elementenergy

Heat mapping and masterplanning in North East Lincolnshire

North East Lincolnshire Council

&

BEIS Heat Network Delivery Unit

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1 Introduction

1.1 Context and objectives

Element Energy have been commissioned by North East Lincolnshire Council (NELC) to undertake a heat mapping and masterplanning study for North East Lincolnshire. 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.

NELC's key drivers for heat network development include:

- **Catalyst for regeneration and economic growth (Primary driver)**. Heat networks offer the potential to attract new business and investment to the region and to contribute to local economic growth.
- **Affordable warmth/reduced energy costs (Primary driver)**. A viable heat network should result in reduced energy costs for its customers, whether households, commercial and industrial users or the public sector. This has the potential to alleviate fuel poverty, increase disposable income, increase competitiveness of businesses and improve the cost-effectiveness of the public sector.
- **Meeting climate targets**. Through the use of low carbon sources of energy, including waste and environmental sources of heat, heat networks can contribute to the reduction of carbon emissions.
- **Revenue generation**. Local authorities are under increasing budgetary pressure as central funding is reduced, and NELC is increasing looking for additional sources of revenue. A heat network funded in part or full using public sector investment could generate substantial returns for the local authority whilst providing the benefits to end customers described above.

1.2 Description of the study area

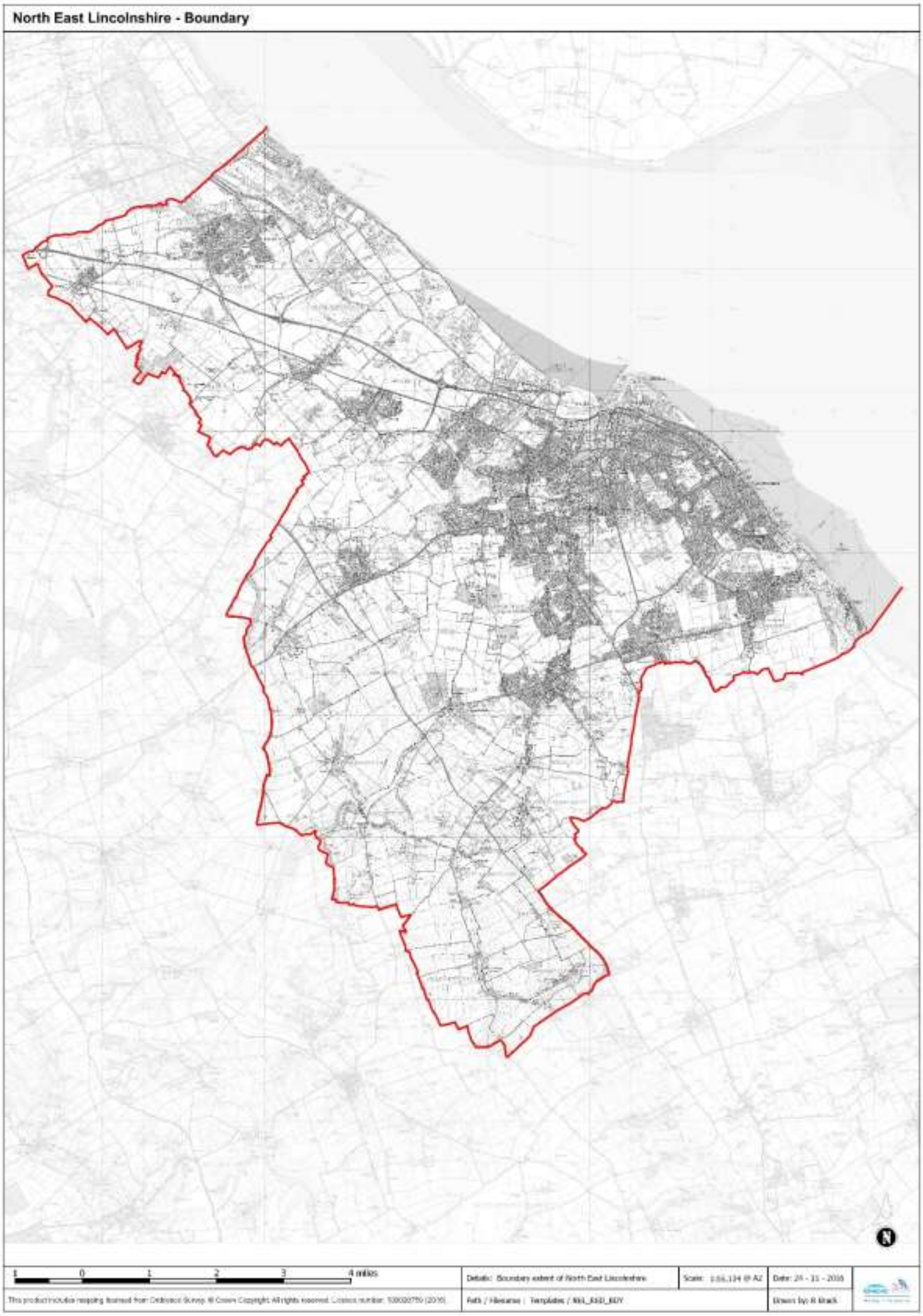
The red-line boundary of the study area is shown in Figure 1-1. This encompasses the entirety of North East Lincolnshire (NEL). As part of this study, however, the areas surrounding the red-line boundary were also reviewed in terms of energy demand and sources of heat, in order to consider the potential for connection outside the boundary.

The main population centres in NEL include Grimsby, Cleethorpes and Immingham, with a substantial number of further inhabitants in the villages located across the region, as well as a range of business parks and industrial sites in various locations. The area has a wide array of successful businesses across a variety of sectors, including ports, chemicals, food processing, renewable energy and tourism. The Grimsby port area hosts much of the seafood industry, while Immingham Port handles bulk solid and liquid fuels including bio-energy products and other cargo. The South Humber Bank area between the two ports and the area surrounding Immingham Port together host a large number of chemicals plants, two large oil refineries, two GW-scale power stations and several other power generating facilities.

Over recent decades, the region has seen a significant decline in one of its most important industries, the seafood and fishing industry. Another of its key sectors, chemicals, faces challenges to remain competitive internationally. Partly as a result of this, the region also suffers from a higher than average rate of fuel poverty.

The emergence of a rapidly growing renewable energy sector in the region, including notably the offshore wind and bio-energy sectors, provides an opportunity to deliver economic and social benefits to the area. A shift towards low-carbon fuels and greater energy efficiency is viewed by NELC as a key factor in enabling greater energy resilience, improved business competitiveness and more affordable warmth.

Figure 1-1: Red-line boundary for the study area



1.3 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 North East Lincolnshire. These steps, described in Table 1-1, are as follows:

1. Review of NELC objectives and critical success factors
2. Review of study area and potential customers
3. Stakeholder engagement and data collection
4. Low carbon heat source mapping
5. Energy demand mapping
6. Constraints mapping
7. Cluster assessment and selection
8. Scheme option definition
9. Technical assessment
10. Economic assessment
11. Scheme options appraisal
12. Review of potential delivery models
13. Preferred scheme options, risks and recommendations

Table 1-1: High-level summary of approach

Task	High-level description of approach
NELC objectives and critical success factors	• NELC's priorities and strategic objectives for heat networks were identified from the outset in order to guide the analysis. • Through the project, a list of critical success factors was developed in partnership with NELC to reflect the Council's specific and strategic priorities with which any heat network project should be aligned. The critical success factors will be used to make a comparison of scheme options and to identify preferred schemes at a later stage in the project (see below).
Review of study area and potential customers	• The study area was agreed; this was defined as the whole of North East Lincolnshire, with the potential to connect to customers or heat sources outside the NE Lincs boundary. • Potential customers were identified; all energy users were considered in scope, including domestic and non-domestic buildings, existing and future development. • A list of the largest several hundred potential customers was produced, in order to prioritise data collection from these users.
Stakeholder engagement and data collection	• We have engaged a large number of stakeholders across NE Lincs to collect data relevant to this analysis. • Potential heat network customers were approached, with assistance from NELC, in order to collect data on heating, cooling and electricity demand including annual fuel demand, peak demand, fuel bills, the nature of the current heating system, planned refurbishments and energy efficiency upgrades and any potential barriers or benefits to connecting to a heat network. • Potential sources of low carbon heat were approached, including developers of existing and planned Energy-from-Waste facilities and industrial organisations. Key metrics include the availability of heat per year, seasonal variation and downtime. • Other key stakeholders engaged include the planning department at NELC to gather information on planned and future developments; Highways & Transport to understand constraints; Economic Development to understand potential impact of inward investment on heat demand and heat sources in the region and Senior Management to understand the Council appetite for leading heat network development.
Low carbon heat source identification and mapping	• A list of heat supply options of interest, including low carbon heat sources (gas CHP, biomass, water-source heat pumps, waste heat and geothermal) was developed and agreed with NELC. • Potential sources of low carbon heat, including waste heat from Energy-from-Waste and industrial facilities, water-source heat and geothermal were reviewed and mapped.
Energy demand mapping	• Heating, cooling and electricity demand was then mapped for the entire study area. • Where available, the energy map was based on metered data collected through the stakeholder engagement phase; where this data was not available, alternative approaches were taken to ensure full coverage of all potential customers. • The alternative approaches taken included examination of the Display Energy Certificate database and use of literature energy demand benchmarks combined with floor area data gathered either through stakeholder engagement or through a GIS-based analysis using OS Mastermap and OS AddressBase. • The energy demands were then mapped using GIS software.
Constraints mapping	• Key constraints for a heat network were mapped in GIS, based on information collected through the use of datasets collected from NELC during the stakeholder engagement and use of mapping datasets. • This includes the mapping of railways, waterways, major roads, designated areas and land ownership.

