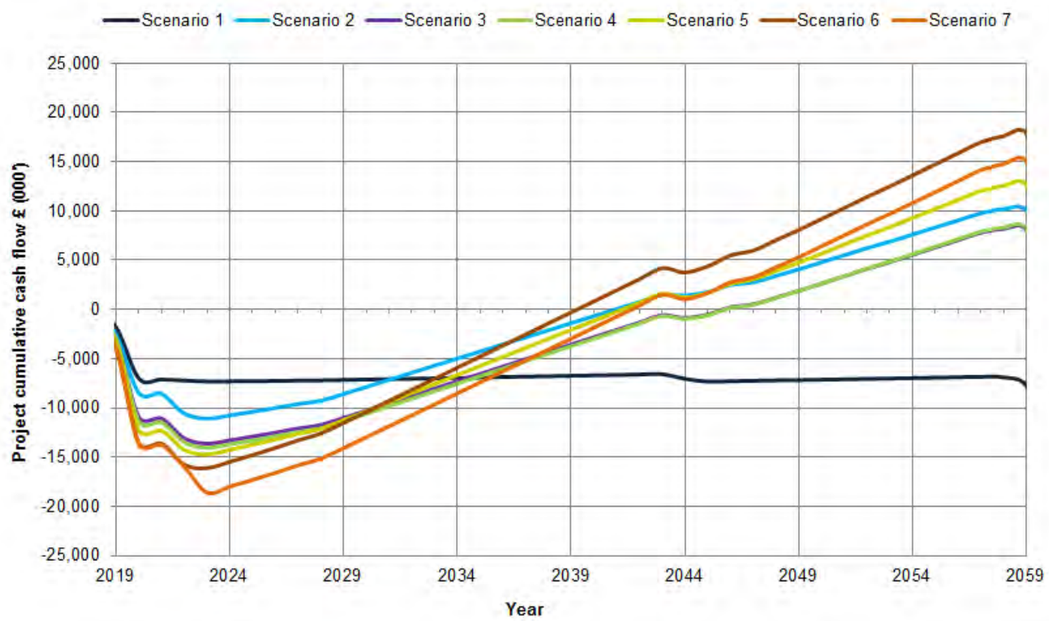


Figure 9-3 Matlock cumulative cash flow

Figure 9-3 shows the cumulative cash flow for network scenarios modelled over the years. The results show that Scenario 6 is expected to present the highest IRR and NPV over the 25, 30 and 40 year assessment periods. Even though Scenario 6 performs better than the other scenarios, it will only see some profit during the 40 year assessment period, where its NPV becomes positive. The IRR of the scheme is likely to be low (3.86% for Scenario 6 in the best case scenario) indicating that the Matlock network will not be an economically viable option, especially when compared to the IRRs of the other networks (Clay Cross and Chesterfield (see next Section 10)). The main reason for this is the considerable distance between the Enthoven facility and the heat loads. This additional pipework increases substantially the capital cost of the investment which, in turn, is not expected to see any significant return from the heat sale due to the size of the heat loads.

9.3 Carbon Emission Savings

Table 9-6 presents the carbon saving results for 25, 30 and 40 year network operation lifetimes. The cumulative carbon savings of the network scenarios for Matlock are shown in Figure 9-4. The Matlock network is served by a zero carbon heat source. The results indicate that the carbon benefits delivered increase over the years as there is an increase in the number of heat loads connected and, in turn, increase in the amount of heat purchased by the Enthoven facility. Depending on the scenario assessed, the scheme can achieve cumulative carbon savings in the range 18,821 – 156,258 tCO_2e over the project lifetime, therefore performing slightly better than the Clay Cross network.

Table 9-6: Matlock carbon emission summary

Carbon Assessment	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
25 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	463	2,111	2,325	2,413	3,141	3,740	3,788
Average annual CO_{2e} reduction (% on counterfactual)	90%	89%	89%	89%	89%	87%	87%
30 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	466	2,148	2,364	2,452	3,185	3,791	3,841
Average annual CO_{2e} reduction (% on counterfactual)	90%	89%	89%	89%	89%	87%	87%
40 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	471	2,195	2,413	2,502	3,241	3,855	3,906
Average annual CO_{2e} reduction (% on counterfactual)	90%	89%	89%	89%	89%	87%	87%
40 year cumulative:							
carbon emission savings (tonnes CO_{2e})	18,821	87,788	96,501	100,061	129,635	154,187	156,258

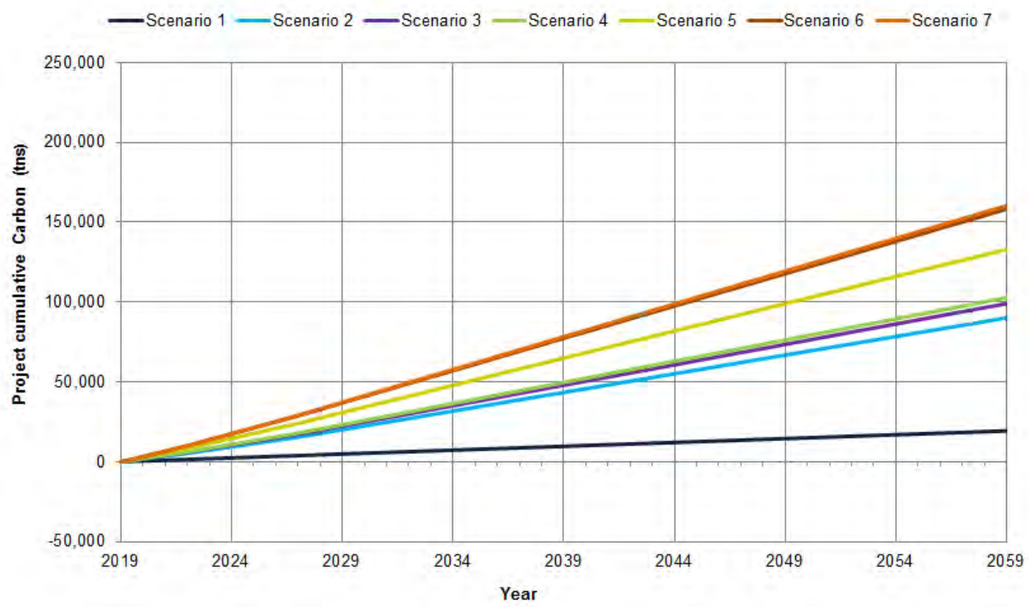


Figure 9-4 Matlock cumulative carbon savings

9.4 Sensitivity Analysis

Sensitivity analysis has been carried out to illustrate the effects of varying CAPEX, OPEX, heat demand, gas purchase cost, connection costs, heat purchase cost from the Enthoven facility and heat sales cost has on the IRR and NPV offered by Scenario 6. (Scenario 6 has been selected for this exercise because it is the best performing scenario for Matlock options.)

As can be seen in Figure 9-5 and Figure 9-6, the scheme is particularly sensitive to the cost of heat sold to the network customers and CAPEX. Increasing the cost of heat sold to customers is not recommended as it would negate the council's aim to provide lower cost heating to residents.

Scenarios where the CAPEX is reduced are equivalent to securing capital grant funding for the project. This may help the Matlock network opportunity meet DCC investment hurdle rates. UK Government schemes such as the HNIP funding stream are available that DCC could apply for in order to fund a portion of the Matlock network. One of the pre-requisites of this scheme is that over 50% of the heat in the network is met through renewable means. This requirement that would be easily met if the assumptions detailed in this report are achieved; the Enthoven facility has been modelled to supply 90% of the network's demand.

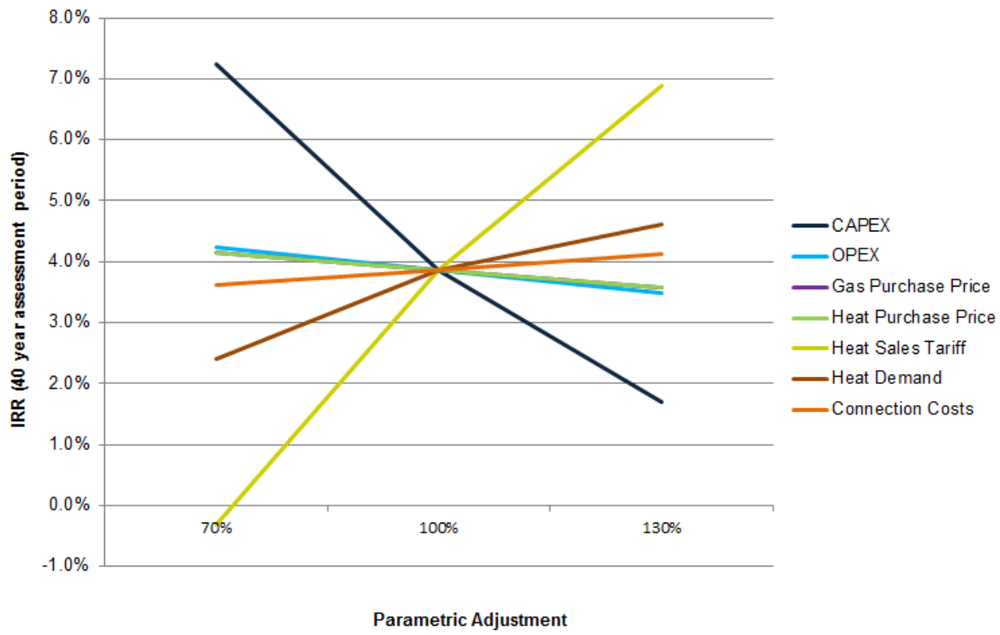


Figure 9-5 IRR sensitivity analysis for Scenario 7, showing the response to driving parameters

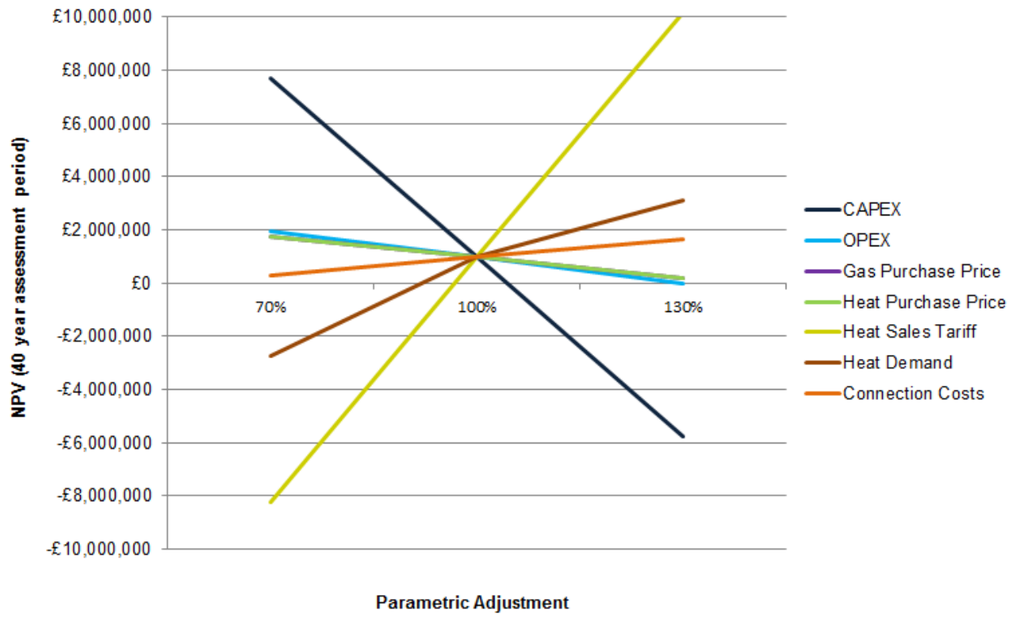


Figure 9-6 NPV sensitivity analysis for Scenario 7, showing the response to driving parameters

10. Techno-Economic Modelling Results: Chesterfield

This section details the results outputs from the techno-economic model for the key network scenarios identified in Table 10-1 and Figure 10-1 for the Chesterfield network. Due to the high number of user-variable parameters throughout the model, not all results can be presented in this report. Instead, sensible parameters for each variable have been chosen (as given in Appendix F) and the resultant outputs detailed in this section. Thereafter, a sensitivity analysis is carried out around some of the key parameters to identify the effects of various parameters on system feasibility.

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

Table 10-1: Chesterfield modelled network scenarios

Scenario	Chesterfield network segment
Scenario 1	Hady Hill
Scenario 2	Hady Hill and Beetwell St
Scenario 3	Hady Hill, Beetwell St and Rose Hill
Scenario 4	Hady Hill, Beetwell St, Rose Hill and Holywell St
Scenario 5	Hady Hill, Beetwell St, Rose Hill, Holywell St and Brimington Rd
Scenario 6	Hady Hill, Beetwell St, Rose Hill, Holywell St, Brimington Rd and Sheffield Way
Scenario 7	Hady Hill, Beetwell St, Rose Hill, Holywell St, Brimington Rd, Sheffield Way and Boythorpe Ave

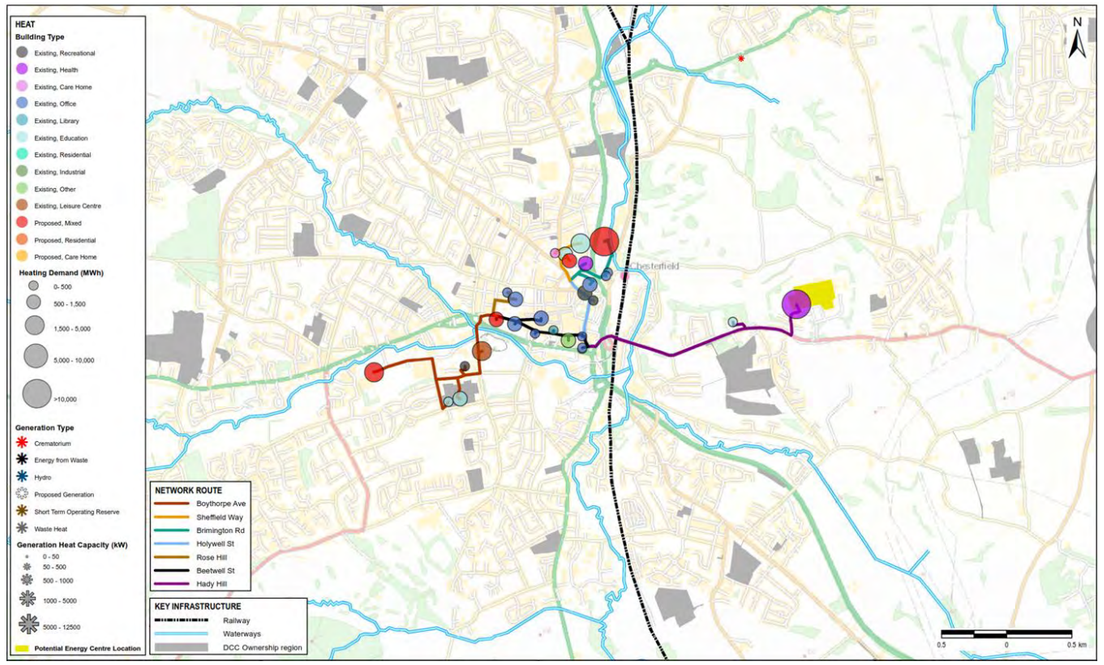


Figure 10-1 Indicative Chesterfield network routing

10.1 Technical Evaluation

The primary technical parameters that affect the resultant financial values for each network option are summarised in Table 10-2 and Table 10-3. Table 10-2 includes plant technical details and network pipework lengths whilst Table 10-3 demonstrates the network's energy balance.

Table 10-2: Chesterfield plant technical parameters

Plant Technical Details	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Boiler plant							
Total capacity (MW_{th})	8.0	11.0	11.0	11.0	20.0	23.0	26.0
CHP plant							
Heat capacity (MW_{th})	3.3	3.9	4.1	4.2	6.0	6.9	7.8
Electric capacity (MW_e)	3.1	3.8	3.9	4.0	5.7	6.6	7.4
Availability	90%	90%	90%	90%	90%	90%	90%
Energy Centre							
Footprint (m^2)	200	275	275	275	500	575	650
Distribution							
Pipework length, (m)	893	3,371	3,767	4,145	5,209	5,891	8,031
No. of new residential connections	0	0	0	0	1,531	1,711	2,124

Table 10-3: Chesterfield energy balance

Energy Balance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Thermal Energy Balance:							
Total thermal consumption (MWh_{th} p.a.)	24,766	29,797	30,884	31,661	45,065	52,179	58,888
CHP heat provision as % of total	83%	82%	81%	81%	79%	79%	78%
Total gas consumption (MWh/year)	63,270	75,662	78,212	80,057	112,786	130,061	146,437
Electricity Balance:							
CHP Electricity generation (MWh_e p.a.)	22,501	26,729	27,546	28,148	39,197	44,989	50,516
Electricity provided to the end users via private wire (MWh_e p.a.)	11,903	12,164	12,221	12,261	12,954	13,324	13,671
Electricity exported to the grid (MWh_e p.a.)	10,598	14,564	15,325	15,888	26,242	31,665	36,845

10.2 Economic Evaluation

A summary of the cash flows of each network scenario is provided in Table 10-4. Values given are for full build out of the network and will vary in the years running up to that point. Full CAPEX and OPEX breakdowns for each scenario are provided in Appendix I. Key economic outputs of the model are shown in Table 10-5, including the IRR, NPV for 25, 30 and 40 year network operation lifetimes. In line with a RIBA Stage 2 design, costs are accurate to -15%/+30%.

Table 10-4: Chesterfield cash flow summary

Financial results, £'000s	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Costs:							
CAPEX	**9,384.1**	**15,234.5**	**16,068.9**	**16,812.9**	**27,786.6**	**31,859.7**	**38,574.1**
Maintenance p.a.	281.2	408.4	429.3	447.1	697.1	798.6	955.3
Gas p.a.	2,237.1	2,675.3	2,765.4	2,830.7	3,987.9	4,598.7	5,177.8
EfW heat import p.a.	189.8	193.8	194.6	195.3	206.3	212.0	217.5
EfW electricity p.a.	2,708.1	3,277.5	3,389.4	3,473.1	4,891.4	5,609.3	6,350.6
Imported electricity p.a.	9,384.1	15,234.5	16,068.9	16,812.9	27,786.6	31,859.7	38,574.1
Total OPEX	**281.2**	**408.4**	**429.3**	**447.1**	**697.1**	**798.6**	**955.3**
Revenues:							
Residential heat p.a.	0.0	0.0	0.0	0.0	1,414.9	1,612.7	2,066.3
Commercial heat p.a.	1,556.1	1,914.6	1,993.3	2,044.2	2,548.3	2,958.0	3,219.1
Private wire electricity sale, p.a.	1,530.5	1,564.1	1,571.4	1,576.5	1,665.7	1,713.2	1,757.9
Electricity export, p.a.	757.1	1,040.4	1,094.8	1,134.9	1,874.6	2,262.0	2,632.0
Total connection revenues (one-off)	1,318.7	1,820.9	1,936.2	1,989.5	5,746.1	6,625.0	7,715.3
Simple payback	**5.1**	**6.6**	**6.7**	**6.8**	**9.7**	**9.4**	**10.2**

Figure 10-2 shows the breakdown of CAPEX between the various network elements.

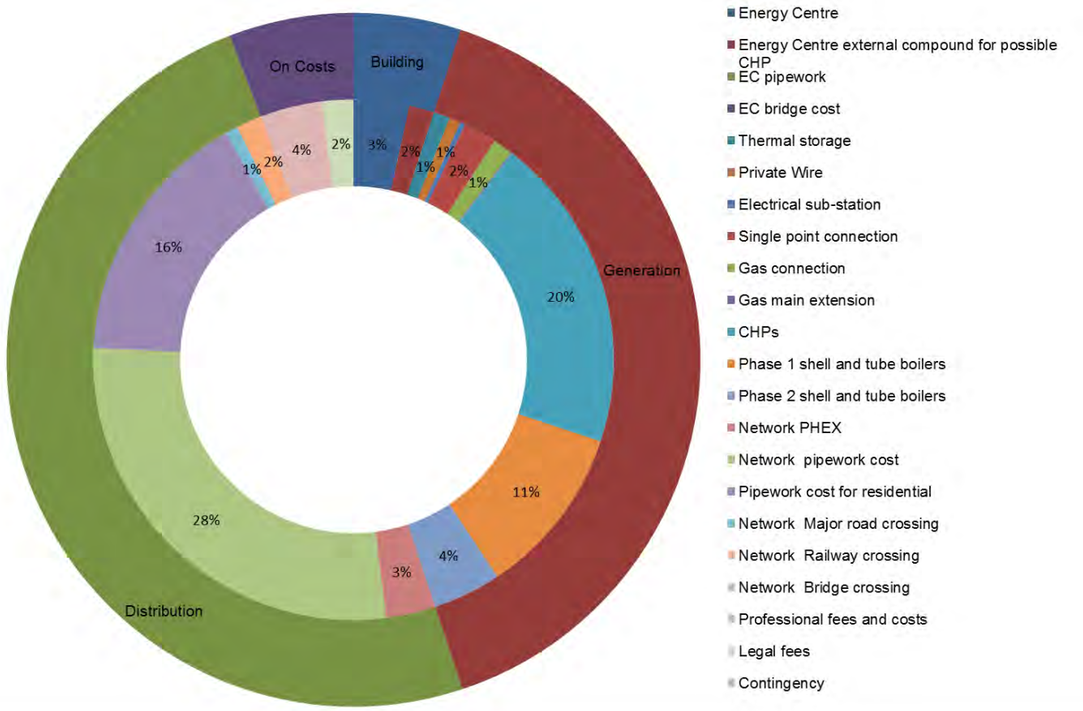


Figure 10-2 CAPEX breakdown chart – Chesterfield

Table 10-5: Chesterfield economic evaluation results summary

Financial assessment	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
25 Year Assessment:							
IRR (%)	13.43%	8.41%	8.10%	7.71%	10.40%	10.28%	9.35%
NPV (000's)	10,057.4	7,236.9	7,078.1	6,710.7	17,304.9	19,498.2	20,160.9
30 Year Assessment:							
IRR (%)	13.62%	8.75%	8.46%	8.08%	10.82%	10.68%	9.80%
NPV (000's)	11,395.5	8,595.3	8,492.6	8,155.7	21,232.7	23,694.5	25,052.5
40 Year Assessment:							
IRR (%)	13.86%	9.27%	9.01%	8.67%	11.22%	11.09%	10.27%
NPV (000's)	14,483.1	11,989.9	11,985.1	11,699.6	28,146.5	31,542.3	33,974.2

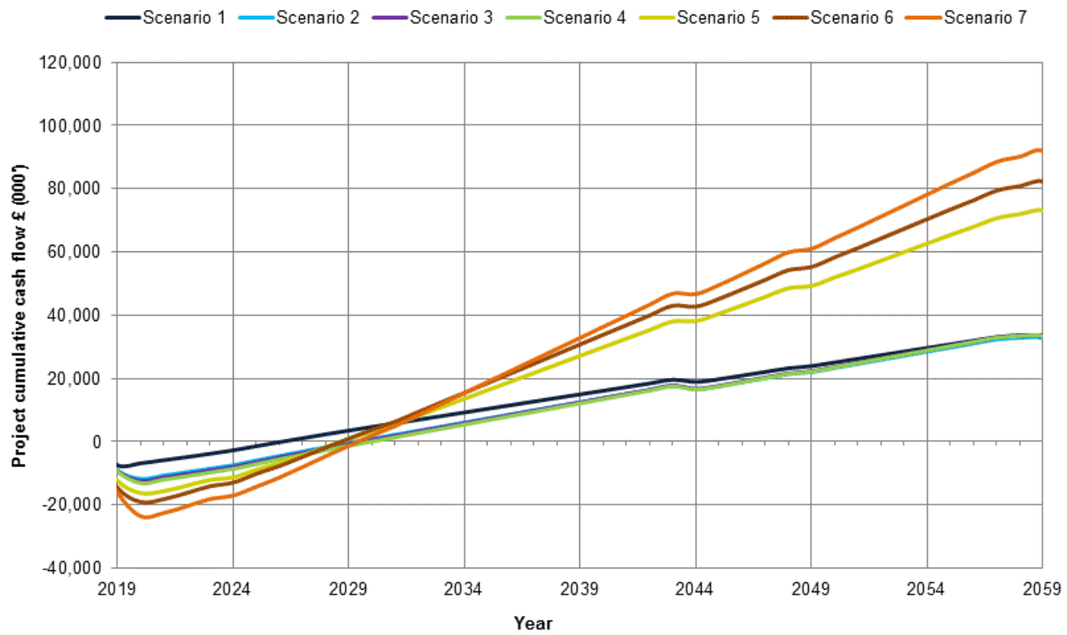


Figure 10-3 Chesterfield cumulative cash flow

Figure 10-3 shows the cumulative cash flow for network scenarios modelled over the 25, 30 and 40 year assessment periods. The results show that Scenario 1 presents the highest IRR among the scenarios assessed, but also offers the least carbon savings due to the scale (section 10.3). This scenario requires the least pipework to connect the largest customer of the network, the Chesterfield and North Derbyshire Royal Hospital. Although Scenario 1 is expected to attract more investment, it is not recommended as it provides heat only to a limited number of buildings: the hospital and St Peter & St Paul School Trust. Instead, it is recommended that the council pursues an option that can deliver financial benefits as well as achieving other council aims such as reducing fuel poverty and carbon emissions whilst delivering operational savings to public buildings. Scenario 6 presents an attractive IRR and NPV while it serves a significant number of buildings in the area, including Council owned buildings.

