elementenergy

SWECO

Heat mapping and masterplanning in Lancaster

BEIS Heat Network Delivery Unit

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1 Executive Summary

1.1 Context and summary of approach

This report presents the findings of a heat mapping and masterplanning study in Lancaster. The study aims to understand the potential for the development of heat network scheme options in the area, and to understand the potential benefits such schemes could deliver. The study will also consider potential constraints, risks, and opportunities related to the delivery of heat networks in the region.

To begin with, key stakeholders in the region were identified and contacted to gather information required to assess the potential for heat networks, such as heat demand across existing buildings and industrial sites, potential low carbon heat sources, planned developments and possible constraints to network development. Several maps were produced to present this information.

Based on the data gathered through stakeholder engagement and desk-based research, the study area was divided into smaller regions or 'clusters', as shown in Figure 1-1. Once defined, each cluster was studied in detail – qualitatively and quantitatively – to capture key characteristics influencing the viability of heat network schemes such as the volume of heat delivered, the level of stakeholder engagement, the linear heat density and the availability of low-carbon heat sources.

The clusters were assessed against these key criteria, with a ranking approach used to undertake a prioritisation of the full list of clusters to the three clusters deemed most likely to yield a viable scheme. This assessment has allowed us to draw insights into how a wider heat network scheme could develop over time through the expansion and interconnection of network(s) developed across the cluster areas presented in Figure 1-1.

1.2 Summary of economic assessment for prioritised clusters

The four highest ranked clusters were as follows:

1. **Bailrigg**
2. **South Lancaster**
3. **City Centre**
4. **Scale Hall**

Although the Bailrigg cluster scored highest, the next three highest scoring clusters were selected to take forward to detailed techno-economic analysis. This was on the basis that Lancaster University has already developed its own heat network plans, which relate to the Bailrigg cluster, to an advanced stage. It was therefore decided to focus here on new areas within the wider Lancaster area rather than risk repeating work already done. The Bailrigg cluster remains an important option and follow up is recommended as a conclusion of this study.

For each of the three prioritised clusters taken forward to the economic assessment, a series of scheme options has been specified in detail, differing in the extent of the heat sources considered, proposed network and the assumption of which customers connect to the scheme. A range of heat supply options have been studied for each cluster, according to the suitability of each heat source to the particular scenario. In the technical assessment, the energy demand data gathered and derived for each customer was used to undertake an outline design of the heat network, including the appropriate primary and auxiliary plant sizing, the network route and length, the pipe sizing, the peak and annual fuel consumption and so on.

Technical analysis was followed by an economic assessment for each scheme option. The key financial metrics reported for each scheme option are the Net Present Value (NPV) and the Internal Rate of Return (IRR). In order to fairly assess the financial viability of all scheme options, a 'Base Case' was used, in which key variables such as fuel cost and heat sale price were kept constant across all iterations. In additional to the Base case, further scenarios were considered:

- A "+RHI Case", consisting of the 'Base Case' with the addition of revenue equivalent to that which could be obtained from the Renewable Heat Incentive (for heat pump-based schemes), calculated according to the tariff levels on offer as of April 2019. Given that the RHI is currently scheduled to close in 2021, the availability of RHI revenue to any new schemes is highlighted as a key project risk.
- An "Optimistic Case", a variation on the 'Base Case' reflecting optimistic but realistic improvements on key assumptions. Only clusters with promising 'Base Case' outputs underwent the 'Optimistic Case' analysis.

A summary of the key outputs of the economic assessment is shown in Table 1-1.

Figure 1-1: Cluster boundaries within the study area

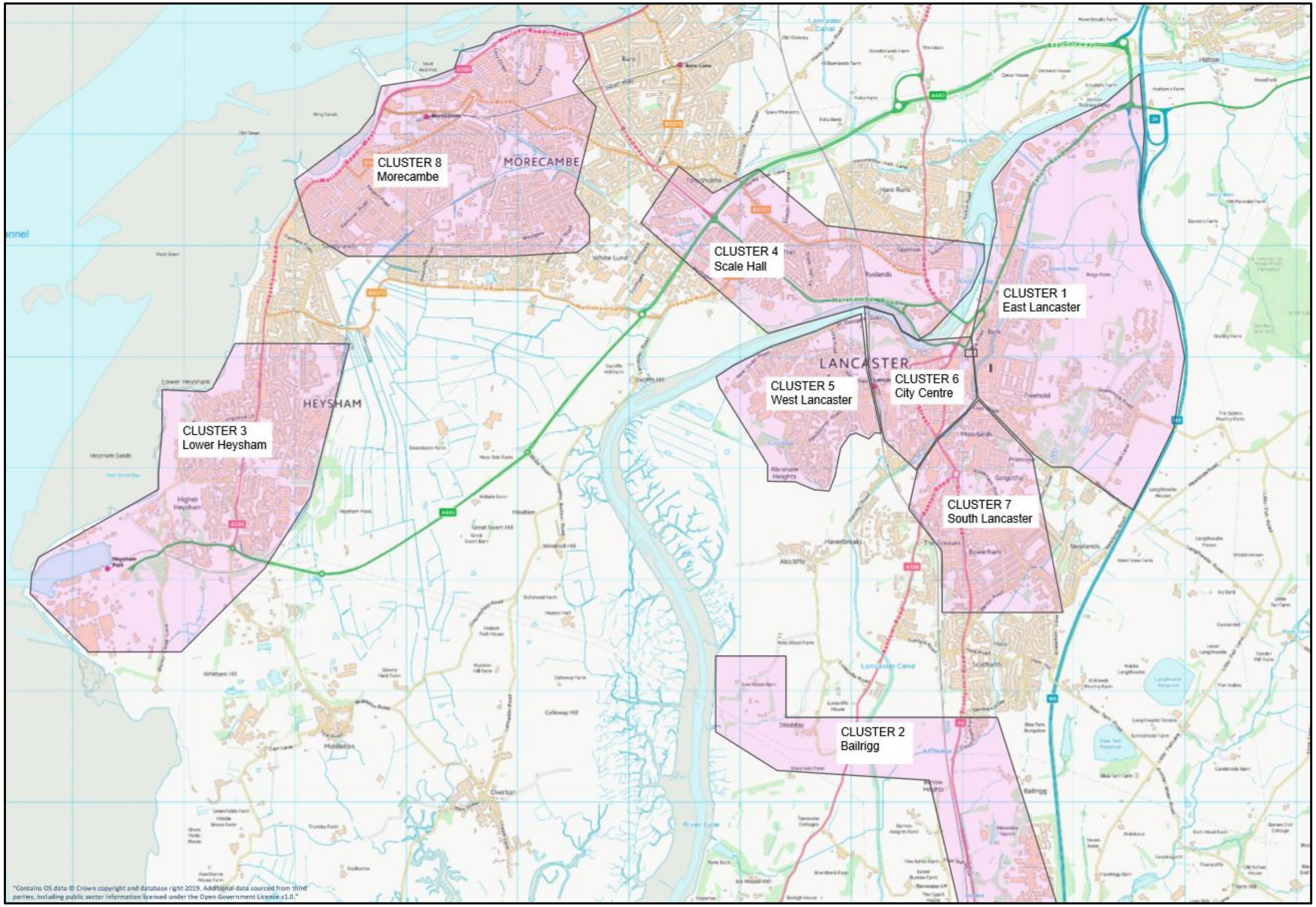


Table 1-1: Key economic outputs

Name	Technology	Economic Case	NPV	IRR
South Lancaster	**WSHP**	**Base Case**	(10,160,000)	-1.51%
South Lancaster	**WSHP**	**+RHI Case**	12,490,000	10.18%
South Lancaster	**WSHP**	**Optimistic Case**	(1,250,000)	3.01%
City Centre	**WSHP**	**Base Case**	(11,070,000)	-8.26%
City Centre	**WSHP**	**+RHI Case**	(4,030,000)	-0.59%
City Centre	**WSHP**	**Optimistic Case**	(8,190,000)	-2.54%
Scale Hall	**WSHP**	**Base Case**	(8,460,000)	-7.56%
Scale Hall	**WSHP**	**+RHI Case**	(3,180,000)	-0.55%
Scale Hall	**WSHP**	**Optimistic Case**	(5,990,000)	-1.99%
Combined Cluster	**WSHP**	**Base Case**	(8,260,000)	0.77%
Combined Cluster	**WSHP**	**+RHI Case**	16,610,000	9.65%
Combined Cluster	**WSHP**	**Optimistic Case**	2,990,000	4.34%

Table 1-1 shows that, providing revenue is available at current levels from the RHI, viable schemes based on water-source-heat pumps have been identified, namely:

- the stand-alone **South Lancaster cluster**
- the **Combined Cluster of South Lancaster and City Centre**

The stand-alone City Centre and Scale Hall schemes give negative IRR for all the economic cases modelled. The +RHI case of South Lancaster achieves an IRR of 10.2% over 40-years without any additional capital support and the Optimistic Case for the same scheme achieves an IRR of 3.0% over 40 years, consistent with a negative NPV (at 3.5% discount rate) of -£1.25m. For the Combined Cluster the +RHI Case and Optimistic Case achieve IRRs of 9.7% and 4.3%, respectively (over 40 years).

1.3 Conclusions and recommended next steps

Based on the analysis undertaken in this heat mapping and masterplanning study, we make the following recommendations on next steps. We suggest that Lancaster City Council are best-placed to take ownership of the majority of the near-term actions, but continued support (both through expertise and further funding) from HNDU will also be crucial.

1. We recommend that HNDU and Lancaster City Council continue to engage with the University of Lancaster, who have plans to further decarbonise and potentially extend the University's existing heat network, to ensure that any opportunities to support that work are identified.

Lancaster University has an existing heat network on campus and is experimenting with innovative approaches to integrate a range of on-site low carbon technologies across the campus, both for research purposes and to be able to meet their carbon reduction targets. The University has expressed an interest in considering how the campus energy system, including the heat network, could be integrated with the wider local energy system to provide mutual benefits.

Based on the advanced level of development of the University's plans for this potential scheme, it was agreed with HNDU that taking this cluster forward for heat mapping and master planning as part of this study would not result in any significant added value.

However, we suggest that HNDU and Lancaster City Council continue to engage with the University to ensure that opportunities for synergies – such as linking the University's energy system with the new development at Bailrigg Garden Village – are identified as early as possible to feed into strategic plans. HNDU may also be able to support the University in identifying sources of funding and/or relevant delivery partners.

2. Review local planning policy to ensure the potential to influence development of heat networks in Lancaster, including at Bailrigg Garden Village and other key developments.

Planning policy is a major lever for the Council to require, or encourage, developers to connect to heat networks, where this is a suitable and economically viable option.

Although new developments are not a major component of the proposed schemes, the connection of several new developments – including the development of new sites such as the Bailrigg Garden Village Growth Area (up to ≈3,500 new homes), where there is the potential to link with the Lancaster University's heat network in the longer term, the New Quay Road Development (≈250 homes) the North Lancaster Strategic Site (≈700 new homes and non-domestic development) and East Lancaster Strategic Site (≈900 new homes and non-domestic development) – could strengthen the economic case for the schemes. In the longer term, planning policy for connection to heat networks could, in principle, be extended to existing buildings, for example at trigger points of major renovation or heating system replacement, where viable and appropriate. This could in future be an important mechanism for ensuring a high rate of connection to the scheme and help to ensure the economic performance and sustainability of the scheme.

At this stage, the Council could consider options to strengthen planning policy on heat networks, such as including a requirement for significant new development to connect to existing heat networks and (more importantly at this stage, since no heat network yet exists) a requirement for new development to be connection ready, for when a heat network is available.

This is, again, an action that is most suitable for the Council to lead on, but support from HNDU could be highly valuable in identifying best practice elsewhere on this theme, and to assist the Council in the development of the detailed policy and supplementary planning guidance documents.

3. We recommend to advance to detailed feasibility stage an opportunity area covering the "South Lancaster" and "City Centre" opportunity areas.

Our economic assessment suggests that a water-source heat pump based heat network covering the "South Lancaster and City Centre" opportunity area could be viable, whether using the River Lune, Lancaster Canal or a borehole. Our analysis finds that this scheme could be viable, with a 40-year IRR of 4.3% even without Renewable Heat Incentive (RHI) support, under the assumptions of lower peak electricity purchase price and heat sale price of 5.7 p/kWh. A scheme based on the less favourable base case assumptions could also be viable, albeit likely to be dependent on revenue from the RHI, or otherwise with a gap funding requirement of at least £8.3m (compared to an overall capex of £20.8m – a funding percentage of around 40%).

We therefore recommend that the area covering these combined clusters is taken forward to detailed feasibility stage, and that this study considers the most appropriate phasing of a scheme across this opportunity area. Our analysis suggests that the most economically attractive scheme may be the one limited to South Lancaster, and so this could be considered as a 'fall-back' option where a more extended scheme is not deemed viable.

Heat supply options should include, as a minimum, a water-source heat pump, with a focus on the most viable sources (i.e. the river, canal or a borehole, or another as yet unidentified option).

We propose that HNDU and Lancaster City Council engage further in order that the Council can consider whether to take on the recommendations of this report, and so that HNDU can explain the application process for feasibility stage funding.

4. We do not recommend advancing other cluster areas to detailed feasibility stage at this point, but that a watching brief should be kept on areas where significant new developments are planned, including East Lancaster, Morecambe and Bailrigg.

Our detailed technical and economic analysis focused on the cluster areas described above, along with the Scale Hall cluster. Our assessment finds that the Scale Hall cluster is unlikely to present a viable opportunity, even when it is assumed that RHI revenue would be available, with very low or negative IRRs under all sensitivities modelled. We therefore do not suggest this cluster area is taken forward to detailed feasibility unless new information on significant heat users or low cost sources of low carbon heat is brought to light, which could support a reconsideration of this cluster.

We have also undertaken a quantitative comparison of a larger number of cluster areas across Lancaster, including an assessment of the volume of heat that could be served, the likely linear heat density and the presence of low carbon heat sources. On the basis of our analysis as a whole, we do not see a clear case at this stage for taking forward to detailed feasibility any other clusters. As explained in Section 6.6, we find that these other clusters are unlikely to be more economically viable than the "South Lancaster" cluster, which we suggest is not studied only as a stand-alone scheme but also in combination with the "City Centre" area. In short, our analysis suggests that the heat density in these other clusters is not sufficiently high to provide a basis for an economically viable scheme.

However, we have identified several potential developments which could improve the prospect for a heat network in other opportunity areas in Lancaster. These include the East Lancaster strategic development site, expected to include up to 900 dwellings, retailing space and a primary school. We suggest that this could be an opportunity for the development of a new-build heat network scheme in the East Lancaster cluster, and that the Council could consider approaches to delivering low carbon heat networks in this area through planning policy (see recommendation 2 above). In Morecambe, the Eden Project has revealed plans to open in the area, which could provide a large source of heat demand (although it is not clear how much of this demand this would be compatible with a heat network system). Since this development could present a stable anchor customer that would improve the deliverability of a scheme in this cluster, we suggest that a watching brief is kept on this opportunity area.

5. Continue engagement with key stakeholders in the area, both ahead of and as part of the detailed feasibility work.

Continued engagement with the relevant stakeholders is crucial, in order (i) to further soft market test interest in connecting to a heat network scheme, and identify any barriers/challenges, to reduce uncertainty; (ii) to fill in gaps in the actual/metered heat demand data gathered and (iii) to better understand the current heat prices incurred by stakeholders.

The major stakeholders in the "South Lancaster and City Centre" opportunity area include the Royal Lancaster Infirmary, the University of Cumbria, several student accommodation blocks, a number of schools and a range of municipal buildings. It is vital to keep the Infirmary engaged as it is a key anchor load, providing around half of the heat demand in the cluster.

The Council is best-placed to lead this ongoing engagement. Where possible, this engagement should be continued between now and the commencement of the feasibility stage work, since it can take a significant time to collect relevant data from stakeholders, and also since it is important that a good relationship is developed between the Council and the various other stakeholders, assuming the Council will be driving much of the process..

6. Monitor availability and level of support from the Renewable Heat Incentive (RHI) and lobby for continuation of incentives of some form for renewable heating, including in heat networks.

Our analysis finds that the “South Lancaster and City Centre” scheme could be viable (albeit marginal) without RHI support. However, availability of the RHI would significantly strengthen the business case, making the scheme more attractive to a range of types of investor, and thus making the scheme more likely to be deliverable. Furthermore, if for any reason the combined “South Lancaster and City Centre” scheme cannot be delivered, and the “South Lancaster” opportunity area is considered as a standalone scheme, the RHI may be required for the scheme to be economically viable.

The current RHI is scheduled to finish in 2021, and it is not yet clear how (or whether) the Government plans to continue providing support for the deployment of renewable heating, including large-scale heat pumps such as those proposed here. Furthermore, the level of incentive offered is subject to review at regular intervals between now and 2021. Given that the development timescales for a heat network scheme in Lancaster are unlikely to involve supply of heat into a network before 2021 at the very earliest (and likely later), it will be important to monitor the availability and level of the RHI for the heat network schemes.

It may also be appropriate for HNDU to provide evidence of the importance of the RHI in rendering these heat network schemes viable to the relevant ministers and policy teams within BEIS, in order to build the case for continued support of some form for renewable heating, including in heat networks.

2 Introduction

2.1 Context and objectives

Element Energy and Sweco have been commissioned by the Heat Network Delivery Unit (HNDU) to undertake a heat mapping and master planning study for Lancaster. The study aims to determine the potential for the development of heat network schemes in the region, to identify the coverage of any viable schemes, and to understand the potential benefits the schemes could provide to the area. The study will also consider the potential constraints, risks, threats and opportunities related to the delivery of heat networks in the region.

HNDU's supporting actions for heat network development include:

- To encourage involvement of local authorities which can help realise the benefits of heat networks, while also delivering jobs and growth.
- To address the capacities and capability challenges which local authorities identified as barriers to heat network deployment in the UK
- To provide grant funding and guidance to local authorities in England and Wales for heat network project development.

2.2 Description of the study area

The red-line boundary of the study area is shown in Figure 2-1. This encompasses regions of the City of Lancaster including; Morecambe, Lancaster, Bailrigg, Heysham, Aldcliffe and Stodday. The study area was reviewed to assess the possible extension of red-line boundary to include any relevant heat sources or key heat users.

The main population centres in this area include Lancaster, Heysham and Morecambe, with a small number of further inhabitants in the villages located across the region. A large residential and working population is associated with Lancaster University, located to the south of Lancaster.

A majority of jobs in the region are within service industries and a small proportion in manufacturing[1]. Parts of Morecambe and Lancaster suffer from unemployment as well as fuel poverty. Fuel poverty statistics published by Department of Energy and Climate Change (now BEIS) in 2014 identified 12% of the total number of households as being in fuel poverty[2]. Employment clusters include Lancaster, Morecambe, the universities (Lancaster University and University of Cumbria), White Lund industrial estate, Heysham's port and power stations.

Lancaster District has a diverse landscape and internationally important habitats including Morecambe Bay (wading birds), limestone pavements, open water and reed bed habitats in the Silverdale area and the Bowland Fells (birds of prey). The District is also a major tourism destination, its countryside including two Areas of Outstanding Natural Beauty (AONBs).

2.3 Low carbon energy utilisation and local planning policies

A variety of renewable energy technologies are present in the area including offshore wind, onshore wind, some small-scale wind, several CHP plants and solar PV. Further growth in these sectors as well as new sectors like small scale hydro, wave and tidal are being planned which are expected to provide opportunities to deliver economic and social benefits to the area. Lancaster City Council has assumed a leading role in supporting the development of renewable and low carbon energy and energy efficiency technologies in the North West region.

[1] http://www.lancaster.gov.uk/planning/planning-policy/about-the-local-plan Core Strategy (Accessed February 2019)

[2] https://committeeadmin.lancaster.gov.uk/documents/s49360/AppendixA1EnergyStrategyv26.pdf (Accessed February 2019)

The council set up targets to reduce energy consumption and the Council's CO_2 emissions by 20% by 2020 against a baseline year of 2012-13. Also, the growing proportion of the council's mileage is aimed to be covered by Ultra-Low Emissions Vehicles.

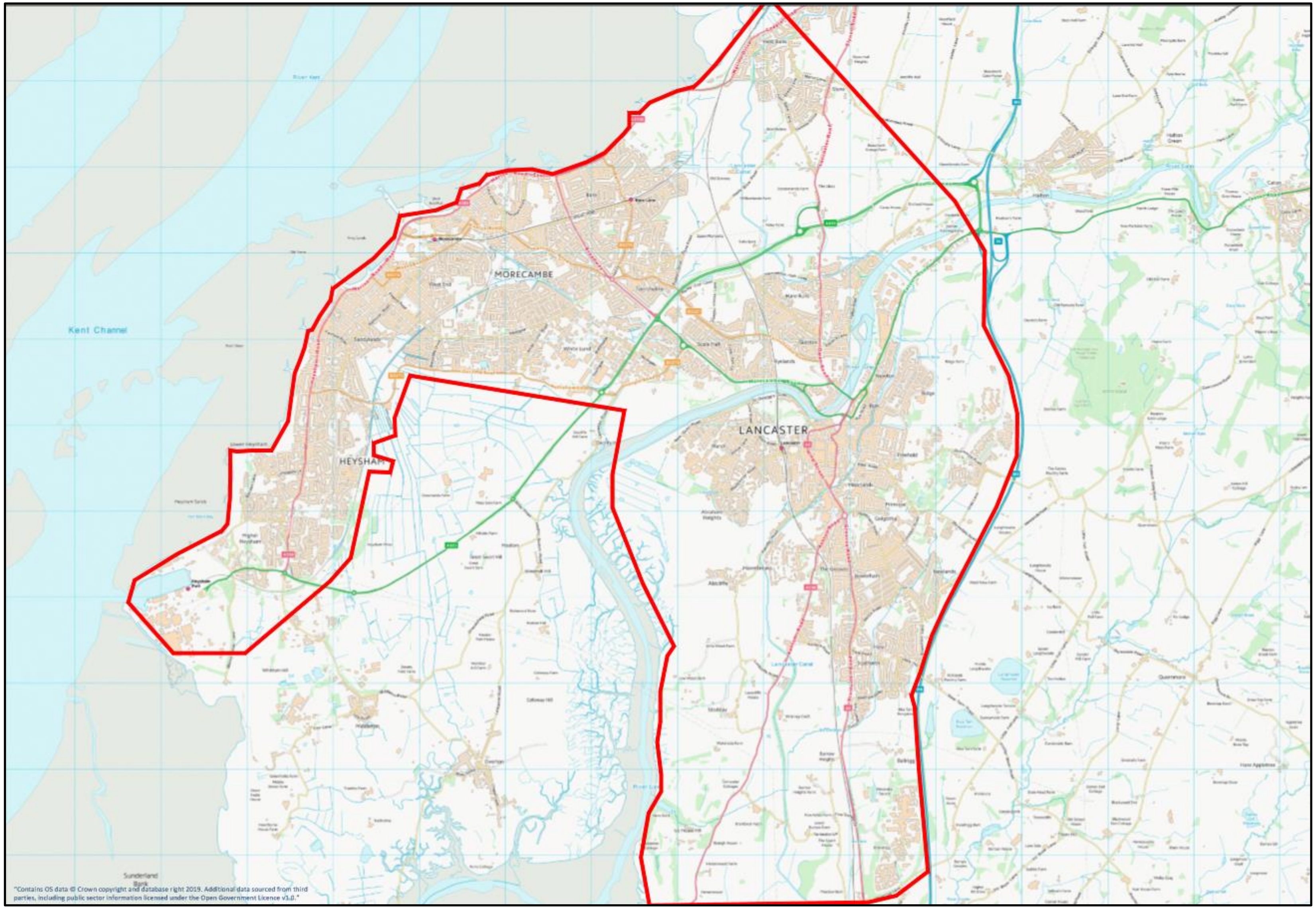
In the second part of the local plan it is mentioned that "the council is supportive of proposals that deliver high standards of sustainable design and construction". Sustainable design policy in the local plan asserts that the Council "will encourage development to deliver high standards of sustainable design and construction through consideration of: measures to reduce energy consumption and carbon dioxide emissions, and water consumption; opportunities for energy supply from on-site, decentralised, renewable or low carbon energy systems; opportunities to contribute to local and community-led energy initiatives; account of landform, layout, building orientation, massing and landscaping to minimise energy, water consumption and water efficiency measures; use of materials that reduce energy demand (for example, insulation) and increase the energy efficiency of the building/development; and the reuse of existing resources (including the conversion of existing buildings) where this would be 'fit for purpose'".

In the local plan for Lancaster planning policy regarding new development proposals which are adjacent to or adjoining the Lancaster Canal are expected to seek "to maximise opportunities for reducing carbon emissions and building resilience, highlighting the potential for using the canal in relation to heating and cooling within new development"[3]. Proposals in the South Heysham area should "explore opportunities aimed at minimising energy use, reducing emissions and maximising energy efficiency", including investigation of "opportunities to deliver district heat systems". Also, in the same local plan, the Council states that "support will be given to developments which seek to adopt sustainable construction and design aimed at minimising energy use, reducing emissions and maximising energy efficiency" given that "opportunities to deliver district heating systems" are investigated in South Carnforth and, North and East Lancaster Strategic Sites.

Bailrigg Garden Village is identified as a growth area in the south of Lancaster. Many new developments are expected such as 3500 new homes, a primary school, a secondary school and a local centre to accommodate for the forecasted population growth in the region. Some 1655 of these homes are to be built from starting from 2020 until 2034. Design of development within Bailrigg Garden Village is expected to be innovative and include investigation of energy delivery through the role of district heating systems and opportunities to encourage a greater role for electric vehicles. Lancaster University – Bailrigg Business Park Development Brief touches upon the importance of energy efficiency through the design of the development[4].

[3] https://planningdocs.lancaster.gov.uk/NorthgatePublicDocs/00917940.pdf (Accessed February 2019)
[4] https://webcache.googleusercontent.com/search?q=cache:0jW16Hu7fXcJ:https://www.lancaster.gov.uk/assets/attach/1223/SPG-205-20Lancaster-20University-20Bailrigg-20Business-20Park-20Development-20Brief.pdf+&cd=3&hl=en&ct=clnk&gl=uk (Accessed February 2019)

Figure 2-1: Final red-line boundary for the study area



2.4 Approach

This heat mapping and masterplanning study has involved a series of steps towards identifying the most promising opportunities for the development of heat networks in Lancaster. These steps are as follows:

1. Stakeholder engagement and data collection
2. Energy demand mapping
3. Low carbon heat source mapping
4. Constraints mapping
5. Cluster assessment
6. Scheme option definition
7. Technical assessment
8. Economic assessment
9. Scheme options appraisal
10. Preferred scheme options, risks and recommendations

3 Stakeholder Engagement and Data Collection

3.1 Approach to engaging stakeholders

All homes, businesses and public sector organisations – including existing and planned future developments – were considered as potential customers of a heat network within the scope of the study. As such, the energy demand of all these consumers is included in our analysis.

However, the core of a heat network is likely to be focused on a small number of larger customers – sometimes known as 'anchor customers'. For these potential customers in particular, it is important to have the most accurate and up-to-date information.

In order to engage these potential anchor customers, a longlist of many of the largest potential customers was developed. This was based on initial desk research, supplemented by further engagement with Lancaster City Council and Lancaster University to identify potentially large energy users during the heat mapping process. Our approach to stakeholder engagement included the following:

- Email contact with project background and an information request
- Telephone calls

Stakeholders were first contacted by email, with a letter of introduction from the HNDU explaining the background to the project, to outline the substance of the information request and how this information would be used in the study. The information requested includes:

- Accurate energy demand data
- Fuel bills or other information on price of heating/cooling/electricity
- Details of the incumbent heating/cooling supply and distribution system
- Gross floor space of the building
- Available rating for building energy certificates
- Potential large sources of heat for a heat network
- Planned upgrades, refurbishments or heating/cooling system replacements
- Likelihood of continuation of the energy demand/source over the long-term
- Barriers to or additional benefits of connection to a heat network

A substantial amount of data was provided by stakeholders via written responses to these emails and was supplemented by data from Lancaster City Council's database. Certain stakeholders expressed an interest in holding a telephone discussion, and a number of such calls were held.

We have been able to engage in depth with Lancaster City Council and Lancaster University, who own and operate a large number of buildings in the area. The Council has provided valuable information regarding important new developments, potentially large energy users and energy demand data for council owned buildings. These buildings included leisure centres with swimming pools, town halls, council housing estates and community centres. In addition, Lancaster University has been very responsive to and interested in the study, providing information about the university's energy demand data, varying energy generation technologies employed at the campus and future plans for development and operation of district heating schemes at the University.

Lancaster University has a carbon reduction target of 4,034tCO2 by 2020-21 which amounts to 21% of 2013-14 carbon emissions. Their new projects identified in Carbon Management Plan document a potential reduction of 5,000tCO2 annually, if fully implemented[5]. In support of Higher Education Funding Council of England's target of achieving 43% reduction in Higher Education sector carbon emissions

[5] https://www.lancaster.ac.uk/media/lancaster-university/content-assets/images/sustainability/FinalCarbonManagementPlan2015.pdf (Accessed February 2019)

by 2020, the University of Cumbria has committed to a 45% reduction in emissions by 2020 from a 2007-08 baseline[6].

A summary of the number of stakeholders engaged through these various approaches, and the amount of data received, is provided in Table 3-1. Further detail on the engagement achieved is provided in Appendix A.

Table 3-1: Summary of number of stakeholders engaged

Category	Item	
Written information request	**Number of stakeholders contacted with information request**	**15**
	Number of written responses	**4**
	Number of buildings for which data was provided	**205**
	Of which energy demand data (Display Energy Certificate & Stakeholder in question)	128
	Of which floorspace and building activity data (Non-domestic Energy Performance Certificate)	71
	Of which other data (Desk based research)	6

3.2 Energy demand data sources

Considering all potential heat network customers – which includes all the homes, businesses and public sector organisations in the region – a hierarchy of approaches was followed in terms of gathering energy demand data. A different approach was taken for existing buildings and new buildings (i.e. buildings which are expected to form part of future development but are not yet built).

In all cases, energy demand was gathered and/or estimated for the following types of energy use:

- **Heating** (space heating and hot water)
- **Electricity** (other than electricity for heating and cooling)

No significant cooling demand was identified for any of the existing or new buildings assessed in this study.

3.2.1 Existing buildings

For existing buildings, the energy demand data source hierarchy was:

1. Metered data provided directly by the stakeholder
2. Metered data provided by the Council based on existing databases
3. Display Energy Certificate (DEC) data for large publicly-accessible buildings
4. Floor area data provided by the stakeholder or obtained from Energy Performance Certificate (EPC) data for non-domestic buildings, combined with energy demand benchmarks
5. Floor area data estimated from an OS Mastermap/AddressBase GIS-based analysis, combined with energy demand benchmarks

The above hierarchy is referred to in Section 5 where heat users identified in the study region are listed. This is not only to state the source of the data but also to indicate the confidence in the data gathered.

6 https://www.cumbria.ac.uk/media/university-of-cumbria-website/content-assets/public/fm/documents/environmentsustainability/CarbonManagementPlan.pdf (Accessed February 2019)

In the case of existing non-domestic buildings for which neither metered data nor DEC data was available, energy demand benchmarks were taken from BEIS's *Building Energy Efficiency Survey* data[7] (Sector Tables), according to an analysis of the closest matching building activity type.

3.2.2 New buildings

Planned developments were identified through the planning permission portal available on Lancaster City Council's website and a variety of building types were considered including residential flats, houses, offices, restaurants and retail units. The Council's most recent Local Planning document states the total number of assessed housing supply and outstanding commitment as 7,016 and 5,392, respectively. The breakdown of this commitment is provided in the local planning document in detail for each area in 5-year plans until 2034. More information about major developments within the study area is included in Section 4.2

The floor area (or number of residential units) and activity type of the development were combined with energy demand benchmarks to estimate building energy loads. For new buildings, energy demand benchmarks are based on the Energy Performance of Buildings Directive (January 2019), produced by the Ministry of Housing, Communities & Local Government[8].

[7] https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees (Accessed July 2017)

[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770783/2nd_UK_Cost_Optimal_Report.pdf (Accessed March 2019)

4 Energy Demand, Heat Source and Constraints Mapping

Following the data collection phase, a series of mapping exercises were undertaken in order to allow the visualisation of various characteristics which will influence the viability of a heat network. The objective of the mapping phase is to identify promising clusters of potential heat network customers in the study area to be prioritised to take forward to the technical and economic assessment. Key characteristics of promising cluster areas include:

- High volume of heat delivered
- High heating and/or cooling demand density
- Deliverability: including high level of stakeholder engagement, presence of planned new developments, strong local planning policies for heat networks
- Proximity to low-carbon heat source(s)
- Potential for innovative district heat network systems
- Mix of user types to provide steady level of heat demand (diurnally and seasonally)

4.1 Energy demand mapping

One of the most important features of an area suitable for a heat network is high heating and/or cooling demand density. There needs to be a sufficiently high demand for energy within an area for the energy sales to cover the cost of installing the heat network; which increases significantly with the length of the network. Another key feature of areas suitable for heat networks is the presence of large energy users which could act as 'anchor' customers for the scheme, providing sufficient certainty of demand to reduce the investment risk. In order to identify potential anchor customers and visualise the density of significant heat users, the maps shown in Figure 4-1 and Figure 4-2 were produced.

The varying size and colour of the icons used in these maps represent the annual heat demand of each significant heat user. These maps were based on the data gathered during the stakeholder engagement, as described in Section 3. No cooling demand has been identified. Therefore, the study proceeds with heating-based scheme designs, with no further consideration of the provision of cooling.

4.2 Key developments areas

As described in Section 3.2, planned developments were identified through the planning permission portal on Lancaster City Council's website as well as the most recent Local Plan document. These key developments are mapped in Figure 4-3 and more information regarding the details of each development is included in Table 4-1.

Table 4-1: Details of key developments within the study area (study area ID refers to Figure 4-3)

ID	Development	Description	Status
1	Bailrigg Garden Village Growth Area	Highlighted area is allocated for controlled and sustainable growth of the region. The area is expected to see the development of 3,500 new homes 1,655 of which is expected by the end of 2034. In addition, a primary school, a secondary school, a local centre, medium scale foodstore and the delivery of Lancaster University Health Innovation Campus are expected to sustain the growth in the region. The Council is seeking a modal shift in local transport movements through delivery of Bus Rapid Transit System and Cycling and Walking Superhighway network.	Growth area
2	New Quay Road Development[9]	New Quay Road Development is located by the River Lune, next to an Industrial Estate. The proposal outlines erection of up to 250 dwellings with associated vehicular and cycle/pedestrian accesses and the application is awaiting decision.	Planned (Awaiting decision on outline planning application)
3	Wyresdale Road Development[10]	Wyresdale Road Development is situated close to M6 within the allocated Leisure Park – Auction Mart Residential Development area. It comprises of 27 dwellings with associated access and the planning permission is awaiting decision.	Planned (Awaiting decision on full planning application)
4	North Lancaster Strategic Site	When fully developed, the site is expected to accommodate approximately 700 dwellings, 2 hectares of high-quality employment land (B1), a primary school and a local centre with 600 m^2 retailing floor space.	Strategic site
5	East Lancaster Strategic Site	East Lancaster Strategic Site covers an area of 120 hectares, and it has been identified as having an indicative capacity for approximately 900 dwellings. In addition, a primary school and a local centre with 800 m^2 retailing floor space to support the delivery of growth desired.	Strategic site
6	Grab Lane Residential Development	The site has been allocated for residential development, and it is expected to accommodate no more than 195 residential dwellings and a range of infrastructure that is necessary to facilitate these new homes.	Allocated as site for Housing development in Local Plan
7	Leisure Park - Auction Mart Residential Development	The site has been identified for residential development, and is expected to accommodate approximately 200 residential dwellings and a range of infrastructure that is necessary to facilitate these new homes	Allocated as site for Housing development in Local Plan
8	Aston Road Residential Development	The site in South Lancaster has been identified for residential development and it is expected to accommodate approximately 71 residential dwellings and a range of infrastructure to facilitate these new homes.	Allocated as site for Housing development in Local Plan

9 https://planning.lancaster.gov.uk/online-applications/applicationDetails.do?activeTab=summary&keyVal=PIYF87IZ03800 (Accessed March 2019)

10 https://planning.lancaster.gov.uk/online-applications/applicationDetails.do?activeTab=map&keyVal=P72DPNIZKHY00 (Accessed March 2019)

Figure 4-1: Significant heat users identified in the study area - 1

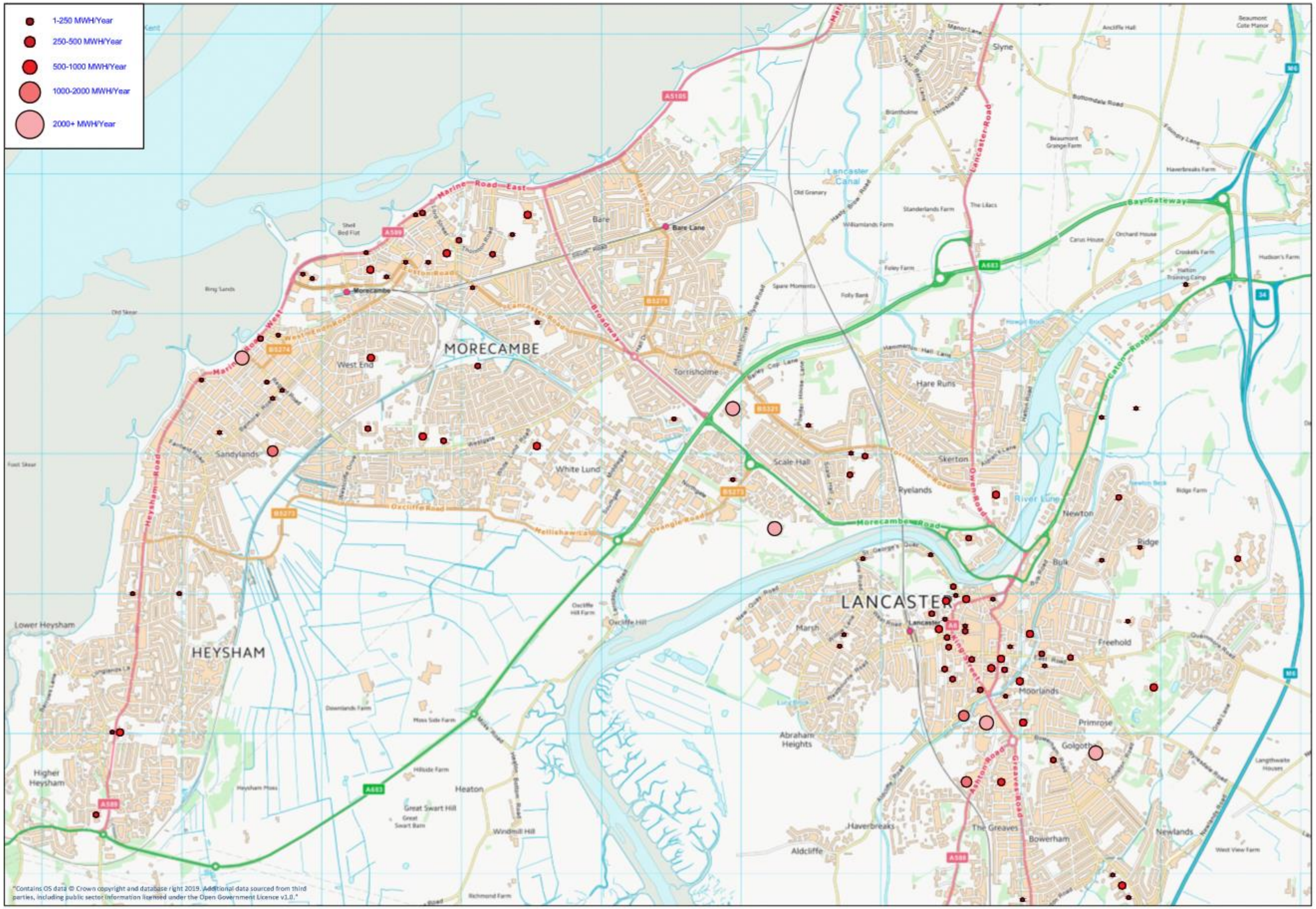


Figure 4-2: Significant heat users identified in the study area - 2

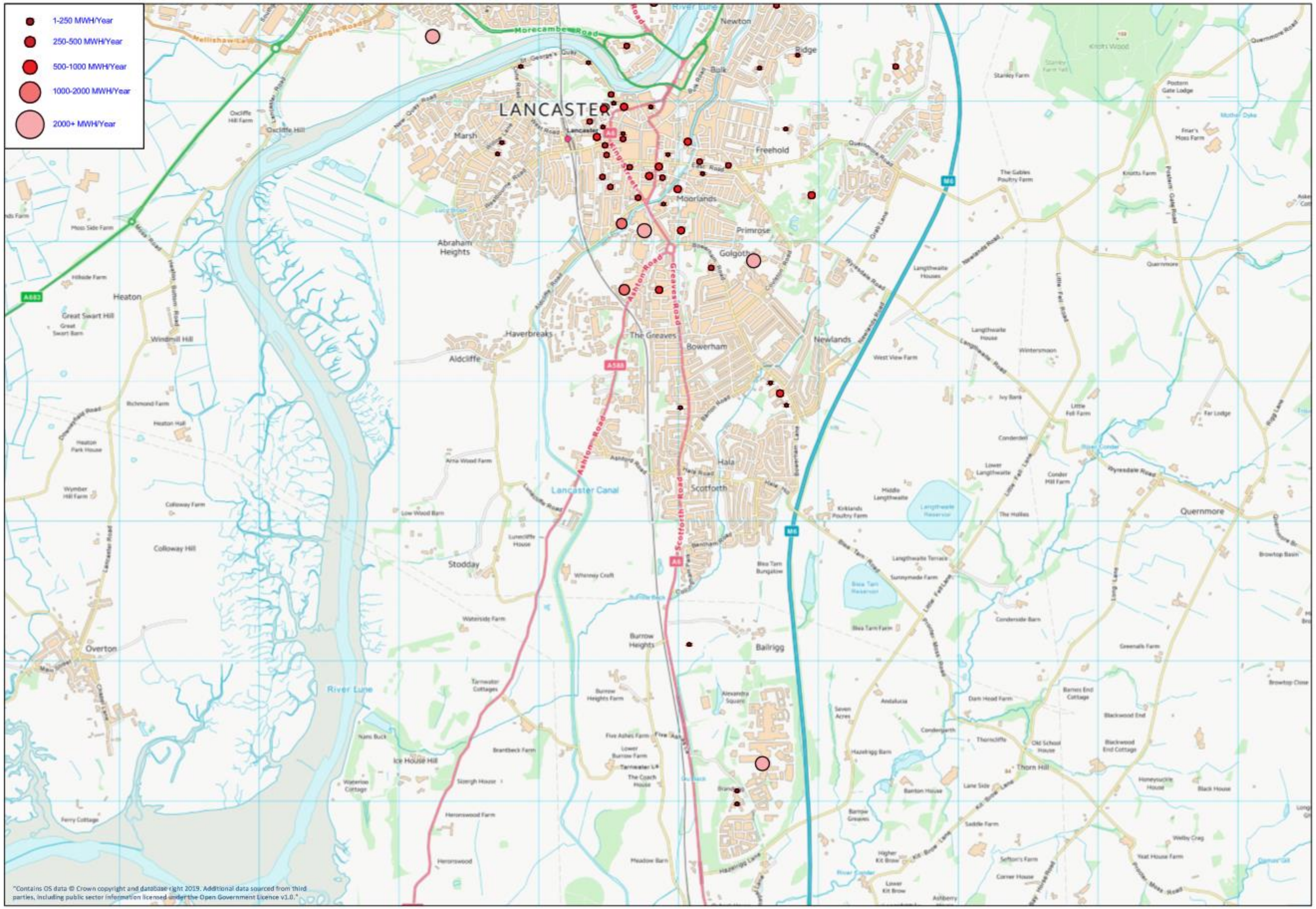
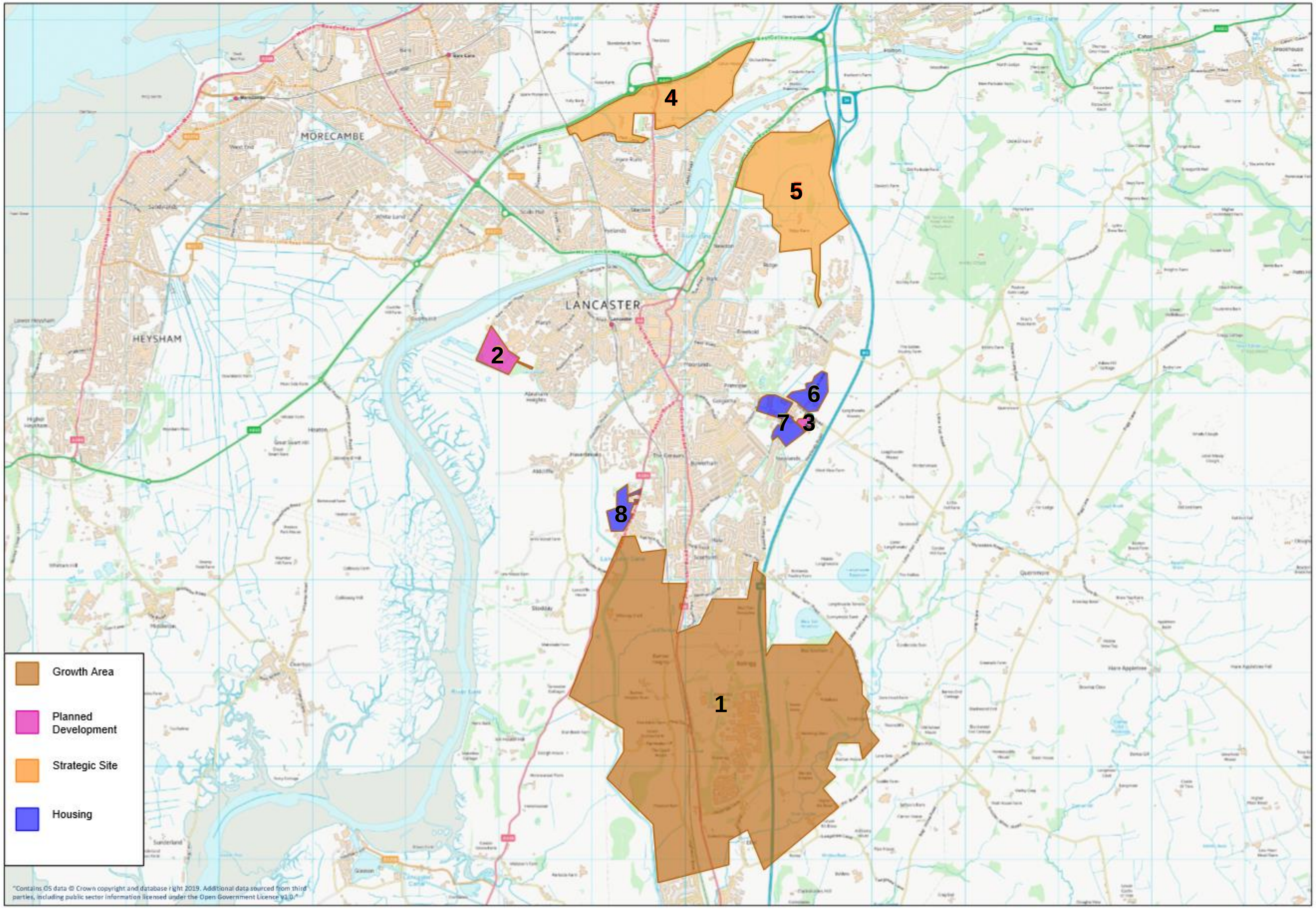


Figure 4-3: Key developments identified within the study area



4.3 Heat source mapping

Information on heat sources in the area gathered through the stakeholder consultation and data collection phase was also mapped. The potential sources are listed in Table 4-2 and mapped in Figure 5-3.

