand is lower than the estimate</td>
<td>Lower energy costs</td>
</tr>
<tr>
<td>Ask Real Estates Development</td>
<td>Ask does not want to be contacted in regard to the heat network project</td>
<td>No interest in the heat network connection.</td>
<td>Lower energy costs, no retrofit costs</td>
</tr>
</tbody>
</table>

Little engagement from the stakeholders in Cluster 2 resulted in most of the energy data being estimated. Even if most stakeholders in this cluster expressed interest in the heat network, actual data for the Heritage Centre only was received. Consumption data for this site was provided from meter readings between March 2013 and August 2016. Where CIBSE benchmarks were used, the floor area has been taken by the item in brackets (e.g. inspection report for Tesco) to provide the floor area and where no data for floor space was available, estimates using google maps scale were used.

The Cluster 2 buildings were assessed for their suitability for a heat network connection. Of the eight stakeholders within Cluster 2, the following buildings did not meet the criteria and so are not considered further in the analysis:

- M&S: The shop is on the list of designated UK shops for closure. Therefore, this stakeholder was removed from the study.
- Ask Real Estates Development: The company informed the council that they do not wish to be contacted in regard to the heat network. This added to the high degree of uncertainty around the development, and the decision was made not to further consider this stakeholder for the study.

Further observations are as follows:

- Christ Church: The building has no heating system. This strongly contributes to fluctuating humidity levels and consequent mould growth. The vestry in the base of the tower is used as a small office used by the custodian where there are three electric heaters to provide some heat. It has been recommended that they should be removed as they are rusty. It has been reported that the church is very randomly used due to its decaying...
condition and that it is very expensive to run. A refurbishment project is planned with a 3 to 5 year timescale and could match the development of the heat network. A wet heating system should be installed to allow connection to a heat network. The heat demand was assessed to be 204,000kWh per year by using a CIBSE benchmark.

- Simpsons Court: This sheltered housing block is the only existing residential connection that is considered for the heat network. Since it has a relatively high heat demand, it would have the ability to balance the heat network and to flatten the daily and annual energy demand profiles. This would allow for an optimal running of the energy generation equipment. Including social housing in the heat network would also have a positive impact on local communities.

Following this analysis, the modelling of Cluster 2 was reduced to the following buildings:

- Tesco Exchange Street
- Heritage Centre
- Salvation Army
- Christ Church
- Ropewalks
- Simpsons Court

It is important to note that in Cluster 2, actual energy data from meter readings was available for the Heritage Centre only which would impact the modelling of Cluster 2 and increase the uncertainty about the results.

### 3.5.3 Cluster 3 potential connections

The energy data collected for each key building in Cluster 3 is presented in Table 8, with the stakeholder interest, risks and benefits outlined in Table 9.

#### Table 8 Cluster 3 energy data.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Floor Area (m²)</th>
<th>Existing Heating systems</th>
<th>Annual Fuel Demand (kWh)</th>
<th>Heat Data Source</th>
<th>Annual Electricity Demand (kWh)</th>
<th>Electricity Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW Sports Fitness</td>
<td>3,768</td>
<td>2 gas boilers</td>
<td>977,000</td>
<td>HH Metered</td>
<td>662900</td>
<td>CIBSE TM46-2008 Benchmark (Stakeholder)</td>
</tr>
<tr>
<td>Medical Centre</td>
<td>1,400</td>
<td>Unknown</td>
<td>238,000</td>
<td>CIBSE TM46-2008 Benchmark (Google maps)</td>
<td>98,000</td>
<td>CIBSE TM46-2008 Benchmark (Google maps)</td>
</tr>
<tr>
<td>Aldi</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>/</td>
</tr>
</tbody>
</table>

The annual gas consumption from September 2015 to August 2016 was received for DW Sports Fitness. HH gas consumption data was provided for this stakeholder and its electricity consumption was assessed with benchmark. The energy demands of the Medical Centre were assessed by using benchmarks as no information was received. Aldi was contacted and informed Arup that they were not interested in connecting to a heat network. As a consequence, its energy
demands were not assessed and this stakeholder was discounted for the rest of the study. Actual data was received for the gas consumption of DW Sports Fitness only which increases the uncertainty around the heat demand for Cluster 3.

Table 9  Cluster 3 potential risks and benefits of connecting to a heat network.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Interest Identified Risks</th>
<th>Benefits to the Stakeholder</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW Sports Fitness</td>
<td>Expressed interest in the heat network connection</td>
<td>Lower energy cost, especially beneficial as a significant quantity of heat is used to heat the pool</td>
</tr>
<tr>
<td>Medical Centre</td>
<td>No interest in the heat network connection</td>
<td>Lower energy costs</td>
</tr>
<tr>
<td>Aldi</td>
<td>Has clearly expressed its non-interest in the heat network</td>
<td>Lower energy costs</td>
</tr>
</tbody>
</table>

Cluster 3 is characterised by its very small size. Indeed, only three potential anchor loads were identified and little information was received following the information requests to the stakeholders. Only the gas consumption and the floor area of DW Sports Fitness were received. This means that there is a great uncertainty around Cluster 3 and its viability for a heat network. Arup was unsuccessful in contacting the relevant people at the Medical Centre due to the complex organisation of the site.

From this study, Cluster 3 was restricted to the following buildings:

- DW Sports Fitness
- Waters Green Medical Centre

3.5.4 Cluster 4 potential connections

The energy data collected for each key building in Cluster 4 is presented in Table 10, with the stakeholder interest, risks and benefits outlined in Table 11.

Table 10  Cluster 4 energy data.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Floor Area (m²)</th>
<th>Existing Heating systems</th>
<th>Annual Fuel Demand (kWh)</th>
<th>Heat Data Source</th>
<th>Annual Electricity Demand (kWh)</th>
<th>Electricity Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk Museum</td>
<td>525</td>
<td>Two gas boilers</td>
<td>120,000</td>
<td>Metered data</td>
<td>44,000</td>
<td>Metered data</td>
</tr>
<tr>
<td>Arighi Bianchi</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>/</td>
</tr>
<tr>
<td>Lidl</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>/</td>
</tr>
<tr>
<td>Duke Street Car Park</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>/</td>
</tr>
<tr>
<td>Peaks &amp; Plains</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>/</td>
</tr>
<tr>
<td>Social Housing</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>/</td>
</tr>
</tbody>
</table>
Table 11  Cluster 4 potential risks and benefits of connecting to a heat network.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Interest</th>
<th>Identified Risks</th>
<th>Benefits to the Stakeholder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk Museum</td>
<td>Expressed interest in the heat network connection</td>
<td>Limited number of stakeholders in the cluster interested in the heat network connection</td>
<td>Lower energy costs, avoidance of replacement CAPEX for heat generating plant and liabilities</td>
</tr>
<tr>
<td>Arighi Bianchi</td>
<td>Unknown</td>
<td>Uncertainty around development and timescale, no interest in heat network connection</td>
<td>Could benefit a new development in the area, lower energy costs</td>
</tr>
<tr>
<td>Lidl</td>
<td>Unknown</td>
<td>No confirmation that the shop is going to be built, no interest expressed in heat network connection</td>
<td>Lower energy costs</td>
</tr>
<tr>
<td>Duke Street Car Park</td>
<td>Unknown</td>
<td>Sewerage pipe running underneath the car park could complicated connection</td>
<td>Could benefit a new development in the area, lower energy costs</td>
</tr>
<tr>
<td>Peaks &amp; Plains Social Housing</td>
<td>Expressed interest in the heat network connection</td>
<td>Uncertainty around future development and timescale</td>
<td>Could benefit a new development in the area, lower energy costs and social benefits</td>
</tr>
</tbody>
</table>

Cluster 4 is made up of five potential sites and constitutes a future opportunity cluster as most of these sites are still undeveloped. These stakeholders are potential connection opportunities should a heat network be extended to the southern area of the town centre and given provisions that these areas will be developed by then. Consumption data was available for the Silk Museum only as it is currently the only development in the area. Consumption data for this site was provided from meter readings between March 2013 and August 2016. Other stakeholders are potential future developments and their predicted heat demand has not been assessed due to uncertainty about plans. The study should be refined in the future when more details about development are known and provisions about heat requirements can be made. Given the great uncertainty about Cluster 4 at this time, this cluster is not considered further in the study.

3.6 Energy Demand Profiles

Once the list of potential stakeholders was refined to meet basic heat network requirements, the heat and electricity demand profiles of each cluster were developed and assessed.

3.6.1 Cluster 1

Table 12 shows the annual energy consumptions and peak demands of the short-listed buildings in Cluster 1.
Table 12  Annual energy consumption of Cluster 1 buildings.

<table>
<thead>
<tr>
<th></th>
<th>Annual Heat Demand (kWh)</th>
<th>Peak Heat Demand (MW)</th>
<th>Annual Electricity Demand (kWh)</th>
<th>Peak Electricity Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police Station</td>
<td>430,200</td>
<td>0.10</td>
<td>215,200</td>
<td>0.034</td>
</tr>
<tr>
<td>Town Hall</td>
<td>782,200</td>
<td>0.52</td>
<td>902,300</td>
<td>0.20</td>
</tr>
<tr>
<td>Royal Mail</td>
<td>346,600</td>
<td>0.22</td>
<td>98,700</td>
<td>0.024</td>
</tr>
<tr>
<td>Library</td>
<td>/</td>
<td>/</td>
<td>227,700</td>
<td>0.035</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,559,000</strong></td>
<td><strong>0.8</strong></td>
<td><strong>1,443,900</strong></td>
<td><strong>0.3</strong></td>
</tr>
</tbody>
</table>

The total annual heat demand and peak demand of Cluster 1 were assessed to be 1,559MWh and 0.8MW respectively, while the total annual electricity demand and peak demand were calculated to be 1,444MWh and 0.3MW respectively.

The Town Hall has the highest energy demand, with its heat demand accounting for half of the total demand of all the Cluster 1 buildings.

Figure 27 shows example daily heat and electricity demand profiles. In the upper graph, it can be seen that the highest heat demand happens between 8am and 9am when people are arriving at work given that Cluster 1 is only made of public sector and retail buildings. It can be seen in the lower graph that the highest electricity consumption happens between 11am and 2pm, probably when buildings are at maximum capacity.

Figure 28 shows the annual heat and electricity demand profiles and demonstrates how the heat demand decreases in the summer while the electricity consumption has a more constant pattern all year round as a small part of the electricity consumption is weather-dependent.

Figure 27  Example of daily energy demand profiles for Cluster 1 (all selected buildings).
3.6.2 Cluster 2

Table 13 shows the annual energy consumptions and peak demands of the short-listed buildings in Cluster 2.

Table 13 Annual energy consumption of Cluster 2 buildings.

<table>
<thead>
<tr>
<th></th>
<th>Annual Heat Demand (kWh)</th>
<th>Peak Heat Demand (MW)</th>
<th>Annual Electricity Demand (kWh)</th>
<th>Peak Electricity Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesco</td>
<td>192,800</td>
<td>0.133</td>
<td>864,000</td>
<td>0.21</td>
</tr>
<tr>
<td>Heritage Centre</td>
<td>213,900</td>
<td>0.15</td>
<td>73,300</td>
<td>0.012</td>
</tr>
<tr>
<td>Salvation Army</td>
<td>44,600</td>
<td>0.02</td>
<td>10,000</td>
<td>0.002</td>
</tr>
<tr>
<td>Ropewalks</td>
<td>304,000</td>
<td>0.22</td>
<td>283,100</td>
<td>0.065</td>
</tr>
<tr>
<td>Christ Church</td>
<td>107,100</td>
<td>0.054</td>
<td>24,000</td>
<td>0.005</td>
</tr>
<tr>
<td>Simpsons Court</td>
<td>535,500</td>
<td>0.25</td>
<td>97,500</td>
<td>0.022</td>
</tr>
<tr>
<td>Total</td>
<td>1,397,900</td>
<td>0.8</td>
<td>1,351,900</td>
<td>0.3</td>
</tr>
</tbody>
</table>

The total annual heat demand and peak demand of Cluster 2 were assessed to be 1,398MWh and 0.8MW respectively, while the total annual electricity demand and peak demand were calculated to be 1,352MWh and 0.3MW respectively.

Tesco is estimated to have the highest electricity demand, accounting for 64% of the total electricity demand of all the short-listed buildings in Cluster 2. However,
the heat demand of the store is relatively low. Simpsons Court is estimated to have the highest heat demand, approximately 38% of the total heat demand of the short-listed buildings in Cluster 2.

Figure 29 shows example daily heat and electricity demand profiles. In the upper graph, it can be seen that the highest heat demand again happens between 8am and 9am, as the cluster consists of primarily public and retail buildings, while the highest electricity consumption happens between 1pm and 3pm. Figure 30 shows the annual heat and electricity demand profiles.

![Figure 29 Example of daily energy demand profiles for Cluster 2 (all selected buildings).](image1)

![Figure 30 Example of annual energy demand profiles for Cluster 2 (all selected buildings).](image2)
3.6.3 Cluster 3

Table 14 shows the annual energy consumptions and peak demands of the short-listed buildings in Cluster 3.

Table 14 Annual energy consumption of Cluster 3 buildings.

<table>
<thead>
<tr>
<th></th>
<th>Annual Heat Demand (kWh)</th>
<th>Peak Heat Demand (MW)</th>
<th>Annual Electricity Demand (kWh)</th>
<th>Peak Electricity Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW Sports Fitness</td>
<td>912,700</td>
<td>0.44</td>
<td>602,900</td>
<td>0.09</td>
</tr>
<tr>
<td>Waters Green Medical Centre</td>
<td>238,000</td>
<td>0.06</td>
<td>98,000</td>
<td>0.016</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,150,700</strong></td>
<td><strong>0.5</strong></td>
<td><strong>700,900</strong></td>
<td><strong>0.1</strong></td>
</tr>
</tbody>
</table>

The total annual heat demand and peak demand of Cluster 3 were assessed to be 1,216MWh and 0.5MW respectively, while the total annual electricity demand and peak demand were calculated to be 701MWh and 0.1MW respectively. DW Sports Fitness is a significant energy consumer, accounting for 80% of the total heat and 86% of the total electricity demand of the Cluster 3 buildings.

Figure 31 shows example of daily heat demand profile and electricity demand profile. In the upper graph, it can be seen that the heat demand remains at a fairly constant level throughout the day, due to the pool heating requirements. The electricity demand profile is also smoother than in the other two Clusters, due to the longer opening hours of the gym.