10.3 Carbon Emission Savings

Table 10-6 presents the carbon saving results for 25, 30 and 40 year network operation lifetimes. The cumulative carbon savings of the network scenarios for Chesterfield are shown in Table 10-4. The cumulative carbon savings delivered by the Chesterfield network over the project lifetime is in the range of 25,951 – 79,474 tCO_2e, depending on the scenario assessed.

Note that these scenarios assume the continued use of CHP throughout the duration of the project. The carbon reductions will therefore not be as significant as the other networks. The carbon savings delivered by CHP technology are expected to fall over the years due to the anticipated decarbonisation of the grid. Table 10-6 demonstrates a fall in the average annual carbon savings, noticable after the first 10 years of the network's operation. Figure 10-4 shows that, after the 10 first years, the cumulative savings will keep presenting an upward trend; although not as significant as the first 10 years.

It is recommended that a reassessment of appropriate heat generating technologies is undertaken near the end of the initial CHP unit's economically useful life. This exercise should aim to determine whether CHP will continue to generate required carbon savings in addition to economic returns. An assessment of potential heat sources is provided here in Table 7-14 indicating performance across a range of parameters, including their potential to deliver carbon emissions reductions. It is recommended that a similar assessment is undertaken in the future to determine appropriate replacement technologies at the end of the CHP's useful life.

Table 10-6: Chesterfield carbon emission summary

Carbon Assessment	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
25 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	1,065	1,262	1,299	1,327	2,434	2,669	2,991
Average annual CO_{2e} reduction (% on counterfactual)	20%	19%	19%	19%	27%	26%	26%
30 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	880	1,060	1,094	1,120	2,045	2,263	2,545
Average annual CO_{2e} reduction (% on counterfactual)	16%	16%	16%	16%	23%	21%	21%
40 Year Assessment:							
Av. annual CO_{2e} savings (tCO_{2e})	649	808	839	863	1,558	1,755	1,987
Average annual CO_{2e} reduction (% on counterfactual)	12%	12%	12%	12%	17%	16%	16%
40 year cumulative:							
carbon emission savings (tonnes $CO2_e$)	25,951	32,312	33,562	34,502	62,329	70,212	79,474

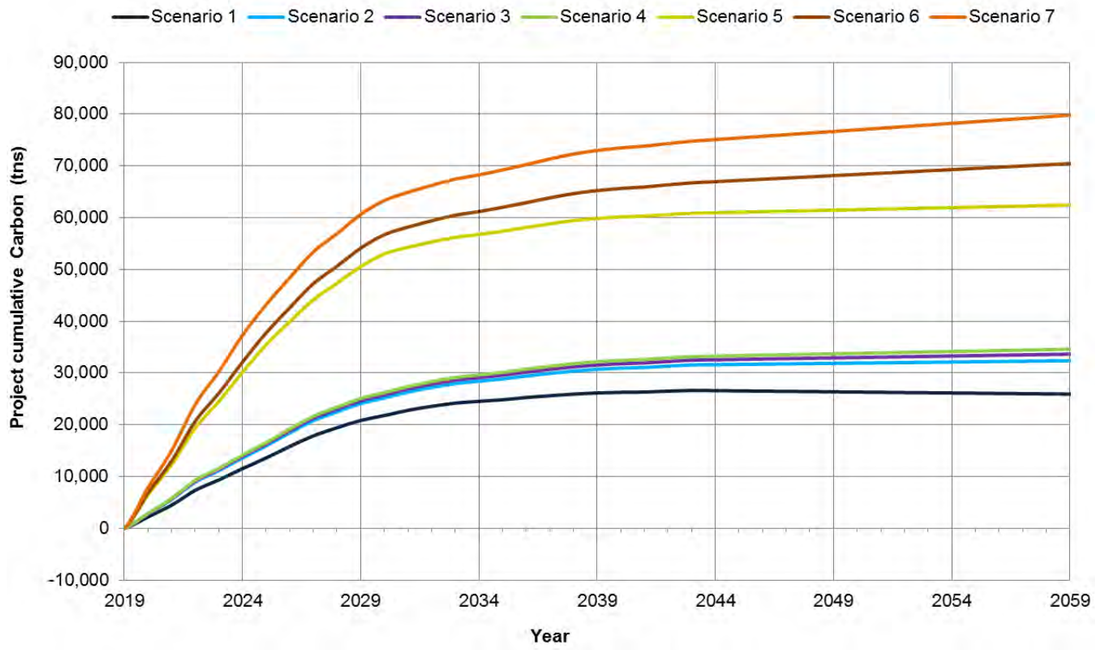


Figure 10-4 Chesterfield cumulative carbon savings

10.4 Sensitivity Analysis

Sensitivity analysis has been carried out to illustrate the effects of varying CAPEX, OPEX, heat demand, gas purchase cost, connection costs and heat and electricity sales tariff has on the IRR and NPV offered by Scenario 6. As can be seen in Figure 10-5 and Figure 10-6 overleaf, the scheme is particularly sensitive to the cost of heat sold to the network customers, gas purchase cost, export price of electricity exported to the grid and CAPEX.

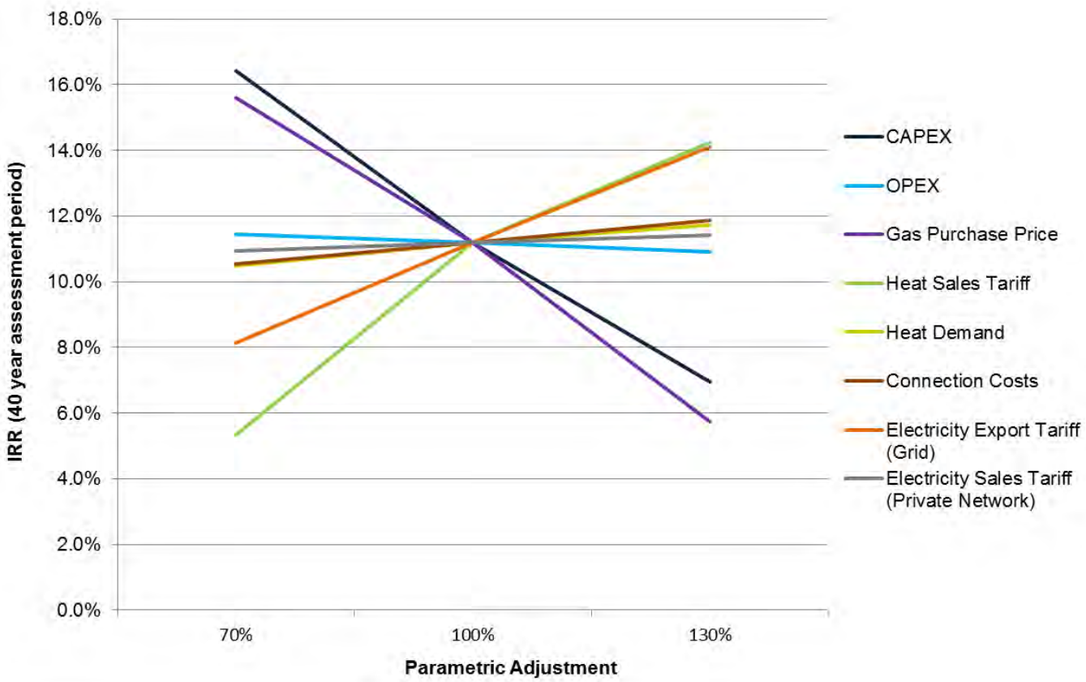


Figure 10-5: IRR sensitivity analysis for Scenario 6, showing the response to driving parameters

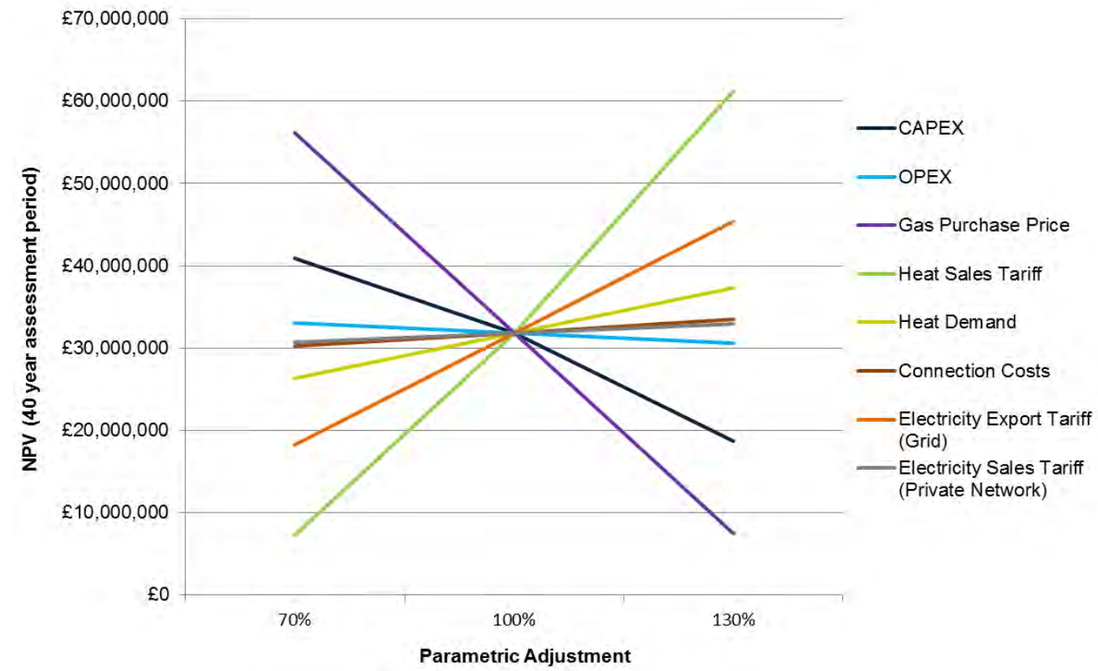


Figure 10-6 NPV sensitivity analysis for Scenario 6, showing the response to driving parameters

11. Risk assessment and management

A full risk register is provided in Appendix A. Some of the key risks found for each network are further explored in this section.

11.1 EC location

If DCC chooses to pursue the Chesterfield network further, it shall need to secure the area for the energy centre location at the earliest opportunity. Failure to confirm the spaces identified in this report would necessitate alternative locations to be sought, which may affect the results provided in this report.

The suggestion made as part of this study is to locate the Chesterfield EC near, or on the site of the Chesterfield and North Derbyshire Royal Hospital. Although it appears that there is ample land available in the vicinity of the hospital, its availability for use to host the EC is unknown. No engagement with the hospital was possible as part of this study – and must be pursued as a priority in further development of the network.

In the cases of the Clay Cross and Matlock network opportunities, the EC location is less of a risk. Through engagement with Enthoven and Lark Energy, AECOM have confirmed that these two operators would be happy to host the EC on their premises.

11.2 Pipework routing

All network opportunities investigated in this study will require the installation of buried insulated pipework in busy roads. Some networks also require this pipework to be laid in sections of road that tunnel under railways, or in bridges that pass over other roads, railways or waterways. The specific barriers to each network route have been summarised in Sections 7.2.4, 7.3.4 and 7.4.4. Should DCC choose pursue any of the networks detailed herein, the barriers identified for that network in question shall require detailed surveys from a relevant contractor in order to assess both the viability and the costs associated with installing pipework along the specified routes.

Existing utilities will also be present along the routes specified. This study has not assessed the presence or location of existing utilities in roads etc; a PAS256 certified scan of buried assets in the routes specified will be necessary to mitigate risks around pipework installation.

11.3 Available heat for import

There is a risk in the case of the Matlock and Clay Cross networks, which rely on heat import from third party suppliers, that the availability of heat in reality differs from that modelled in this report.

The site visit to and engagement with Enthoven and Sheffield University attempted to mitigate this risk for the Matlock network. By surveying the plant and assessing work carried out to date, AECOM were able to sense check the heat output and availability figures provided. The costs associated with the modifications necessary to allow the export of heat have not been verified, but relevant fees and legal on-costs have been applied as usual.

The Clay Cross energy recovery facility has been granted planning for plant with an output capacity of 10MWth. At the meeting with the EfW operators, Lark Energy, on 16 October 2017, it was suggested that the actual installed capacity is likely to be much lower. This is due to difficulties associated with securing fuel supply for the initial expected capacities. The work carried out in this report has used a more conservative estimate of 4MWth output for the Clay Cross facility, in line with conversations held at the meeting.

11.4 Building connections

There is a risk that some of the buildings identified for connection to the networks will either not be interested in connection, or technically unviable. In particular, operators of the identified existing private buildings must be engaged with as early on in the network development as possible. Full buildings audits must be carried out to assess technical viability.

Developers of future buildings must be consulted on connection and made aware of any planning conditions that will affect them, but which are necessary for the development of the network.

For any council owned buildings on networks pursued, facilities managers and relevant stakeholders must be engaged with early on in the process.

11.5 Network temperature and future proofing

The ability to install a future proofed network with lower operating temperatures is dependent on the design of the buildings on the network and their eligibility for accepting lower supply temperatures than would be conventionally designed for.

Through engagement with the owners/occupiers of eligible buildings, DCC shall need to ascertain the temperature requirements of the buildings proposed for connection. This assessment will inform the lowest available operating temperature of the networks.

11.6 Private wire electricity sales

The financial viability of the Chesterfield network is underpinned by the assumption that some of the electricity that is generated by the onsite CHP is sold privately (between 27% and 53% depending on the scenario chosen). The working assumption of the modelling is that electricity is sold privately to the Chesterfield and North Derbyshire Royal Hospital only, with the remainder exported to the grid.

This assumption requires the network operator to take over the supply of all electricity to the hospital through the private wire network. In other words, the hospital would be physically removed from its current DNO supply, and connected via the energy centre. This assumption remains a risk until the hospital agrees to switch supplier.

During the commercialisation phase of the project this process must be given due attention early enough in the process to secure the private sale of sufficient electricity to back up the financial performance of the network.

11.7 Site topology

Derbyshire lies in an inherently undulating area of the UK. Laying pipework over large variations in altitude entails certain risks. Firstly, pipework has to be installed that is capable of operating at higher pressures. Every 10m of altitude will add approximately 1 Bar of operating pressure to the system. Higher pressures also require pumps to be larger in size, in order to overcome the additional head pressure.

It may be necessary or cheaper to hydraulically separate parts of the network, thereby reducing pressures in each separated section. In these instances, satellite pumping stations would be required to serve each network leg. Whist this adds cost, it may prove to be cheaper than installing pipework that is rated for higher pressures across the whole network. Hydraulic separation also reduces efficiency as each hydraulic separation entails a temperature drop.

Cost allowances provided in this study are for pipework rated to around 10Bar. The maximum pipework height difference in Matlock is around 80m, i.e. static pressure will be around 8Bar. Adding a typical dynamic pressure of 2Bar would give a system operating pressure of 10Bar, i.e. on the limit of the pipework.

In Chesterfield the maximum height difference is around 60m. Operating pressure in this network is likely to be in the region of 8Bar, which is under the assumed 10Bar pipework operating pressure. However, including a margin on these estimates would push the operating pressure closer to the maximum allowable pressure, so topology is still a risk in Chesterfield.

Height differences in Clay Cross are much lower at around 30m. Site topology is therefore not considered a risk for this network.

It is recommended that the network operator/designer pursues a detailed topological survey to inform the pressure requirements of the network(s) and to ensure equipment and pipework is selected properly.

11.8 Future network expansion

All currently known future development/redevelopment in Derbyshire has been captured by this study.

It is recommended that during more detailed design development, DCC stipulates that the network is future proofed for further heat loads. This could be achieved by specifying the correct pipe sizing to allow for expansion, and by installing capped pipes at strategic locations on the network where expansion may occur. It is suggested that DCC specify the amount of expansion allowance required if this is desired in future.

No dedicated future expansion provision has been made in the proposed Energy Centre or network. Development could be accommodated by increasing the boiler selection capacity. This has a small impact to the proposed project CAPEX and would be a cost effective method of connecting any new buildings if they are located near the proposed heat network. The pipework sizing charts provided in Appendix H would allow for a c. 20% increase in heat load without having a significantly adverse effect on pumping power. Furthermore, return temperatures could be dropped in future to increase network capacity without resizing plant/pipework.

11.9 Air quality

The Chesterfield network is based around heat being generated by gas fired CHP engines. If not properly mitigated, generating heat and electricity with gas CHP can have adverse effects on air quality in the local area. This can be mitigated through the use of Selective Catalytic Reduction (SCR) converters installed in the plant room. Whilst the modelling detailed in this report has allowed for SCR in Chesterfield, DCC must ensure this is carried forward in any future development of network designs.

The council must also work to ensure that the proposed network serves to improve air quality in the local area when compared to the business as usual case. Detailed air dispersion modelling is necessary to show both the BAU and the proposed scheme effects.

12. Recommendations & Conclusions

This section summarises the findings of the energy mapping and masterplanning study carried out for Derbyshire County Council.

12.1 Energy Mapping

Key commercial and residential buildings in Derbyshire were identified and their energy requirements assessed through various means. Where actual data for gas and electricity consumption was not available, energy use was deduced from Energy Performance Certificates and Display Energy Certificates if applicable or appropriate industry standard benchmarks based on building type.

Heating, cooling and electricity demands were mapped out in GIS to illustrate the energy use in the county by location.

12.2 District Energy Masterplanning

A total of 19 eligible clusters of high heat demand were identified from the heat maps. This list was then shortlisted to three key areas for further investigation. Clusters were compared and shortlisted based on the following criteria:

- the nature of buildings in the cluster;
- presence of new developments in the vicinity;
- proximity of heat demands to existing sources of waste heat (e.g. Energy from Waste plants);
- output capacity of heat sources, and proportion of cluster demand that could be met from renewable means;
- density of heat demand; and
- barriers to network construction, such as major roads and railways.

Clusters were scored against these criteria in order to identify the three best opportunities for District Energy in Derbyshire. Those selected were as follows:

- Clay Cross – importing 4MW of heat from the proposed Clay Cross Energy Recovery Facility, which has had planning consent granted.
- Matlock – exploiting up to 4MW of waste heat from the Enthoven battery recycling facility.
- Chesterfield – supplying Derbyshire's largest heat load, the Chesterfield and North Derbyshire Royal Hospital, as well as other buildings in the town centre, with heat generated on site.

Each network underwent Energy Masterplanning to shortlist buildings for connection, plan pipework routes and select energy centre locations. Surveys were carried out in each area to verify the assumptions made.

Identified buildings in each area were subject to a selection procedure which determined whether they were likely to be connected to a future network and as such included in the technical and commercial evaluation phase of this study. Criterion against which buildings were judged for inclusion included:

- Expected thermal energy demand/requirement
- Physical barriers such as railways or rivers separating buildings from each other
- Secondary side system type and eligibility for connection to a wet district energy network
- Whether buildings could be considered as 'anchor loads'
- Distance of buildings from anchor loads

A total of 13 heat generation technologies were appraised both generally and in their relation to the Chesterfield network, where no existing heat sources are available. The appraisal recommended that gas CHP was the most applicable heat generation technology currently. When the initial CHP engines reach the end of their useful life (10-12 years depending on use) it is recommended that other technologies are re-evaluated to ensure that the most effective and best available technology is adopted.

The co-generation of heat and electricity will provide the network operator with revenue streams for the sale of both. Electricity could be sold to local users via 'sleeving' or a private wire or exported back to the grid for wider use elsewhere. Securing local users can be difficult, but often vital for the commercial and technical viability of the network. This is because electricity can be sold privately for around 80-90% of the retail price, whilst electricity exported to the grid sells at the wholesale price, which is typically around 40-50% of the retail price. The Chesterfield and North Derbyshire Royal Hospital was identified as a high consumption local customer that may be interested in purchasing lower cost electricity.

Energy centre locations for the three networks were proposed as follows:

- Clay Cross: on the site of the EfW facility. The site operator, Lark Energy, expressed an interest in hosting the EC at the engagement meeting on 16 October 2017.
- Matlock: on the site of the Enthoven battery recycling facility in Darley Dale. Enthoven engineers expressed a keenness to host the EC at the site survey and meeting on 16 October 2017.
- Chesterfield: in close proximity to the Chesterfield and North Derbyshire Royal Hospital. Exact location to be determined. This is a high risk assumption that needs mitigation. The location is proposed because the hospital is such a large anchor load.

Using these locations, and the list of prioritised buildings, high level network routes were planned, accounting for local infrastructure and physical barriers and constraints in the areas.

12.3 Techno-Economic Modelling

Seven network scenarios were identified for each network area, and assessed in a techno-economic model to test their level of viability and inform DCC's decision on which could warrant further investigation. In order for a network to be commercially viable, it must present the operator/investor with a good rate of return on their investment, whilst also offering the customers a saving when compared to the base case.

The bespoke model was built from first principles and allows the user to select various key parameters in the operation and installation of a network, such as:

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

The assumptions made in the modelling of networks are provided in Appendix F. Key outputs used to compare networks include the IRR and NPV assessed over 25, 30 and 40 year project lifetimes, as well as carbon emissions savings against a business as usual case. Factors such as the reduction of fuel property and operational cost savings made to public buildings are also accounted for in the comparison of networks. In all cases, it is ensured that customers would make a saving through connection to the heat network.

12.4 Economic Results

Each of the seven network scenarios account for different combinations of pre-determined network areas. In Clay Cross, the Town Centre only scenarios were found unviable. It was only when the proposed new Biwater development, 1,000 new homes adjacent to the proposed EfW facility, was added into the network that it began to provide positive returns on investment. Extending the network north into Wingerworth to serve a number of other new developments there, as well as the Tupton Hall School connection via Brassington Lane, was found unviable.

Scenario 4 performed highest, with a 40 year IRR of 8.9% and NPV of £6.7M. Returns could be improved by negotiating a lower EfW heat price than the assumed 2p/kWh.

The Enthoven battery recycling facility in Darley Dale (Matlock) offers a significant opportunity for the re-use of around 4MW of waste heat. However, the location of the facility and lack of large heat loads in the vicinity mean that long pipework runs are necessary to reach loads of any significance. Pipework costs alone were shown to make up 62% of the total network cost. Such high capital investment at the outset of the project mean that most network scenarios will not provide a positive return on investment. Those that do are still not attractive; the highest performer being Scenario 6 giving a 40 year IRR of 3.68% but with an NPV of just £968,000. These figures are despite the already low assumed cost of heat purchased from Enthoven at 0.5p/kWh. The sensitivity analysis showed that with a capital grant funding scenario of 30% (c. £7m), the IRR could be as high as 7.0%. Securing a UK Government grant such as HNIP funding may help the Matlock network opportunity reach or surpass the DCC IRR hurdle rates.

In Chesterfield, gas CHP is proposed to generate electricity and heat. The revenues from the sale of both mean that the network shows higher returns on investment than Clay Cross and Matlock. The best performing Scenario is that which includes only the Chesterfield and North Derbyshire Royal Hospital and a nearby school, due to the reduced pipework lengths (as the EC is located adjacent) in comparison to other scenarios. However, this particular scenario would offer no benefit to the multitude of public buildings in Chesterfield. Scenario 6 represents a large district heating network serving many of the buildings and new developments in Chesterfield, as well as the hospital. Its 40 year IRR was shown to be 11.1% and NPV to be £31.5M.

12.5 Carbon Emissions Results

Scenario 4 of the Clay Cross network, which would import approximately 91% of its heat from the Clay Cross Energy Recovery Facility, inherently emits much less carbon than its business as usual equivalent case of using gas boilers. However, the imported heat does have some carbon emissions associated with it, which may increase with the next update to building regulations. Over 40 years of operation, Scenario 4 achieves a 68% saving over the counterfactual, with a total cumulative saving of 64,900tCO_2e.

In Matlock, waste heat from the Enthoven battery recycling facility is entirely renewable, as it would otherwise be emitted to the atmosphere. In other words, the carbon emissions associated with its use are zero. In the best performing of the options studied, Scenario 6, 89% of the network's heat demand would be met by heat recovered at Enthoven's facility. Over a 40 year project life this equates to a 87% saving over the business as usual and a cumulative saving of 154,200 tCO_2e.

In Chesterfield, the network starts off by performing well in terms of carbon emissions savings. Looking further ahead and taking account of the predicted decarbonisation of the electrical grid in the UK, generating electricity and heat with gas CHP no longer provides the carbon emissions savings it does currently. Over the 40 year assessment period Scenario 6 of the Chesterfield network is only shown to provide 16% savings over the equivalent gas boiler solution. However, due to the scale of the network this still equates to 70,200 tCO_2e in cumulative savings over the same period.

12.6 Recommendations and next steps

The networks investigated as part of this study all provide different benefits to Derbyshire County Council and Derbyshire as a whole. All networks were designed in a fashion that ensured savings could be realised by customers who connect to the network. However, no social housing schemes are currently located in the three focus areas, so Derbyshire's poorest communities will not benefit from these savings. However, the communities in the areas studies would all benefit from the use of renewable energy and the reduction in carbon emissions and air pollutants the technologies would provide.

All networks were modelled to include for a phased installation of plant and pipework to enable future connection of new developments as they are built. This approach improves cash flow and therefore the financial performance of networks. It is recommended that DCC pays close attention to the implementation dates of new developments so that any installation of a DHN can be phased appropriately.

Table 12-1 below provides a high level overview of the results of the three best performing scenarios for each of the three networks investigated as part of this study. The Matlock network is shown to have extremely long pipework lengths, which are risky, costly and time consuming to install. Whilst it would deliver the highest overall carbon savings, the investment returns and net present value at 40 years are not attractive enough to interest even public sector investment. However, the sensitivity analysis showed that IRRs of c. 7% could be achieved with a capital grant of 30%. This could be achieved with HNIP funding, a UK Government Scheme available for heat networks, if the necessary criteria are met.