Table 4-2: Summary of heat sources included in the assessment

ID	Heat source	Operational or planned	Description
1	Waste Water Treatment Works – United Utilities	Operational	Waste water treatment plant, including a 500 kW CHP Plant installed in 2011. It is not known whether any heat from this source is not already used, so this source is not considered in the analysis in Section 6.
2	Heysham Nuclear Power Plant	Operational	Nuclear Power Plant with a capacity of 1,155 MW and an expected end of generation in 2024. Due to the imminent end of life, we have not included this source in the analysis in Section 6.
3	Planned Energy-from-Waste plant	Planned	There is a plan for an Energy-from-Waste facility in lower Heysham. Development application is made by Veolia and the application has recently finished consultation process. The status of this potential heat source should be monitored.
4	Walney Offshore Wind Farm Extension Substation	Operational	Substation of Walney Offshore Windfarm Extension.
5	Lancaster University data centre cooling systems	Operational	There are three data centre cooling systems in different locations across Lancaster University. Estimated current heat rejection for the two systems is on the order of 1MW.
6	River Lune	Potential	River Lune was identified to have potential for water source heat pump deployment by the Department of Energy & Climate Change in their National Heat Map: Water source heat map layer report in March 2015 with an estimated heat capacity of 37 MW_{th}. Use of this source is likely to be viable only where the energy centre can be located close to the river. Note that in the analysis in Section 6 we have not identified suitable locations for an energy centre close to the river, and so we propose borehole-based WSHP schemes; however, the potential to use the river should be reviewed in any feasibility stage study.
7 (not shown on map)	Groundwater (borehole)	Potential	In cases where the energy centre cannot be located near the river, or the river cannot be used as source for a WSHP for any other reason, we have aimed to identify a potential location for a borehole-based WSHP. A feasibility and/or detailed project development stage study should include further site assessment, including environmental assessment and hydrogeological survey to better determine the viability of a borehole-based WSHP for any given scheme.

5 Cluster Assessment

5.1 Cluster assessment approach

A list of clusters was defined based on the findings of the mapping exercises. Clusters were identified to combine areas of high heat demand, to separate areas according to major constraints, to capture areas planned for substantial development and so on. In this way, eight separate clusters were defined which cover the majority of the study area. Their indicative boundaries are shown in Figure 5-1.

In this section, we undertake an assessment of all clusters identified, in order to understand the technical potential for the development of heat network schemes across the study area, and to describe how these schemes could develop over time and potentially be connected to each other over the long term. Clusters are analysed based on the data gathered through publicly available data and the stakeholder engagement activities described in Section 3.

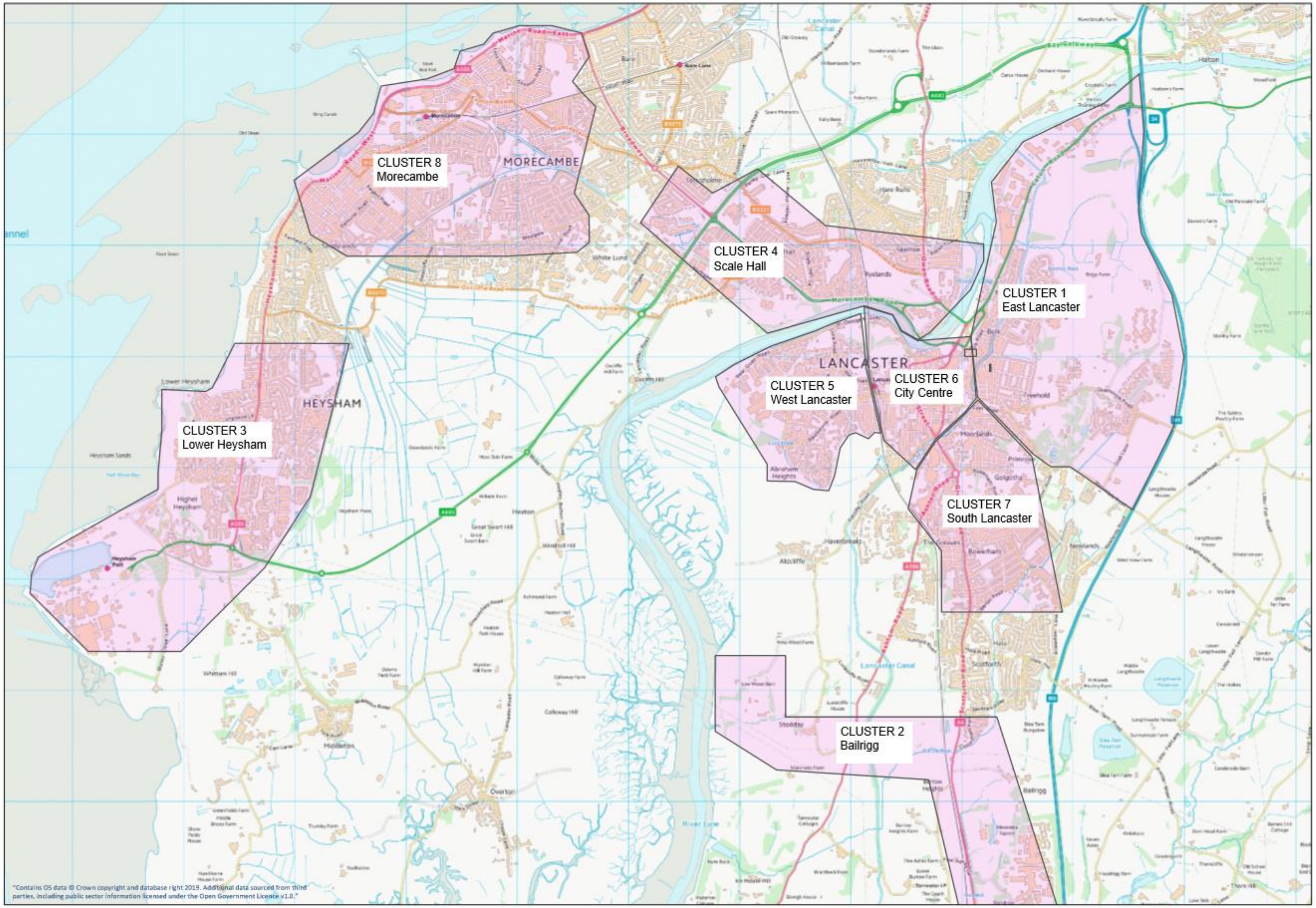
Table 5-1 lists energy demand sources for existing buildings and new developments. The scoring is used later when analysing each cluster to indicate reliability of the scheme.

Table 5-1: Energy demand data sources

Data Source	Scoring
Existing buildings	
Metered data (annual/monthly[11]) provided by the stakeholder	1
Annual metered data (annual/monthly) provided by the Council based on existing database	2
Display Energy Certificate (DEC) data for large publicly-accessible buildings	3
Floor area data provided by the stakeholder or obtained from Energy Performance Certificate (EPC) data for non-domestic buildings, combined with energy demand benchmarks	4
Floor area estimated from an OS Mastermap/AddressBase GIS-based analysis, combined with energy demand benchmarks	5
New developments	
Floor area (or number of residential units) and activity type of the development, combined with energy demand benchmarks	6

[11] All energy demand data provided by stakeholders was annual or monthly (not half-hourly or hourly).

Figure 5-1: Indicative cluster boundaries



5.1.1 Cluster 1: East Lancaster

East Lancaster cluster contains both public and private sector buildings. The Holiday Inn Lancaster constitutes the largest heat demand, which amounts to one third of the heat demand of the cluster. Engagement with the Council was effective and heat demand data for Williamson Park and Glebe Court were obtained from them. Most of the data in this cluster was obtained from DEC and EPC certificates, as shown in Table 5-2 with the full list of major heat users identified.

Within the cluster a large area is defined as a strategic development site by the Council. This site is expected to include up to 900 dwellings, retail space and a primary school. The council expects new developments to start in 2020 reaching 350 dwellings by the end of 2035. However, there are no planning applications yet and hence no demand figures are included in Table 5-2.

Many of the heat users in this cluster border the River Lune, which could be a suitable source of low carbon heat in combination with a water-source heat pump.

The cluster is bordered by the river in the north and west, and the M6 motorway in the east. An initial estimate of the network length required to connect all the heat users listed in the table above was 5km, which results in a linear heat density of 1.0 GWh/km. This value is relatively low considering other clusters defined in the study. However, with the progression of new developments it has the opportunity for higher heat demand and consequently a higher linear density.

Table 5-2: Heat users identified in Cluster 1.

ID	Building	Data Source	Heat Demand (MWh/yr)	Electricity Demand (MWh/yr
1	Holiday Inn Lancaster	4	1,200	
2	Lancaster Royal Grammar School	3	800	210
3	Williamson Park	2	750	
4	Glebe Court	2	620	30
5	Dolphinlee House	3	460	150
6	HM Young Offenders Institute	3	380	160
7	Premier Inn	4	350	
8	Central Lancaster High School	3	230	530
9	Lancaster Christ Church CoE Primary School	3	150	70
10	Ridge Community Primary School	3	130	80
11	Dennison Trailer Ltd	4	80	
12	Lancaster Town House	4	40	
	TOTAL		**5,200**	**1,200**
	Domestic		1,000	200
	Non-domestic		4,200	1,000
	Initial estimate of network length (km)		**5.0**	
	Estimated linear heat density (GWh/km)		**1.0**	

5.1.2 Cluster 2: Bailrigg

The high energy demand of Lancaster University provides a suitable potential anchor load. The campus includes a sports centre (with a swimming pool), several on-campus student accommodations and a hotel as well as faculty buildings. Lancaster University has been responsive to information requests and keen on the potential benefits the study has to offer in Lancaster. Both the Energy Manager and Project and Laboratory Manager of the University were consulted during stakeholder engagement. Lancaster University is experimenting with innovative approaches to integrate a range of on-site low carbon technologies, both for research purposes and to be able to meet their carbon reduction targets. Also, the University has expressed an interest in how their energy system could be integrated with the wider local energy system to provide mutual benefits.

The University has several data centres inside the campus whose cooling systems could be integrated into a district heating system to offer a low carbon heat source. Another potential heat source in the cluster is the 500 kW CHP plant at Lancaster Waste Water Treatment Works. The facility is operated by United Utilities and the CHP unit was installed in 2011. Otherwise, a water-source heat pump could be deployed, though this is likely to need to be borehole-based since most of the cluster is distance from the river, and it is not clear whether other surface bodies of water would have the heat capacity required to supply a large network.

Bailrigg Garden Village is identified as a broad location for growth by the Lancaster City Council and substantial new development is proposed, including 3500 new homes, a Health Innovation Campus by Lancaster University, a primary school, a secondary school and a local centre. Indicative options for development calculate the potential number of dwellings based on a relatively low density of 30-40 dwellings per hectare, roughly corresponding to a typical semi-detached build density. Assuming a very approximate annual heat demand of 5 MWh/yr per home, for high efficiency new build, this corresponds to a heat demand density in the range 15-20 kWh/m^2. Based on local planning policies, design of new developments is expected to be innovative and opportunities for energy delivery through via district heating systems should be investigated.

Table 5-3: Heat users identified in Cluster 2.

ID	Building	Data Source	Heat Demand (MWh/yr)	Electricity Demand (MWh/yr)
1	Lancaster University	1	36,000	34,000
2	Sandpiper Health Club	5	160	
3	Lancaster House	5	150	
4	Lancaster University Health Innovation Campus	-	Data not available	Data not available
	TOTAL		**36,000**	**34,000**
	Domestic			
	Non-domestic		36,000	34,000
	Initial estimate of network length (km)		**4.0**	
	Estimated linear heat density (GWh/km)		**9.0**	

Following further engagement with the Energy Manager at Lancaster University on the University's heat network plans, it became clear that a great deal of research has been undertaken encompassing all areas of the future district heating scheme development and operation, which was not realised during the first phase of stakeholder engagement. Details of the plans include; consideration of a variable flow and variable temperature system; extensions to the existing district heat network; an improvement project for secondary distribution systems (i.e. systems within University's buildings); developing district heating control algorithms for improved optimisation of individual buildings and for optimised control of the networks, which is built on top of the University's existing Energy Information System.

The aim is to avoid further gas fired CHP or biomass boilers and move towards biomass CHP and WSHPs. To reduce the temperatures on the network, the introduction of local heat pumps between the DH network and the buildings are being considered which would enable de-coupling of temperatures and give much greater flexibility of integrating renewables into the system.

5.1.3 Cluster 3: Lower Heysham

The Lower Heysham cluster is the southern region of the residential Heysham area. There are only five buildings that were identified as potential heat users, which are listed in Table 5-4.The volume of heat that could be provided for this cluster is 1.3 GWh/year and with an estimated network length of 1.7 km to connect these buildings, the resulting linear heat density is 0.8 GWh/km. Energy demand data gathered in this cluster is from DEC and EPC databases.

The area also includes some important potential low carbon heat sources such as the Nuclear Power plant, Walney Wind Farm Extension substation and a possible development of an EfW plant. The EfW plant is planned by Veolia UK with sufficient capacity to supply energy for 60,000 homes. The project has completed public consultation and the final plans are being produced. This cluster has the potential to supply available waste heat to areas with higher linear heat density and annual heat demand.

Table 5-4: Heat users identified in Cluster 3.

ID	Building	Data Source	Heat Demand (MWh/yr)	Electricity Demand (MWh/yr)
1	Heysham Primary Care Centre	4	750	
2	Trumacar Nursery and Community Primary School	3	250	90
3	Mossgate Primary School	3	160	82
4	Fernbank Rest Home	4	110	
5	Strawbery Gardens Medical Practice	4	54	
	TOTAL		**1,300**	**170**
	Domestic			
	Non-domestic		1,300	170
	Initial estimate of network length (km)		**1.7**	
	Estimated linear heat density (GWh/km)		**0.8**	

5.1.4 Cluster 4: Scale Hall

This cluster is populated with public sector buildings, comprising mainly schools and a leisure centre with a total annual heat demand of 8.4 GWh. The leisure centre contains a swimming pool and is operated by the Council. Data for the leisure centre was obtained from the council, however, data from the schools are based on the historic DEC data. The reason for this is the devolution of power between Lancaster City Council and Lancashire County Council which holds data on the schools in the region.

A suitable low carbon heat source for this cluster could be a water source heat pump using the River Lune, which lies all along the southern part of the cluster. The diversity in the mix of user types is modest. Due to the large number of schools in the cluster, their demand profiles are likely to dominate the overall demand profile of the cluster – this may not be ideal for district heating, due to the relatively short occupied hours and long holiday periods (this can be mitigated if the school buildings are used for other uses outside of school hours).

Table 5-5: Heat users identified in Cluster 4.

ID	Building	Data Source	Heat Demand (MWh/yr)	Electricity Demand (MWh/yr)
1	Salt Ayre Leisure Centre	2	3,100	1,000
2	Lancaster & Morecambe College	3	2,800	1,400
3	Chadwick High School Lancaster	3	900	170
4	Our Lady's Catholic College	3	410	380
5	Ryelands Primary School	3	300	100
6	Loyne School	3	290	160
7	Children & Parenting Support Services	3	210	40
8	Morecambe Road School	3	190	90
9	Morecambe and Heysham Governor Park Primary School	3	180	60
10	Vale of Lune RUFC	4	50	
	TOTAL		**8,400**	**3,400**
	Domestic			
	Non-domestic		8,400	3,400
	Initial estimate of network length (km)		**4.5**	
	Estimated linear heat density (GWh/km)		**1.9**	

5.1.5 Cluster 5: West Lancaster

West Lancaster cluster is surrounded by the River Lune in the north and west and by the railways in the east. The existing heat demand of the cluster is 440 MWh/year. Three significant heat users and a planned new development were identified in the area, as shown in Table 5-6. The New Quay Road development plan is submitted for review and is pending decision; the development is expected to deliver up to 250 dwellings. To connect the listed buildings and the new development, a network length of 1.2 km is estimated which gives 1.3 GWh/km of linear heat density.

The River Lune could be also be utilised as heat source for this cluster, in combination with a water source heat pump. However, aside from the Scaleford Retirement Home, the most significant heat users identified in this cluster do no border the river, so this cluster is not deemed as favourable as others bordering the river in terms of the presence of a suitable low carbon heat source.

Table 5-6: Heat users identified in Cluster 5.

ID	Building	Data Source	Heat Demand (MWh/yr)	Electricity Demand (MWh/yr)
1	Scaleford Retirement Home	4	200	
2	Willow Lane Community Primary School	3	160	62
3	Appletree Children's Centre	3	80	27
4	New Quay Road Development	6	1,100	
	TOTAL		**1,540**	**89**
	Domestic		1,100	
	Non-domestic		440	89
	Initial estimate of network length (km)		**1.2**	
	Estimated linear heat density (GWh/km)		**1.3**	

5.1.6 Cluster 6: City Centre

There are several public and private sector buildings with fairly high heat loads in this cluster. Some of these buildings are student accommodation, such as Wyre House Chancellors Wharf (Lancaster University), Cable Street Student Accommodation, Mill Hall Halls (University of Cumbria), Damside Student Accommodation and City Block Student Accommodation. Besides student accommodation, there are a number of public sector buildings, such as the Jobcentre Plus, police station, schools and local government buildings. Hence, a good mix of user types are present in the cluster.

There has been a good level of engagement with the Council, which operates a considerable number of the buildings in this cluster. However, engagement with private sector buildings are yet to be established. Some notable constraints are the railways to the west, River Lune to the north and the canal to the south of the cluster as well as the historic city centre. As mentioned before, connection with South Lancaster cluster is possible over the canal where several bridges are available.

The proximity of the River Lune to the City Centre means that this could also be a suitable low carbon heat source for this cluster, using a water-source heat pump.

Table 5-7 tabulates heat users identified and their annual energy demand within the boundaries of the cluster. There is an annual total heat demand of 10GWh. A network length of 2.5 km is estimated to connect the heat users identified, which results in a linear heat density of 4 GWh/km.

Table 5-7: Heat users identified in Cluster 6.

ID	Building	Data Source	Heat Demand (MWh/yr)	Electricity Demand (MWh/yr)
1	Wyre House Chancellors Wharf	3	1,200	90
2	Cable Street Student Accommodation	4	980	
3	Mitre House	3	760	250
4	Lancaster Police Station	3	740	700
5	The Storey	2	650	230
6	Lancaster Town Hall	2	640	260
7	Mill Hall Halls	3	530	85
8	Lancaster Girl's Grammar School	3	480	230
9	Lancaster Magistrate's Court	3	450	100
10	Travelodge Lancaster Central	4	430	
11	Royal King's Arm	4	420	
12	Royal Mail Office	3	350	130
13	City Block Student Accommodation	4	340	
14	Lancaster City Museum	3	280	50
15	Castle Parade	3	270	50
16	Damside Student Accommodation	4	260	
17	Dallas Road CP School	3	250	100
18	Fire Station	3	210	80
19	Lancaster Central Library	3	210	70
20	City Lab	2	190	140
21	Judges Lodgings Museum	3	150	20
22	Lancaster Maritime Museum	3	120	45
23	YMCA	4	100	
	TOTAL		**10,000**	**2,600**
	Domestic		3,300	200
	Non-domestic		6,500	2,400

	Initial estimate of network length (km)		**2.5**
	Estimated linear heat density (GWh/km)		**4.0**

5.1.7 Cluster 7: South Lancaster

The cluster contains several suitable potential anchor heat loads, including Royal Lancaster Infirmary, the University of Cumbria and Ripley St. Thomas School. Considering the hospitals, University campus, housing estate, local government buildings and a number of public schools, the cluster contains a good mix of user types. Engagement with major stakeholders like Royal Lancaster Infirmary and University of Cumbria has been limited. On the other hand, the Council has been very responsive to information requests, providing data on schools, the housing estate and community centre.

There is an overall heat demand of 31 GWh/year that corresponds to a linear heat density of 7.8 GWh/km. The cluster has the potential for the network to expand to serve the surrounding residential buildings and also to join with the City Centre and East Lancaster clusters. The cluster is separated from the city centre by the Canal, however, there are several bridges which could support the connection of the clusters.

The South Lancaster cluster is more distant from the River Lune, and this may therefore not be a suitable heat source. No data has been identified on the potential heat capacity of the Lancaster Canal, which runs through this cluster, but this is significantly smaller than the river and is not deemed likely to be a suitable source for a large scheme. A borehole-based water-source heat pump may be the most appropriate option, but further assessment of the potential yield and environmental constraints would be required at detailed feasibility stage. This cluster is therefore not deemed as favourable as those bordering the river in terms of the presence of a suitable low carbon heat source.

Table 5-8: Heat users identified in Cluster 7

ID	Building	Data Source	Heat Demand (MWh/yr)	Electricity Demand (MWh/yr)
1	Royal Lancaster Infirmary	3	21,000	6,900
2	University of Cumbria	3	5,500	1900
3	Ripley St. Thomas School	3	1,600	470
4	Lancashire County Council Youth & Community Service	3	720	230
5	BMI Lancaster Hospital	4	630	
6	Moorside Primary School	3	550	140
7	Greaves Housing Estate	2	540	43
8	Bowerham School	3	400	80
9	Fraser Houser, Job Centre	3	160	70
10	Scotforth St. Paul's CoE Primary School	3	150	90
11	The Cathedral Catholic Primary School	3	100	50
12	Stepping Stones Short Stay School	3	60	15
13	St Bernadette's Catholic Primary School	3	50	60

	TOTAL		**31,000**	**10,000**
	Domestic			
	Non-domestic		31,000	10,000
	Initial estimate of network length (km)		**4**	
	Estimated linear heat density (GWh/km)		**7.8**	

5.1.8 Cluster 8: Morecambe

Morecambe town is thought of as a cluster of its own. The area is being considered for major redevelopment plans by the Council, in an attempt to revive the town with tourist attractions and to create jobs. Fifty-five buildings were identified as potential heat users, but only 33 are included here, which are those that have an annual heat demand greater than 100 MWh. Many of these buildings are within the hospitality industry and energy demand data is based on DEC and EPC databases.

The majority of buildings have an annual heat demand less than 1,000 MWh; however, the combined heat demand of the cluster is 14 GWh due to large number of buildings. The buildings are widely spread in this cluster and to connect all buildings listed in Table 5-9, a network length of 7 km was estimated. This results in 2 GWh/km of linear heat density.

However, the fact that the heat demand is made up of a large number of smaller, mainly private sector organisations is expected to lead to challenges in delivery of a heat network scheme in this cluster.

Table 5-9: Heat users identified in Cluster 8.

ID	Building	Data Source	Heat Demand (MWh/yr)	Electricity Demand (MWh/yr)
1	Clifton Hotel	4	3,000	
2	Heysham County High School	3	1,400	470
3	Queen Victoria Hospital	3	800	360
4	Woodhill House	3	680	120
5	Westgate Primary School	3	580	140
6	Post Office	3	570	85
7	Morecambe Community High School	3	540	270
8	White Lund Depot	2	530	170
9	Westgate Housing Estate	2	520	50
10	Altham Meadows Retirement Home	3	460	90
11	Morecambe Football Club	4	400	
12	Alders Retirement Home	4	330	
13	Morecambe Police Station	3	320	20
14	Fire Station	3	300	85
15	Clarendon Hotel	4	250	

16	Belle Vue Hotel	4	250	
17	Morecambe Library	3	240	250
18	Park Hotel	4	240	
19	Summerfields Retirement Home	4	230	
20	Morecambe Bay CP School	3	220	120
21	Festival Market	3	220	250
22	The Platform	2	230	80
23	Jobcentre Plus	3	190	60
24	Lancaster Road Primary School	3	190	100
25	Sandylands CP School	3	180	80
26	West End Primary School	3	170	70
27	King's Arm Hotel	4	170	
28	St. Mary's Catholic Primary School	3	140	65
29	York Hotel	4	140	
30	West End Medical Practice	4	120	
31	Eidsforth Hotel	4	120	
32	Tregothnan Retirement Home	4	120	
33	Glenthorne Hotel	4	110	
	TOTAL		**14,000**	**3,000**
	Domestic			
	Non-domestic		14,000	3,000
	Initial estimate of network length		**7.0 km**	
	Estimated linear heat density		**2.0 GWh/km**	

5.2 Quantitative and qualitative assessment of clusters

The clusters have been assessed through careful consideration of a range of key characteristics of areas suitable for a heat network which are listed in Table 5-10.

Table 5-10: Key characteristics of an area suitable for heat network.

Key characteristic	Reason for importance
High volume of heat delivered	High volume of heating (or cooling) to be delivered is desirable which would result in wider benefit of decarbonising heat to reduce greenhouse gas emissions.
High heating and/or cooling demand density	Sufficient heating (or cooling) demand density is of critical importance, so that the network infrastructure costs are kept low enough to be offset over time by the revenues from heat sales.
Deliverability	The deliverability relates to the likelihood of a project being able to go ahead and deliver the associated benefits within the proposed project timescales. The deliverability has been assessed through a range of factors, including the number and type of stakeholders involved; the level of engagement the stakeholders have shown to date; and the ability for local authority planning policy to influence development of the scheme.
Proximity to low carbon heat source(s)	The availability of low cost and/or low carbon sources of heat in close proximity to the heat demand is a significant advantage. Sources may include waste heat from industry or power stations or water sources such as rivers or the sea. The distance to the heat source(s) will impact the network infrastructure cost.
Potential for innovative district heat network systems	Potential availability of elements of 4th or 5th generation district heating and cooling networks that enable low temperature heat distribution circuit with minimised heat losses.
Mix of user types	A mix of user/sector types provides a diverse heat demand profile, helping to 'smooth' peaks and provide a steady load for the network to serve. It is likely to be most difficult to base a scheme around existing domestic sector buildings given the large number of consumers involved.

The "Volume of heat delivered" criterion was adopted as one of the four Heat Network Investment Project (HNIP) assessment criteria, which is used for scoring eligible applications for funding. This would quantify the heat supplied by the network either as an extension to an existing heat network or as a new heat network.

The "Heat density" criterion is a strong indicator for the likely economic viability of a heat network in the cluster. In order to quantify the heat density of a cluster, an initial network length was estimated that would connect the buildings listed in the cluster.

The "Deliverability" criterion is another of the four HNIP assessment criteria and is incorporated in this study as a scoring criterion which assesses many aspects of the realisation of the project, including engagement with stakeholders, number of stakeholders, local planning policies, new developments and physical constraints. Where relevant, any constraints relating to energy centre location have been considered under the deliverability criterion

The "Low carbon heat source" criterion takes into account the carbon intensity of the heat source, distance between the source and the demand, heat capacity of the source and uncertainty and risks related to the use of the source.

The "Innovation" criterion is important for highlighting the possibility of strategically important opportunities that would play a significant role in the future of heat networks. Elements of 4th and 5th generation district heat networks are the main consideration under this criterion.

Finally, the "Mix of users" criterion evaluates the demand profile through the day and the year, to assess the likelihood of achieving economic plant sizing and operation. A summary of the scoring of key characteristics are shown in Table 5-11.

Table 5-11: Scoring criteria for key characteristics identified for the assessment of clusters.

Key Characteristics	Scoring Description
1 – Volume of heat delivered	This criterion will score clusters based on the potential volume of heat delivered: • Score 3 is given for total heat demand equal to or greater than 15 GWh/year • Score 2 is given for total heat demand equal to or greater than 3 GWh/year but less than 15 GWh/year • Score 1 is given for total heat demand less than 3 GWh/year
2 – Heat Density	This criterion will score clusters based on the linear heat density estimated: • Score 3 is given for heat density equal to or greater than 8 GWh/km • Score 2 is given for heat density equal to or greater than 2 GWh/km but less than 8 GWh/km • Score 1 is given for heat density less than 2 GWh/km
3 – Deliverability	A cluster would receive a score of 3, if: • There are new developments with a major share of the heat demand and good planning policies are adopted by the local government and/or; • There has been good level of engagement with stakeholders that make up a major share of heat demand, • Unless minor constraints are identified for energy centre location and network routes, which could result in a lower score (see below). A cluster would receive a score of 2, if: • There is a weak engagement with major stakeholders and/or; • There are new developments with a major share of the heat demand but planning policies are relatively weak regarding connection of new developments to heat networks, • Unless major constraints are identified for energy centre location and network routes, which could result in a lower score (see below). A cluster would receive a score of 1, if: • New developments making up a major share of the heat demand are already being built and/or; • There has been very limited engagement with major stakeholders and/or; • Stakeholders have indicated that they are not interested in joining to a heat network and/or; • There are major constraints for energy centre location and network routes
4 – Low carbon heat sources	This criterion will score cluster to indicate preference for: • Low carbon intensity of the heat source • Small distance between the heat source and heat demand • High heat capacity of the source compared with heat demand to be served • Low uncertainty and risk related to the use of the source
5 – Innovation	This criterion will score clusters to indicate preference for schemes that could potentially be innovative integrating elements of 4th and 5th generation heat networks such as: • Low temperature heat distribution circuit • Demand side response • Thermal energy storage • Integration of waste heat opportunities – from any building or process that rejects heat above ambient ground temperature
6 – Mix of users	This criterion would be based on qualitative analysis of the type of buildings involved in the cluster, to indicate preference for a mix of users that is expected to bring a balanced demand over the day and over the year.

Table 5-12: Cluster assessment against key characteristics

ID	Cluster	Volume of heat delivered	Deliverability	Low carbon heat sources	Heat density	Innovation	Mix of users
1	East Lancaster	2	2	3	1	2	2
2	Bailrigg	3	3	2	3	3	2
3	Lower Heysham	1	1	3	1	2	1
4	Scale Hall	2	3	3	2	2	1
5	West Lancaster	1	1	2	1	2	1
6	City Centre	2	2	3	2	2	3
7	South Lancaster	3	2	1	3	2	3
8	Morecambe	2	1	2	2	2	3

The outcome of the cluster assessment against the key characteristics expected to determine the viability of a heat network, based on the scoring criteria described above, is presented in Table 5-12. This assessment will be used in the following section to prioritise the clusters, in order to focus the detailed technical and economic assessment on the cluster areas with the highest likelihood of allowing a 'kick-starter' scheme in Lancaster to be developed.

The assessment above also allows us to draw insights into how a wider heat network scheme could develop over time through the expansion of the initial network(s) and potentially the interconnection of the cluster areas presented above. It also allows us to highlight the potential challenges in doing that.

As described in Section 5, the cluster boundaries are to some extent limited by physical constraints such as waterways, railways and roads. Nonetheless, there are several good opportunities for interconnection of clusters in a phased manner.

Interconnection of the cluster areas studied would also bring the potential for extending the heat network to regions of the city between the identified clusters, which are mainly existing residential areas not expected to be suitable for a heat network scheme in their own right. These regions could be incorporated into the network over the longer term once the heat network has reached an extent and a 'critical mass' to be able to support the gradual connection of these customers.

Interconnection of the City Centre, South Lancaster and East Lancaster clusters could form a single, central district heat network. These clusters, individually, have disadvantages, such as peaky heat demand profiles, due to lack of variety of user types, and space for energy centre. However, when combined, the overall cluster would have a smoother heat demand profile and the network could be designed more efficiently, resulting in economically more favourable scheme options.

All three clusters score relatively well in the assessment above, although East Lancaster has much lower heat density than the other two and so the impact on the scheme economics would need careful consideration. East Lancaster can also be considered for connection as a next phase, when a significant amount of the development expected in the East Lancaster Strategic Site is completed, which would increase the heat density of the cluster. West Lancaster is surrounded by railways and the River Lune, which make it difficult to connect with other parts of Lancaster.

Bailrigg cluster contains Lancaster University which is a good opportunity for a district heat network, even within the boundaries of the university. Since considerable amount of development is expected in the region and there are strong local planning policies, interconnection of the developments with the University to form a bigger network is possible. Lancaster University is 3 km away from the southern part of cluster 7. Hence, joining the cluster with the central network would be possible and would add extra benefit for the central network increasing the heat demand to be met substantially, allowing later connection of residential buildings around Scotforth.

The Lower Heysham cluster contains many low-carbon, high capacity energy sources that cannot be utilised fully within the cluster, due to the low heat demand of only 1.3 GWh/year. Connection of Lower Heysham with Morecambe would mean better utilisation of the available waste heat and meeting the heat demand of Morecambe. The distance between heat sources in Lower Heysham and heat users in Morecambe is roughly 6 km. Hence, the main challenge of this connection would be costs associated with heat pipes of the length and diameter required to distribute the heat. The Scale Hall cluster could also be connected to the same network at a later stage, also capturing potential heat users in Middlegate White Lund Industrial Estate.

As a potential step towards the development of a city-wide heat network, in the long term, interconnection of the grouping of Clusters 1, 2, 6 and 7 and with the grouping of Clusters 3, 4 and 8 could be considered. This could allow the heat demand across all those clusters, totalling 107 GWh/yr to be served by a combination of low carbon heat sources, including water-source-heat-pumps and potentially an Energy-from-Waste facility. It is also important to point out that the heat density of clusters vary significantly and the impact of interconnection of the scheme economics would need careful consideration.

5.3 Cluster prioritisation

Within the constraints of this study, it was necessary to prioritise the list of clusters under consideration and to select several of the most promising clusters to take forward to the technical and economic assessment.

Table 5-13: Weighting factor of applied

Key Characteristics	Weighting factor
Volume of heat delivered	*3*
Heat density	*3*
Low carbon heat sources	*3*
Deliverability	*3*
Innovation	*2*
Mix of users	*2*

Each cluster was scored on a scale of 1 to 3 for each characteristic. The characteristics were assigned weighting factors on the basis of a judgement on their relative importance for heat network schemes, and overall scores for each cluster thus derived. Weighting factors applied during the prioritisation process are listed in Table 5-13 and the overall scores for each cluster are presented in Table 5-14.

Table 5-14: Cluster assessment summary

ID	Cluster	Weighted score	Taken forward?	Summary rationale if not taken forward
2	Bailrigg	43	No	Heat networks already under consideration by Lancaster University
7	South Lancaster	37	Yes	N/A
6	City Centre	37	Yes	N/A
4	Scale Hall	36	Yes	N/A
1	East Lancaster	32	No	Low heat density
8	Morecambe	31	No	Low deliverability due to large number of smaller, private organisations making up the heat demand
3	Lower Heysham	24	No	Low heat density
5	West Lancaster	21	No	Low heat density

Following this procedure, a consultation was held with the HNDU in order to agree on which clusters to take forward to the technical and economic assessment. The decision was based on the assessment procedure described above which incorporated some of the HNIP funding criteria and input from HNDU.

A summary of the clusters taken forward to the economic assessment, and the main rationale, is provided in Table 5-14. Although the Bailrigg cluster scored highest, the next three highest scoring clusters were selected to take forward to detailed techno-economic analysis. Considering the advanced stage of Lancaster University's heat network plans, it was decided to focus here on new areas within the wider Lancaster area rather than risk repeating work already done. The Bailrigg cluster remains an important option and follow up is recommended as a conclusion of this study. The prioritisation also took account of the need to find the appropriate balance, in the heat mapping and masterplanning study, between number of clusters taken forward for technical and economic assessment, and the level of detail that would be possible within the time available.

The prioritised clusters are described in greater detail in Section 6.3. Based on the results of the techno-economic analysis, the clusters that were not prioritised will be assessed later in Section 6.7, in order to draw insight in to the potential for these clusters to be developed as later phases of heat network development across the city.

5.4 Heating technology options appraisal

Based on the heat source mapping undertaken in Section 4.3, a range of potential heating technologies were considered for the prioritised clusters, including the following:

- Waste heat from Energy-from-Waste plant
- Water-source heat pump
- Gas combined heat and power (CHP)
- Biomass boiler/CHP

Further relevant information on the potential application of these options, and the rationale for the options selected to be taken forward, is provided below.

Waste heat from Energy-from-Waste plant

There is a plan for an Energy-from-Waste facility in lower Heysham, which would offer the potential for capture of waste heat to serve a heat network in the Lancaster area. However, this (planned) EfW plant would be more than 5-6 km from the prioritised clusters, leading to large costs in the transmission of heat to the network. Given this distance, and the uncertainty over the development of the plant, this option is not taken forward for the prioritised clusters.

Water-source heat pump

Heat pumps extract thermal energy from a renewable source, such as the air, ground or a body of water, transfer the heat to a refrigerant and use an electrically driven compression-expansion cycle to first increase the temperature of the heat and then deliver it to the heated space.

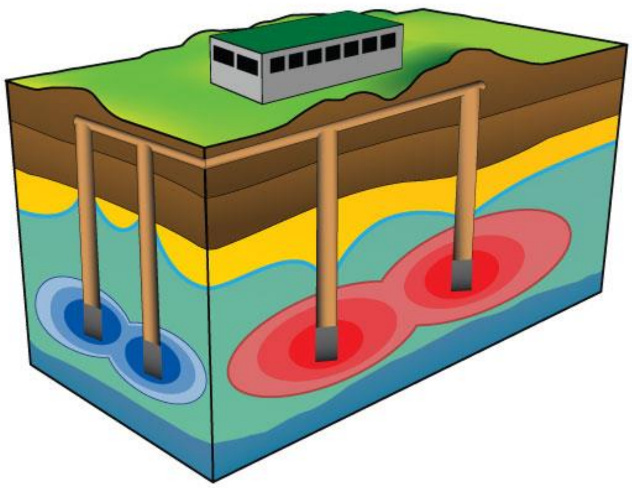
Water-source heat pump systems, as the name suggests, take water as the heat source, whether this be a river, sea or sub-surface groundwater. WSHP systems may be *open loop*, in which case water is physically abstracted from the source before some of its heat is extracted, and the water rejected back to the source, or *closed loop*, in which case no water is abstracted from the water source. For closed loop systems, an enclosed volume of water running through pipework submerged in the water source extracts heat from the water source by conduction, before being transported to the heat pump.

In Lancaster, both open loop and closed loop systems could be relevant. As described in the heat source mapping in Section 4.3, the River Lune is a potential source of heat. The Lune was identified, in the Department of Energy & Climate Change's *National Heat Map: Water source heat map layer* report, to have an estimated heat capacity of 37 MWth.

For clusters further away from the river, or where a suitable energy centre location cannot be identified sufficiently close to the river, systems based on abstraction of groundwater via boreholes (e.g. from aquifer layers) could be most suitable. A schematic diagram of an open-loop groundwater aquifer-based WSHP system is shown in Figure 5-2. In a site with a suitable hydrogeology, a single pair of boreholes (one extraction and one rejection borehole) can deliver between 250 kW and 500 kW of thermal power. Multiple boreholes can be used to deliver multiples of this thermal power.

The efficiency of a water-source heat pump (as for any heat pump) is dependent on the source temperature and output (i.e. network flow) temperature; the closer these temperatures the higher the efficiency. In this study, we make a conservative assumption of 90°C flow and 70°C return temperature, since the proposed schemes serve multiple existing buildings for which we have not yet been able to ascertain compatibility with low flow temperatures. The ability to reduce the network temperature would allow a higher heat pump efficiency to be achieved.

Figure 5-2: Schematic of an open-loop system with abstraction and rejection of aquifer water[12]



[12] Image courtesy of G-Core (2016)

Gas combined heat and power (CHP)

Gas combined heat and power (CHP) systems are a mature and proven technology, and are used in the majority of heat networks currently installed in the UK.

However, Gas CHP is not considered a suitable low carbon solution in the context of the potential heat networks schemes studied here. This is based on the fact that should any DH design become a live project, it is possible the scheme would still be operational 15-20 years later from a start date unlikely to be earlier than 2021. This implies the continuing use of gas into the mid to late 2030s. This is not considered to be compatible with a pathway towards net zero carbon emissions by 2050 as is likely to be targeted by the UK Government following the Paris Accord.