Cluster assessment and selection	• A longlist of areas ('clusters') were then defined and assessed against key characteristics likely to impact the viability of a heat network. • This step was necessary to filter down the longlist of clusters under consideration and to select a tractable number to take forward to the technical and economic assessment (which could not be undertaken for the entire NE Lincs area). • Key characteristics for the assessment include the density of existing heat demand; the presence of potential anchor customers; the mix of potential customer types; the likelihood of significant new development; the presence of low carbon (potential low cost) sources of heat; absence of major constraints and favourable dig conditions; suitable site for the energy centre. • This resulted in 5 selected clusters to take forward to the technical and economic assessment.
Scheme option definition	• For the 5 clusters selected, several scheme options were defined in detail. The scheme options differ in terms of extent and in the assumption of which customers connect to the scheme. • A range of heat supply options were studied for each cluster. Potential energy centre locations were defined for each scheme option.
Technical assessment	• For each scheme and heat supply option, an initial technical assessment was then undertaken based on the heat demand profile and the physical layout of the scheme. • This includes a calculation of the appropriate primary and auxiliary plant sizing, network route and length, pipe sizing, peak and annual fuel consumption and so on. Comparative metrics including the linear heat density were calculated for each scheme option.
Economic assessment	• An economic assessment was then undertaken for each scheme and heat supply option. • This includes calculation of: cost of all required generation plant and infrastructure, including upfront costs, replacement costs and ongoing operational and fuel costs; potential revenue from heat sales, based on an estimate of the counterfactual price of heat that could be expected for the customers connected with a 10% discount applied; potential revenue from electricity sales, for the case of CHP, based on either on-site/private wire sale of electricity and/or grid export; potential revenue from the Renewable Heat Incentive, for the case of biomass, heat pumps and geothermal. • Outputs derived include capital cost, project internal rate of return, net present value, lifetime cost of heat supply, lifetime CO_2 emissions savings and the 'funding gap' to project viability in line with HNDU's HNIP funding guidance.
Scheme options appraisal	• Outputs of the technical and economic assessment were then used to make a comparison of the scheme options against NELC's critical success factors defined earlier in the project. • Scheme options were also compared against key metrics used by HNDU to assess HNIP funding applications, including the carbon savings value for money and the heat price.
Review of potential delivery models	• The various potential delivery models for the heat network were identified and described, with particular emphasis on the implications for the role of the Council in project funding and delivery. • The viability of delivery of each scheme option studied using each delivery model was then assessed, based on the likely financial requirements of the (private and public sector) stakeholders involved.
Preferred scheme options, risks and recommendations	• On the basis of the steps above, the preferred scheme options to take forward to detailed feasibility were identified. • The key risks for each scheme option were highlighted, and recommendations made on next steps for NELC.

2 Stakeholder Engagement and Data Collection

2.1 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 several hundred of the largest potential customers was developed. This was based on an initial list provided by NELC, supplemented by further research by the project team, including identification of potentially large energy users during the heat mapping process. Our approach to stakeholder engagement included the following:

- Email contact with project background and information request
- Telephone calls
- Site visits and in-person meetings
- Public briefing sessions

Stakeholders were first contacted by email, with a covering letter from the Council 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
- 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. Certain stakeholders expressed an interest in holding a telephone discussion, and a number of such calls were held.

We also carried out two days of site visits across Grimsby, Cleethorpes, Immingham and the surrounding region to understand the characteristics of the study area. As part of these visits, we met with a number of key stakeholders who agreed to participate, including the NELC Operations team, the NELC Inward Investment & Growth team and several potential heat customers and energy centre hosts. The NELC Highways team were consulted on potential energy centre locations and network routes.

Finally, four public briefing sessions were held in Grimsby to raise awareness of the study. This included a description of heat networks and the potential benefits they could provide to the region; a summary of the Government support for heat network development; the scope of the current study; and a description of the type of information that stakeholders could usefully provide to assist the analysis. Two briefing sessions were held towards the start of the project, during the data collection phase, and two further briefing sessions were held towards the end of the study to disseminate the draft findings of the work.

A summary of the number of stakeholders engaged through these various approaches, and of the amount of data received, is summarised in Table 2-1. A summary of the key data received by stakeholders during this project is provided in Appendix I.

Table 2-1: Summary of number of stakeholders engaged

Category	Item	
Written information request	**Number of stakeholders contacted with information request**	**236**
	Number of written responses	**49**
	Number of buildings for which data provided	**156**
	Of which energy demand data	152
	Of which floorspace and building activity data	2
	Of which other data	2
Public briefing sessions	Number of stakeholders at the public briefing sessions	50+

2.2 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)
- **Space cooling**
- **Storage cooling** (cooling other than space cooling, typically cold storage in the food processing, cold storage and retail sector)
- **Electricity** (other than electricity for heating and cooling)

2.2.1 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, combined with energy demand benchmarks or sub-national (postcode level) energy consumption data
5. Floor area data estimated from an OS Mastermap/AddressBase GIS-based analysis, combined with energy demand benchmarks

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[1] (Sector Tables), according to an analysis of the closest matching building activity type.

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

For existing residential buildings, for which metered data was not generally collected directly from stakeholders, an estimated heat demand was derived at postcode level using BEIS's *Sub-national gas consumption data (*Postcode level data)[2].

Where floor area data was not available from the stakeholder data collection, floor areas were estimated from a GIS-based analysis of OS Mastermap and OS AddressBase. The procedure can be summarised as the following:

- Match all address points (with associated building activity type attributes) in AddressBase dataset to building polygons in Mastermap dataset;
- Assign all building polygons in the Mastermap dataset an activity type based on the most frequent activity type of address points matched to that polygon;
- Estimate floor area based on the building footprint in Mastermap and an estimate of the number of storeys;
- Use energy demand benchmarks to derive initial estimates of the energy demand per building;
- Refine estimates of energy demand for the largest energy users and those in key areas of interest, by verifying (or modifying) the assigned activity type and floor area using desk research methods (e.g. internet searches) – this was an iterative process as priority clusters were identified and scheme options developed.

Finally, the potential for energy efficiency improvements leading to a reduction in heat demand over time was incorporated. A number of stakeholders within potential large heat customers provided details of planned efficiency upgrades to 2020; the reduction in demand associated with these planned upgrades were incorporated directly into the estimates of heat demand.

2.2.2 New buildings

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

1. Floor area (or number of residential units) and activity type data provided by NELC planning department, combined with energy demand benchmarks
2. Floor area (or number of residential units) data provided by NELC planning department and activity type data estimated in partnership with NELC, combined with energy demand benchmarks
3. Floor area and activity data estimated in partnership with NELC, combined with energy demand benchmarks

In the case of new non-domestic buildings, energy demand benchmarks were taken from a range of sources, including Part L guidance documents, CIBSE Guide F (Best Practice) and using data on recently-constructed buildings of the same type in North East Lincolnshire.

Due to uncertainty in the likely energy demand of new non-domestic buildings (particularly when the activity type of the buildings is not known with a high degree of confidence), we have studied sensitivities on the energy demand in these cases. For new domestic buildings, energy demand benchmarks are based on the Zero Carbon Hub's proposed Fabric Energy Efficiency Standard[3].

[2] https://www.gov.uk/government/collections/sub-national-gas-consumption-data (Accessed July 2017)

[3] Zero Carbon Hub, *Fabric Energy Efficiency for Part L 2013: Worked examples and fabric specifications* (2012)

3 Low Carbon Heat Supply Options

A range of heat supply technologies have been assessed in the heat network options appraisal. These technologies, their relative pros and cons and their relevance to heat networks in North East Lincolnshire, are described here.

3.1 Description of heat supply options

3.1.1 Gas combined heat and power (CHP)

Gas combined heat and power (CHP) systems generate both electricity and heat. As such, the business case for a Gas CHP-based system depends on the ability to sell the generated electricity as well as the generated heat. The heat-to-power ratio of the CHP system can be varied according to the relative size of the heat and electricity demand being served, and value of the sale of each fuel. Typically, CHP systems serving heat networks are heat-led, with heat-to-power ratios on the order of 2:1. In many cases, the electricity generated is exported to the grid, attracting a relatively low value. However, there is also the opportunity to meet electricity demand directly on-site, or to meet the demand of nearby electricity users through ‘private wire’. In this case, the effective value of the generated electricity is greater, since it offsets the cost of purchasing electricity from the grid, which is significantly higher than the value obtained by exporting to the grid.

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

3.1.2 Water-source heat pump (WSHP)

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.

WSHP 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 North East Lincolnshire, both open loop and closed loop systems could be relevant. The Humber provides a large potential source of heat for networks close to the coast, whereas systems based on abstraction of groundwater (e.g. from aquifer layers) could be most suitable away from the coast. A detailed study of the suitability of the area for WSHP would need to be carried out by a qualified hydrogeologist at a more advanced stage, followed by a text borehole if appropriate. At this stage, no reason to rule out WSHP has been found[4]. A schematic diagram of an open-loop groundwater aquifer-based WSHP system is shown in Figure 3-1. 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.

[4] See appendix E for maps of water sources and groundwater protection zones in the area

Figure 3-1: Schematic of an open-loop system with abstraction and rejection of aquifer water[5]

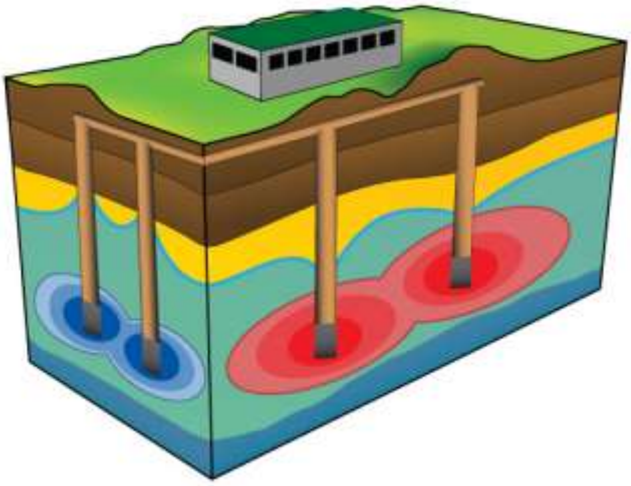


Figure 3-2: Example images of a housing for a single borehole for a WSHP system[6]

3.1.3 Waste heat

An important feature of heat networks is that the economies of scale they provide mean there is the opportunity to make use of a variety of secondary and ambient sources that otherwise cannot easily be recovered. Potential sources of waste and secondary heat include heat from power stations, industrial processes, cooling water from data centres, heat from wastewater treatment facilities and others. Ideally, the waste heat source should provide an almost uninterrupted flow of heat, operating at all times of the day and year-round. This is often the case for power stations and industrial facilities, with only short periods of annual maintenance work interrupting the supply. The operation of the facility is managed externally to the heat network to which it supplies heat such that the responsibility for operating the energy centre and sourcing the fuel is removed.