The Chesterfield network shows the highest rates of return and net present value after 40 years, but also requires the greatest up-front expenditure. If the hospital is engaged with and agrees to having its heat and electricity supplied by the network operator, this would mitigate the greatest risk around this network. There are a large number of public buildings in Chesterfield, meaning this option would provide the greatest benefit to the council through the future supply of low cost heat. However, the amount of total carbon emissions saved for the investment required is lower than Matlock or Clay Cross options.

The Clay Cross network presents the best value for money in terms of carbon emissions. It is the lowest cost option and is lower risk than the other networks due to a shorter overall pipework length, minimal difference in altitude across the network, and planning is already granted for the EfW facility. The greatest risk lies in the actual installed capacity of the EfW plant and the required negotiations around the price of heat. The rates of return on investment are attractive enough for public investment and are close to attracting private investment too (typically above 10%).

Table 12-1: Overall results summary and comparison table

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

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

- **Clay Cross:** Reliant on the Clay Cross Energy Recovery Facility going ahead, and with the same installed generation capacity as detailed in this report.
- **Matlock:** If DCC can secure a capital grant to support the costs of implementation. The analysis showed that a 30% capital grant of c. £7m would give an IRR of 7.0%. DCC must decide whether this rate is favourable enough to promote investment from the council (i.e. is it above the hurdle rate).
- **Chesterfield:** Particularly if the Chesterfield and North Derbyshire Royal hospital is found to be interested in switching its heating supply and is positive about hosting an energy centre on or near the site.

It is recommended that Derbyshire County Council pursues the above key uncertainties as it decides which of the networks to pursue further. Continued engagement with Lark Energy, the HNDU and the hospital would help inform the council whether the individual scenarios for each network are achievable. Other key risks the council should seek to mitigate are provided in Section 11.

Table 0-2 shows the project development process for HNDU funded projects. This study has incorporated Stages 1, 2 and parts of 3, up to the end of detailed techno-economic modelling. Should DCC choose to proceed with any of the network opportunities identified herein, further funding for the stages below can be applied for with the HNDU to develop those opportunities. Proceeding to the next phase of project development would not commit DCC to implementing district heating in Derbyshire, rather it would provide the council with better certainty of the feasibility of DH in the county. Completing stage 3 and undertaking stages 4 and 5 is likely to take around 18 months, depending on the appetite for engagement from stakeholders, consultant performance and level of council/HNDU involvement.

Table 12-2: HNDU Stages of work[21]

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

In summary, district heating in Derbyshire could help the council achieve a number of key aims set out at the beginning of this report:

- **Reduction in energy prices –** the modelling undertaken herein has based the cost of heat for network customers by applying a discount to the calculated business as usual cost of heat. This ensures that customers will realise a saving by connecting to the network. See Appendix F for details.
- **Compliance with environmental policies –** all of the heat networks developed in this report have the potential to deliver CO_2 reductions in Derbyshire.
- **Energy security –** high plant efficiencies and resilience in the Energy Centre, combined with heat and power generated from alternative fuel sources, increases energy security and reduces reliance on fossil fuels.
- **Local dividends – networks have been shown to be profitable;** the council can reinvest the profits generated to local authorities, communities, and/or businesses.
- **Local economy –** the construction and operation of a network can create employment and opportunities for local businesses to be involved in the supply chain, driving growth in the area.

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

Appendix A Risk Register

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/01	**Energy Centre location**	It has been suggested to locate the Chesterfield energy centre on land adjacent to the Chesterfield and North Derbyshire Royal Hospital. While there is space available in this location, its availability for use to host the EC is unknown. No engagement with the hospital was possible as part of this study. Hence the relevant stakeholders consent must be secured to ensure the area is available.	Med.	High	High	1. Engage with stakeholders and land owners from the outset if it is decided to pursue the Chesterfield network further. 2. Provide details on Energy Centre design to stakeholders at the earliest opportunity to ensure they understand energy centre particulars 3. Seek explicit consent for the location at earliest opportunity
R/02	**Customer satisfaction**	Customer satisfaction and retention in Derbyshire will depend to a large degree on having fair and equitable contracts. It is important that the service level for the heat supplied is defined as this will ultimately determine the design and hence the costs of delivering the heat.	Low	High	Med.	1. Engage with customers were education is required to communicate what a Heat Network is and how it operates 2. Provide reports on energy supply and use and bills that are clear and informative; 3. Develop communications with customers that meet customer expectations; 4. State levels of service provision and response times to reported failures: 5. Customers to meet agreed obligations. 6. Consider adoption of a Code of Conduct scheme such as Heat Trust 7. Adoption of agreed performance guarantees to be monitored and reviewed
R/03	**Heat Tariff**	Heat tariff may require change due to external influences, in order to remain attractive or compliant with future guidance	Low	High	Med.	1. Establish proposed heat tariff (fixed and variable element) and demonstrate current cost effectiveness against identified counterfactual 2. Conduct sensitivity analysis on future heat tariff rates based on risk identified within this document 3. Consider within sensitivity testing that future heat rate tariffs may be capped against identified metrics
R/04	**Customer bad debt**	The customer fails to pay on submitted bills and falls into Debt.	Med.	High	High	1. Establish whom holds debt risk within commercial structure 2. Identify possible level of debt risk 3. Conduct sensitivity analysis and establish level of debt that could be accommodated within the heat tariff 3. Develop revenue protection strategy that can be applied throughout the lifespan of the system 4. Establish suitable heat sale agreements. 5. Consider adoption of Heat Trust scheme.
R/05	**Assessment of thermal loads**	The peak heat demand drive capital costs as plant and network capacity increases. Oversized assets also lead to increased operational costs. The annual heat consumption determines the heat revenues to the scheme and, together with the daily and annual profiles of this consumption will determine the capacity of the low carbon plant which will supply the majority of the heat. Oversizing is more likely to occur than under sizing.	High	Med.	High	1. Establish peak and annual loads based on best available data as defined within Heat Networks Code of Practice. If potential loads are unknown, document assessment basis. 2. Conduct sensitivity analysis on the projected loads based on the level of certainty of projected loads being present and connecting 3. Establish likelihood of load being connected by engaging with responsible representative 4. Confirm projected loads with responsible representative; occupation rates, periods of occupation etc. 5. For existing residential buildings, the heat network provider will need to estimate peak and annual demands based on modelling or experience from supplying buildings of similar size and type, or where block boilers are used from fuel consumption data.

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/06	**Connection of thermal loads**	The projected peak and annual thermal loads do not occur due to some of the buildings identified for connection to the networks not being interested, or the connection is technically unviable.	Med.	Low	Med.	1. Engage with operators of the identified existing private buildings as early on in the network development as possible. 2. For any council owned buildings on networks pursued, engage with the facilities managers and relevant stakeholders early on in the process. 3. Carry out full buildings audits to assess technical viability. 4. Maintain dialogue until connection is made 5. Identify heat sale agreements with commercial information being made available 6. Ensure that the heat network offering is competitive with the counter factual
R/07	**Realisation of thermal load**	The projected thermal loads of connected customers fail to be realised.	High	Med.	High	1. Establish peak and annual loads based on best available data as defined within HNCoP. If potential loads are unknown, document assessment basis. 2. Conduct sensitivity analysis on the projected loads based on the level of certainty of projected loads being present and connecting 3. Establish likelihood of load being connected by engaging with responsible representative 4. Confirm projected loads with responsible representative; occupation rates, periods of occupation etc. 5. Develop heat sales agreements with consideration of guaranteed annual thermal energy purchase with a minimum connection duration
R/08	**Change of connected thermal loads**	Connected thermal loads change due to alteration of building usage, improvement in energy performance or connection termination	Low	High	Med.	1. Maintain dialogue with customer to identify potential for future change 2. Develop heat sales agreements with consideration of guaranteed annual thermal energy purchase with a minimum connection duration
R/09	**Network operating temperatures**	Operating temperatures are a key aspect of heat network design and will determine both the capital cost of the network and the heat losses and pumping energy. Designing for a future proofed network with lower operating temperatures can result in higher efficiencies, but this depends on the design of the buildings on the network and their eligibility for accepting lower than conventional supply temperatures.	Med.	High	High	Through engagement with the owners/occupiers of eligible buildings, DCC shall need to ascertain the temperature requirements of the buildings proposed for connection. This assessment will inform the lowest available operating temperature of the networks. The designer has also to consider constraints such as the temperatures used for existing heating systems and the degree that these can be varied.
R/10	**Heat losses**	Losses (proportion of annual thermal energy lost in kWh or MWh) are often incorrect leading to inaccurate energy centre plant and financial planning. The HNCoP states a best practice of 10% annual thermal production is lost to below ground pipework (energy centre to building). The HNCoP states a best practice of 10% annual thermal loss of vertical and lateral pipework, up to and including the HIU.	Med.	Med.	Med.	Detailed assessment of below ground and above ground losses. Review of insulation applied, pipework diameter, length of pipe and operating temperatures. 15% has been assumed as part of the modelling in order to provide more conservative estimates on performance
R/11	**Combustion plant size**	Benchmarking energy use of buildings can often lead to overestimating the peak demand requirements of buildings. When this is the case for a number of buildings on a network, this can lead to significant oversizing of thermal generation equipment. This adds unnecessary cost and can reduce operating efficiencies.	Low	Med.	Med.	1. Identify and agree peak thermal loads assessment 2. Consider development of the peak thermal load if the system is to have phased completion 3. Identify thermal resilience strategy with specific consideration of boiler capacity and low carbon system capacity. Boilers at N+1 with CHP as supplementary heat (not considered in peak capacity) is common. 4. Review impact of capex inclusive of material, labour, maintenance as well as spatial impact

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/12	**Heat controls**	Heat controls result in poor operation of the system at generation, distribution and customer level. Key issues are optimisation of the system's resultant heat carbon factor and maintenance of flow and return temperatures.	Med.	Low	Med.	Appropriate generation, distribution (primary and secondary) and customer side controls should be designed, installed, commissioned and monitored. Employ suitable designers and operators and review proposals with Commissioning Manager. Ensure the systems are put in place, commissioned and operate as intended
R/13	**Inefficient heat network routes, pipe sizes and reliability**	The capital cost of the heat network is likely to be a major component of the project cost. The routes for the network will define the length, installation difficulty and hence cost.	Med.	High	High	The quality of materials, design, construction and operation of the heat network are important in determining the reliability of the system. An optimisation study shall be carried out under high standards to achieve: 1. Energy efficient heat network; 2. Low cost network - optimisation of routes and pipe sizing for minimum lifecycle cost; 3. Reliable network with a long life and low maintenance requirements; 4. Efficient heat distribution system within a multi-residential building; 5. Other buried utility coordination; 6. Geographical obstacle review; 7. Land ownership
R/14	**Inappropriate building interface connection**	A fundamental design choice is whether the buildings or dwellings are directly connected to the heat network (where the 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.	Low	High	Med.	1. A study shall be carried out to assess the costs and benefits of each connection methods at a building level and at an individual dwelling level; 2. Where indirect connection is used the heat exchanger shall be sized with an approach temperature (primary return (outlet) temperature – secondary return (inlet) temperature) of less than 5 °C; 3. Where boilers are being retained within the building for use at times of high demand the connection design shall ensure that the heat network heat supply is prioritised and the boilers used only when required to supplement this; 4. Large bodied strainers with fine mesh shall be specified to reduce the risk of dirt accumulating on valves and heat exchangers; 5. Control valves shall be two-port so that a variable volume control principle is established; 6. The design of plantrooms for the heat network interface substations shall provide sufficient space for maintenance access and for future replacement of equipment. It shall provide suitable power supplies including for use when carrying out maintenance, lighting, ventilation, water supply and drainage facilities.
R/15	**Assessment of Environmental Impacts**	The potential for negative environmental impacts that need to be considered, in particular there may be additional NOX and particulate emissions, increased noise and visual impact.	Med.	Med.	Med.	A more detailed evaluation of environmental impacts and benefits will be required at the design stage to support a planning application, to comply with legislation and to make the case for the project in terms of CO2 reductions.
R/16	**Air quality requirements**	Optimism that emissions standards can be met with ease, without any flue scrubbing and emissions reduction technologies (which are costly)	Low	Med.	Med.	1. Assess local planning requirements in addition to any environmental permitting 2. Analyse plant flue gas performance 3. Develop mitigation strategy as required i.e. change plant or install flue treatment systems 4. Financially plan for proposed approach 5. Conduct appropriate flue gas/air quality assessment 6. Confirm final solution 7. Demonstrate operational performance when appropriate
R/17	**Health and safety issues in construction, operation and maintenance**	Reducing health and safety risks is of primary importance in any project. The health and safety of the general public during construction must be considered particularly as heat networks are often installed through publicly accessible areas.	High	High	High	1. The client body shall recognise their role and obligations under the CDM Regulations and register the project as one governed by the CDM Regulations prior to the start of the design process. 2. The designer has a key role to carry out a designer's risk assessment and then to mitigate these risks by taking appropriate design decisions. The requirements of the COSHH and DSEAR Regulations shall be taken into account in developing the design. Consider undertaking a HAZOP assessment

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/18	**Poor performance of central plant**	The principal rationale for any heat network is that heat can be produced at lower cost and with a lower carbon content at a central plant than at a building level. In particular certain heat sources are only feasible at scale (e.g. deep geothermal, energy from waste). The economic case for the heat network will depend on achieving the cost and environmental benefits at the central plant.	Med.	High	High	1. Designers will need to refer to detailed guidance on various aspects of central plant design as appropriate and identify a performance level 2. Monitor the operation of the central plant and to provide regular reports to the owner/developer so that a high standard of performance can be maintained. 3. Conduct sensitivity analysis based on the poor performance of the plant
R/19	**Inadequate thermal energy supply**	Failure to deliver the required amount of heat to each customer, critically at the times of peak demand.	Low	High	Med.	1. ensuring that each customer cannot take more than the design flow rate that has been set in the supply contract (typically defined as a kW supply rate at defined flow and return temperatures); 2. For residential properties, a hydraulic interface unit (HIU) is often used to provide a central control and metering point at each dwelling; 3. Commission cost effective, accurate and reliable heat meters in accordance with the Measuring Instruments Directive (MID) and shall be Class 2 accuracy; 4. Implement guaranteed performance standards within the contract
R/20	**Thermal Connection Arrangements**	Anchor load customers/developers can prove key to the financial success of a network. Failure to secure these connections can result in financial failure of the heat network	Med.	High	High	Discussions with key anchor load customers should be undertaken as early as possible in order to establish both the technical and the commercial viability of providing heat utilities to them. Time and resource should be itemised in the business plan to allow for these. Negotiations may be required in order to secure connections
R/21	**Future fuel price variation**	The price of heat would include fuel cost, standing charge, maintenance cost, etc. These cost are significant parts of Opex, variation of which will impact the revenue.	High	High	High	Conduct sensitivity analysis on projections of future fuel and electricity prices such as those published by the Inter-departmental Analysts Group (IAG), HM Treasury. Operator can help mitigate risk through use of future heat sale prices and linking to identified and agreed indices.
R/22	**Change of regulation**	Financial incentives and various funding scheme have significant impact on the case financial model.	Med.	High	High	Financial analysis based on both current regulations and potential policies under consultation.
R/23	**Industry Regulation**	The heat industry is not regulated by an external third party. Formation of external regulatory body will incur additional management costs	Med.	High	High	Whilst the industry is currently unregulated, there have been a number of motions that have been applied by central Government, independent trade groups and professional bodies to improve the base level quality of the industry. Future external regulation may still occur given the current and predicted state of the market. Conduct sensitivity analysis on the potential for increased management/governance costs in the future. Sensitivity should be higher if not already assessing costs associated with current schemes i.e. CHPQA, Heat Trust, Heat Network Regulations
R/24	**Professional experience**	Without the correct set of skills or experience within the delivery team, a potential project may face increased costs at any stage of the project.	Med.	High	High	1. Promoter role can include the review of project requirement's and develop a delivery team that covers the identified roles with sufficient expertise; 2. Ensure companies and individuals have sufficient experience by reviewing CVs, case studies, references and training; 3. Consider specifying project to be delivered under the requirements of a formal structure, such as the Heat Networks Code of Practice.

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/25	**Fuel incomer requirement**	Risk that gas main infrastructure near chosen scheme site is not of sufficient pressures and kW capacity to service energy centre.	High	Med.	High	Energy centres often require significant gas main peak capacity and pressure which cannot always be readily provided locally from the existing in situ pipework. Early investigation of gas mains infrastructure recommended.
R/26	**Fuel incomers costs**	Assumed that connection of gas network to Energy Centre is straightforward when it can be onerous and costly	Med.	Low	Med.	Early investigation of gas mains infrastructure recommended.
R/27	**Water quality**	Water treatment is sometimes not considered, impacting CAPEX and OPEX. Hard water means extensive water treatment is required to reduce mineral content of the water. Without water treatment, plant lifespans will be reduced which is unlikely to be considered in life-cycle costs. Slightly hard water is found in Clay Cross and Chesterfield, which may cause some concern.	Low	Med.	Med.	1. Level of water treatment required should be investigated early. 2. Water treatment plant to be identified along with capex and opex costs 3. Water quality to be maintained whilst the system is operational.
R/28	**DNO electrical connection**	Electric DNO fee to connect and export to grid is underestimated/unknown at design stage (can often lead to huge one-off expense to connect for grid reinforcement works). Initial budget costs are often not tested soon enough within the project life cycle. Requirement to undertaken lengthy G59 application means it's often not done at early feasibility stages, which can lead to optimism on DNO connection cost/procedure. Occasionally, DNO infrastructure connection requirements/costs can halt a project completely.	High	High	High	Initial budget costs to be developed based on knowledge and experience of the local utilities. Identify changes in the current connection; increased import capacity (Heat Pumps) or ability to export (CHP) and amend price accordingly Seek quotations as soon as practically possible Identify key technical requirements are addressed within and quotations; security of supply, faults, capacity. Ensure cost of connection is contained within the business case and verified. Continue to engage with the market to ensure prices remain accurate and fit-for-purpose
R/29	**No private wire customers identified**	The revenues associated with private wire are much higher than exporting to the grid. The financial viability of the Chesterfield network is underpinned by the assumption that some of the electricity is sold privately (between 27% and 53% depending on the scenario chosen). The working assumption of the modelling is that electricity is sold privately to the Chesterfield and North Derbyshire Royal Hospital only, with the remainder exported to the grid. This assumption remains a risk until the hospital agrees to switch supplier.	Med.	High	High	During the commercialisation phase of the project relevant stakeholder engagement must be carried out early enough in the process to secure the private sale of sufficient electricity to back up the financial performance of the network
R/30	**Electric export market**	Electrical energy generated on-site, not evaluated suitability based on the perceived inability to connect to suitable loads, resulting in 100% export	Med.	Low	Med.	Local grid constraints to be assessed at Feasibility Stage. Identify opportunities to sell electricity to higher value connections. Conduct sensitivity analysis based on assumed average unit price per kWhe. As the project progresses, further mitigate risk and sensitivity by proving viability of connections and entering commercial negotiations with potential customers

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/31	**Electrical load available for sleeving/private wire**	Sleeving/private wire end customer might not have the electric load requirement it is assumed to have or be willing to enter contract due to pre-existing electrical supply arrangements	Low	High	Med.	Early engagement with potential customers is required to establish the real electrical load available. Discussion around potential costs and willingness to enter contractor to be commenced at an early stage to de-risk item.
R/32	**Sleeving/Private wire arrangements**	Assumption of sleeving to end customers is assumed to be technically easy, requiring little or no upgrade to electrical infrastructure. Cost can directly impact maximum sale price per MWh.	Low	High	Med.	Capital costs to be identified, based on the level of design information available. Risk of price increased to be considered and appropriate contingency value put in place until risk designed out.
R/33	**Electrical export**	Parasitic loads, transmission losses and transformer inefficiency often under-estimated/ignored.	Med.	Med.	Med.	Assess potential parasitic loads and losses that could impact the quantity of electrical energy available for sale. Can reduce saleable electricity by up to 10%.
R/34	**Electric revenue/private wire sales**	Achievable sale price of electric often assumed to be too high (retail/wholesale). Assumed private wire electricity sales are dependent on identifying relevant and willing customers	Med.	High	High	Consider value of electricity used to generate heat and evaluate cost benefit of making loads parasitic Identify suitable electrical customers as early as possible. Assess mid-point sale price per kWh for each point of sale. Agree a lower price and a higher price to sensitivity analysis
R/35	**Heat meters**	Heat meters either not present, not installed properly or unable to transmit recorded information	Low	Low	Low	Suitable heat meters are to be installed in accordance with the relevant regulations and Heat Networks Code of Practice. The heat meter should be appropriate to the system design and installed in accordance with the manufacturer's requirements. Installed meters are to be commissioned and proven to operate over a continuing period of time, including data transmission. Meters will require on-going maintenance and possible recalibration, as identified during the planned maintenance process.
R/36	**Energy Centre size and cost metrics**	No industry standard benchmark on physical size requirements, so often energy centres can be under-estimated. When at design stage, these errors can impact construction costs, cause programme delay and land use/developer availability. Furthermore, no industry standard benchmarks are available for construction/procurement costs (£/m2).	Med.	Med.	Med.	Limited information or specific published metrics available therefore assessment to consider plant size, movement and maintenance. Internal heights and location of heavy plant also to be considered. AECOM is developing budget costs based on data held within the organisation and submitting for Client review
R/37	**Connection to external heat sources**	Potential current/future requirements to connect to other external heat sources e.g. Energy from Waste plants. External heat sources will impact both peak and base load generation requirements for the heat network.	Low	High	Med.	1. Assess potential for current/future connections to external heat sources and their technical compatibility 2. Identify drivers that would lead to connection and the cost impact of the connection 3. Establish possible timescale in which a connection would be made 4. Review impact on peak thermal generation plant (possible redundancy) 5. Review impact on LZC plant due to reduced run hours 6. Review impact on plant area required

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/38	**Connection to other DH networks**	Potential current/future requirements to connect to other heat networks. External heat network will impact both peak and base load generation requirements for the heat network.	Med.	High	High	1. Assess potential for current/future connections to external heat networks and their technical compatibility 2. Identify drivers that would lead to connection and the cost impact of the connection 3. Establish possible timescale in which a connection would be made 4. Review impact on peak thermal generation plant (possible redundancy) 5. Review impact on LZC plant due to reduced run hours 6. Review impact on plant area required
R/39	**DH pipework design**	Pipe lengths often assumed to be too short than is necessary Installation of pipework is assumed to be straightforward, without the need to coordinate with utilities/highways which is rarely the case Pipework insulation performance overestimated, impacting energy losses and load on Energy Centre Inappropriate DeltaT can result in larger (increased capital and operational costs) Adverse design parameters can result in the shortening of the systems lifespan	Med.	High	High	Principles of network design (pipe sizing, DeltaTs, velocities, stress) should be based on agreed standards i.e. HNCoP and manufacturers recommendations. Networks should be designed for identified connected loads and documented allowance for any future expansion (increase in diversified peak capacity). Routes of pipework are to be established at any early stage with an identified allowance for additional pipework that has yet to be accounted for i.e. inaccuracy in routing and expansion loops. As the design progresses, routes detailed and confirmed, the additional allowance proportion should be reduced to zero.
R/40	**DH pipework costs**	Pipework costs often underestimated at early stages of the project until installation. Additional costs arise from the location of the pipework; soft dig, sub-urban, urban or central urban hard dig.	Med.	High	High	Establish lengths, sizes and routes at Feasibility stage and apply appropriate metrics dependant on dig type, location and obstacles Engage with manufacturers and installers to review and improve pricing accuracy when detail is available. This should be conducted as early as possible and prior to completion of the outline business case.
R/41	**DH pipework maintenance**	Pipe failures are not accounted for. If they are accounted for, they are assumed to be easy to maintain. In reality, to fix a failed pipe is difficult, takes time and is costly - due to ground excavation works, welding costs etc. Servicing of loads from DH network will be interrupted, requiring a short-term servicing strategy to be put in place and temporary plant to be brought onto site - this is often unaccounted for.	Low	Med.	Med.	OPEX cost estimates for pipework failure/servicing should be allowed for in the economic model. Consider use of leak detection, water quality monitoring and extended warrantees
R/42	**Secondary/Tertiary system compatibility (existing buildings)**	Within existing buildings it can be assumed to be easy to convert/changeover secondary side systems to be compatible with network connection. Cost of ensuring technical compatibility to be considered In new build, how SH and DHW services are designed can have a significant impact on the capital costs and operating costs of the heat network. For example, achieving consistently low return temperatures will reduce capital costs for the network and thermal store, result in lower heat losses and pumping energy and in some cases reduce the cost of low carbon heat production.	High	High	High	1. Identify existing buildings that may wish to connect to the heat network 2. Estimate initial cost of connection based on anticipated supply arrangement 3. Confirm and validate operational parameters of the existing system 4. Confirm age and condition of existing/retained assets 5. Develop costs to reflect works to be undertaken and risk levels present i.e. re-commissioning of customer system from 82°C/71°C to 80°C/60°C flow and return temperatures.