Gas CHP was therefore not included as a heat source in the Technical and Economic assessment.

Biomass

Biomass boilers are similar to conventional gas and oil boilers but are fuelled by biomass; typically, wood chips or wood pellets although energy crops can also be used. The key advantage of biomass over Gas CHP is the significantly lower carbon intensity of the fuel. It is for this reason that Biomass boilers are currently eligible for the Renewable Heat Incentive (RHI) in the UK.

Biomass boilers are relatively cost-effective as compared with other renewable heating technologies. However, the key disadvantages of biomass include:

- **Fuel supply logistics and storage**. Assuming delivery by road, the impact of vehicle movements on local traffic needs to be considered. Furthermore, additional space in the energy centre will be required for a wood fuel store.
- **Impact on air quality** associated with biomass combustion. In particular, biomass combustion releases NOx and fine particulates, whose concentrations should be minimised. This means that biomass is less suitable for densely populated residential, educational or employment areas.
- **Security of fuel supply**. The risk of an interruption to biomass fuel supply can be minimised by entering into a long-term supply contract. Given the requirement for delivery by road, however, even with such a contract in place, there is some risk of a temporary interruption to supply associated with access (e.g. due to a road closure).

Biomass heating was reviewed as a potential heat source in this study, but rejected due to the urban location of the prioritised clusters, where the adverse air quality impacts and delivery logistics are deemed unlikely to be acceptable.

Table 5-15: Summary of pros and cons of heat supply options

Option	Pros	Cons
Waste heat from Energy-from-Waste plant	✓ Potential to be **very low cost heat** ✓ **Low carbon** (exact carbon intensity depending on source)	• Unless heat source close to demand centres, heat transmission cost can be high • Likely to have some downtime so additional backup plant required
Water-source heat pumps (WSHP)	✓ Potential to be very **low carbon** ✓ Can be relatively cost-effective particularly where **supported by RHI** ✓ Where **cooling** is also required, economics improved significantly	• High capital cost • Requires substantial electrical grid capacity • Risk of RHI support being reduced/withdrawn (scheme planned for closure 2021)

Gas combined heat and power (CHP)	✓ **Mature and proven** technology ✓ Relatively **cost-effective** without subsidy ✓ Opportunity to deliver **on-site electricity**	• Fossil fuel-based, carbon savings will become minimal and then negative, during the 2020s, as grid decarbonises further
Biomass boiler	✓ Potential to be very **low carbon** ✓ Cost-effective option where **supported by renewable heat incentive** (RHI)	• Regular deliveries and/or large storage required for biomass • Air Quality and environmental issues mean less suitable for urban areas • Risk of RHI support being reduced/withdrawn (scheme planned for closure 2021)

Table 5-16: Summary of heat source options taken forward for each cluster

Cluster	Waste heat from Energy-from-Waste plant	Water-source heat pump[13]	Gas CHP	Biomass
4: Scale Hall	Excluded (too distant)	**Included** – open-loop system using water from borehole	Excluded (lock-in of high carbon intensity)	Excluded (adverse air quality and delivery logistics in urban context)
6: City Centre		**Included** – open-loop system using water from borehole		
7: South Lancaster		**Included** – open-loop system using water from borehole		

[13] Specification of water source is based on selected energy centre location as described later in the report – see Section 6.3.

5.5 Constraints within the study area

Major constraints on heat network routes in the study area were also mapped. Figure 5-4 shows the railways, waterway and major roads. The River Lune and Lancaster canal present a significant constraint across the region, dividing the city into several parts, requiring bridges to be used to connect between clusters. Railway routes are also plotted to highlight the regions where the interconnection of heat users would be obstructed by railway lines. These regions are mainly Morecambe and Central Lancaster.

Three Air Quality Management Areas (AQMA) have been declared by the Council in the City of Lancaster. Two of these are outside of the red-line boundary which are in Central Carnforth and Galgate. The only AQMA within the study area is Central Lancaster which is marked with a red triangle. The Air Quality Annual Status Report 2018 states "*Currently the main air quality issues in Lancaster remain linked to emissions from road traffic. These emissions continue to cause exceedance of air quality objectives for the pollutant nitrogen dioxide (NO2) and contribute towards elevated levels of particulate (PM10 and PM2.5).*"[14]

These physical constraints were taken into account in the definition of potential clusters and their potential connections together.

[14] http://www.lancaster.gov.uk/environmental-health/environmental-protection/air-quality/air-quality-reviews-and-assessments, Air Quality Annual Status Report 2018 (Accessed April 2019)

Figure 5-3: Heat sources identified within the study area

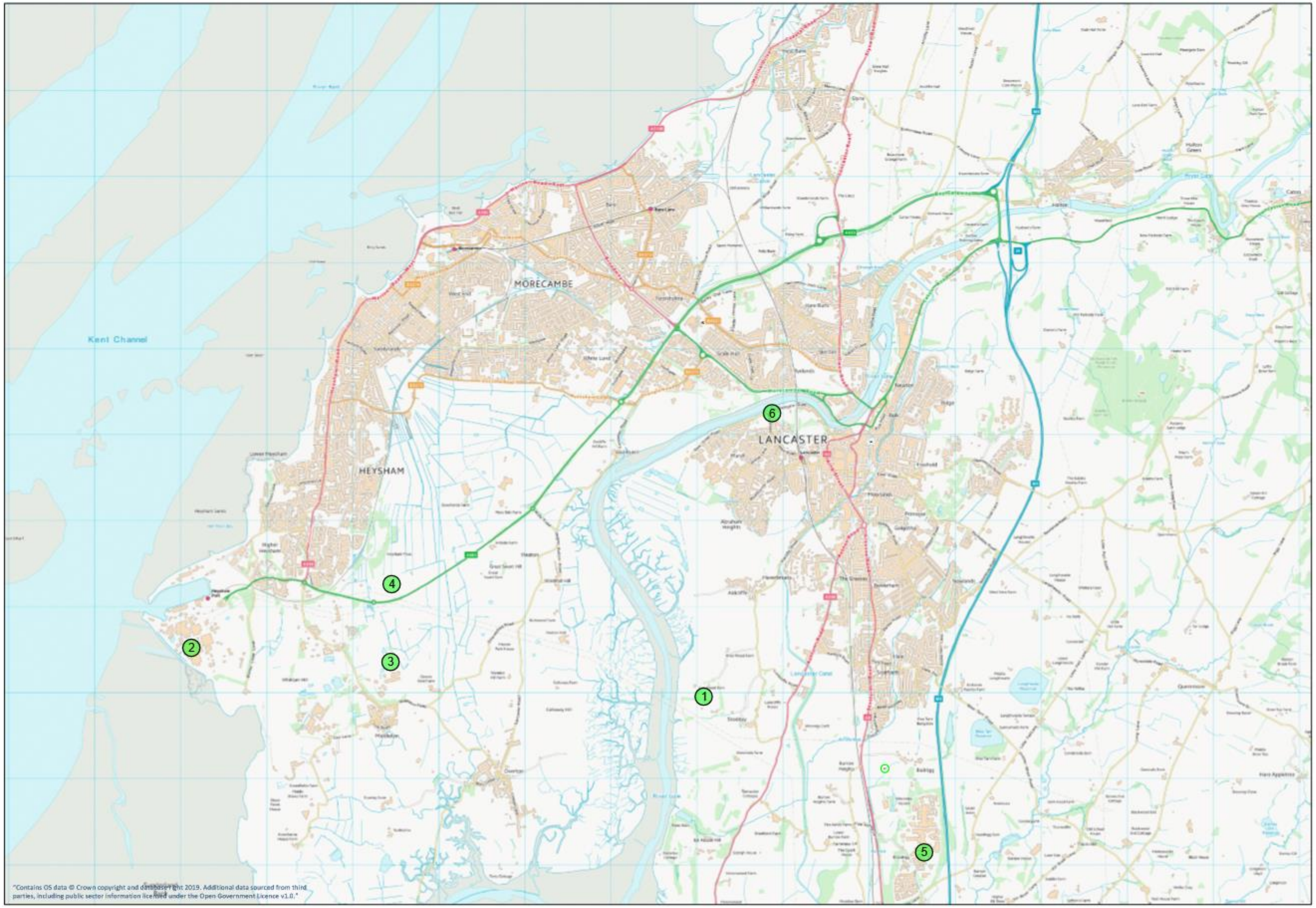
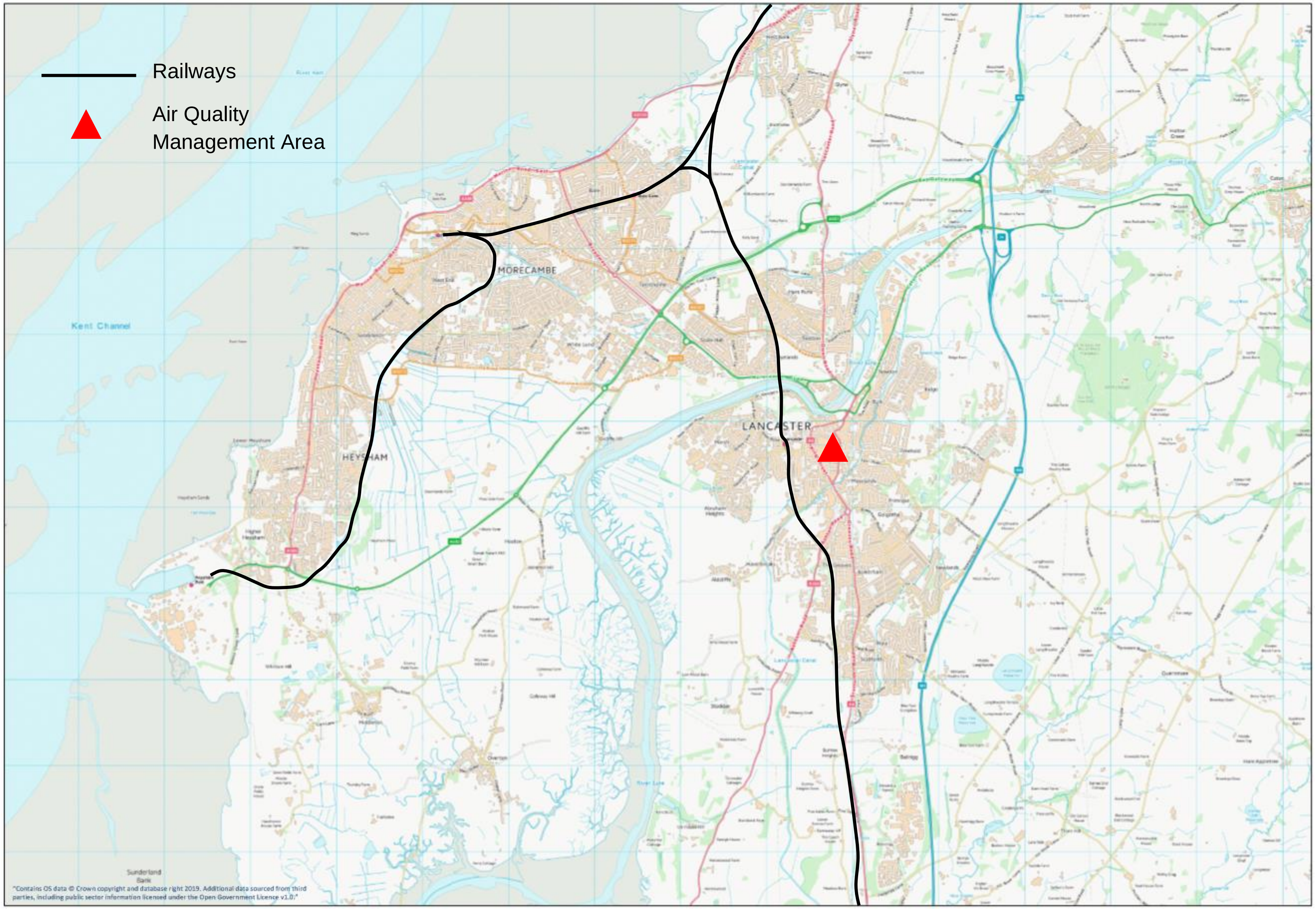


Figure 5-4: Constraints map of Lancaster



A further important constraint for consideration is the electrical grid capacity. A leading heat source option in the area is a water-source heat pump. Since this will represent a large electrical load, limited demand capacity on the relevant substations presents a potential constraint, the impact of which on project timescales and cost would need to be further understood. Electricity North West develop a *Heatmap tool*[15], which presents the location and headroom of 33 kV, 11 kV and 6.6 kV substations.

A table based on data on the 11 kV and 6.6 kV substations from the *Heatmap tool* is presented below, containing the ten such substations closest to Lancaster[16]. The table shows that five out of ten of the 11 kV and 6.6 kV substations have no more than 3.1 MW headroom, with two having no headroom at all. Those with no headroom include Trimpell, in Morecambe, and another in Claughton, outside our red-line boundary. The next three most highly constrained include Westgate and Woodhill Lane, also in Morecambe, and Burrow Beck, between Lancaster and Bailrigg. It would be important, in the detailed feasibility and detailed project development stages, to understand the impact of this on the timescale and cost of a project using a heat pump as heat source.

11 kV and 6.6 kV substations near Lancaster

Primary Substation	BSP Group	GSP Group	Primary Substation Location		Headroom (MW)
			Easting	Northing	
SPRING GARDEN ST 11kV	LANCASTER	HEYSHAM	347661	461494	18.3
SPRING GARDEN ST 6.6KV	LANCASTER	HEYSHAM	347651	461484	11.7
LANCASTER	LANCASTER	HEYSHAM	348644	463628	1.8
BURROW BECK	LANCASTER	HEYSHAM	347903	458401	3.1
BROADWAY	LANCASTER	HEYSHAM	344792	464471	11.2
WESTGATE	LANCASTER	HEYSHAM	343077	463204	1.2
WOODHILL LANE	LANCASTER	HEYSHAM	343294	463785	2.2
BOLTON LE SANDS	LANCASTER	HEYSHAM	347707	467237	6.4
TRIMPELL	-	HEYSHAM	341861	458979	0.0
CLAUGHTON	LANCASTER	HEYSHAM	355872	466268	0.0

[15] https://www.enwl.co.uk/get-connected/network-information/heatmap-tool (Accessed May 2019)
[16] Data on the 33 kV substation serving Lancaster suggests there is around 25 MW headroom on that substation, which would not currently present a constraint.

6 Scheme Options Appraisal

6.1 Technical assessment approach

The technical and economic assessment has been undertaken for each of the three selected clusters. The assessment was carried out in accordance with the CIBSE Heat Networks Code of Practice CP1.

For each cluster, a series of scheme options have been specified in detail, differing in the extent of the heat sources considered, proposed network and the assumption of which customers connect to the scheme. A range of heat supply options are studied for each cluster, according to the suitability of each heating option to the particular scenario.

In the technical assessment, the energy demand data gathered and derived for each customer, as described in Section 3, was used to undertake an outline design of the heat network, including the appropriate primary and auxiliary plant sizing, the network route and length, the pipe sizing, the peak and annual fuel consumption and so on. Key assumptions used in the technical assessment are provided in Appendix B.

Energy demand profiles, diversity and estimate of peak demand

Where thermal energy demand was based on actual meter readings, it was weather-corrected using the appropriate degree-day data for that year.

The annual heat demand for each building was then converted into hourly demand profiles, distinguishing the heating and hot water components. The heat demand profiles applied have been generated over past projects, using Matlab to produce profile values based on data taken from real world projects, accredited publications (CIBSE Guide F / TM46), and thermal modelling software (IES).

A light diversity factor of between 20% and 50% was applied to the domestic hot water. However, the impact on plant sizing was minimal in comparison to the heating demand.

The individual hourly demands were combined so that an annual heat load duration curve could be plotted and the peak demands calculated. It is acknowledged that due to the typical lack of diversity in the building types in each cluster, the peak heat demand calculated may be slightly overestimated. It is likely in practice that the peak demand would be somewhat lower than modelled here, and hence our analysis can be seen as conservative in the sense that plant is sized to meet the higher estimate of the peak demand. Refinement of this analysis would require more detailed hourly energy use data for each building.

Plant sizing

In order to select the most suitably sized clean tech plant for the energy centre, an analysis of the thermal demand on each cluster using energy data from the 15th of each month (e.g. 15th January, 15th February, up to 15th December) was used. The 15th of the month is selected as it avoids any dates during Christmas week or summer bank holidays.

It was found that thermal demand changes rapidly over the course of the day reaching a peak around 8am until 7pm when it then drops significantly until 4am the next day. This differential is significantly more prominent during the winter months.

The clean tech plant within the energy centre must provide heating to meet both maximum winter and minimum summer loads, whilst at the same time optimising its operating regime to pass on the benefits to the customer connections. Equipment selection must avoid choosing a single plant sized on the maximum thermal demand as this will result in oversizing and the plant being mothballed for a large proportion of the year.

The amount of thermal storage included in the scheme has been optimised in order to reduce the number of operating hours that supplementary fossil fuel plant is needed to assist the low carbon 'base load' heating plant, at times of high demand. Numerous performance runs were carried out sampling various combinations of low carbon plant and thermal storage vessels capacities, to select the most appropriate size.

For this study, thermal storage has been based on capacity variables of 50 m^3, a typical storage capacity used by district heating providers in the UK. The amount of thermal energy in a vessel is calculated by:

$$\text{Thermal Energy Storage} = \frac{m^3 \text{ capacity x temperature difference (K) x CP (kJ/kgK) x 1000}}{3600 \text{ (seconds per hour)}}$$

Assumptions

- Specific Heat (CP) = 4.2 =kJ/kg°K
- Temperature difference = 20K
- Density of water with inhibitor solution at 80°C = 0.9718 kg/l
- 90% of thermal storage volume available to store heat

On this basis, a 50,000-litre vessel can store around 1050kWh.

Note this storage capacity is based on a district heating scheme where connections are of a more traditional type, running at an 80°C flow and 60°C return temperature. If all new connections can be designed to operate on lower temperatures with a wider difference (e.g. 70°C flow and 40°C return) then additional energy storage becomes available from the thermal stores. This may need to be carried out alongside refit works at existing customers premises (e.g. installation of new radiators, adjustments / modifications to the AHU's, circuit rebalancing, etc).

The predicted thermal output for each of the three prioritised clusters in Peterborough is provided in Appendix B.

6.2 Economic assessment approach

An economic assessment was then undertaken for each scheme option. On the basis of the scheme design and sizing, the cost of all required generation plant and heat network infrastructure was derived, including upfront costs, replacement costs and ongoing operational and fuel costs. The potential value of revenue streams was calculated, including the value of heat sales based on an estimate of the counterfactual price of heat that could be expected for the customers connected; potential revenue from electricity sales (where relevant); potential revenue from the Renewable Heat Incentive, for the case of heat pumps. Key assumptions used in the economic assessment, including all costs and revenues are provided in Appendix C.

The economic analysis of the scheme options in Peterborough has been undertaken for a number of different scenarios, differing in terms of key parameters that influence the system economics. Not all scenarios are relevant to all scheme options, as follows:

- **Base Case scenario** – Each of the scheme options has been assessed under Base Case assumptions.
- **Base Case + RHI** – In this scenario the Base Case assumptions are applied, but RHI revenues are included. This scenario is only relevant to scheme options that include an RHI eligible heating technology.
- **Optimistic Case** – Although not a formal optimisation, we have considered how the economics could be improved under a more 'optimistic' set of input assumption. The 'Optimistic Case' has not been applied to all scheme options, only those where the Base Case economics are marginal.

The key assumptions in these three cases are as summarised below:

Table 6-1: Key assumptions used in the techno-economic modelling for three different cases

Parameter	Base Case	+RHI	Optimistic Case
Heat sales price (p/kWh)	5.1	As Base Case	5.7
Gas purchase price (p/kWh)	2.4	RHI included at the following tariff rates: Tier 1: 9.36 p/kWh Tier 2: 2.79 p/kWh RHI paid for a period of 20-years	2.4
Peak electricity price (p/kWh)	11.7		10.0
Off-peak electricity price (p/kWh)	7		7
Off-peak electricity usage (WSHP)	40%		40%
WSHP C.O.P	280%		280%

The BEIS Existing Policies scenario has been used as the source for the energy prices and their subsequent growth.

The heat sale price to the scheme off-takers is a key parameter in the economic assessment. The Base Case heat sale price has been calculated through the estimation of the counterfactual cost of generating heat. In order to calculate the counterfactual cost to the consumers we estimated their variable and fixed tariffs. In estimating the variable tariff, the BEIS Baseline policies service sector gas price and a boiler efficiency of 85% was used. The fixed elements of the counterfactual heat price has been calculated on the basis of the assumptions shown in Appendix C, Table 11-2. For this analysis we have used a 'blended' heat sale prices – there are two aspects of this:

i. **The heat sale price is the same for all off-takers** – our calculation of the counterfactual heat price varies for differing quantities of gas consumption due to changes in the fixed elements of the price (the same unit cost for gas is assumed irrespective of annual quantity consumed). The blended heat sale price is a weighted average of the counterfactual heat price that would be paid by off-takers based on their consumption band (weighted by their annual consumption).
ii. **The heat sale price only has a volume dependent element** – While fixed and variable elements of the counterfactual heat price have been taken into account in calculation of the heat tariff, the total counterfactual heat cost has been divided by the total counterfactual gas consumption to derive a unit cost for the heat tariff, without splitting out a fixed element.

Water Source Heat Pump Scheme Option:

In the scheme options where water source heat pumps are the main heat generators, we have analysed three different scenarios: Base Case, Base Case + RHI, and Optimistic Case.

In the base case, we have used the same variables as in all other base cases, irrespective of technology. In the Base Case + RHI scenarios, we have calculated the additional revenue provided by the subsidy scheme (over a 20-year period for the non-domestic RHI). We have used the tiered values available between 1 January 2019 and 1 April 2019 which are shown in the table below:

Table 6-2 Tiered RHI Incentives Available for Water Source Heat Pumps

Tier	Incentive in p/kWh
Tier 1 (paid for first 1,314 hours of peak output)	9.36
Tier 2 (paid for remainder of heat generated)	2.79

In the Optimistic Case analysis, we have changed the variables to improve the overall case in line with the other scheme options while also changing the Peak electricity price to 10 p/kWh under the assumption that a high energy user would have the negotiating power to achieve this pricing point.

The scheme options we have analysed are:

Cluster Name	Scheme Option Name
South Lancaster	South Lancaster – Water Source Heat Pump (assuming an open-loop system using water from borehole)
City Centre	City Centre – Water Source Heat Pump (assuming an open-loop system using water from borehole)
Scale Hall	Scale Hall – Water Source Heat Pump (assuming an open-loop system using water from borehole)
South Lancaster and City Centre Combined Cluster	South Lancaster and City Centre Combined Cluster – Water Source Heat Pump (assuming an open-loop system using water from borehole)

For each case, a set of common outputs were derived to allow a comparison of the scheme options considered against each other, and against typical performance benchmarks for the viability of a heat network. These include the project capital cost, the internal rate of return (IRR), the net present value (NPV), the lifetime cost of heat supply, lifetime CO_2 emissions savings and the 'funding gap' to project viability.

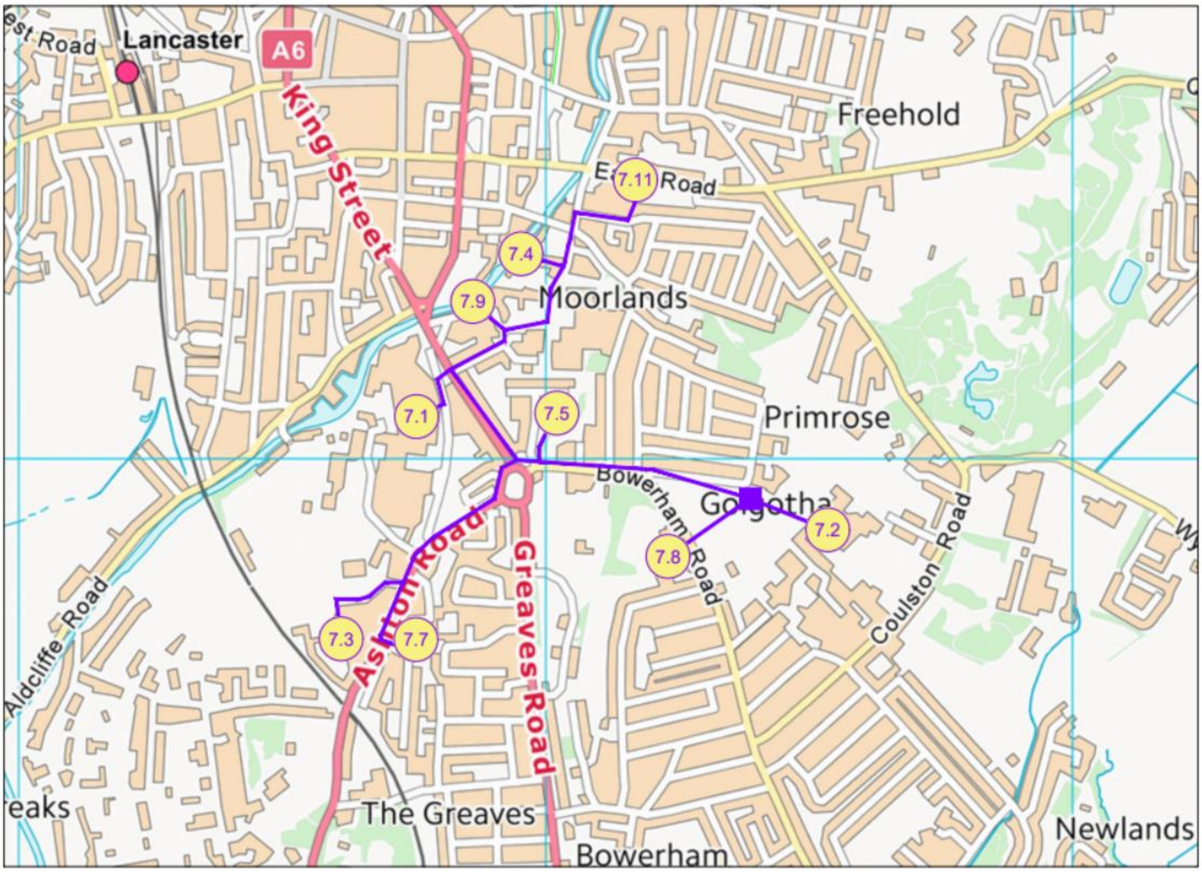
6.3 Technical and economic assessment results

6.3.1 South Lancaster

The network route for the proposed scheme for South Lancaster cluster is presented in Figure 6-1 and the customers connected are shown in Table 6-4. Lancaster Royal Infirmary and Cumbria University form the core of the scheme. Besides the hospital and the University, the cluster includes several schools, a community centre, a council housing estate and the job centre.

Royal Lancaster Infirmary was not responsive to our engagement attempts. Therefore, other sources were used to gather information about the hospital such as the Estates Return Information Collection (ERIC) 2017/18 report. It was found from this report that the hospital does not include any on-site energy generation. Data regarding Cumbria University was obtained from the DEC database which is the main source of information in this cluster. On the other hand, a good engagement with Lancaster City Council was established and data regarding the Greaves Housing Estate was obtained directly from them.

Figure 6-1: Scheme network route for South Lancaster



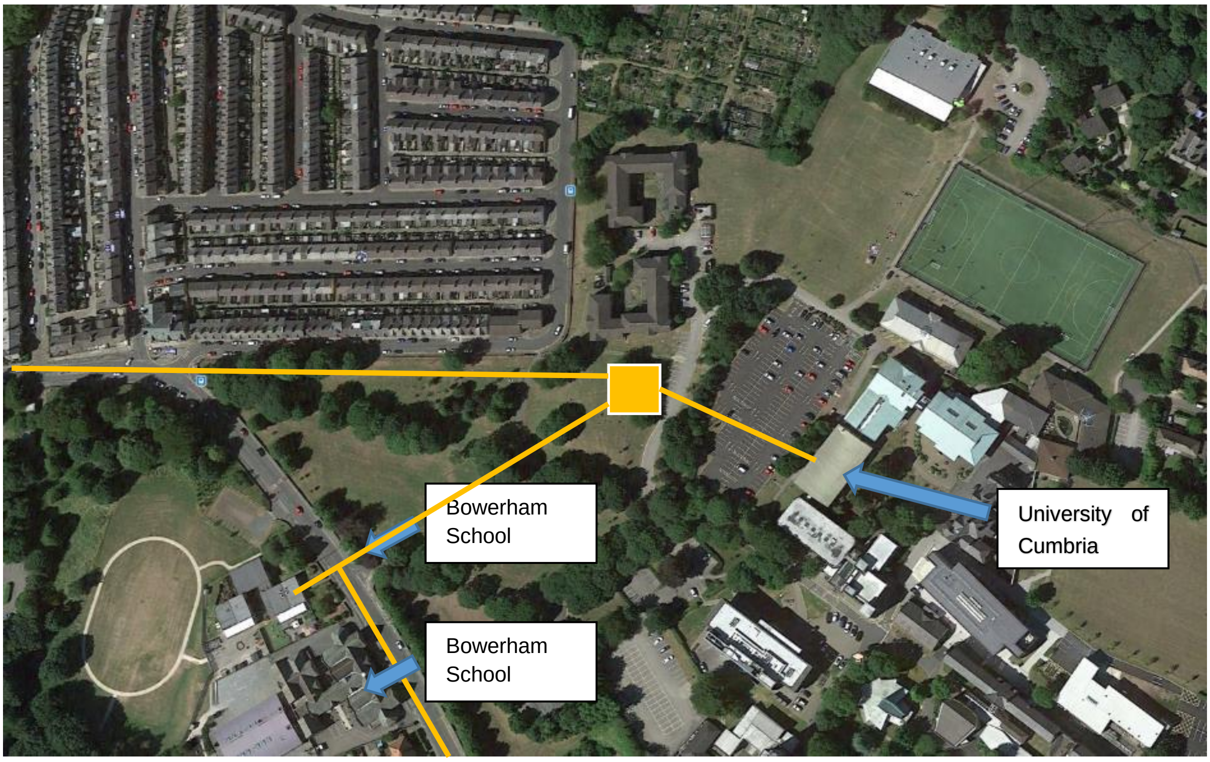
Selection of energy centre location

Where possible, it is preferable to locate the energy centre near to large anchor heat customers, in order to reduce the length of large diameter pipework. For this cluster the two anchor customers are as follows:

- Royal Lancashire Infirmary = 21000 MWh, peak load 6022 kW
- University of Cumbria = 550 MWh, peak load 3528 kW

We have assumed that a green field site would be made available to locate the South Lancaster cluster's energy centre within the University of Cumbria site, on the basis that the University becomes involved with the scheme. Typically, universities have tended to be strong adopters of district heating schemes. For example, the neighbouring University of Lancaster is keen to redevelop its existing district heating network, integrating new developments in district heating best practice into the design.

Figure 6-2: South Lancaster, energy centre location



Alternative energy centre locations were assessed, as shown in Figure 6-3. The advantages and disadvantages of the alternative options, leading to the selection of the University of Cumbria site, are explained in Table 6-3.

Figure 6-3, South Lancaster – energy centre locations considered

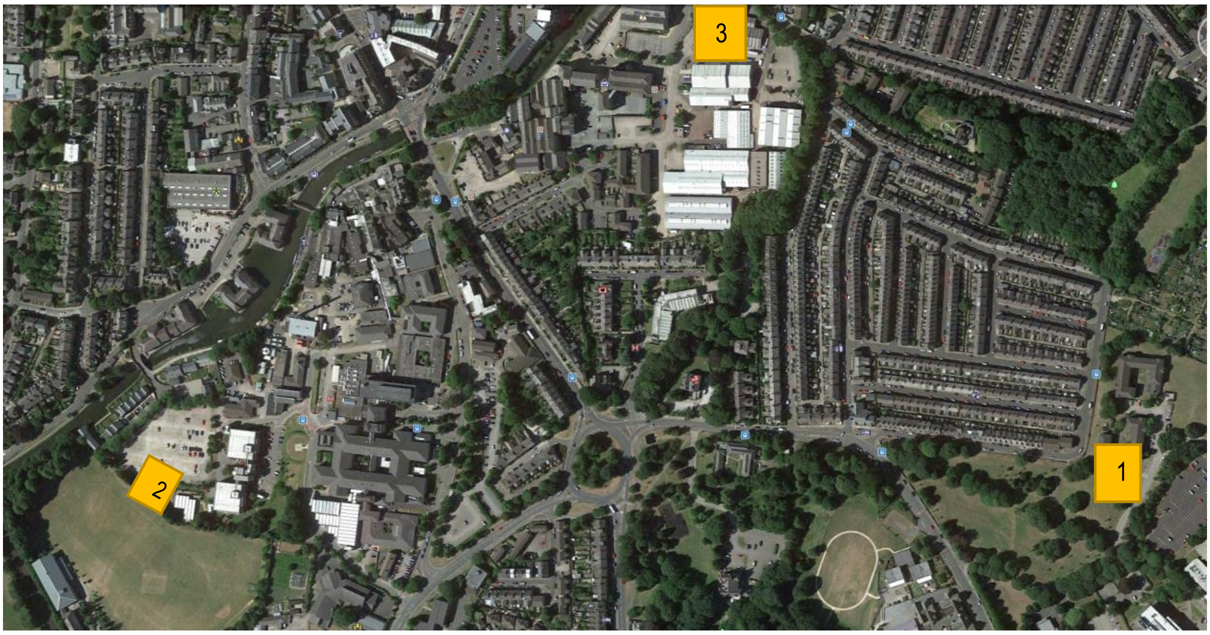


Table 6-3: Comparison of energy centre locations considered

No	Energy Centre Location	Advantages	Disadvantages	Selected for modelling	Issue for further research
1	University of Cumbria	• Green field area. • Energy centre close to large user.	• Planning permission issues due to location in landscaped park area. • Assumed ground water source is available with no environmental constraints.	Yes	• Registered owner of land. • Confirmation of future use for development land. • Electrical supply confirmation of suitable 3phase electrical connection point. • Secondary heating system operating temperatures and control philosophy installed used for central heating and hot water at all proposed connections. • Stakeholder engagement with facilities manager for each connection. • Ground water survey to determine availability, yield and environmental constraints associated with ground water source.
2	Royal Lancaster Infirmary	• Energy centre close to the largest heat loads. • Energy centre close to local river water source.	• Compromises number of carparking spaces for hospital. • Tall building close by, potential issues with flue height.	No	
3	White Cross Business Park	• Industrial area location. • Energy centre close to local river water source.	• Availability of suitable industrial unit. • Civil works modification to industrial unit for foundations, electrical connection, flues. • Energy centre considerable distance from large heat loads.	No	

Table 6-4: Scheme customers in South Lancaster

ID	Customer	Data Source	Estimated Heat Demand (MWh/year)	Peak Heat Demand (kW)	Estimated Electricity Demand (MWh/year)
1	Royal Lancaster Infirmary	3	20,800	6,022	6,900
2	University of Cumbria	3	5,490	3,528	1,900
3	Ripley St. Thomas School	3	1,620	1,018	470
4	Lancashire County Council Youth & Community Service	3	720	335	230
5	BMI Lancaster	4	630	203	-
7	Greaves Housing Estate	2	540	181	43
8	Bowerham School	3	400	138	80
9	Fraser House, Job Centre	3	160	98	70
11	The Cathedral Catholic Primary School	3	100	63	50
	Total		**30,453**	**11,170**[17]	**9,790**

A summary of the technical assessment for the South Lancaster cluster is shown in Table 6-5. The total heat demand in the cluster is 30.5 GWh/year with a peak demand of 11.2 MW (this is effectively an undiversified peak – see the start of Section 6.1 for a description of the treatment of diversity). The total distribution length, including the main distribution network and the service pipe serving individual buildings, is 2.8 km which results in a linear heat density of 10.9 GWh/year/km.

Table 6-5: A summary of technical assessment for South Lancaster

		Unit	Value
Annual heat demand at full build-out	Total	GWh/yr	30.5
Peak heat demand	Total	MW	11.2
Number of connections	Total	#	9
Network route length	Distribution	km	1.1
	Service		1.7
Network temperature	Network flow/return temperature	ºC	90/70
	Network delta T		20
Linear heat density		GWh/yr/km	10.9

[17] Peak Heat Demand (kW) is not in general equal to the sum of the individual building peaks, since these do not in general coincide.

The proposed plant selection has been designed to maximise the usage of low carbon heat from the energy centre, hence includes a large capacity of thermal storage (estimated at 5362 kWh in the thermal stores and DH pipework). The sizing of thermal plant is shown in Table 6-6.

Table 6-6: Summary of proposed plant for South Lancaster

Plant Suggestion	No.	Individual Capacity	Notes
Thermal Store	2	100 m^3	200 m^3 required in total
WSHP	2	3500 kW	Assumes open-loop WSHP using water from borehole. Assumed SPF of 2.80.
Main gas boiler back up plant	3	3700 kW	Based on heat rating 3700 kW to 925 kW
Modular gas boiler plant	2	470 kW	Based on heat rating from 436 to 85 kW

On a peak winter heating day, the WSHP operates fairly continuously at high output. The thermal storage is filled overnight, but due to the size of the morning peak demand it is discharged relatively quickly, such that the gas boilers are required to operate in concert with the WSHP to meet the load throughout the day. The operating profiles for these plant components on a typical winter day are shown in the figure below.

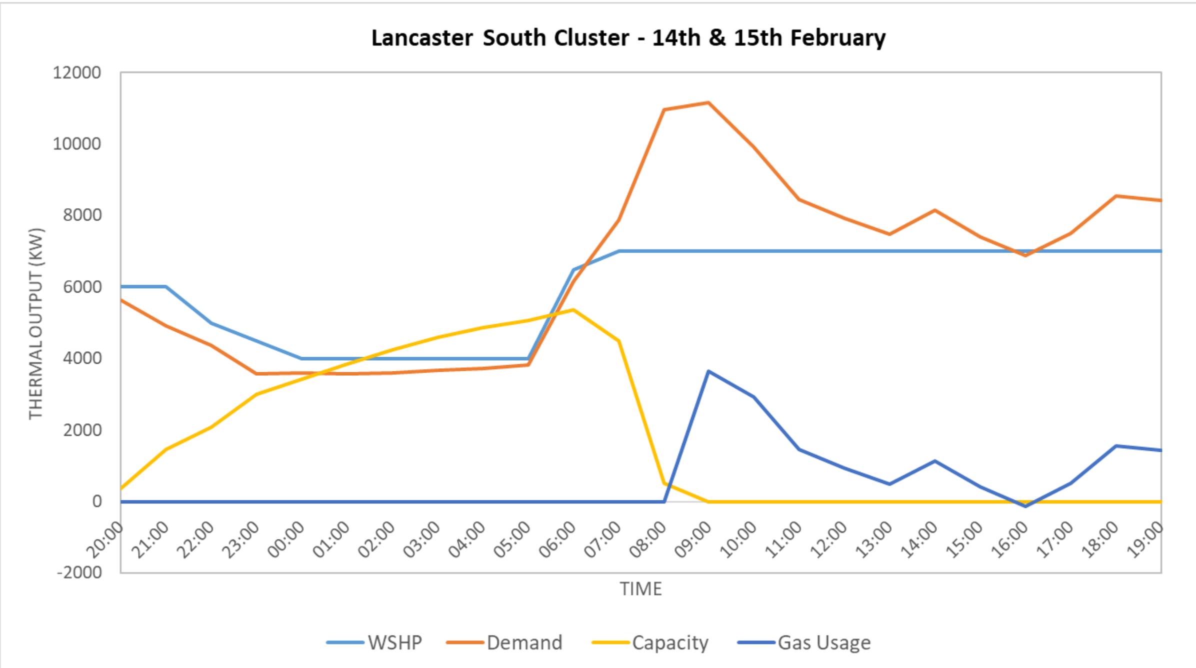


Figure 6-4: Plant operating profiles for the South Lancaster scheme on a typical winter day

In summer, due to the much lower demand, the WSHP utilisation drops considerably and the gas boilers do not need to operate. The operating profiles of the plant components on a typical summer day are shown below.