Figure 32 shows the annual heat and electricity demand profiles.
Figure 32 Example of annual energy demand profiles for Cluster 3 (all selected buildings).

3.7 Heat Network Options

Once the list of potential stakeholders had been refined and the energy requirements of the clusters had been studied, the IRM appraisal process presented in Section 2.2 was used to consider the opportunities and risks involved in locating a heat network in the different clusters.

As Cluster 1 was considered to be the lowest risk area, with several council-owned buildings and good stakeholder buy-in, it was included in all the scenarios. Additionally, due to the limited number of stakeholders in Cluster 3, as well as its close proximity to Cluster, it was only included as part of an assessment with Cluster 2. Cluster 4 was not considered in the IRM appraisal as the development in this area is particularly uncertain. Therefore, the scenarios considered were:

- Scenario 1: Cluster 1 only
- Scenario 2: Clusters 1 and 2
- Scenario 3: Clusters 1, 2 and 3

The full assessment can be found in Appendix B.

The average score of each scenario is presented in Figure 33.
Due to the small area and fewer stakeholders in Cluster 1, but similar heat and electricity demands of Clusters 1 and 2, Scenario 1 appears to be the scenario scoring highest in the Economic category. Cluster 1 comprises public buildings with the highest energy demands in close location in the town centre. Thus, there are no ownership issue which significantly reduces the overall risk. A wider network involving Clusters 2 and 3 would require higher initial investment, as well as higher O&M costs. For Clusters 2 and 3, there are a significant number of buildings for which no or little information has been obtained which results in significant uncertainty about their heat demand and future plans and so about their viability to be included in this study.

Considering planning and delivery, Scenario 1 is the least complex option with likely the shortest timescale for development.

Deploying the technology on a wider-scale for a bigger heat network involving Clusters 2 and 3 would require more space for pipework, energy centre, thermal storage and fuel storage as the heat demand to be met increases.

The social benefits of the heat network will be highest for Cluster 1 which comprises several public buildings.

However, limiting the network to Cluster 1 reduces the potential carbon saving and the positive impact on climate change compared to a wider network extending to Clusters 2 and 3. Additional connections to other clusters in a later stage would increase these benefits.

Scenario 1 obtained the lowest average risk score and Cluster 1 is, therefore, the chosen scenario for the rest of this study. Also, it has been agreed with Cheshire East Council that the feasibility study should focus on a smaller workable scheme with tangible information rather than a bigger scheme with estimated data and approximate timescale. Once well-established, the proposed scheme could act as a catalyst for further development, attract more stakeholders and extend to other clusters. However, it is noted that the energy demand profiles of Cluster 3 buildings could help smooth the overall demand and extending the heat network to this cluster in the future, to connect the medical centre and future social housing, could also improve the social benefits of the scheme.

---

**Figure 33  Scoring of cluster options.**

<table>
<thead>
<tr>
<th>Options</th>
<th>Economic</th>
<th>Strategic</th>
<th>Legislative</th>
<th>Technical</th>
<th>Social</th>
<th>Environmental</th>
<th>Average Score</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1: Cluster 1</td>
<td>2.4</td>
<td>2.6</td>
<td>2.0</td>
<td>2.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>1</td>
</tr>
<tr>
<td>Scenario 2: Cluster 1 and 2</td>
<td>2.8</td>
<td>2.3</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.0</td>
<td>2.7</td>
<td>2</td>
</tr>
<tr>
<td>Scenario 3: Cluster 1, 2 and 3</td>
<td>3.0</td>
<td>2.4</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.0</td>
<td>3.0</td>
<td>3</td>
</tr>
</tbody>
</table>

---

4 Technology Selection

This section considers a broad range of heat generation technologies which are further studied in regard to their suitability for a Macclesfield heat network. A long list of possible technologies is identified and assessed against a variety of criteria using the IRM approach. The IRM analysis results in a short list of options which are then taken forward for further consideration in the later sections of the report.

4.1 Long List of Options

The primary set of technology options assessed include:

- Gas Fired CHP Engine
- Gas CHP & Biomass Boilers
- Gas CHP & Bio-Liquid Boilers
- Biomass ORC Turbine
- Biomass Gasification Plant
- Biomass Steam Turbine
- Biomass Boilers (Standalone, no electrical generation)
- Air Source Heat Pumps (ASHP)
- Water Source Heat Pumps (WSHP)
- Ground Source Heat Pump (GSHP)
- Deep Geothermal
- Energy from Waste (EfW)
- Waste Industrial Heat
- Solar Thermal

A full list of technology options, their description and their suitability to a heat network are provided in Appendix C. A summary of the advantages and disadvantages of each technology option is provided in Table 15.

Table 15 Advantages and disadvantages of different technologies.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Fired CHP Engine</td>
<td>Proven technology with good reliability</td>
<td>Limited flexibility in output</td>
</tr>
<tr>
<td></td>
<td>Can achieve good reduction in energy costs</td>
<td>Limited carbon emission reduction</td>
</tr>
<tr>
<td></td>
<td>Good efficiency</td>
<td>High investment costs especially for small-scale systems</td>
</tr>
<tr>
<td>Biomass Boilers</td>
<td>Mature technology</td>
<td>Periodic fuel delivery</td>
</tr>
<tr>
<td></td>
<td>Relatively low integration costs</td>
<td>Space required for fuel storage</td>
</tr>
<tr>
<td></td>
<td>Uses a CO\textsubscript{2} neutral energy source</td>
<td>Emission filtration can be required in urbanised area with air quality constraints</td>
</tr>
<tr>
<td>Gas CHP &amp; Bio-liquid Boilers</td>
<td>Reduced CO\textsubscript{2} emissions</td>
<td>Cost of bio-diesel higher than the price of conventional hydrocarbon diesel</td>
</tr>
<tr>
<td></td>
<td>Modular installation to match demand growth</td>
<td>Requires a local bio-diesel supplier</td>
</tr>
<tr>
<td></td>
<td>Can be integrated in today’s infrastructure</td>
<td>Spatial requirements for fuel storage tanks</td>
</tr>
<tr>
<td>Technology</td>
<td>Benefits</td>
<td>Challenges</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Biomass CHP (ORC Turbine)</td>
<td>High cycle efficiency, High CO₂ saving potential, Higher heat to power ratio than gas engine</td>
<td>High capital costs, Large spatial requirements, Emission filtration can be required in urbanised area with air quality constraints, Slow to start up</td>
</tr>
<tr>
<td>Biomass CHP (Gasification Plant)</td>
<td>High CO₂ saving potential, Uses a carbon neutral source</td>
<td>Low efficiency, Large space requirements, Small-scale gasification plant is still under development, Not suitable in air quality restraint areas</td>
</tr>
<tr>
<td>Biomass CHP (Steam Turbine)</td>
<td>Flexible heat to power ratio, High CO₂ saving potential</td>
<td>Not suitable for small-scale applications (&lt;5MW), Regular fuel delivery, Large fuel costs</td>
</tr>
<tr>
<td>Air Source Heat Pumps</td>
<td>Less maintenance than combustion heating systems, Cheap to operate, Reduces carbon emissions</td>
<td>High capital costs, Decrease in efficiency in cold areas, Electricity is required to run the heat pumps (decarbonisation of grid electricity is a consideration)</td>
</tr>
<tr>
<td>Water Source Heat Pump</td>
<td>Renewable energy source, Little maintenance, Higher coefficient of performance than the ground source and air source heat pumps, so for every unit of electricity used to operate them, they can produce more hot water</td>
<td>Requires a body of water available onsite, Electricity is required to run the heat pumps (decarbonisation of grid electricity is a consideration), Installation may lead to significant disruption in busy areas</td>
</tr>
<tr>
<td>Ground Source Heat Pumps</td>
<td>Less maintenance than combustion heating systems, Cheap to operate, Reduces carbon emissions</td>
<td>High capital costs, Important space requirements, Installation may lead to significant disruption in busy areas, Research is required to understand the movement of heat and the local geology</td>
</tr>
<tr>
<td>Deep Geothermal</td>
<td>Almost a clean energy source, Can be used in combination with heat pump and as energy storage for solar energy, High energy efficiency, Minimal surface space requirement</td>
<td>Prime sites are very location-specific, Prime sites are often far from population centres, Losses due to long distance transmission, High investment costs</td>
</tr>
<tr>
<td>Energy from Waste</td>
<td>Cheap fuel, Creates use of waste that would otherwise be put in landfill, CO₂ reduction</td>
<td>Fuel deliveries, EfW should not compromise the waste hierarchy (prevention, re-use, recycle, energy recovery, disposal), Requires environmental permit, involving consultation and agreement from local community, local authority and public health bodies</td>
</tr>
<tr>
<td>Waste Industrial Heat</td>
<td>Can significantly increase the efficiencies of local industry, Consistent source of ‘free’ heat, CO₂ reduction</td>
<td>Requires relevant industries in close proximity, Increased risk and complexity for processes integrated through heat recovery measures</td>
</tr>
<tr>
<td>Solar Thermal</td>
<td>Clean and renewable technology, Reduced energy consumption, energy bills and carbon emissions, Well suited to urban areas, Can utilise thermal storage to better match supply with demand</td>
<td>High investment cost, Heat production is weather-dependent with more hot water being produced in the summer than in the winter, Intermittent generation, Requires seasonal storage and/or a backup energy source to ensure demand is met whatever the weather</td>
</tr>
</tbody>
</table>
Following an initial screening of the technologies listed above according to the constraints and potentials of Macclesfield, some options were immediately discounted for the following reasons:

- **Water Source Heat Pump:** As described in Section 3.4.2, there are 2 main water bodies in the East of Macclesfield which are the Macclesfield Canal and the river Bollin. However, they are not located in the town centre and are far from the loads considered. In addition, there would be issues due to topography as Cluster is located on top of a hill.

- **Deep Geothermal:** This is a relatively new technology in the UK. Cheshire East Council is investigating deep geothermal opportunities as Cheshire Basin has been identified as a potential aquifer. The potential of geothermal for Macclesfield has been studied previously through the investigation of thickness of aquifer and thermal and hydro-physical parameters. It has been concluded in the paper\(^{17}\) that geothermal exploration would not be economically viable in Macclesfield as the local geology is not favourable. In addition, the scale of the project would not make the implementation of geothermal viable.

- **Solar thermal:** Due to the discrepancy between peak seasonal generation and peak seasonal demand, use of solar thermal will significantly increase the reliance on the backup gas boilers or large seasonal storage. The technology comes with high investment costs and hence the project is unlikely to achieve significant CO\(_2\) savings or financial viability.

- **Energy from Waste:** There is no potential existing energy supply from waste in or around Macclesfield.

- **Waste Industrial Heat:** The Macclesfield Crematorium has been identified as a potential heat source from the AECOM report. However, the heat generation is expected to be greatly intermittent. Thus, this option has been discarded as the grade and availability of heat is unlikely to be suitable for a district heating. It is noteworthy to mention that the Hurdsfield AstraZeneca facility (located 1.4 miles to the north of the town centre) which is outside of the redline boundary of this study represents an opportunity, however it is understood to be the subject of another assessment.

All the remaining technologies were included in the shortlist. It should be noted that to improve resilience and security of supply, and to enable load flexibility to meet peak demand, gas boilers were assumed to be included within the operational strategy of all the technologies. However the dependence of the system on the gas boilers varied due to the prime mover selected.

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\(^{17}\) A brief summary of geothermal potential in Macclesfield – investigating thickness of aquifer, thermal and hydro-physical parameters, Chris Brown CEC/Keele
4.2 IRM Technology Assessment

The shortlisted technology options were subjected to an IRM assessment. Figure 34 shows the scores each technology was allocated to reflect its performance against the assessment criteria. The scores range from 1 (very positive) to 5 (very negative).

![Figure 34 - Scoring of technology options.](image)

### 4.2.1 The economic category results

It can be seen that gas fired CHP arrives first in the economic category. This can be explained as this is a well-established and affordable technology that can potentially achieve high energy cost savings. Biomass boilers rank second as their operation and maintenance costs are low. Another advantage is that little infrastructure upgrade is required and they are easy to integrate into existing infrastructure.

It should be noted that energy cost saving in the IRM does not include revenue or savings from electricity generation, hence a higher average score for biomass boiler is shown than could potentially be expected. The impact of electricity sales revenue on the financial performance of the proposed scheme is discussed in later sections, however it is noted here that heat-only technologies are unlikely to result in a financially viable scheme. If revenue generation was included as a criterion in the analysis, biomass boiler would have a lower average score for this category.

### 4.2.2 The strategic category results

The technology which achieves the highest score in the strategic category is gas fired CHP. Indeed, this technology would result in the least disruption to town centre running as no fuel deliveries are required. Also, it would ensure reliability and security of supply to consumers. In addition, this system is easy to design to accommodate future increase in heat demand should the heat network be expanded. However, future proofing of this solution is debatable if the government decides in the future that the energy mix should move away from natural gas and focus on renewables. Air source heat pumps arrive second in the
ranking as they are the safest system based on combustion and provide a reliable and steady source of heat while using a renewable energy source.

4.2.3 The legislative category results

The legislative category does not appear to be decisive in the choice of the most suitable technology. After review of the New Local Development Plan and discussion with the Planning Team of the Council, it has been concluded that there is no major constraints which could impact on planning application or delivery timescale. Cheshire East Local Plan aims for the regeneration of the town centre, including generating jobs, empowering local people, using brownfields and improving environmental quality. The main objectives of the plan are creating conditions for business growth; this could be achieved by developing a strong biomass supply chain bound by contracts and partnerships. However, statutory consent can be lengthy in town centre involving biomass and emission filtration can be required in urbanised or densely populated areas with air quality restraints. Planning application can be required depending on flue design of biomass installations. The plan also mentions reducing impact on climate change and promoting renewable energy. As a result, heat pumps rank first in the legislative category as they use clean renewable energy sources.

4.2.4 The technological category results

The technology which ranks first in the technological category is gas fired CHP. The solution is a mature technology with good efficiency and a small space requirement. No fuel storage is required. Also, gas fired CHP combined with back up gas boilers is flexible and able to meet changes in demand. As Macclesfield town centre is connected to the gas grid, there is no concern about the robustness of the fuel supply chain.