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/43	**Secondary/Tertiary system compatibility (new buildings)**	How SH and DHW services are designed can have a significant impact on the capital costs and operating costs of the heat network. For example, achieving consistently low return temperatures will reduce capital costs for the network and thermal store, result in lower heat losses and pumping energy and in some cases reduce the cost of low carbon heat production.	High	High	High	1. Conduct specific design study to review the various options available for space heating and DHWS in relation to supply from heat networks.2. Implement agreed design, installation, commissioning standards and review their implementation3. Operator and Land Developers, or persons responsible for customer heat systems, to coordinate and ensure compatibility.
R/44	**Secondary/Tertiary systems operation**	Poor secondary/teritiary side operation can result in high return temperatures, corridor overheating and poor system performance	Med.	Low	Med.	1. Develop and agree a heat network design manual that covers design, installation, commissioning and operation. 2. Consider making technically measurable items contractually binding i.e. return temperatures during summer and low loads 3. Review operational interface if customer plant is being retained. 4. Ensure that the heat taken from the network is maximised, measured and monitored. Emphasis to be placed on measuring return temperatures to the network.
R/45	**Secondary/Tertiary systems commissioning**	Poor secondary/tertiary side commissioning can result in high return temperatures, corridor overheating and poor system performance	Med.	Med.	Med.	Potentially significant risk. Impact can be reduced by incentivising down streamsystem owners to optimise their systems, or by commissioning systems as part of the network (this would require associated costs to be included in the business case). Network operator may not wish to undertake downstream side systems.
R/46	**Planning consent and Way leave agreements**	Planning process often not considered, or are assumed to be straightforward. Energy Centre building planning performance requirements often not considered. Assumption that wayleave consent for preferred pipework routing will be granted, meaning in reality the required pipework lengths may increase and/or target anchor heat loads may not be connectable.	Med.	High	High	Often overlooked. Early engagement with relevant bodies within local authority recommended (planning, highways etc.) to establish requirements for the energy centre, environmental performance and routing option viability. If above ground pipework (pipe bridges) are being considered, additional Planning engagement may be required. Way leaves agreement may take considerably longer than anticipated.
R/47	**Carbon content of fuels**	Future carbon content of electric offset is uncertain, potentially impacting future carbon tax abatement. Unknown carbon content of future fuel used in the Energy Centre, impacts the carbon content of electrical/heat export.	Med.	Med.	Med.	Whilst utility carbon content is projected to reduce, the exact reductions are unknown. Use of DECC projections is recommended for initial assessment and DECC CHP bespoke carbon factors.
R/48	**Technology costs with maturity**	Expectations of significant reductions in technology costs, particularly for technologies that currently are only marginally viable that may not have much scope for quick price reductions (e.g. platinum content fuel cells). Impacts the technologies that are considered in current studies.	Med.	Med.	Med.	Significant unknowns. Conservative estimates recommended. Review opportunities to future proof the heat network both technically and commercially. Consider heat network suitability for current alternative technologies that are not yet commercially viable.
R/49	**Technology availability**	Expectation that future technologies that replace CHP as the prime mover become available at scale, and are compatible with designed and installed network.	Med.	Low	Med.	Cost allowances should be made in the business case to allow technology changeover. Review opportunities to future proof the heat network both technically and commercially.

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/50	New energy centre location	Should the initial chosen location not prove viable in future discussions and negotiations, an alternative location will need to be sought. The risks associated with adopting an alternative location include potentially increased CAPEX costs (depending on land ownership, location and nearby utilities, particularly MP gas mains), and OPEX costs (through increases in pumping energy and heat losses through increased pipework lengths).	Med.	Med.	Med.	Alternative locations must be identified at the earliest possible stage. It is recommended that any change in Energy Centre location considers the impact on its proximity to the MP gas main and the potential increase in DH network length required to service the customer buildings. Additionally, any Energy Centre location will have to consider the impact on the lengths required to provide private wire services where required. Visual impacts should also be considered.
R/51	Future-proofing of the network	The approach taken to future-proofing of the network to accommodate potential future demand expansion is inadequate -(this concerns projects that haven't yet been considered and/or approved). Future development does not have the opportunity to connect due to the inadequate future-proofing, or its connection would make the scheme sub-optimal. Not accounting for future expansion, could lead to increased O+M or capital costs, or missed opportunites and future savings.	Med.	High	High	Development plans have been requested, to ensure best prediction for future. Any future newbuilds to be obliged to connect to the scheme, with information to be provided to stakeholders (including contractors) as early as possible. Options to future proof design have been identified at feasibility stage. To be further considered at procurement stage and require contractor to future proof design e.g. through oversizing pipes, planning for nodal system. Consider potential contractual issues involved in connecting with other existing networks. Take into account future potential of new nearby developments. Must weigh up initial investment vs future impact/costs, but ensure no sacrificial plant, and existing scheme plant not oversized (to cater for future unconfirmed demand).
R/52	Insufficient gas supply to the energy centre available.	May influence scheme size if fuel supply is limited	Med.	High	High	Ensure there is enough capacity - consult with National Grid. Could alter the CHP specification, to increase the electrical rating.
R/53	Failure to gain approvals/political sign-off	Programme delay or overall threat to connection	Med.	High	High	Ensure the clinical side of hospital approvals needed is kept informed of works needed, and can influence the construciton schedule
R/54	Scheme fails to achieve an acceptable debt rate with customers	This would result in high charges for heat. High charges for heat would result in no (or insuffient) take-up of the scheme.	High	High	High	As only a small number of customers expeected, an acceptable debt rate should emerge as a result of the feasbility and design process.
R/55	Economic performance insufficient	It cannot provide discounted heat sales and the marginal business case fails to attract investment, whether from the council or a third party. If the network cannot give an economic benefit over the status quo, it is unlikely to be adopted.	High	High	High	This is of lower risk where there is larger public sector involvement and likelihood of accepting a smaller heat price discount. If the case is marginal, the council may need to raise the capital for the development. Negotiation with potential customers will be needed based on feasibility results and options identified. If the scheme does not achieve the desired IRR then an emphasis on the 'bigger picture' may be required to attract customers. e.g. being part of the first phase of an expanding low carbon network.

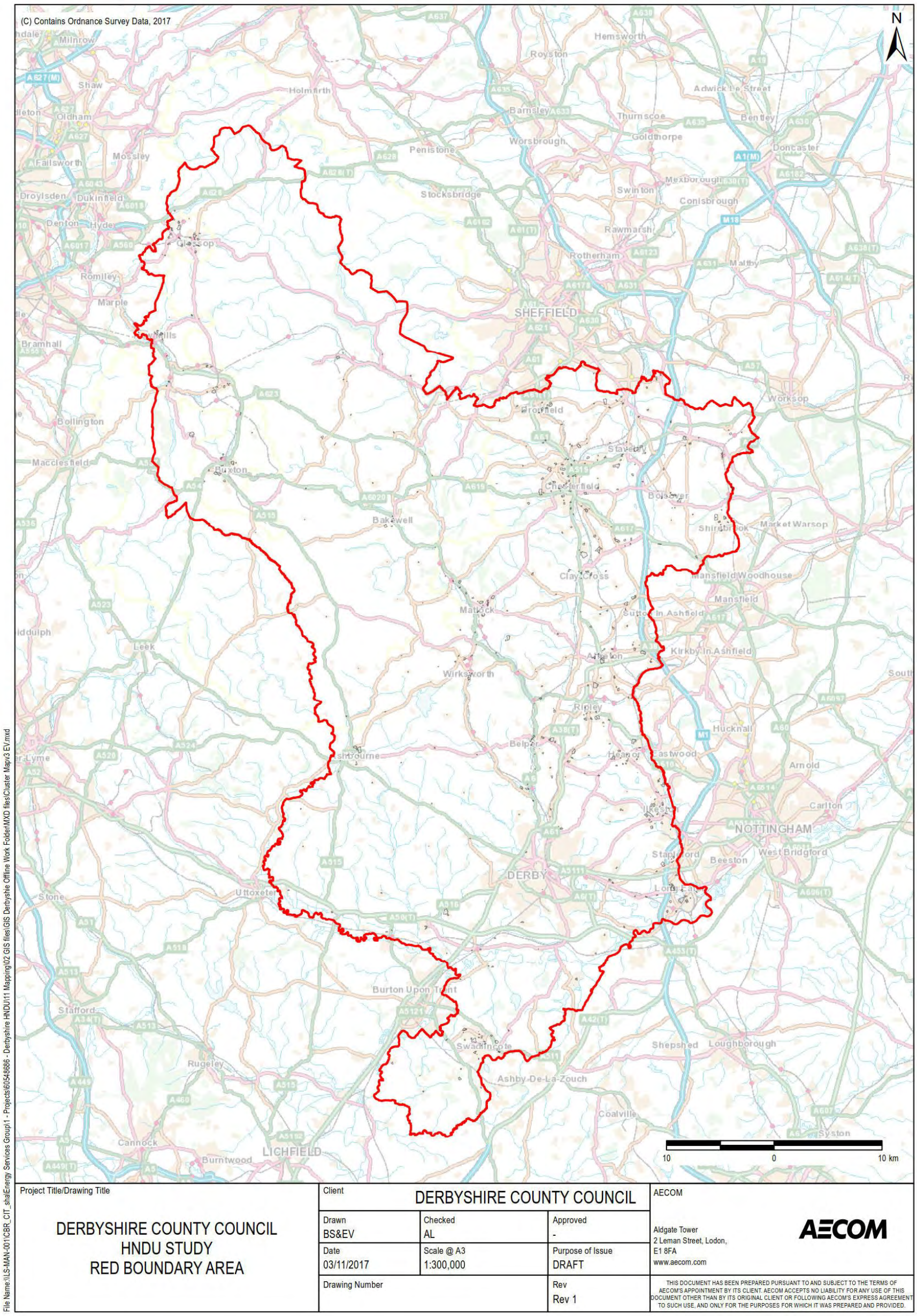
Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/56	**Sub-optimal capital programme**	Release/availability of funding drives phasing and impacts design decisions	High	High	High	Capture as much information as possible for the feasibility study. Communicate modelling assumptions and understanding regularly to check future plans are appropriately captured. Identify alternative funding sources.
R/57	**Uncertainty over capital cost**	This can lead to funding issues. This could be, for instance, contractor costs increase. Reduced NPV or IRR for the scheme, or scheme is mothballed.	Med.	High	High	Costs to be reviewed through process. Further work will be needed at detailed design stage to determine capital costs. Specific items such as energy centre or distribution network costs need further negotiation.
R/58	**Operation and maintenance costs of DH network**	If the capital spend profile included for maintenance and cyclical plant replacement is too low, scheme will suffer from reduced returns and increased operational costs	Med.	High	High	The initial phase scheme proposals are for gas CHP which is a reliable and mature technology. Costs to be reviewed through process. Further work will be needed at detailed design stage to determine capital costs. Specific items such as O&M costs need further negotiation.
R/59	**Cost of carbon and available subsidies.**	If the cost of carbon emissions increases, this might result in reduced returns and increased operational costs	Med.	High	High	Costs to be reviewed through process, with any changes to Government policy and the utilities markets noted. Further work will be needed at detailed design stage to determine such costs.
R/60	**Selection of sub-optimal procurement option**	Lack of understanding of procurement options available may lead to selecting sub-optimal supply chain partner	Med.	High	High	Procurement workshops; soft market testing. Engage with potential procurement partners as early as possible.
R/61	**Costs of metering and billing for heat sales with customers.**	Impacts on scheme viability	Med.	Med.	Med.	Unlikely to be high with small number of customers involved. Review in future if network expands.
R/62	**TRIAD and STOR model assumptions (which feed into energy cost/payment data) overly optimistic.**	Actual financial performance worse than that modelled, resulting in lower returns.	Med.	Med.	Med.	Use existing site data, and also lessons learnt from previous projects. Use worst case assumptions. Undertake sensitivity analysis
R/63	**Assumptions about avoidance of carbon costs wrong**	Impact on modelled financial performance, potentially resulting in lower returns.	Med.	Med.	Med.	Use existing site data, and also lessons learnt from previous projects. Use worst case assumptions. Undertake sensitivity analysis
R/64	**The proposed scheme gas consumption is significantly increased**	Insufficient network capacity may be available for a large increase in gas consumption.	Med.	Med.	Med.	Investigate network capacity and utility information.
R/65	**Failure to manage stakeholder expectations**	Stakeholders may pull out of agreement at an advanced stage. Uncertain scheme uptake would threaten the technical and economic viability of the scheme	Med.	High	High	Regular and clear contact with key stakeholders. Key customers are public sector which should reduce risk. Ongoing consultation and early negotiation of contract terms and signing of contract.
R/66	**Proposed energy centre(s) building not big enough to accommodate required energy source in future (no spare space for expansion).**	Missed potential to connect future development and concurrently improve performance of the proposed scheme.	Med.	High	High	If possible, building to be designed to be able to extend. Other site(s) may be needed for future expansion, and the team should continue to consider these alternative locations.

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/67	**Lack of integration with existing and planned future minor works (e.g. repair and replacement) or site activities that might disrupt DH scheme works.**	Potential lost revenue, unneccesary costs or delayed programme	High	Med.	High	Consider key potential constraints. Coordinate works with existing projects, work with stakeholders to ensure aware of these. Stakeholder activity constraints may include busy periods/ events.
R/68	**Remaining life of existing plant may be good. Risk of 'sunk' costs to connect to heat network**	Potential customers may be less likely to join up, or would want to get some use out of their existing plant or some costs recouped.	High	High	High	Will need to negotiate with customers on these points. Potential customers in private sector are likely to have new plant. Possibly the scheme might pay to adopt decentralised plant, or use temporary plant until the network is operational. Could let people connect as and when, but this impacts the financial case. Detailed engagement and contractual negotiations requried. Site survey undertaken has identnfied plant and will make allowances in the planned connection times to suite plant end of life unless agreed otherwise.
R/69	**Ability to retain customers on longer term contracts.**	Uncertain scheme uptake would threaten the sustained technical and economic viability of the scheme	Med.	High	High	Heat sales prices and contracts will need to be robust and attractive, and without break clauses. Draft Head of Terms to be developed under next stage and explored with stakeholders
R/70	**Complex works access to the selected Energy Centre(s).**	1. Delays to the programme schedule 2. Additional costs 3. Potential to be picked up by the media	Med.	High	High	Define costs (allow for high estimate) and works clearly, Early engagement with contractor and engagement with other stakeholders e.g. FM. 3. Soft testing
R/71	**Programme delays at construction stage (e.g. due to getting approval for works in roads, delivery delays, requirements for limiting work timescales due to events or building requirements).**	Cost and programme	Med.	Med.	Med.	Careful forward planning and management should be undertaken to manage and minimise delays. Detailed procurement programme to be presented with TC documents. If completion date is not met, buildings due to connect will need to be able to utilise their existing heat systems. Ensure programme not too tight and managed appropriately.
R/72	**Risks which may impact on programme e.g. discovering asbestos or ground conditions**	Cost, programme, technical and economic viability	High	High	High	Detailed surveys of each building to be undertaken where builders work is to be carried out, including asbestos survey, and GPR survey. Tio be undertaken in te next stage of design works
R/73	**Local political risk**	Changes to council administrations results in lower priority for heat networks or even abandonments through removal of resource. Reduction in long-term scheme support	Med.	Med.	Med.	Continued engagement with the Council senior management is essential for the scheme to be given the resources and priority required. Reduce risk by contracturally mandating this.
R/74	**National political risk**	Changes to national administration or strategy results in move away from heat networks, or powers which allow local authorities to develop and invest in heat networks. Reduction in available funding, incentives or difficulting in achieving planning for this strategy	Med.	Med.	Med.	This may place a greater emphasis on schemes being economically attractive for commercial investment. Engagement with national government required. Scheme to be optimised and future-proofed as far as possible to ensure long term viability.
R/75	**Risk of obsolete components needing replacing over the lifetime of the scheme.**	Increased replacement costs	Med.	Med.	Med.	Ensure spares will be available for long period.
R/76	**Financial incentives and various funding schemes have significant impact on the long term financial model.**	The financial case may change based on future regulation, negatively impacting the performance of the scheme.	Med.	High	High	Financial analysis based on both current regulations and potential policies under consultation.

Ref.	Risk	Commentary	Risk			Suggested Risk Mitigation
			Probability	Impact	Severity	
R/77	**Available heat for import - reliance on third party**	For the Clay Cross and Matlock networks, heat will be supplied from a third party, specifically the Larkfleet Energy from Waste facility and the Enthoven battery recycling facility. This leads to additional risk both in the timely delivery of the network and security of heat supply. The availability of heat in reality may differ from that modelled by AECOM	Med.	High	High	A site visit and engagement with Enthoven and Sheffield University enabled AECOM to sense check the heat output and availability figures provided. The costs associated with the modifications necessary to allow the export of heat will need to be verified, but relevant fees and legal on-costs have been applied as usual. The Clay Cross energy recovery facility has been granted planning for plant with an output capacity of 10MWth, however it has been suggested that the actual installed capacity is likely to be much lower. This is due to difficulties associated with securing fuel supply for the initial expected capacities. Hence our work has assumed a more conservative estimate of 4MWth output for the Clay Cross facility, in line with conversations held with Lark Energy.
R/78	**Insufficient cash flow and revenue streams**	Financial risk due to uncertainty in revenue streams.	Med.	Med.	Med.	Phased installation of network over several years, allowing initial network operation to be established and cash flow demonstrated. . Additional heat generation plants can be added later in order to meet the network's developing heat load.
R/79	**Installation of Chesterfield sub-station**	Sub-station including private HV transformers, HV switch room, LV switch gear, connection cost. One off cost of around £100,000, subject to G59 application of local HV infrastructure upgrade requirements.	Med.	Low	Med.	Make G59 application early, to assess whether there are any additional costs not accounted for currently.
R/80	**Third party heat and electricity costs**	The cost of heat highly affects the network finanical viability . For the Clay Cross and Matlock networks it is assumed that the third party energy suppliers will charge for heat and electricity where appropriate, i.e the EfW operator and .Enthoven facility. For modelling purposes, the year 1 heat cost for these networks has been set based on AECOM's experience of similar projects. However in practice it will depend on the third party supplier.	Med.	Med.	Med.	Confirm costs with the associated party as early as possible.
R/81	**Projection of energy prices**	Trend projections of future energy prices are taken from the BEIS Green Book supplementary guidance. However, the projections made in the Green Book do not show any change to price beyond c. 2027, which is an unlikely scenario and could affect the viability of the networks going forward	Med.	Med.	Med.	
R/82	**Site topology**	Derbyshire lies in an inherently undulating area of the UK. Laying pipework over large variations in altitude entails certain risks. Firstly, pipework has to be installed that is capable at operating at higher pressures. Every 10m of altitude will add approximately 1 Bar of operating pressure to the system. Higher pressures also require pumps to be larger in size, in order to overcome the additional head pressure. Cost allowances provided in this study are for pipework rated to around 10Bar. For the Matlock and Chesterfield networks the maximum hieght differences are estimated as 80m and 60m respectively. Once a typical dynamic pressure of 2Bar and an estimate margin are taken account, these heights entail a risk for the pipework.	Med.	High	High	The network operator/designer needs to pursue a detailed topological survey to inform the pressure requirements of the network(s) and to ensure equipment and pipework is selected properly. Hydraulically seperating of parts of the Matlock and Chesterfield networks should be considered to reduce pressures.

Appendix B Red Line Project Boundary Area

Figure B-1 Specification: CTP 847 Heat Mapping and Energy Masterplanning, Derbyshire County Council



File Name:\\LS-MAN-001\CBR_CIT_shal\Energy Services Group\1 - Projects\60548686 - Derbyshire HNDU\11 Mapping\02 GIS files\GIS Derbyshie Offline Work Folder\MXD files\Cluster Map\3 EV.mxd

Project Title/Drawing Title	Client			AECOM
DERBYSHIRE COUNTY COUNCIL HNDU STUDY RED BOUNDARY AREA	DERBYSHIRE COUNTY COUNCIL			Aldgate Tower 2 Leman Street, Lodon, E1 8FA www.aecom.com
	Drawn BS&EV	Checked AL	Approved -	
	Date 03/11/2017	Scale @ A3 1:300,000	Purpose of Issue DRAFT	
	Drawing Number		Rev Rev 1	THIS DOCUMENT HAS BEEN PREPARED PURSUANT TO AND SUBJECT TO THE TERMS OF AECOM'S APPOINTMENT BY ITS CLIENT. AECOM ACCEPTS NO LIABILITY FOR ANY USE OF THIS DOCUMENT OTHER THAN BY ITS ORIGINAL CLIENT OR FOLLOWING AECOM'S EXPRESS AGREEMENT TO SUCH USE, AND ONLY FOR THE PURPOSES FOR WHICH IT WAS PREPARED AND PROVIDED.

Appendix C List of heat supplies in Derbyshire

Table C-1 List of energy supply opportunities in Derbyshire

Operator	Name	Postcode	Easting	Northing	Capacity	Notes
Alkane Energy	Power Response plant, methane electrical generation	S44 5HS	444890	371924	1MW	
Clay Cross	Clay Cross Energy Recovery Facility	S45 9NY	439485	364052	10MWth	Planning granted for 10MWth, actual future installed capacity unknown
Drakelow	Drakelow Renewable Energy Facility		423160	319666	15MWe	
White Peak Distillery		Ambergate	434198	352256	Unknown	They've applied to EA for a license to dispose heat into the River
Severn Trent Water	Carsington overflow resevoir		424133	351608		
Derwent Hydro Limited	A number of Hydro projects on the Derwent	Various				
H. J. Enthoven	Battery recycling facility	DE4 2LP	426070	362315	1.5 - 1.8 MW constant, up to 3.5MW const. @ 90'C	
Local Council	Chesterfield and District Crematorium	S43 1AU	439718	373075	280kW	Assumption: 200kWh per cremation, 1500 cremations per year
Local Council	Mansfield and District Crematorium	NG18 5BJ	453883	358469	280kW	Assumption: 200kWh per cremation, 1500 cremations per year
Local Council	Amber Valley Memorial Park and Crematorium	DE55 1BH	440542	354234	280kW	Assumption: 200kWh per cremation, 1500 cremations per year
Local Council	Bramcote Crematorium	NG9 3GJ	450097	338983	280kW	Assumption: 200kWh per cremation, 1500 cremations per year
Local Council	Bretby Crematorium	DE15 0QE	428927	322675	280kW	Assumption: 200kWh per cremation, 1500 cremations per year

Appendix D Drakelow vs Chesterfield high level network comparison

Technical note: high level assemessmend of the Swadlincote and Chesterfield district heating network opportunities.

D.1 Introduction

The Energy Mapping and Masterplanning study for Derbyshire County Council aims to identify the best opportunities for district heating in Derbyshire. The study began by mapping all the heat demands and supplies in the county, and identifying the three best opportunities to advance into the masterplanning and modelling phase of the study.

Of the 19 heat clusters identified, seven were found to be of most interest as a result of the client heat mapping workshop held in Matlock on September 1st, 2017. These seven were subjected to a high level assessment for viability, a result of which was that there were two areas that were front runners (Matlock and Clay Cross) but that the third and final network was less clear.

This note details an assessment of the characteristics of the network opportunities in Swadlincote and Chesterfield, making a recommendation for which network should be taken forward for further development and techno-economic modelling as part of the final phase of the study.

D.2 Methodology

Development of the total heat demand of each network was carried out, whereby buildings that were not eligible for connection were omitted. The assessment was based on whether they met the threshold requirement of 3MWh per metre of pipework necessary the building.

With the buildings that remained eligible for connection to the network, a peak heating load assessment of each building was carried out, to inform the heating plant requirements and associated costs necessary to serve each network.

Network routes were proposed, and pipework costs estimated. Networks were then costed based on the plant, energy centre, pipework, building level requirements, with an allowance made for “on” costs (prelims, design and legal fees).

D.3 CAPEX assumptions

The assumptions made on the capital cost of networks are built around the metrics detailed in Table D-1.

Table D-1 - CAPEX assumptions

Classification		Cost	Metric
Energy centre costs	Building fabric	2,000	£/ m^2
	External CHP compound	500	£/m^2
	PHEX cost	32	£/ kWth
	Thermal Storage	1,000	£/m^3
	Boilers and ancillaries	235	£/kW
	CHP plant	950	£/kWe
Distribution	Pipework	1,200	£/m
	Bridge Crossings	2,500	£/m
	PHEX (building level)	32	£/kW
	Private wire	450	£/kW
Utilities Connections	Electrical substation	100,000	£/MVA
	Electrical connection	100,000	£/MVA
	Gas connection	10,000	£/MW
	Gas main extension	120	£/m
On-costs	Professional fees	5%	Of CAPEX
	Legal fees	2.5%	Of CAPEX

D.4 OPEX assumptions

OPEX and fuel costs were developed for each network based on the plant types selected. The assumptions on the operating costs of the networks are based on metrics detailed in Table D-2.

Table D-2 - OPEX assumptions

Classification		Cost	Metric
Energy centre maintenance	Energy Centre	2.5	£/ m^2
	CHP	10	£/MWhe
	Boilers and ancillaries	2.25	£/kW
Distribution maintenance	Pipework	1%	Of CAPEX
	PHEX (building level)	1	£/kW
	Private wire	1%	Of CAPEX
Fuel Costs	Heat purchased from third parties, e.g. EfW	30.0	£/MWh
	Gas (small consumer)	27.1	£/MWh
	Gas (large consumer)	18.9	£/MWh
	Electricity imported from grid	98.1	£/MWh
	Electricity imported from third parties, eg EfW	57.0	£/MWh

D.5 Revenue assumptions

Revenues were derived based on the connected loads, including an allowance for the different revenues associated with residential and non-residential customers. Revenues were based on a connection fee priced at 50% of the counterfactual cost of replacing each customers’ heating system, a fixed cost based on the peak requirements of each building, and a variable charge for the amount of heat actually consumed. A breakdown of these costs is provided in Table D-3. No metering and billing costs are assumed for commercial customers, due to the relatively fewer actual customers than when compared with residential developments.