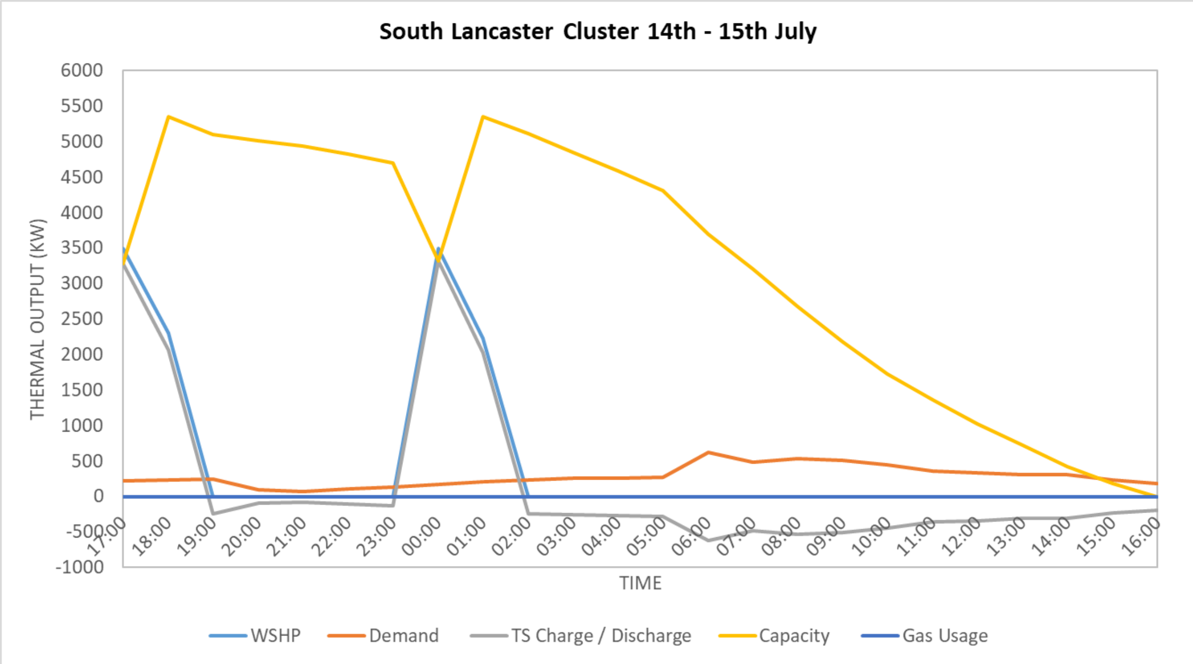


Figure 6-5: Plant operating profiles for the South Lancaster scheme on a typical summer day

Table 6-7: Associated costing of the network for South Lancaster

Cost Breakdown	Value (£)
WSHP	6,720,000
Boiler	421,400
Network (pipe)	3,867,00
Heat interface units (HIUs)	160,000
Energy Centre	1,500,000
Thermal Storage	170,000
Engineering procurement & project management	870,000
Other costs	290,000
Contingency (10%)	1,426,207
TOTAL	**15,688,280**

Table 6-8: Annual Opex estimates for South Lancaster system

Cost Breakdown	Value (£/yr)
Thermal plant O&M	263,000
Network O&M	2,100
Fuel costs (in Year 1)	1,306,951
Staff costs	50,000
Metering & billing	70,000
Insurance	20,000
TOTAL	**1,712,050**

6.3.1.1 South Lancaster Cluster – WSHP Base Case

Key Base Case assumptions

Heat sale price 5.1p/kWh

Gas purchase price 2.4 p/kWh – BEIS Existing Policies Industrial Gas Price

Peak electricity purchase price 11.7 p/kWh – BEIS Existing Policies Industrial Electricity Price

Off-peak electricity purchase price 7 p/kWh

WSHP electricity supply assumed to be 40% off-peak

Table 6-9 Key economic indicators for the South Lancaster Cluster - WSHP, Base Case

Years	**25**	**30**	**40**
IRR	-7.56%	-4.26%	-1.51%
NPV (@3.5%)	£ (11,900,000)	£ (11,250,000)	£ (10,200,000)
Discounted Payback Period	-	-	-

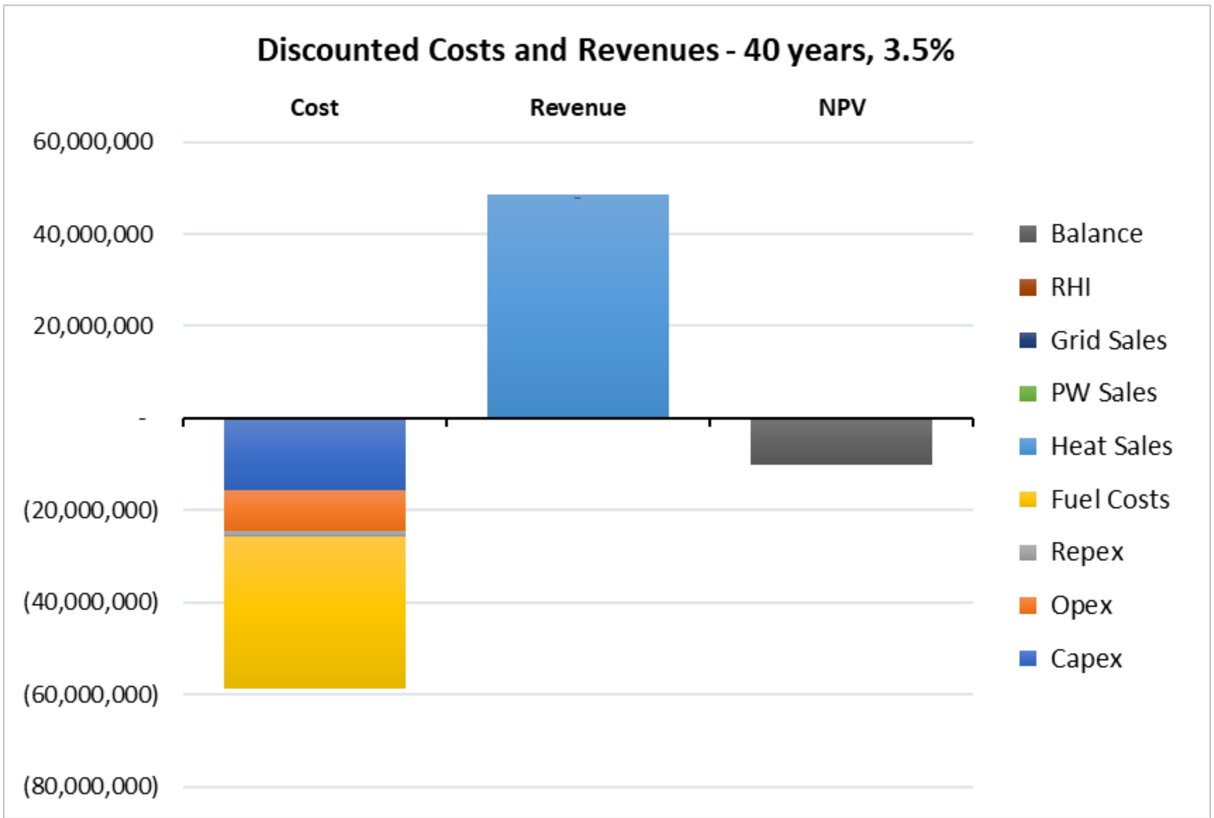


Figure 6-6 Balance of discounted costs and revenues for the South Lancaster Cluster - WSHP, Base Case

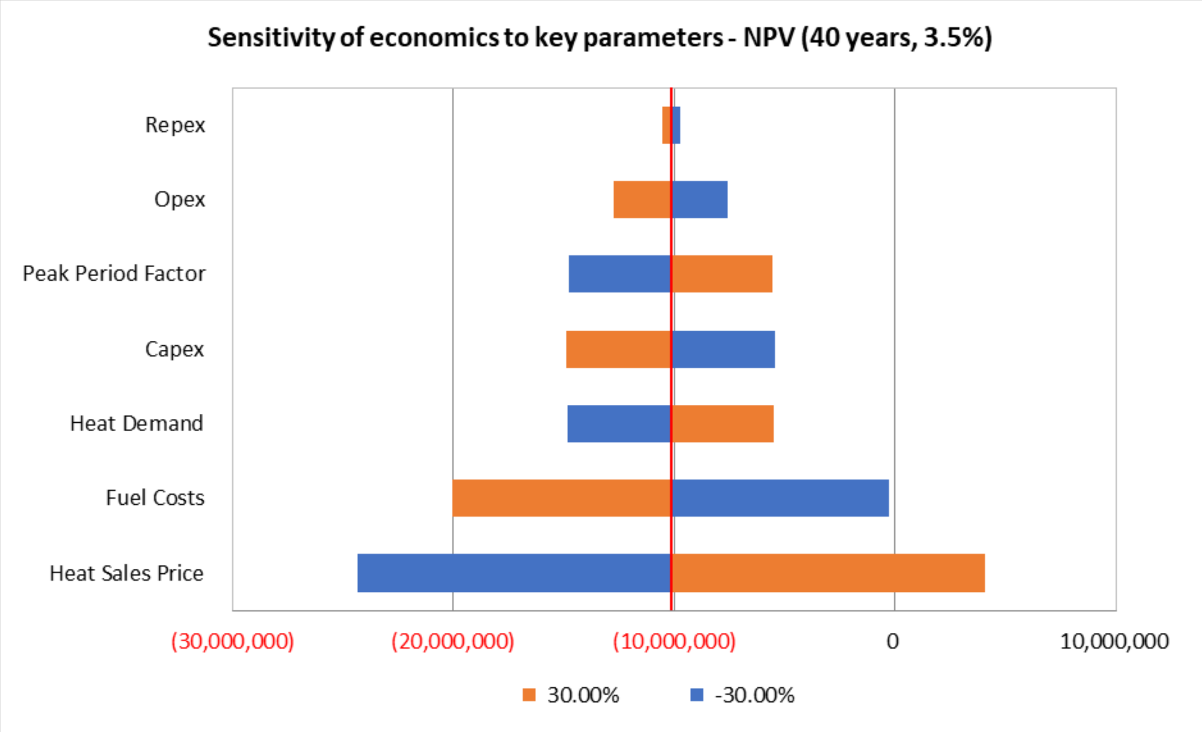


Figure 6-7 Sensitivity of NPV to key parameters for the South Lancaster Cluster - WSHP, Base Case

6.3.1.2 South Lancaster – WSHP +RHI

The economic results below are calculated using the same Base Case economic assumptions, but on the basis that the scheme could access support under the RHI or equivalent.

Table 6-8 Key economic indicators for the South Lancaster Cluster - WSHP, +RHI

Years	**25**	**30**	**40**
IRR	9.95%	10.07%	10.18%
NPV (@3.5%)	£ 10,700,000	£ 11,400,000	£ 12,500,000
Discounted Payback Period	11	11	11

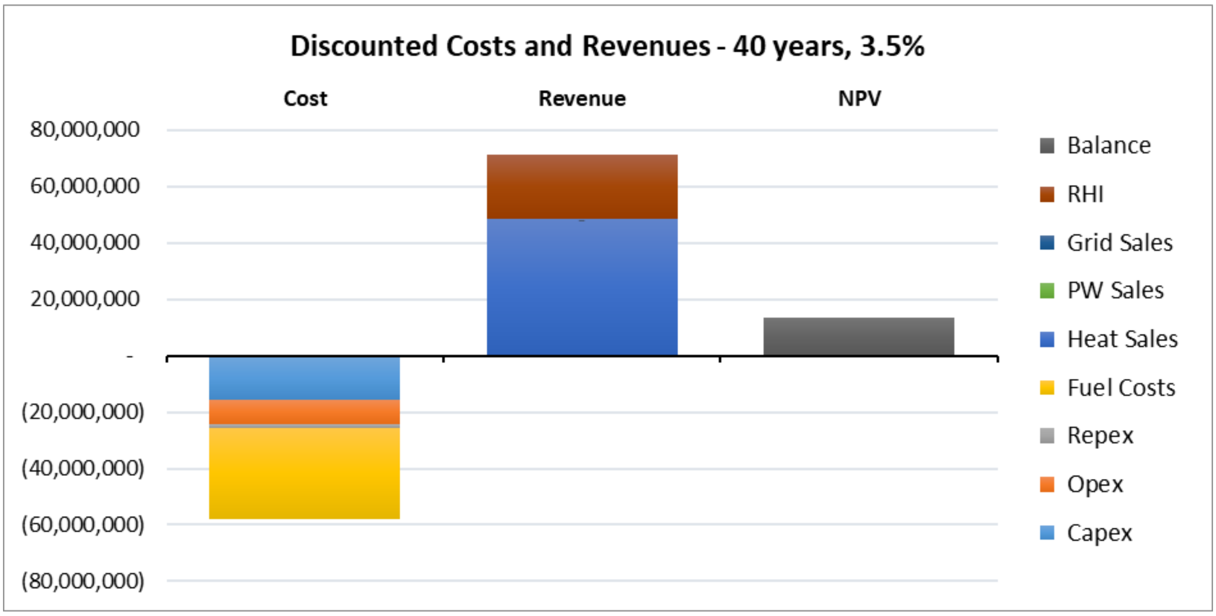


Figure 6-9 Balance of costs and revenues for the South Lancaster Cluster - WSHP, +RHI

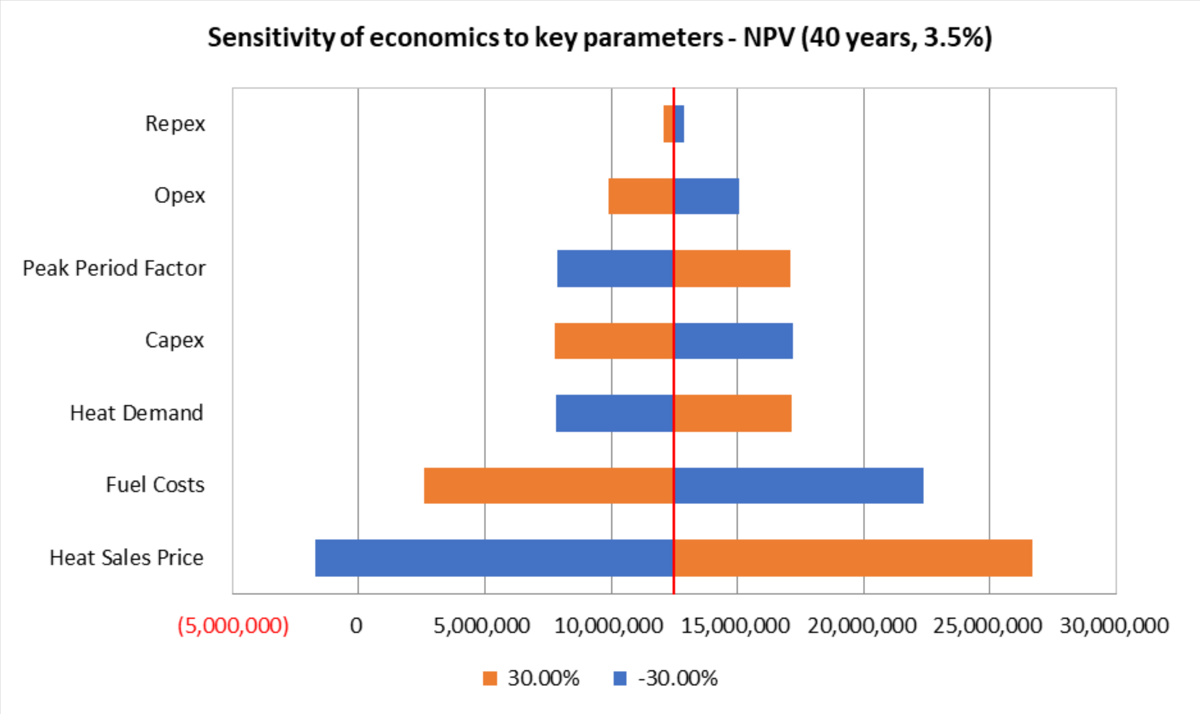


Figure 6-10 Sensitivity to key parameters for the South Lancaster Cluster - WSHP, +RHI

6.3.1.3 South Lancaster – WSHP, Optimistic Case

Key Optimistic Case assumptions

Heat sale price 5.7p/kWh

Peak electricity price (WHSP) 10 p/kWh – BEIS Baseline Policies Industrial electricity price

WSHP electricity supply assumed to be 40% Off Peak

Gas Purchase price 2.4 p/kWh – BEIS Existing Policies Industrial Gas Price (Base Case assumption)

Table 6-10 Key economic indicators for the South Lancaster Cluster - WSHP, Optimistic Case

Years	**25**	**30**	**40**
IRR	0.12%	1.58%	3.01%
NPV (@3.5%)	£ (5,200,000)	£ (3,650,000)	£ (1,250,000)
Discounted Payback Period	-	-	-

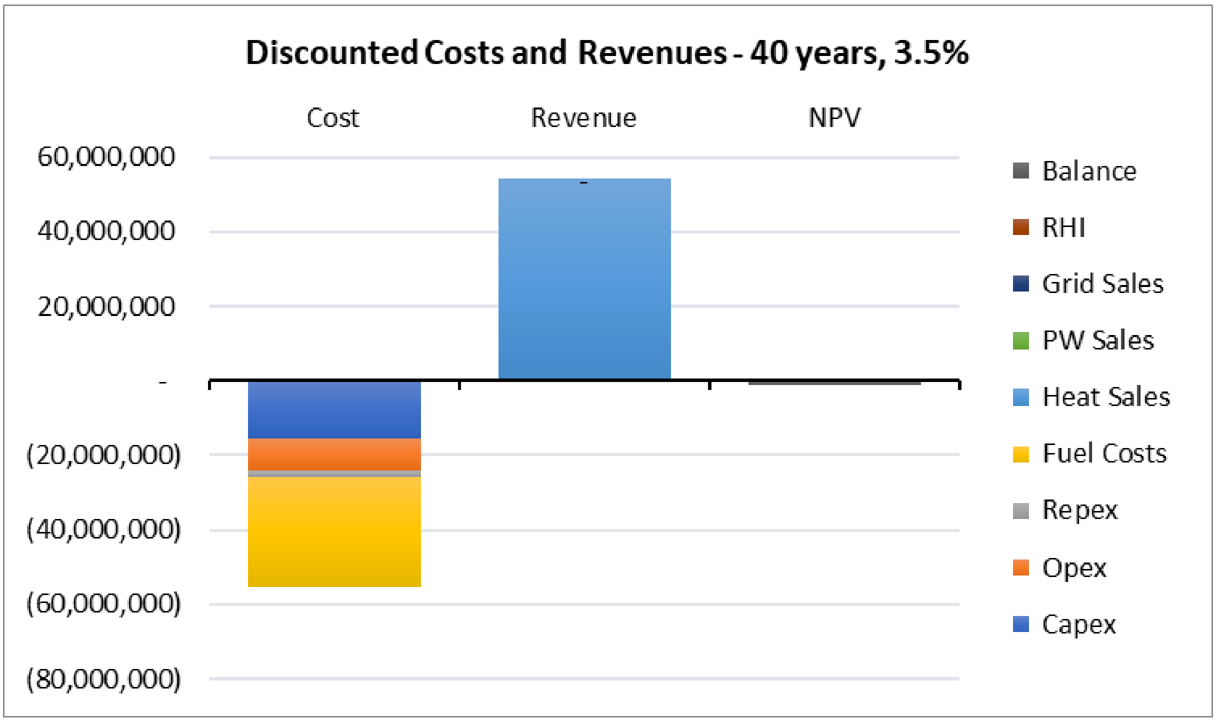


Figure 6-11 Balance of costs and revenues for the South Lancaster Cluster - WSHP, Optimistic Case

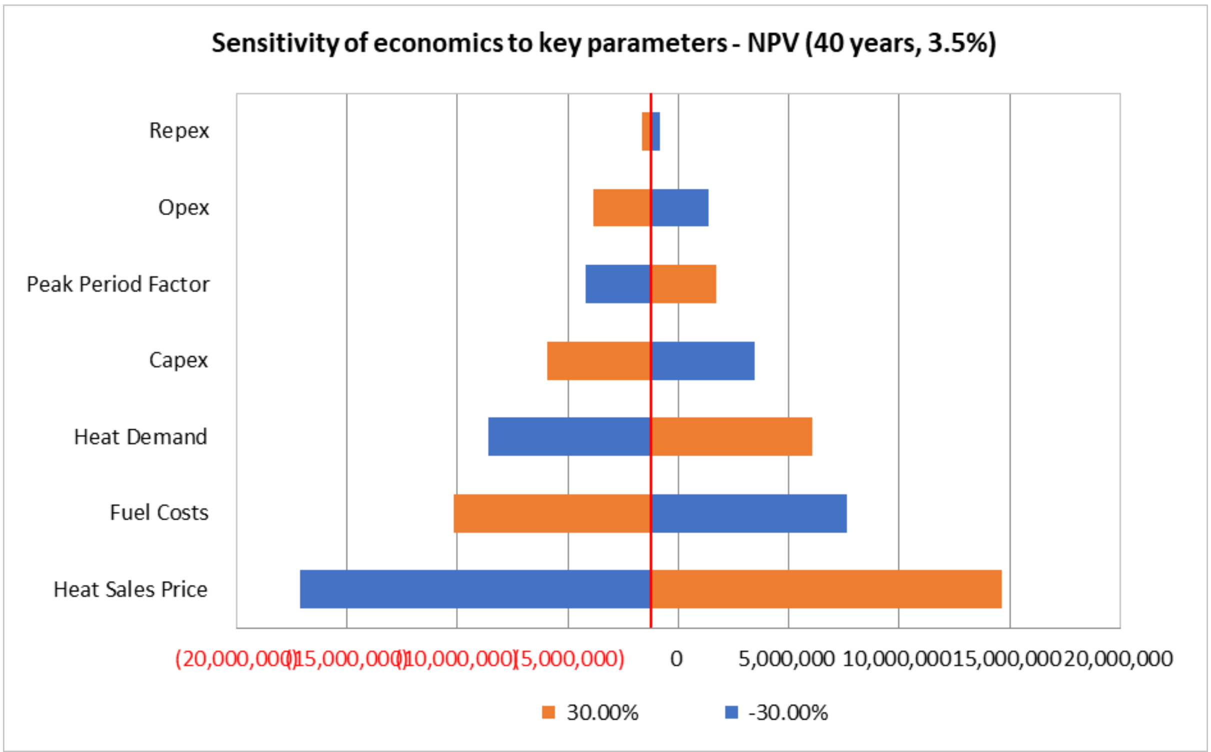


Figure 6-12 Sensitivity to key parameters for the South Lancaster Cluster - WSHP, Optimistic Case

In the case that the South Lancaster cluster is supplied heat from a new energy centre based on a water source heat pump thermal plant, the required initial investment is £15.7m in year 0, including a

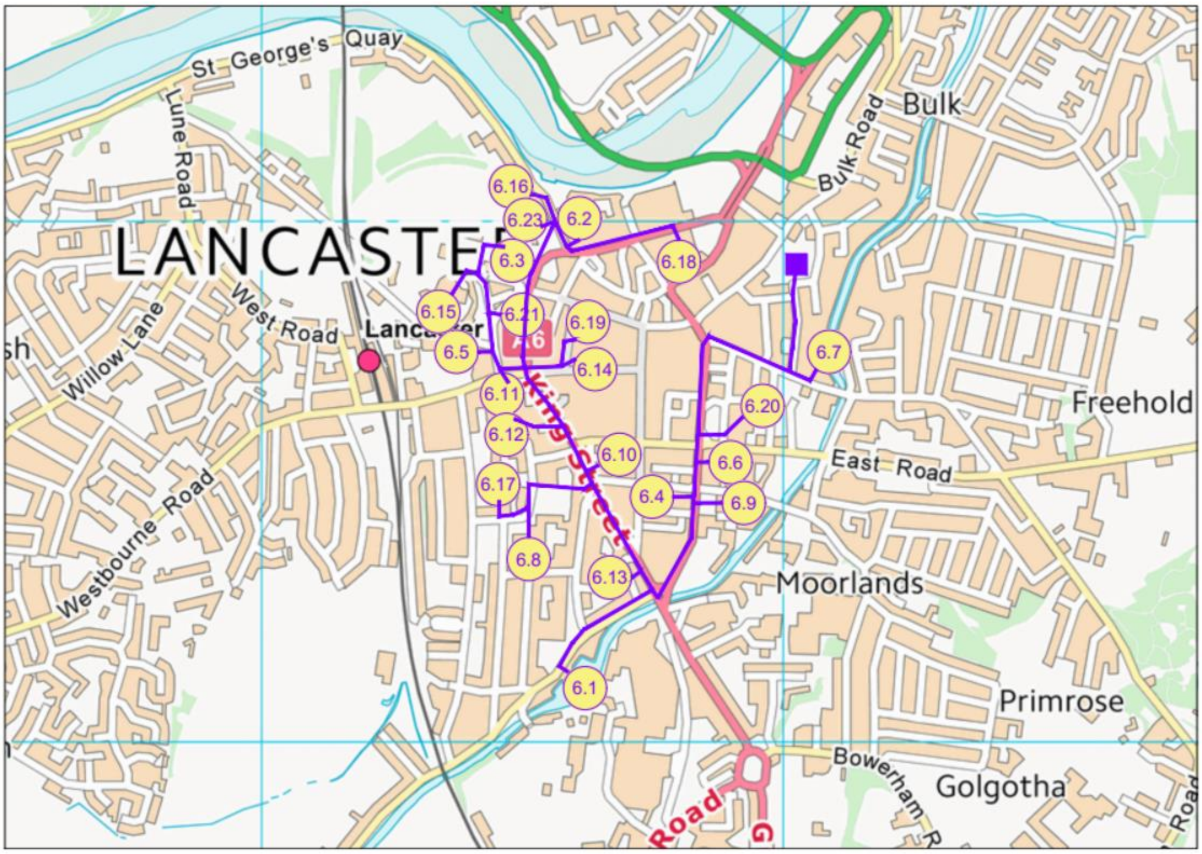
10% contingency (see Table 6-7). The WSHP plant incurs very significant operating costs of £43m over its 40-year lifetime, largely related to electricity costs, while generating revenues of £48.5m (3.5% discount rate) in the base case. This would result in an NPV of £-10.2m. If the scheme were to benefit from support along the lines of the existing renewable heat incentive (RHI) it would generate additional revenue of £22.6m which would result in an NPV of £12.5m, and an IRR of 10.2%.

In the optimistic case, the scheme would benefit from slightly reduced operational costs of £39.6m and increased heat sale revenues of £54m. This would result in an NPV of £-1.25m and an IRR of 3.0%.

6.3.2 City Centre

The network route for the proposed scheme for the City Centre cluster is presented in Figure 6-13 and the customers connected are shown in Table 6-12. The main heat users are student accommodations in this cluster. Other users include schools, hotels, the police station, jobcentre and local government buildings such as the town hall. Some of the data is obtained directly from Lancaster City Council, some are benchmarked according to the floor area obtained from EPCs and majority are from historic DECs.

Figure 6-13: Scheme network route for City Centre



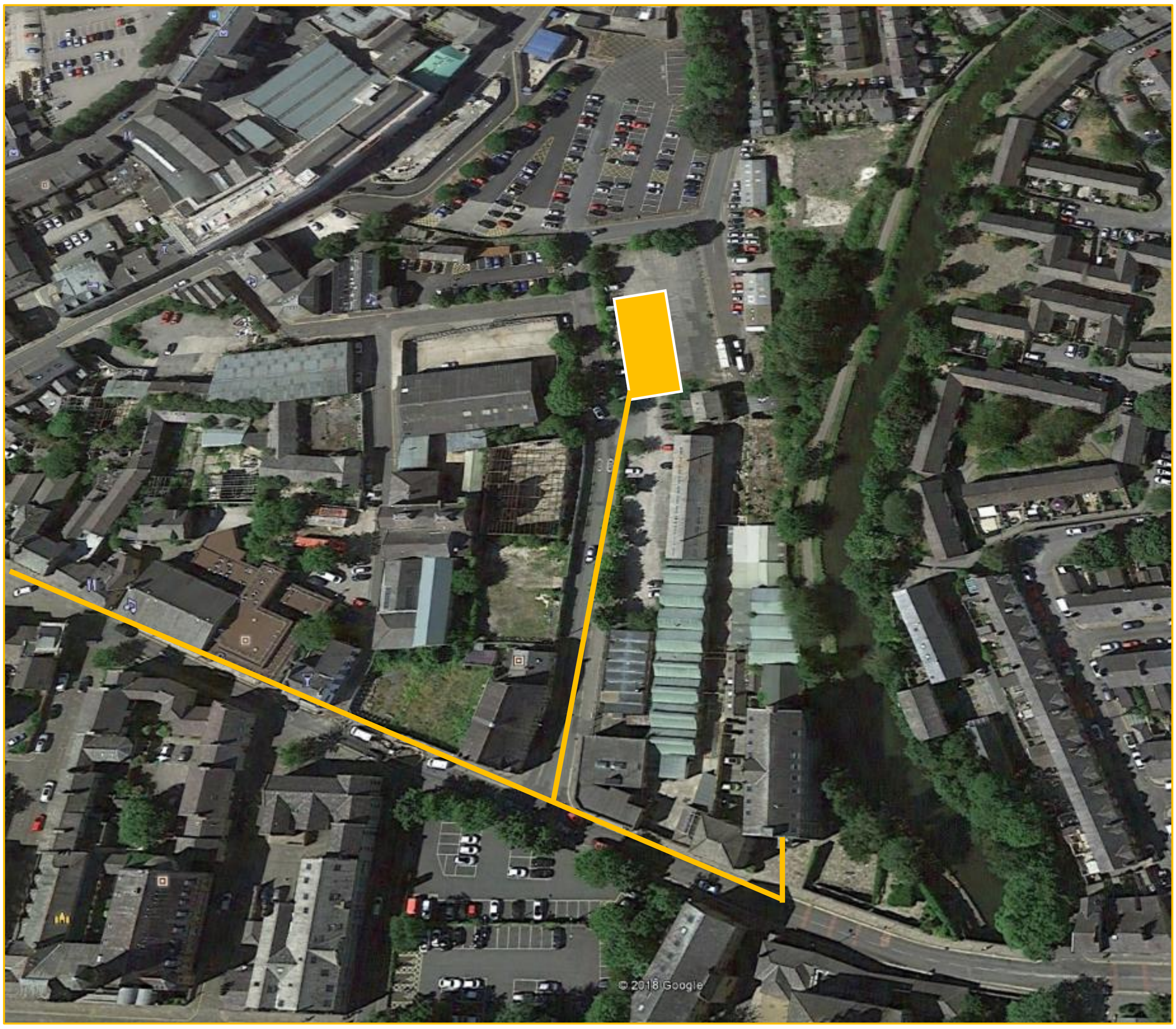
Selection of energy centre location

The cluster is a very compact network serving the city centre with the peak loads for each connection varying between 441kW and 46kW. Unlike other clusters no large heat users such as colleges, universities or hospital buildings are present. Therefore, finding a location close to the largest anchor load is less beneficial in this case.

Available land to house an energy centre in Lancaster city centre is very limited, especially in the historic part of the city close to the Castle or the water front by the River Lune. Through analysis of satellite images, no available site was identified inside the A6 loop inner ring road. A potential location on industrial land has been identified near to the Mill Hill Hall of residence, as can be seen in Figure 6-14.

For ease of estimating and aligning with the OS details provided on the AutoCAD plan, the energy centre appears on a patch of hard-standing. Further stakeholder engagement, alongside a site survey will be needed to determine whether the land is suitable or if the adjacent alternative locations shown are more suitable.

Figure 6-14: Lancaster City Centre, energy centre location



Alternative energy centre locations were assessed, as shown in Figure 6-15. The advantages and disadvantages of the alternative options, leading to the selection of preferred location (Edward Street car park), are explained in Table 6-11.

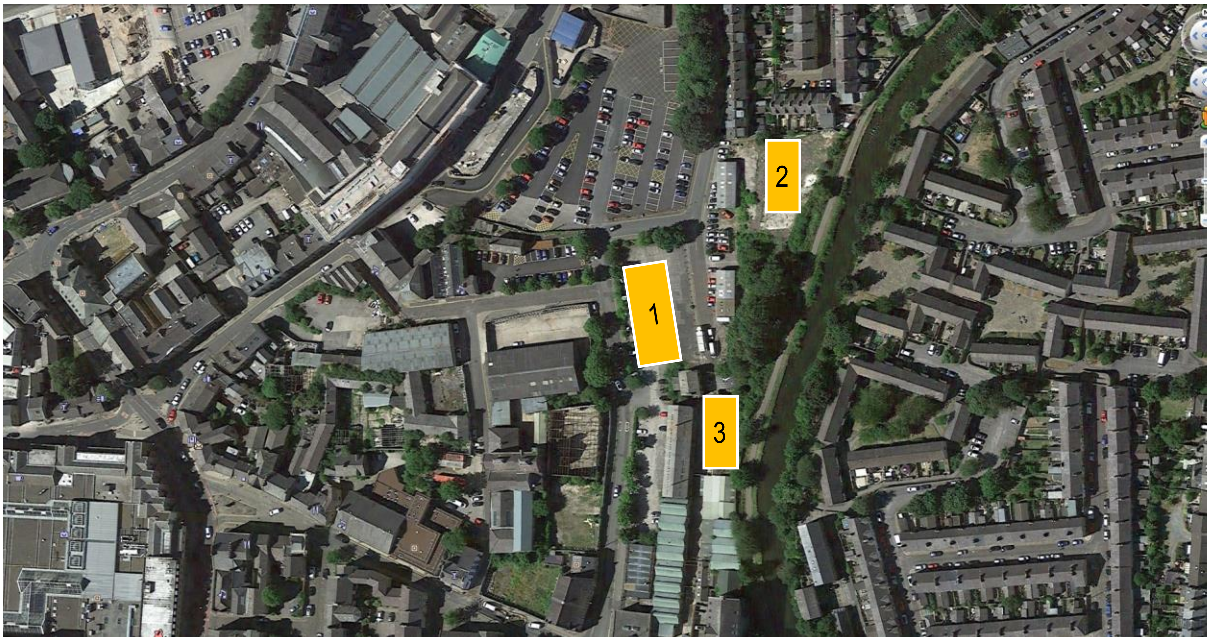


Figure 6-15: Lancaster city centre cluster – energy centre locations considered

Table 6-11: Comparison of energy centre locations considered

No	Energy Centre Location	Advantages	Disadvantages	Selected for modelling	Issue for further research
1	Edward Street Car park	• Industrial area location. • Largest available space of all three options.	• Extra distance for river water source. • Reduced car parking spaces. • Disruption to public during installation.	Yes	• Registered owner of land. • Future uses for selected land area. • 3phase electrical connection supply. • Secondary heating system operating temperatures and control philosophy installed used for central heating and hot water at all proposed connections. • Stakeholder engagement with facilities manager for each connection. • Ground works survey to determine availability, yield and environmental constraints associated with water source.
2	Alfred Street	• Industrial area location. Energy centre close to local river water source.	• Additional length of pipework.	No	
3	Edward Street Car Park Waste Land	• Industrial area location. • Energy centre close to local river water source.	• Additional space needed for thermal storage will involve clearing river bank wooded area.] • Potential issues with HGV during energy centre installation and plant overhauls.	No	

Table 6-12:Scheme customers in City Centre

ID	Customer	Data Source	Estimated Heat Demand (MWh/year)	Peak Heat Demand (kW)	Estimated Electricity Demand (MWh/year)
1	Wyre House Chancellors Wharf	3	1,200	441	90
2	Cable Street Student Accommodation	4	980	319	-
3	Mitre House / Jobcentre	3	760	267	250
4	Lancaster Police Station	3	740	248	700
5	The Storey	2	650	304	230
6	Lancaster Town Hall	2	640	233	260
7	Mill Hall Halls	3	530	180	85
8	Lancaster Girl's Grammar School	3	480	305	230
9	Lancaster Magistrate's Court	3	450	158	100
10	Travelodge Lancaster Central	4	430	122	-
11	Royal King's Arm	4	420	118	-
12	Royal Mail Office	3	350	122	130
13	City Block Student Accommodation	4	340	118	-
14	Lancaster City Museum	3	280	132	50
15	Castle Parade	3	270	126	50
16	Damside Student Accommodation	4	260	89	-
17	Dallas Road Community Primary School	3	250	153	100
18	Fire Station	3	210	71	80
19	Lancaster Central Library	3	210	92	70
20	City Lab	2	190	67	140
21	Judges Lodgings Museum	3	150	61	20
23	YMCA	4	100	46	-
	TOTAL		**9,890**	**3,080**[18]	**2,585**

[18] Peak Heat Demand (kW) is not in general equal to the sum of the individual building peaks, since these do not in general coincide.

A summary of the technical assessment for the City Centre cluster is shown in Table 6-13. The total heat demand in the cluster is 9.9 GWh/year with a peak demand of 3.1 MW (this is effectively an undiversified peak – see the start of Section 6.1 for a description of the treatment of diversity). The total distribution length, including the main distribution network and the service pipe serving individual buildings, is 3.8 km which results in a linear heat density of 2.6 GWh/year/km.

Table 6-13: A summary of technical assessment for City Centre

		Unit	Value
Annual heat demand at full build-out	Total	GWh/yr	9.9
Peak heat demand	Total	MW	3.1
Number of connections	Total	#	22
Network route length	Distribution	km	2.0
	Service		1.8
Network temperature	Network flow/return temperature	ºC	90/70
	Network delta T		20
Linear heat density		GWh/yr/km	2.6

Table 6-14: Summary of proposed plant for City Centre

Plant Suggestion	No.	Individual Capacity	Notes
Thermal Store	1	100 m^3	200 m^3 required in total, may be split into 2 x 50,000 litre vessels
WSHP	2	1,050 kW	Assumes open-loop WSHP using water from borehole, given that energy centre location selected is not close to the river. The river would be an alternative water source if a suitable location can found (the canal is not expected to be a suitable source for a large scheme). Assumed SPF of 2.80.
Main gas boiler back up plant	2	1,500 kW	Based on heat rating 1500 kW to 375 kW
Modular gas boiler plant	2	395 kW	Based on heat rating from 367 kW to 73 kW

The proposed thermal plant selection for the City Centre scheme is shown in Table 6-14. Similarly to the South Lancaster cluster, the design is focussed on maximising the fraction of the heat demand met by the low carbon plant. This involves using the WSHP to fill the thermal storage overnight during the winter heating season, to be discharged to meet the peak heating demand in the morning. Due to the rapid discharge of the thermal store, despite the large capacity provided, gas boilers are required alongside the WSHP operating at maximum output in order to meet demand through the day.

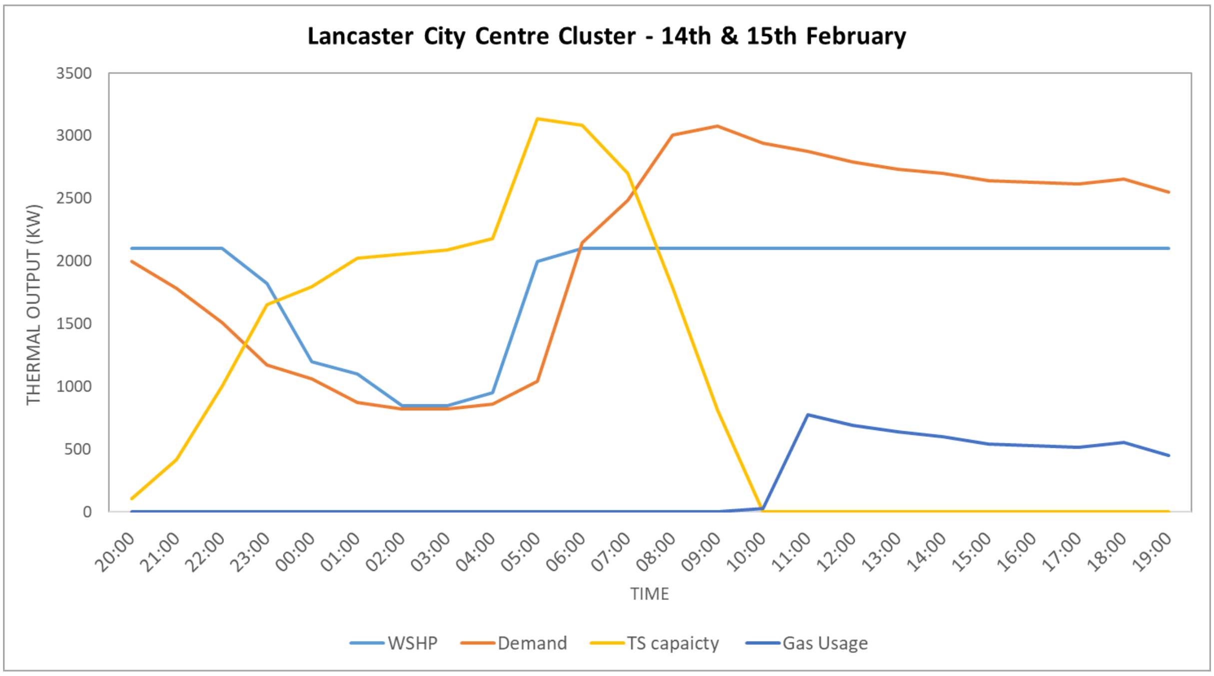


Figure 6-16: Plant operating profiles on a typical winter day

The thermal demand in this scheme drops to very low levels during the high summer period, such that very limited operation of the WSHP is required and no gas boiler operation is needed. As shown in Figure 6-17, just one hour of operation of the WSHP plant at full load is sufficient to charge the thermal storage to the extent required to meet the thermal demand on the system over the next day.