Biomass installations require more space for energy centre, thermal storage and fuel storage. This is an important issue in the town centre as limited space is available. Biomass technologies are also usually harder to procure/install and the robustness of the fuel supply chain would depend on the local biomass suppliers. In addition, biomass CHP technologies are not suitable for small-scale applications.

4.2.5 The environmental category results

Heat pumps are the highest ranking technology in the environmental category. They use clean and renewable ambient energy sources which significantly reduces emissions and limits climate change. However, electricity is required to run heat pumps which means that they are not entirely carbon neutral.

High heat generation from biomass installations will increase the low carbon potential of the district heating. It will increase carbon saving opportunities and the positive impact on climate change. It can also promote renewable energy on a large scale and enhance the environment if appropriate design is used to limit additional emissions (i.e. particulate matter needs to be filtered). Reputational
benefits can be another incentive especially given the importance of this to the local population.

4.3 Short-Listed Technologies

Figure 35 presents the results of the IRM assessment for technology selection. The average score obtained by each technology is shown, as well as the overall ranking of the technologies. Gas fired CHP engine ranks the highest in the assessment, followed by, first, standalone biomass boilers and, then, gas fired CHP combined with biomass boilers. However, as explained in Section 4.2.1, the economic category does not take into account electricity generation revenue which results in an optimistic economic score for stand-alone biomass boiler and an electricity generation plant might be financially more viable.

Note: The rest of the study considered the technical and economic feasibility of the three highest ranking technologies as the prime movers for the Macclesfield heat network. The sizing and operational strategies of these technologies are considered in Appendix D. However, Section 5 explains why gas fired CHP was ultimately selected as the only viable option due to space and access constraints.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Economic</th>
<th>Strategic</th>
<th>Legislative</th>
<th>Technological</th>
<th>Environmental</th>
<th>Average Score</th>
<th>Ranking</th>
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<td>5%</td>
<td>25%</td>
<td>15%</td>
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<td>1</td>
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<tr>
<td>Gas CHP &amp; Biomass Boilers</td>
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<td>2.8</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>2.8</td>
<td>3</td>
</tr>
<tr>
<td>Gas CHP &amp; Bio-Liquid Boilers</td>
<td>3.5</td>
<td>3.0</td>
<td>2.5</td>
<td>2.7</td>
<td>3.0</td>
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<td>5</td>
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<td>Biomass CHP (ORC Turbine)</td>
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<td>2.8</td>
<td>2.5</td>
<td>3.6</td>
<td>2.7</td>
<td>3.3</td>
<td>7</td>
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<tr>
<td>Biomass CHP (Gasification Plant)</td>
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<td>3.3</td>
<td>2.5</td>
<td>4.0</td>
<td>2.7</td>
<td>3.7</td>
<td>9</td>
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<tr>
<td>Biomass CHP (Steam Turbine)</td>
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<td>4.0</td>
<td>2.7</td>
<td>3.4</td>
<td>8</td>
</tr>
<tr>
<td>Biomass Boilers</td>
<td>2.5</td>
<td>2.8</td>
<td>2.5</td>
<td>3.1</td>
<td>2.7</td>
<td>2.7</td>
<td>2</td>
</tr>
<tr>
<td>Air Source Heat Pumps</td>
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<td>2.3</td>
<td>2.9</td>
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<td>Ground Source Heat Pumps</td>
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</tbody>
</table>

Figure 35 Results of the technology IRM assessment.
5 Energy Centre

This section considers the energy centre for the Macclesfield heat network. First, options for the energy centre location are discussed. The section then describes the preferred location, giving information about the proposed operation and layout.

5.1 Selection of the Preferred Location

The energy centre would ideally be located on council land. Figure 36 shows the boundary of the land owned by the council (red line) as provided by Cheshire East Council in October 2016. It should be noted, however, that the Churchill Way Car Park was sold to Ask Real Estates at the beginning of 2016.

Figure 36 Council land ownership.

Six potential locations for a future energy centre serving the town centre heat network were determined based on previous studies and stakeholder engagement. These are shown in Figure 37 and described below.
1. **Town Hall.** The town hall has a central location in Cluster 1 and, as the building with the highest heat and electricity demand, would be an ideal location for the energy centre. Several possible locations were identified within the Town Hall complex:

   a) **Town Hall Car park.** The installation and operation of an energy centre at the Town Hall car park would result in least amount of disruption to the Town Hall running. However, several constraints were identified: Loss of car parking space would be an issue, as the car park is used by staff, residents and public. Figure 38 shows the location of residential buildings adjacent to the Town Hall car park. Visual impact and noise from the energy centre would likely result in objections by the residents. The vehicle weight limit at the car park is 7.5t. The car park potentially also has structural issues, and any proposals to use this location would need to assess ground conditions, including impact of the proposed energy centre on existing retaining walls and their recent improvements. Another significant constraint is the location of the car park on top of a hill, with views from Macclesfield station and other parts of the town. It is thought that planning consent would be difficult to obtain for this location.

   b) **Existing Town Hall plant rooms.** The Town Hall has two existing plant rooms serving the old and new parts of the building. The Old Town Hall plant room is located on the ground floor of the building. The New Town Hall plant room is located on the second floor. Neither of the plant rooms...
has enough space to accommodate the full energy centre. Access to the second floor plant room is a further constraint.

c) **Town Hall bike shed.** There is a long and fairly narrow space at the back of the car park which is currently used as a bike shed and emergency exit from the Town Hall. The space is hidden from the direct view of the cottages. There is good access to the space via the car park, but an energy centre would need to be designed to allow for the emergency exit to be maintained. Additionally, the height of the energy centre is limited to below the first floor windows of the New Town Hall and the height of the stone wall separating the space from a garden on the other side.

Access to any of the above locations would be via the Town Hall car park, access to which is via a single lane road with sharp corners.

![Figure 38 Location of residential buildings close to the Town Hall.](image-url)

2. **Gas Road.** A private landowner has offered the use of an approximately 100m² plot of land he owns for the energy centre. The land is located at the edge of the town on Gas Road, close to Travelodge, and offers benefits in terms of minimising disruption to town centre running during installation, operation and maintenance. The landowner is also an entrepreneur developer and green energy enthusiast, they are particularly interested in the biomass technology option. Preliminary discussions revealed plans for an office building which could be designed to accommodate a biomass boiler on the ground floor level. There is good access to the land for biomass deliveries, but
space for biomass storage is limited and nearby rail bridges have a height limitation. This option carries an increased risk due to the private ownership of land. This area of the town is also located on a lower level than the rest of Cluster 1, resulting in an increased capital cost for pipework and operational cost for pumping. Flue design would need to consider the impact of the energy centre on the residential buildings which are located on the hill above the plot of land.

3. Churchill Way Car Park. Churchill Way Car Park in Cluster 2 is owned by Ask Real Estate which has plans for a leisure-led development containing a cinema, restaurants and a retail unit. The car park was identified as a potential location for an energy centre in the Aecom pre-feasibility study. This is a potentially large area which could be designed to accommodate an energy centre. However, Arup was asked not to contact Ask Real Estate for this study and no further information is currently available. It is understood that there are ongoing uncertainties over the development and, while there are some valuable advantages to be had, the energy centre and the heat network connection could be perceived as added complications to the development. Due to the distant location of the car park from Cluster 1, this option was not considered further.

4. Royal Mail. During the stakeholder engagement for this study, it was found that Royal Mail have an under-utilised plant room and potentially also an unused garage which could be investigated for suitability as energy centre locations. Royal Mail landlord Cushman & Wakefield expressed an interest in the potential rental income from the scheme, but due to the short timescale, no further information was received. It was, however, found through council engagement that Royal Mail is investing in this location significantly and is expected to remain in the area for the foreseeable future. This option could be explored with the landlord further, but the additional cost of renting the space would need to be factored in. Additional drawbacks of utilising this location include the increased risks due to private ownership of land (and potentially also building). However, access to the Royal Mail site is designed for vans and this option would result in minimal disruption to the town centre running.

5. Old Police Station. Another option was the Old Police Station on Churchside. This currently unutilised building is located next door to the Town Hall, with access from the Town Hall car park as well as Churchside. The building is a prime regeneration target and it was thought that a visible energy centre located within it could provide a new use, as well as an educational purpose, for the building. However, the Cheshire East Council’s Regeneration team advised that the selected future use of the building would likely include uses which significantly increase footfall in the town centre, and an energy centre would be unlikely to fulfil this requirement. Additional issues with utilising the building would include the likely requirements to reinforce flooring, replace ceiling, and tear down internal walls to create a large enough space. Consent for this would be unlikely for this Grade II* listed building.

6. Pickford Street Car Park. This car park was briefly considered due to its location in Cluster 3, away from the listed buildings and heritage nature of Cluster 1. The car park is leased to the council, however the terms of the lease...
are unknown to Arup. The car park is enclosed by two to three storey high buildings, thought to include shops, cafes, restaurants, offices and residential. Difficulties in obtaining planning permission would be expected.

From these options, Town Hall was selected as the location with least risk and cost. Due to the issues with locating the energy centre at the car park, it is proposed that the energy centre utilises the space currently used as the bike shed and also takes advantage of the room within the existing New Town Hall plant room. The relocation of the bike shed would need to be considered, as well as the visual impact of the energy centre on the surroundings cottages. The option also has the disadvantage of limited space, which rules out the use of biomass in this location: The selected location cannot accommodate the increased spatial requirement of a biomass boiler nor is there space for a fuel store. There would also be restrictions for fuel deliveries and objections by the local residents would be likely. Out of the potential energy centre locations considered, only the privately owned land on Gas Road and the Royal Mail Delivery Office could offer opportunities for the use of biomass boilers in Cluster 1.

Whilst biomass boiler is not considered as a preferred technology further in this report, indicative technical analyses of both a stand-alone biomass boiler and biomass boiler combined with a gas CHP engine have been prepared and are available in Appendix D, should the preferred energy centre location change and these to become viable options again. However, it should be noted that stand-alone biomass boilers are usually not economically viable due to lack of electricity generation revenue and savings.

5.2 Plant Configuration

The main heating plant supplying the district heating and private wire network will be located in an energy centre space currently occupied by the bike shed and redundant air coolers on the side of the New Town Hall building (see Figure 39). A modular configuration will be used in order to make use of the space available in an efficient and cost effective manner.
Due to space limitation, the prime mover (CHP gas engine) and its ancillary equipment (intercooler, ventilation, control panel, plate heat exchanger for interface with the LTHW (low temperature hot water) system, pumps, exhaust gas heat exchanger) will be supplied as containerised units. The CHP containerised unit will be positioned along the stone wall (similar to the existing bike shed) so that it does not obstruct the emergency exit from the Town Hall. Space will be required at the front to allow for access for maintenance and replacement.

It can be seen that the space available is very tight which constrains the configuration of the plant. Should the heat network be expanded, a heat substation could be located near additional loads as increased plant capacity in the proposed location is not possible.

A 35m³ (approx. 3.0m dia x 5.9m high) thermal store will be located outside the CHP container and connected to the CHP heat recovery circuit. The thermal store has been designed by studying different storage capacities and the storage content profile over a year. The optimisation of the thermal storage has been undertaken in EnergyPRO. The thermal store will be insulated, cladded and weather proofed in order to minimise heat losses and visual impact.

The CHP engine flue will be directed towards the outside wall of the Town Hall building and extended to the top of the building, with a clearance of 3m from the highest openable window of the building.

Two condensing modular boilers, each rated at 719kW will be installed in the existing New Town Hall boiler room, located on the second floor of the building. The boilers selected will be modular type Hamworthy Modumax MK3 (or
equivalent) boilers, consisting of three modules stacked vertically. These boilers will provide the required supplementary heat to the heat network and provide for N+1 resilience to the system.

It is recommended that the existing gas boilers in the New Town Hall plant room (shown in Figure 40) are removed to make space for the new boilers. These boilers are nearing their end of serviceable lifetime and would in any case require replacing in the near future in order to provide for a more efficient source of heating. The existing boilers are estimated to have an overall heating efficiency of approximately 70%, while the proposed new heating supply via the CHP and the condensing boilers is estimated to have an overall efficiency of approximately 87%.

Figure 40  Old boilers in the New Town Hall plant room.

The boilers will be connected to the CHP circuit and main heating system header via pipework which will run from the second floor plant room down the existing riser to the corridor outside the New Town Hall building. From there, it will run below ground to the container containing the main heating header and distribution pumps.

An additional small containerised unit located near the CHP will house pumping and ancillary equipment. The container will host the district heating (DH) pumps (duty-standby) and a header arrangement where the LTHW connections from the CHP-Thermal store system and the boilers system common flow/return will connect. The header arrangement will be placed in a vertical arrangement to allow
for space saving. The main control panel and pressurisation unit will be located in the New Town Hall boiler room.

The option of locating the main control panel in the UPS container situated at the rear of the Old Town Hall was also considered. However, engagement with the Facilities Management Team revealed that the container hosts a generator that powers the computer room in the Town Hall. It is permanent placement for the equipment and there is no room for additional equipment in the container. As a result, both the main control panel and the pressurisation unit will be located in the New Town Hall.

Figure 41 shows the container locations for the CHP engine and pumping station, as well as the proposed location of the thermal store to the west of the CHP engine and the New Town Hall plant room. The size of the pumping station has been minimised and has the following dimensions: 2.5m wide, 3m long and 3m high, with a footprint of 7.5m². This containerised unit cannot be located within the courtyard but will be positioned alongside the external wall to minimise visual impact on neighbours. The shape of the DH pumping station cannot be modified given the specific equipment it hosts and the internal layout required. However, it is positioned in such a way that both the emergency exit of the Town Hall and the neighbour’s gate are kept clear for garden access. The area required for CHP access/removal is also kept clear. A better resolution drawing is provided in Appendix G. An indicative configuration of the plant and equipment is provided in Figure 42, and this is also available in full resolution in Appendix G.

![Diagram of proposed plant location](image)

Figure 41 Proposed plant location. A full scale drawing is available in Appendix G.
Figure 42  3D Configuration of the proposed energy centre layout.
5.3 CHP Operational Strategy

The proposed system is shown in Table 16. The scheme includes a 250kWe (291kWth) CHP engine and 2No. supplementary boilers each rated at 719kW. Each boiler is anticipated to contain numerous modules to allow the boilers to modulate to closely match demands. No heat rejection has been considered to maximise the use of the heat produced by the system. A thermal store of $35\text{m}^3$ (approx. 3.0m dia x 5.9m high) has been utilised to store any excess heat produced by the CHP and to optimise the techno-economic performance of the scheme.