Table D-3 - Revenue assumptions

Classification	Revenue Item	Cost, £	Metric
Residential	Connection fee	514.85	per kW installed capacity
	Availability charge	23.45	per kW installed capacity p.a
	Metering and billing	105.02	per dwelling
	Variable rate	0.0626	per kWh metered energy use p.a
Commercial	Connection fee	105.61	per kW installed capacity
	Availability charge	17.07	per kW installed capacity p.a
	Variable rate	0.0341	per kWh metered energy use p.a

This assessment, when paired with more objective comparators (such as risk) was used to show which of the two networks presented a better opportunity for Derbyshire County Council.

D.6 Swadlincote network

The buildings included in the Swadlincote network analysis are provided in Table D-4.

Table D-4 – Swadlincote building list

Building Name	Status	Type	Heat demand kWh	Peak Load kW
Former power station	Proposed	Residential	9,720,000	8,144
Steel Stock (B O T) Ltd Ryder Close	Existing	Industrial	467,821	340
Keystone Lintels Limited Appleby Glade Industrial Estate	Existing	Industrial	1,065,956	1,638
Edward House Appleby Glade Industrial Estate	Existing	Industrial	130,596	185
Unit 1 Tetron Point William Nadin Way	Existing	Industrial	134,645	247
William Nadin Way/Woodlands Road/Park Road	Proposed	Residential	2,462,400	2,317
Tnt Archive Services Limited William Nadin Way	Existing	Industrial	1,414,875	2,122
Plot 2 Boardman Industrial Estate Boardman Road	Existing	Industrial	395,693	125
Fakro House Astron Business Park Hearthcote Road	Existing	Industrial	264,650	337
Portal Place Astron Business Park Hearthcote Road	Existing	Industrial	322,639	523
Registration Of Births Deaths And Marriages Civic Way	Existing	Offices	197,582	35
Leisure Centre Civic Way	Existing	Leisure Centre	142,426	364
44 Snooker Centre Grove Street	Existing	Recreational	125,361	49
South Derbyshire District Council Civic Offices Civic Way	Existing	Offices	219,024	295
Police Station Civic Way	Existing	Police Station	110,613	47
Swadlincote Health Centre Civic Way	Existing	Health	488,466	189
A514	Proposed	Residential	1,944,000	1,881
Swadlincote Fire Station Civic Way	Existing	Emergency services	206,316	62
Belmont Primary School Belmont Street	Existing	School	198,735	77
Depot Darklands Road	Existing	Offices	71,093	179
Yard Close	Proposed	Residential	120,960	214
The Pingle School Coronation Street	Existing	School	1,314,284	929
St Edwards Rc Primary School Newhall Road	Existing	School	135,674	77
Springfield County Junior School Springfield Road	Existing	School	195,843	182
Alexandra Road	Proposed	Residential	216,000	320
Swadlincote A C E Rink Drive	Existing	Other Education	134,558	76
Total			**22,200,209**	**20,953**

These are broken down by type in Table D-5.

Table D-5 – Swadlincote buildings by type

Revenue Class	Classification	% of total heat
Residential	Residential	65%
Commercial	Industrial	19%
	Offices	2%
	Leisure Centre	1%
	Recreational	1%
	Emergency Services	1%
	Health	2%
	School	8%
	Other Education	1%
Total		**100%**
(Of which public)		**13%**
Existing		35%
Proposed		65%
Total		**100%**

The network in Swadlincote is based around the proposed Drakelow energy from waste facility. As such, heat is expected to be bought by the network operator from the EfW plant operator. Peaking and backup plant will be provided in the form of gas fired boilers. The technical assumptions made in the CAPEX and OPEX assessment is provided in Table D-6.

Table D-6 – Swadlincote technical assumptions

Class	Item	Metric	Unit
EC	Boiler Efficiency	85%	
	Heat Served by EFW	95%	of heat demand
	Heat Served by boilers	5%	of heat demand
Electricity	Electricity for EC operation (Imported from EFW)	4.5%	of heat demand
	Electricity for EC operation (Imported from grid)	0.5%	of heat demand

D.7 Chesterfield network

The buildings included in the Swadlincote network analysis are provided in Table D-7.

Table D-7 – Chesterfield building list

Building name	Status	Type	Heat demand, kWh	Peak heating load, kW	Electric demand, kWh
Chesterfield Royal Hospital	Existing	Health	24,583,839	7,666	11,807,292
Jobcentre Plus, Markham House	Existing	Offices	282,565	160	120,774
H M Revenue & Customs	Existing	Offices	127,925	105	212,205
DWP, Beetwell House	Existing	Offices	475,345	234	190,808
Derbyshire Constabulary	Existing	Police station	1,003,275	478	853,125
Chesterfield Central Library	Existing	Library	467,078	366	496,533
Chesterfield & District Register Office	Existing	Offices	127,767	42	33,304
Post Office, 1 Future Walk	Existing	Offices	807,570	698	1,525,410
81 Dents Chambers	Existing	Recreational	147,870	83	106,133
Office 3 Market Hall	Existing	Offices	617,540	281	429,070
Elder Way	Proposed	Mixed	1,121,807	626	656,135

Town Hall	Existing	Offices	898,620	617	396,450
North Derbyshire Commmunity Drug Team, Bayheath House	Existing	Offices	188,670	70	116,181
NE Derbyshire Council House	Existing	Offices	599,697	245	375,249
Pomegranate Theatre	Existing	Recreational	188,940	94	115,240
Winding Wheel, New Exibition Centre, 13 Holywell Street	Existing	Recreational	587,696	224	207,610
Chesterfield Magistrates Court	Existing	Offices	518,331	261	484,770
National Probation Service	Existing	Offices	141,276	51	71,004
Brimington Road (Waterside)	Proposed	Mixed	7,362,065	6,245	2,155,440
Basil Close	Proposed	Mixed	837,701	502	263,750
St Helena Centre	Existing	University	794,432	270	117,924
Queens Park Conference Centre	Existing	Leisure Centre	2,426,017	446	543,674
Wallis Barracks	Existing	Recreational	261,027	188	99,567
Parkside Community School	Existing	School	758,536	485	117,127
William Rhodes Primary School	Existing	School	179,958	181	52,071
Brampton	Proposed	Mixed	2,226,078	2,398	888,665
Total			**47,731,625**	**23,016**	**22,435,510**

The buildings under consideration are broken down by type in Table D-8.

Table D-8 – Chesterfield buildings by type

Revenue Class	Classification	% of total heat
Residential	Residential (incl. mixed use)	24%
Commercial	Library	1%
	Offices	10%
	Leisure Centre	5%
	Recreational	2%
	Emergency Services	2%
	Health	52%
	School	2%
	University	2%
Total		**100%**
(Of which public)		**62%**
Existing		76%
Proposed		24%
Total		**100%**

The Chesterfield network is predicated on a gas CHP solution for the generation of heat and electricity, with backup and peak heating supplied by gas boilers. It is assumed that a private wire network is installed to sell the electricity produced to the customers on the network. Table 9 details the technical assumptions made as part of the financial assessment.

Table D-9 – Chesterfield technical assumptions

Class	Item	Metric	Unit
EC	Boiler efficiency	85%	
	Diversity	70%	of peak load
	Heat Served by CHP	75%	of heat demand
	CHP Elec. efficiency	39%	
	CHP Heat/Power Ratio	1.05	
	Heat Served by boilers	25%	of heat demand
Electricity	Ancillary equipment elec	5.0%	of heat demand

D.8 Network comparison

The results of the network assessment as detailed in this note are shown in Table D-10. Results are shown for Year 1 only, with no accounting for Phasing; it is assumed all buildings connect to the network on day one of operation.

Table D-10 – Network results comparison

Cost, £m's	Swadlincote	Chesterfield
CAPEX	-£24.9	-£27.4
Recovered CAPEX through connection revenues	£7.5	£5.6
Year 1 costs	**-£17.4**	**-£21.8**
OPEX, per annum	-£1.0	-£2.9
Heat and electricity sale revenues, per annum	£2.0	£5.3
Annual Profit, per annum	**£1.0**	**£2.4**
High level payback period, years	**17.6**	**9.0**

The high level analysis shows that the Swadlincote network pays back in 17.6 years, whilst the Chesterfield network would pay back in 9.0 years, based on the assumptions provided in this report.

The following additional comparisons can be drawn between the two network opportunities:

- The buildings included in the Chesterfield network contain a much higher proportion of public buildings than the Swadlincote network. This means a network in the Chesterfield area would bring greater savings to the Council and other public bodies than the Swadlincote network.
- The higher proportion of new build residential developments in Swadlincote are unlikely to be to fully constructed at the time of network operation, meaning that full revenues from the sale of heat would not be realised until later on in the scheme's operation.
- The Chesterfield network contains Derbyshire's largest heating load, the Chesterfield and North Derbyshire Royal Hospital. This scale of heat load is hugely beneficial to the operation of a heat network, acting as an anchor load and driving the base heat load.

D.9 Conclusions

Based on the findings of the assessment detailed in this technical note, it is proposed that of the two networks investigated, that the Chesterfield network opportunity is taken forward for further investigation as part of the wider Derbyshire Heat Mapping and Energy Masterplanning study. The Chesterfield network presents better financial performance, as well as a number of qualitative benefits over the Swadlincote network.

Appendix E Energy Masterplanning Methodology

E.1 Introduction

This section outlines the energy masterplanning methodology followed for the three Derbyshire areas considered for district heating networks. Specifically, the approach for building prioritisation, surveying, network routing and energy centre planning are explained in detail. The respective findings for Clay Cross, Matlock and Chesterfield are outlined in sections 7.2, 0 and 1.1.

E.2 Building prioritisation

Within the areas identified, only a proportion of the buildings are suitable for connection to a wider district heating network. Each building has been assessed individually to ascertain whether it is viable for connection to a district heating network.

Priority was given to buildings such as residential developments, leisure centres and hospitals that were deemed to present high and stable heat loads over the year, typically with wet heating distribution systems already installed. Buildings situated in close proximity to each other were also prioritised.

Buildings have been scored against the following key criteria:

- **Heat load and distance from 'anchor load' area** – Buildings underwent high level assessment as to whether the CAPEX costs associated with installing the pipework necessary to serve them would be paid back through the revenues generated through additional heat and electricity sales. A high level threshold of 3,500 kWh of heating demand per meter of necessary pipework was used to ascertain whether a building would be commercially viable for connection.
- **Physical barriers** – Buildings that have significant physical barriers such as railways and waterways between them and the anchor load score lower in the prioritisation assessment. In addition, buildings located in the protected areas (i.e. conservation areas; AQMAs; areas of high grade agricultural land, etc.) and flood risk areas are less prioritised.
- **Ownership** – Council owned buildings and new developments that the council can influence (e.g. through the planning systems) are deemed to be a high priority for a district heating network connection and are therefore scored highly.
- **Future developments** – Undeveloped buildings or future redevelopments are typically high priority for connection to a DH scheme, as their design can be influenced throughout the early stages of planning and their design, such that they are compatible with the network.
- **Heating system type** – Customer buildings will be required to be compatible with a wet heating system. Buildings that use electric systems to provide heating and DHW are not typically compatible with DH services and are of lower priority. While converting existing electric or non-compatible systems is possible, the cost, complexity and extensive engagement required with the buildings' landlords/owners associated with their conversion, represents a significant obstacle for inclusion within a DH network.

E.3 Surveys

Site surveys were carried out for the three areas under consideration. This involved thorough visits of the catchment areas by AECOM in November 2017. The purpose was to verify the existence and use of buildings to check for any diversions from mapping, and note any significant physical barriers within the locality.

Non-intrusive building surveys were carried out to look for evidence of what heating systems were currently employed in the buildings. Those that were evidently heated electrically were omitted from the network.

E.4 Heat distribution

The design of DH networks must consider local conditions, existing or planned infrastructure, physical or regulatory barriers and the potential for future expansion of the proposed network. For each area under consideration, information on the existing infrastructure barriers including main roads, railways and waterways was collected. Crossing such barriers was avoided where possible.

In addition, an investigation of the protected areas (i.e. conservation areas; AQMAs; areas of high grade agricultural land, etc.) and flood risk areas was undertaken to identify any potential environmental and/or urban considerations that should be taken into account in the development of an energy network.

Should a network option be chosen for further development, these routes should be subject to further scrutiny and planning. This would include detailed surveys of the proposed routes, and further granularity added to the cost estimates, such that more appropriate cost metrics are applied to each pipework length. Metrics would be adjusted to allow for prevailing conditions such as dig type – soft, medium, hard etc., traffic considerations, relocation of/coordination with existing subsurface services (such as mains water, mains gas, telecommunications networks in road surfaces, etc.) and other factors that affect the installation of pipework.

For the purposes of this study, the network routing is used to estimate pipework lengths required for each identified network. This allows for approximate network costs to be developed – see Appendix F for details of the CAPEX assumptions for soft and hard dig pipework installation.

Coordination with existing utilities

Coordination of pipework routing and existing utilities will need to be undertaken, particularly when directing pipework under roads and footpaths. Detailed utility searches will need to be undertaken including the location, depth and required exclusion zones for:

- Gas, water and sewage mains
- Electrical cabling (HV and LV)
- Telecommunications (e.g. broadband)

Many of these services cannot be routed immediately adjacent to one another and may require certain distances to be maintained between them and the proposed DH pipework. It is recommended that a review of these services is undertaken at an early design stage in order to confirm the proposed pipework route.

Pipework

It is important that good quality pipework, with high levels of insulation and manufacture is specified. Additionally, installation of the pipework should be undertaken by experienced contractors in order to reduce the potential for damage during installation. Damaged or defected pipework is likely to increase heat losses while in operation and has a higher risk of developing a leakage. See Appendix H for pipework sizing schedules for each proposed network.

Network distribution losses

Energy losses from the distribution network result from the temperature difference between the distribution pipework and the medium in which the pipework is sited (usually in the ground). As ground temperatures are typically ~10°C, pipework that is located in the ground experience losses due to a temperature difference between the fluid in the pipework and the ground of up to ~80°C. Despite these challenges, distribution losses can be reduced significantly through appropriate network design (reducing unnecessary network lengths and appropriate sizing of pipework), the specification of good quality and well-manufactured pipework, the use of appropriately sized and specified insulation at all points across the network and careful installation on site. Good quality heat networks can achieve heat losses as low as 10% or less, although this figure is affected by a number of factors such as the heat density and the proportion of buried pipework and pipework within buildings. Therefore, for this particular study, heat losses have been assumed to be in the order of 15%[22].

Operating temperatures

Conventionally, temperatures of 82/71°C flow/return are used to serve radiators and other water based-heat emitters for space heating in existing buildings. However, in recent years there has been a drive to reduce network and service temperatures, both through the use of lower mean flow temperatures and achieving lower return temperatures, in an effort to both reduce distribution losses and to increase the efficiency of heat generating plant.

[22] Chartered Institute of Building Services Engineers (CIBSE) (2015) *Heat Networks: Code of Practise for the UK*. London: CIBSE and the Association for Decentralised Energy (ADE)

Ultra-low temperature (<70°C flow) networks are more efficient and potentially offer a more viable network for using heat pumps, since the efficiency of heat pumps reduces as operating temperatures increase.

The operating temperature of any district heating network will depend on the buildings that are connected to it. The network temperature should be reduced as much as possible whilst still being able to serve the heating loads on the network.

Where networks are serving predominantly older buildings with more conventional heating supply temperatures (~82/71°C flow/return), reducing network temperatures below this requires careful consideration. Many older radiators are oversized and are therefore capable of meeting heating demands with lower temperatures, but this requires detailed assessment. Where this is not possible, secondary heating supply networks can be changed to accommodate lower temperatures, but this entails significant and potentially prohibitive costs for the network.

For networks serving significant new developments, ultra-low temperature DH networks operating in the region of 60-70°C flow (as opposed to conventional 90°C flow networks) may be more applicable.

Building Connections

The connection of customer buildings and loads to the DH network will require a choice regarding how heat is drawn from the network and put to use in the customer buildings. A fundamental design choice is whether the buildings are directly connected to the heat network (where the water in the network flows directly through the heating circuits of the buildings) 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.

Hydraulically separated systems (indirect connection through the installation of heat interface units or heat substations) are usually considered to be a better option, since they offer better control of network operating conditions and ensure contaminants from customer services do not compromise the DH network and Energy Centre plant (a problem that is often encountered when using direct connection).

There may be some requirement to undertake changes to the heating services in customer buildings, depending on the nature of the building. If the existing heating system is a wet LTHW system, then works will be minimal and plant room based only.

The design of plantrooms within customer buildings for the heat substations should provide sufficient space for maintenance access and for future plant replacement.

For new residential developments, the network operator shall be required to work with the developer to connect each individual dwelling. Early engagement is crucial, to ensure buy-in from the developer and that pipework can be phased accordingly with the construction of the development. At this stage in the process, limited design information is available about new developments, so detailed pipework planning cannot be undertaken. An assumed connection cost on a per unit basis is therefore assumed for new developments. This must be further developed when the location and quantum of dwellings in a given development is more concrete.

E.5 Heat generation technology appraisal

The heat networks in Clay Cross and Matlock rely on heat imported from a third party supplier (the Clay Cross EfW plant and Enthoven battery recycling facility respectively). No such third party heat supplier exists in Chesterfield. As such, a range of heat generation technologies have been appraised in relation to their use there.

In order to assess each technology fairly, they are scored against a range of criteria which are of key concern. These criteria fall into four categories:

- **Technical** – Different technologies have been assessed against their suitability to deliver the scale and the profile of the required heat demand and to operate under required supply temperatures. Examples have been called on to provide evidence of technology maturity and the reliability of the technology's integration with a DHN while security on fuel delivery has been further considered.
- **Environmental** - A range of environmental implications have been considered for each technology. Direct impacts such as pollution and changes to the local air quality have been discussed for the various technologies. The scale of carbon savings have been estimated on the basis of both current and predicted carbon emission factors. The carbon saving for each technology has been discussed in the context of the fuel used, efficiencies attainable and the relevant emission factors.
- **Financial** - The financial benefit of each technology has been assessed in relation to current and projected fuel prices, efficiency and the expected maintenance level required over the technology's lifetime. Long term financial risks were also taken into account.
- **Deliverability** - Consideration has been given to the criteria that may affect the deliverability such as reliance on third parties together with implications on space requirement and energy centre size/design. Technologies were further evaluated based on their suitability on a local level.

Each technology was then scored between 1 and 5 against each criterion and shown in a matrix to determine the most viable technology for the DHN. Using each criterion's weighting importance, the weighted totals have been calculated for each technology and the technologies were ranked. The methodology was conducted for two scenarios; 0-15 years of DHN operation and 15+ years of DHN operation.

Table E-1 details each criterion and their given 'Importance', a score between zero and five to reflect its impact on the overall assessment. Please note that zero represents low importance and five represents high importance. Each criterion is then given a proportional weighting, which is calculated based on the score, such that all weightings sum to 100.

Table E-1: Technology appraisal criteria weighting

Category	Criterion	Relative Importance 1 - 5	Weighting %
Technical	Technology maturity and availability	**5**	**10**
	Suitability for scale and profile of heat demand	**2**	**4**
	Security of supply	**3**	**6**
	Suitability for required supply temperatures	**4**	**8**
	Proximity to heat demands	**2**	**4**
Environmental	Level of CO_2 emission savings	**5**	**10**
	Air quality implications	**5**	**10**
	Wider environmental impacts	**2**	**4**
Financial	Technology cost	**3**	**6**
	Impact on scheme financial viability	**5**	**10**
	Long term financial risks	**3**	**6**
Deliverability	Suitability to Chesterfield	**4**	**8**
	Implications for energy centre size/design	**3**	**6**
	Implications for additional space requirements	**2**	**4**
	Reliance on third parties	**2**	**4**
Total			**100**

E.6 Energy Centre Considerations

The delivery of district heating to buildings in Derbyshire would be through the following means:

- Clay Cross: heat purchased from the neighbouring EfW facility
- Matlock: industrial waste heat recovery (from the Enthoven battery recycling facility)
- Chesterfield: heat generation
- In all cases: backup boiler provision installed to meet the full network heat demand in the event that the alternative low carbon technology is not available (e.g. it is down for maintenance).

Heat generation plant, heat exchangers to enable the import of heat from third parties and all other associated equipment will reside in an Energy Centre (EC): a safe and secure enclosed environment protected from adverse weather and fire and suitably designed such that noise emitted from within the enclosure is attenuated and any exhaust emissions are appropriately dispersed.

The proposed ECs will require a significant amount of floor area in order to accommodate all the necessary plant and equipment, whilst also allowing for the appropriate spatial requirements for the installation, maintenance and removal of plant. The masterplanning phase of the study estimates the size requirements of the EC for each network, and provides suggestions/inputs on where to locate it.

Peak Heating Demand

The peak network demand for heat is a key factor in calculating thermal generation plant sizes and overall energy centre size and component requirements. Network peak demand is an aggregate of all the peak heat demands of the buildings on the network, with a Diversity Factor (D) applied to account for the fact that the peak loads of each building are not experienced at exactly the same time.

The diversity factor chosen depends on the nature of the buildings on the network. Diversity applies most to the DHW requirements of residential developments with a hundred or more units. DHW demands are short term and sporadic, and are often not experienced simultaneously across all units. In this case, the diversity factor has been calculated in line with the CIBSE Code of Practice for Heat Networks (using the Danish standard DS439).

Commercial buildings often operate similar hours of occupation, and as such diversity factors are typically much higher. For the purposes of this study, a diversity factor of 0.70 has been applied to commercial properties and the space heating element of residential dwellings.

Analysis was undertaken with an AECOM in-house tool which uses degree day analysis and suitable occupancy patterns per building type to estimate the peak demand from an annual total consumption. The tool allows for space heating and DHW peak demand to be calculated separately. To do so, annual total space heating consumption and annual total DHW consumption are estimated with the split assumptions outlined in Table E-2.

Table E-2: Space heating/DHW Split for different building types

Use	Data Source	Space Heating	DHW
Retail	Modelling Experience	90%	10%
Health	CIBSE Guide F	70%	30%
Leisure Centre	CIBSE Guide F	20%	80%
Offices	Modelling Experience	87%	13%
School	Modelling Experience	90%	10%
Other Education	Modelling Experience	90%	10%
Emergency Services	Modelling Experience	90%	10%
Hotel	CIBSE Guide F	70%	30%
Residential	Modelling Experience	40%	60%
Care Home	CIBSE Guide F	40%	60%

Heat Demand Profiling

The annual heat loads were categorised by building class (residential, hotel, general office etc.), summed for each class, and subjected to AECOM's in house heat load profiling tool. This tool uses assumptions on the usage of these building types during both weekdays and weekends to split the annual heat use into 8,760 hourly loads (representing each hour of the year). All profiles for the different building classes were then summed together to give an overall hourly network demand profile which is to be met by the energy centre (plus an assumed annual network loss of 15%, as per good practice guidance in the CIBSE Heat Network Code of Practice[23]). Diversification was applied to residential DHW loads in line with the Code of Practice. Refer to Appendix G for the network load profiles.

Energy Centre Capacity

Analysis of the peak annual heating demands and diversity of loads required for each areas was undertaken, together with other key considerations such as required boiler resilience and heat generation provision. This helped identify an appropriate composition for each EC plant.

Based on the anticipated loads for the schemes identified, boiler plant capacity required to service the different heat networks can be sized. Where co-generation is proposed, high level CHP sizing is made from assumed CHP run hours of 6,500, with 75% of all heat supplied via CHP. Appropriate numbers of engines will be selected based on the scale of the CHP requirement and in order to provide good turn down levels. The remaining 25% heat consumption would be met by boilers.

Where networks rely on import of heat from third parties, appropriate heat exchangers have been selected to hydraulically separate the heat export pipework from the wider district heating network pipework.

Required energy centre footprint for a given energy centre thermal output capacity is based on extensive AECOM experience in energy centre design and has been validated against actual installation details. However, as with any assumption of this nature, there are risks associated with its use and the actual required energy centre size can only be confirmed once the energy centre design has been developed further.

Note that, at this stage, there has been no assessment of whether the space requirements for the proposed Energy Centres align with the space availability in the locations discussed in Sections 0, 7.3.6 and 7.4.5, and. This assessment must undergo further analysis in future stages of this study order to ascertain whether the locations identified can accommodate the required Energy Centre.

Energy Centre Location Appraisal

A key consideration for the EC location is land ownership and its proximity to the major thermal loads in the area; lower pipework lengths between an EC and the loads being serviced reduce both CAPEX costs associated with laying the pipes and the earth works, and the OPEX costs associated with additional pumping power, maintenance, and pipework distribution heat losses.

Locating the EC on council owned land is preferred as it will help the development of the DHN by avoiding the work involved with leasing/buying or re-appropriating other areas of land, or by depending on 3rd party developers to provide space for the EC.

Total required EC footprint is dependent on its thermal output capacity, the thermal generation technology chosen, and other considerations, including any requirement to boost gas pressures, pumping equipment, etc. Certain technologies also require additional outdoor space for the storage of other equipment such as biomass fuel storage, heat rejection or storage units.

The location of the EC is a key factor in the viability of DHNs in Derbyshire and will require the following consideration in future:

- Detailed assessment of required EC capacity, footprint and utilities provision;
- Identification of access routes for plant installation;
- Detailed existing utilities infrastructure assessment

[23] CP1: Heat networks: Code of Practice for the UK; CIBSE; 2015

Gas Connections

It is proposed that the Energy Centre would be connected to the mains gas network, if necessary by providing an extension of the mains pipework to the EC.

Further investigation into connection with the local gas mains will be undertaken at a later design stage to identify the location, type (low pressure, medium pressure) and capacity of available gas mains in the vicinity of the potential energy centre locations.

Electricity Generation

In the case of any proposed co-generation schemes (e.g, implementation of gas CHP), utilising the electrical output is of a high priority. It is of particular importance to identify a robust solution in order to ensure the potential revenue that could result from electricity sales is maximised, while also ensuring the effective operation of the generating plant.