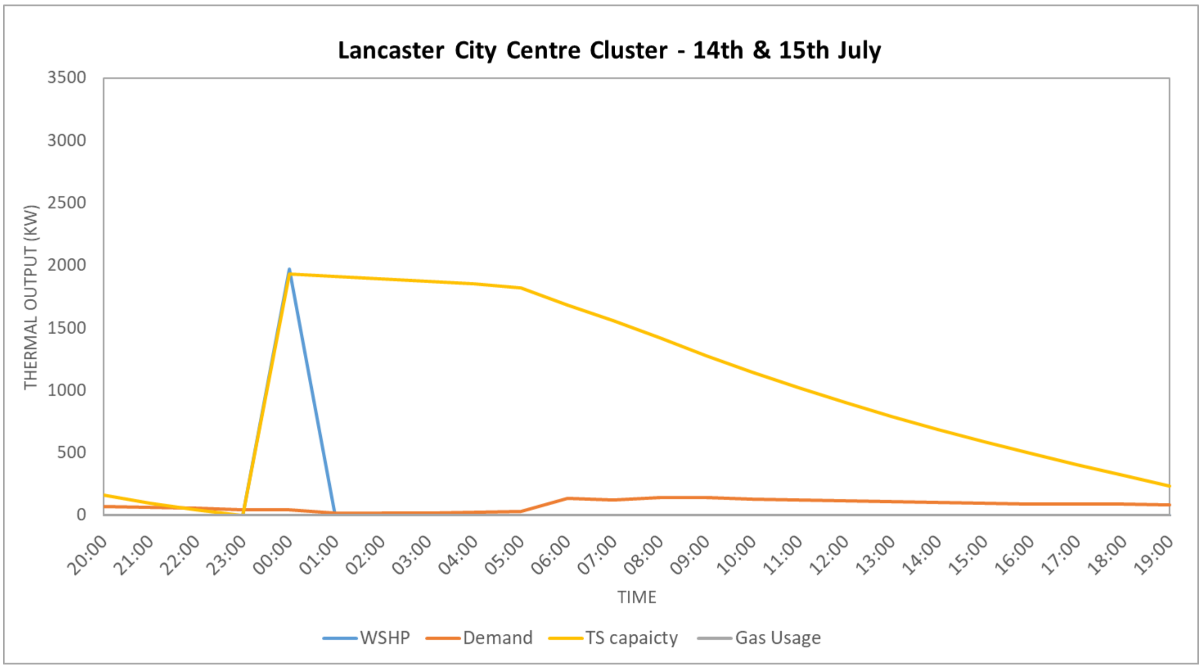


Figure 6-17: Plant operating profiles on a typical summer day

Table 6-15: Associated costing of the network for City Centre

Cost Breakdown	Value (£)
WSHP	2,016,000
Boiler	150,000
Network (pipe)	5,055,000
Heat interface units (HIUs)	100,637
Energy Centre	1,500,000
Thermal Storage	170,000
Engineering procurement & project management	870,000
Other costs	290,000
Contingency (10%)	1,023,000
TOTAL	11,250,000

Table 6-16: Annual Opex estimate for the City Centre scheme

Cost Breakdown	Value (£/yr)
Thermal plant O&M	96,400
Network O&M	2,897
Fuel costs (in Year 1)	415,213
Staff costs	50,000
Metering & billing	70,000
Insurance	20,000
TOTAL	**654,500**

6.3.2.1 City Centre –WSHP, Base case

Key Base Case assumptions

Heat sale price 5.1p/kWh

Gas purchase price 2.4 p/kWh – BEIS Existing Policies Industrial Gas Price

Peak electricity purchase price 11.7 p/kWh – BEIS Existing Policies Industrial Electricity Price

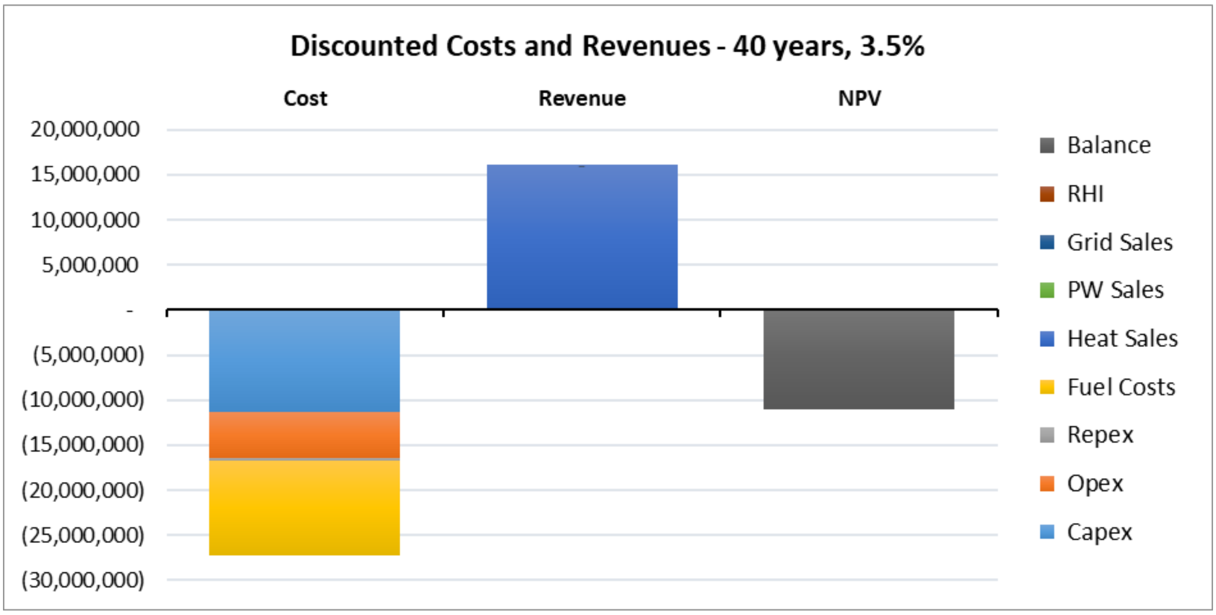
Off-peak electricity purchase price 7 p/kWh

Off-peak electricity usage 40%

Table 6-17 Key economic indicators for the City Centre Cluster - WSHP, Base Case

Years	25	30	40
IRR	N/A	-13.90%	-8.26%
NPV (@3.5%)	£ (11,300,000)	£ (11,200,000)	£ (11,100,000)
Discounted Payback Period	-	-	-

Figure 6-18 Balance of costs and revenues for the City Centre Cluster - WSHP, Base Case



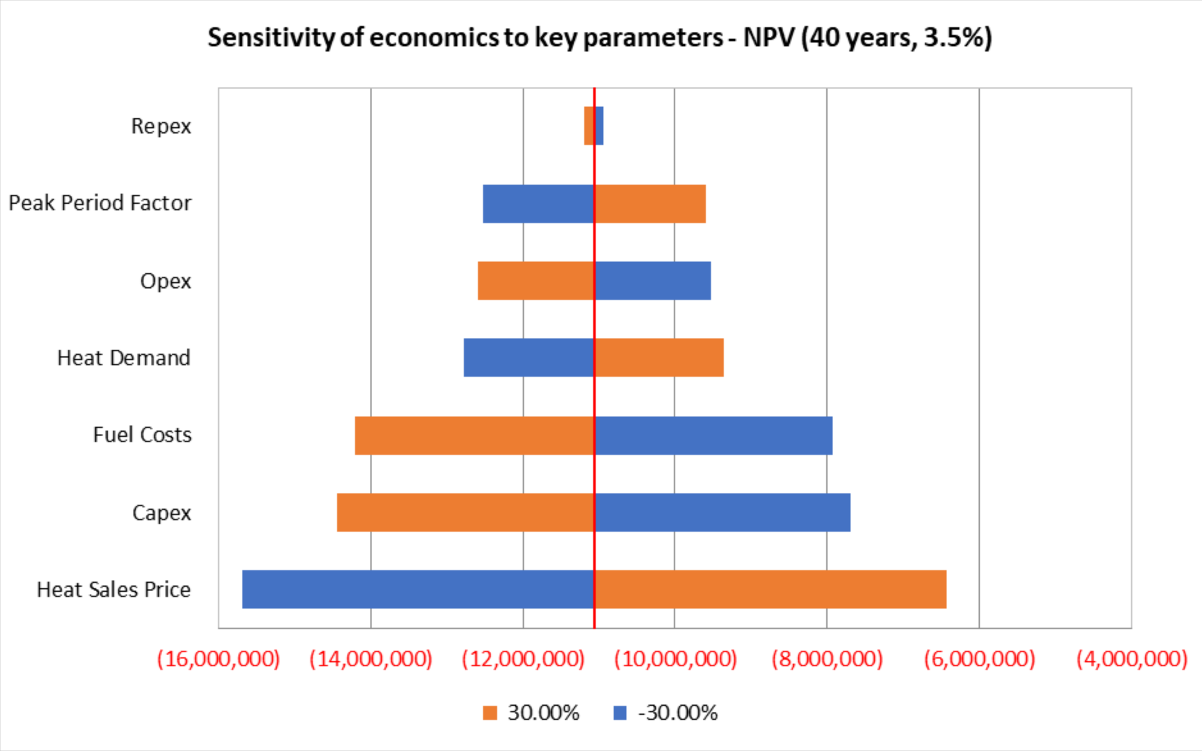


Figure 6-19 Sensitivity to key assumptions for the City Centre Cluster - WSHP, Base Case

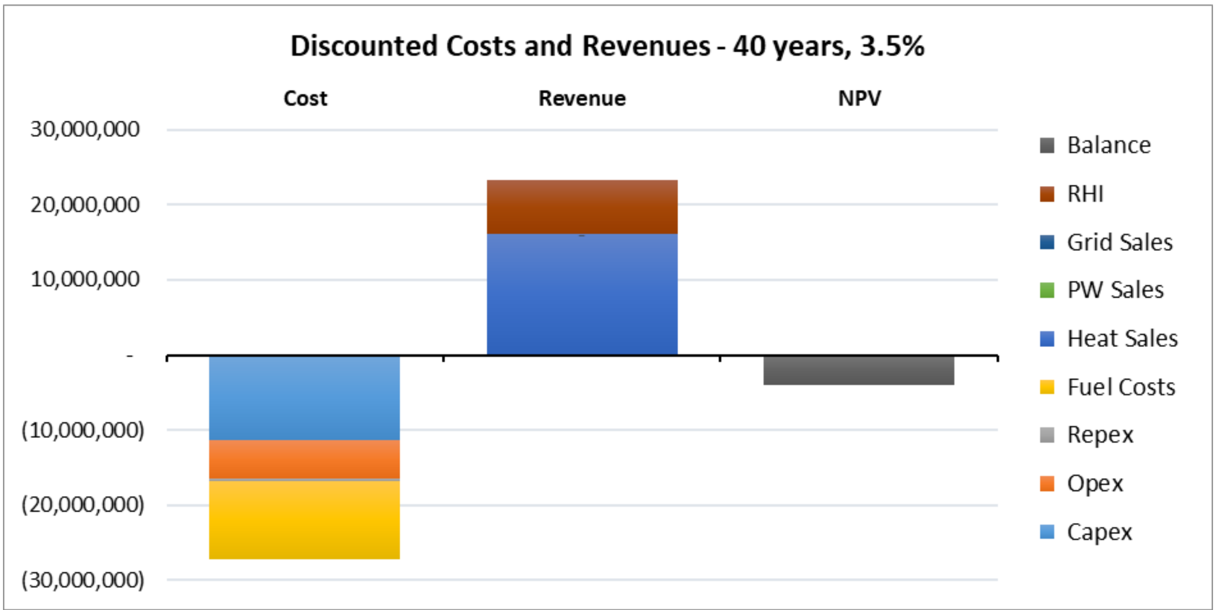
6.3.2.2 City Centre WSHP, +RHI

The economic results below are calculated using the same Base Case economic assumptions, but on the basis that the sceme can access support under the RHI.

Table 6-20 Key economic indicators for the City Centre Cluster - WSHP, +RHI

Years	25	30	40
IRR	-1.28%	-1.03%	-0.59%
NPV (@3.5%)	£ (4,240,000)	£ (4,160,000)	£ (4,030,000)
Discounted Payback Period	-	-	-

Figure 6-18 Balance of costs and revenues for the City Centre Cluster - WSHP, +RHI



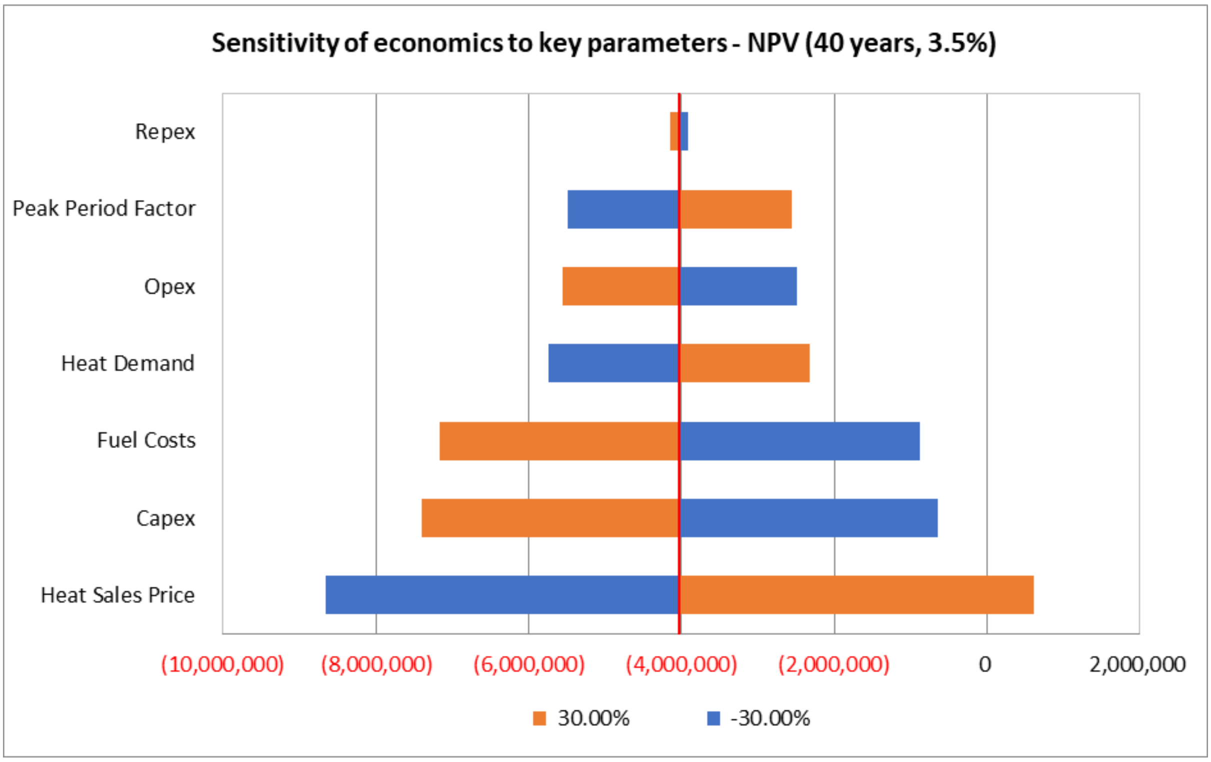


Figure 6-19 Sensitivity to key assumptions for the City Centre Cluster - WSHP, +RHI

6.3.2.3 City Centre – WSHP, Optimistic Case

Key Optimistic Case assumptions

Heat sale price: 5.7 p/kWh

Gas purchase price 2.4 p/kWh – BEIS Existing Policies Industrial Gas Price

Peak electricity purchase price: 10 p/kWh – BEIS Baseline Policies Industrial Electricity Price

Off-peak electricity purchase price 7 p/kWh

WSHP electricity supply assumed to be 40% off-peak

Table 6-21 Key economic indicators for the City Centre Cluster - WSHP, Optimistic Case

Years	25	30	40
IRR	-7.91%	-5.21%	-2.54%
NPV (@3.5%)	£ (9,100,000)	£ (8,740,000)	£ (8,200,000)
Discounted Payback Period	-	-	-

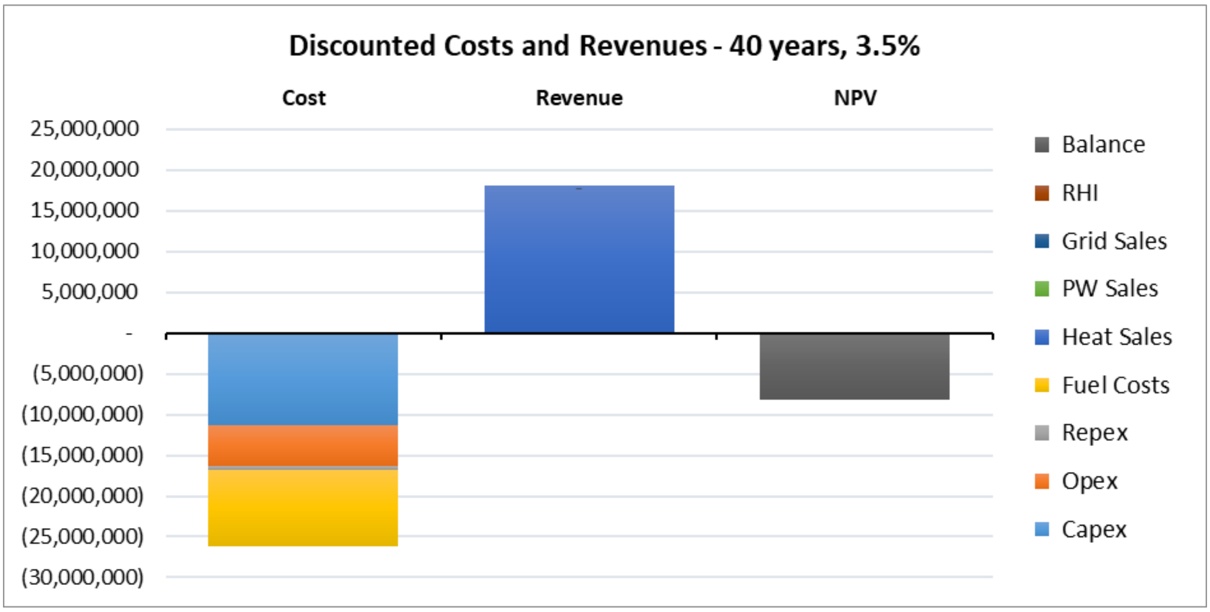


Figure 6-20 Balance of costs and revenues for the City Centre Cluster - WSHP, Optimistic Case

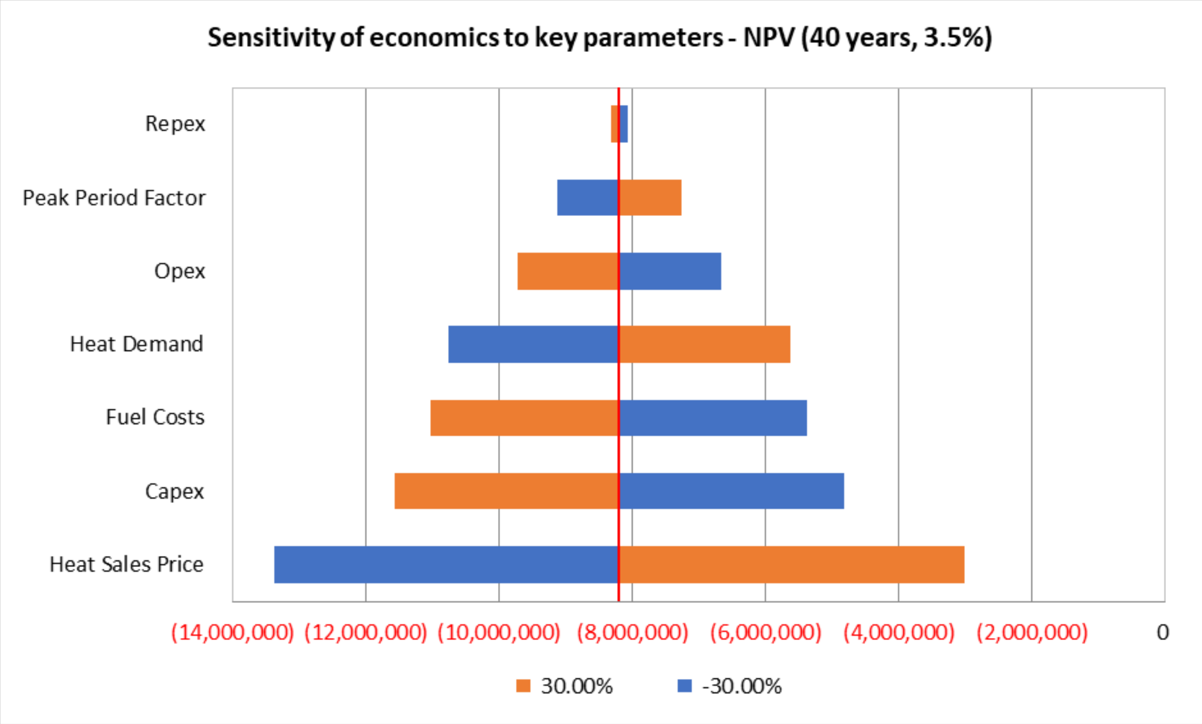


Figure 6-21 Sensitivity to key assumptions for the City Centre Cluster - WSHP, Optimistic Case

The base case of this cluster results in a negative NPV of £-11m. This is due to a high initial capital outlay in year 0 of £11.2m and lifetime running costs of £16m (40 years at 3.5% discount rate). With a total revenue present value of £16.2m, the NPV of the project is £-11.1m. By comparison, with additional RHI revenues of £7m, the project would reach an NPV of £-4m over 40 years.

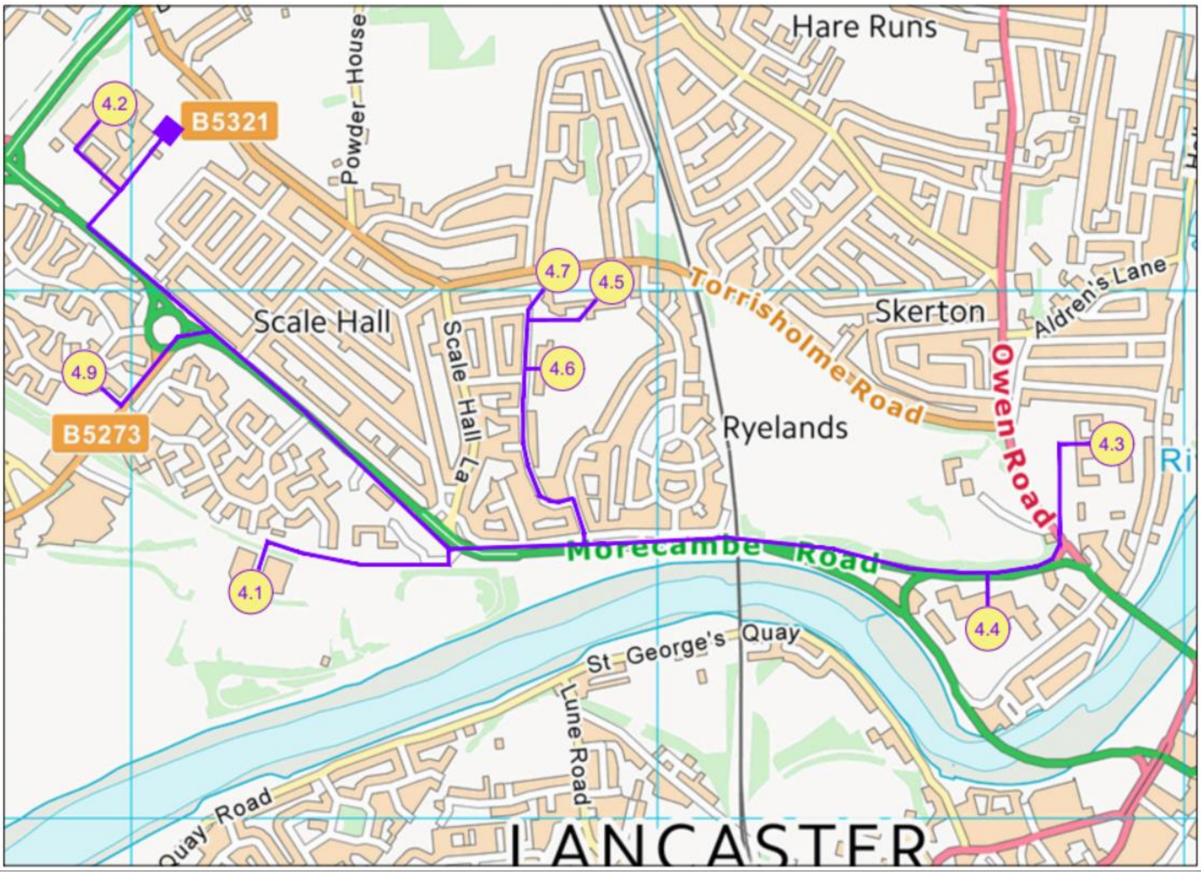
The high capital and fuel costs are the result of a high reliance on water source heat pumps. They constitute the majority of the capex and their running costs are also high, due to the relatively high electricity price.

In the Optimistic case, where the reduced fuel costs and an increased heat sale price work together to improve the economics, the resulting NPV is £-8.2m.

6.3.3 Scale Hall

The network route for the proposed scheme for Scale Hall cluster is presented in Figure 6-22 and the customers connected are shown in Table 6-23. The main heat users are schools and one leisure centre with an indoor swimming pool in the cluster. Data for the leisure centre was obtained from the Council which is also the operator of the facility and the remaining data for the schools are from the DEC database.

Figure 6-22: Scheme network route for Scale Hall



Selection of energy centre location

Two main anchor customers of similar size demand have been identified in the Scale Hall cluster, hence, energy centre locations close to each site have been examined. The two anchor customers are as follows:

- Salt Ayre Leisure Centre = 3,100MWh, peak load 1,452kW
- Lancaster & Morecambe College = 2,800MWh, peak load 1,768kW

Due to the anticipated size and height of the storage thermal vessels, up to 8m, consideration is needed to determine the visual impact on any adjacent properties.

As can be seen on the satellite image in Figure 6-23, an athletics track, a series of all-weather playing fields and football pitches are located on land surrounding the leisure centre. There are also a number of tree-lined minor roads and car parking spaces. Only the land immediately to the south west appears to be an option for locating an energy centre. More stakeholder engagement would be needed to determine whether the owners / developers of the land would be able to accommodate an energy centre at this location. If there is an intention for this land to be used for residential development, then there is a strong likelihood that this possibility would be rejected on the basis of visual impact, see Figure 6-23.

Figure 6-23: Scale Halls cluster, Salt Ayre Leisure Centre connection

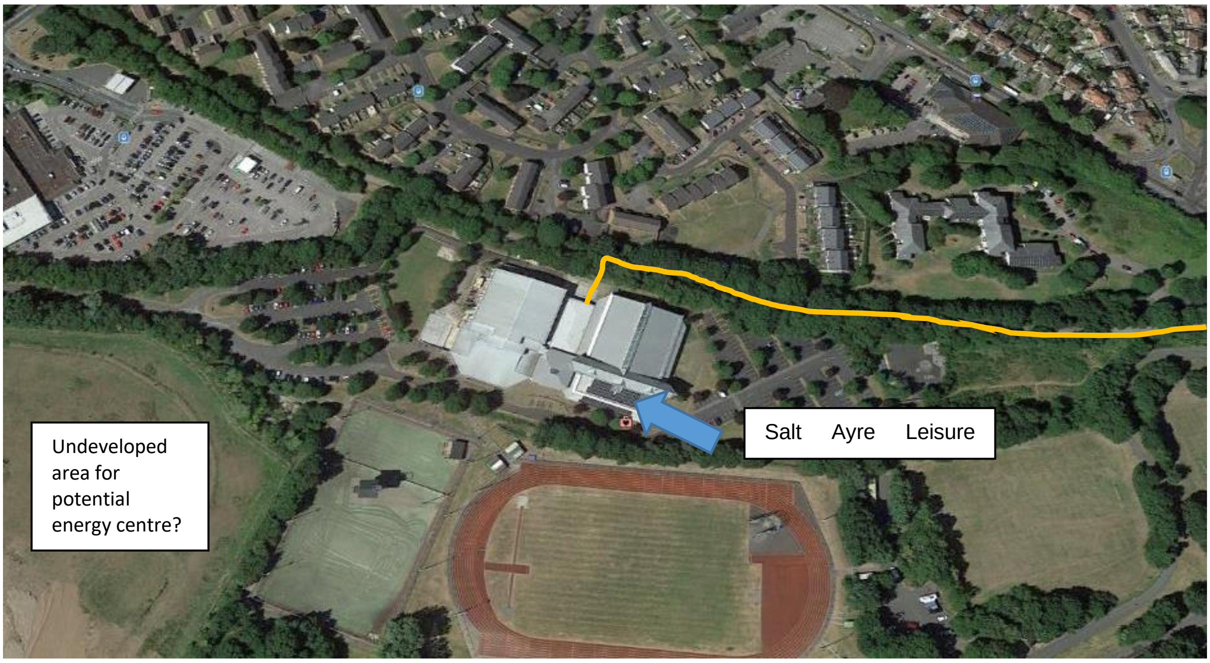


Figure 6-24: Scale Hall cluster, Lancaster and Morecambe College connection

Therefore, an assumption was made that land could be made available within the college site, as shown in Figure 6-24. This assumption would need to be tested in discussion with the college. Within the college grounds, the height of the thermal stores would be less of a concern as there are already a number of tall buildings. The heat network route shown is conservative and may be optimised when a full site survey investigation is undertaken.

The advantage and disadvantages of the two energy centre location options, leading to the preference for the Lancaster and Morecambe College site, are discussed in Table 6-22 below.

Table 6-22: Comparison of energy centre locations considered

No	Energy Centre Location	Advantages	Disadvantages	Selected for modelling	Issue for further research
1	Lancaster and Morecambe College	• Open space • Ease of access to main road.	• Removal of trees • Groundwork	Yes	• Registered owner of land. • Future uses for selected land area. • 3phase electrical connection supply. • Secondary heating system operating temperatures and control philosophy installed used for central heating and hot water at all proposed connections. • Stakeholder engagement with facilities manager for each connection. • Ground works survey to determine availability, yield and environmental constraints associated with water source.
2	Doris Henderson Way	• Open space. • Energy centre close to largest heat load.	• Suspected future use of site will restrict energy centre development.	No	

Table 6-23: Scheme customers in Scale Hall

ID	Customer	Data Source	Estimated Heat Demand (MWh/year)	Peak Heat Demand (kW)	Estimated Electricity Demand (MWh/year)
1	Salt Ayre Leisure Centre	2	3,100	1,450	1,000
2	Lancaster and Morecambe College	3	2,700	1,780	1,400
3	Chadwick High School	3	900	580	170
4	Our Lady's Catholic College	3	410	270	380
5	Ryelands Primary School	3	300	110	100
6	Loyne School	3	290	180	160
7	Children & Parenting Support Services	3	210	80	40
9	Morecambe & Heysham Governor Park Primary School	3	180	120	60
	TOTAL		**8,090**	**3,110**[19]	**3,310**

A summary of the technical assessment for the Scale Hall cluster is shown in Table 6-24. The total heat demand in the cluster is 8.1 GWh/year with a peak demand of 3.1 MW (this is effectively an undiversified peak – see the start of Section 6.1 for a description of the treatment of diversity). The total distribution length, including the main distribution network and the service pipe serving individual buildings, is 2.4 km which results in a linear heat density of 3.4 GWh/year/km.

Table 6-24: A summary of the technical assessment for Scale Hall

		Unit	Value
Annual heat demand at full build-out	Total	GWh/yr	8.1
Peak heat demand	Total	MW	3.1
Number of connections	Total	#	8
Network route length	Distribution	km	0.8
	Service		1.6
Network temperature	Network flow/return temperature	ºC	90/70
	Network delta T		20
Linear heat density		GWh/yr/km	3.4

The proposed plant selection for the Scale Hall scheme is provided in Table 6-25. As in the other schemes assessed, the overall design logic has been to provide a relatively large amount of thermal storage in order to maximise the fraction of heat load served by the WSHP. This involves the WSHP operating at high output overnight during the winter heating season in order to fill a large thermal store, which can then be discharged during the period of peak demand in the morning. As has been

[19] Peak Heat Demand (kW) is not in general equal to the sum of the individual building peaks, since these do not in general coincide.

seen in the other clusters, the gas boiler plant is still required to operate during the day in winter in order to meet the heating demand once the thermal storage has fully discharged. This arrangement is more economical than sizing the WSHP to meet the high winter demands, while still limiting the amount of gas consumed to a relatively minor level. Typica daily plant operating profiles are shown in Figure 6-25.

Table 6-25: Summary of proposed plant for Scale Hall

Plant Suggestion	No.	Individual Capacity	Notes
Thermal Store	2	100 m^3	200 m^3 required in total, may be split into 4 x 50,000 litre vessels
WSHP	2	700 kW	Assumes open-loop WSHP using water from borehole, given that energy centre location selected is not close to the river. The river would be an alternative water source if a suitable location can found (the canal is not expected to be a suitable source for a large scheme). Assumed SPF of 2.80.
Modular gas boiler plant	1	3,200 kW	Based on heat rating 3,000 kW to 750 kW
Main gas boiler back up plant	2	470 kW	Based on maximum demand of 435.8 kW, turndown to 85.2 kW

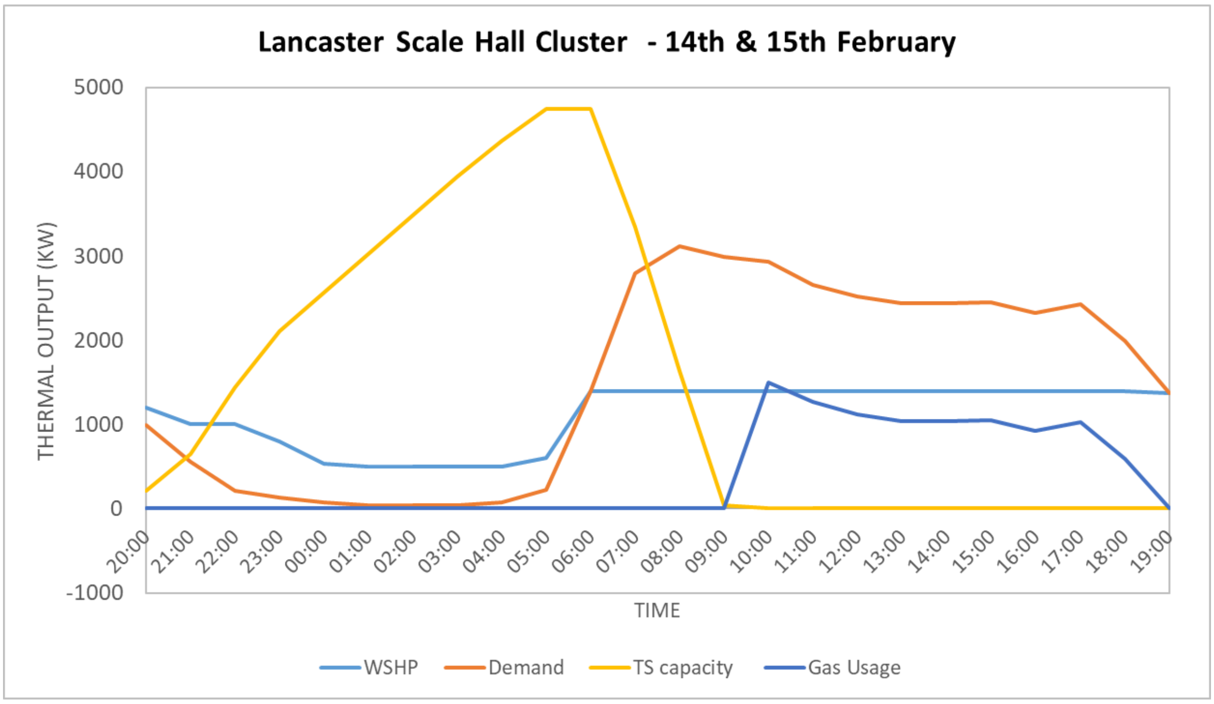


Figure 6-25: Daily plant operating profiles for the Scale Hall scheme on a typical winter day

The summer day plant operating profile is also similar to that observed in the modelling of the other clusters. Due to the low levels of demand, only a very limited period of WSHP operation is required to fill the thermal stores to an adequate level to meet the entirety of the next day's demand on the district heating system. The gas boilers are not used during this period. Typical summer day operating profiles are shown in Figure 6-26.

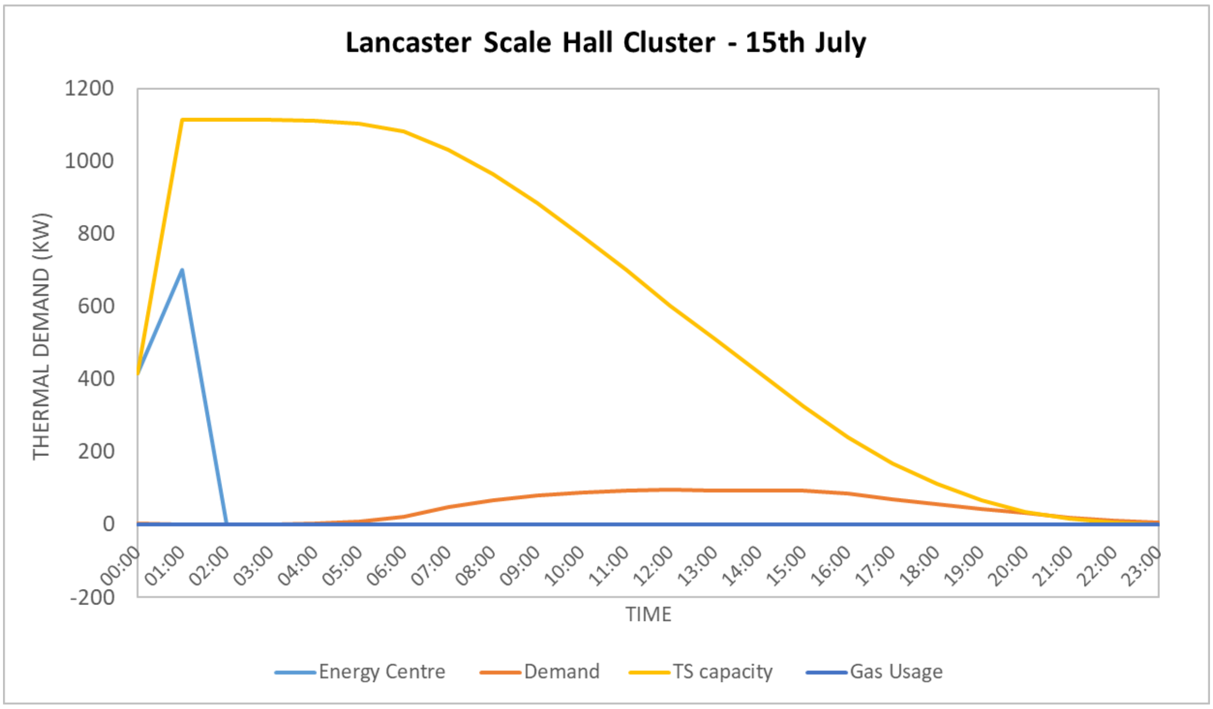


Figure 6-26: Daily plant operating profiles for the Scale Hall scheme on a typical summer day

The estimated capital and operating costs associated with the proposed plant, the district heating network and annual operation of the system are shown in Table 6-26 and Table 6-27, below.

Table 6-26: Associated Capex of the network for Scale Hall

Cost Breakdown	Value (£)
WSHP	1,344,000
Boiler	161,000
Network (pipe)	3,214,000
Heat interface units (HIUs)	270,145
Energy Centre	1,500,000
Thermal Storage	170,000
Engineering procurement & project management	870,000
Other costs	290,000
Contingency (10%)	793,559
TOTAL	8,729,144

Table 6-27: Annual Opex estimate for the Scale Hall scheme

Cost Breakdown	Value (£/yr)
Thermal plant O&M	72,600
Network O&M	1,774
Fuel costs (in Year 1)	360,780
Staff costs	50,000
Metering & billing	70,000
Insurance	20,000
TOTAL	**575,150**

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6.3.3.1 Scale Hall – WSHP, Base case

Key Base Case assumptions

Heat sale price 5.1p/kWh

Gas purchase price 2.4 p/kWh – BEIS Existing Policies Industrial Gas Price

Peak electricity purchase price 11.7 p/kWh – BEIS Existing Policies Industrial Electricity Price

Off-peak electricity purchas price 7 p/kWh

Off-peak electricity usage 40%

Table 6-28 Key economic indicators for the Scale Hall Cluster - WSHP, Base Case

Years	25	30	40
IRR	Negative	Negative	Negative
NPV (@3.5%)	£ (8,650,00)	£ (8,580,000)	£ (8,460,000)
Discounted Payback Period	-	-	-

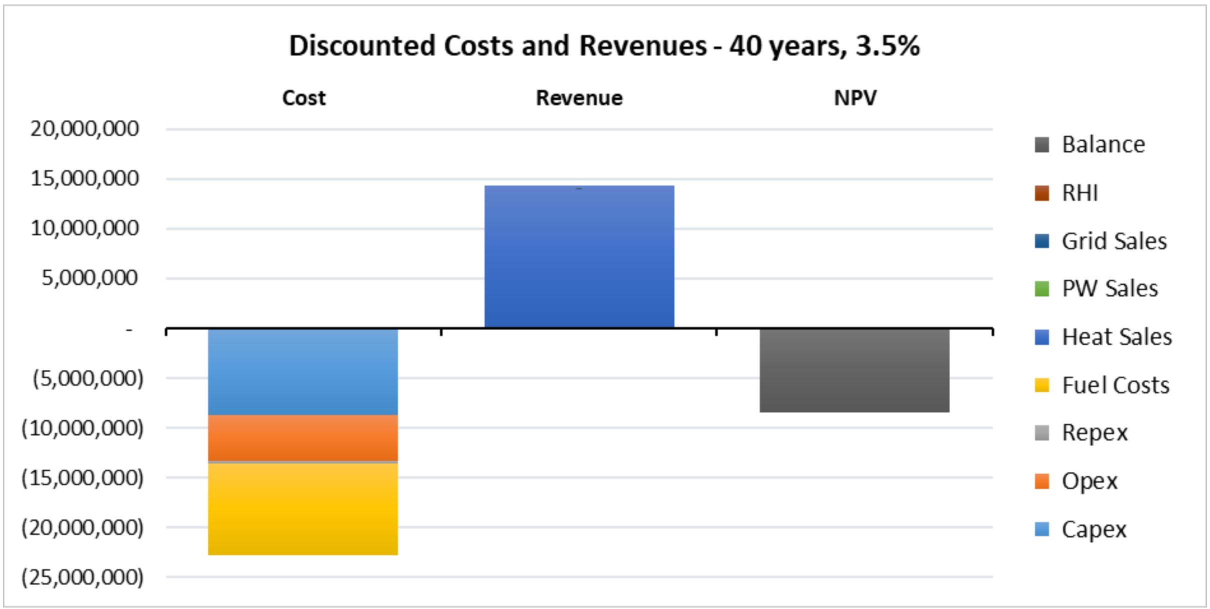

Figure 6-27 Balance of costs and revenues for the Scale Hall Cluster - WSHP, Base Case

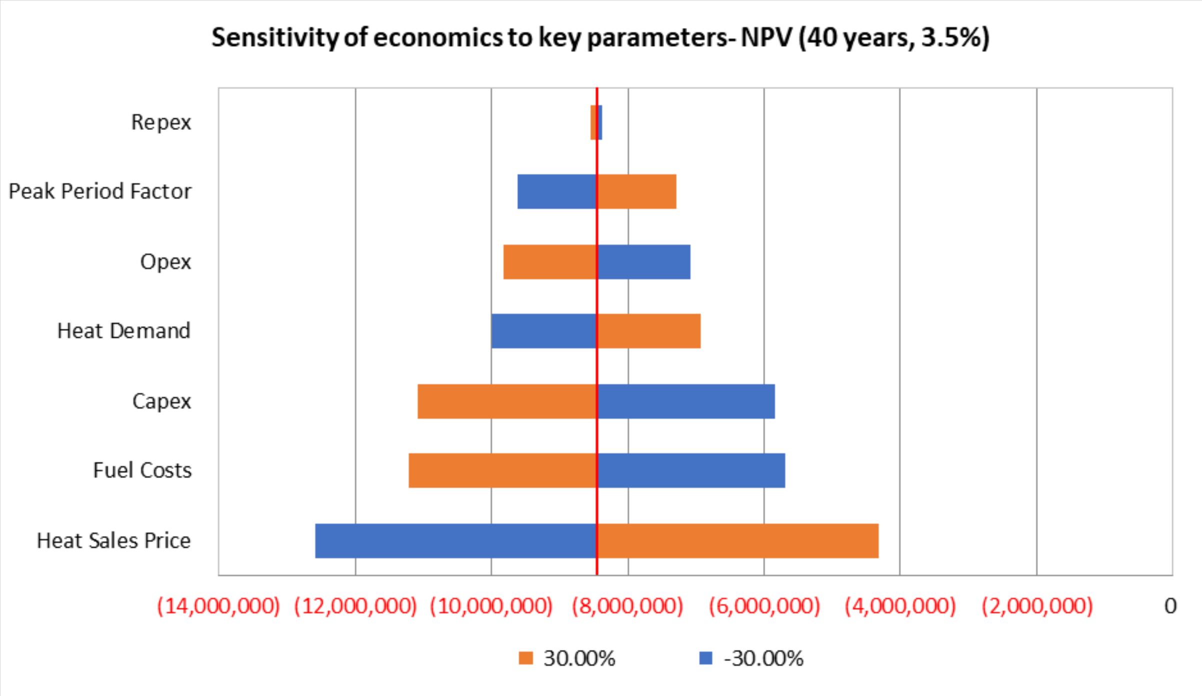

Figure 6-28 Sensitivity to key assumptions for the Scale Hall Cluster - WSHP, Base Case

6.3.3.2 Scale Hall – WSHP, +RHI

The economic results below are calculated using the same Base Case economic assumptions, but on the basis that the scheme can access support under the RHI.