There is a wide range of potential heat sources in North East Lincolnshire, as described in Section 4.3. This includes industrial sites and power stations, as well as a number of operational and planned Energy-from-Waste (EfW) facilities. The scale of EfW facilities means they are frequently suitable for provision of heat to heat networks, and several networks in the UK already make use of heat from EfW plant, including in Nottingham, Southwark (SELCHP) and Sheffield.

Waste heat can be found at a variety of temperatures, which may be above the required heat network flow temperature or below it, in which case a heat pump would still be required to raise the

[5] Image courtesy of G-Core (2016)
[6] Left: a below-ground well housing; centre and right: above-ground/exposed well housings. All images courtesy of Iftech.

temperature further. In the case of waste heat from EfW facilities, the heat can be provided at high temperature (potentially even as steam), meaning that the heat network can be supplied directly. This entails a small reduction of efficiency in electricity generation, so it is typical for the heat to carry a small charge. However, since multiple units of heat can be extracted for every unit of electricity foregone via the reduction in electrical efficiency (this ratio, often known as the 'Z-factor', is typically in the range 7-10) the heat purchase price may be many times smaller than the cost of a unit of gas. Furthermore, EfW plant can be eligible for higher electricity sale tariffs under Contracts for Difference, but this requires that a minimum fraction of the heat produced is recovered for useful purposes. This can provide a strong incentive for EfW operators to find heat customers.

3.1.4 Biomass boiler

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. To be eligible for the RHI, the heat produced from the biomass boiler will need to be metered. This will help ensure that the biomass boiler is fully utilised and that the gas boilers are only used for backup. Biomass boilers are relatively cost-effective as compared with other renewable heating technologies.

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).

3.1.5 Deep geothermal

In deep geothermal, water is pumped down into hot rocks where it is heated before being brought back to the surface. This technology is distinct from an open loop groundwater-source WSHP and a closed loop ground-source heat pump (GSHP) in terms of the depth accessed by the borehole. While those system typically access the ground heat at a depth of several metres to tens of metres, deep geothermal typically refers to access of heat at least several hundred metres and possibly several kilometres below the surface. The objective of accessing the greater depths is to access higher temperatures; while a groundwater-source WSHP might access temperatures in the range 10-20ºC, a deep geothermal system may access temperature far in excess of this, depending on the local geology.

The temperatures obtained can be high enough that a heat pump is not required to reach temperatures compatible with space heating and hot water, but in many cases a heat pump will still be required to reach the desired temperatures. In this case, the heat pump would nonetheless be expected to operate with a higher efficiency due to the higher water source temperature. However, the cost of drilling a deep geothermal borehole is much higher than the cost of drilling a shallow borehole, so the viability of deep geothermal is strongly dependent on the temperature and amount of heat that can be accessed.

Several studies have identified North East Lincolnshire as a potentially viable source of deep geothermal heating. A British Geological Survey report from 1986[7] presents the results of a test borehole drilled at Cleethorpes, where a borehole yield of 20 litres/second was achieved at a temperature of 53ºC. This was consistent with the findings of an earlier study by Gale et al.[8] which suggested that the aquifer across east Yorkshire and Lincolnshire represents the largest store of low enthalpy geothermal energy in the UK, but at the relatively low temperature of 40-55ºC. A more recent report by Rogerson and Ferrier at the University of Hull[9] presents an assessment of the evidence to date on this topic, and summarises the geothermal potential in the region at two depth ranges: (i) low depth, 750-1200m, with a temperature of approximately 40ºC and (ii) high depth, 1200-1600m, with a temperature of approximately 60ºC. The Rogerson and Ferrier study suggests that “it is unlikely that it will be possible to produce water at >70ºC in East Humberside”.security

In the technical assessment, we therefore study two sensitivities for Deep geothermal: a Low T geothermal option with a source temperature of 40ºC, and a High T geothermal option with a source temperature of 55ºC. In both cases, a heat pump is required to reach the network flow temperature.

3.2 Carbon emissions reduction potential of heat supply options

One of the key objectives for the deployment of heat networks, both for NELC and for HNDU, is to contribute to the reduction of carbon emissions. An assessment of the likely impact of each technology option on overall emissions reduction should therefore form part of the assessment of the preferred scheme.

The relative carbon intensity (i.e. the amount of CO_2 emissions per unit of heat generated) of several of the technology options is dependent on the carbon intensity of the electricity grid because they either use electricity (e.g. Heat Pumps) or produce electricity (e.g Gas CHP). This is illustrated in Figure 3-3, which presents the carbon intensity of heat from Gas boilers, Heat pumps and Gas CHP as a function of the carbon intensity of grid electricity. The carbon intensity of Gas boilers is not dependent on the carbon intensity of the electricity grid (as they neither consumer nor produce electricity) and is a constant value of approximately 230 gCO_2/kWh, depending on the efficiency of the boiler[10]. The carbon intensity of a heat pump varies linearly with the carbon intensity of the electricity used to run the heat pump. For example, for a heat pump efficiency of 350% (producing 3.5 units of heat energy for every unit of electricity consumed), the carbon intensity of heat from a heat pump is 1/3.5 of the carbon intensity of the electricity used to supply it. The carbon intensity of heat from a Gas CHP follows the opposite dependence; since a CHP unit produces electricity, it displaces grid electricity. Where electricity from Gas CHP displaces low carbon electricity such as renewable electricity from wind, biomass or solar PV, Gas CHP can lead overall to an increase in carbon emissions. For a Gas boiler efficiency of 85%, heat from Gas CHP effectively leads to an increase in carbon emissions relative to the Gas boiler for grid electricity carbon intensity below approximately 270 gCO_2/kWh.

For context, Table 3-1 shows the projection of grid electricity carbon intensity in the HMT Treasury Green Book[11]. This suggests that by 2020, both the grid average and the long-run marginal carbon intensity are below 270 gCO_2/kWh, meaning that (for the plant efficiencies assumed above), Gas CHP leads to a net increase in carbon emissions relative to gas boilers. As the grid decarbonises further

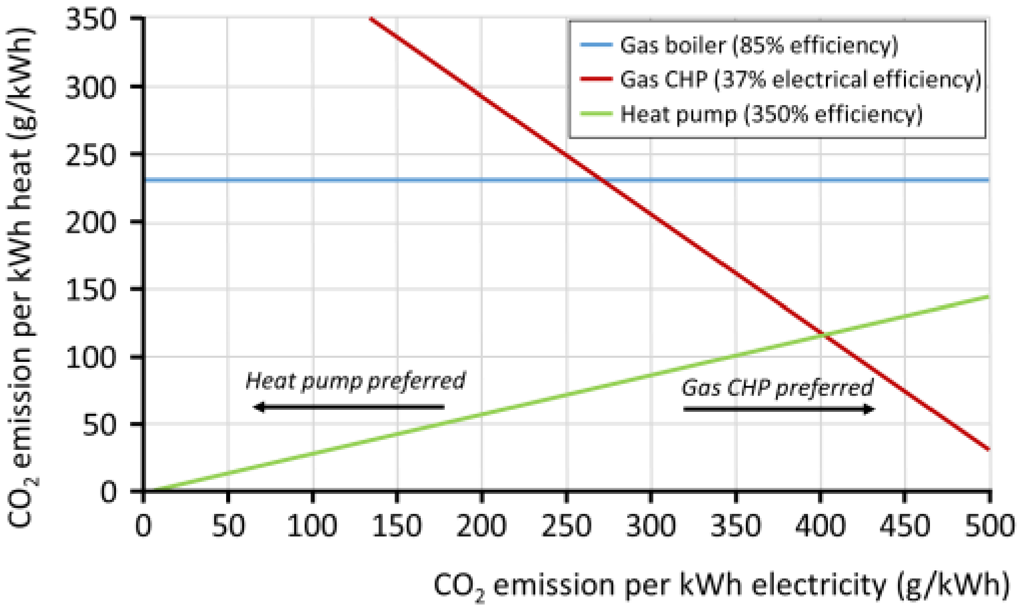
[7] British Geological Survey, Cleethorpes Geothermal Exploration Borehole: Drilling and Testing Programme, General Report Energy Technology Support Unit (1986).
[8] Gale et al., The post-Carboniferous rocks of the East Yorkshire and Lincolnshire Basin, *Invest. Geotherm. Potent.,* UK Inst. Geol. Sci. (1983).
[9] Rogerson and Ferrier, *Review of the Low Enthalpy Geothermal Prospects in East Humberside*, University of Hull.
[10] A small amount of decarbonisation of the gas grid is anticipated in the future but the degree of decarbonisation and timescales are very uncertain. For the purposes of this study, the carbon intensity of gas is considered to be constant over time.
[11] HMT Green Book Guidance Table 1 (March 2017)

beyond 2020, Gas CHP results in a greater increase in carbon emissions. This analysis suggests that heat networks installed today are likely to result, over their lifetime, in a substantial increase in emissions relative to Gas boilers.

Waste heat can be considered to be very low carbon, depending somewhat on the source of waste heat. If the heat is entirely secondary, and is produced in any case, use of the waste heat can be considered zero carbon. More typically, waste heat from an EfW plant or other power station results, as described above, in a small electricity efficiency penalty according to the Z-factor, meaning that a small amount of additional electricity must be produced elsewhere. In this case, the carbon intensity of the waste heat could be considered to be the carbon intensity of the additional electricity produced, divided by the Z-factor. Since the Z-factor is typically large (7-10), this will still represent a very low carbon heat source.

The carbon intensity of biomass is a complex (and frequently controversial) topic. Biomass fuel is often considered to be zero carbon, since the fuel is 'zero-rated' according to the EU Renewable Energy Directive, on the basis that the emissions are accounted for in land-use emissions inventories and should not be double counted. In reality, the lifecycle emissions of biomass are on-zero, and highly dependent on the source of the biomass, the method of production and harvest and the transportation distance and method, among other factors. For the purposes of this study, the carbon intensity of biomass is taken as 16 gCO_2/kWh.