The operational strategy of the energy centre has been optimised for thermal efficiency over a constrained daily period using EnergyPRO modelling software. A study of the different operational strategies is provided within Appendix D. Operating the engine at its full output for a maximum of 16 hours a day has been selected as the preferred operational strategy to minimise impact on neighbours and equates to a modelled hours of operation of 4,656 hours. While this mode of operation suits neighbourhood constraints it is clearly not maximising the utilisation of the plant to capitalise on manufactured capabilities of operational availability. However, the mode of operation selected is not excessive, it is well within the manufactured abilities in terms of starts/stops. Despite the plant not being utilised to its maximum potential, overall, with good quality O&M procedures, the negatives of start/stop operation are anticipated to be balanced by the positives of reduced run-hours/lifetime.

Four weeks of annual CHP downtime has been included within the models to simulate realistic levels of plant availability. This is aligned with CHP manufacturers’ data of typical annual availability of 92% being achievable. It is quite usual for gas CHP engines to have scheduled checks and minor maintenance items carried out (oil check, filter cleaning etc.) over 2 to 4 hours every 7 to 14 days. A two week summer shutdown for annual maintenance items is additionally usual and combines to make up the 4 weeks overall annual downtime.

Figure 43 shows the simulated operation of the CHP for a single day. The engine meets the majority of the day time electricity demand. Imports of electricity are required at night and during peak demand periods. The engine meets most of the heat demand during the day and the excess heat is stored in the thermal store. The thermal store is charged during periods of low demand and discharged either at night when the engine is not operational or when demand rises. When the thermal store is fully discharged, the supplementary boilers turn on to meet heat demand.

Figure 44 shows the profile over a whole year, clearly displaying the decrease in heat demand (upper graph) in the summer and a more constant weekly pattern of electrical demand (lower graph) all year round as only a small part of electricity consumption is weather-dependent. The break in the CHP output during the summer is due to maintenance.
Table 16 Proposed system.

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<td>CHP engine total fuel input gross</td>
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<td>CHP maximum turndown ratio</td>
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<td>CHP run hours</td>
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</tr>
<tr>
<td>Electricity import</td>
</tr>
<tr>
<td>Electricity efficiency</td>
</tr>
</tbody>
</table>

Figure 43 Example daily heat and electrical generation and consumption.
Figure 44 Yearly heat and electrical generation and consumption.

5.4 CHPQA Criteria

The Combined Heat and Power Quality Assurance Programme (CHPQA) is a Government initiative to encourage the application of good quality combined heat and Power, community heating and alternative fuel technologies. CHPQA is a scheme under which registration and certification of CHP schemes are carried out according to defined quality criteria. The minimum combined heat and power quality index for all types of CHP should be 105 with a power efficiency greater than 20%.

Attainment of a CHPQA certificate supports claims for the benefits offered to Good Quality CHP schemes. These include CCL exemption on fuel inputs to and power outputs from the scheme. To be eligible for CCL exemption, a CHP scheme must have a Secretary of State (combined heat and power) exemption certificate for the scheme. CHPQA can also be used to claim Enhanced Capital Allowances (ECAs). This also requires a Secretary of State Certificate of Energy Efficiency.

The CHPQA standard aims to measure, monitor and improve the quality of CHPs across the UK. It does this by:

- Defining, assessing and monitoring the quality of CHP schemes on the basis of energy efficiency and environmental performance
- Ensuring fiscal and other benefits are in line with environmental performance
- Providing clear signals to users and potential users to minimise the costs of energy demand through CHP
- Achieving the above at minimum costs to CHP users and the Government

Certification issued under the CHPQA programme may be used for determining the eligibility of schemes for fiscal or other benefits and for determining compliance of schemes with regulatory requirements where quality is relevant to entitlement.

The application of CHPQA is dependent on the complexity of the scheme. CHP schemes can be categorised as ‘simple’ or ‘complex’, as explained in Table 17.
Table 17  CHPQA simple and complex schemes.

<table>
<thead>
<tr>
<th>A simple scheme</th>
<th>A complex scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generating capacity &lt; 2MWe</td>
<td>Generating capacity ≥ 2MWe</td>
</tr>
<tr>
<td>Single reciprocating engine</td>
<td>Prime mover not a single reciprocating engine</td>
</tr>
<tr>
<td>Single conventional fuel used</td>
<td>Non-conventional fuel used</td>
</tr>
<tr>
<td>No heat only boiler present</td>
<td>Fired boiler(s) included within scheme boundary</td>
</tr>
</tbody>
</table>

Schemes are subjected to a self-assessment involving a series of calculations.

- Scheme boundary and selected Quality Index definition
- Monitoring and recording provisions
- Power Efficiency
- Heat Efficiency
- Quality Index (QI)
- Qualifying Power Capacity (CHPQPC)
- Qualifying Heat Capacity (CHPQHC)
- Qualifying Fuel Input (CHPQFI)
- Qualifying Power Output (CHPQPO)
- Qualifying Heat Output (CHPQHO)

In order to complete the necessary calculations, detailed design or operational data is required. Consequently, at this stage of analysis, it is only possible to form a high-level view of the likely level CHPQA compliance. Given the indicative modelling outputs, the QI achieved by the CHP on the complete scheme is 149 with a power efficiency of 39%. This is greater than the required 105 QI and 20% power efficiency, hence it is expected that this scheme would qualify as CHPQA.

Cheshire East Council should be aware of CHPQA and specify the requirement that the network be eligible to the detailed design team to ensure access to the fiscal benefits available. Note that CCL exemption has been included in the financial model.

5.5  HNIP Funding Requirements

HNIP has released applicant guidance for the Pilot Scheme\textsuperscript{18,19}. Applicants will need to demonstrate that their projects satisfy the minimum eligibility criteria at the pre-qualification stage including:

---

\textsuperscript{19} Note: the first round of HNIP funding was awarded in April 2017, with a total of £24m awarded to 9 local authorities. The main funding scheme is expected to launch by the end of 2017. Source:
• Eligibility (i.e. Projects in England and Wales only; Heat networks providing heating and/or cooling and those that also generate electricity; Networks with no technical / contractual impediment to expansion)

• Compliance with Heat Networks (Metering and Billing) Regulations 2014

• Heat source requirements (i.e. 75% of heat from non-renewable fuelled CHP or 50% of heat from a renewable source, recovered heat or a combination of renewable/recovered heat and non-renewable fuelled CHP)

• Where the chosen heat source is CHP, CHPQA accreditation

• Adherence to CIBSE ADE Code of Practice CP1:2015

• Commitment to become a member of Heat Trust (if within scope, otherwise to offer equivalent standards)

• Are only eligible investment costs included? (i.e. future capital costs only, commercialisation is only eligible as part of a construction application)

• Can the heat network demonstrate carbon savings and will the heat price be no more than the counterfactual?

• Will the applicant be able to provide evidence of a funding gap at full application and pass one of the additionality tests?

Applications meeting these requirements will then be invited to submit a full application.

Table 18 sets out the requirements to meet HNIP funding in consistency with the Energy Efficiency Directive where an efficient network must use at least 50% renewable energy, 50% waste (recovered) heat, 75% cogenerated (CHP) heat or 50% of a combination of such energy and heat. It can be seen that the proposed Macclesfield scheme meets the 75% threshold for CHP heat generation compared to heat demand.

Table 18  HNIP funding criteria.

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Proposed Scheme</th>
<th>HNIP Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Carbon Saving</td>
<td>[tCO₂]</td>
<td>149</td>
<td>-</td>
</tr>
<tr>
<td>(averaged over 15 years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>[%]</td>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td>Recovered Heat</td>
<td>[%]</td>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td>CHP Heat</td>
<td>[%]</td>
<td>80%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Further HNIP requirements at the full application stage are expected to include similar requirements to the Pilot Scheme, e.g. completion of a shadow financial model to allow the robustness of the scheme to be assessed independently and demonstration that funding can be secured for the full amount. The proposed

scheme has been designed to be HNIP compliant as far as the requirements have been known.

5.6 Energy Centre Gas Connection

The gas distribution network in the area is owned and operated by National Grid. Enquiries were made with National Grid to determine suitable location(s) from where a new gas supply to the energy centre can be taken. National Grid proposed that the nearest suitable connection point is a low pressure main located in Churchside, approximately 30m from the proposed energy centre site in the Town Hall. National Grid has confirmed that it currently has sufficient capacity to serve the energy centre demand. A low pressure main indicates that a gas booster is likely to be required for the CHP engine and this has been allowed for in the financial analysis.

![Gas connection point for the energy centre.](image.png)

5.7 Energy Centre Electricity Connection

Section 7 details the electricity connection requirements for the energy centre.

5.8 Energy Centre Utilities Connection

The water distribution and waste water network in the area is owned and operated by United Utilities. Connection is required for domestic purposes inside the energy centre and it has been assumed that this can be taken from the existing supply to the Town Hall.

20 Source: [https://hnip.salixfinance.co.uk/information](https://hnip.salixfinance.co.uk/information) (accessed 19 April 2017).
5.9 **Energy Centre Parasitic Load**

The parasitic load of the energy centre, including distribution pumps, has been estimated at 2% of the total heat supplied, in line with the Code of Practice.
6 Heat Network

This section considers the proposed heat network, including the connected proposed pipe route, pipe lengths, heat network connections and future proofing of the network.

The buildings to be connected to the heat network, and their heat demands, are listed in Table 19, organised in the order of the buildings’ heat demand.

Table 19 Building connections for the proposed scheme.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Building</th>
<th>Annual Heat Consumption (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Town Hall</td>
<td>782,200</td>
</tr>
<tr>
<td>2</td>
<td>Cheshire Constabulary</td>
<td>430,200</td>
</tr>
<tr>
<td>3</td>
<td>Royal Mail</td>
<td>346,600</td>
</tr>
<tr>
<td>4</td>
<td>Library</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td><strong>Total Consumption</strong></td>
<td><strong>1,559,000</strong></td>
</tr>
</tbody>
</table>

The annual heat demand of Cluster 1 is estimated to be 1,559MWh, with the Town Hall accounting for 50% of this total.

6.1 Pipe Work

6.1.1 Pipe route

A provisional pipe route for the Cluster 1 heat network is shown in Figure 46. The pipe route was designed to follow the road network and routes through those stakeholder estates which are likely to connect to the network, for ease of installation. The route avoids the newly cobbled Market Place / Jordangate by connecting the Town Hall, Cheshire Constabulary police station and Royal Mail Delivery Office through the back streets. The route is entirely hard dig with no opportunities for soft dig.

The proposed heat network crosses the path of existing electrical cables between the Town Hall and the Police Station car park. This can be seen in Figure 50 in Section 7.3 which depicts the electrical infrastructure of the town centre. Further investigation should be conducted before installing pipework in this area and this could lead to additional cost.
Figure 46  Provisional heat network route.

6.1.2  Pipe lengths

Assumptions made when designing the pipe network are shown in Table 20. A flow temperature was selected for compatibility with existing buildings. It is assumed that all buildings will have an indirect connection to the network through a heat interface unit (HIU) or commercial plate heat exchanger (with required ancillaries).
Table 20  Heat network pipe assumptions.

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Temperature</td>
<td>85</td>
<td>°C</td>
</tr>
<tr>
<td>Return Temperature</td>
<td>55</td>
<td>°C</td>
</tr>
<tr>
<td>Delta T</td>
<td>30</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Flow Velocity</td>
<td>1.21</td>
<td>m/s</td>
</tr>
<tr>
<td>Maximum pressure drop</td>
<td>250</td>
<td>Pa/m</td>
</tr>
</tbody>
</table>

Lower flow temperatures could be considered and would help to reduce pipework heat losses. However, heating systems in the majority of existing buildings are sized for higher flow temperatures. Radiators for example are typically sized based on 82-71°C flow and return temperatures. The code of practice stipulates that radiators can be rebalanced to achieve a larger temperature difference (80-60°C). However, a lower flow temperature would likely require conversion of the existing heating systems. This would incur significant additional capital cost and disruption. Consequently, a flow temperature of 85°C is recommended for compatibility with existing systems.

Indicative trench dimensions are shown in Figure 47. This displays how the trench should be sufficiently large for installation. Warning tape should be laid above the pipes to prevent accidental damage by works. In areas of heavy traffic or where the minimum soil cover is not possible, the pipes should be protected.

Figure 47  Indicative trench dimensions (source: Logstor Industry Catalogue).

Table 21 outlines the required pipework lengths and costs. The total network for the Macclesfield town centre network is 370m, with a total pipe length of 750m. The total heat network pipe cost is estimated to be £249,000.
Table 21  Pipe lengths and costs.

<table>
<thead>
<tr>
<th>Nom Pipe Dia [mm]</th>
<th>Length (F&amp;R)</th>
<th>Material</th>
<th>Insulation</th>
<th>Heat Loss [MWh/y]</th>
<th>Installed Pipework [£]</th>
<th>Civil [£]</th>
<th>Ancillary Pipework, Joints, Bends, Building Entry Valve sets [£]</th>
<th>Ducting [£]</th>
<th>Total Cost [£]</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>45</td>
<td>Steel Conti</td>
<td>Logstor series 2</td>
<td>2.99</td>
<td>887</td>
<td>10,319</td>
<td>2,078</td>
<td>1,077</td>
<td>14,361</td>
</tr>
<tr>
<td>40</td>
<td>400</td>
<td>Steel Conti</td>
<td>Logstor series 2</td>
<td>30.05</td>
<td>8,295</td>
<td>94,813</td>
<td>10,042</td>
<td>9,899</td>
<td>123,049</td>
</tr>
<tr>
<td>100</td>
<td>300</td>
<td>Steel Conti</td>
<td>Logstor series 2</td>
<td>31.09</td>
<td>16,867</td>
<td>60,306</td>
<td>27,285</td>
<td>7,577</td>
<td>112,035</td>
</tr>
<tr>
<td>TOTAL</td>
<td>745</td>
<td></td>
<td></td>
<td>64.13</td>
<td>26,049</td>
<td>165,438</td>
<td>39,405</td>
<td>18,554</td>
<td>249,446</td>
</tr>
</tbody>
</table>

A pair of steel conti pipes was selected for the study. For the selected design supply temperatures of 85°C for the heat network, a pre-insulated steel pipe system, designed and manufactured in accordance to EN 253, will be expected to have a lifetime of 60 years, when used in a heat network system designed as per the requirements of the UK Heat Networks Code of Practice. For a similar polymer pipe system, operating at the same supply temperatures, the expected lifetime of the pipes, according to manufacturer’s data is only 25 years. The considerable difference between the expected lifetimes of the two pipe systems outweighs the potential savings on the project CAPEX from the use of polymer pipes. As a result, steel pipes are a more sustainable and cost-efficient option and so are the recommended option.