Table 6-29 Key economic indicators for the Scale Hall Cluster - WSHP, +RHI

Years	25	30	40
IRR	Negative	Negative	Negative
NPV (@3.5%)	£ (3,370,000)	£ (3,300,000)	£ (3,180,000)
Discounted Payback Period	-	-	-

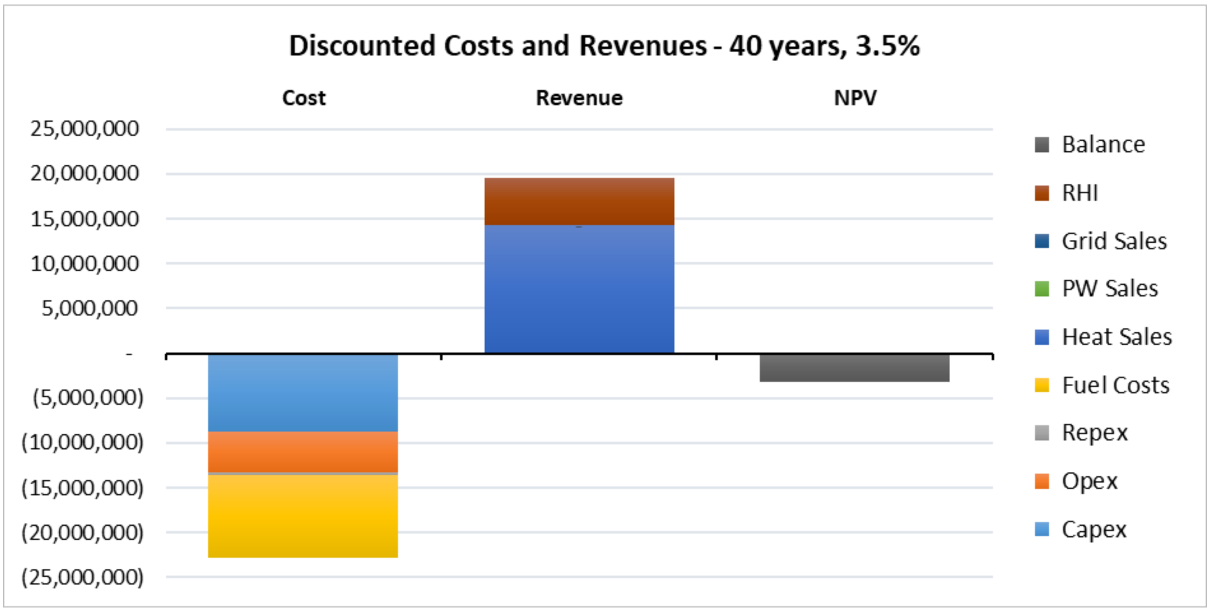

Figure 6-29 Balance of costs and revenues for the Scale Hall Cluster - WSHP, +RHI

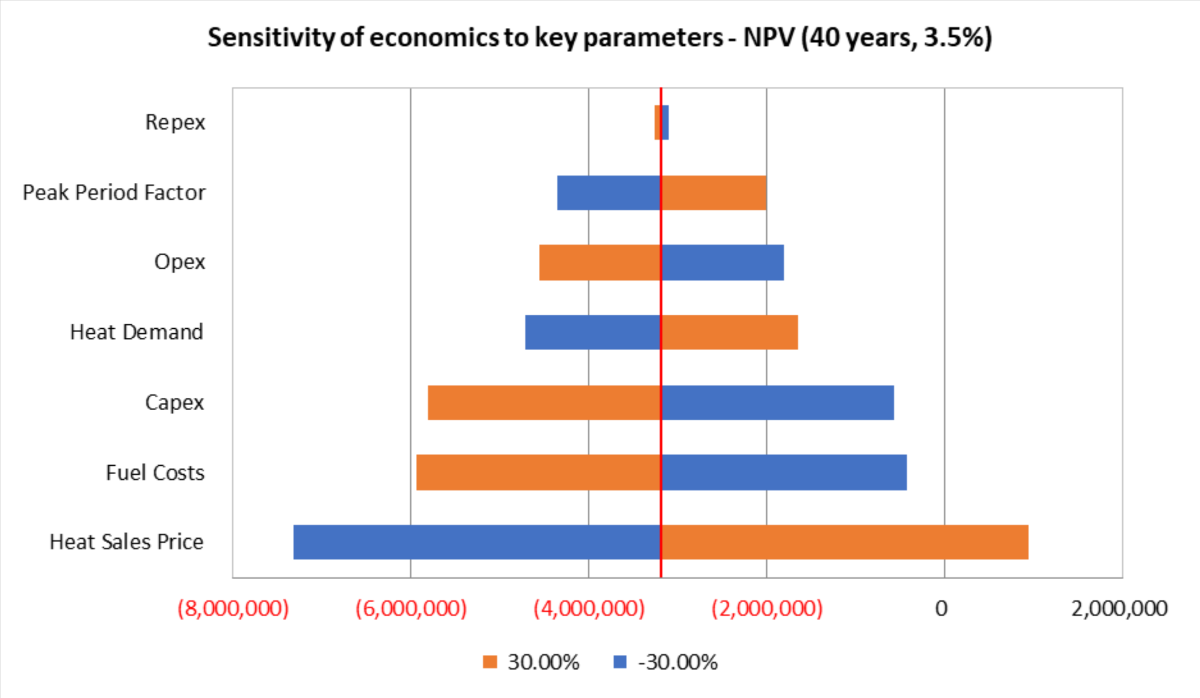

Figure 6-30 Sensitivity to key assumptions for the Scale Hall Cluster - WSHP, +RHI

6.3.3.3 Scale Hall – WSHP, Optimistic Case

Key Optimistic Case assumption

Heat sale price: 5.7 p/kWh

Gas purchase price 2.4 p/kWh – BEIS Existing Policies Industrial Gas Price

Peak electricity purchase price: 10 p/kWh – BEIS Baseline Policies Industrial Electricity Price

Off-peak electricity purchase price 7 p/kWh

WSHP electricity supply assumed to be 40% off-peak

Table 6-30 Key economic indicators for the Scale Hall Cluster - WSHP, Optimistic Case

Years	25	30	40
IRR	Negative	Negative	Negative
NPV (@3.5%)	£ (6,780,000)	£ (6,470,000)	£ (5,990,000)
Discounted Payback Period	-	-	-

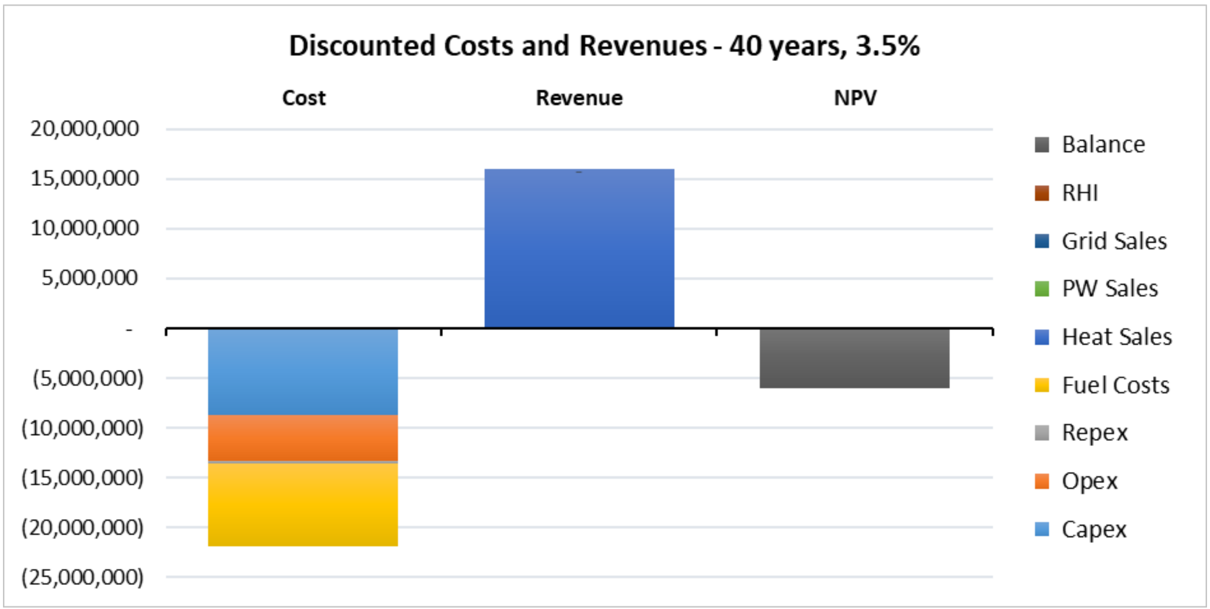

Figure 6-31 Balance of costs and revenues for the Scale Hall Cluster - WSHP, Optimistic Case

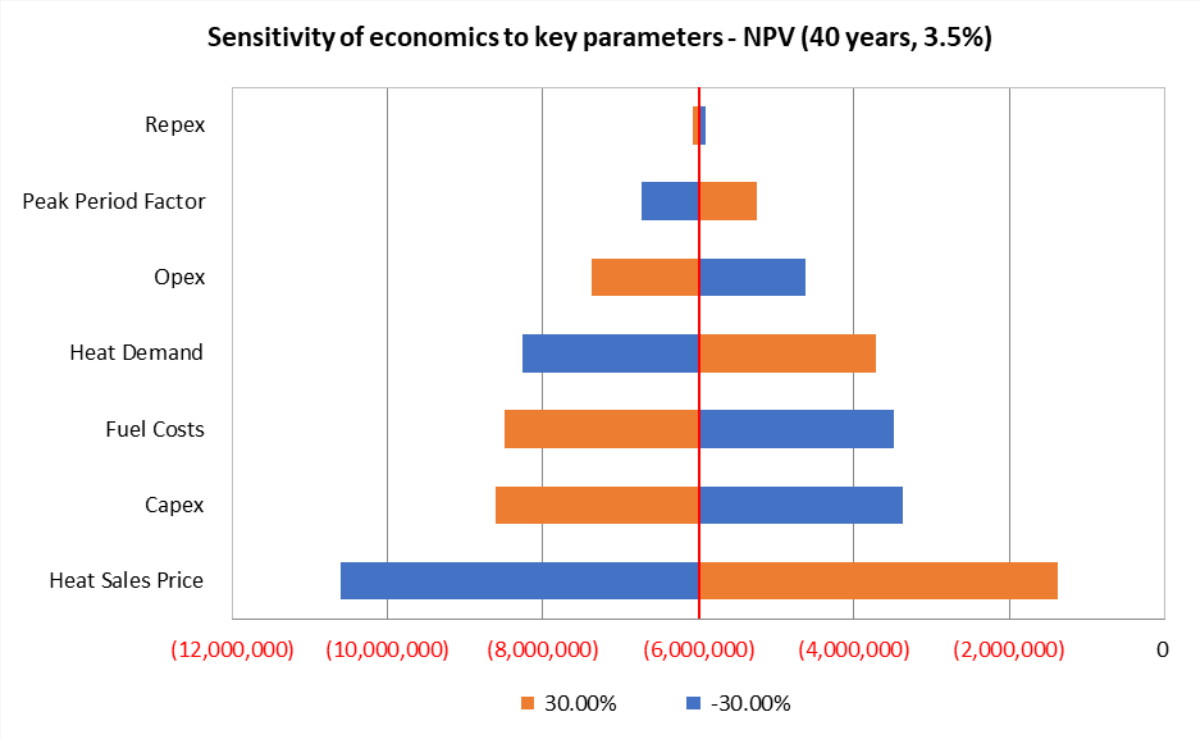

Figure 6-32 Sensitivity to key assumptions for the Scale Hall Cluster - WSHP, Optimistic Case

The base case of the Scale Hall cluster results in a negative NPV of £-8.5m. The cluster has a total demand of 8.1GWh and requires a total investment of £8.7m in year 0. During its 40 year lifetime, the project incurs costs of £14m and generates £14.3m in revenue (3.5% discount rate). If the scheme were to benefit from the RHI, it would generate an additional revenue of £5.3m over 40 years, discounted at 3.5% resulting in an NPV of £-3.2m.

6.4 Combined Cluster – City Centre and South Lancaster

A summary of the technical assessment for the City Centre and South Lancaster cluster is shown in Table 6-31. The total heat demand in the cluster is 40.4 GWh/year with a peak demand of 14.3 MW. The total distribution length, including the main distribution network and the service pipe serving individual buildings, is 6.4 km which results in a linear heat density of 6.3 GWh/year/km.

Figure 6-33: Scheme network route for City Centre and South Lancaster clusters

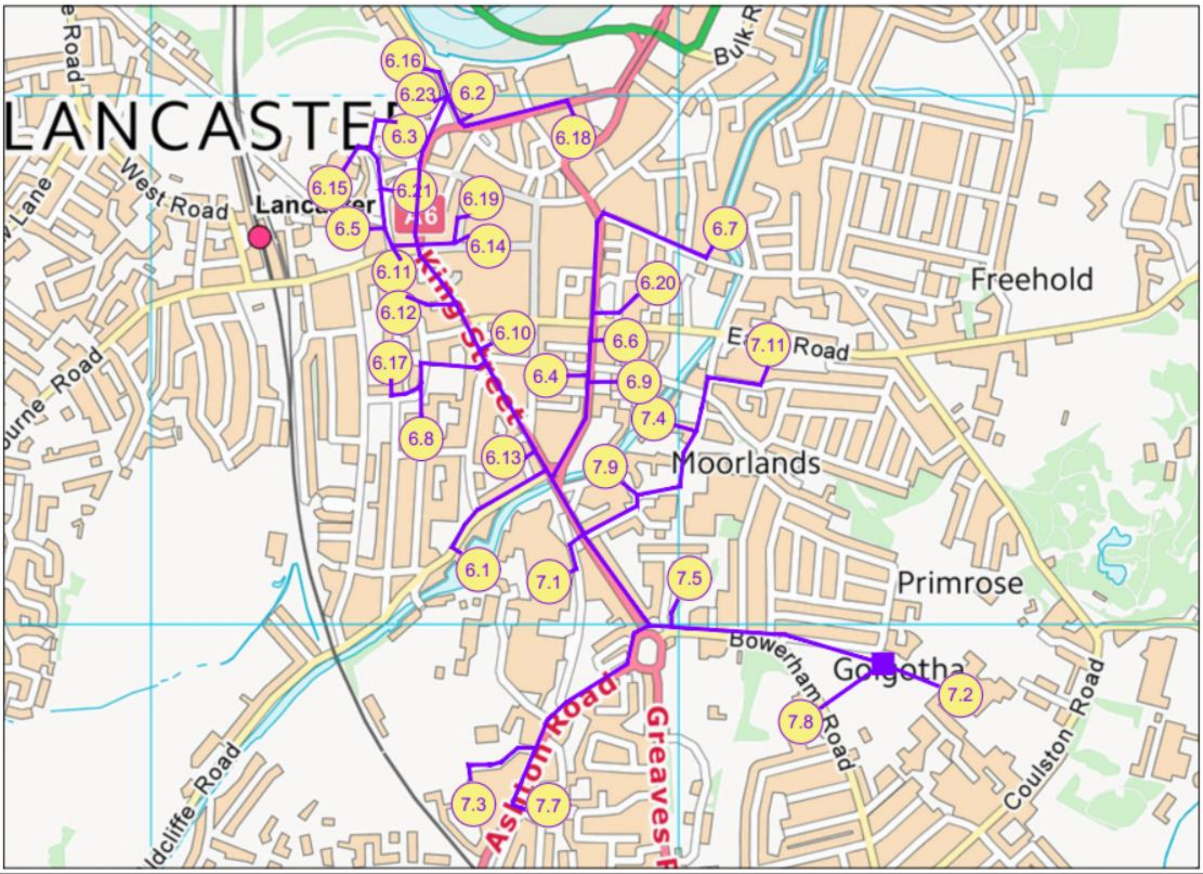

Table 6-31: A summary of the technical assessment for City Centre and South Lancaster

		Unit	Value
Annual heat demand at full build-out	Total	GWh/yr	40.4
Peak heat demand	Total	MW	14.3
Number of connections	Total	#	62
Network route length	Distribution	km	3.3
	Service		3.1
Network temperature	Network flow/return temperature	ºC	90/70
	Network delta T		20
Linear heat density		GWh/yr/km	6.3

The proposed selection and sizing of thermal plant for the Combined Cluster is shown in Table 6-32, below. As in the individual clusters, the design philosophy has been to maximise the contribution of the low carbon plant, i.e. the WSHP, to meeting thermal demands, while minimising gas use. This is achieved by providing a large amount of the thermal storage capacity, as well as a WSHP sized at a significant fraction of the peak demand.

Table 6-32: Summary of proposed plant for City Centre and South Lancaster

Plant Suggestion	No.	Individual Capacity	Notes
Thermal Store	2	100 m^3	200 m^3 required in total, may be split into 4 x 50,000 litre vessels
WSHP	2	3,500 kW	Assumes open-loop WSHP using water from borehole. Assumed SPF of 2.80.
Modular gas boiler plant	3	3,200 kW	Based on heat rating 4200kW to 1050kW
Main gas boiler back up plant	3	620 kW	Based on heat rating from 577kW to 114kW

The Capex and annual Opex estimates for the proposed plant operating to meet the heat demand in the Combined Cluster scheme are shown in Table 6-33 and Table 6-34, below.

Table 6-33: Associated costing of the network for City Centre and South Lancaster

Cost Breakdown	Value (£)
WSHP	6,720,000
Boiler	520,000
Network (pipe)	8,450,000
Heat interface units (HIUs)	192,000
Energy Centre	1,500,000
Thermal Storage	170,000
Engineering procurement & project management	870,000
Other costs	290,000
Contingency (10%)	1,897,466
TOTAL	**20,872,130**

Table 6-34: Annual Opex estimate for the Combined Cluster

Cost Breakdown	Value (£/yr)
Thermal plant O&M	263,000
Network O&M	4,838
Fuel costs (in Year 1)	1,647,911
Staff costs	50,000
Metering & billing	70,000
Insurance	20,000
TOTAL	**2,055,749**

6.4.1 City Centre and South Lancaster – WSHP, Base Case

Key Base Case assumptions

Heat sale price 5.1p/kWh

Gas purchase price 2.4 p/kWh – BEIS Existing Policies Industrial Gas Price

Peak electricity purchase price 11.7 p/kWh – BEIS Existing Policies Industrial Electricity Price

Off-peak electricity purchase price 7 p/kWh

Off-peak electricity usage 40%

Table 6-34 Key economic indicators for the City Centre and South Lancaster Cluster - WSHP, Base Case

Years	25	30	40
IRR	-3.02%	-1.11%	0.77%
NPV (@3.5%)	£ (11,760,000)	£ (10,390,000)	£ (8,260,000)
Discounted Payback Period	-	-	-

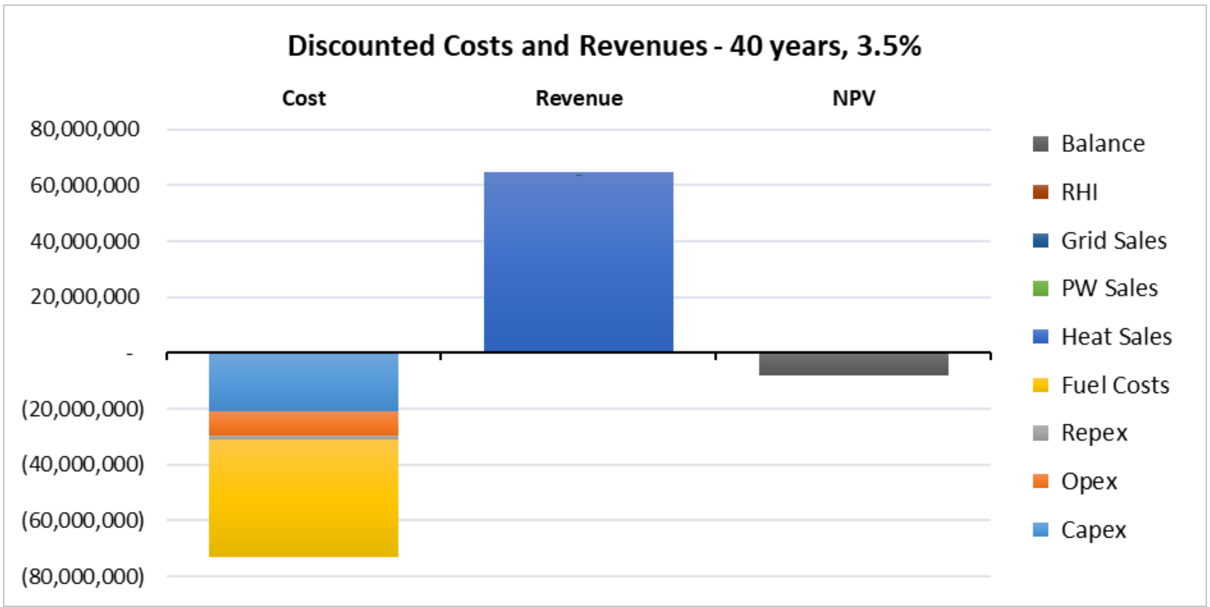

Figure 6-35 Balance of costs and revenues for the City Centre and South Lancaster Cluster - WSHP, Base Case

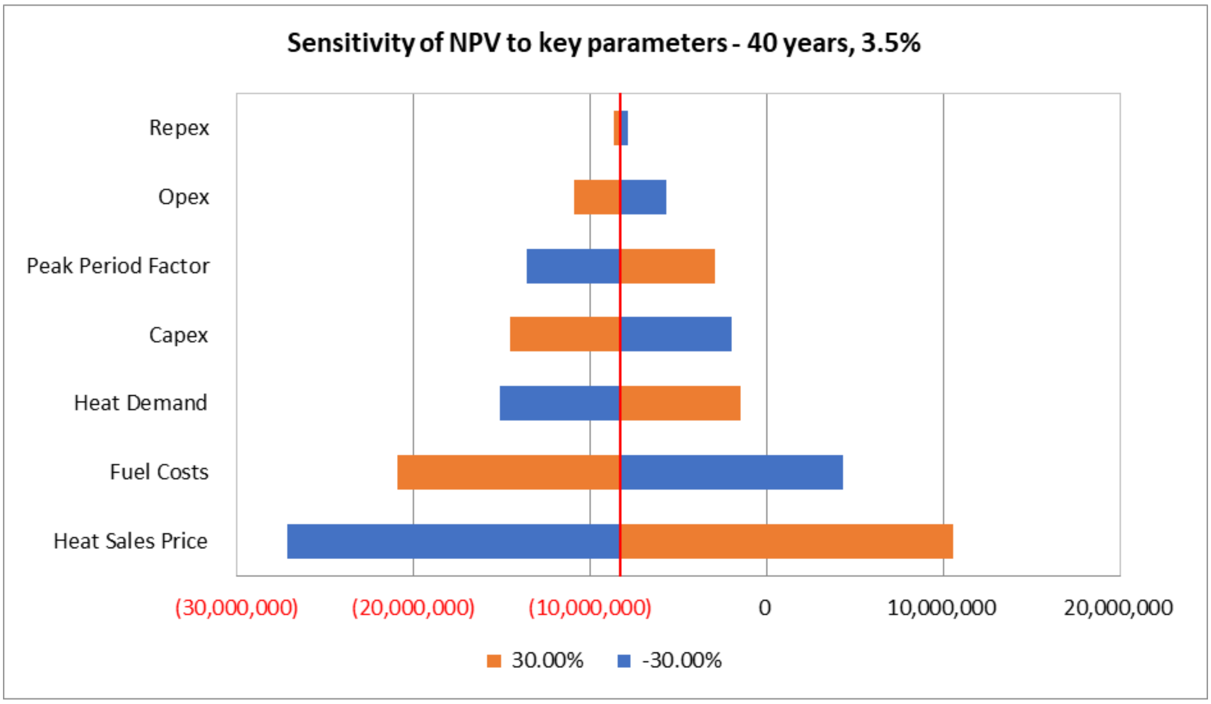

Figure 6-36 Sensitivity to key assumptions for the City Centre and South Lancaster Cluster - WSHP, Base Case

6.4.2 City Centre and South Lancaster – WSHP, +RHICase

The economic results below are calculated using the same Base Case economic assumptions, but on the basis that the scheme can access support under the RHI.

Table 6-35 Key economic indicators for the City Centre and South Lancaster Cluster - WSHP, +RHI Case

Years	25	30	40
IRR	9.28%	9.47%	9.65%
NPV (@3.5%)	£ 13,120,000	£ 14,500,000	£ 16,620,000
Discounted Payback Period	11	11	11

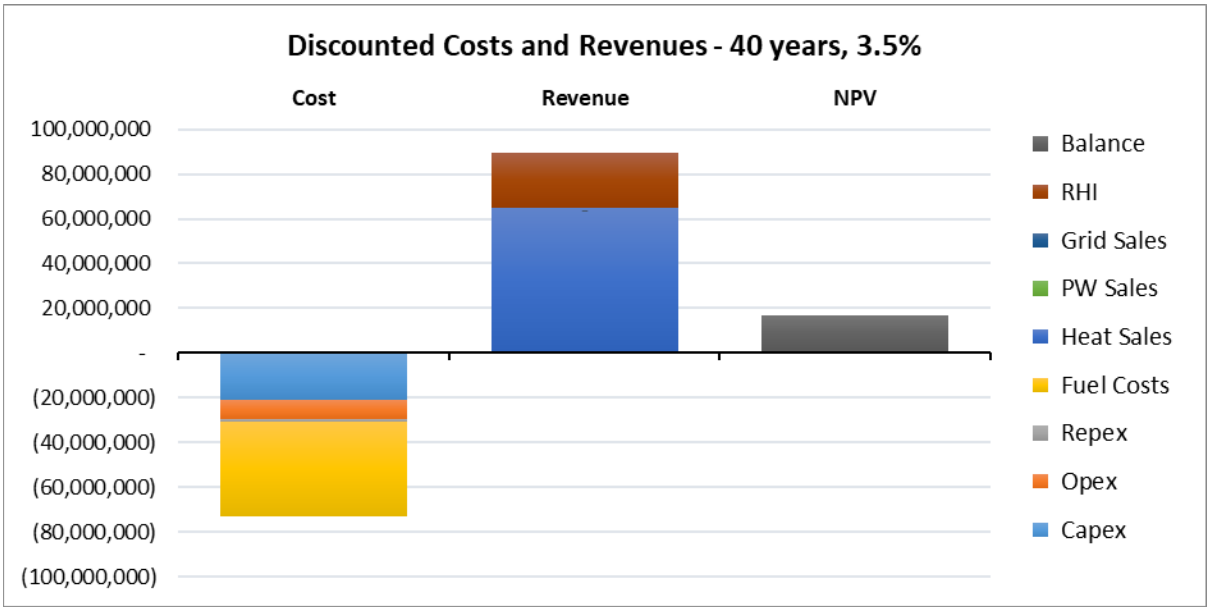

Figure 6-37 Balance of costs and revenues for the City Centre and South Lancaster Cluster - WSHP, +RHI Case

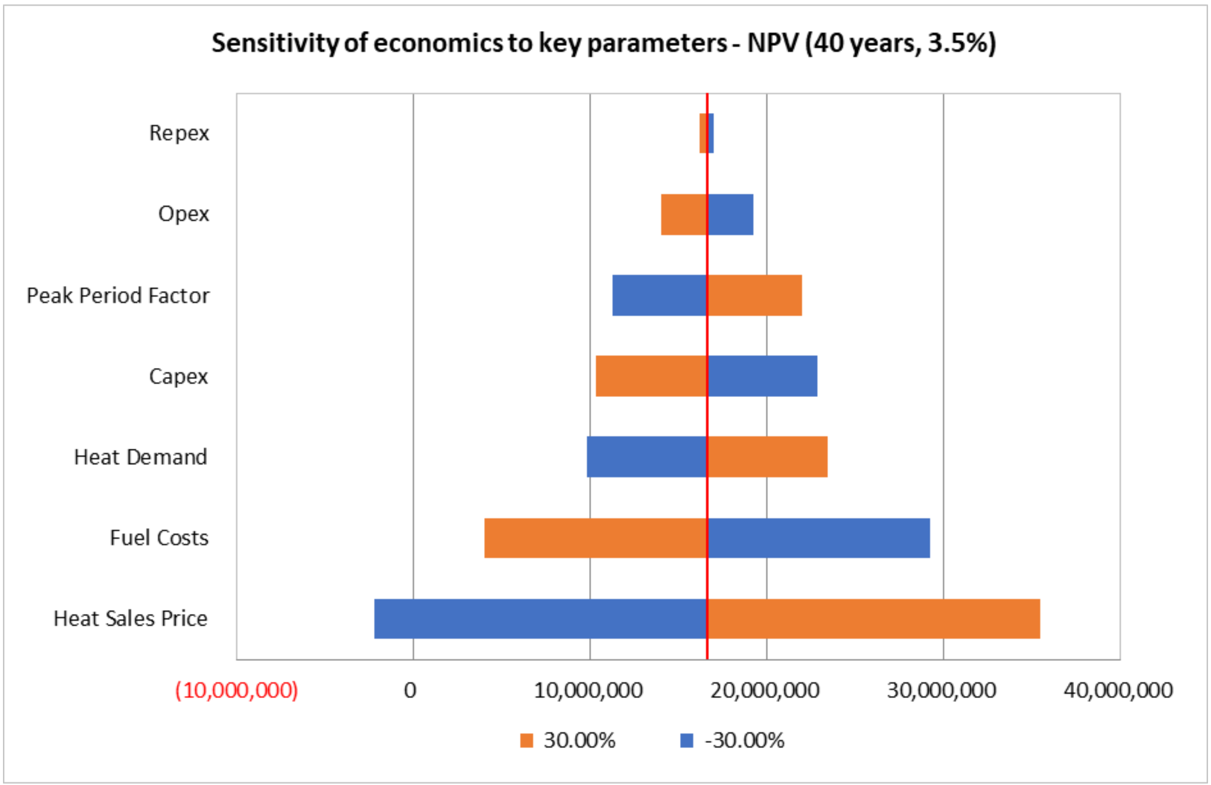

Figure 6-38 Sensitivity to key assumptions for the City Centre and South Lancaster Cluster - WSHP, +RHI Case

6.4.3 City Centre and South Lancaster – WSHP, Optimistic Case

Key Optimistic Case assumptions

Heat sale price: 5.7 p/kWh

Gas purchase price 2.4 p/kWh – BEIS Existing Policies Industrial Gas Price

Peak electricity purchase price: 10 p/kWh – BEIS Baseline Policies Industrial Electricity Price

Off-peak electricity purchas price 7 p/kWh

WSHP electricity supply assumed to be 40% off-peak

Table 6-36 Key economic indicators for the City Centre and South Lancaster Cluster - WSHP, Optimistic Case

Years	25	30	40
IRR	2.05%	3.21%	4.34%
NPV (@3.5%)	£ (3,230,000)	£ (790,000)	£ 2,990,000
Discounted Payback Period	No Payback	No Payback	32

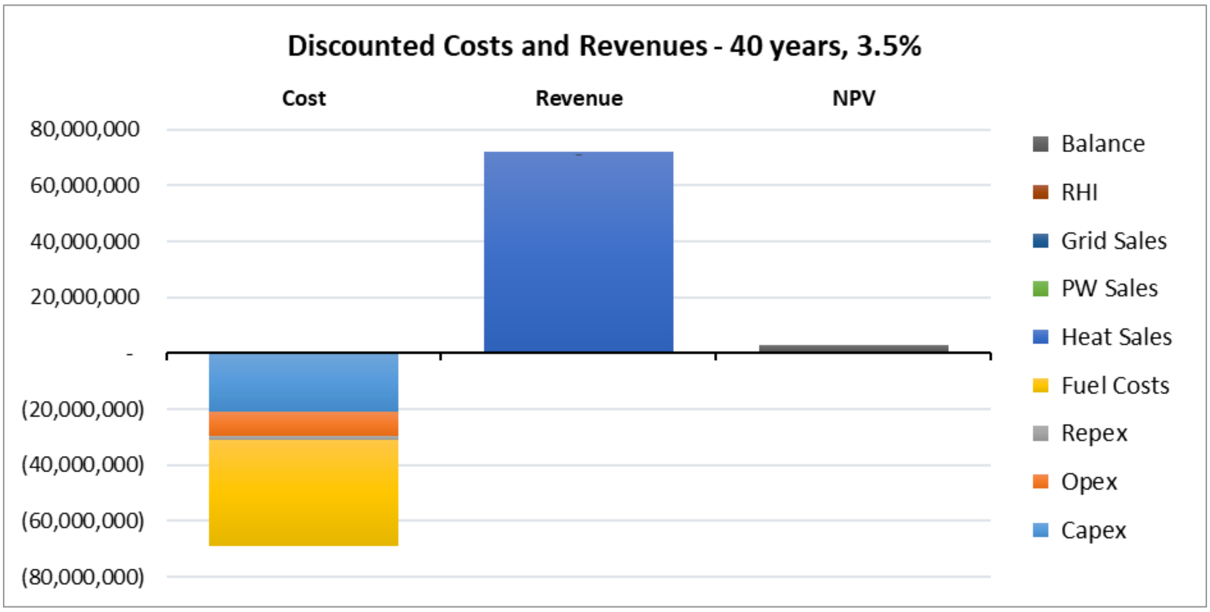

Figure 6-37 Balance of costs and revenues for the City Centre and South Lancaster Cluster - WSHP, Optimistic Case

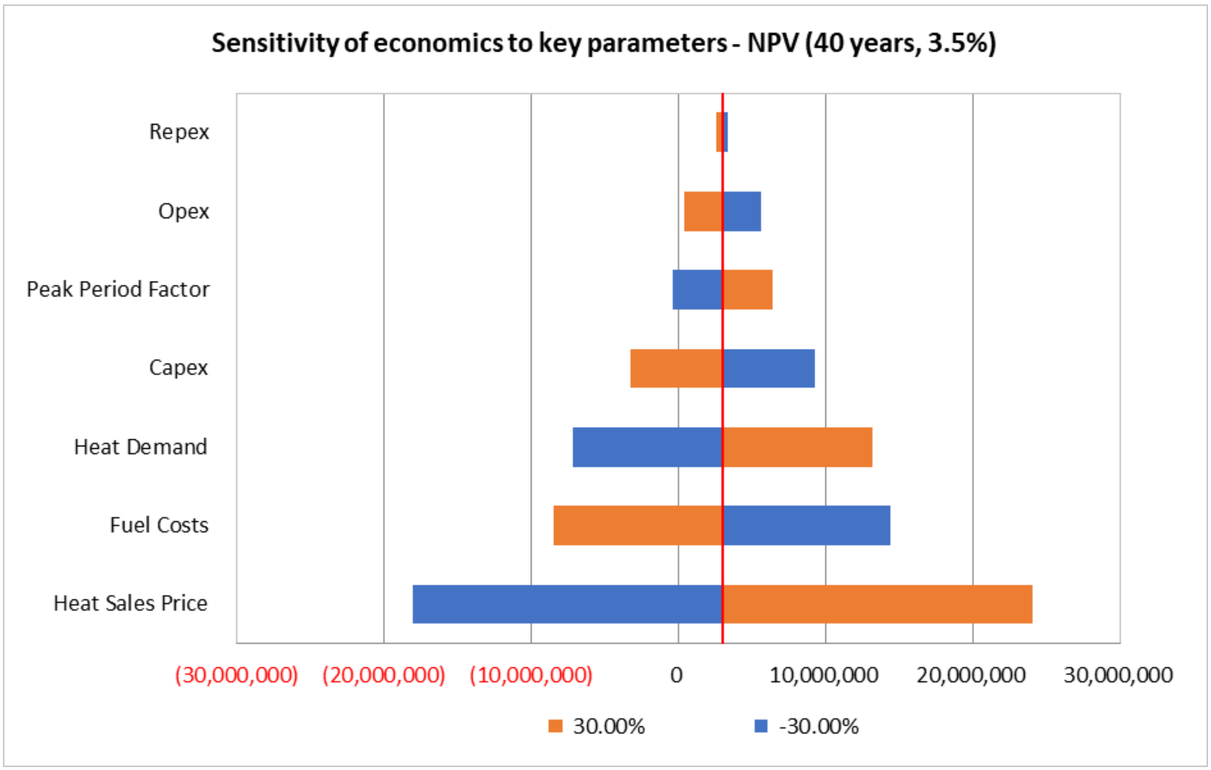

Figure 6-39 Sensitivity to key assumptions for the City Centre and South Lancaster Cluster - WSHP, Optimistic Case

6.5 Carbon emissions reduction

The analysis shows that the cumulative carbon emissions savings measured in tonnes of CO_2 are directly linked to the total annual demand for heat measured in GWh.

The CO_2 savings derive from the substantial displacement of natural gas fired heating with electric heating at relatively high efficiency (a seasonal performance factor (SPF) of 2.8 is assumed for the WSHP in each cluster, due to the assumption that heat is supplied at a high flow and return temperature – reduction of the flow temperature could increase the SPF and hence the associated emission savings).

The scale of CO_2 saving is predicated on the assumption of a decarbonising electricity grid over the period of the analysis. The emissions factor for grid electricity drops from around 0.3kgCO_2/kWh to around 0.03kgCO_2/kWh in 2050 (based on HM Treasury Green Book assumptions[20]), while the gas emissions factor is assumed to remain constant. The high CO_2 emissions reductions achieved are also a result of the plant sizing philosophy, which has sought to maximise the output of the clean technologies and limit the contribution of the back-up gas boilers.

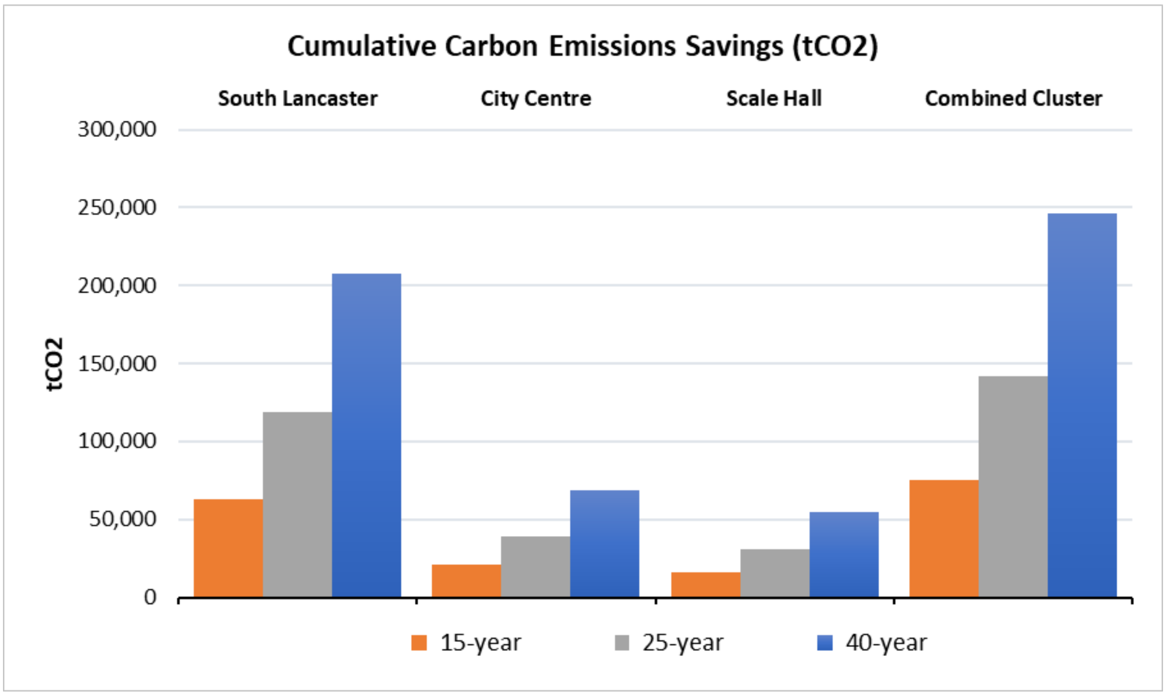

Figure 6-40 Cumulative carbon emissions reductions for each scheme option over 15, 25 and 40-years of operation.

In addition to the analysis of carbon savings delivered by the schemes, we have also assessed the reduction in the NOx emissions compared to the case that the heating demands of the clusters are met by individual gas boilers. The NOx emissions for each case and associated reductions are tabulated below.

[20] *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*, March 2019, www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Table 6-38 NOx emissions in each cluster - DH schemes vs counterfactual case

Cluster	Heat network case			Counterfactual NOx Emissions (kg)	Reduction in Annual NOx Emissions (kg)
	Total Energy (MWh)	Gas Energy Usage (MWh)	NOx Emissions (kg)		
South Lancaster	15,548	466	26.1	870.7	844.6
City Centre	8,304	257	14.4	465.0	450.6
Scale Hall	36,600	4868	272.6	2,049.6	1,777.0
South Lancaster and City Centre	23,850	3100	173.6	1,335.6	1,162.0

6.6 Summary of economic assessment

The techno-economic analysis has shown that the economics of low carbon district heating systems in the prioritised clusters are generally rather challenging, characterised by high capital costs and negative or low rates of return over the 40-year assessment period. The best performing options have been found to be those clusters that maximise the utilisation of the assets and serve a large number of district heating clients.

A summary of the economics of all the clusters in Lancaster under base case assumptions is shown below in

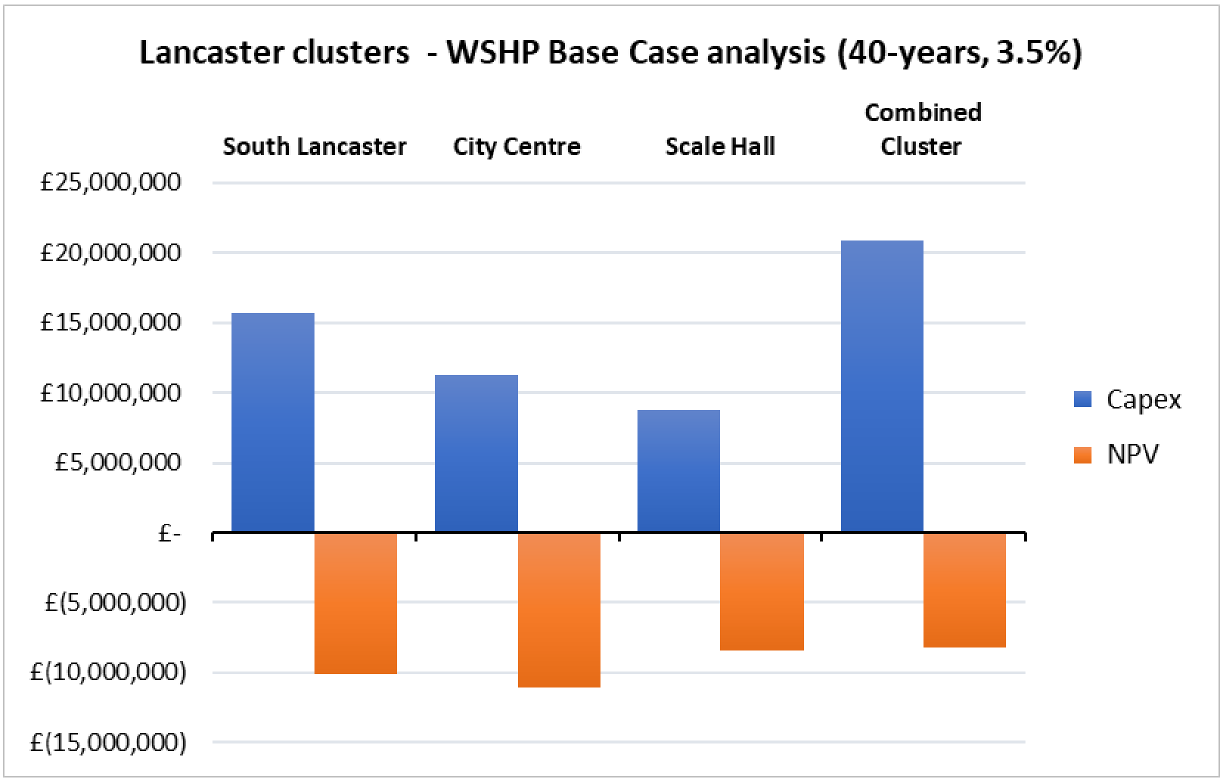

Figure 6-41.

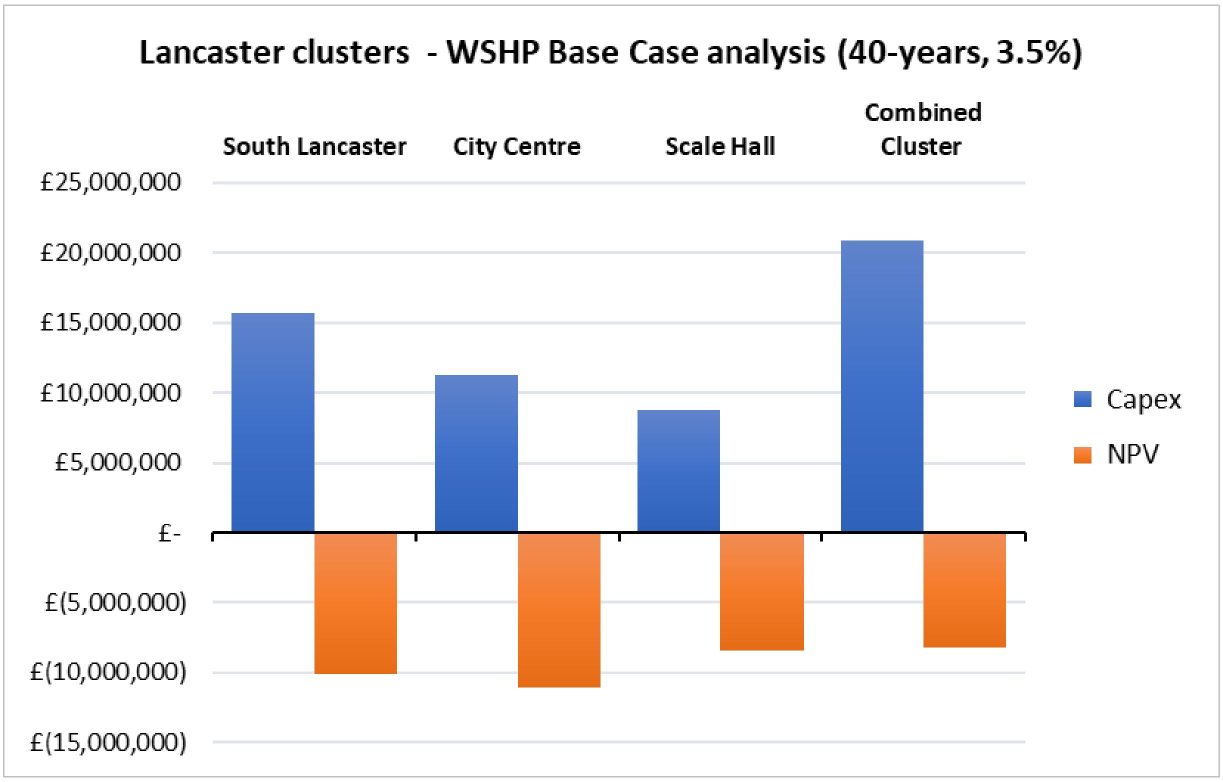

Figure 6-41 Comparison of key economic parameters across all cluster in Lancaster under base case assumptions

As the analysis of the individual clusters shows, none of the scheme options provide a positive 40-year NPV (at 3.5% discount rate). In each case, the scheme options are negatively affected by high capital and electricity costs of the water source heat pump. In the base case, the only cluster that has a positive IRR is the City Centre and South Lancaster combined cluster at 0.77% (40 years). Under base case assumptions, the combined cluster scheme option and the South Lancaster scheme option are the only schemes that generate an operating profit in the first year of operation. The other schemes rely on the increasing heat sale price over time, which is indexed to the BEIS service sector gas price forecast, to improve annual revenues such that they fully cover the operational costs. Annual fuel costs also increase, the electricity price for the WSHP is indexed to the BEIS industrial electricity price forecast, but at a slower rate than the heat price.