Figure 3-3: CO_2 emissions per kWh of heat as a function of grid electricity carbon intensity[12]



[12] Figure adapted from '*A Heated Debate: Sustainable heat for a low carbon future'*, Graeme Gidney and Paul Woods, Aecom, 30/10/12

Table 3-1: Projection of grid electricity carbon intensity

Year	CO_2 emissions per kWh electricity[13] (g/kWh)	
	Long-run marginal	Grid average
2015	307	334
2020	260	198
2025	198	174
2030	118	107
2040	48	48
2050	25	25

3.3 Summary of pros and cons of heat supply options

A summary of the pros and cons of the heat supply options studied, as described above, is provided in Table 3-2.

Table 3-2: Summary of pros and cons of heat supply options

Option	Pros	Cons
Waste heat from industry, power and Energy-from-Waste plants	✓ Potential to be **very low cost heat** ✓ **Very 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 where **supported by RHI** ✓ Where **cooling** is also required, economics improved significantly	• High capital cost • Requires substantial electrical grid capacity • Some risk of RHI support being reduced/withdrawn
Geothermal	✓ Potential to be very **low carbon** ✓ Can deliver heat without need for heat pump **if temperature sufficiently high** ✓ **Supported by RHI**	• High capital cost • Uncertainty over suitability of resource until test well drilled • Some risk of RHI support being reduced/withdrawn
Gas combined heat and power (CHP)	✓ **Mature and proven** technology ✓ Relatively **cost-effective** without subsidy ✓ Opportunity to deliver **on-site electricity**	• Fossil fuel-based, so carbon savings may not be large (and may be negative in future)
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 • Some risk of RHI support being reduced/withdrawn

[13] HMT Green Book Guidance Table 1 (March 2017)

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 to be prioritised to take forward to the technical and economic assessment. Key characteristics of promising cluster areas include:

- High heating and/or cooling demand density
- Presence of potential anchor customer(s)
- Mix of user types
- Plans for substantial new development
- Proximity to low carbon heat source(s)
- Absence of major constraints
- Suitable land ownership
- Presence of suitable site(s) for the energy centre

Table 4-1: Key characteristics of areas suitable for a heat network

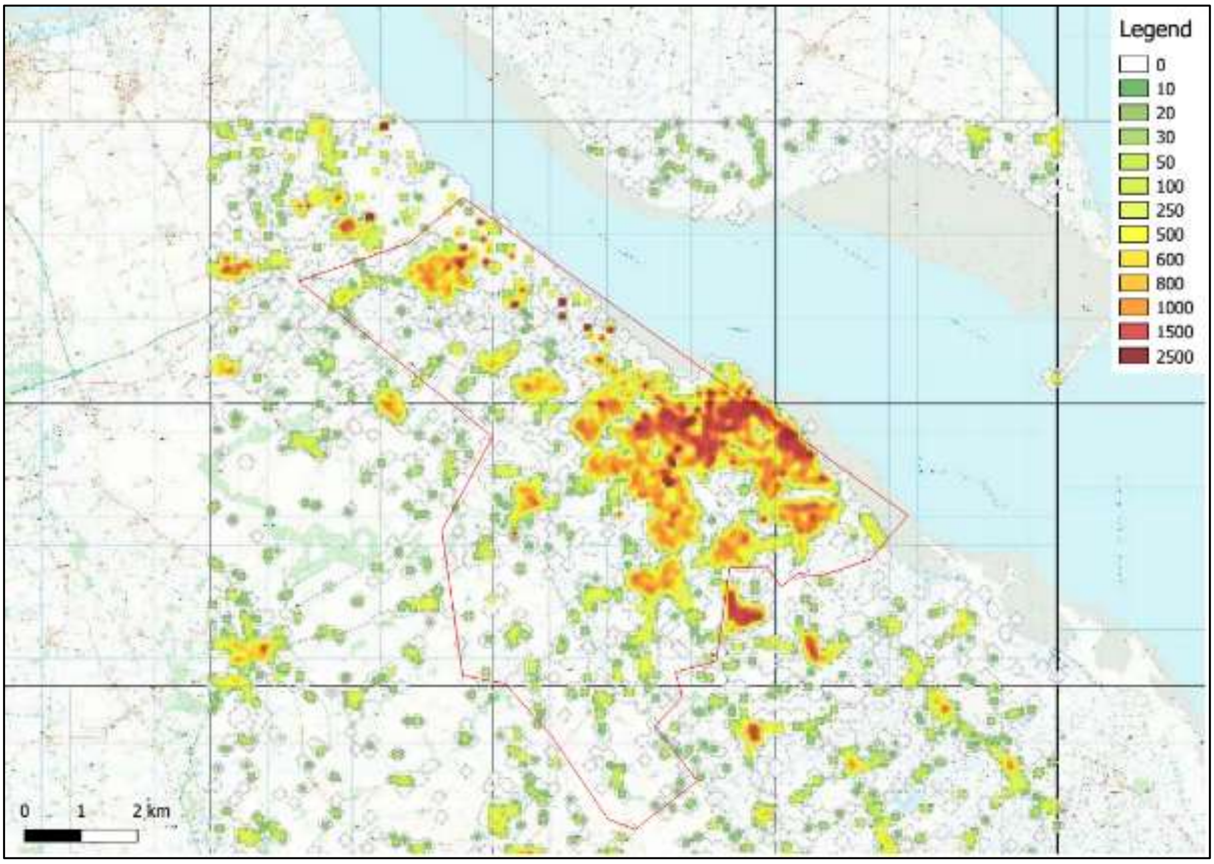
Key characteristic	Reason for importance
High heating and/or cooling demand density	Sufficient heating (or cooling) demand density is of critical importance, so that the network infrastructure costs are kept low enough to be offset over time by the revenues from heat sales.
Presence of potential anchor customer(s)	Individual users of high demand can provide initial demand certainty for the developer. Public authority buildings often act as anchor loads due to level of Council influence; large commercial or industrial users could also act as anchor loads.
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.
Plans for substantial new development	New developments are attractive for heat network developers since all customers can potentially be connected as soon as the development is occupied, and without the need to sign up users individually (through a contract with the building developer). Furthermore, heat network developers can charge a connection cost to building developers since district heating can help building developers meet Part L energy and carbon requirements.
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, water sources such as rivers or the sea, or geothermal sites. The distance to the heat source(s) will impact the network infrastructure cost.
Absence of major constraints	Heat network pipes may be constrained by major roads, waterways, railway lines, utility infrastructure, or due to environmental or heritage designations and other landscape features. Some areas (e.g. town centres) will be more expensive to dig than others (e.g. greenfield areas).
Suitable land ownership	Where the heat network route passes through private land, wayleaves will need to be negotiated, potentially increasing the cost and impacting on the delivery timeline. For this reason, the less fragmented the land ownership the better. Publicly-owned land is likely to be most favourable for the same reason.
Presence of suitable site(s) for the energy centre	An energy centre will be required to house the energy supply plant (including backup boilers, storage, pumps and other plant). The proximity of a suitable plot of land for the energy centre, and the land price, will impact the upfront network cost.

4.1 Energy demand mapping

As described in Table 4-1, an important feature of an area suitable for a heat network is a 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 of installing the heat network; which increases significantly with the length of the networkThe heating and cooling demand density (in MWh of demand per 100m x 100m square) was mapped for the whole study region based on the energy demand data and analysis described in Section 2.2.

Figure 4-1 shows a heat demand density map for the red-line study area. The map presents the total estimated heat demand in each square of a 100m by 100m grid across the region. The colour coding is indicated in the legend in units of MWh per 100m x 100m grid square. The heat demand density map shows a large nearly continuous region of particularly high heat density (greater than 1,500 MWh per grid square) including the centre of Grimsby, the region along the coast southeast of Grimsby to Cleethorpes, and the regions south and west of the centre of Grimsby. There are numerous isolated areas of similarly high heat demand density along the South Humber Bank, corresponding to the large industrial users in this area. There are then a series of clusters of moderately high heat demand density (greater than 800 MWh per grid square) corresponding to the other urban centres (mainly villages) across the area.

Figure 4-1: Heat demand density map for whole study area (units MWh per 100m x 100m square)



Similar maps were produced for two types of cooling demand: space cooling and storage cooling. Figure 4-2 and Figure 4-3 show the space cooling demand density and the storage cooling demand density respectively, both focusing on Grimsby and Cleethorpes and the surrounding area.

Figure 4-2: Space cooling demand density map for Grimsby and Cleethorpes and around (units MWh per 100m x 100m square)