6.1.3  Heat losses

Heat loss through the pipework described in the previous section was determined by using the online Logstor Calculator. Pipe specifications and assumptions used for the calculations are detailed in the Appendix F. The total heat loss was assessed to be 64MWh/year.

6.1.4  Utility Constraints

As described in Section 6.1 with regard to heat network routing and Section 7.3 with context to existing utilities, there are constraining influences on heat and private wire network designs to be considered.

The proposed heat network would follow public highway routes also used by the utilities. Site investigations would need to be carried out to inform heat network final route proving prior to trench design detailing. However, from utility investigations made it is considered that for Cluster 1 the proposed heat network route is not overly constrained by existing utilities. (See also Section 7.3 for details about the existing electricity infrastructure in the area.)
6.2 Building Connections

6.2.1 Direct or indirect connections

A fundamental design choice is whether the buildings are directly connected to the heat network (where water in the network flows directly through the heating circuits of the building) or indirectly where a heat exchanger is used to provide a physical barrier to the water. The choice has an impact on cost and operating temperatures and pressures.

The key advantages of a direct system are:

- Lower cost than indirect systems
- Less complex than indirect systems, thus maintenance costs and points of failure are reduced
- Secondary pumping is not required
- Space is saved compared to indirect systems

An indirect system is where the heat network is hydraulically separated from a building’s heating system via a heat exchanger. The advantages of an indirect system are:

- Any leaks within a building’s heating system will have limited impact as systems are hydraulically separated
- Buildings’ heating systems are not subject to high heat network pressures
- Risk of contractual disputes over contamination is reduced due to hydraulic separation

Both indirect and direct connections have been used in UK schemes, however, since indirect connections are more prevalent, it has been assumed that this will be the method of connection for all buildings at this stage.

6.2.2 Heating substations

This subsection provides a detailed description of the proposed building connection apparatus which acts as the interface point between the heat network and the building heating systems.

Figure 48 shows a typical heating substation arrangement, consisting of two plate heat exchangers, each sized for 60% of the peak heat demand, and all relevant valves, sensors and gauges. Note industry practice dictates that for a secondary network with a capacity of less than 750kW, one heat exchanger should be used with a capacity of 120% of the secondary network capacity. It is only when the capacity of the secondary network exceeds 750kW that two heat exchangers shall be used (as in the Figure).
Heating substations will typically be housed within a plant room adjacent to an exterior wall preferably at ground level. Each substation shall be serviced by water, drainage and sufficient electrical power. The room should be readily accessible for inspection and maintenance as well as for disconnection and removal of equipment for repair or replacement without the need for removing external walls.

The substation shall include the following equipment:

- Isolating valves
- Strainers
- Temperature and pressure gauges
- Heat exchangers
- Motorised regulation valves
- Heat meters
- Temperature sensors
- Control panel
- Test points
- Hydraulic connections
- Drain valves
- Commissioning valve sets
- Pressurisation unit
- Power and instrumentation (fibre) connections

Pressure regulation and control in the heat substation will be performed by a self-controlling spill and fill type pressurization system. This unit will interlink with the SCADA system for monitoring and control. The unit will be fitted with an appropriately sized accumulator/buffer vessel to maintain a stable system and limit spill to the tank once the system has reached temperature. The system design
should be in accordance with BS EN 12828:2012. Depending on water hardness, a water softener may also be required on the feed water line.

Table 22 Schedule of proposed heat substation capacities.

<table>
<thead>
<tr>
<th>Building</th>
<th>Number of Heat Exchangers</th>
<th>Capacity of Each Heat Exchanger [kW]</th>
<th>Total Capacity [kW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheshire Constabulary</td>
<td>1</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Royal Mail Delivery Office</td>
<td>1</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Town Hall</td>
<td>2</td>
<td>310</td>
<td>620</td>
</tr>
</tbody>
</table>

6.3 Heat Network Interface Connections

When connecting a building to a heat network, it is important to understand how the design and operation of the building’s existing heating system will affect the operation of the whole network. In particular, the following points should be considered:

- The existing building heating systems (secondary systems) should be designed, modified and commissioned to achieve low return water temperatures, particularly during periods of low demand.
- The temperature difference between flow and return in the building systems must be kept as large as possible.
- All plant (heat exchangers, pumps, valves etc.) should not be oversized and should be capable of low turndown.
- Two-port control valves and variable speed pumping should be used to avoid returning high temperature water back to the heat substation heat exchanger.

For the Macclesfield heat network, only non-residential buildings are anticipated to be connected to the heat network.

6.3.1 Non-residential interface connections

Non-residential heating systems are by their nature diverse. The scenario shown below represents a generic solution to the types of variable, constant and low temperature loads that might be seen in the individual buildings connected to the Macclesfield heat network.

A building heat substation will provide hydraulic separation between the heat network (primary side) and the building heating system (secondary side). Within the Town Hall, the existing boiler plant in the Old Town Hall plant room will be retained on the primary side to provide additional capacity to the heat network.

Figure 49 shows a generic schematic for the recommended connection arrangement of a non-residential building to a district heating network.
The following modifications to the existing building’s heating system should be considered when connecting a building under this interface scenario:

- The building heating system should use split headers and avoid the use of low loss header arrangements.
- Two-port rather than three-port control valves should be used for weather compensation. Generally, two-port valves exhibit better regulating characteristics. In addition, three-port valves do not cope well under pressure. For existing systems, it is advised that all three-port controls are changed to two-port.
- Distribution pumps should be modulating and controlled by differential pressure to maintain temperature.
- For wet heating systems with radiators, low Kv TRVs should be used in combination with DPC valves to allow radiator temperatures to modulate smoothly rather than cycle from hot to cold.
- On variable temperature circuits, weather compensation control should be used, where feasible, to lower the distribution temperature in milder weather. This measure will reduce operating costs and promote low return temperatures.
- A jockey pump should be considered to deliver heating energy for low load operating periods, when flow rates are low.

Site visits were undertaken at the Town Hall and Royal Mail Delivery Office to establish that sufficient room is available to accommodate HIUs and other additional plant. The Police Station plant room was not inspected during this study.

Figure 49 Generic non-residential interface schematic showing possible connections.
6.3.2 Operating temperatures

A key aspect of heat network design is the selection of system flow and return temperatures. These temperatures will largely influence both the capital cost of the network and the heat losses and overall efficiency of operation.

To keep capital costs of the network low, the targeted difference between flow and return temperatures on the primary heat network under peak demand conditions shall be as high as possible. The Heat networks: Code of Practice for the UK recommends temperature differences of between 25ºC and 30ºC. The techno-economic model for the Macclesfield heat network therefore utilizes a ΔT of 30ºC.

To connect the secondary (building) heating systems to the network, the existing heating systems will have to be rebalanced to ensure that return temperatures to the heat network are kept as low as possible. For example, in cases where the existing building heating system consists of a radiator circuit designed for 82ºC flow and 71ºC return, the system will easily be rebalanced to achieve 80ºC and 60ºC return. Operating temperatures can be changed either by installing new radiators/ emitters with a lower mean heating temperature or by reducing the flow to the existing radiators. Such a change in operating temperature will only incur a 12% reduction in the design output of the existing radiators when compared to the design mean temperatures of the two configurations. This reduction will easily be mitigated either by the oversizing factor allowed during radiator sizing and selection or through the operating regime of the building heating system.

6.3.3 Heat metering

The Energy Efficiency Directive 2012/27/EU is being transposed into UK legislation, with requirements for metering and billing applying to both the non-domestic and domestic sectors. These have been implemented through the Heat Network (Metering and Billing) Regulations 2014. Heat meters are required at each multi-customer building supplied by a heat network and individual customer heat meters are to be installed for all new developments (district heating schemes only, not communal heating schemes) and where a relevant major renovation is undertaken.

Heat meter accuracy is vital to facilitate accurate billing thus protecting revenue streams. Legal challenge may be brought against poor or inaccurate heat metering. Generally, heat meters are built into domestic building HIUs. The Heat networks: Code of Practice for the UK states that heat meters should be in accordance with the Measuring Instruments Directive (MID) and shall be Class 2 accuracy. On a scheme of the scale proposed, it is best practice to choose meters that allow automatic meter reading (AMR) and should incorporate AMR software to allow collection of heat network data in a centralised database. All meters should be in accordance with CHPQA scheme guidelines. Ultrasonic flow meters are most commonly utilized. Heat meter prices have been included in the economic analysis.
6.4 Future Proofing

In order to allow for the extension of the heat network to Clusters 2 and 3 in the future, it is recommended that a capped connection is included in the design on Brunswick Street outside Cheshire Constabulary.

Note that sufficient redundancy has been included in the pipework design for flow to be reversed to the Town Hall. As such, the energy centre may be moved to another location in the future and the demands of the existing connections can continue to be met.

Given the containerised nature of the planned energy centre, further consideration in future phases should be given to the operation of multiple energy centres.
7 Private Wire Network

7.1 Considering Private Wire

The sale of electricity to buildings and export of electricity to the grid offers a major revenue stream for the network operator.

The scale of revenue achievable varies significantly between a scheme where generated electricity can only be exported to the grid and one where sales to individual consumers are also possible via a local or private wire network. A private wire network creates a direct connection between the generator and the consumer whereby a private cable connection is installed between the two. The network owner typically owns, pays for and maintains this infrastructure. Although installation costs can be a barrier, a private wire allows the generator to sell electricity for a higher tariff whilst the consumer also pays a lower tariff as the electricity is not subject to use of system charges.

District energy schemes can also benefit from a variety of licence exemptions to keep administration costs down. The exemption limits are set out in the Electricity (Class Exemption from the Requirement for a Licence) Order 2001. This rules that operators need to determine if they meet the Order’s requirements to qualify for an exemption.

In the case of the Macclesfield town centre scheme, the detailed design and commercialisation stages will need to satisfy the requirements of:

- Schedule 2 Generation Exemptions
- Schedule 3 Distribution Exemptions including:
  - Small Distributors (Class A)
  - On-site Distribution (Class B)
  - Distribution to Non-Domestic Consumers (Class C)
- Schedule 4 Supply Exemptions including:
  - Small Supplies (Class A)
  - Resale (Class B)
  - On-site Supply (Class C)
7.2 Considering Virtual Private Wire

Another power distribution option for a local generator is a Virtual Private Network (VPN) also known as slewing. In this instance, the generator enters into a contract with the DNO in which the power is distributed to selected consumers via the DNO’s infrastructure. This reduces capital expenditure in the scheme whilst maintaining preferential tariffs, however maintenance and usage charges will be applied by the DNO which reduces income benefits. Slewing is a form of power purchase agreement (PPA) whereby the end-consumer is typically local to the generating technology. More traditional PPAs usually involve the sale of power to a large utility provider. A traditional PPA would still be required to export excess electricity generation to the grid at a low tariff, however, slewing offers the benefit of a mutually beneficial tariff which is higher for the generator than exporting to the grid via a traditional PPA.

7.3 Macclesfield Private Wire

Of the two options, private wire and slewing, private wire is financially beneficial to large electrical loads, where the additional infrastructure costs can be recovered. For smaller distributed loads, a slewing arrangement could be considered by the Council at the detailed design stage.

Table 23 lists the three private wire connections utilised within the techno-economic model for the Macclesfield heat network. The selection of the private wire connections was made based on the building’s electricity demand and location: The three biggest electricity loads (Town Hall, Cheshire Constabulary and the Library – all publicly owned) are recommended for connection. Royal mail was dismissed for a private wire connection due to a very low electricity load and a further location from the other connections.

Table 23 Private wire connections utilised in the techno-economic model.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Building Connection</th>
<th>Annual Electricity Consumption [kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Town Hall</td>
<td>902,300</td>
</tr>
<tr>
<td>2</td>
<td>Cheshire Constabulary</td>
<td>215,200</td>
</tr>
<tr>
<td>4</td>
<td>Library</td>
<td>227,680</td>
</tr>
</tbody>
</table>
Figure 50 Macclesfield town centre existing electricity infrastructure.

Figure 50 shows the layout of the existing electricity network in Macclesfield town centre. This shows that there are existing low voltage (LV) cables, assumed to be 400V, supplying electricity to each of the buildings proposed for connection to the private wire network. It is assumed to be feasible to directly connect the buildings to a 400V private wire network which means that electrical connection costs will be relatively low compared to a high voltage (HV) private wire network.

If a 400V network is not feasible, a HV network is an alternative option. Compared to a 400V private wire network, a HV private wire network would require additional 11/0.4kV transformers and HV switchgear at the energy centre and in each building, adding cost. Further assessments should be carried out to fully ascertain the viability of the 400V private wire network. This would include surveys of existing electrical supplies to each building, final cable routes and cable calculations. This work would also involve a full power system study to consider thermal and voltage constraints as well as the impacts of distributed generation on the proposed private wire network.
At this stage it is believed that a 400V private wire connection is feasible. This is subject to final cable routes and electrical detailed design; in particular a volts drop assessment needs to be carried out as part of the cable calculations. An off site bulk DNO connection and a new transformer are not required compared to a HV connection, and this significantly reduces the associated costs. Appropriate switchgear, HV protection and an auxiliary transformer would also be required within the distribution substation for the HV scenario. The proposed simplified LV system decreases the capital cost by £155,000 compared to a HV system.

To connect the distribution substation to the buildings, XLPE private wire cabling is to be installed in a trench adjacent to the district heating pipework. Figure 51 shows an example layout of this arrangement.

Figure 51  Indicative layout of district heating pipework and private wire cabling occupying the same trench.

An estimated cost build-up for the aforementioned works is included within the economic model discussed in Section 9.

The proposed PW network route is shown in Figure 52. The total length of the PW network is assessed at 370m.
Figure 52  Proposed PW network route.
8  Cooling Network

In certain circumstances, tri-generation (heat, cooling and power) can increase the overall efficiency of a network, particularly where waste heat can be utilised.