Under these assumptions, additional support will be required for these schemes to be viable, for example from the Renewable Heat Incentive (RHI).

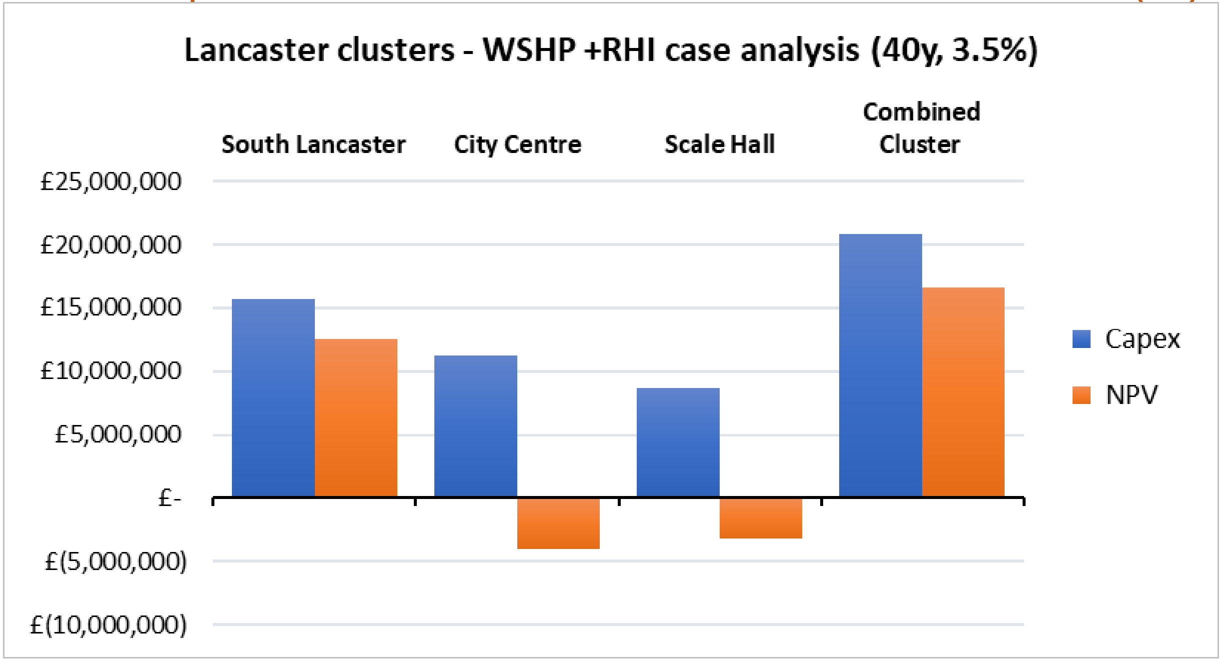

Figure 6-42 displays the effect that the RHI has on the scheme options in Lancaster.

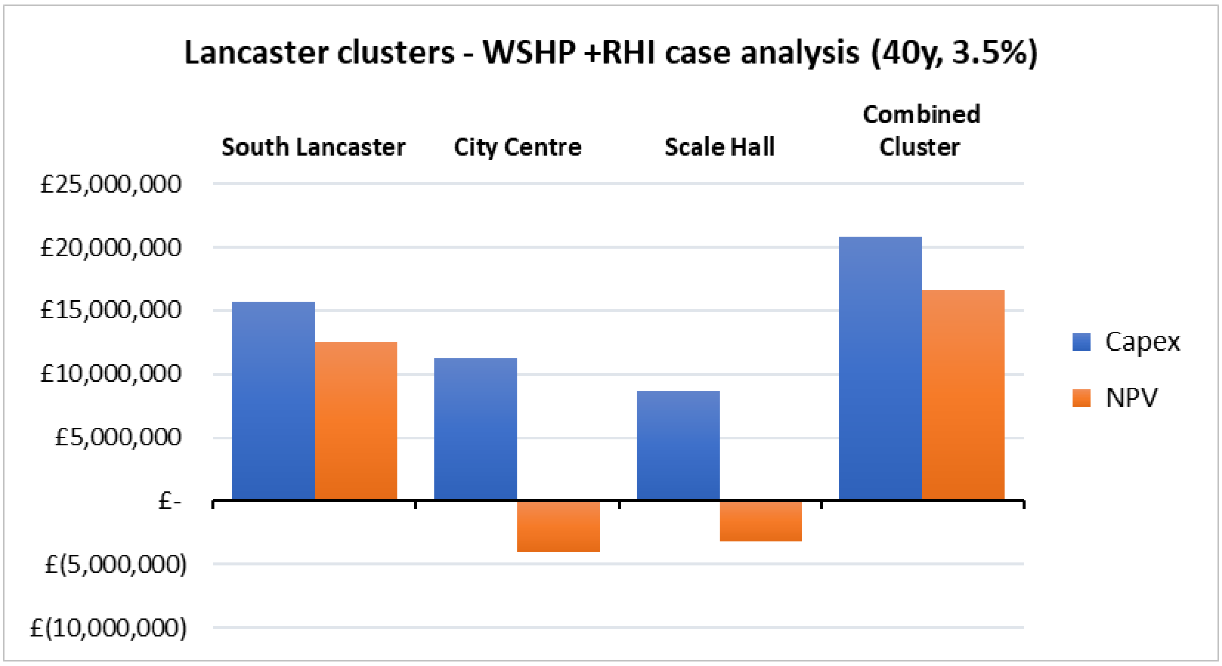

Figure 6-42 Comparison of key economic parameters across all cluster in Lancaster under +RHI case assumptions

The Renewable Heat Incentive (RHI) has been calculated on the basis of the tariffs in effect between 1 January 2019 and 1 April 2019 (see Table 6-2 for the tiered tariff structure). The subsidies calculated under Tier 1 have been calculated for the water source heat pumps running at maximum capacity for 1,314 hours. The remainder of the heat produced receives the tier 2 tariff.

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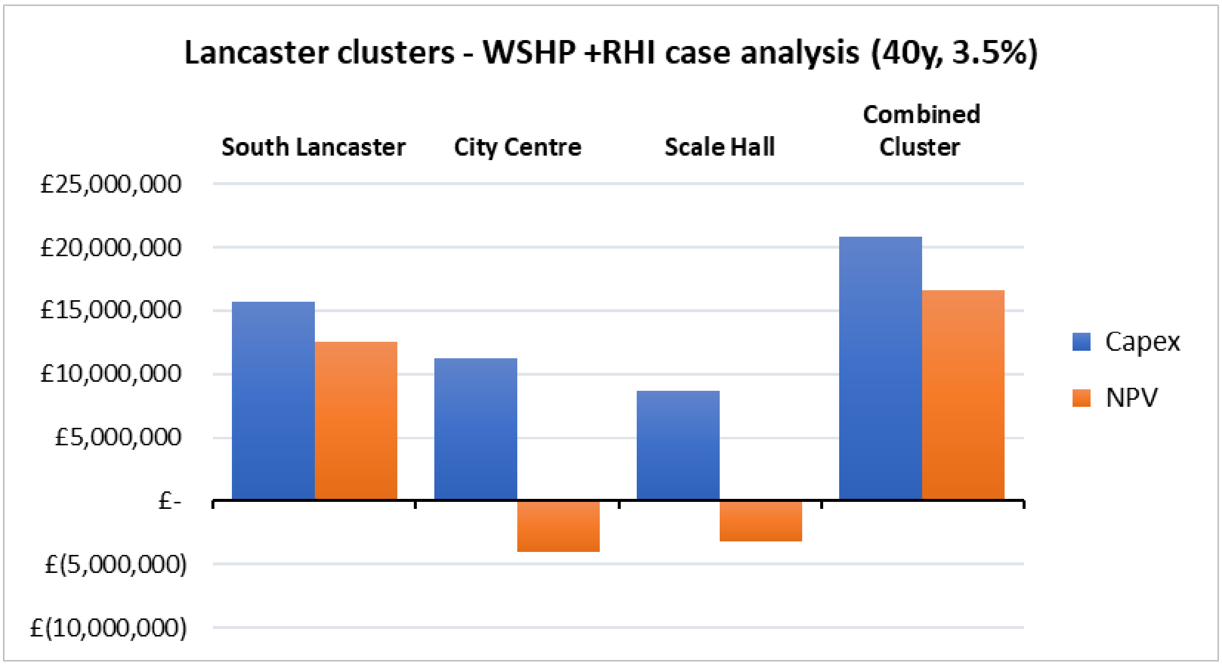


Figure 6-42 displays above, the RHI has a significant effect on all the scheme options in this study. Most notably, it affects the South Lancaster and Combined Cluster Scheme options. This is due to the large heat demand in the clusters and due to the fact that the water source heat pumps were sized to service a substantial amount of the required heat, ranging from 83% to 98%. In terms of revenue generated from the RHI scheme, the range is from £5.3m in Scale Hall to £24.9m in the combined cluster. However, the RHI has the most beneficial effect on the economics of the South Lancaster scheme option, increasing its IRR to 10.18% over the 40-year period. This results from the large amount of heat generated by the WSHP in this scheme.

In addition to the +RHI analysis case, we have undertaken an analysis based on 'optimistic' variables. The Optimistic Case comprises realistic modifications to key economic variables which result in a positive change in the scheme economics. The changes made were as follows:

- An increase in the heat sale price from 5.1 p/kWh to 5.7 p/kWh. This assumption was made on the basis that the district heating clients would be willing to pay a premium over the counterfactual heat cost for low carbon heating.
- A decrease in the peak electricity purchase price from 11.7 p/kWh to 10 p/kWh. This assumption was made on the basis that a large electricity consumer would have the purchasing power to negotiate a better electricity price.

The results of the clusters with these economic assumptions are shown in

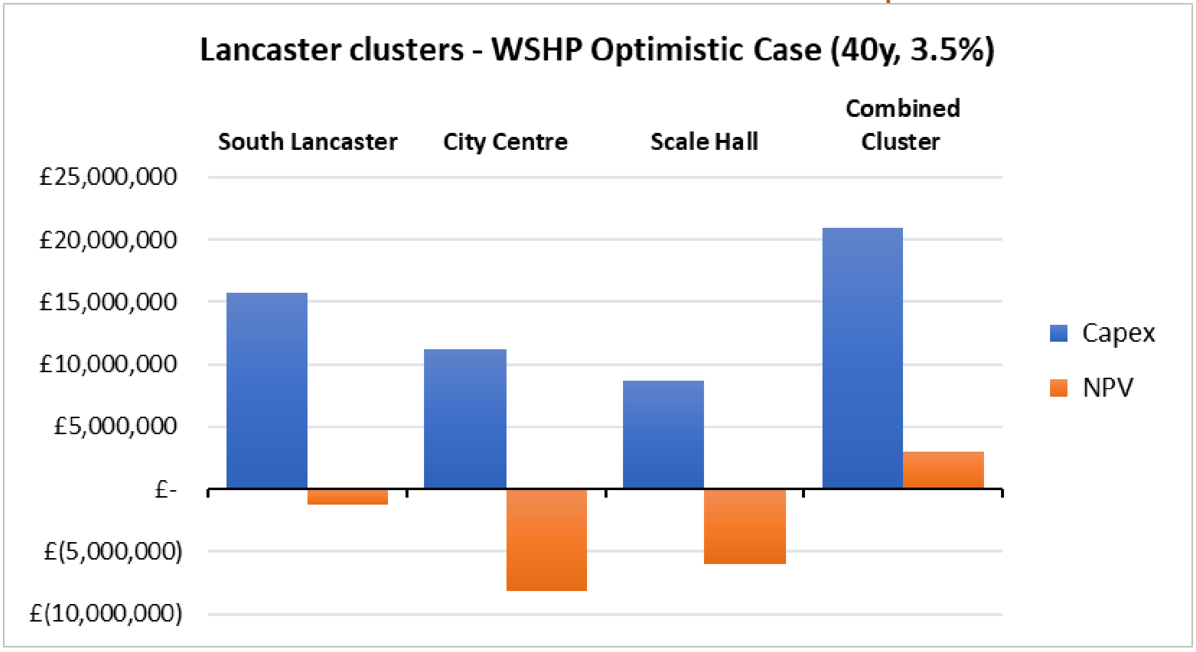


Figure 6-43 below.

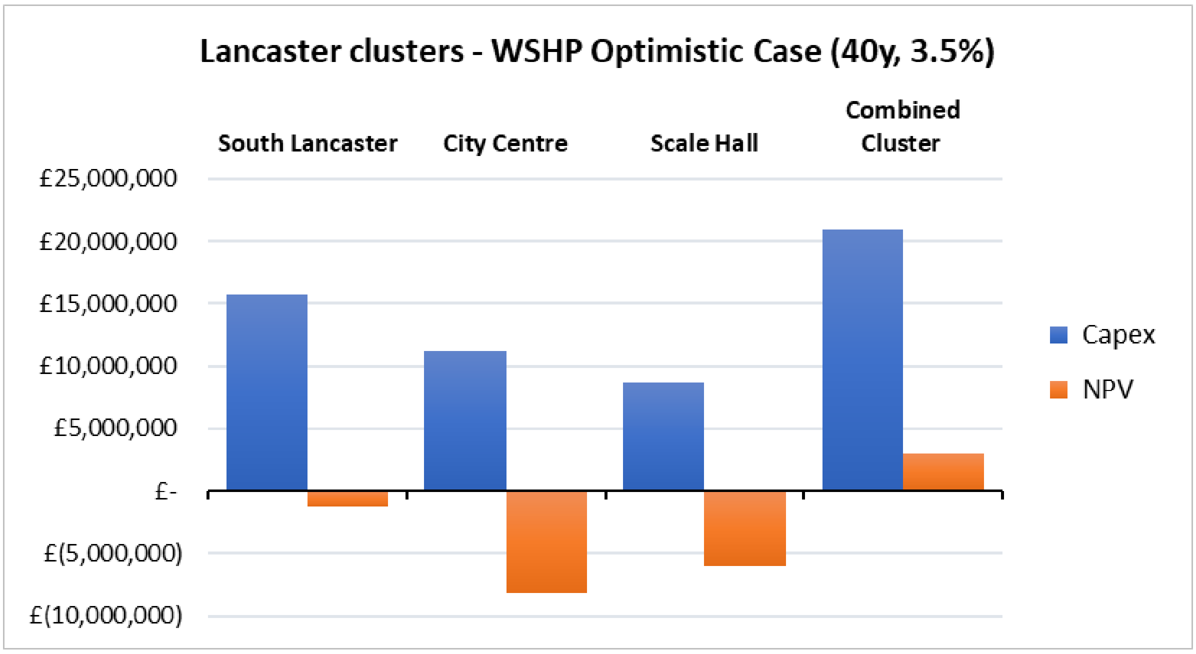


Figure 6-43 Comparison of key economic parameters across all cluster in Lancaster under Optimistic case assumptions

In the optimistic case analysis, it can be seen that the same trend continues as in the base case and +RHI case analysis, namely that there is a positive relationship between overall cluster demand and the NPV of the scheme. As shown in

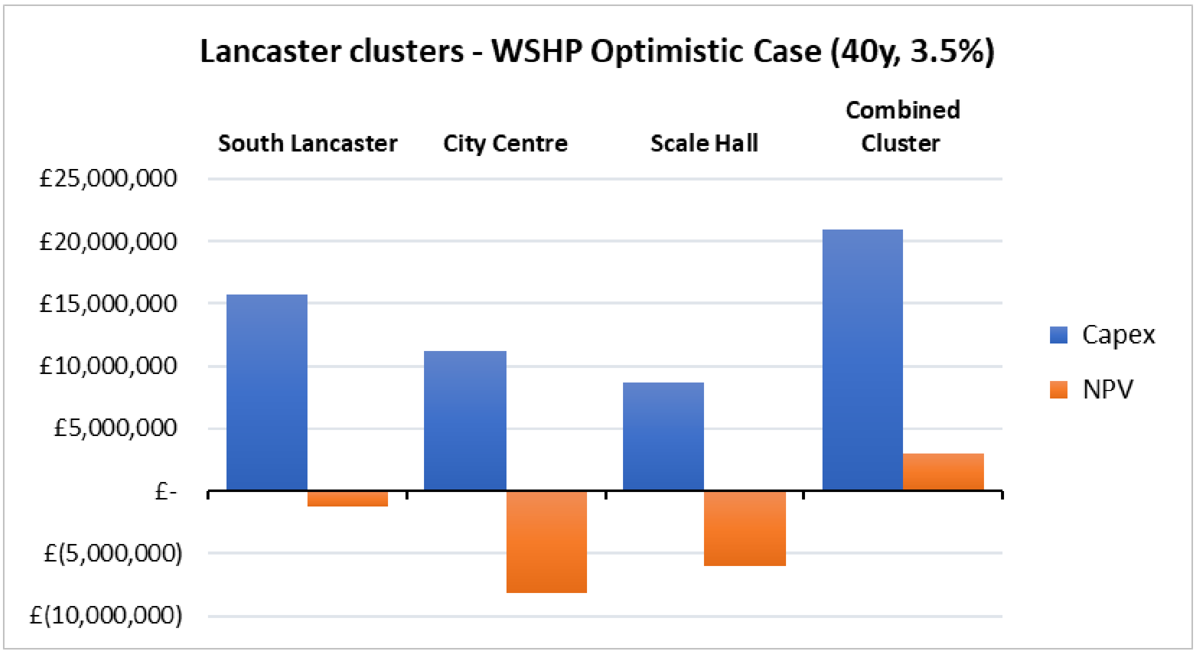


Figure 6-43, the best results relate to the South Lancaster cluster and the Combined Cluster scheme options, which have a demand of 31GWh and 40GWh respectively.

The best performing scheme in this case is the Combined Cluster which has an NPV of £3m with an IRR of 4.3%. The reduction of the peak electricity costs reduced the cumulative 40 year fuel costs (discounted at 3.5%) by £3.8m to £38.1m, whereas the increase in the heat sale price increase revenues by £7.4m to £72.1m.

The second best performing scheme in this case is the South Lancaster cluster, which has a 40-year IRR of 3.0% and a negative NPV of around - £1.25m (over 40 years at 3.5%).

The improved economics of the Combined and South Lancaster clusters suggest that it may be plausible for these schemes to become financeable if gap funding were available from the HNIP. If we look at the 25-year NPVs of these schemes in the Optimistic Case, they are - £3.23m and - £5.2m for the Combined cluster and South Lancaster cluster respectively. Gap funding of equivalent amounts would result in IRRs of 3.5% over 25-years. This may be deliverable under a public sector finance model, although more likely an IRR of closer to 5% would be required even in the case of public sector financing (requiring higher levels of gap funding or further optimisation of the economic parameters).

The remaining City Centre and Scale Hall scheme options have negative IRRs in the optimistic case and would require gap-funding of £8.2m and £6m to generate an IRR of 3.5% over 40-years (increasing to £9.1m and £6.8m to generate a 3.5% IRR over 25 years). In both cases this gap-funding is a very significant fraction of the scheme capex (the City Centre and Scale Hall schemes have estimated Capex of £11.25m ad £8.7m respectively). On this basis, the City Centre and Scale Hall schemes do not appear viable.

6.6.1 *Summary results tables*

The NPV and IRR results for each of the scheme options are tabulated below. The first table includes the scheme options (described by the combination of cluster, heating plant option and economic case) that have generated positive NPVs and IRRs > 3.5% (evaluated over 40 years).

Table 6-39 NPV and IRR for scheme options that provide a positive 40-year NPV

Name	Technology	Economic Case	NPV	IRR
South Lancaster	WSHP	+RHI Case	12,500,000	10.18%
Combined Cluster	WSHP	+RHI Case	16,600,000	9.65%
Combined Cluster	WSHP	Optimistic Case	3,000,000	4.34%

The remaining scheme options are included in the table below. These scheme did not generate positive 40-year NPVs and in some cases the schemes do achieve a positive IRR and could be considered for gap funding.

Table 6-40 NPV and IRR for scheme options that provide a negative 40-year NPV

Name	Technology	Economic Case	NPV	IRR
South Lancaster	WSHP	Optimistic Case	(1,250,000)	3.01%
Combined Cluster	WSHP	Base Case	(8,260,000)	0.77%
Scale Hall	WSHP	+RHI Case	(3,180,000)	-0.55%
City Centre	WSHP	+RHI Case	(4,030,000)	-0.59%
South Lancaster	WSHP	Base Case	(10,160,000)	-1.51%
Scale Hall	WSHP	Optimistic Case	(5,990,000)	-1.99%
City Centre	WSHP	Optimistic Case	(8,190,000)	-2.54%
Scale Hall	WSHP	Base Case	(8,460,000)	-7.56%
City Centre	WSHP	Base Case	(11,070,000)	-8.26%

6.7 Discussion on the whole study area

Combining the results of the economic assessment for the prioritised clusters, presented above, with the qualitative and quantitative comparison of the full list of cluster areas presented in Section 5.2, it is possible to comment on the likelihood of the non-prioritised clusters being viable for heat network development.

In the prioritisation of the clusters, the “Bailrigg” cluster scored significantly higher than the other clusters. The “South Lancaster” and “City Centre” clusters ranked next highest receiving the same score, with the “Scale Hall” just behind, and all other clusters given significantly lower scores.

As mentioned before, Bailrigg cluster was not taken forward for a detailed techno-economic study despite scoring the highest during the prioritisation process. Two reasons for that were the lack of detailed development timeline of the Bailrigg Garden Village Growth Area and the advanced stage of development Lancaster University has reached regarding the University’s heat network plans, which meant that there was limited added value in studying further within this masterplanning study.

Therefore, the next best three clusters (South Lancaster, City Centre and Scale Hall) were taken forward for the techno-economic study. The relative scoring of those clusters is supported by the outcome of the economic assessment. While potential viable schemes have been identified in the South Lancaster cluster and City Centre cluster (when combined with South Lancaster in a combined scheme), we found that a stand-alone scheme in the Scale Hall cluster is unlikely to be viable.

Given that our economic assessment has established that a stand-alone scheme in the Scale Hall cluster is unlikely to be viable, this enables us to form a view – albeit with less certainty than based on a detailed economic assessment – the likelihood that heat networks in the non-prioritised clusters will be viable.

Comparing the non-prioritised Clusters 1, 3 and 5 with the Scale Hall cluster (based on Table 5-12 and the more detailed data in Section 5.1) it can be seen that the non-prioritised clusters have both a lower volume of heat delivered and a lower heat density than the Scale Hall cluster. Similarly to Scale Hall cluster, Clusters 3 and 5 also scored low for mix of user types. This criterion is important for plant sizing to meet the peak heat demand as well as total heat demand, which affects the capital cost substantially. Given that both the volume of heat delivered and the heat density of each of these clusters is lower than for Scale Hall, it is highly likely that an economic assessment of these clusters would show that a heat network in these areas would not be viable.

Potentially, the East Lancaster cluster can be connected with the combined South Lancaster and City Centre cluster, especially with the expected energy demand increase due to new developments predicted in the East Lancaster Strategic Site. However, it is expected that a significant increase in the volume of heat demand and linear heat density would be required for a district heating network to become viable in this cluster.

The Bailrigg cluster has a similar annual heat demand to the combined cluster and an even higher linear heat density. Hence, we would expect the economics of this cluster to be at least comparable if not better. A factor that would be important for an area wide scheme rather than a heat network scheme for only Lancaster University is incorporation of the upcoming developments in the Bailrigg Garden Village Growth Area.

Comparing Cluster 8 (Morecambe) with the City Centre cluster in a similar way, we note that Cluster 8 has a slightly higher volume of heat delivered (14 GWh/yr vs 10 GWh/yr) but a lower linear heat density (2 GWh/km vs 2.6 GWh/km). Eden project has revealed plans to open an outpost in Morecambe bay, which is expected to result in increase of heat demand in the town. This development could present a stable anchor customer that would improve the deliverability of this cluster, which currently has many moderately sized heat users. Given the similarity of the heat density and volume of heat delivered between these clusters, the findings of our analysis that a stand-alone system in the City Centre cluster is unlikely to be viable, we suggest this indicates that a scheme in Morecambe, under current circumstances, would also not be viable.

Acknowledging that this high-level quantitative analysis carries less certainty than the detailed economic assessment undertaken for the prioritised clusters, the analysis nonetheless quite clearly suggests that heat network schemes in the prioritised clusters are unlikely to be viable. We suggest therefore that these opportunity areas – except for Bailrigg/Cluster2 - should not be taken forward unless new information is brought to light, such as the identification of large new (or previously unidentified) heat users or significant new development plans, which could improve the prospect for a heat network in these areas.

7 Conclusions and recommended next steps

Based on the analysis undertaken in this heat mapping and masterplanning study, we make the following recommendations on next steps. We suggest that Lancaster City Council are best-placed to take ownership of the majority of the near-term actions, but continued support (both through expertise and further funding) from HNDU will also be crucial.

1. We recommend that HNDU and Lancaster City Council continue to engage with the University of Lancaster, who have plans to further decarbonise and potentially extend the University's existing heat network, to ensure that any opportunities to support that work are identified.

Lancaster University has an existing heat network on campus and is experimenting with innovative approaches to integrate a range of on-site low carbon technologies across the campus, both for research purposes and to be able to meet their carbon reduction targets. The University has expressed an interest in considering how the campus energy system, including the heat network, could be integrated with the wider local energy system to provide mutual benefits.

Based on the advanced level of development of the University's plans for this potential scheme, it was agreed with HNDU that taking this cluster forward for heat mapping and master planning as part of this study would not result in any significant added value.

However, we suggest that HNDU and Lancaster City Council continue to engage with the University to ensure that opportunities for synergies – such as linking the University's energy system with the new development at Bailrigg Garden Village – are identified as early as possible to feed into strategic plans. HNDU may also be able to support the University in identifying sources of funding and/or relevant delivery partners.

2. Review local planning policy to ensure the potential to influence development of heat networks in Lancaster, including at Bailrigg Garden Village and other key developments.

Planning policy is a major lever for the Council to require, or encourage, developers to connect to heat networks, where this is a suitable and economically viable option.

Although new developments are not a major component of the proposed schemes, the connection of several new developments – including the development of new sites such as the Bailrigg Garden Village Growth Area (up to ≈3,500 new homes), where there is the potential to link with the Lancaster University's heat network in the longer term, the New Quay Road Development (≈250 homes) the North Lancaster Strategic Site (≈700 new homes and non-domestic development) and East Lancaster Strategic Site (≈900 new homes and non-domestic development) – could strengthen the economic case for the schemes. In the longer term, planning policy for connection to heat networks could, in principle, be extended to existing buildings, for example at trigger points of major renovation or heating system replacement, where viable and appropriate. This could in future be an important mechanism for ensuring a high rate of connection to the scheme and help to ensure the economic performance and sustainability of the scheme.

At this stage, the Council could consider options to strengthen planning policy on heat networks, such as including a requirement for significant new development to connect to existing heat networks and (more importantly at this stage, since no heat network yet exists) a requirement for new development to be connection ready, for when a heat network is available.

This is, again, an action that is most suitable for the Council to lead on, but support from HNDU could be highly valuable in identifying best practice elsewhere on this theme, and to assist the Council in the development of the detailed policy and supplementary planning guidance documents.

3. We recommend to advance to detailed feasibility stage an opportunity area covering the "South Lancaster" and "City Centre" opportunity areas.

Our economic assessment suggests that a water-source heat pump based heat network covering the "South Lancaster and City Centre" opportunity area could be viable, whether using the River Lune, Lancaster Canal or a borehole. Our analysis finds that this scheme could be viable, with a 40-year IRR of 4.3% even without Renewable Heat Incentive (RHI) support, under the assumptions of lower peak electricity purchase price and heat sale price of 5.7 p/kWh. A scheme based on the less favourable base case assumptions could also be viable, albeit likely to be dependent on revenue from the RHI, or otherwise with a gap funding requirement of at least £8.3m (compared to an overall capex of £20.8m – a funding percentage of around 40%).

We therefore recommend that the area covering these combined clusters is taken forward to detailed feasibility stage, and that this study considers the most appropriate phasing of a scheme across this opportunity area. Our analysis suggests that the most economically attractive scheme may be the one limited to South Lancaster, and so this could be considered as a 'fall-back' option where a more extended scheme is not deemed viable.

Heat supply options should include, as a minimum, a water-source heat pump, with a focus on the most viable sources (i.e. the river, canal or a borehole, or another as yet unidentified option).

We propose that HNDU and Lancaster City Council engage further in order that the Council can consider whether to take on the recommendations of this report, and so that HNDU can explain the application process for feasibility stage funding.

4. We do not recommend advancing other cluster areas to detailed feasibility stage at this point, but that a watching brief should be kept on areas where significant new developments are planned, including East Lancaster, Morecambe and Bailrigg.

Our detailed technical and economic analysis focused on the cluster areas described above, along with the Scale Hall cluster. Our assessment finds that the Scale Hall cluster is unlikely to present a viable opportunity, even when it is assumed that RHI revenue would be available, with very low or negative IRRs under all sensitivities modelled. We therefore do not suggest this cluster area is taken forward to detailed feasibility unless new information on significant heat users or low cost sources of low carbon heat is brought to light, which could support a reconsideration of this cluster.

We have also undertaken a quantitative comparison of a larger number of cluster areas across Lancaster, including an assessment of the volume of heat that could be served, the likely linear heat density and the presence of low carbon heat sources. On the basis of our analysis as a whole, we do not see a clear case at this stage for taking forward to detailed feasibility any other clusters. As explained in Section 6.6, we find that these other clusters are unlikely to be more economically viable than the "South Lancaster" cluster, which we suggest is not studied only as a stand-alone scheme but also in combination with the "City Centre" area. In short, our analysis suggests that the heat density in these other clusters is not sufficiently high to provide a basis for an economically viable scheme.

However, we have identified several potential developments which could improve the prospect for a heat network in other opportunity areas in Lancaster. These include the East Lancaster strategic development site, expected to include up to 900 dwellings, retailing space and a primary school. We suggest that this could be an opportunity for the development of a new-build heat network scheme in the East Lancaster cluster, and that the Council could consider approaches to delivering low carbon heat networks in this area through planning policy (see recommendation 2 above). In Morecambe, the Eden Project has revealed plans to open in the area, which could provide a large source of heat demand (although it is not clear how much of this demand this would be compatible with a heat network system). Since this development could present a stable anchor customer that would improve the deliverability of a scheme in this cluster, we suggest that a watching brief is kept on this opportunity area.

5. Continue engagement with key stakeholders in the area, both ahead of and as part of the detailed feasibility work.

Continued engagement with the relevant stakeholders is crucial, in order (i) to further soft market test interest in connecting to a heat network scheme, and identify any barriers/challenges, to reduce uncertainty; (ii) to fill in gaps in the actual/metered heat demand data gathered and (iii) to better understand the current heat prices incurred by stakeholders.

The major stakeholders in the “South Lancaster and City Centre” opportunity area include the Royal Lancaster Infirmary, the University of Cumbria, several student accommodation blocks, a number of schools and a range of municipal buildings. It is vital to keep the Infirmary engaged as it is a key anchor load, providing around half of the heat demand in the cluster.

The Council is best-placed to lead this ongoing engagement. Where possible, this engagement should be continued between now and the commencement of the feasibility stage work, since it can take a significant time to collect relevant data from stakeholders, and also since it is important that a good relationship is developed between the Council and the various other stakeholders, assuming the Council will be driving much of the process..

6. Monitor availability and level of support from the Renewable Heat Incentive (RHI) and lobby for continuation of incentives of some form for renewable heating, including in heat networks.

Our analysis finds that the “South Lancaster and City Centre” scheme could be viable (albeit marginal) without RHI support. However, availability of the RHI would significantly strengthen the business case, making the scheme more attractive to a range of types of investor, and thus making the scheme more likely to be deliverable. Furthermore, if for any reason the combined “South Lancaster and City Centre” scheme cannot be delivered, and the “South Lancaster” opportunity area is considered as a standalone scheme, the RHI may be required for the scheme to be economically viable.

The current RHI is scheduled to finish in 2021, and it is not yet clear how (or whether) the Government plans to continue providing support for the deployment of renewable heating, including large-scale heat pumps such as those proposed here. Furthermore, the level of incentive offered is subject to review at regular intervals between now and 2021. Given that the development timescales for a heat network scheme in Lancaster are unlikely to involve supply of heat into a network before 2021 at the very earliest (and likely later), it will be important to monitor the availability and level of the RHI for the heat network schemes.

It may also be appropriate for HNDU to provide evidence of the importance of the RHI in rendering these heat network schemes viable to the relevant ministers and policy teams within BEIS, in order to build the case for continued support of some form for renewable heating, including in heat networks.

	Recommendation	Owner	Key actions	Key risks
1	Continue to engage with the University of Lancaster regarding their plans to decarbonise and further extend the University's existing heat network, to ensure that opportunities to support that work are identified.	HNDU, Lancaster City Council	HNDU and Lancaster City Council to engage further with the University of Lancaster to explore options for integrating the campus district heating system with the wider local energy system, including the potential to connect to new developments, such as Bailrigg Garden Village	The University of Lancaster scheme progresses ahead of Lancaster City Council developing strategic planning around heat networks, such that opportunities are missed. Developers of new development sites such as Bailrigg Garden Village are not interested in connecting to a heat network or the timings of the new developments are not complementary with the development of the University's heat network scheme.
2	Review local planning policy to ensure the potential to influence development of heat networks.	Lancaster City Council	Lancaster City Council to consider options to strengthen planning policy on heat networks for new development, such as a requirement to connect or to be connection ready. Lancaster City Council also to consider how local policy could be extended to cover existing buildings, e.g. requiring or incentivising connection to existing heat networks at times of heating system replacement or significant refurbishment.	Extended timescales for developing and adopting local policies means that opportunities are missed.
3	Advance to detailed feasibility stage an opportunity area covering the "South Lancaster" and "City Centre" clusters.	HNDU, Lancaster City Council	HNDU and Lancaster City Council to engage further in order that partners can consider whether to take on the recommendations of this report in some form, and whether to do this through leverage of HNDU feasibility stage funding	Lack of interest in taking the opportunity forward among key stakeholders, especially Lancaster City Council; University of Cumbria, Royal Lancaster infirmary and so on. Land not available or not suitable at proposed energy centre locations; Low carbon heat sources proposed not viable; Grid connection constraints preclude use of heat pumps;

				Lack of compatibility of identified buildings to connect to the scheme(s)
4	We do not recommend advancing other clusters to detailed feasibility at this stage, but recommend that a watching brief be kept on areas where significant new development is planned.	Lancaster City Council	Linked to recommendation (2) above, Lancaster City Council to consider options to promote low carbon heat networks in areas of significant new development such as East Lancaster, Morecambe and Bailrigg.	Timescales for developing and adopting planning policy means that opportunities are missed. Developers lack interest in connecting to a heat network and, in the absence of local planning policy, building regulations do not require its consideration.
5	Continue engagement with key stakeholders in the area, both ahead of and as part of the detailed feasibility work.	Lancaster City Council	Lancaster City Council to continue to engage with key anchor customers, such as the Royal Lancaster Infirmary and University of Cumbria to foster interest in connecting to a heat network scheme, prior to commencement of a detailed feasibility study.	Key stakeholders lack interest in connecting to a network, despite engagement efforts. Investigation during (or in advance of) detailed feasibility identifies compatibility issues between major anchor customers and supply by DH scheme.
6	Monitor availability and level of support from the Renewable Heat Incentive (RHI) and lobby for continuation of incentives for renewable heating in heat networks	HNDU, all major stakeholders	HNDU and all major stakeholders to monitor the availability of the RHI, as this has a significant impact on the project viability HNDU to consider lobbying for continued support for renewable heating, including in the context of supply to a heat network	Non-availability of the RHI

8 Appendix A – Stakeholder Engagement Details

Stakeholder	Organisation	Contact Details	Notes on Engagement
Stephen Wrigley	Lancaster University	s.wrigley@lancaster.ac.uk	• General information provided about the study and suggestions received on suitability of various regions across the city for heat networks • Important contacts were provided including EDF energy and Lancaster City Council
Jan Bastiaans	Lancaster University	j.bastiaans@lancaster.ac.uk	• Information obtained regarding the energy demand, generation and use of the University, and University's future plans for extension of the network
James Johnson, Reina Kotynia	North West Energy Hub	James.Johnson@localenergynw.org; renia.kotynia@localenergynw.org	• Heat mapping and masterplanning study was discussed and feedback received on how this relates to the wider energy goals in the region
Mark Davies	Lancaster City Council	MDavies@lancaster.gov.uk	• Guidance provided on some development plans in the area • Information provided on development plans
Phillip Sinclair	EDF Energy	phillip.sinclair@edf-energy.com	• Heat mapping and masterplanning study was discussed Information provided on the potential use of substation waste heat and heat from the nuclear power station

9 Appendix B – Technical Assumptions

Figure 9-1: Summary of technical assumptions

Item	Value	Unit	Comment
Efficiency			
Gas boiler	86%	%	
WSHP with primary temperature at 90°C flow / 70°C return	280%	%	
WSHP with primary temperature at 70°C flow / 50°C return	370%		
Biomass boiler	80%	%	
Auxiliary and losses			
Energy centre parasitic load (e.g. pumping)	2%	% of heat production	
Network losses: heat low parameter	0.20	W/mK	
Minimum % annual heat demand			
WSHP	90-100	%	Achieved using thermal storage
Biomass boiler	50%	%	
Capacity of auxiliary boiler and thermal storage			
Gas boiler	120%	% of peak demand	
Thermal storage	Varies	Hours of annual average heat demand	Reviewed on an individual scheme option
Carbon intensity			
Gas	185	gCO_2/kWh	
Waste heat	Linked to grid electricity	gCO_2/kWh	Calculated on basis of lost EFW electrical generation (assumed Z-factor = 7)
Biomass	0.2	gCO_2/kWh	
Grid electricity[21] – 2020	290	gCO_2/kWh	
Grid electricity – 2025	203	gCO_2/kWh	
Grid electricity – 2030	127	gCO_2/kWh	
Grid electricity – 2040	53	gCO_2/kWh	
Grid electricity – 2050	27	gCO_2/kWh	

[21] Electricity emissions factors are based on Long-run marginal emissions factors for commercial and public sectors, published in *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*, March 2019, www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