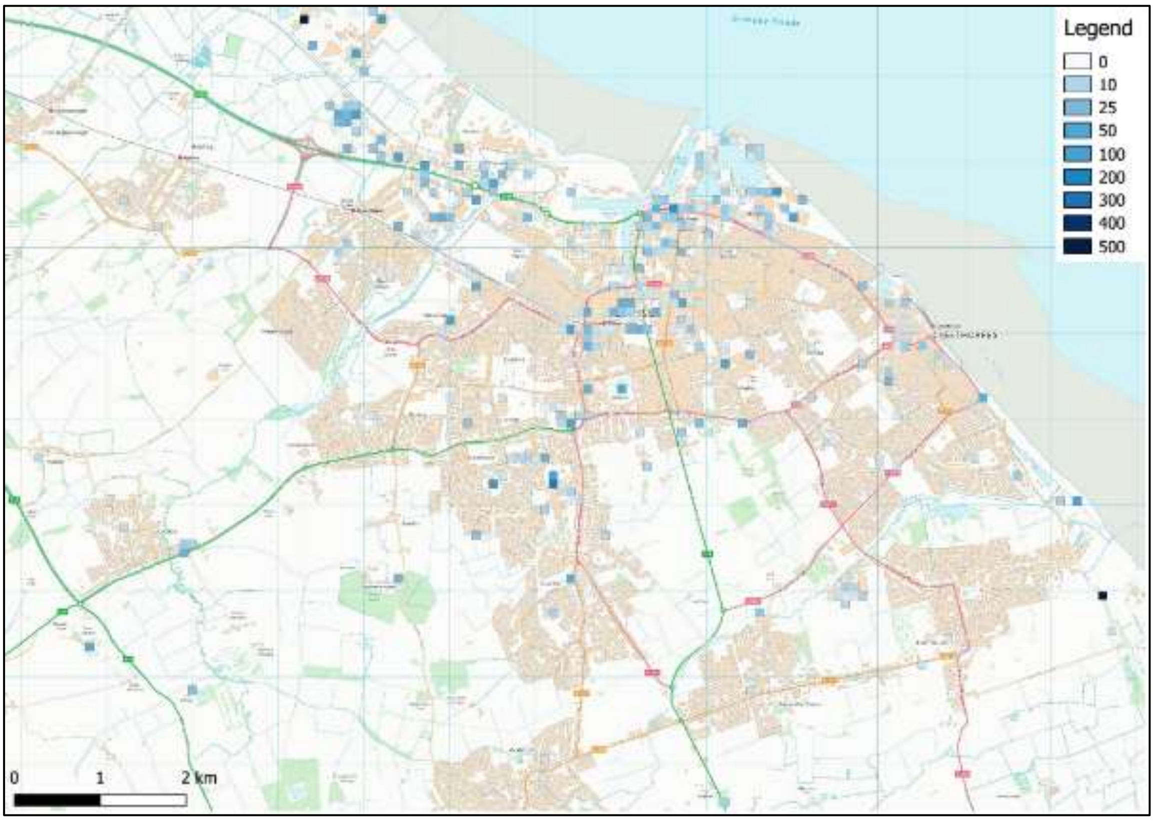
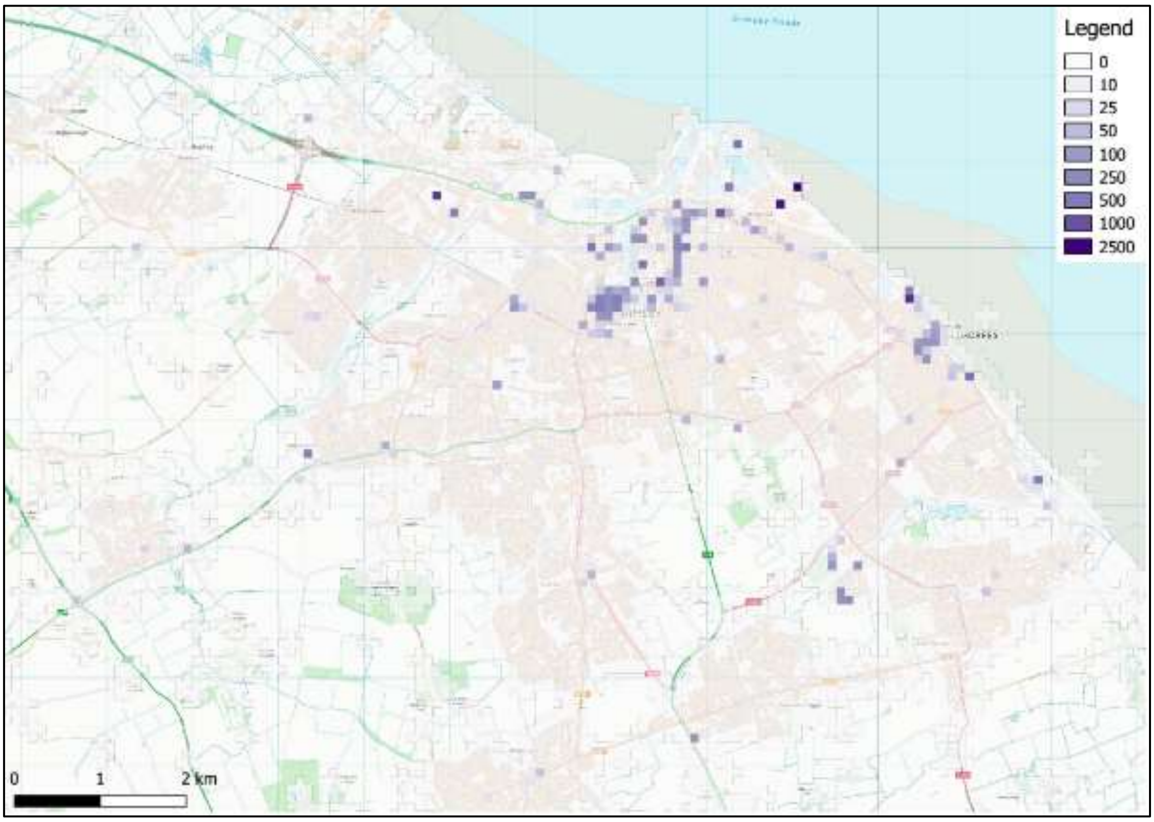


Figure 4-3: Storage cooling demand density map for Grimsby and Cleethorpes and around (units MWh per 100m x 100m square)



Since space cooling and storage cooling are less prevalent than heating, the cooling maps show more isolated areas of high demand density. Space cooling density across the area is relatively low, rarely rising above 500 MWh per 100m x 100m grid square. This is expected to be associated, in particular, with the retail and office space. Storage cooling, however, rises in a number of locations above 1,000 MWh per grid square. While a moderate storage cooling demand is associated with retail and supermarket space and is hence present across the town centres, the areas of particularly high storage cooling demand density relate to the presence of coldstores, used mainly to store seafood. Large coldstores are found in a number of locations including the area around Grimsby Dock and the area around Great Coates Industrial Estate. Coldstores present an opportunity for a heat network to provide heat to drive absorption chillers capable of maintaining deep-freeze temperatures.

A further key characteristic of areas suitable for heat networks, as described above, is the presence of large energy users who could act as anchor customers for the scheme. In order to identify clusters containing one or more potential anchor customers, the largest energy users were mapped separately. Large users of heating, space cooling and storage cooling are shown in Figure 4-4 (which presents the region around Grimsby and Cleethorpes) and Figure 4-5 (which presents the region around Immingham and the South Humber Bank). The colour coding refers to heating, space cooling or storage cooling as in the legend, and the size of the circles approximately represents the magnitude of the user's annual energy demand.

Figure 4-4 shows several very large heat users (red circles) southwest of Grimsby centre, corresponding to the Diana, Princess of Wales Hospital and Grimsby Institute. A large number of moderately large energy users, including large heat users and large storage cooling users (purple circles) are also found in Grimsby Town, in the Grimsby Docks area, in Cleethorpes and other areas across the region. Figure 4-5 shows a number of large and very large heat users on the South Humber Bank and Immingham Port. The major heat users in the key clusters are described in more detail in the following sections.

4.2 Key development areas

As described in Section 2.2, key areas earmarked for future development were identified through consultation with stakeholders, and particularly the Planning and Economic Growth teams at NELC. Many new development areas are included in GIS layers provided by NELC. Figure 4-6 and Figure 4-7 show these GIS layers for new developments in two parts of the study area.

We note that, in addition to the GIS layers presented here, the NELC team were able to provide more up-to-date information on development plans in the region not available in the GIS layers. This information was incorporated into our analysis, and is presented in Section 6 in relation to the clusters selected for further assessment.

Figure 4-4: Large energy users (1 of 2)

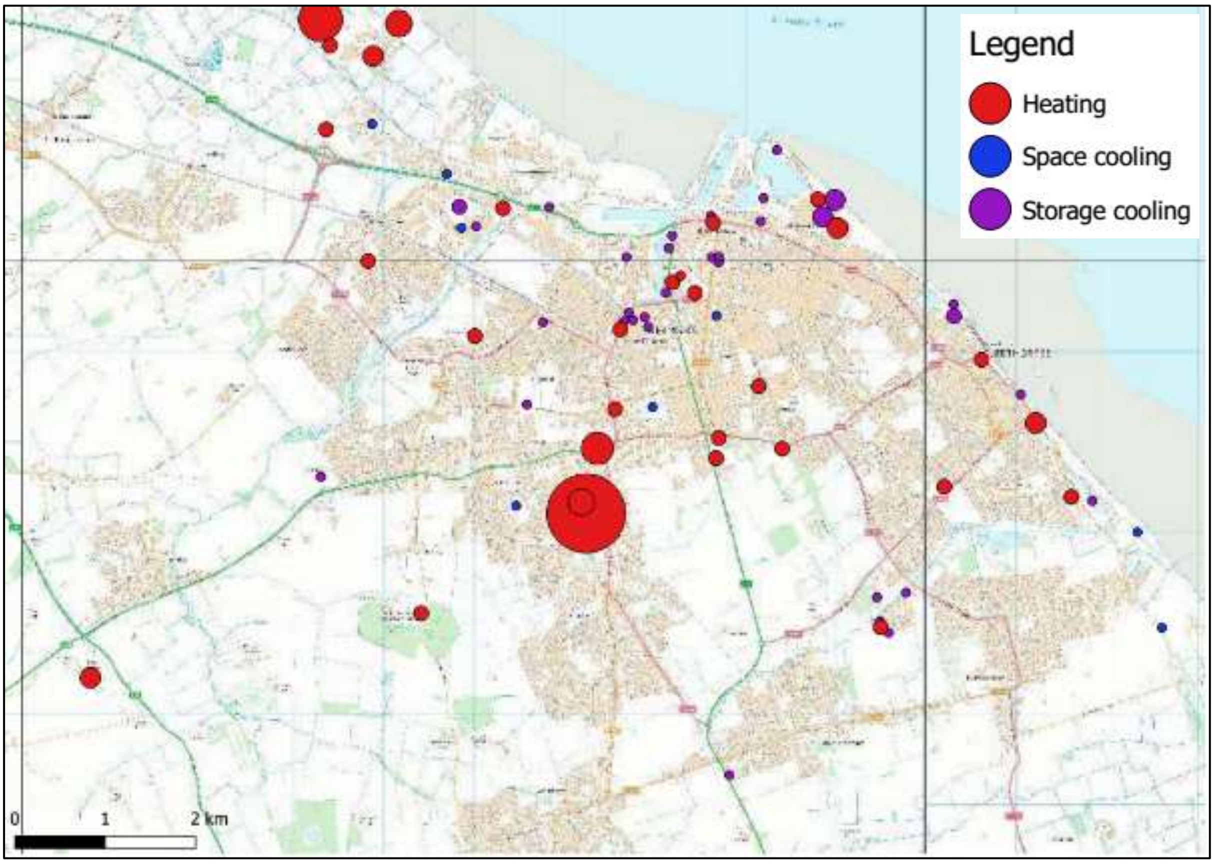


Figure 4-5: Large energy users (2 of 2)