Options for the sale of generated electricity include providing private wire services to a large electricity consumer in the area; entering into a private power purchase agreement with a third party consumer, to take electricity via 'sleeving' of electrical output via the grid; and exporting directly to the grid.

Private Wire and Sleeving Arrangements

Private wire is considered the least technologically attractive solution, due to the dependence of electrical demand from the end customer, but is the most commercially attractive solution due to higher revenues associated with electricity sold privately (and which can therefore compete with retail prices for electricity). Should electrical demand at the end customer not be sufficient to absorb the electrical output from the Energy Centre, excess electricity will need to be exported to the grid, such that the co-generation plant continues to meet heat demands and operates in a 'thermally-led' mode.

The £/kWh price for electrical sales would need to be negotiated with the end customer, and would likely need to be offered at a discount (around 5-20%) to the retail price paid currently by the customer (often between £0.08-0.13/kWh, depending on the customer's scale of usage and tariff) in order to incentivise its use. Additionally, a long term contract (~15 years) will need to be drawn up between the generating entity and the end customer, in addition to an agreement regarding the quantity of electricity the customer would be required to purchase per year and the indexation mechanism to allow for price rises over time.

The best customers for the sale of private-wire electricity are those that have constant demands, such as industrial and commercial users.

A more technologically secure solution is to 'sleeve' electrical output to an end customer via connection to the grid. This solution protects against the possibility of low electrical demand from the end customer, since surplus electrical generation can be exported to the grid on the wholesale market. Any direct sales to an end customer would need to be agreed in the form of a power purchase agreement (similar to that agreed for the private wire option), which would commit the end customer to purchase a minimum quantity of electricity per year, and determine the price levels and indexation of price rise in the future. As for the private wire option, the sale price achievable benefits are competing with the retail price currently paid by the end customer. However, a discount to the retail price (similar to the 20% suggested above) would likely need to be offered in order to secure agreement.

Electricity Export

Alternatively, electrical sales can be made by exporting directly to the grid. This option does not require power purchase agreements to be in place with 3rd parties, and offers the greatest technical resilience and lowest risk option. However, a major drawback of this option is the low prices that can be achieved for electricity sales, since sales are made on the wholesale electricity market (typically ~£0.04-0.06/kWh at present rates).

If electricity export is required, then the network's capacity and associated required upgrades will need to be further investigated with UK Power Networks (UKPN) via a G59 application at a later design stage.

Other Considerations

In addition to the key considerations (plant size, use of electrical output, connection to gas mains) analysed above, there are other important considerations that will have to be taken into account when designing an Energy Centre. These are outlined below, as follows:

- **Air Quality** – The UK's air quality is strictly regulated and attention must be paid to emissions levels. Of relevance to Energy Centres, Selective Catalytic Reduction (SCR) systems can reduce NOx emissions from combustion plant by up to 95%. SCR units utilise urea as a catalyst to reduce the NOx gases back into their constituent elements, nitrogen and oxygen.
- **Flue Arrangements** - Exhaust gases from the combustion plant will need to be expelled to atmosphere. This is typically done through flue chimneys that are sufficiently high to disperse the exhaust. Typically this requires the flue to be at least higher than surrounding buildings.
- **Acoustics** - Acoustic protection (in the form of acoustic baffles and enclosures) might be necessary to reduce the external effects of noise resulting from plant operation.
- **Visual Impacts** - Visual impacts of the DH scheme will be limited to those relating to the Energy Centre, since the pipework will be located beneath roads and pathways, and connections to customer buildings would be located within customer building premises (and likely within their plantrooms). Additionally, it is recommended that the external design of the Energy Centre complements its surroundings and reduces potential negative visual impacts.

Appendix F Techno-economic Modelling Assumptions

F.1 Introduction

A full techno-economic model has been developed from first principles to allow for the comparison of the networks within Clay Cross, Matlock and Chesterfield. This section details the assumptions made during this assessment.

The purpose of the model is to give an indication of the financial viability of the project under the assumed capital and operational costs, and associated energy sales revenues. A number of sensitivity scenarios on key parameters have been investigated within the model to help understand the economic robustness of the projects and to identify risks to economic performance.

F.2 Scenarios and Timing

Each network has undergone modelling of potential scenarios, as given Table F-1. The model assumes that network operation will start in 2020. The installation of different aspects of the network will be phased over the course of a few years, as discussed in Section 7. Such an approach allows an initial network operation to be established, its operation and cash flow to be demonstrated, and to provide revenue streams to reduce financial risk. Additional heat generation plant will then be added later to meet demand.

Table F-1: Modelled network scenarios

Network	Clay Cross	Matlock	Chesterfield
Scenario 1	Bridge Street (North) and Harris Way	Oldfiled Ln and Bakewell Rd (North)	Hady Hill
Scenario 2	Bridge Street (North & South), Harris Way, Bridge Street (South) and Market St (West)	Oldfiled Ln and Bakewell Rd (North & South)	Hady Hill and Beetwell St
Scenario 3	Bridge Street (North & South), Harris Way, Bridge Street (South) and Market St (West & East)	Oldfiled Ln, Bakewell Rd (North & South) and Bank Rd (East)	Hady Hill, Beetwell St and Rose Hill
Scenario 4	Bridge Street (North & South), Harris Way, Bridge Street (South), Market St (West & East), Furnace Hill Road (East & West)	Oldfiled Ln, Bakewell Rd (North & South) and Bank Rd (East & West)	Hady Hill, Beetwell St, Rose Hill and Holywell St
Scenario 5	Bridge Street (North & South), Harris Way, Bridge Street (South), Market St (West & East), Furnace Hill Road (East & West) and Coney Green Rd	Oldfiled Ln, Bakewell Rd (North & South), Bank Rd (East & West) and Smedley Street	Hady Hill, Beetwell St, Rose Hill, Holywell St and Brimington Rd
Scenario 6	Bridge Street (North & South), Harris Way, Bridge Street (South), Market St (West & East), Furnace Hill Road (East & West) and Coney Green Rd and Brassington Lane	Oldfiled Ln, Bakewell Rd (North & South), Bank Rd (East & West), Smedley Street and Lime Tree Rd (East & West)	Hady Hill, Beetwell St, Rose Hill, Holywell St, Brimington Rd and Sheffield Way
Scenario 7	Bridge Street (North & South), Harris Way, Bridge Street (South), Market St (West & East), Furnace Hill Road (East & West) and Coney Green Rd, Brassington Lane and Wingerworth	Oldfiled Ln, Bakewell Rd (North & South), Bank Rd (East & West), Smedley Street, Lime Tree Rd (East & West), and Snitterton Rd	Hady Hill, Beetwell St, Rose Hill, Holywell St, Brimington Rd, Sheffield Way and Boythorpe Ave

F.3 CAPEX Assumptions

Values are derived from AECOM experience and suitable industry standards (such as SPONS), which have been back checked with contractors during the tender stages of other DH projects to ensure that values are up to date and accurate. In line with a RIBA Stage 2 design, costs are accurate to -15%/+30%.

The key assumptions made in the estimation of the capital costs (CAPEX) of each network option are given below. The model updates the CAPEX values to reflect the user-selected parameters, for example whether a given building is included in the calculations.

The breakdown of CAPEX assumptions for networks is provided in Table F-2. Certain items do not apply to all networks, for example items specific to CHP or heat recovery.

Table F-2: CAPEX metric assumptions (applied where relevant)

CAPEX item	Metric	Based on	Network relevance
Energy Centre:			
Energy Centre Construction (new)	£2,000/m^2	This value reflects an EC building with aesthetic/architectural finish.	All
Energy Centre external compound (new)	£500/m^2	This value reflects an external compound for housing the CHP engines	Chesterfield
Heat Generation Systems:			
Heat exchanger	£32/kW	EfW/heat recovery plant heat export capacity	Clay Cross/Matlock
Gas CHP engines	£950/kWe	CHP thermal output capacity	Chesterfield
Thermal storage systems	£1,000/m^3	Total volume of required thermal storage vessels	All
Boilers	£35/kW	Boiler thermal capacity	All
Ancillary equipment (incl. flues; ventilation; distribution pumps; energy centre electrical costs and pipework; water treatment; pressurisation and expansion; and BMS/Controls)	£205/kW	Boiler thermal capacity	All
Electrical Ancillaries:			
Sub-station including private HV transformers, HV switch room, LV switch gear, connection cost	£100,000	One off cost, subject to G59 application of local HV infrastructure upgrade requirements. Significant risk item – see Risk Register in Appendix A	Chesterfield
DNO connection to the Energy Centre	£100,000/ MVa	CHP electric output capacity	Chesterfield
Gas Systems:			
Gas Connection	£10/kW	Boiler and CHP thermal capacity	All
Extension of gas main	£120/m	Assumed trench length of 200m	All
External works:			

CAPEX item	Metric	Based on	Network relevance
New development connection costs	£3,000/ unit	Number of units each development is proposed to include	All
DH pipework	£1,200/m for hard dig £900/m for soft dig	Pipework length for each network option (average, to account for a mixture of hard dig and soft dig trenching)	All
Customer heat exchanger	£32/kW	Undiversified heat load	All
Private Wire	£450/m	Cost per meter	Chesterfield
Bridge crossing	£2,500/m	Cost per meter	All
Other Costs/Fees:			
Professional fees	2.5%	Of sub-total	All
Legal fees	5.0%	Of sub-total	All

A large element of network costs is associated with the distribution of heat. In particular, in scenarios which include large numbers of new residential developments, distribution costs are even higher. The business as usual case for new developments is to install a gas boiler in each dwelling. The district heating alternative being offered to new developments is to install heating pipework to serve homes and a heat interface unit (HIU) in each dwelling. Since this alternative solution is more expensive than the business as usual case (in terms of capex), the network operator will be required to pay for the up-front costs of heat distribution, as well as the operation of these aspects throughout the lifetime of the project. A certain amount of this cost can be recovered through connection charges.

F.4 Third party supplier costs

The Enthoven battery recycling facility is not currently configured to recover waste heat. As such a certain amount of plant upgrades and re-configuration of pipework will be necessary on site to enable the export of heat. Through correspondence with plant operators, the costs of these upgrades and alterations have been estimated at £650,000. It is proposed that the network operator bears the cost of these changes, in return for the purchasing of low cost and low carbon heat for resale.

Any third party costs for Clay Cross are assumed to be borne by Lark Energy, and have not been considered as part of this study. Lark Energy shall need to assess the revenue estimates for the sale of heat to ensure that configuring plant to allow for heat export is profitable within their acceptable timeframes. For the figures used in this study, see Appendix F: TEM assumptions.

F.5 Asset replacement cycles

The following assumptions have been made on the required replacement cycles of plant and equipment on the basis that a like-for-like replacement will be sought throughout the network lifespan. All other plant and equipment is assumed to last beyond the project lifetime. Plant replacement at the end of the lifespan is assumed to be accounted for an additional CAPEX cost items when required.

Table F-3: Asset replacement assumptions

Technology/asset	Replacement cycle	Replacement year	Source
EC boilers, incl. ancillary equipment	Every 25 years	2049 (install 2019)	CIBSE Guide M
Gas CHP	Every 70,000 hours operation	Approximately 11-12 years after initial installation	Manufacturers data
Heat exchangers	Every 25 years	2045 (install 2020)	CIBSE Guide M
Gas connection/Extension	Every 30 years	2049 (install 2019)	CIBSE Guide M

F.6 OPEX Assumptions

Fuel Costs

Retail Fuel Costs

Fuel unit prices for gas and electricity are based on energy price analysis published by the Department for Business, Energy & Industrial Strategy (BEIS). Domestic values are specific to regions; those published for the East Midlands have been used for the current study.

Year 1 prices are based on the average values over the last two years. The price of the fuel varies based on the quantity of heat and electricity purchased. The larger the quantity of fuel purchased, the lower the fuel price. This means that the network operator will be able to buy fuel at a lower cost than customers in the area are currently paying.

The price for gas and electricity used by the model is presented in the table below. Networks which consume more gas pay less per unit due to the lower tariffs associated with higher consumption.

Table F-4: Fuel price assumptions

Network	Gas Price (p/kWh)			Electricity Price (p/kWh)
	Network Operator	Current tariff paid by customers		Network Operator[24]
		Commercial[25]	Residential[26]	
Clay Cross	2.7	2.7	3.7	10.9
Matlock	2.4	2.7	3.7	10.9
Chesterfield	1.9	2.7	3.7	10.9

Please note that the prices above are fully delivered prices, including Climate Change Levy. However, they do not account for any uplift due to VAT.

Third party heat and electricity costs

It is assumed that the third party energy suppliers will charge for heat and electricity where appropriate. In Clay Cross it is assumed that the network operator is purchasing heat *and* electricity (via a private wire) from the EfW

[24] QEP 3.4.1 and 3.4.2 https://www.gov.uk/government/statistical-data-sets/gas-and-electricity-prices-in-the-non-domestic-sector
[25] QEP 3.4.1 and 3.4.2 https://www.gov.uk/government/statistical-data-sets/gas-and-electricity-prices-in-the-non-domestic-sector
[26] QEP 2.3.3 https://www.gov.uk/government/statistical-data-sets/annual-domestic-energy-price-statistics

operator. Electricity is assumed to be purchased at a discount rate of 20% against the BEIS published statistical retail electricity price (for Year 1). The Year 1 heat price was set in line with AECOM of other projects.

In Matlock and Clay Cross, the Year 1 heat price is set based on AECOM experience of similar projects. These costs need to be confirmed with the associated party. It is important to note that the cost of heat highly affects the network financial viability and thus changes to the values will have a significant impact on the feasibility of Clay Cross and Matlock networks (see risk item 80 in Appendix A).84

The heat price for heat recovered from Enthoven has been reduced as far as possible in an attempt to improve the financial viability of the network there, see Table F-5.

Table F-5: Third party energy prices

Network	Heat source	Heat Price, £/MWh	Electricity Price, £/MWh
Clay Cross	EfW	£20	£97
Matlock	Enthoven	£5	-

Future fuel price projections

Trend projections of future energy prices are taken from the BEIS Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal[27]. Year 1 costs are taken as described above, with future prices indexed to the trends provided. Heat purchased from third party suppliers is indexed to the future gas projection.

Within the Green Book tables, three bands of prices are given: High, Central and Low. For the purposes of the model, it is assumed that customers are currently paying the Central price for gas and electricity.

Figure F-1 shows the HM Treasury Green Book future fuel price projections, showing the Central scenario for electricity and gas. Whilst the trend of these projections have been used in the model, the projections made in the Green Book do not show any change to price beyond c. 2027, an unlikely scenario. This could pose a risk for the viability of the network and thus it has been registered as a risk item in Appendix A.

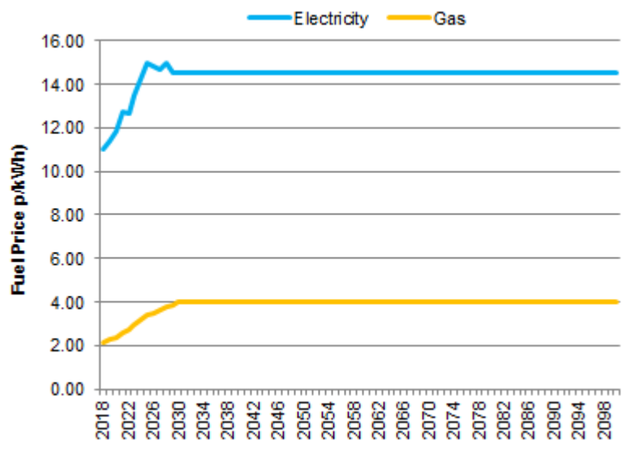


Figure F-1 HM Treasury Green Book future fuel price projections: central scenario

Maintenance Costs

Maintenance and staffing costs are assumed to be constant over the lifespan of the project. The figures given in Table F-6 are based on AECOM experience and recent quotes from contractors and developers.

Table F-6: OPEX assumptions

OPEX item	Metric	Based on	Network relevance
Maintenance:			
Energy Centre	2.5/m^2		All
Gas CHP	£0.010/kWh$_e$ p.a.	CHP electricity generation	Chesterfield
Energy centre boilers	£2.25/kW p.a.	Boiler thermal output capacity	All
Heat exchanger	£1.00/kW p.a.	Undiversified heat load	All
Pipework	1%	Pipework CAPEX	All
Private Cables	1%	CAPEX for Private Wire and DNO connection to the Energy Centre	All

F.7 Revenue

Revenue will come from a number of sources, including direct charges for heat and fixed charges for operation (comparable to standing charges on conventional utility services). For the Chesterfield network, revenue will also come from any electricity income (from CHP-generated electricity) which may be available through sales to the grid or directly to electricity consumers. Other one-off sources of revenue are also often charged, for example to help cover the cost of connecting individual customers to the network.

Counterfactual heat price

The counterfactual heat price is what customers on the heat network currently pay for heat, assuming heating is provided with a conventional gas boiler. This depends on whether they are residential or commercial customers, and is made up of the cost of their fuel consumption (i.e. the variable charges) and the cost of operating and maintaining their heating system (maintenance costs and standing charges). Heat tariffs for network customers are then based on the counterfactual costs, to ensure that customers will realise a saving by connecting to the network,

The counterfactual costs used in the modelling are shown in Table F-7. The adjusted non variable charges of the counterfactual heat price differ between areas because it is based on a building by building basis, assuming a fixed charge per unit for residential, and per kW for commercial. When this fixed charge is adjusted to a variable rate it is affected by how much heat each unit is consuming. Residential unit consumption values vary depending on the size and type of homes being proposed under each development.

[27] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Table F-7: Year 1 counterfactual heat price breakdown

		Clay Cross	Matlock	Chesterfield
Residential	Assumed replacement costs per unit	1,600	1,600	1,600
	Number of units	1,989	597	1,711
	Replacement cycle	20	20	20
	Annual standing charge per unit[28]	£85.45	£85.45	£85.45
	Annual maintenance[29] per unit	£192.00	£192.00	£192.00
	Adjusted non variable charges, p/kWh	**5.3**	**4.9**	**7.5**
	Gas price, p/kWh	3.7	3.7	3.7
	Boiler efficiency	86%	86%	86%
	Variable charges, p/kWh	**4.3**	**4.3**	**4.3**
	Total counterfactual cost, p/kWh	**9.6**	**9.1**	**11.8**
Commercial	Assumed replacement costs per kW	£350	£350	£350
	Replacement cycle, years	25	25	25
	Commercial maintenance costs, £/kW	£4.0	£4.0	£4.0
	Adjusted non variable charges, p/kWh	**1.0**	**0.7**	**0.8**
	Gas price	2.7	2.7	2.7
	Boiler efficiency	86%	86%	86%
	Variable charges per kWh	**3.2**	**3.2**	**3.2**
	Total counterfactual cost	**4.1**	**3.9**	**4.0**

One off charges

Connection Charge

A Connection Charge is a one off contribution towards the capital cost of initiating a customer's connection to the heat network. The connection charge could be designed to cover:

- The capital outlay required to contribute to the scheme
- An amount not more than the cost which would be incurred for connection to/installation of an alternative heat source
- An amount not more than the cost incurred of replacing existing plant for that building
- Planning Authority requirements

Derbyshire County Council may wish to consider if it has any funds available for injection into the scheme as a capital contribution or whether any of the potential customers to the schemes may be willing to pay a connection charge.

For the purposes of the model, connection charges have been assumed to be linked to the cost of replacing boiler plant in each building, less a user-specified discount rate. For commercial customers, the default values chosen for the results of the model are that plant is assumed to be replaced once over the 25 year lifespan of the network, and that the cost of this replacement is equal to £350/kW of the building's peak heating demand. A discount of 50% is then applied thereafter.

[28] Uswitch check of EDF standard variable

[29] British Gas Home Care: One boiler only with no excess

For developers of new residential housing, connection costs are assumed to be higher due to planning conditions to connect to the network that can be imposed by the council. Connection costs are based on a 10% discount on the counterfactual case of installing a boiler in each dwelling.

Heat Sale

Heat networks typically charge for heat via a Fixed Charge plus a Variable Charge (based on consumption), similar to most electricity or gas supply contracts. Some schemes charge using a Flat Charge, but this method of charging is no longer allowed under the Heat Network (Metering and Billing) Regulations 2014 unless it is not technically possible and economically justified to implement metering and charging based on actual consumption.

It has been assumed that heat demand does not fluctuate from year to year over the assessment period (except for the phased delivery of new buildings), i.e. no allowance is made for future developments, or redevelopment of existing buildings, beyond those captured by the energy mapping study herein.

Fixed/Standing Charge

Fixed charges are often set to cover the fixed costs or minimum running costs of the scheme. This gives comfort to the operator (and funder) of the financial viability of the scheme. A common complaint made by customers is that Fixed Charges are too high, and therefore a commercial decision should be taken as to whether the full extent of fixed costs should be included in the Fixed Charge. The higher the element of Fixed Charge relative to Variable Charge, the lower the risk to the operator, i.e. variability in income relative to demand.

Variable (unit) Charge

The variable charge is often set to cover the marginal costs of supplying heat to the customer, e.g. fuel costs and efficiency losses. It would also be expected that an element of profit would be included within the variable charge on a 'for-profit' project.

Modelled Charges

When setting heat charges, prices will need to be set low enough that they are competitive to attract customers to connect to the scheme (i.e. will need to be considered with respect to current heating costs). At the same time, prices will need to be set high enough such that a satisfactory return on investment is met.

The model uses the counterfactual heat price as calculated in Table F-7 to inform the revenues generated by the scheme. A user-specified discount is applied to the counterfactual price such that value can be offered to customers. Model users can alter the discount rates to explore the limitations of what can be charged to customers in order to offer them a saving whilst also delivering an attractively high IRR.

Electricity Revenue (Chesterfield only)

The proposed heat generation technology for Chesterfield is CHP. The electricity generated by the CHP can either be sold privately or exported to the grid.

Revenue generated through the sale of electricity via private wire or a sleeving arrangement is dependent on the agreement with the customer. The prices will usually be linked to the prevailing retail price, such that the customer benefits from a reduction in its energy bills over what they would pay otherwise. The default values for the purposes of the results given in this report are that electricity is sold privately at a discount rate of 10% against the BEIS published statistical retail electricity price. The remaining electricity is assumed to be exported to the grid at a discount rate of 50% against the BEIS published statistical retail electricity price (which in recent years has been representative of the wholesale price).

Although private wire electricity distribution demands certain up front capital expenditure, the revenues generated are much higher than exporting to the grid. As such, the ratio of electricity generated which is sold via a private wire or sleeving arrangement to that which is exported at whole sale rates affects the commercial viability of the network significantly. As such, this is highlighted as a key risk item that should be subject to further investigation in subsequent studies. Whilst it is preferable to sell all generated electricity privately, AECOM recognises that this may not be technically feasible. Instead, a conservative assumption is made, that electricity is sold privately only to the Chesterfield and North Derbyshire Royal Hospital, with the remainder exported.

F.8 Default Parameters

The default values defining revenue that were chosen for the modelling as described in this section are summarised below.

Table F-8: Default revenue parameters used within the model for analysis

Parameter	Value
First year of scheme operation	2020
CHP heat provision, % of total	At least 75%
Network distribution heat losses	15%
Electricity sold via private wire	Only to the Chesterfield and North Derbyshire Royal Hospital
Private wire electricity discount rate against retail price	10%
Exported electricity discount rate against retail price (i.e. wholesale)	50%
Connection charge discount against customer boiler replacement costs - commercial	50%
Connection charge discount against customer boiler replacement costs – residential new development	10%
Heat sale discount against counterfactual heat price	10%
Discount rate	3.5%

F.9 Carbon

Scheme carbon savings depend on the input fuel and the associated carbon factors of the fuel which is being offset by the heat generation technology. Emissions associated with the combustion of gas are assumed to be constant over the lifetime of the project, where the emission factor used is 0.184kgCO_2e/kWh, based on UK Government GHG Conversion Factors 2016[30]. In cases where grid electricity is displaced by CHP electricity, carbon factors are taken from the BEIS bespoke CHP emissions factors[31] spreadsheet for electricity exported and used on site (Figure F-2). This analysis accounts for the decarbonisation of the grid, where emissions are calculated based on the amount of electricity generated by the CHP that is used on site, as opposed to that which is exported. The model calculates the CO_2 emissions savings for each year of operation, based on the forecast carbon factors. Full project life savings will also be reported.

Gas CHP currently delivers carbon savings as the electricity produced is cleaner than that which is taken from the grid. However, as outlined by the DECC emission projections, the CO_2 emissions attributed to grid electricity are expected to fall. As a result, the carbon savings associated with the use of gas CHP schemes is expected to decrease over time.

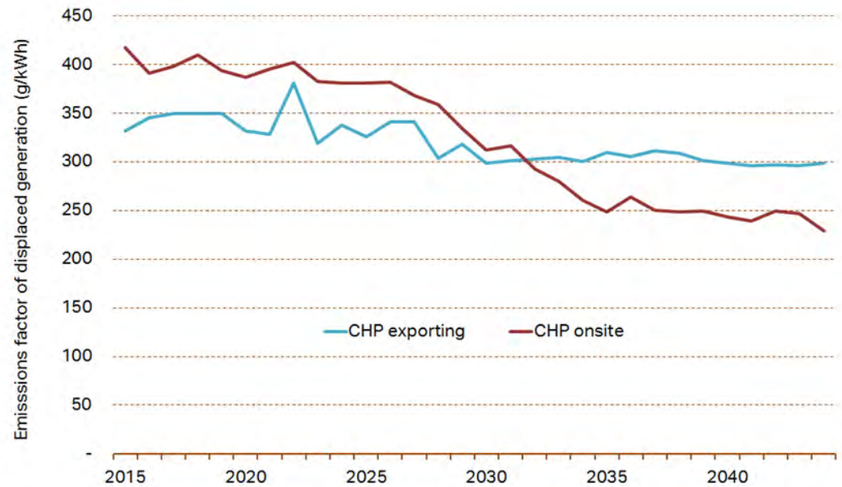


Figure F-2 Bespoke emission factors for electricity displaced by gas CHP (gCO2/kWh) (BEIS, 2014)

In cases, when heat and electricity is imported from the EfW facility, the model assumes that the energy provided has a carbon value of 0.047kgCO_2e/kWhth. This figure is taken from Table 12 of SAP 2012: The Government's Standard Assessment Procedure for Energy Rating of Dwellings. Note that the unadopted Draft SAP 2016 Consultation is proposing to increase this figure to 0.074kgCO_2e/kWhth.