It should be noted that no metered cooling data was available. Cooling consumption calculations relied upon benchmarked values (BSRIA BG9/2011).

Cluster 1 was examined for tri-generation potential. Assuming that the buildings’ cooling demand depends only on the external temperature, and using a reference temperature of 21°C above which cooling would be required, the analysis indicated that cooling would only be required on few days of the year. Therefore, it is not recommended that tri-generation is utilised in Macclesfield as the demand is not sufficient to warrant a centralised chilling facility. Additionally, as there is limited waste heat available, electrical chillers are the preferred technology due to their significantly better coefficients of performance compared to absorption chillers. A cooling network would be unadvisable, as the benefits of a centralised electric chiller plant would not outweigh the additional CAPEX and risk of connection factors. There is no significant benefit to the consumer over having a local electric chiller to meet their demand.
9 Economic Case

This section discusses the results of the economic analysis of the proposed Cluster 1 heat network.

9.1 Heat and Electricity Tariffs

9.1.1 Heat sales revenue

Heat networks generate revenue from the sale of heat. Table 24 shows the consumer heat tariffs. These are based on a gas comparator heat tariff which is the equivalent total cost per kWh of heat from a gas boiler system, considering:

- Gas consumption
- Gas tariff (estimated if information not available)
- Boiler capacity, life expectancy and estimated long term replacement cost
- Estimated boiler operation and maintenance costs

Actual gas tariff has been used for the Town Hall (1.45p/kWh, excluding standing charges). Gas import tariffs have been defined according to the DBEIS Table 3.4.2: Price of fuels purchased by non-domestic consumers in the UK (according to consumer size) for the stakeholders who have not provided any actual gas tariff.

An estimate of current plant efficiency is also required. This was taken to be 85% for all the buildings, resulting in a conservative estimate of the heat tariff.

Given this information, heat tariffs were deducted for each consumer anticipated to connect to the heat network. No reduction has been applied to heat tariffs as two out of the three buildings considered have shown interest in the heat network and the buildings are expected to connect without additional incentive. A reduction in tariff would add an extra incentive for consumers to connect to the heat network.

The size of the consumers has been estimated along with their boiler capacities from the gas consumption of the building (available from bills for the Town Hall and Royal Mail Delivery Office and DEC for the Police Station). According to Spon’s data related to boiler capacity, the boiler cost has been estimated. Assuming a boiler life expectancy of 20 years, the long term replacement cost in £/year and then in p/kWh has been determined. The net gas tariff has been assessed according to the DBEIS Table 3.4 if no actual tariff has been provided. The gross gas tariff has then been worked out by adding CCL and annual sum of daily connection charges if required. VAT has been set to 0% and no daily connection charges have been considered. The build-up heat tariff captures the boiler efficiency, the long term replacement costs and the O&M cost. No margin has been applied to the heat tariff. A full list of assumptions used for the calculation of the heat tariff is presented in Appendix E.

As a result, the build-up heat tariff is probably higher than the fuel tariff seen by the consumers on their monthly gas bill, but gives a more accurate view of what the consumer pays for heat while connected to a gas-fired boiler system. The heat
network and associated plants are operated and maintained externally and plant replacement costs are avoided for the customer which balances the increased heat tariff.

Rather than charging each building a specific rate, the Council may want to consider, for example, a tenant specific charging structure, based on the consumers’ current usage of heat (unavailable for this analysis) or a flat fee for heat. RICS Code of Practice ‘service charges in commercial property’ provides further advice on best practice.

At this stage, it has been agreed with the Council that no heat tariff reduction would be applied as it would result in financial loss for the owner of the energy centre and network as it reduces the revenue of the scheme and the IRR. The impact of the customer saving on the IRR has been investigated as part of the sensitivity analysis and can be seen in Section 9.6.

Table 24 Heat tariffs of buildings proposed to be connected to the heat network.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Building Name</th>
<th>Annual Heat Demand [kWh]</th>
<th>Heat Tariff [p/kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Town Hall</td>
<td>782,200</td>
<td>2.32</td>
</tr>
<tr>
<td>2</td>
<td>Police Station</td>
<td>430,200</td>
<td>3.50</td>
</tr>
<tr>
<td>3</td>
<td>Delivery Office</td>
<td>346,600</td>
<td>3.61</td>
</tr>
</tbody>
</table>

9.1.2 Electricity sales revenue

A private wire electricity connection to the buildings was included in the economic analysis. Actual electricity tariffs for the Town Hall and the Library have been used to determine PW electricity tariffs. DBEIS’s Quarterly Energy Prices have been used for the Police Station due to a lack of consumer engagement which prevented actual tariffs being used. Table 25 presents the electricity sales tariffs of consumers. As discussed in Section 9.1.3, no customer discount has been applied to these tariffs as buildings are expected to connect without additional incentives.

Section 9.6 presents a sensitivity analysis of the electricity sales revenue on the IRR. Customer discounts and impacts on the financial viability of the scheme will be more discussed in this section.

Table 25 Electricity tariffs of buildings proposed for connection to the private wire network.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Building Name</th>
<th>Annual Electricity Demand [kWh]</th>
<th>PW Tariff [p/kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Town Hall</td>
<td>902,300</td>
<td>9.51</td>
</tr>
<tr>
<td>2</td>
<td>Police Station</td>
<td>215,200</td>
<td>12.12</td>
</tr>
<tr>
<td>4</td>
<td>Library</td>
<td>227,700</td>
<td>11.26</td>
</tr>
</tbody>
</table>
Where electricity export to grid takes place, the tariff is assumed to be 4.0p/kWh. Allowing the CHP to export electricity, while common in practice, is speculative at this stage and therefore its effect on the business case is not accurately known. Exports may incur charges if the grid is not capable of absorbing the additional supply. Alternatively, if a high export tariff can be agreed, there could be significant benefits to the energy centre owner, and the IRR would increase.

9.2 Capital Costs

The breakdown of capital costs for the preferred option is provided in Table 26. These figures show the initial capital expenditure. Further costs are incurred at times of CHP and boiler replacement (at intervals of 15 and 25 years respectively). These replacement costs are taken into account in the financial model. CHP replacement cost is assumed to be 80% of the initial capital expenditure, boiler replacement cost is assumed to be 100% of initial capital expenditure. Gas connection to the nearest connection point to the Town Hall is considered which leads to a gas connection cost of £22,500. As it is a LP point, a £5,000 gas booster is also included.

Table 26 Capital cost breakdown.

<table>
<thead>
<tr>
<th>Plant Item</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Containerised CHP Engine</td>
<td>£345,000</td>
</tr>
<tr>
<td>Gas Boilers</td>
<td>£43,100</td>
</tr>
<tr>
<td>Thermal Store</td>
<td>£33,700</td>
</tr>
<tr>
<td>Energy Centre Pumps, Controls and Heat Exchangers</td>
<td>£56,800</td>
</tr>
<tr>
<td>Heat Network</td>
<td>£249,400</td>
</tr>
<tr>
<td>Building Heat Network Connections</td>
<td>£97,600</td>
</tr>
<tr>
<td>Gas Connection, Skid and Booster Set</td>
<td>£52,500</td>
</tr>
<tr>
<td>Private Wire Network</td>
<td>£113,900</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>£992,000</strong></td>
</tr>
<tr>
<td>Project Development Costs (2.5%)</td>
<td>£24,800</td>
</tr>
<tr>
<td><strong>TOTAL (Incl. Project Development Costs)</strong></td>
<td><strong>£1,016,800</strong></td>
</tr>
</tbody>
</table>

The costs for the containerised CHP engine, gas boilers and thermal store include installation, electrical and commissioning costs. Heat network costs include costs for pipework installation and associated bends, joints, valves, civils, t-junctions and communication ducts. Building heat network connections include costs for heat exchanger install, testing and commissioning and controls integration in each building connected to the heat network. Gas connection costs allow for connection to the nearest gas main, approximately 30m from the proposed CHP engine installation location, and a gas booster set to increase gas pressure. Private wire network costs include all necessary switchgear, switchboard, cabling and power supply connections for a LV network connecting to all proposed buildings.
It is assumed that Design/CDM costs are present in the capital costs given. Contingency is not included to avoid ‘double counting’; this can be considered through the sensitivity study presented in Section 9.6.

A project development cost of 2.5% has been added to the scheme CAPEX, as shown in Table 26. The optimism bias analysis included as part of the cashflow model considers an increased project development cost. The impact of this can be viewed in the cashflow model and the sensitivity analysis presented in Section 9.6.

9.3 Annual Operation and Maintenance Costs

Table 27 presents operation and maintenance costs for the energy centre.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP Gas Import</td>
<td>£43,600</td>
</tr>
<tr>
<td>Boiler Gas Import</td>
<td>£5,000</td>
</tr>
<tr>
<td>CHP Maintenance Costs</td>
<td>£11,600</td>
</tr>
<tr>
<td>Boiler Maintenance Costs</td>
<td>£700</td>
</tr>
<tr>
<td>Heat Network Maintenance</td>
<td>£1,000</td>
</tr>
<tr>
<td>Heat Exchanger Maintenance</td>
<td>£1,000</td>
</tr>
<tr>
<td>Billing and Customer Service</td>
<td>£200</td>
</tr>
<tr>
<td>Transformer Maintenance</td>
<td>£1,800</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>£63,800</strong></td>
</tr>
</tbody>
</table>

9.4 Revenue Streams

Table 28 presents the annual revenue streams for the scheme split by buildings. Note that the costs of importing electricity to meet building demands that are not met by the CHP engine (i.e. during periods of low demand or CHP downtime) are also included in the analysis.

It can be seen that the Town Hall is the main source of revenue to the Scheme. Electricity sales make up 77% of the annual revenues, which confirms that stand-alone biomass boiler is unlikely to be a financially viable technology for the heat network. In addition, 92% of the annual electricity sales come from PW sales with a total of £87,000 per year (Electricity PW Sales minus Electricity Import) against £13,000 from grid export. The total annual revenue from heat sales and electricity sales is £145,000.

The analysis assumes that the energy centre will benefit from the low cost gas and electricity that are currently available to the Town Hall. This means that the Council would need to retain the risk of fuel purchases. If the fuel purchases were made by another party without the purchasing power of Cheshire East Council, the cost of gas and electricity may rise. The Electricity Import cost shown in Table 28 uses the Town Hall day time electricity tariff.
Table 28  Annual revenue streams.

<table>
<thead>
<tr>
<th>Revenue</th>
<th>Town Hall</th>
<th>Library</th>
<th>Police Station</th>
<th>Royal Mail</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Sales (£)</td>
<td>£18,100</td>
<td>/</td>
<td>£15,100</td>
<td>£12,500</td>
<td>£45,700</td>
</tr>
<tr>
<td>Electricity PW Sales (£)</td>
<td>£85,800</td>
<td>£25,600</td>
<td>£26,100</td>
<td>/</td>
<td>£137,500</td>
</tr>
<tr>
<td>Electricity Export Revenue (£)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>£12,600</td>
</tr>
<tr>
<td>Electricity Import (£)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-£50,500</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>£145,000</td>
</tr>
</tbody>
</table>

### 9.5 Key Financial Indicators

Table 29  Key financial indicators.

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>3.5%</th>
<th>10%</th>
<th>12%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV (25 years)</td>
<td>£139,000</td>
<td>-£349,000</td>
<td>-£324,000</td>
</tr>
<tr>
<td>NPV (35 years)</td>
<td>£325,000</td>
<td>-£319,000</td>
<td>-£414,000</td>
</tr>
<tr>
<td>NPV (40 years)</td>
<td>£436,000</td>
<td>-£308,000</td>
<td>-£408,000</td>
</tr>
<tr>
<td>IRR (25 years)</td>
<td>4.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple Payback (rounded)</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount Payback (rounded)</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifetime CAPEX (40 years, including all replacement costs)</td>
<td>£1,627,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grant funding to achieve 6% IRR</td>
<td>£105,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grant funding to achieve 11% IRR</td>
<td>£392,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 29 presents key performance indicators for the energy centre. This shows that the internal rate of return (IRR) of the scheme is below 6% and therefore sub-economic. This low return on investment occurs because of a lack of large heat loads and a restricted number of possible connections in the town centre. Grant funding of £105,000 would be required to increase the IRR (25 years) to 6%, and of £392,000 to increase the IRR (25 years) to 11%.

The 40 year IRR of the scheme is 6.3%.

The installation and successful operation of a heat network within the town centre could encourage other stakeholders to connect to a heat network. There is potential within Macclesfield for a heat network to grow to encompass Clusters 2 and 3.

A full cashflow model is provided in a separate file for the recommended scheme.
9.6 Sensitivity Analysis

Figure 53 to Figure 58 show the outputs of a sensitivity analysis for the preferred scheme. The analysis shows the impact on IRR caused by incurring a percentage adjustment on a series of cost and price factors. The analysis shows that the return of the scheme is extremely sensitive to electricity price and electricity sales revenues. The two factors are closely linked: electricity price is the average price paid and/or received for electricity imports, exports and sales. Electricity sales revenue focuses solely on the sales revenue aspect of the electricity price sensitivity. The sensitivity shows that an increase in the spark spread, the difference in cost between electricity and gas, is likely to be favourable to the economic performance of the scheme. On the other hand, a reduction in electricity sales revenue, perhaps due to a fall in demand will have a very negative impact on the economic return of the scheme. If the electricity sales revenue decreases by 10%, for example if a 10% customer discount is applied, the IRR drops from 4.8% to 2.4%. This shows that the IRR is very sensitive to electricity sales revenue and that the financial viability of the scheme mainly depends on it. Given this observation, Section 9.7 will study the opportunity of increasing electricity sales through the installation of battery storage.

It can be seen that if the heat sales revenue decreases, for example if 5% and 10% discounts are applied to heat sales tariff, the IRR decreases to 4.5% and 4.1%, respectively.

As the IRR is more sensitive to electricity sales revenue than to heat sales revenue, it is recommended that if a customer discount has to be applied to encourage connection, it should be applied to heat tariff rather than to electricity tariff.

The scheme is also sensitive to adjustments in capital expenditure. Should savings be made in installing the scheme, its economic performance would improve. A 10% saving on CAPEX increases the IRR to 6.1%.