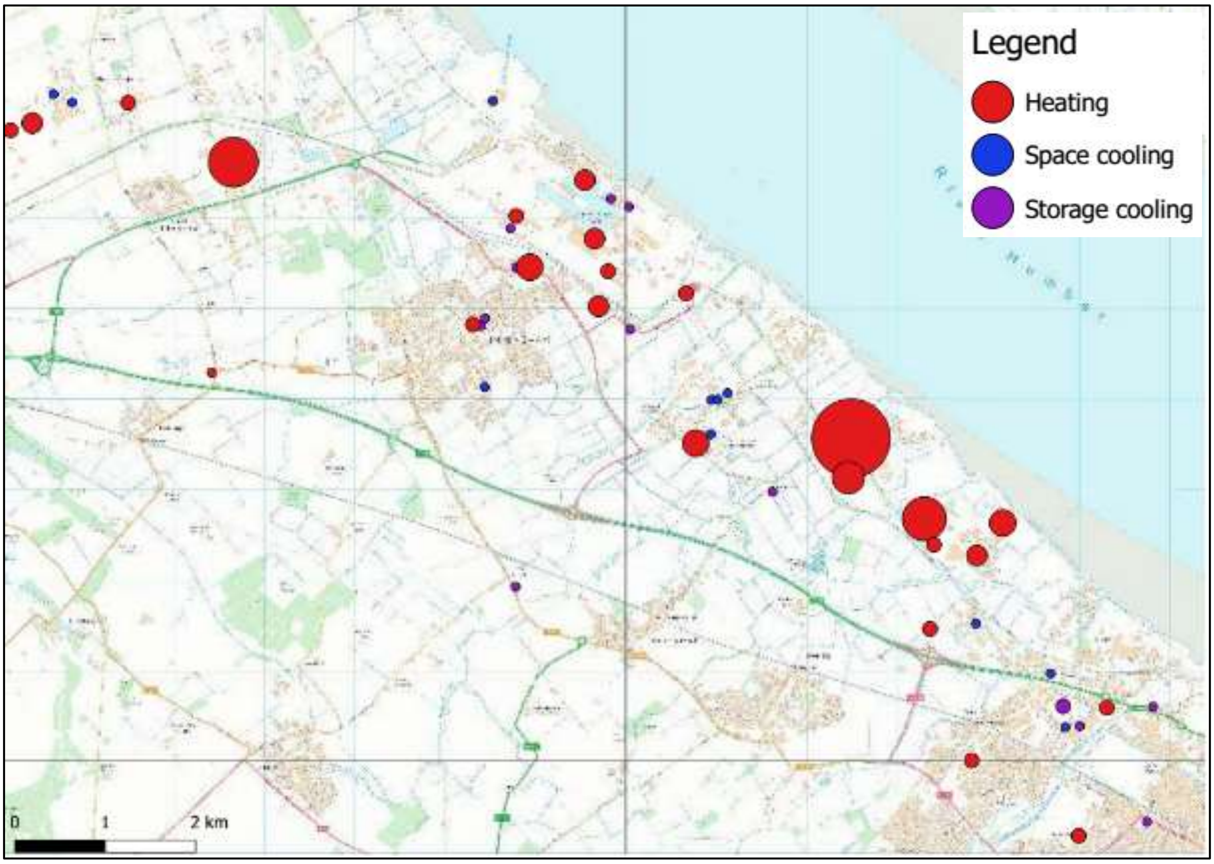


Figure 4-6: New development areas described in the Local Plan 2013 (1 of 2)

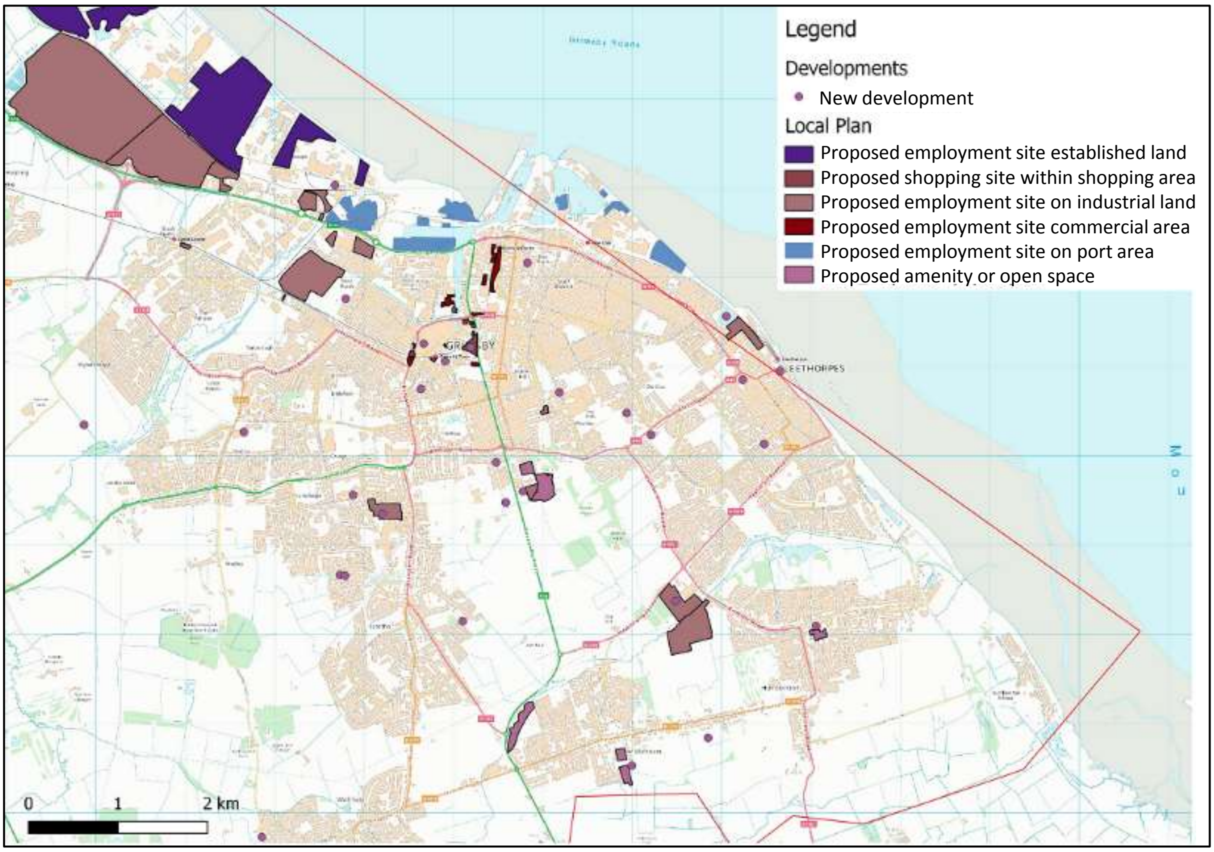
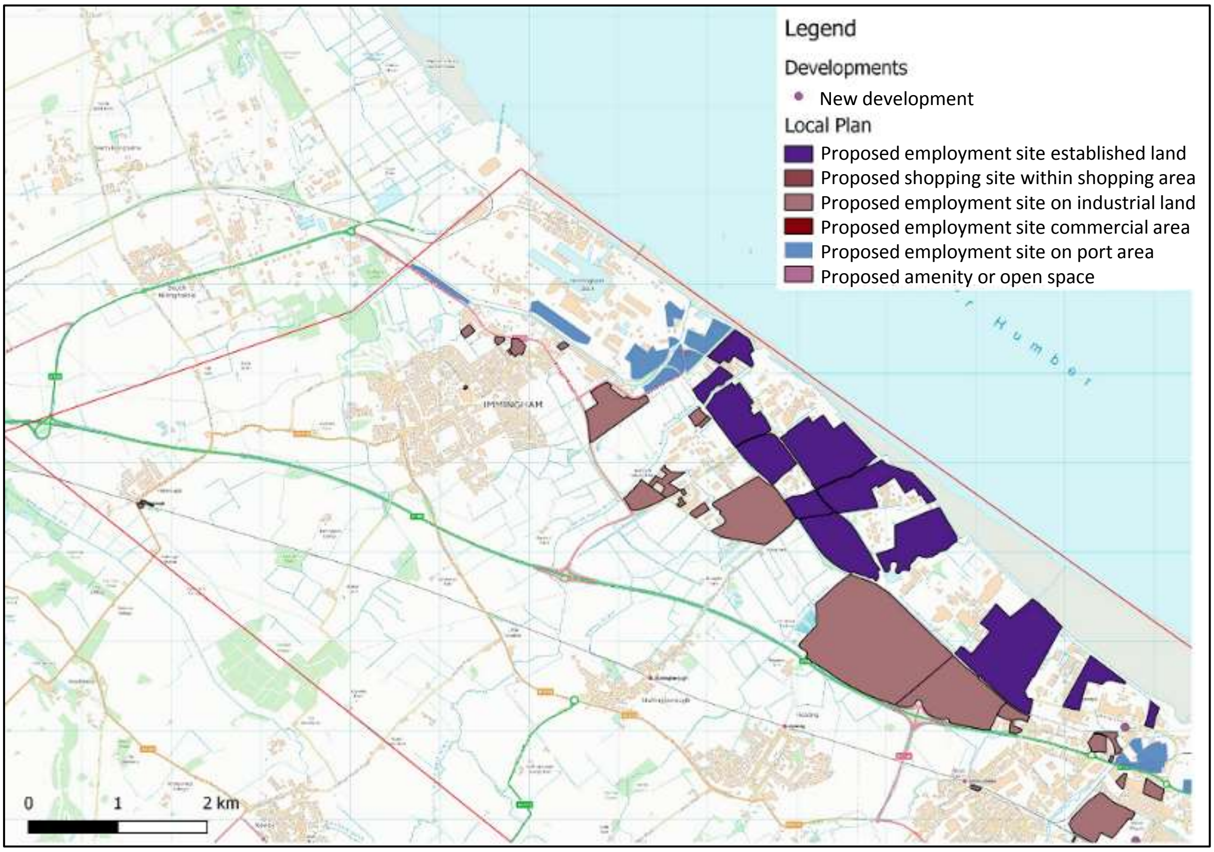


Figure 4-7: New development areas described in the Local Plan 2013 (2 of 2)



4.3 Heat source mapping

Information on heat sources in the area gathered through the stakeholder consultation and data collection phase was also mapped. Potential sources include:

- Energy-from-Waste facilities
- Waste heat from other power stations and CHP facilities
- Waste heat from large industrial processes

Figure 4-8 presents the approximate location of heat sources identified. The size of the circle corresponds approximately to the annual heat generated (which may not necessarily all be available for a heat network). A description of these heat sources is provided in Table 4-2. Whilst some of the waste heat sources identified are already being used to some extent, there remains a very large amount of waste heat available. The key issue is therefore not the quantity of waste heat available but the location of the waste heat sources relative to the areas of high heating and/or cooling demand. Discussions with NELC staff suggest that there is the potential for a number of further Energy-from-Waste facilities to be developed in the region; however, since these plans are either at very early stages, or remain confidential, these are not described further here. However, we have accounted for this possibility in the scheme options considered, as presented in Section 6.