F.10 Tax

We have not modelled VAT in the model as it only has a small impact on the cashflow due to the short construction period. Since this overlaps with operation it is therefore not be expected to impact the feasibility of the project.

F.11 Scheme Ownership

The model assumes the network is operated by a separate entity, referred to as the 'ESCo', or Energy Supply Company. Costs are borne by the new company, and if the network includes DCC buildings, then they are treated as any other customer on the network, experiencing the same costs and savings as the other customers.

F.12 Discount Rates

Discount rates are used to represent the future value of money spent now. In the UK, the government makes decisions based on 'discounted Net Present Value (NPV)', which is a calculation that helps inform whether a capital outlay made today will be worthwhile in the future. The model assumes a constant discount rate over the life of the network of 3.5%[32].

F.13 Financing Options

The model does not consider at this stage the impact of financing (e.g. the cost of raising finance, servicing debt, debt limits, types of credit etc.). The next stage of this study will advance the modelling of a chosen network option, accounting for these elements.

[30] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/526958/ghg-conversion-factors-2016update_MASTER__links_removed__v2.xls accessed 20th July 2016

[31] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/446512/Emissions_Factors_for_Electricity_Displaced_by_Gas_CHP.xlsx accessed 20th July 2016

[32] Based on values taken from https://data.gov.uk/sib_knowledge_box/discount-rates-and-net-present-value, accessed 1st August 2016

Appendix G Load Demand Profiles

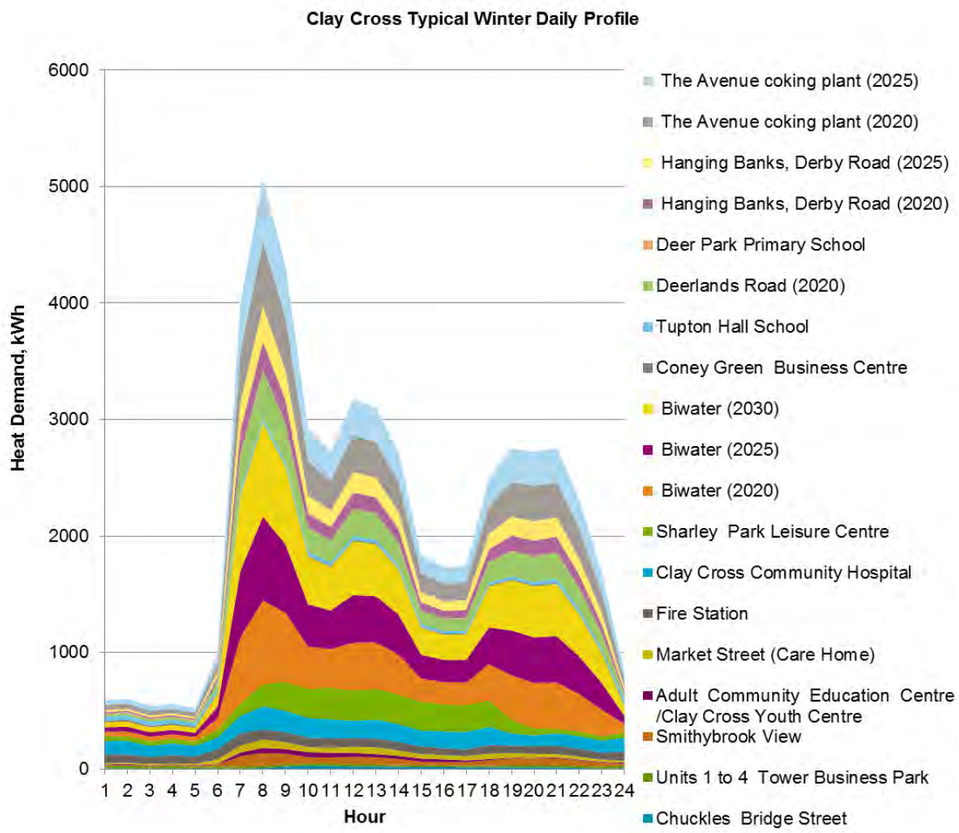


Figure G-1 Typical winter daily heat demand – Clay Cross buildings

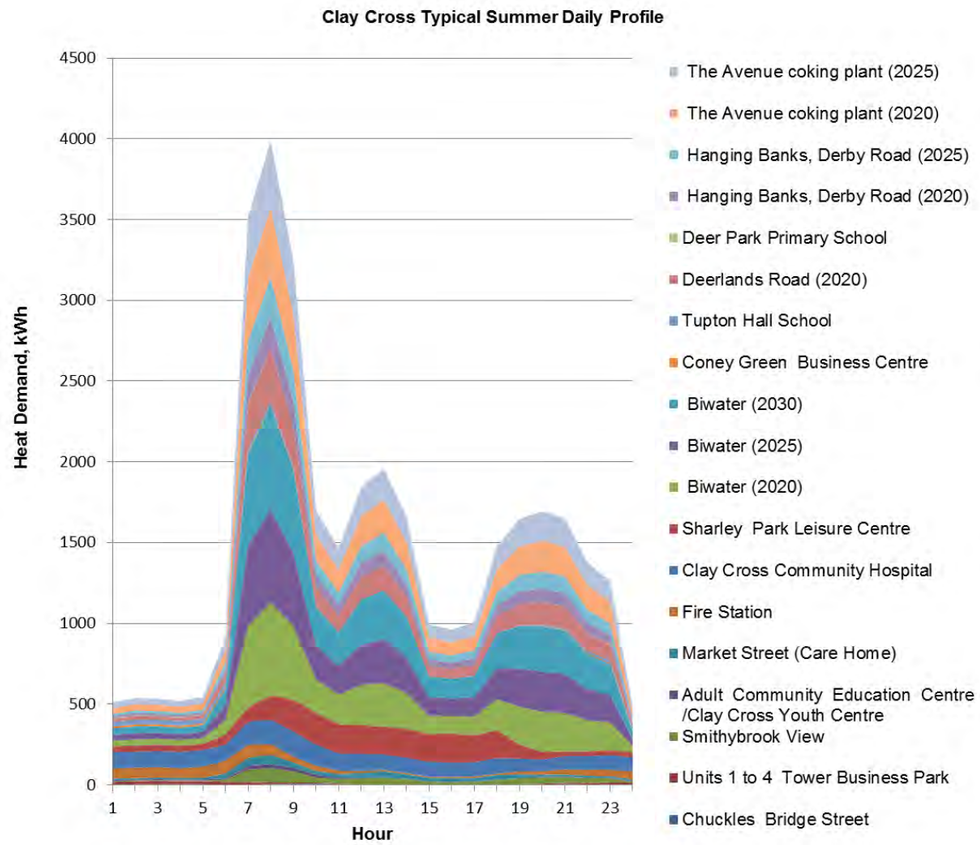


Figure G-1 Typical summer daily heat demand – Clay Cross buildings

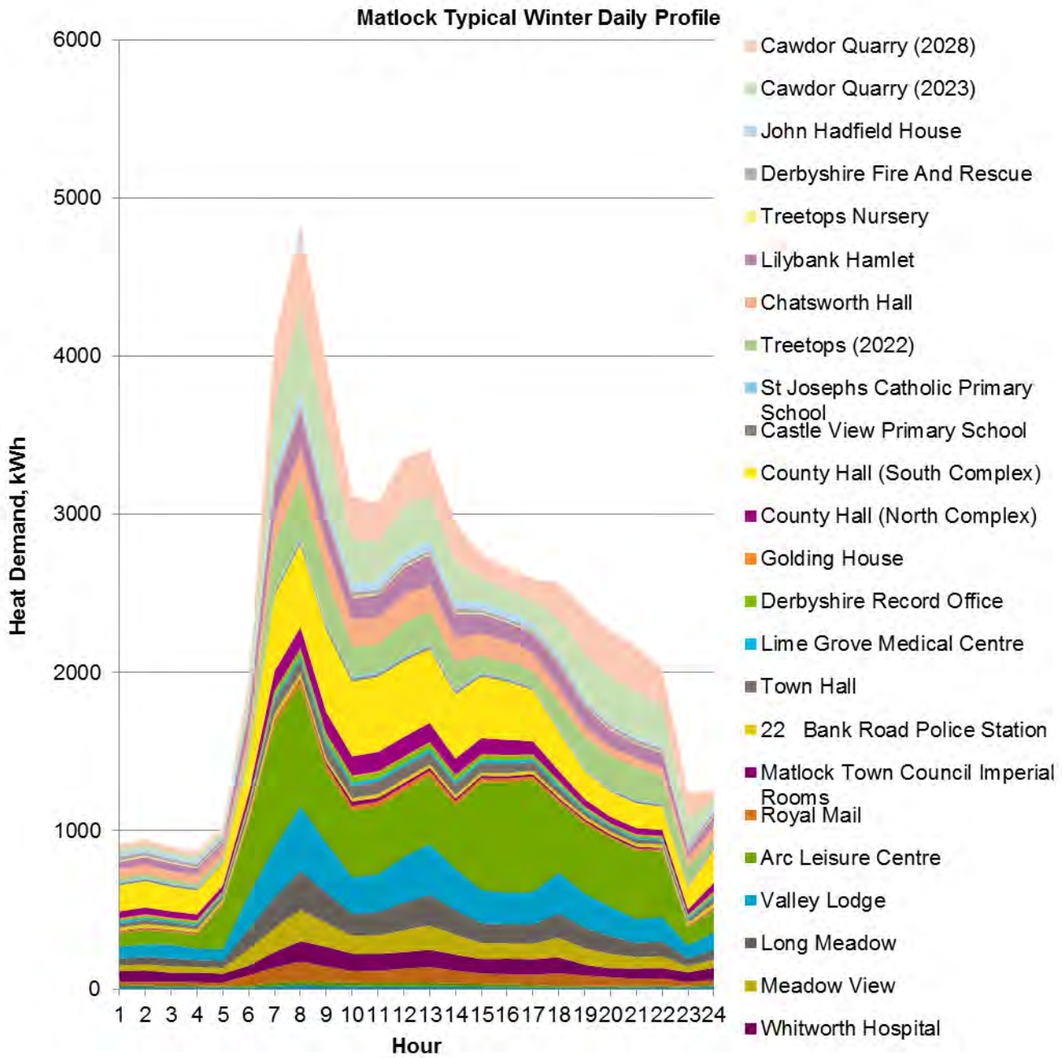


Figure G-3 Typical winter daily heat demand – Matlock buildings

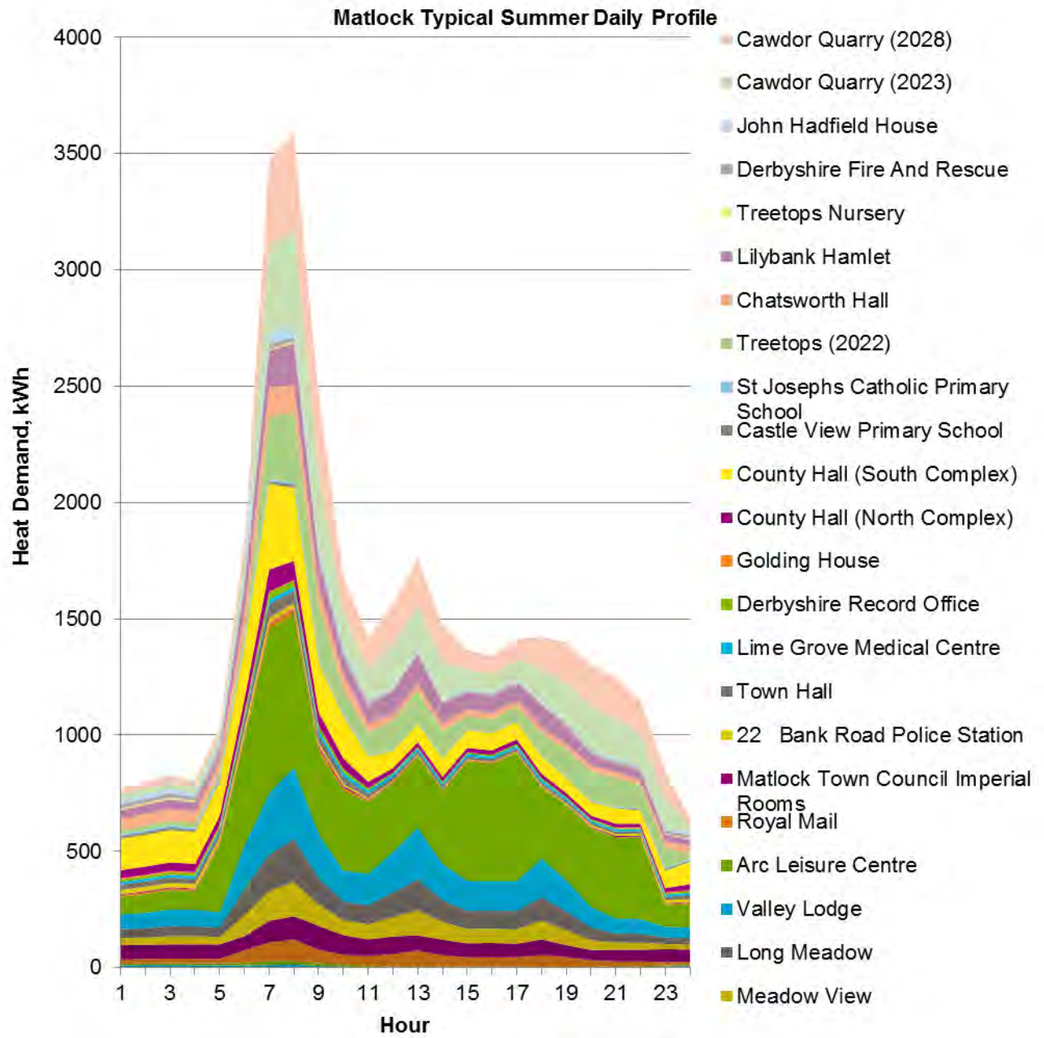


Figure G-4 Typical summer daily heat demand – Matlock buildings

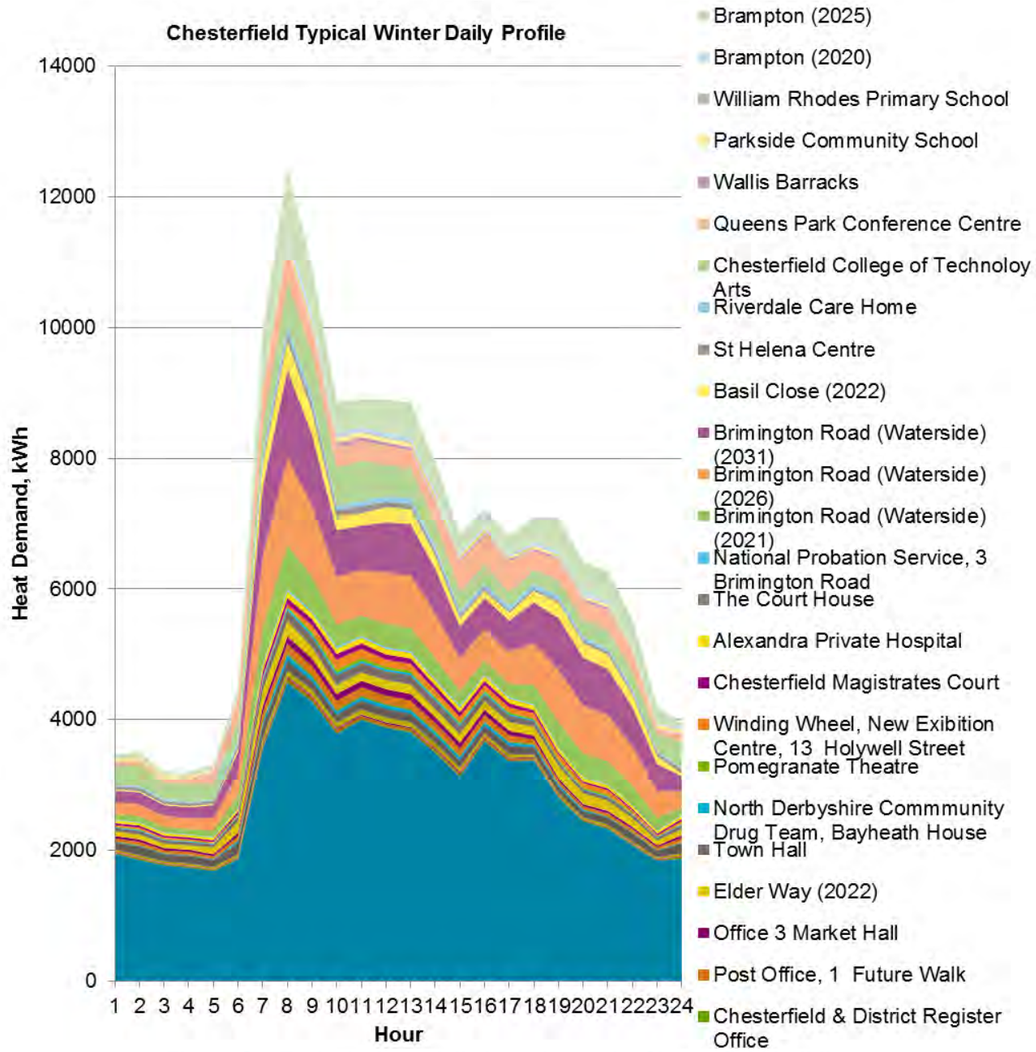


Figure G-5 Typical winter daily heat demand – Chesterfield buildings

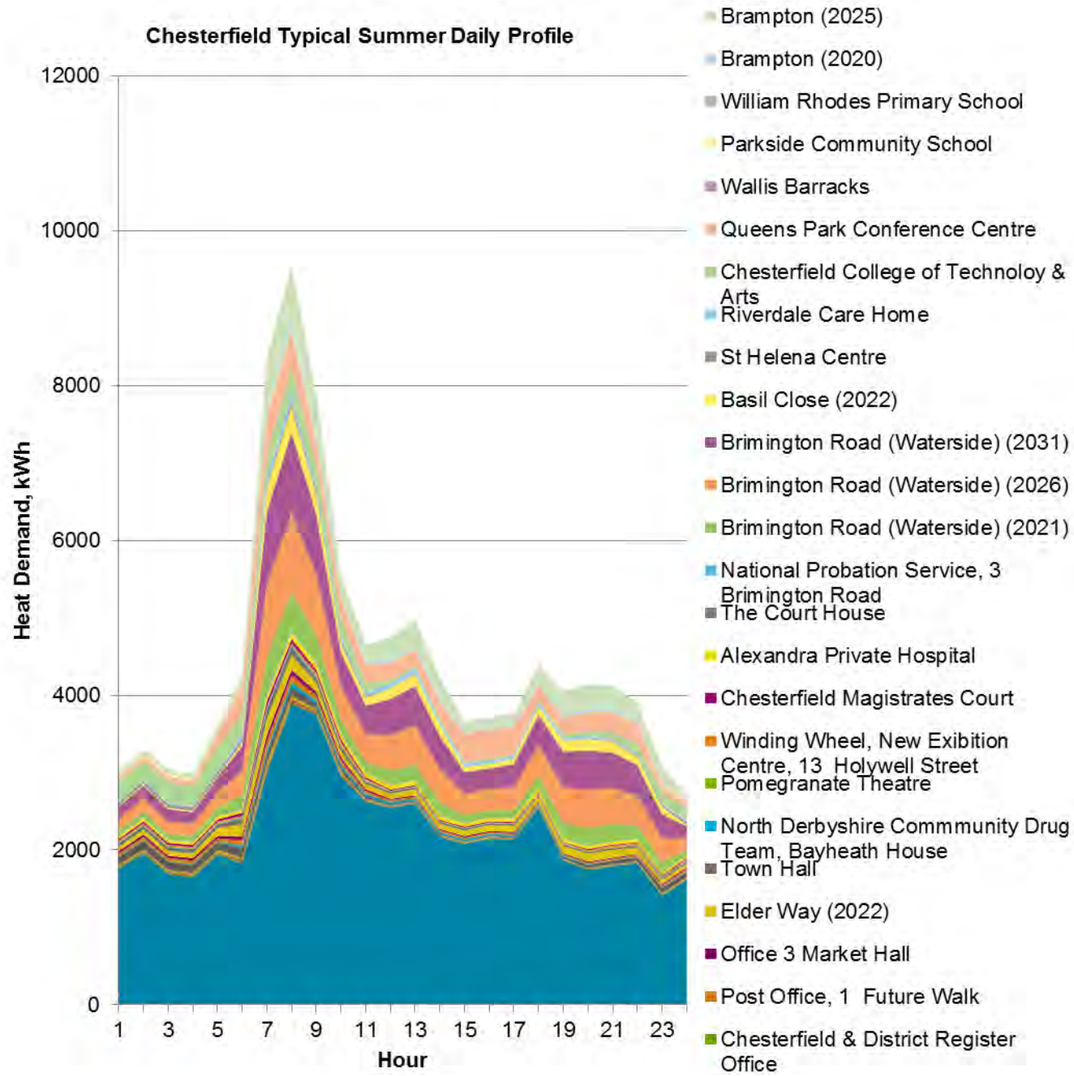


Figure G-6 Typical summer daily heat demand – Chesterfield buildings

Appendix H Pipework Sizing Tables

Table H-1 Breakdown of pipe sizes and flow rates – Clay Cross network

Pipe	Load number	Next branch no.1	Next branch no.2	Next branch no.3	Directly connected load	Undiv total load in pipe	Div load	Mass flow	Mass flow	Flow rate	Pipe diameter	Trench length
					MW	MW	kW	kg/s	kg/hr	m3/hr	mm	m
1		2	17		0.00	17.65	17,650	140.75	506,687	506.69	400	0.00
2		3	6		0.00	1.81	1,808	14.42	51,904	51.90	125	512.00
3		4	5		0.00	0.29	291	2.32	8,354	8.35	65	68.00
4	Chuckles Bridge Street				0.03	0.03	29	0.23	833	0.83	25	19.00
5	Units 1 to 4 Tower Business Park				0.26	0.26	262	2.09	7,522	7.52	50	297.00
6		7	12		0.00	1.52	1,517	12.10	43,550	43.55	100	218.00
7		8	9		0.00	0.91	908	7.24	26,067	26.07	100	26.00
8	Smithybrook View				0.41	0.41	408	3.25	11,713	11.71	65	110.00
9		10	11		0.00	0.50	500	3.99	14,354	14.35	65	47.00
10	Adult Community Education Centre /Clay Cross Youth Centre				0.12	0.12	116	0.93	3,330	3.33	40	25.00
11	Market Street (Care Home)				0.38	0.38	384	3.06	11,024	11.02	65	70.00
12		13	14		0.00	0.61	609	4.86	17,483	17.48	80	205.00
13	Fire Station				0.03	0.03	27	0.22	775	0.78	25	17.00
14		15	16		0.00	0.58	582	4.64	16,708	16.71	80	319.00
15	Clay Cross Community Hospital				0.27	0.27	269	2.15	7,722	7.72	50	23.00
16	Sharley Park Leisure Centre				0.31	0.31	313	2.50	8,986	8.99	65	172.00
17		18	21		0.00	15.84	15,842	126.33	454,782	454.78	400	149.00
18		19	20		0.00	6.90	6,900	55.03	198,093	198.09	250	271.00
19	Biwater				6.55	6.55	6,552	52.25	188,103	188.10	250	44.00
20	Coney Green Business Centre				0.35	0.35	348	2.78	9,990	9.99	65	518.00
21		22	23		0.00	8.94	8,941	71.30	256,689	256.69	250	1,609.00
22	Tupton Hall School				1.22	1.22	1,218	9.71	34,967	34.97	100	829.00
23		24	27		0.00	7.72	7,723	61.59	221,723	221.72	250	895.00
24		25	26		0.00	1.37	1,374	10.96	39,445	39.44	100	1,127.00
25	Deerlands Road				1.28	1.28	1,279	10.20	36,718	36.72	100	439.00
26	Deer Park Primary School				0.10	0.10	95	0.76	2,727	2.73	32	880.00
27		28	29		0.00	6.35	6,349	50.63	182,278	182.28	250	1,420.00
28	Hanging Banks, Derby Road				1.85	1.85	1,845	14.71	52,967	52.97	125	92.00
29	The Avenue Coking Plant				4.50	4.50	4,504	35.92	129,311	129.31	200	742.00