The Optimism Bias analysis presented in the full cashflow model of the preferred option indicates that the optimism bias adjusted CAPEX of the project is approximately 22% higher than that shown in Table 26. The sensitivity analysis indicates that the IRR of the project would fall to 3% as a result of a 20% increase in CAPEX.

The performance of the scheme is less sensitive to adjustments in operating expenditure and gas costs has an insignificant impact on the IRR.

Figure 59 presents the impact on grant funding on the IRR. The Macclesfield heat network project could benefit from the next round of HNIP funding to move from development to commercialisation. Investors such as infrastructure funds commonly look for returns in the range 12-15% pre-finance IRR, although DBEIS’s engagement with potential investors indicates that low returns need not in and of themselves be a barrier to heat network investment. If 10% of the capital cost is grant funded, the IRR increases to 6% and if 30% of the capital cost is grant funded, the IRR increases to 9.1%. Around 40% of the capital cost is required to be grant funded to achieve an 11% IRR and hence for the scheme to become commercially viable to Cheshire East Council. Whilst unconfirmed, it is
thought that this level of capital support is unlikely to be received from HNIP and further funding sources should be investigated.

Figure 53  IRR sensitivity to gas price.

Figure 54  IRR sensitivity to electricity price.

Figure 55  IRR sensitivity to CAPEX.

Figure 56  IRR sensitivity to OPEX.

Figure 57  IRR sensitivity to heat sales revenue.

Figure 58  IRR sensitivity to electricity sales revenue.

Figure 59  IRR sensitivity to grant funding.

9.7  On Site Battery Storage

It has been shown in Sections 9.4 and 9.6 that the sale of electricity through the private wire electricity network is the main source of revenue of the scheme. In order to study opportunities for the scheme to increase its financial viability, electricity storage has been considered as part of the energy system.
The potential to include battery storage in the system design has been considered to minimise electrical export to the grid, maximise revenue per unit generated and reduce electricity import when the CHP is offline, creating a system which is less dependent on external sources. Thus, energy storage would appear to be an attractive solution to balance intermittent generation, time-shift supply and so better match supply with demand.

Figure 60 illustrates how peak shaving can be achieved by energy storage compared to a traditional energy system without energy storage. Energy storage could shift some electricity generation from low demand period to peak periods, which would require less export from power plants (the grid). This would result in a more stable energy demand profile. From a financial point of view, energy storage could be used to take advantage of grid rates by consuming the electricity produced onsite when grid electricity tariff is high and by selling electricity to consumers at a higher rate than the grid export tariff.

![Diagram of battery energy storage system demand profile](http://www.21stcentech.com).

Table 30 shows a review of battery technologies which are currently commercially available and considered to be suitable for the Macclesfield scheme, including Lead Acid and Lithium-Ion (Li-ion) batteries. A Li-ion battery was selected as the preferred technology due to its long life and high efficiency. Li-ion technology is still considered as a new technology and hence capital costs are likely to continue to decrease in the coming years as shown in Table 30.

Lithium-ion batteries offer the lowest self-discharge rates from any battery, however due to the length of time the battery is required to hold charge in this setup, this is not considered as a key metric.
Table 30  Comparison of Lead acid and Li-ion battery characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Lead Acid</th>
<th>Li-ion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>year</td>
<td>2013</td>
</tr>
<tr>
<td>Round trip efficiency [%]</td>
<td></td>
<td>70-90</td>
</tr>
<tr>
<td>Lifetime [years]</td>
<td></td>
<td>5-10</td>
</tr>
<tr>
<td>CAPEX [£/kWh]*</td>
<td></td>
<td>384</td>
</tr>
<tr>
<td>Fixed O&amp;M [%CAPEX]</td>
<td></td>
<td>1.4</td>
</tr>
<tr>
<td>Variable O&amp;M [£/MWh]</td>
<td></td>
<td>0.64</td>
</tr>
</tbody>
</table>

* CAPEX includes ancillary electrical systems required, such as inverter, switchgear and instrumentation.  

To balance the system operationally with the addition of a battery, the CHP size was reduced. This allows the CHP to charge the battery during times of lower demand during the day, and discharge during peak times during the day. The battery was constrained to prevent it exporting power to the grid during the night when electricity tariffs are lower, and instead uses the charge to meet the peak on site demand.

Note: if the CHP was kept the same size, with the same hours of operation, the battery would charge during the day and discharge during the night. This would not make commercial sense, as higher day tariffs are accessible when exporting electricity, and lower during the night. Hence the battery would be operating in the opposite manner to which would be advised.

Although this operational strategy meets the technical requirements for the project, it is not advisable economically. The significant additional CAPEX (battery and ancillaries are estimated at £219,000) and extra O&M maintenance costs for the battery (estimated to be £3,000/year) significantly reduce the project’s IRR which for the preferred CHP setup with the addition of a 250kWh battery is -0.6%. There would be no significant financial savings by using this setup, as connection to the grid would still be required.

The setup reduces the export to the grid from 416MWh/y (preferred option, no battery) to 94MWh/y (with battery storage), however it only reduces the imported electricity from 485MWh/y (no battery) to 372MWh/y (with battery). This is due to a smaller CHP being used. The benefits of reduced import tariffs cannot be gained this way, as the CHP no longer meets the peak electrical demand and hence imported ‘peak tariff’ electricity is occasionally used to meet the peaks when the battery is fully discharged. Both strategies import electricity throughout the night when the CHP is offline. As a result, there are no benefits financially to having battery storage in this scheme.

The Macclesfield heat network project has struggled to find a suitable location for the energy centre, and the location agreed upon does not have the available space required to house a battery and the additional electrical ancillaries. Sophisticated control arrangements will need to be put in place, paralleling the batteries and

CHP with the grid. This development of essentially a SMART grid will increase setup and maintenance costs and complexity.

Whilst a battery is not advised at this stage in the project, if the network were to develop significantly, the setup should be revisited and a SMART grid looked at again. Battery storage could become feasible if, for example, the demand profiles changed, the CHP was allowed to run 24 hours a day or other additionality could be found (e.g. protection against weak network connection).

### 9.8 Avoided Costs

The gas boilers in the New Town Hall and Royal Mail Delivery Office are known to be nearing the ends of their useful lives. Although unconfirmed, this is potentially also the case for the boilers at the Police Station. The total like-for-life replacement cost for these boilers (including main plant only) is estimated to be approximately £60,000, as shown in Table 31. This accounts for approximately 5% of the total capital cost. If this cost was recognised as being avoidable and deducted from the total capital cost of the heat network, or, conversely, was a capital contribution to the scheme by the stakeholders, then the IRR of the scheme would rise to approximately 5.5%, as shown in the previous section.

**Table 31 Estimated replacement costs for existing plant.**

<table>
<thead>
<tr>
<th>Building</th>
<th>Estimated Replacement Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Town Hall</td>
<td>£35,000</td>
</tr>
<tr>
<td>Royal Mail</td>
<td>£15,000</td>
</tr>
<tr>
<td>Police Station</td>
<td>£10,000</td>
</tr>
</tbody>
</table>
10 Future Expansion Potential

The proposed scheme is designed as the first step towards a wider Macclesfield heat network, with expansion potential:

- In its immediate vicinity if suitable buildings are identified in the future (e.g. critical regeneration projects such as the Old Police Station).

- Within the wider town centre to connect to, for example, future social housing and areas of high heat demand. Cluster 3 is seen as a particularly attractive connection choice due to the social benefits it would bring to the scheme. A case study is provided below to illustrate some of the considerations if the proposed scheme was to expand to Cluster 3. Cluster 2 also provides some connection potential, with new developments and regeneration projects (such as Christ Church) planned. In Cluster 2, stakeholder engagement is seen as a vital step to ascertain stakeholder appetite.

- To other areas of high heat and power demand such as Hurdsfield. This area is part of a separate heat network study and it is recommended that the study will take into consideration the proposed town centre heat network.
Case Study: Expansion of the town centre heat network to Cluster 3

Expansion of the proposed heat network to cover Cluster 3 would result in several benefits:

- Cluster 3 is located away from the town centre conservation area which results in fewer constraints for the development of a heat network.
- There is potential to include other technologies, such as biomass, due to fewer constraints in this Cluster.
- The two existing buildings forming this cluster (a medical centre and a gym/swimming pool) provide large varied loads for balancing the heat network.
- There is also potential for new social housing to be built to the south of the area. A heat network could provide reasonably priced heat and therefore reduce fuel poverty and increase well-being of the future residents.

The performance of the expanded network has been modelled, assuming that both DW Sports Fitness and the medical centre are connected to the heat and private wire networks but that the energy centre remains at the Town Hall. As there is no room for additional generation capacity at the proposed energy centre location at the Town Hall, the additional heat demand is met by gas boilers. As for other modelled scenarios, Appendix D (Scenario 7) provides details of the system and its operational performance. The expanded route is shown in Figure 61.

Figure 61 Expanded heat network to cover Cluster 3 connections.
Two energy centre locations are shown in Figure 61. The one in the Town Hall is the location of the proposed energy centre, while the second energy centre in the south of the area refers to a potential location for additional heat generation equipment in Pickford Street car park. (Please note that the additional system capacity in this location has not been used for modelling. This only highlights a future opportunity to increase the generation capacity of the system if the heat network has to be extended and to reduce the use of gas boilers.)

Table 32 shows the energy demands of the stakeholders considered for the expanded scheme. The additional capital costs required to connect the Cluster 3 buildings are provided in Table 33.

Table 32 Energy demands in Cluster 3.

<table>
<thead>
<tr>
<th>Plant Item</th>
<th>Annual Heat Demand (kWh)</th>
<th>Peak Heat Demand (MW)</th>
<th>Annual Electricity Demand (kWh)</th>
<th>Peak Electricity Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW Sports Fitness</td>
<td>912,700</td>
<td>0.44</td>
<td>602,900</td>
<td>0.09</td>
</tr>
<tr>
<td>Waters Green Medical Centre</td>
<td>238,000</td>
<td>0.06</td>
<td>98,000</td>
<td>0.016</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,150,700</strong></td>
<td><strong>1.0</strong></td>
<td><strong>700,900</strong></td>
<td><strong>0.4</strong></td>
</tr>
</tbody>
</table>

Table 33 Additional capital costs required to connect Cluster 3.

<table>
<thead>
<tr>
<th>Plant Item</th>
<th>Additional Capital Cost to Connect Cluster 3 Buildings (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Network</td>
<td>£382,400</td>
</tr>
<tr>
<td>Building Heat Network Connections</td>
<td>£63,600</td>
</tr>
<tr>
<td>Private Wire Network</td>
<td>£65,700</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>£511,700</strong></td>
</tr>
<tr>
<td>Project Development Costs (2.5%)</td>
<td>£12,800</td>
</tr>
<tr>
<td><strong>TOTAL (Incl. Project Development Costs)</strong></td>
<td><strong>£524,500</strong></td>
</tr>
</tbody>
</table>

The heat and electricity tariffs for the Cluster 3 buildings are shown in Table 34. The expanded network benefits from higher heat and electricity sales, both because of the additional heat sales to Cluster 3 buildings but also because of the most efficient use of the CHP and the need for less imported electricity. The electricity export revenue is lower than in the proposed scheme due to most of the electricity generated being used within the private wire network. The total additional annual revenues from the Cluster 1 and Cluster 3 network, as compared to the Cluster 1 only network, are assessed to be £82,600. The annual O&M costs for the expanded network are £31,500 higher than for the proposed scheme. This means an annual operating surplus of £51,100, as compared to the proposed scheme.

Table 35 presents the key financial indicators of the project.

Table 34 Heat and electricity tariffs.

<table>
<thead>
<tr>
<th>Plant Item</th>
<th>Heat Tariff (p/kWh)</th>
<th>Electricity Tariff (p/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW Sports Fitness</td>
<td>3.55</td>
<td>10.86</td>
</tr>
<tr>
<td>Waters Green Medical Centre</td>
<td>3.52</td>
<td>12.12</td>
</tr>
</tbody>
</table>
### Table 35  Key financial indicators for the expanded scheme.

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>3.5%</th>
<th>10%</th>
<th>12%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV (25 years)</td>
<td>£456,000</td>
<td>-£410,000</td>
<td>-£556,000</td>
</tr>
<tr>
<td>NPV (35 years)</td>
<td>£822,000</td>
<td>-£351,000</td>
<td>-£521,000</td>
</tr>
<tr>
<td>NPV (40 years)</td>
<td>£1,002,000</td>
<td>-£333,000</td>
<td>-£512,000</td>
</tr>
<tr>
<td>IRR (25 years)</td>
<td>6.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple Payback (rounded)</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount Payback (rounded)</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifetime CAPEX (40 years, including all replacement costs)</td>
<td>£2,151,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grant funding to achieve 11% IRR</td>
<td>£486,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The expanded scheme has an IRR of 6.2%. However, the following uncertainties in the assessment are noted:

- Neither consumption nor tariff data has been received for Waters Green Medical Centre and the interest of this stakeholder in the heat network is unknown. Benchmarks have been used to estimate energy demand and DBEIS Table 3.4 has been used in the tariff build up.
- DW Sports Fitness has expressed an interest in the study by providing gas consumption data. However, no further information about the current plant and the stakeholder’s interest to connect has been received.
- No electricity data has been received for DW Sports Fitness and electricity demand has been estimated using benchmarks.
- No tariff data has been received for DW Sports Fitness, consequently average tariff data from DBEIS Table 3.4 has been used in the tariff build up.

As the level of engagement with the Cluster 3 connections has been poor, and the risk of including this Cluster in the proposed scheme is therefore high, it is recommended that its connection is considered for future expansion, once Cluster 1 is already established and operational.
11 Environmental and Social Benefits

11.1 Greenhouse Gas Emissions

The greenhouse gas emissions of the proposed scheme were modelled by comparing a base case (i.e. whereby heat is generated by gas boilers) against the recommended scheme where a CHP engine and boilers are used to produce heat and electricity.

Marginal emissions factors from a report for DECC (now DBEIS) (‘Modelling the impacts of additional Gas CHP capacity in the GB electricity market’), as shown in Figure 62, were used in the modelling. These factors represent the CO2 intensity of the marginal unit of generation displaced by additional gas CHP generation, satisfying onsite demand (blue line) and exporting to grid (red line).

![Figure 62](image1)  
**Figure 62** Marginal emissions factors used in the greenhouse gas emissions analysis.