Figure 4-8: Existing potential heat sources in the region

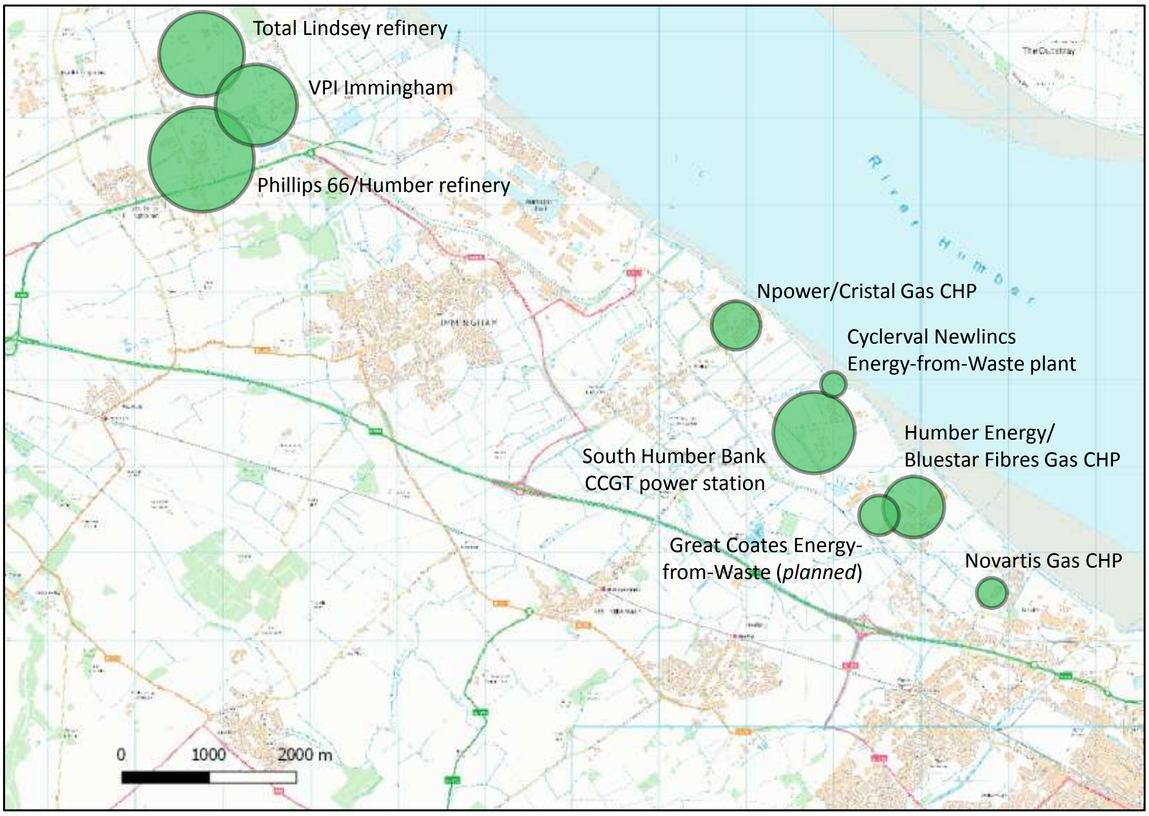


Table 4-2: Summary of heat sources included in the assessment

Heat source	Operational or planned	Description
Cyclerval Newlincs Energy-from-Waste	Operational	Energy-from-Waste facility using municipal solid waste (56,000 tonnes per year). Some or all of the heat produced is supplied to a neighbouring chemicals plant.
Great Coates Energy-from-Waste	Planned	Planned Energy-from-Waste facility (capacity not known). The heat generated by this facility could supply a heat network.
Total Lindsey refinery	Operational	Oil refinery. There could be the potential for low grade waste heat to supply a heat network.
VPI Immingham	Operational	1,180 MWe Gas CHP plant supplying heat and power to the Humber and Lindsey oil refineries. There could be the potential for low grade waste heat to supply a heat network.
Phillips 66 Humber refinery	Operational	Oil refinery. There could be the potential for low grade waste heat to supply a heat network.
Npower Cristal Gas CHP	Operational	16 MWe Gas CHP plant supplying heat and electricity to the Cristal industrial facility.
South Humber Bank CCGT power station	Operational	1,310 MWe CCGT power station
Humber Energy Bluestar Fibres Gas CHP	Operational	46 MWe Gas CHP plant supplying heat and electricity to the Bluestar Fibres industrial facility.
Novartis Gas CHP	Operational	8 MWe Gas CHP plant supplying heat and electricity to the Novartis industrial facility.
Planned Energy-from-Waste plants (Various locations)	Planned	There are early and/or confidential plans for further Energy-from-Waste facilities in the region. The heat generated by these facilities could be used to supply a heat network.

4.4 Constraints mapping

Major constraints on heat network routes in the study area were also mapped. Figure 4-9 shows the railways, waterway and major roads in the Grimsby and Cleethorpes area. The railways present a significant constraint on the potential network routes across several key areas, including Grimsby Town and Docks, the West Marsh area of Grimsby and parts of the South Humber Bank. The impact of major roads and rivers was also considered in the specification of the clusters presented in the following section.

Figure 4-11 presents a series of land designations in the same area. Several Conservation Areas are contained within the study area. Figure 4-13 presents Council adopted land, also focusing on the Grimsby and Cleethorpes area. It can be seen that there is a substantial amount of adopted land within the study area, some of which could be suitable as a site for an energy centre.

The impact of constraints and land ownership on the potential heat network routes is considered in more detail for the clusters selected for further assessment in Section 6.

Figure 4-9: Railways, waterways and major roads (1 of 2)

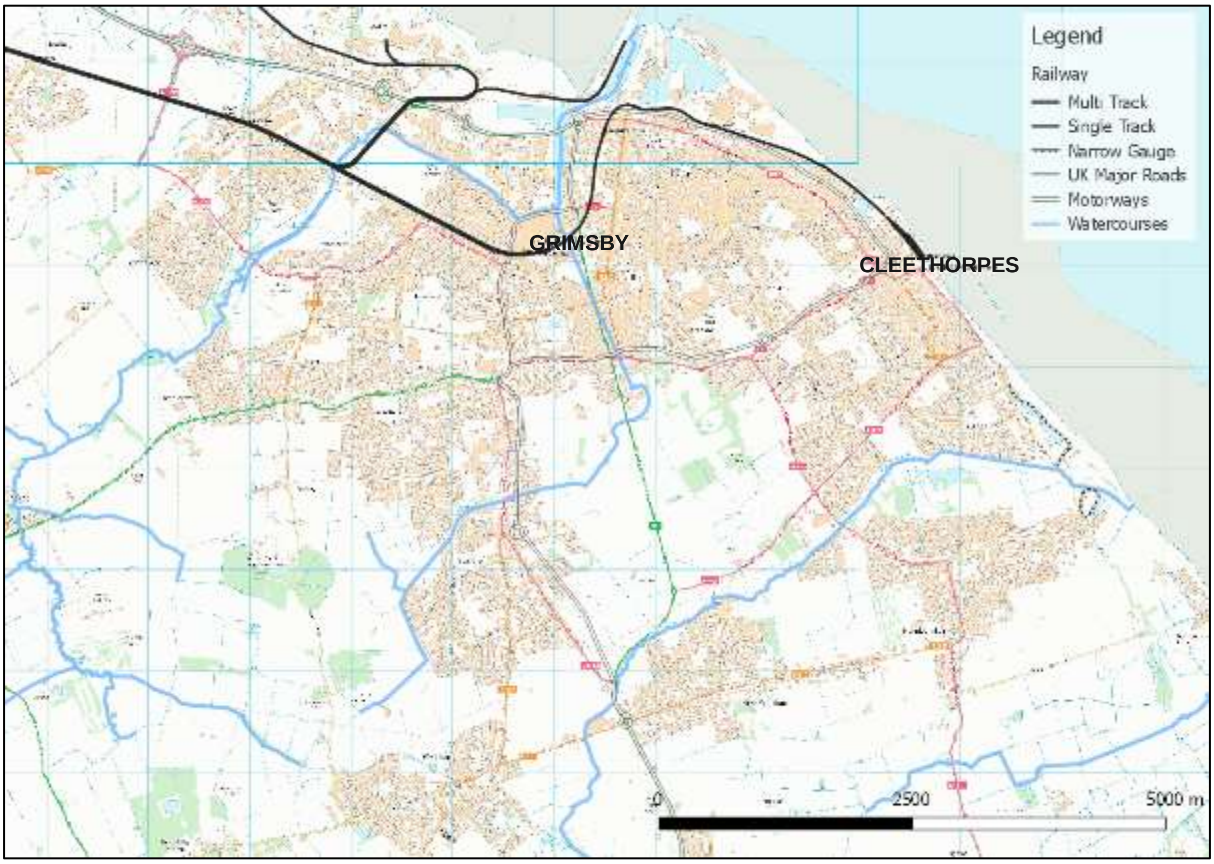


Figure 4-10: Railways, waterways and major roads (2 of 2)