Table H-2 Breakdown of pipe sizes and flow rates – Matlock Network

Pipe	Load number	Total upstream assets	Next branch no.1	Next branch no.2	Next branch no.3	Directly connected load	Undiv total load in pipe	Div load	Mass flow	Mass flow	Flow rate	Pipe diameter	Trench length
						MW	MW	kW	kg/s	kg/hr	m3/hr	mm	m
1		0	2	3		0.00	9.94	9,941	79.27	285,388	285.39	300	2,413.00
2	Darley Dale Primary School	0				0.08	0.08	80	0.64	2,297	2.30	32	391.77
3		0	4	5		0.00	9.86	9,861	78.64	283,091	283.09	300	312.00
4	Shand House	0				0.13	0.13	132	1.05	3,789	3.79	40	73.87
5		0	6	7		0.00	9.73	9,729	77.58	279,301	279.30	300	165.60
6	St Elphins Extra Care Facility	0				0.56	0.56	556	4.43	15,962	15.96	80	102.38
7		0	8	9		0.00	9.17	9,173	73.15	263,340	263.34	250	541.26
8	Whitworth Hospital	0				0.24	0.24	241	1.92	6,919	6.92	50	22.00
9		0	10	11		0.00	8.93	8,932	71.23	256,421	256.42	250	110.00
10	Meadow View	0				0.18	0.18	181	1.44	5,196	5.20	50	49.80
11		0	12	13		0.00	8.75	8,751	69.78	251,225	251.22	250	82.00
12	Long Meadow	0				0.51	0.51	509	4.06	14,612	14.61	65	28.00
13		0	14	15		0.00	8.24	8,242	65.73	236,612	236.61	250	234.00
14	Valley Lodge	0				0.75	0.75	749	5.97	21,502	21.50	80	37.00
15		0	16	17		0.00	7.49	7,493	59.75	215,110	215.11	250	302.00
16	Arc Leisure Centre	0				0.37	0.37	365	2.91	10,478	10.48	65	162.70
17		0	18	21		0.00	7.13	7,128	56.84	204,632	204.63	250	229.95
18		0	19	20		0.00	3.56	3,561	28.40	102,230	102.23	200	268.50
19	Cawdor Quarry	0				3.40	3.40	3,397	27.09	97,522	97.52	150	0.00
20	John Hadfield House	0				0.16	0.16	164	1.31	4,708	4.71	50	1,879.00
21		0	22	23		0.00	3.57	3,567	28.44	102,402	102.40	200	1,122.00
22	Royal Mail	0				0.08	0.08	75	0.60	2,153	2.15	32	26.45
23		0	24	25	28	0.00	3.49	3,492	27.85	100,249	100.25	200	9.57
24	Matlock Town Council Imperial Rooms	0				0.03	0.03	32	0.26	919	0.92	25	92.78
25		0	26	27		0.00	0.36	356	2.84	10,220	10.22	65	49.80
26	Town Hall	0				0.29	0.29	292	2.33	8,383	8.38	65	20.39
27	22 Bank Road Police Station	0				0.06	0.06	64	0.51	1,837	1.84	32	15.14
28		0	29	30		0.00	3.10	3,104	24.75	89,110	89.11	150	158.00
29	Lime Grove Medical Centre	0				0.06	0.06	61	0.49	1,751	1.75	32	18.70
30		0	31	32		0.00	3.04	3,043	24.27	87,359	87.36	150	119.00
31	Derbyshire Record Office	0				0.18	0.18	184	1.47	5,282	5.28	50	68.00
32		0	33	34		0.00	2.86	2,859	22.80	82,077	82.08	150	128.00
33	Golding House	0				0.05	0.05	53	0.42	1,522	1.52	32	56.07
34		0	35	38		0.00	2.81	2,806	22.38	80,555	80.56	150	126.00
35		0	36	37		0.00	1.66	1,663	13.26	47,742	47.74	100	48.60
36	County Hall (South Complex)	0				1.30	1.30	1,297	10.34	37,234	37.23	100	51.00
37	County Hall (North Complex)	0				0.37	0.37	366	2.92	10,507	10.51	65	25.00
38		0	39	40	45	0.00	1.14	1,143	9.11	32,813	32.81	100	347.58
39	Castle View Primary School	0				0.13	0.13	128	1.02	3,675	3.67	40	135.00
40		0	41	42		0.00	0.60	598	4.77	17,167	17.17	80	89.00
41	Lilybank Hamlet	0				0.50	0.50	504	4.02	14,469	14.47	65	13.00
42		0	43	44		0.00	0.09	94	0.75	2,699	2.70	32	37.00
43	Treetops Nursery	0				0.04	0.04	38	0.30	1,091	1.09	32	55.46
44	Derbyshire Fire And Rescue	0				0.06	0.06	56	0.45	1,608	1.61	32	68.33
45		0	46	47		0.00	0.42	417	3.33	11,971	11.97	65	259.38
46	St Josephs Catholic Primary School	0				0.29	0.29	292	2.33	8,383	8.38	65	97.00
47		0	48	49		0.00	0.13	125	1.00	3,589	3.59	40	99.60
48	Treetops (2022)	0				0.06	0.06	64	0.51	1,837	1.84	32	35.00
49	Chatsworth Hall	0				0.06	0.06	61	0.49	1,751	1.75	32	124.10

Table H-3 Breakdown of pipe sizes and flow rates – Chesterfield Network

Pipe	Load number	Next branch no.1	Next branch no.2	Next branch no.3	Directly connected load	Undiv total load in pipe	Div load	Mass flow	Mass flow	Flow rate	Pipe diameter	Trench length
					MW	MW	kW	kg/s	kg/hr	m3/hr	mm	m
1		2	3		0.00	13.48	13,479.00	107.49	386,956.94	386.96	300	100
2	Chesterfield and North Derbyshire Royal Hospital				7.67	7.67	7,666.00	61.13	220,076.56	220.08	250	100.00
3		4	5		0.00	5.81	5,813.00	46.36	166,880.38	166.88	200	658.00
4	St Peter & St Paul School Trust				0.18	0.18	183.00	1.46	5,253.59	5.25	50	135.00
5		6	7	8	0.00	5.63	5,630	44.90	161,627	161.63	200	1,296.00
6	Jobcentre Plus, Markham House				0.16	0.16	160	1.28	4,593	4.59	50	44.00
7	H M Revenue & Costums, Markham House				0.11	0.11	105	0.84	3,014	3.01	40	0.00
8		9	10		0.00	5.37	5,365	42.78	154,019	154.02	200	90.00
9	DWP, Beetwell House				0.23	0.23	234	1.87	6,718	6.72	50	22.00
10		11	26		0.00	5.13	5,131	40.92	147,301	147.30	200	14.00
11		12	13		0.00	3.90	3,901	31.11	111,990	111.99	200	126.00
12	Derbyshire Constabulary				0.48	0.48	478	3.81	13,722	13.72	65	36.00
13		14	15		0.00	3.42	3,423	27.30	98,268	98.27	150	118.00
14	Chesterfield Central Library				0.37	0.37	366	2.92	10,507	10.51	65	26.00
15		16	17		0.00	3.06	3,057	24.38	87,761	87.76	150	133.00
16	Chesterfield & District Register Office				0.04	0.04	42	0.33	1,206	1.21	32	22.00
17		18	19	20	0.00	3.02	3,015	24.04	86,555	86.56	150	162.00
18	Post Office, 1 Future Walk				0.70	0.70	698	5.57	20,038	20.04	80	26.00
19	Office 3 Market Hall				0.28	0.28	281	2.24	8,067	8.07	65	208.00
20		21	22		0.00	2.04	2,036	16.24	58,450	58.45	125	127.00
21	Elder Way (2022)				0.63	0.63	626	4.99	17,971	17.97	80	27.00
22		23	47		0.00	1.41	1,410	11.24	40,478	40.48	100	31.00
23		24	25		0.00	0.69	687	5.48	19,722	19.72	80	249.00
24	Town Hall				0.62	0.62	617	4.92	17,713	17.71	80	53.00
25	North Derbyshire Commmunity Drug Team, Bayheath House				0.07	0.07	70	0.56	2,010	2.01	32	63.00
26		27	28		0.00	1.23	1,230	9.81	35,311	35.31	100	266.00
27	Pomegranate Theatre				0.09	0.09	94	0.75	2,699	2.70	32	33.00
28		29	30		0.00	1.14	1,136	9.06	32,612	32.61	100	66.00
29	Winding Wheel, New Exibition Centre, 13 Holywell Street				0.22	0.22	224	1.79	6,431	6.43	50	14.00
30		31	40		0.00	0.91	912	7.27	26,182	26.18	100	151.00
31		32	33		0.00	0.49	489	3.90	14,038	14.04	65	72.00
32	Chesterfield Magistrates Court				0.26	0.26	261	2.08	7,493	7.49	50	171.00
33		34	35		0.00	0.23	228	1.82	6,545	6.55	50	42.00
34	Alexandra Private Hospital				0.14	0.14	144	1.15	4,134	4.13	50	79.00
35		36	37		0.00	0.08	84	0.67	2,411	2.41	32	194.00
36	The Court House				0.03	0.03	33	0.26	947	0.95	25	19.00
37		38	39		0.00	0.05	51	0.41	1,464	1.46	32	26.00
38	National Probation Service, 3 Brimington Road				0.05	0.05	51	0.41	1,464	1.46	32	23.00
39	Brimington Road (Waterside)				0.00	0.00	0	0.00	0	0.00	25	287.00
40		41	44		0.00	0.42	423	3.37	12,144	12.14	65	180.00
41		42	43		0.00	0.27	270	2.15	7,751	7.75	50	54.00
42	Basil Close (2022)				0.00	0.00	0	0.00	0	0.00	25	33.00
43	St Helena Centre				0.27	0.27	270	2.15	7,751	7.75	50	25.00
44		45	46		0.00	0.15	153	1.22	4,392	4.39	50	75.00
45	Riverdale Care Home				0.08	0.08	83	0.66	2,383	2.38	32	41.00
46	Chesterfield College of Technoloy & Arts				0.07	0.07	70	0.56	2,010	2.01	32	275.00
47		48	49		0.00	0.72	723	5.77	20,756	20.76	80	379.00
48	Queens Park Conference Centre				0.09	0.09	94	0.75	2,699	2.70	32	28.00
49		50	51		0.00	0.63	629	5.02	18,057	18.06	80	282.00
50	Wallis Barracks				0.22	0.22	224	1.79	6,431	6.43	50	111.00
51		52	53		0.00	0.41	405	3.23	11,627	11.63	65	58.00
52	Parkside Community School				0.26	0.26	261	2.08	7,493	7.49	50	186.00
53		54	55		0.00	0.14	144	1.15	4,134	4.13	50	167.00
54	William Rhodes Primary School				0.14	0.14	144	1.15	4,134	4.13	50	306.00
55	Brampton				0.00	0.00	0	0.00	0	0.00	25	624.00

Appendix I Detailed results tables

I.1 Clay Cross

Technical Evaluation

Table I-1: Clay Cross plant technical parameters

Plant Technical Details	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Boiler plant							
Phase 1 capacity (MW_{th})	2.0	2.0	3.0	4.0	4.0	5.0	8.0
Phase 2 capacity (MW_{th})	0	0	0	4.0	4.0	4.0	6.0
Total capacity (MW_{th})	2.0	2.0	3.0	8.0	8.0	9.0	14.0
Heat recovery plant							
Heat recovery capacity (MW_{th})	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Electric capacity (MW_e)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Availability	90%	90%	90%	90%	90%	90%	90%
Energy Centre							
Footprint (m^2)	50	50	75	200	200	225	350
Thermal storage (m3)	60	60	90	240	240	270	420
Delta T	30	30	30	30	30	30	30
Distribution							
Pipework length, (m)	384	1,102	1,616	1,660	3,110	5,548	11,143
No. of new residential connections	0	90	90	1,090	1,090	1,090	1,989

Table I-2: Clay Cross energy balance

Energy Balance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Network Thermal Energy Balance:							
Total thermal consumption (MWh_{th} p.a.)	877	2,351	5,406	12,318	12,879	13,971	21,323
Thermal consumption incl losses (MWh_{th} p.a.)	1,009	2,704	6,217	14,166	14,811	16,067	24,521
EfW heat import (MWh_{th} p.a.)	937	2,463	5,641	12,831	13,413	14,522	21,598
As % of total	93%	91%	91%	91%	91%	90%	88%
Heat network top up boiler heat generation (MWh_{th} p.a.)	72	242	578	1,339	1,402	1,549	2,931
Total gas demand (MWh/year)	84	281	672	1,557	1,630	1,802	3,408
Heat recovery facility:							
Total Heat Generation (MWh_{th} p.a.)	31,536	31,536	31,536	31,536	31,536	31,536	31,536
Heat export to network (MWh_{th} p.a.)	937	2,463	5,641	12,831	13,413	14,522	21,598
Heat rejected (MWh_{th} p.a.)	30,599	29,073	25,895	18,705	18,123	17,014	9,938
Electricity export to network (MWh_e p.a.)	46	122	281	638	667	725	1,105

Economic Evaluation

Table I-3: Clay Cross CAPEX breakdown

CAPEX breakdown, £'000s	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
EC Construction	100	100	150	400	400	450	700
Heat Generation Systems:							
Heat exchanger	280	280	280	280	280	280	280
Thermal storage	60	60	90	240	240	270	420
Boilers Phase 1*	520	520	780	1,040	1,040	1,300	2,080
Boilers Phase 2 *	0	0	0	600	600	600	900
* incl. flues; ventilation; distribution pumps; energy centre electrical costs and pipework; water treatment; pressurisation and expansion; and BMS/Controls							
Gas Systems:							
Gas Connection	20	20	30	80	80	90	140
Extension of gas main	24	24	24	24	24	24	24
External works:							
New development connection costs	0	270	270	3,270	3,270	3,270	5,967
DH pipework	460	1,322	1,939	1,992	3,732	6,657	13,371
Customer heat exchanger	10	43	63	293	305	347	618
Bridge crossing	0	0	0	0	0	0	0
Other Costs/Fees:							
Professional fees	75	133	182	272	360	526	1,010
Legal fees	37	66	91	136	180	263	505
Total	**1,587**	**2,839**	**3,900**	**8,627**	**10,510**	**14,078**	**26,016**

Table I-4: Clay Cross OPEX breakdown

OPEX breakdown, £'000s p.a	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7

EC Construction	0.1	0.1	0.2	0.5	0.5	0.6	0.9
Heat Generation Systems:							
Heat exchanger	8	8	8	8	8	8	8
Boilers Phase 1*	4.5	4.5	6.8	9	9	11.2	18
Boilers Phase 2*	0	0	0	9	9	9	13.5
* incl. flues; ventilation; distribution pumps; energy centre electrical costs and pipework; water treatment; pressurisation and expansion; and BMS/Controls							
External works:							
New development connection costs	0	5.4	5.4	65.4	65.4	65.4	119.3
DH pipework	9.2	26.4	38.8	39.8	74.6	133.2	267.4
Customer heat exchanger	0.3	1.3	1.8	8.4	8.7	9.9	17.7
Total OPEX p.a.	**22.1**	**45.7**	**60.9**	**140.1**	**175.2**	**237.3**	**444.8**

Table I-5: Clay Cross economic evaluation results summary

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

I.2 Matlock

Technical Evaluation

Table I-6: Matlock plant technical parameters

Plant Technical Details	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Boiler plant							
Phase 1 capacity (MW_{th})	2.0	3.0	4.0	4.0	5.0	6.0	6.0
Phase 2 capacity (MW_{th})	0.0	3.0	3.0	3.0	3.0	4.0	4.0
Total capacity (MW_{th})	2.0	6.0	7.0	7.0	8.0	10.0	10.0
Heat recovery plant							
Heat recovery capacity (MW_{th})	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Availability	90%	90%	90%	90%	90%	90%	90%
Energy Centre							
Footprint (m^2)	50	150	175	175	200	250	250
Thermal storage (m3)	60	180	210	210	240	300	300
Delta T, K	30	30	30	30	30	30	30
Distribution							
Pipework length, (m)	4,182	5,296	7,039	7,410	8,143	9,021	10,900
No. of new residential connections	0	507	507	507	507	597	597

Table I-7: Matlock energy balance

Energy Balance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Thermal Energy Balance:							
Total thermal consumption (MWh_{th} p.a.)	2,335	11,748	12,828	13,272	17,061	20,657	21,019
Total network thermal load, incl losses (MWh_{th} p.a.)	2,685	13,510	14,752	15,263	19,620	23,756	24,172
Enthoven heat Import (MWh_{th} p.a.)	2,436	12,211	13,339	13,800	17,633	21,032	21,332
As % of total	91%	90%	90%	90%	90%	89%	88%
Heat network top up boiler heat generation (MWh_{th} p.a.)	250	1,302	1,417	1,467	1,992	2,729	2,844
Total gas demand (MWh/year)	291	1,514	1,647	1,705	2,316	3,173	3,308
Enthoven heat recovery facility:							
Heat Generation (MWh_{th} p.a.)	31,536	31,536	31,536	31,536	31,536	31,536	31,536
Heat export to Matlock network (MWh_{th} p.a.)	2,436	12,211	13,339	13,800	17,633	21,032	21,332
Heat rejected (MWh_{th} p.a.)	29,100	19,325	18,197	17,736	13,903	10,504	10,204

Economic Evaluation

Table I-8: Matlock CAPEX breakdown

CAPEX breakdown, £'000s	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
EC Construction	100	300	350	350	400	500	500
Heat Generation Systems:							
Upgrades necessary to Enthoven plant	280	280	280	280	280	280	280
Heat exchanger	60	180	210	210	240	300	300
Thermal storage systems	520	780	1,040	1,040	1,300	1,560	1,560
Boilers Phase 1 *	0	450	450	450	450	600	600
Boilers Phase 2 *	280	280	280	280	280	280	280
*(incl. flues; ventilation; distribution pumps; energy centre electrical costs and pipework; water treatment; pressurisation and expansion; and BMS/Controls)							
Gas Systems:							
Gas Connection	20	60	70	70	80	100	100
Extension of gas main	0	0	0	0	0	0	0
External works:							
New development connection costs	0	1,521	1,521	1,521	1,521	1,791	1,791
DH pipework	5,018	6,355	8,446	8,892	9,771	10,825	13,080
Customer heat exchanger	42	217	236	244	307	387	393
Bridge crossing	228	228	228	228	228	228	265
Other Costs/Fees:							
Professional fees	347	586	709	732	796	896	1,011
Legal fees	173	293	354	366	398	448	505
Total	**6,787**	**11,250**	**13,894**	**14,382**	**15,771**	**17,915**	**20,385**

Table I-9: Matlock OPEX breakdown

OPEX breakdown, £'000s p.a	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7

EC Construction	0.1	0.4	0.4	0.4	0.5	0.6	0.6
Heat Generation Systems:							
Heat exchanger	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Boilers Phase 1 *	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boilers Phase 2 *	4.5	6.8	9.0	9.0	11.3	13.5	13.5
*(incl. flues; ventilation; distribution pumps; energy centre electrical costs and pipework; water treatment; pressurisation and expansion; and BMS/Controls)							
External works:							
New development connection costs	0.0	30.4	30.4	30.4	30.4	35.8	35.8
DH pipework	100.4	127.1	168.9	177.8	195.4	216.5	261.6
Customer heat exchanger	1.2	6.2	6.7	7.0	8.8	11.1	11.2
Total OPEX p.a., £'000s	**114.2**	**178.9**	**223.5**	**232.7**	**254.4**	**285.5**	**330.8**

Table I-10: Matlock economic evaluation results summary

Financial assessment	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
25 Year Assessment:							
IRR (%)	-12.93%	0.89%	-0.30%	-0.34%	0.73%	1.66%	0.56%
NPV (£'000s)	-£6,452	-£3,048	-£5,153	-£5,356	-£4,273	-£3,230	-£5,470
30 Year Assessment:							
IRR (%)	-	1.73%	0.54%	0.51%	1.52%	2.39%	1.38%
NPV (£'000s)	-£6,711.1	-£2,329	-£4,497	-£4,672	-£3,423	-£2,180	-£4,441
40 Year Assessment:							
IRR (%)	-10.74%	3.33%	2.34%	2.31%	3.14%	3.86%	3.04%
NPV (£'000s)	-£6,618	-£312	-£2,418	-£2,544	-£849	£968	-£1,321

I.3 Chesterfield

Technical Evaluation

Table I-11: Chesterfield plant technical parameters

Plant Technical Details	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Boiler plant							
Phase 1 capacity (MW_{th})	7.0	9.0	9.0	9.0	10.0	13.0	14.0
Phase 2 capacity (MW_{th})	1.0	2.0	2.0	2.0	10.0	10.0	12.0
Total capacity (MW_{th})	8.0	11.0	11.0	11.0	20.0	23.0	26.0
CHP plant							
Heat capacity (MW_{th})	3.3	3.9	4.1	4.2	6.0	6.9	7.8
Electric capacity (MW_e)	3.1	3.8	3.9	4.0	5.7	6.6	7.4
Availability	90%	90%	90%	90%	90%	90%	90%
Energy Centre							
Footprint (m^2)	200	275	275	275	500	575	650
Thermal storage (m^3)	175	225	225	225	250	325	350
Delta T	30	30	30	30	30	30	30
Distribution							
Pipework length, (m)	893	3,371	3,767	4,145	5,209	5,891	8,031
No. of new residential connections	0	0	0	0	1,531	1,711	2,124

Table I-12: Chesterfield energy balance

Energy Balance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Thermal Energy Balance:							
Total thermal consumption (MWh_{th} p.a.)	24,766	29,797	30,884	31,661	45,065	52,179	58,888
Total network thermal load, incl losses (MWh_{th} p.a.)	28,481	34,266	35,517	36,410	51,825	60,006	67,721
CHP heat generation (MWhth p.a.)	23,626	28,065	28,923	29,556	41,157	47,238	53,042
As % of total	83%	82%	81%	81%	79%	79%	78%
Heat network top up boiler heat generation (MWh_{th} p.a.)	4,855	6,201	6,594	6,854	10,667	12,767	14,678
Total gas demand (MWh/year)	63,270	75,662	78,212	80,057	112,786	130,061	146,437
Electricity Balance:							
CHP Electricity generation (MWh_e p.a.)	22,501	26,729	27,546	28,148	39,197	44,989	50,516
Electricity provided to the end users via private wire (MWh_e p.a.)	11,903	12,164	12,221	12,261	12,954	13,324	13,671
Electricity exported to the grid (MWh_e p.a.)	10,598	14,564	15,325	15,888	26,242	31,665	36,845

Economic Evaluation

Table I-13: Chesterfield CAPEX breakdown

CAPEX breakdown, £'000s	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
EC Construction	350	500	500	500	950	1,100	1,250
Energy Centre external compound	235	282	293	300	427	495	558
Heat Generation Systems:							
CHPs	2,973	3,577	3,708	3,801	5,410	6,264	7,070
Thermal storage systems	175	225	225	225	250	325	350
Boilers Phase 1 *	1,820	2,340	2,340	2,340	2,600	3,380	3,640
Boilers Phase 2 *	0	150	150	150	1,350	1,350	1,650
*(incl. flues; ventilation; distribution pumps; energy centre electrical costs and pipework; water treatment; pressurisation and expansion; and BMS/Controls)							
Gas Systems:							
Gas Connection	150	197	200	203	336	389	441
Extension of gas main	24	24	24	24	24	24	24
Electrical Ancillaries:							
Sub-station including private HV transformers, HV switch room, LV switch gear, connection cost	100	100	100	100	100	100	100
DNO connection to the Energy Centre	313	377	390	400	570	659	744

External works:							
New development connection costs	0	0	0	0	4,593	5,133	6,372
DH pipework	1,340	5,056	5,650	6,218	7,813	8,836	12,047
Customer heat exchanger	275	379	403	414	822	979	1,141
Private Wire	225	225	225	225	225	225	225
Bridge crossing	750	750	750	750	750	750	750
Other Costs/Fees:							
Professional fees	436	702	740	775	1,044	1,234	1,475
Legal fees	218	351	370	388	522	617	738
Total	**9,384**	**15,235**	**16,069**	**16,813**	**27,787**	**31,860**	**38,574**

Table I-14: Chesterfield OPEX breakdown

OPEX breakdown, £ p.a	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
EC Construction	0.5	0.7	0.7	0.7	1.3	1.4	1.6
Heat Generation Systems:							
CHPs	229.5	272.6	281.0	287.1	399.8	458.9	515.3
Boilers Phase 1*	15.8	20.3	20.3	20.3	22.5	29.3	31.5
Boilers Phase 2*	2.3	4.5	4.5	4.5	22.5	22.5	27.0
*incl. flues; ventilation; distribution pumps; energy centre electrical costs and pipework; water treatment; pressurisation and expansion; and BMS/Controls)							
External works:							
New development connection costs	0.0	0.0	0.0	0.0	73.5	84.3	109.1
DH pipework	26.8	101.1	113.0	124.4	156.3	176.7	240.9
Customer heat exchanger	7.8	10.8	11.5	11.8	23.5	28.0	32.6
Other:							
Private Cables	5.4	6.0	6.2	6.3	7.9	8.8	9.7
Total OPEX p.a., £'000s	**288.0**	**416.0**	**437.1**	**455.0**	**707.3**	**809.9**	**967.7**

Table I-15: Chesterfield economic evaluation results summary

Financial assessment	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
25 Year Assessment:							
IRR (%)	13.43%	8.41%	8.10%	7.71%	10.40%	10.28%	9.35%
NPV (000's)	10,057,396	7,236,921	7,078,058	6,710,670	17,304,936	19,498,183	20,160,892
30 Year Assessment:							
IRR (%)	13.62%	8.75%	8.46%	8.08%	10.82%	10.68%	9.80%
NPV (000's)	11,395,464	8,595,285	8,492,545	8,155,684	21,232,720	23,694,516	25,052,486
40 Year Assessment:							
IRR (%)	13.86%	9.27%	9.01%	8.67%	11.22%	11.09%	10.27%
NPV (000's)	14,483,159	11,989,878	11,985,076	11,699,639	28,146,489	31,542,338	33,974,197

Appendix J Full Derbyshire building list

An excel spreadsheet of the buildings and associated heating and electrical loads in Derbyshire has been issued alongside this report.

aecom.com