Figure 63 shows the emissions savings of the scheme over time, as compared to the base case. The modelling shows that the scheme presents a carbon saving each year until 2035. The average annual carbon saving over the next 15 years is assessed at approximately 149tCO2. This corresponds to a capital spend of £458 per tonne of CO2 saved (assuming a capital cost of £1,016,800 and total CO2 emissions of 2,218tCO2 for the first 15 years). This timeframe coincides with the replacement interval for the CHP. The scheme owner may wish to evaluate a more carbon friendly generating technology to replace the gas CHP engine at this stage.

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Figure 63  Greenhouse gas savings of the preferred scheme.
11.2 Future Decarbonisation of the Heat Network

With decarbonisation of the UK electricity grid over time, the carbon abatement benefit of gas fired CHP will diminish. The crossover point where, compared to the counterfactual supply of heat and electricity, gas fired CHP systems will change from avoiding to emitting more carbon emissions is likely to coincide with the CHP engine coming toward the end of its lifetime and thus requiring replacement.

Technological advancements may help some of the technologies considered during the options appraisal overcome implementation barriers to become cost-effective, carbon friendly sources of energy for the heat network. At this time, Arup can only speculate as to the impact potential technological advancements might have.

There is potential for decarbonisation of the gas grid to occur coincident to decarbonisation of the electricity grid. This could be done through hydrogen reforming of natural gas coupled with carbon capture and storage (CCS). This could allow replacement of the gas engine with a hydrogen internal combustion engine or more likely a hydrogen fuel cell. The key barriers to this currently are costs for conversion of the gas grid and CCS.

Current heat pump incarnations struggle to operate cost effectively and efficiently at the high flow temperatures required of the heat network. Technological developments may help to bridge this efficiency gap, however, conversion of building heating systems to operate at lower flow temperatures may be necessary to allow this technology to become an effective gas fired CHP replacement.

A further option for future consideration is biomass, given the availability of a suitable location. Improvements in the supply chain for biomass, possibly in the form of biofuel, biogas or syngas, coupled with advancements in generation technology may minimize local disruptions whilst making biomass a cost effective alternative.
11.3 Key Social Benefits

Heat networks can provide a catalyst to improved social value in the area and, if undertaken with care, can lead to a long term legacy through investment into the community. The proposed heat network can lead to reduced fuel bills for the connected customers, including Cheshire East Council and Cheshire Constabulary. In the future, it is envisaged that the expansion of the network will allow further social benefits to be realized through the connection of social housing units (as planned by Peaks & Plains) and the Medical Centre. This can have a positive impact in terms of reducing fuel poverty and lowering local healthcare costs, as well as raising awareness about the climate change and improving the health of the local population through reduced greenhouse gas emissions. Indirectly, the Macclesfield heat network can stimulate the Green Economy, influencing wider energy efficiency measures, further improving conditions for both connected tenants and the wider area.

From the outset of the scheme, the local community should be engaged. Opening communication channels improves public perception of schemes and enables developers to promote key positive impacts such as reduced carbon emissions, while understanding and alleviating public concerns. Engagement with the local community can be strengthened pre- and post-construction through the use of existing forums such as Make it Macclesfield. This can also help further increase awareness, although it is recognized that the audience at these events already seems knowledgeable about energy related issues and some of the potential technologies that may offer solutions (e.g. biomass and electricity storage).

During construction, apprenticeships, work experience placements, school engagement and curriculum support can be offered. Through collaboration with local authorities, local education facilities, community groups and the supply chain, these can ensure the progression of local people into employment. Making use of local supply chains increases available work for local people and businesses and recirculates financial gains into the local economy. The main contractor could exert influence on their supply chain and can attract inward investment into the local area, while supporting local charities and community groups. Macclesfield College has already expressed their interest in the heat network project as an opportunity for apprenticeships and have offered their help to explore the Apprenticeship Levy and standards/trailblazers.

23 Personal communication with Karl Coppack, Employer Engagement Officer, karl.coppack@macclesfield.ac.uk on 22 March 2017. Karl Coppack is also the contact person for future queries beyond the feasibility stage.
12 Conclusions and Next Steps

This report has considered the options for a Macclesfield heat network and presented proposals for modestly sized heat and private wire networks around the Macclesfield Town Hall. The proposed heat network connections include the Town Hall, Cheshire Constabulary Police Station and Royal Mail Delivery Office, whilst the private wire network would connect to the Town Hall, Library and Cheshire Constabulary Police Station. Electricity and heat would be generated by a 250kWe CHP engine located behind the Town Hall at the location of the current bike shed. The energy centre would be designed to include two containers and a 35m$^3$ thermal store, with pipes connecting these to the New Town Hall plant room where a new set of boilers (2No. 719kW) would replace the ageing boilers and provide top up heat and resilience to the system. The scheme would provide some savings in greenhouse gas emissions (average of 149t CO$_2$/year over the next 15 years) from the current level.

The economic analysis of the proposed scheme estimated a capital cost of £1,017,000 and an IRR of 4.8%. Grant funding of £105,000 would be required to increase the IRR to 6% while £392,000 would be required to increase the IRR to 11%. The heating systems in the New Town Hall and Royal Mail, and likely also the Police Station, are nearing the end of their useful lives. If the replacement costs for these are factored into the analysis and considered as avoided costs to be taken out of the total capital cost, then the scheme would yield an IRR of 5.5%.

The scheme has potential to be expanded into other areas of the town centre in the future. However, stakeholder interest levels in these areas is currently low, resulting in unavailability of data for this phase of work.

12.1 Recommendations

The following recommendations are made:

- Increasing stakeholder interest and buy-in. It is recommended that stakeholder enthusiasm increased through regular updates and communication. Possible avenues could include the Make It Macclesfield forum, to which a presentation was given during this study, and Macclesfield Express, which has previously published a story about the pre-feasibility stage of the study.
- New developments and regeneration projects. It is recommended that any new developments in the Cluster 1 vicinity are investigated for their potential for connecting to the heat network. In particular, the regeneration of the Old Police Station in Cluster 1 and the refurbishment of the Christ Church in Cluster 2 may provide connection opportunities.
- Cluster 3 connections. It is recommended that communication with the Cluster 3 stakeholders, in particular, is maintained, in order to explore the potential of expanding the scheme to this cluster. This would have several benefits, including the smoother demand profile and increased social benefits of the scheme.
• Social housing. It recommended that communication with social housing providers is maintained in order to identify future connections for the heat network. As above, this could help smooth the heat demand profile and increase the social benefits of the scheme, including alleviating fuel poverty.

12.2 Outline Business Case and Other Outputs

Outputs from this project include:

• A draft Outline Business Case (OBC). A draft OBC has been populated based on the results presented in this report and is available in a separate document.

• Cashflow model for the recommended scheme

• Appendices, as discussed throughout the report

• GIS maps in pdf format and corresponding geodatabase files

All the outputs are available as separate documents.

12.3 Heat Network Outline Delivery Plan

Cheshire East Council is yet to formally identify its preferred business model for the scheme. The outputs of this study will assist in the selection. Delivery vehicles might involve formal corporate entities created for the purpose of heat network delivery (e.g. a Joint Venture body or Special Purpose Vehicle), or they may make use of existing organisational structures.

Delivery models are typically conceived as ranging from “public” to “private” but in reality there are many potential combinations of parties fulfilling the various roles, and thus the choice of delivery model is more of a continuum of solutions rather than a defined set of solutions. To help simplify this, four main types of delivery model can be identified, depending on the parties undertaking the different roles:

1. Private sector led (for example, the council is in an existing joint venture with Engie)
2. Public-private shared leadership
3. Public sector led
4. Community Company (CoCo)

This typology broadly follows the categories outlined in the CIBSE and ADE publication ‘Heat Networks: Code of Practice for the UK’ (CP1) set of solutions.

The proposed scheme has a sub-economic IRR of 4.8%. If the council wants to take the project further, we consider a public-sector led project as the most appropriate. In order to obtain an IRR of 11% to make the project commercially viable to the Council, a grant funding of £392,000 would be necessary. The document ‘Guidance on Strategic and Commercial Case’ included within ‘Draft:'
Detailed Project Development Guidance Documents’ (September 2016: Version 02) provides useful guidance on the different roles the council may assume, and the responsibilities and risks associated with them. Sections 4.10 to 4.12, in particular, consider installation, operation and heat sales, including topics such as contractual issues, metering and billing, customer service requirements etc.

An Outline Delivery Plan has been prepared to help begin to scope the next stages of project development.

### 12.3.1 Outline delivery plan

The following steps are proposed within the delivery plan:

- **Step 1**: Heat network delivery team set up
- **Step 2**: Customer preliminary negotiations
- **Step 3**: Outline planning permissions
- **Step 4**: Develop business case
- **Step 5**: Secure funding
- **Step 6**: Secure Energy Supply Agreements
- **Step 7**: Investment decision
- **Step 8**: DBOM tender

An indicative programme is shown below.

<table>
<thead>
<tr>
<th>Activity</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility Study</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat network delivery team set up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer preliminary negotiations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outline planning permissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop business case</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secure funding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secure Energy Supply Agreements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment decision</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBOM tender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract award</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction, commissioning and handover</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following sections describe these steps in more detail. Note that the activities are not always sequential and some of the steps would likely be carried out in parallel.
12.3.1.1 Heat network delivery team setup

A dedicated delivery resource would need to be put in place to oversee the development of the project leading to the procurement and delivery of DBO contracts. This resource would effectively be the Project Delivery Team and would consist of Council representatives supported by a dedicated project manager, stakeholder liaison, technical, legal and commercial experts made up from internal and external advisors.

12.3.1.2 Customer preliminary negotiations

One of the main risks for the scheme development involves the appetite to connect to the network. In this assessment it has been assumed that, as well as the council-owned Town Hall and Library, both Royal Mail and the Police Station connect to the network. The council will need to communicate both the financial and the non-financial benefits of the heat network (e.g. greenhouse gas savings, resiliency of the system, reduced boiler maintenance and replacement needs, availability of space previously used to house boilers for business purposes) to the prospective customers effectively in order to increase their buy-in. This is particularly relevant with regard to the Town Hall and Library as key anchor loads.

There has been some reticence expressed by Council Facilities Management (FM) leadership as to their appetite to incorporate additional O&M responsibility into their operations. If this matter continues to remain the case then it will influence the delivery model to include a contracted out O&M service. It will, however, remain for the Council as ‘promoter’ and ‘part funder’ to use the initial findings of this study to begin to engage with the scheme customers in order to confirm the potential appetite for participation in the heat network scheme. A Memorandum of Understanding (MoU) could be signed with the customers to secure connection to the scheme on the basis of reasonable Heads of Terms for Energy Supply Agreements of heat and power.

12.3.1.3 Outline planning permissions

The scheme is dependent on an energy centre located behind the Town Hall at the location of the existing bike shed, and planning permission would be required. Planning permissions for energy centres typically require concept design including building form and scale, emissions considerations and access requirements. The determination period is normally about eight weeks from the date of the planning application.

Given there is no Local Development Order (LDO) in place to provide permitted development rights for a heat network, planning permission will also be required for the network route(s).

Work on developing a dedicated heat network planning policy and planning mechanism such as an LDO is recommended. This would provide a suitable ‘policy hook’ for the council to then develop a local decentralised energy and / or network policy for the wider town centre area.
For the buried heat network installation, an LDO could expedite the programme by providing permitted development rights, thereby negating the need for planning permission. Some forms of development are already deemed to be ‘permitted development’ and are automatically granted planning permission. These ‘permitted development rights’ are set at a national level. LDOs provide a mechanism to amend these permitted development rights at a local level in order to permit a greater range and scale of development. LDOs can either apply to the whole of a local planning authority’s area or particular parts of it. Once adopted, if a proposed development falls within the categories defined in the LDO, and provided that it satisfies certain conditions and development requirements, it is assumed that for planning purposes consent is granted. The benefits of LDOs are that they:

- Remove concerns relating to the cost of, and the uncertainties associated with, submitting a planning application.
- Provide greater flexibility for the development of existing assets and reduce procedural delays associated with making a planning application.
- Improve investor confidence.

Both the Energy Centre planning permission and LDO tasks are envisaged as being an early stage task of the Project Delivery Team.

12.3.1.4 Develop business case

A business case should be developed by the council, potentially with support from external advisors. It is recommended that the relevant guidance is followed: HM Treasury Green Book Five Cases Model and the DBEIS Heat Network Detailed Project Development Resource. This should include the preferred business structures, procurement strategy, and detailed business modelling including business rates and insurance. During this process, the CAPEX and OPEX for the scheme will be refined by the Project Delivery Team.

12.3.1.5 Secure funding

Based on outcomes of previous steps, the council could then seek to secure appropriate funding. Possible sources of funding are DBEIS Heat Networks Investment Project (HNIP), Salix Finance, and Public Works Loan Board. Match-funding from green investment funds is also available; this type of funding can be low-cost and can de-risk projects. Borrowing costs can then be revised, if necessary, in the business model.

12.3.1.6 Secure Energy Supply Agreements

In order to develop and agree Energy Supply Agreements (ESAs), the council is likely to need to release funding for commercial and legal advisory services to develop and negotiate the required contracts. Technical, commercial and legal advisors appointed as part of the Project Delivery Team would normally draw-up
Heads of Terms and Energy Supply Agreements, the latter taking the form of Power Purchase Agreements. These agreements would set out the obligations, the particulars of the contracts and the tariffs on offer between supplier and consumer.

12.3.1.7 Investment decision

The recommended initial scheme is for a limited area containing several public buildings and Royal Mail whose recent investment and communication with the council implies long term plans to remain in the area. This presents the council with an easily implementable and low risk heat network scheme, with potential for future expansion into other clusters.

12.3.1.8 DBOM tender

The Project Delivery Team will prepare documentation for the DBOM (Design, Build, Operate, Maintain) tender for a single specialist provider offering all services or tendered in lots for individual specialists. Documentation should include description of the sites, the works to be carried out, client and contractor responsibilities, and draft construction and operation contracts.

The tender stage may include: preparation / mobilisation of capital; preparation and issue of a prior information notice (PIN); soft market testing; preparation and issue of a PQQ; evaluation of PQQ returns; preparation and issue of an ITT; evaluation of tender returns; selection and announcement of preferred bidder; and negotiations between parties.