10 Appendix C – Predicted thermal output for each of the three prioritised cluster

Figure 10-1: Predicted thermal output for South Lancaster Cluster

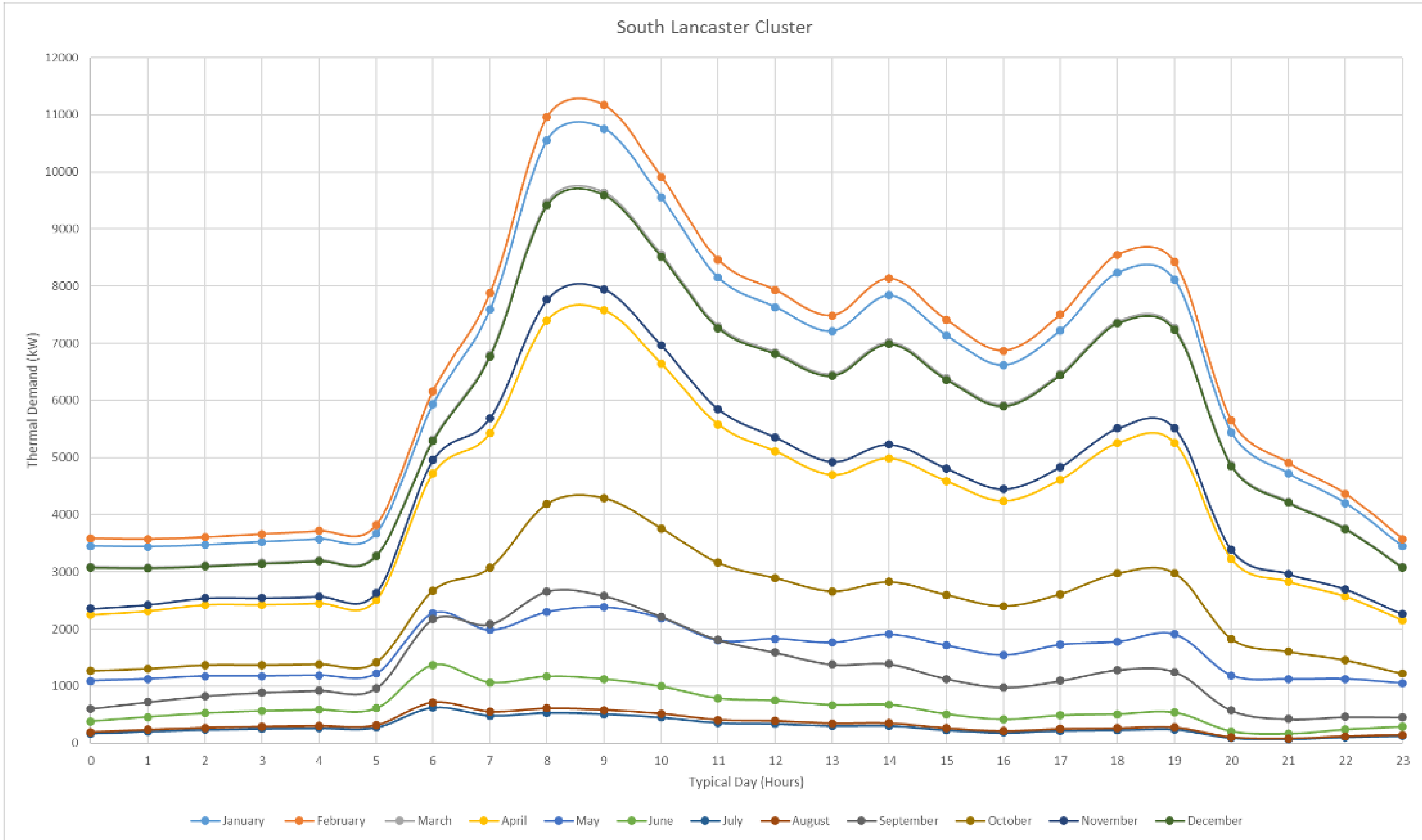


Figure 10-2: Predicted thermal output for City Centre Cluster

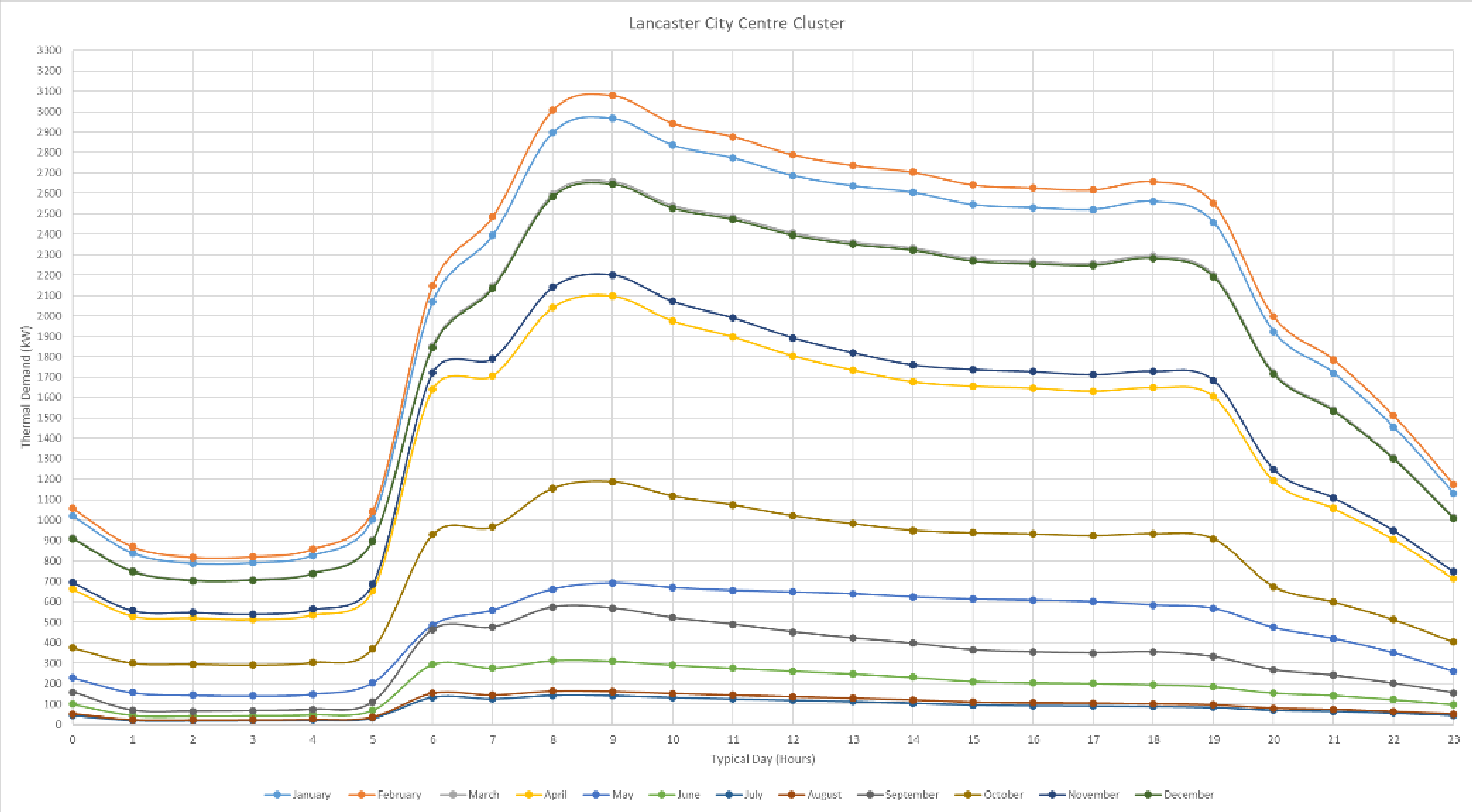


Figure 10-3: Predicted thermal output for Scale Hall Cluster

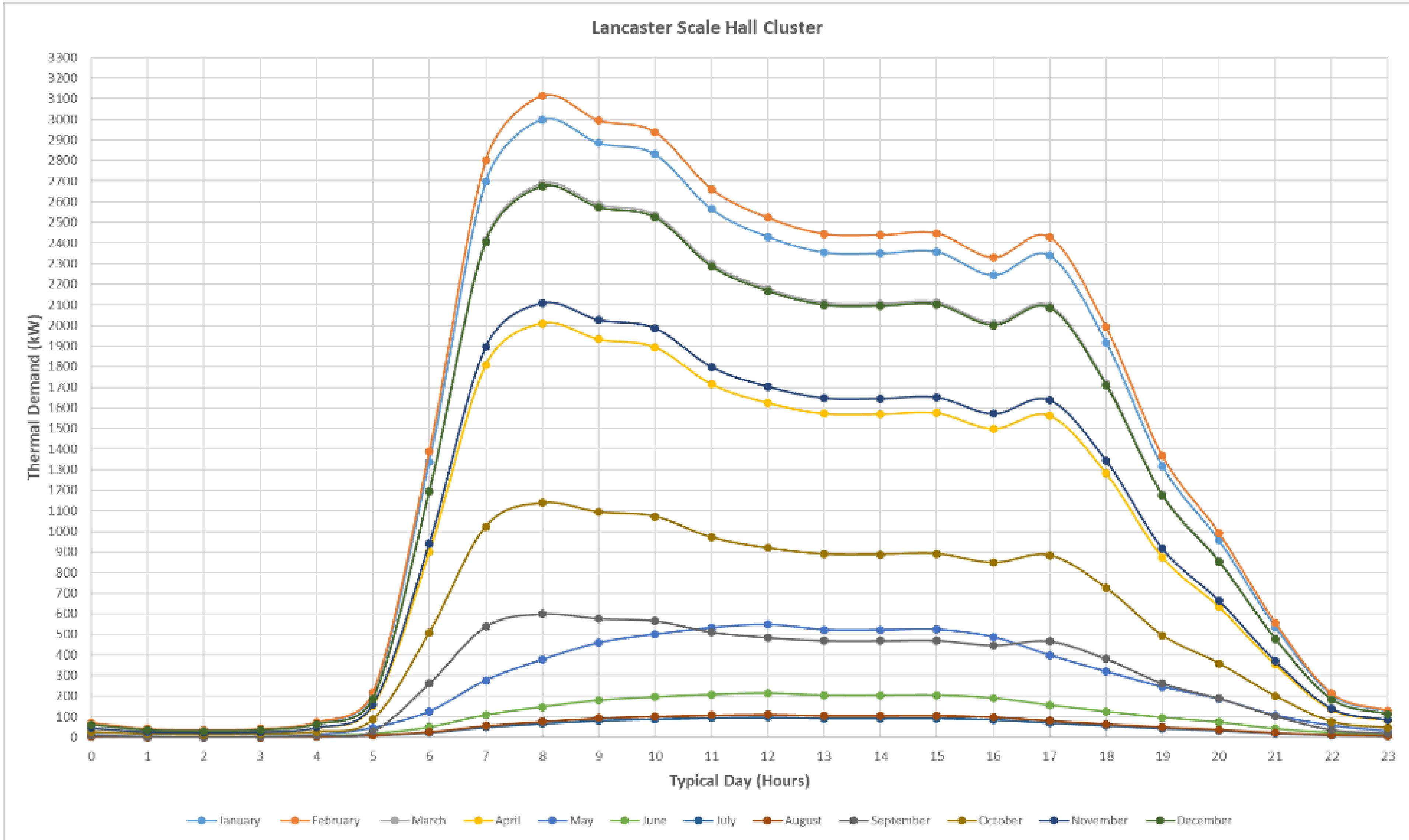
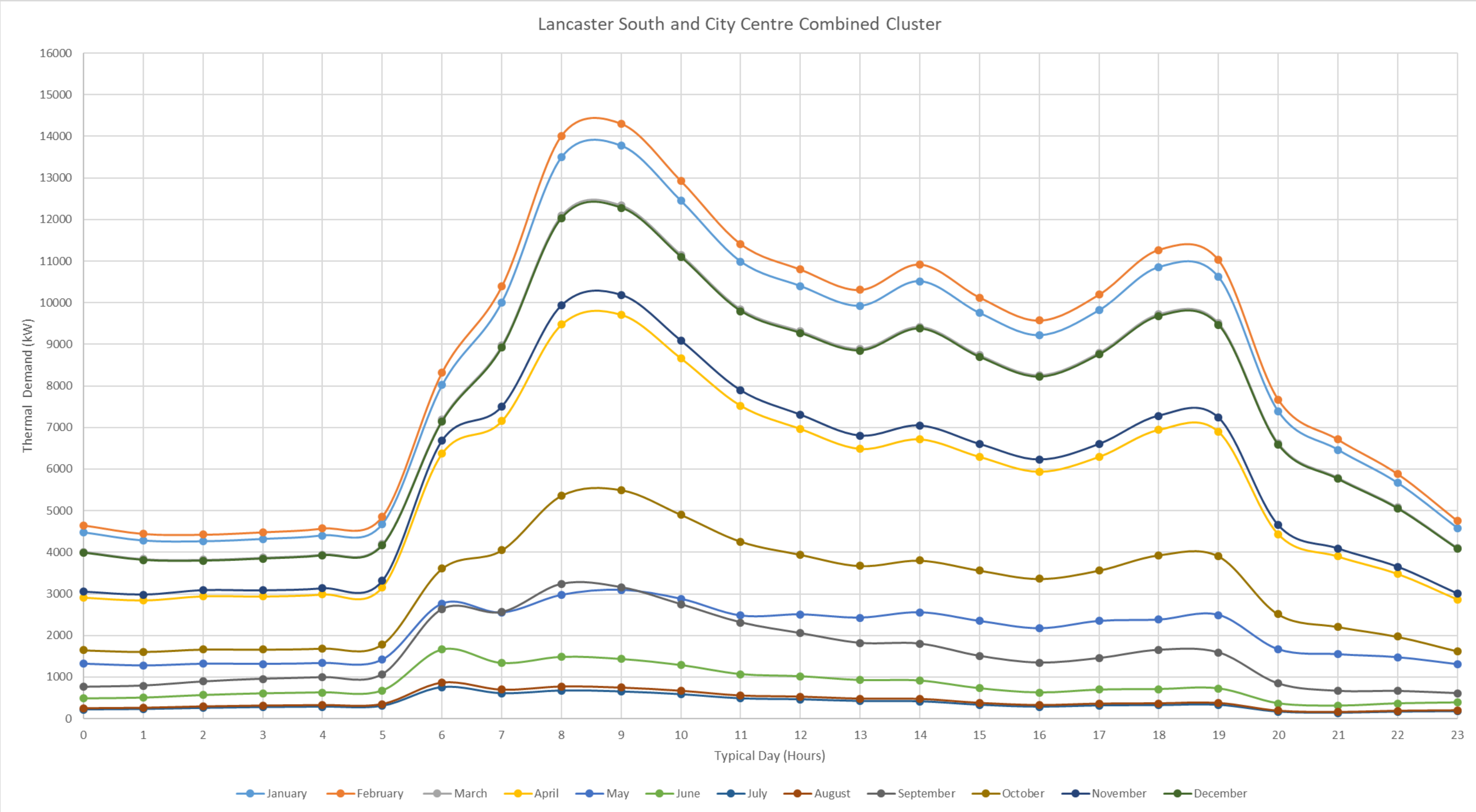


Figure 10-4: Thermal output for South Lancaster and City Centre Clusters



11 Appendix D – Economic and Financial Assumptions

Table 11-1: Summary of economic and financial assumptions

Item	Value	Unit	Comment
Capital costs			
Gas boiler – Commercial and network-scale	35-40	£/kWth	Price range varies according to capacity of gas boilers Taken from previous technical feasibility study, reviewed by Switch2 in association with project bid February 2019
WSHP	960	£/kWth	Pricing from previous technical feasibility study for a 2 MW marine-source WSHP, based on quotation from Star Renewable Energy. This data point was reviewed and corroborated by Switch2 in association with Shoreham Harbour project bid February 2019. Values sense-checked against projects costs for the 2x2.5 MW WSHP installation at Queen's Quay in Glasgow. This cost is applied for both river-source and borehole-source heat pumps, which is deemed appropriate for the current stage analysis based on consultation with Star Renewable Energy.
Thermal storage	0.85	£/litre	
Heating Network pipes sourced from Vital Energi, February 2019 **Note that these estimates are commercially sensitive and must be redacted before any publication or sharing outside BEIS**	Length (m)	Pipe only supply and installation cost (£/m)	Trenching and civils cost (£/m)
DN25		301.17	420.18
DN32		324.25	534.34
DN40		365.54	591.41
DN50		383.75	647.28
DN65		418.97	756.57
DN80		442.04	837.94
DN100		516.12	876.80
DN125		579.27	910.80
DN150		644.85	944.81
DN 200		691.00	971.52
DN 250		794.22	1,001.88
DN 300		836.72	1,077.18
DN 350		1,032.24	1,134.25

DN400		1,117.25	1,335.84
DN450		1,211.98	1,578.73
DN500		1,700.17	1,760.89
DN600		2,615.83	2,185.93
DN700		3,521.77	2,428.81
DN800		4,037.89	2,732.41
Heat interface unit	13.34	£/kW	Based on pricing provided by SAV Systems for a 1500kW HIU unit in February 2019
Engineering, procurement and project management costs	870000	£	Assumed fixed across all networks as is highly subject to economies of scale. Cost is expected to be accurate for a tolerance of +/- 30%
Other non-design project elements	291000	£	Assumed fixed across all networks as is highly subject to economies of scale. Cost is expected to be accurate for a tolerance of +/- 30%
Operating and maintenance costs			
WSHP	34000	£/MW	
Annual abstraction and discharge effect for WSHP	25000	£/yr	Assumed constant
Network	0.75	£/m/year	Estimate provided by Eon in 2018
Heat interface unit and heat meter – Domestic		% of capex/yr	Or £/MW
Heat interface unit and heat meter – Non-domestic		% of capex/yr	Or £/MW
Administrative and billing	70000	£/yr	Assumed fixed across all networks as is highly subject to economies of scale. Cost is expected to be accurate for a tolerance of +/- 30%
Staff and management costs	50000	£/yr	Assumed fixed across all networks as is highly subject to economies of scale. Cost is expected to be accurate for a tolerance of +/- 30%
Insurance costs	20000	£/yr	Assumed fixed across all networks as is highly subject to economies of scale. Cost is expected to be accurate for a tolerance of +/- 30%

Table 11-2: BAU heating cost assumptions used to calculate total counterfactual heat costs and set the heat sale tariff

Minimum Demand (kWh)	Maximum Demand(kWh)	BAU Standing Charge (£ p.a.)	BAU Maintenance Cost (£ p.a.)	Annualised Replacement Cost (£ p.a.)
1	50,000	300	214	476
50,001	100,000	300	342	761
100,001	300,000	1,000	1,027	2,283
300,001	500,000	1,500	1,284	2,854
500,001	1,000,000	3,300	2,568	5,708
1,000,001	2,000,000	5,700	3,425	7,610
2,000,001	3,000,000	7,800	5,137	11,416
3,000,001	5,000,000	11,600	8,562	19,026

12 Appendix E – Schematics of network designs

Figure 12-1: Schematics of network design for South Lancaster Cluster

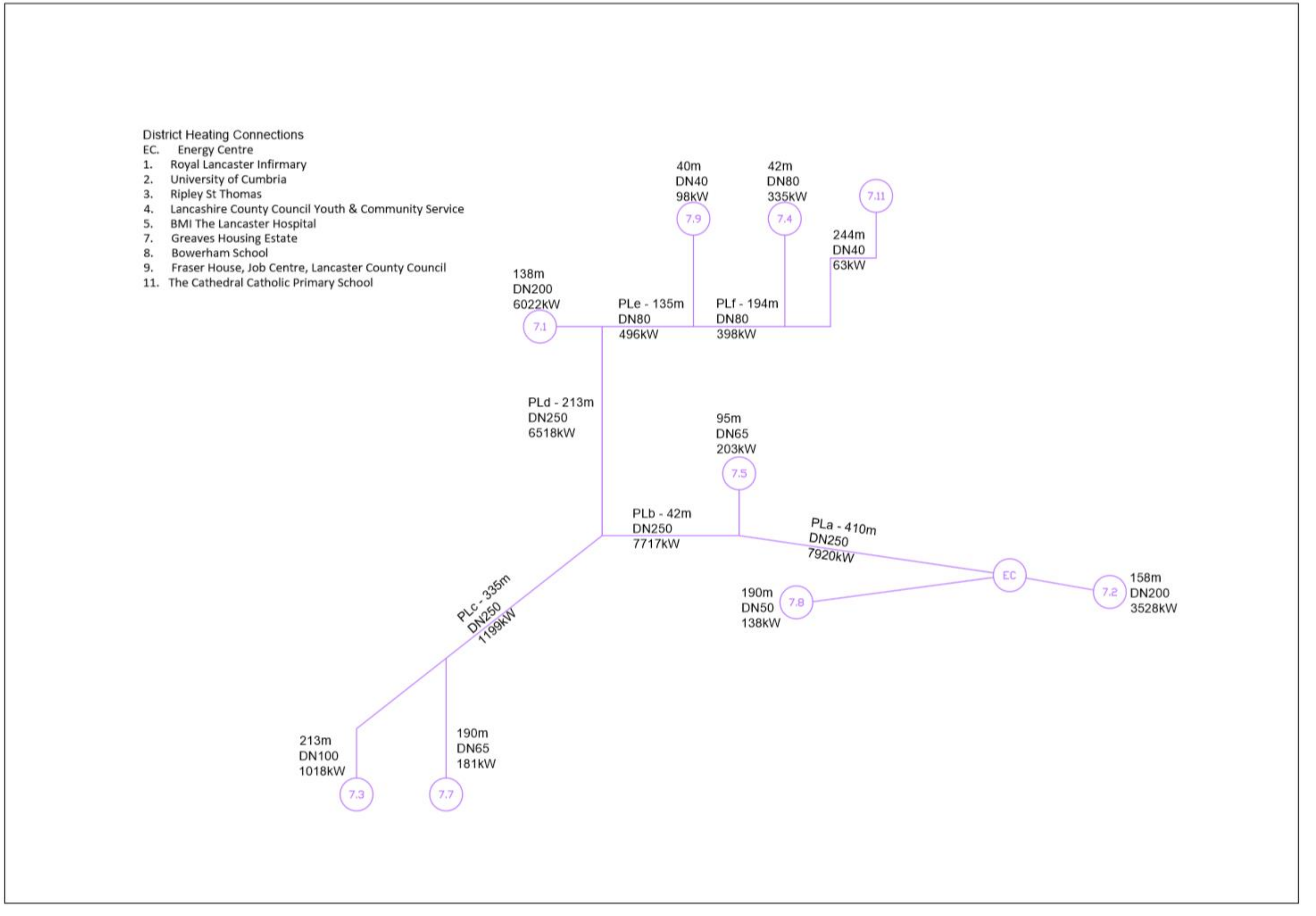


Figure 12-2: Schematics of network design for City Centre Cluster

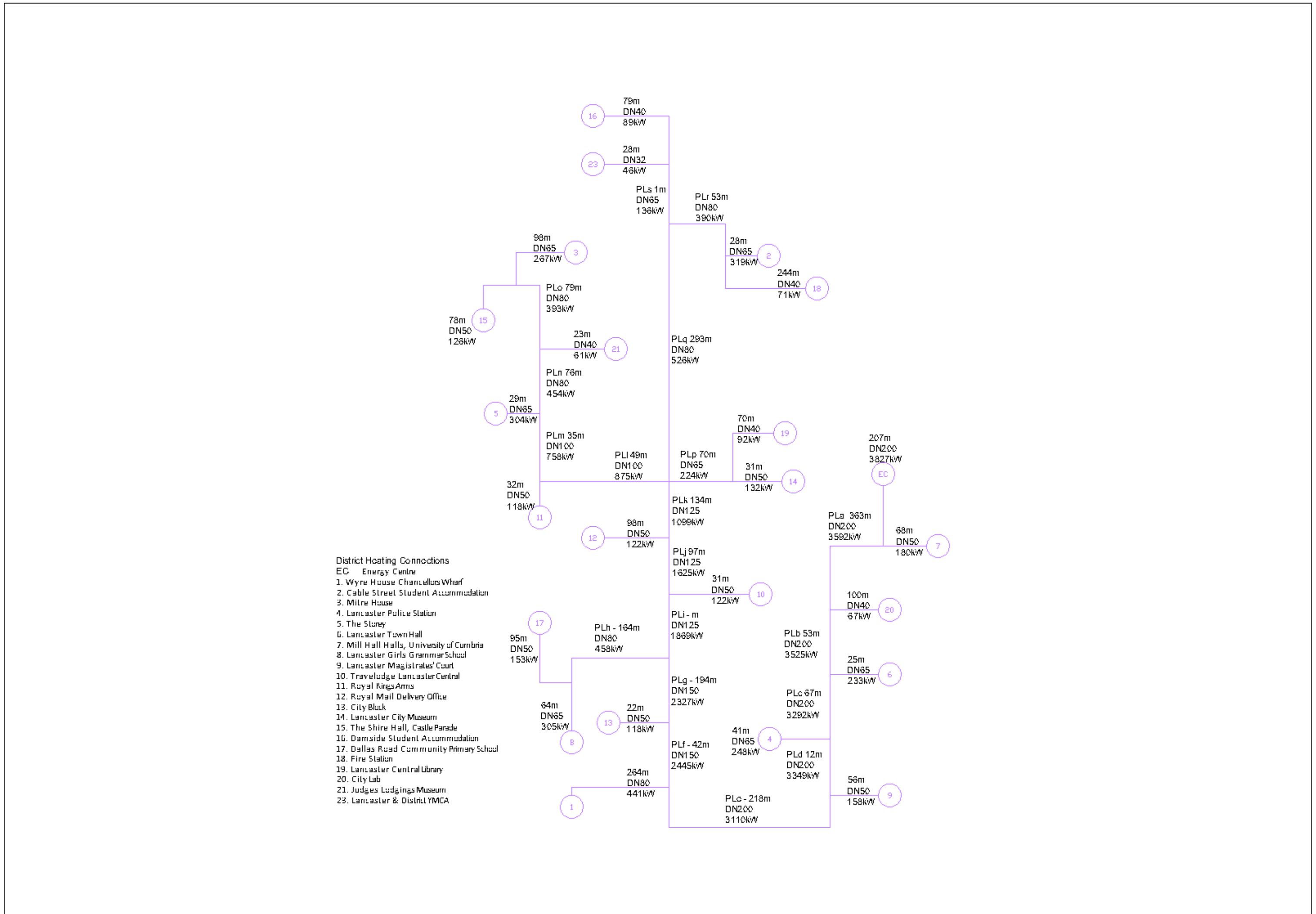


Figure 12-3: Schematics of network design for Scale Hall Cluster

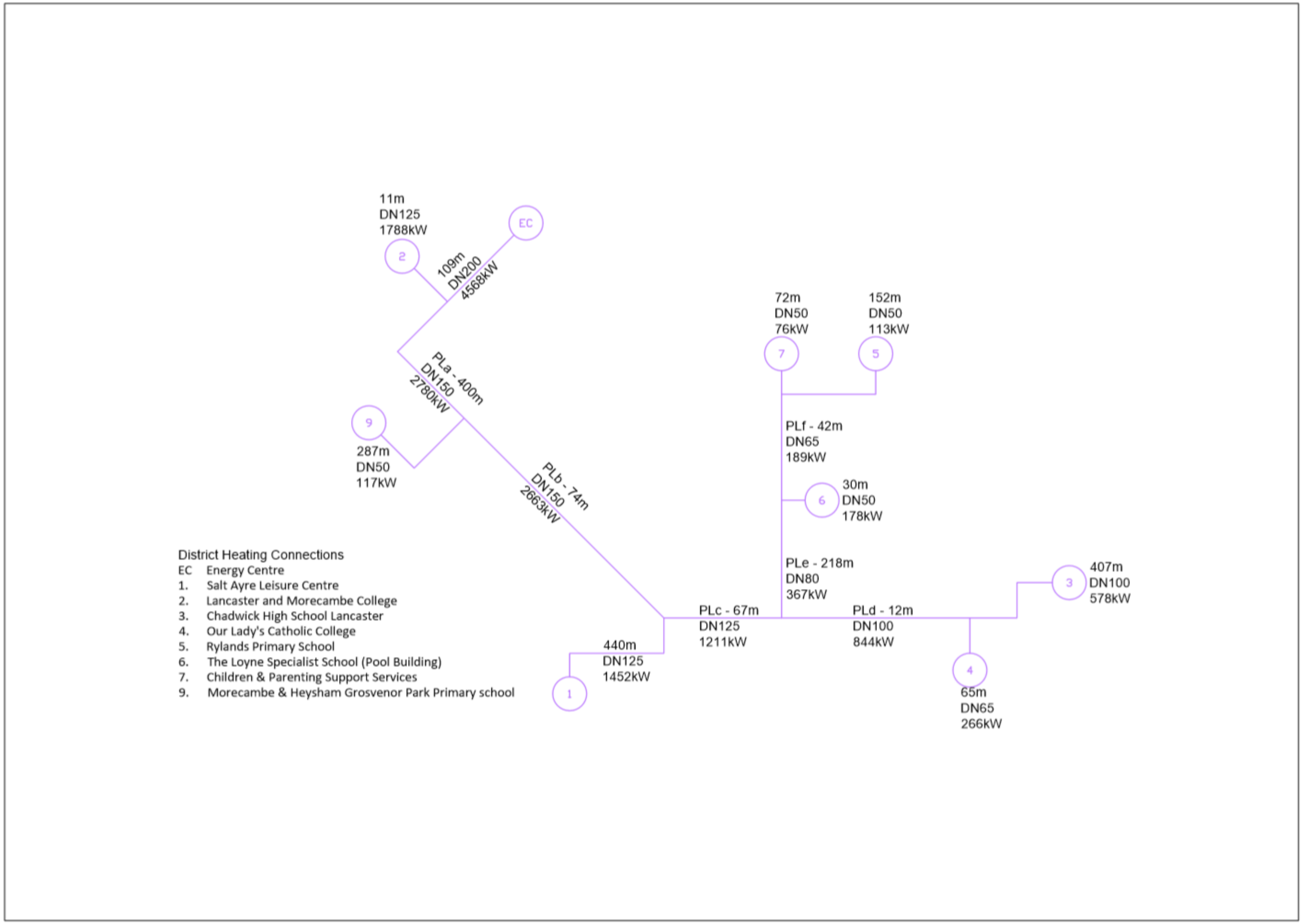
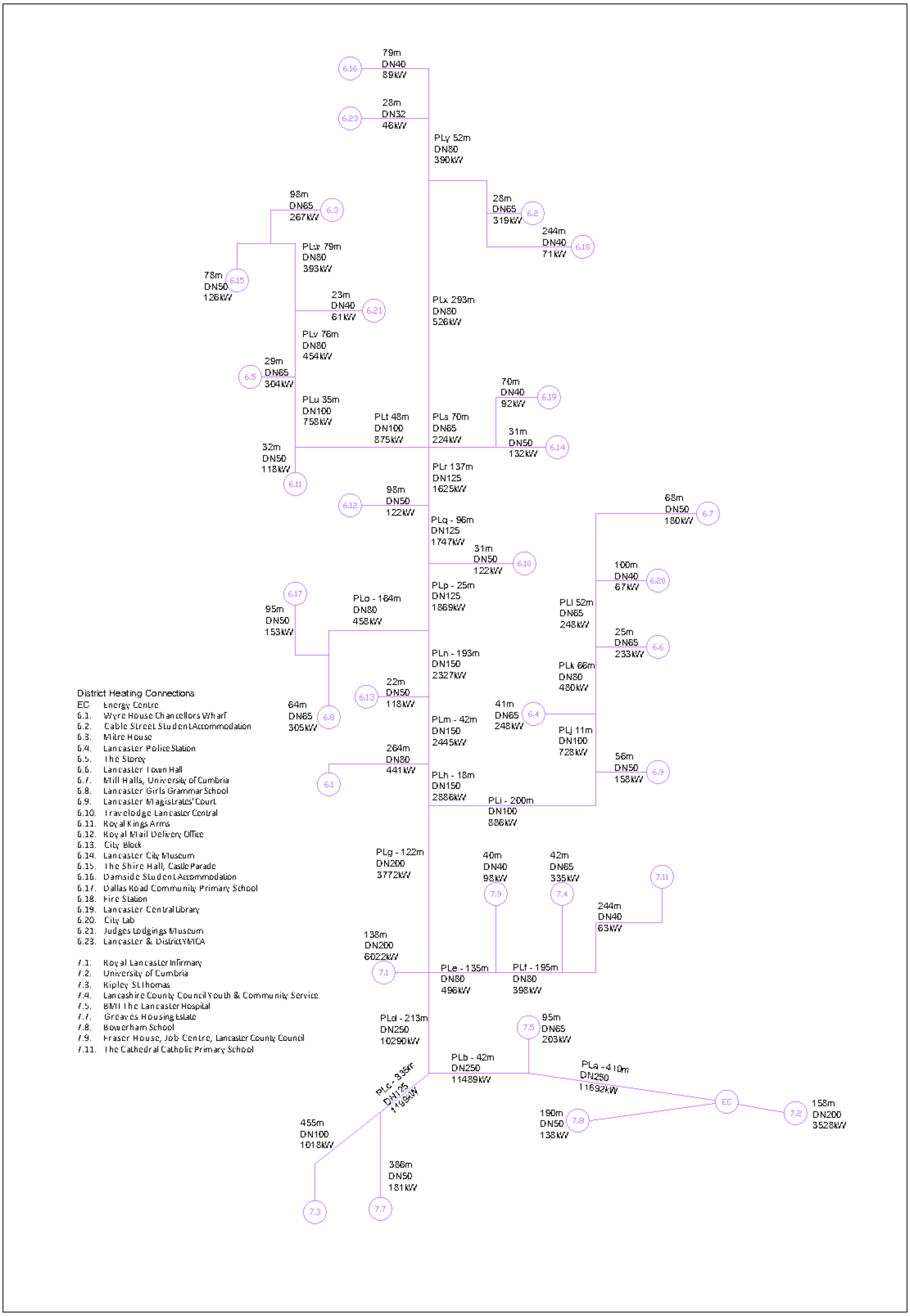


Figure 12-4: Schematics of network design for South Lancaster and City Centre Clusters



13 Appendix F – Block plan of proposed energy centres

Figure 13-1: Block plan of energy centre for South Lancaster Cluster

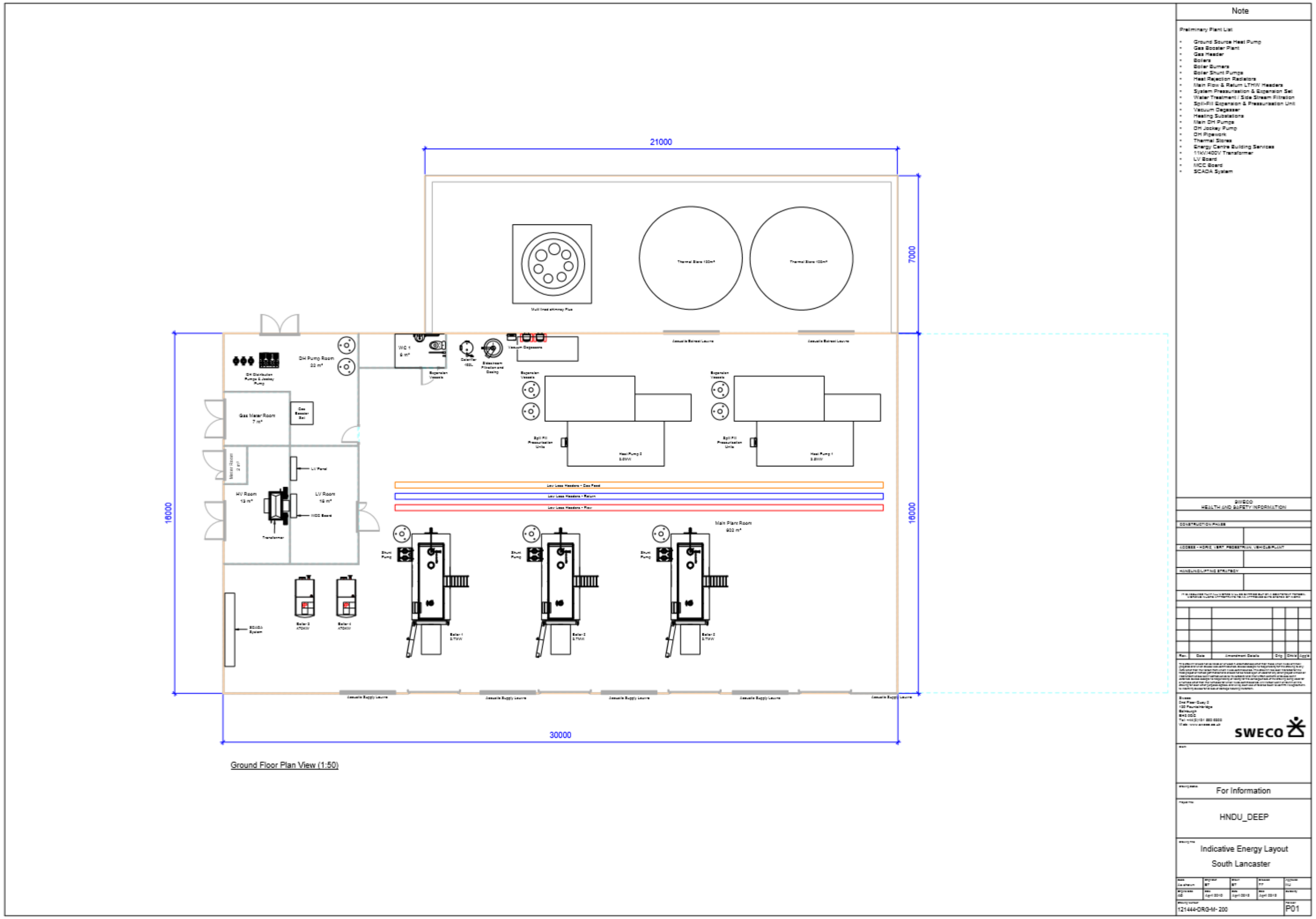


Figure 13-2: Block plan of energy centre for City Centre Cluster

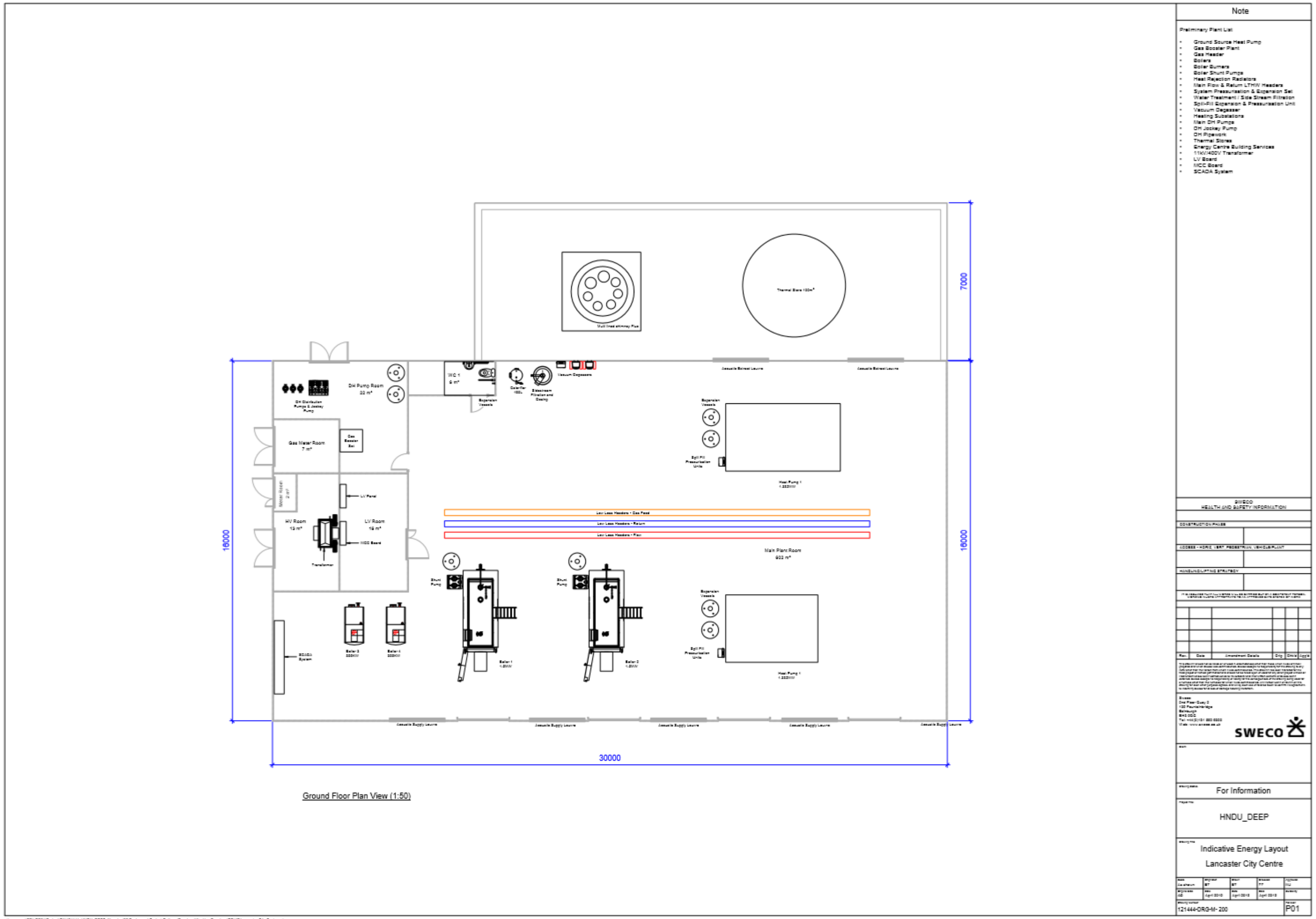
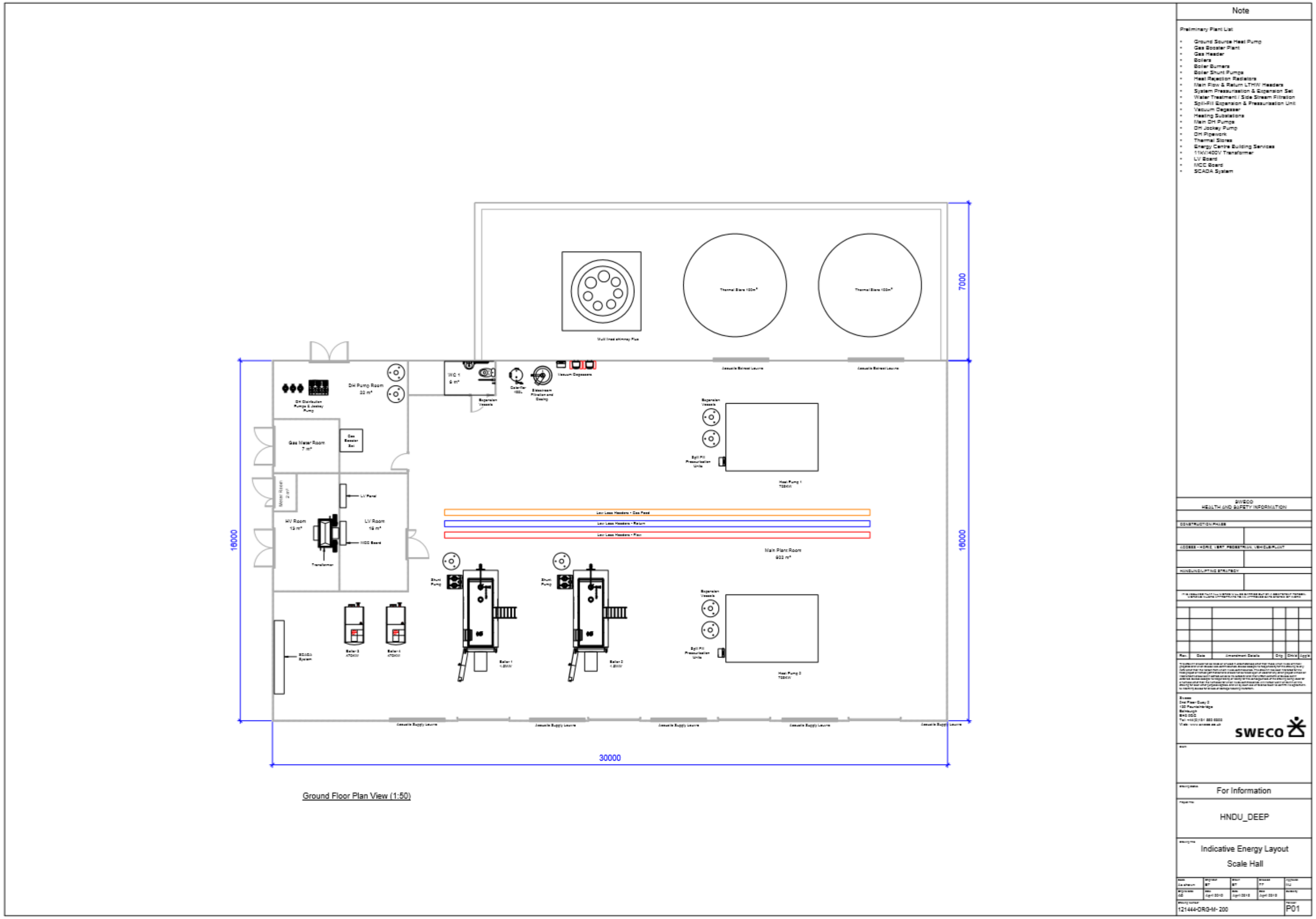


Figure 13-3: Block plan of energy centre for Scale Hall Cluster



14 Appendix G – Risk Register

Table 14-1: Risk register table for the study area

c			Risk Assessment			Mitigation & Action	
Risk No.	**Risk description**	**Risk category**	**Impact (low 1- high 4)**	**Likelihood (low 1- high 4)**	**Current Risk Rating**	**Mitigation to date**	**Further Action**
1	*Non-availability of the RHI*	*Economics*	*3*	*3*	*9*	*None*	*Monitor availability of RHI. HNDU to consider lobbying for continuation of support for renewable heat.*
2	*Grid connection constraints preclude use of heat pumps*	*Energy centre*	*4*	*2*	*8*	*- Electricity North West's (ENW) Heatmap tool has been used to identify potential constraints on primary substations in close proximity to the proposed energy centre locations.* *- No further consultation undertaken with ENW at this stage.*	*Feasibility stage consultant to engage with ENW to identify potential constraints and likely grid connection costs in detail.*
3	*Lack of low carbon heat sources in the vicinity*	*Energy centre*	*2*	*2*	*4*	*- For each of the clusters the proposed water source heat pump plants would rely on ground-water as the water source (accessed via boreholes)* *- Ground-water surveys have not been undertaken for these sites, hence there is a risk that an adequate ground-water yield will not be available.*	*Feasibility and/or detailed project development stage consultant to undertake further site assessment, including environmental assessment and hydrogeological survey for borehole based WSHP.*

4	*Land not available or not suitable at proposed energy centre locations*	*Energy centre*	*4*	*2*	*8*	*Appropriate energy centre locations have been identified, but no detailed engagement with landowners has been undertaken.* *In particular, proposed energy centre locations have been identified within the grounds of existing sites, e.g. the University of Cumbria (South Lancaster) and Lancaster and Morecambe College (Scale Hall), which may depend on the interest of these organisations in connecting to the system.*	*Feasibility stage consultant to engage landowners and undertake further site visits to assess viability.*
5	*Lack of interest within the Council(s) in progressing to detailed feasibility*	*General*	*3*	*3*	*9*	*Strong level of engagement and interest shown by the Council. It is not yet known whether there will be interest in taking this forward.*	*HNDU to engage with Lancaster City Council to gauge interest in progressing to next stage*
6	*Lack of engagement from key stakeholders in the opportunity areas*	*Energy demand*	*4*	*2*	*8*	*Initial stakeholder engagement achieved with several stakeholders including University of Lancaster and Lancaster City Council, however, engagement with other key stakeholders, such as University of Cumbria, Royal Lancaster infirmary and the private sector organisations has been more limited.*	*HNDU to continue to engage with key stakeholders. Feasibility stage consultant to continue engagement to establish likelihood of connecting.*
7	*Lack of compatibility of identified buildings to connect to the scheme(s)*	*Energy demand*	*4*	*2*	*8*	*N/A*	*Feasibility stage consultant to undertake site visits to key potential customers to consider the internal building systems and their suitability for connection to DH.*