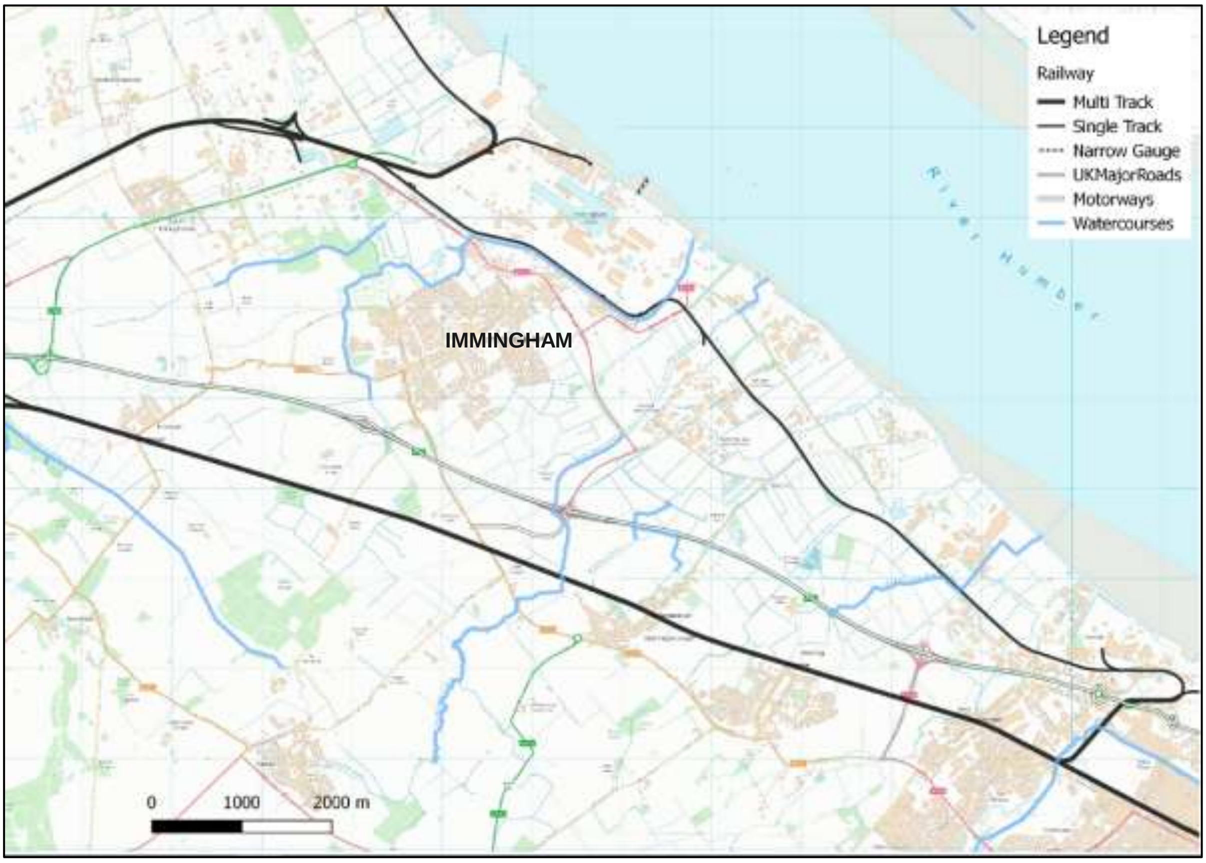


Figure 4-11: Land designations (1 of 2)

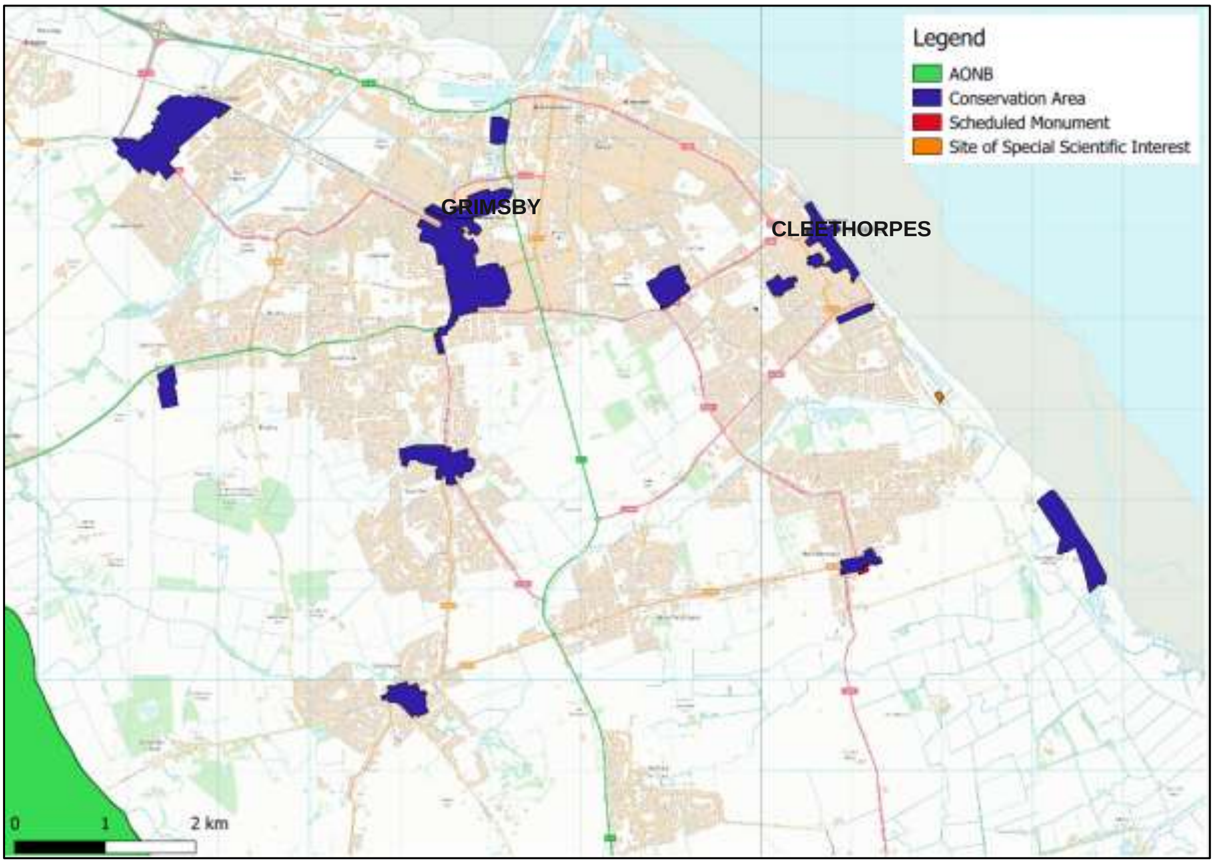


Figure 4-12: Land designations (2 of 2)

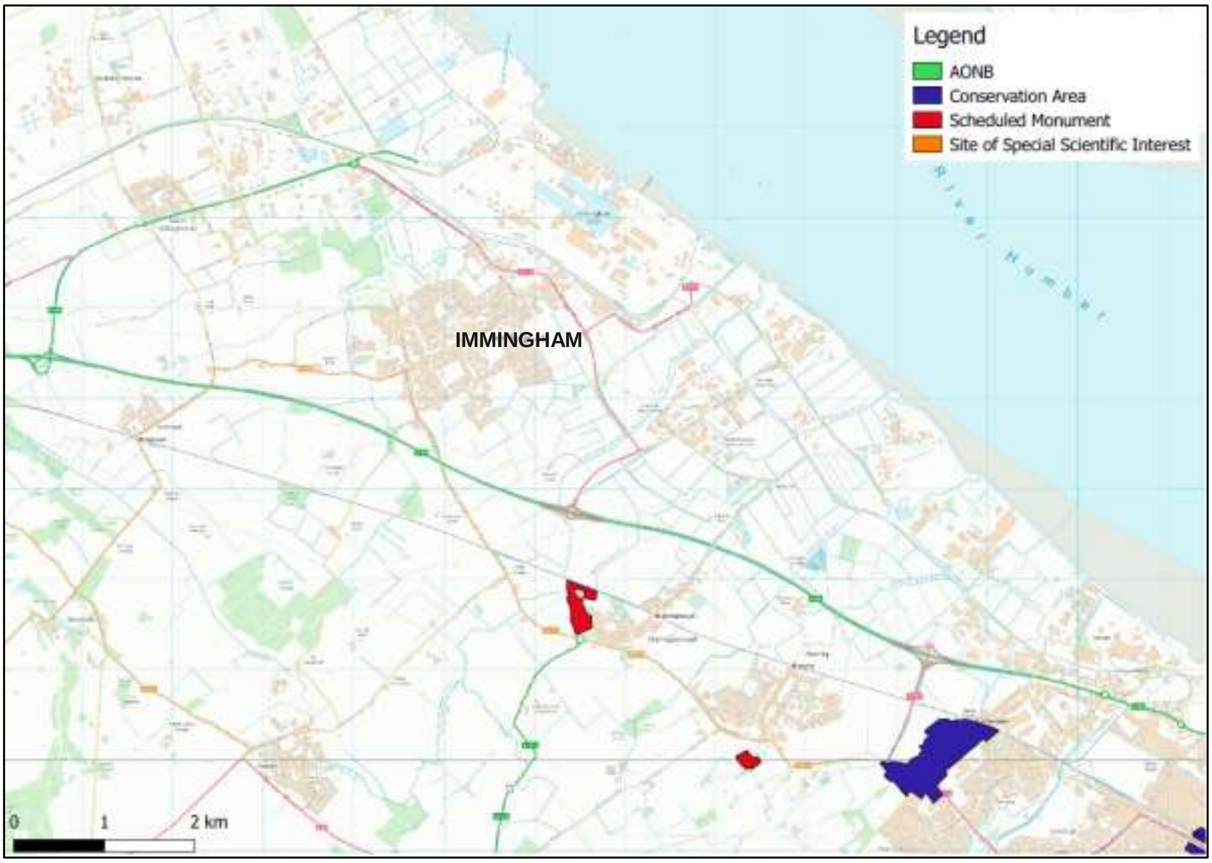


Figure 4-13: Council adopted land (1 of 2)

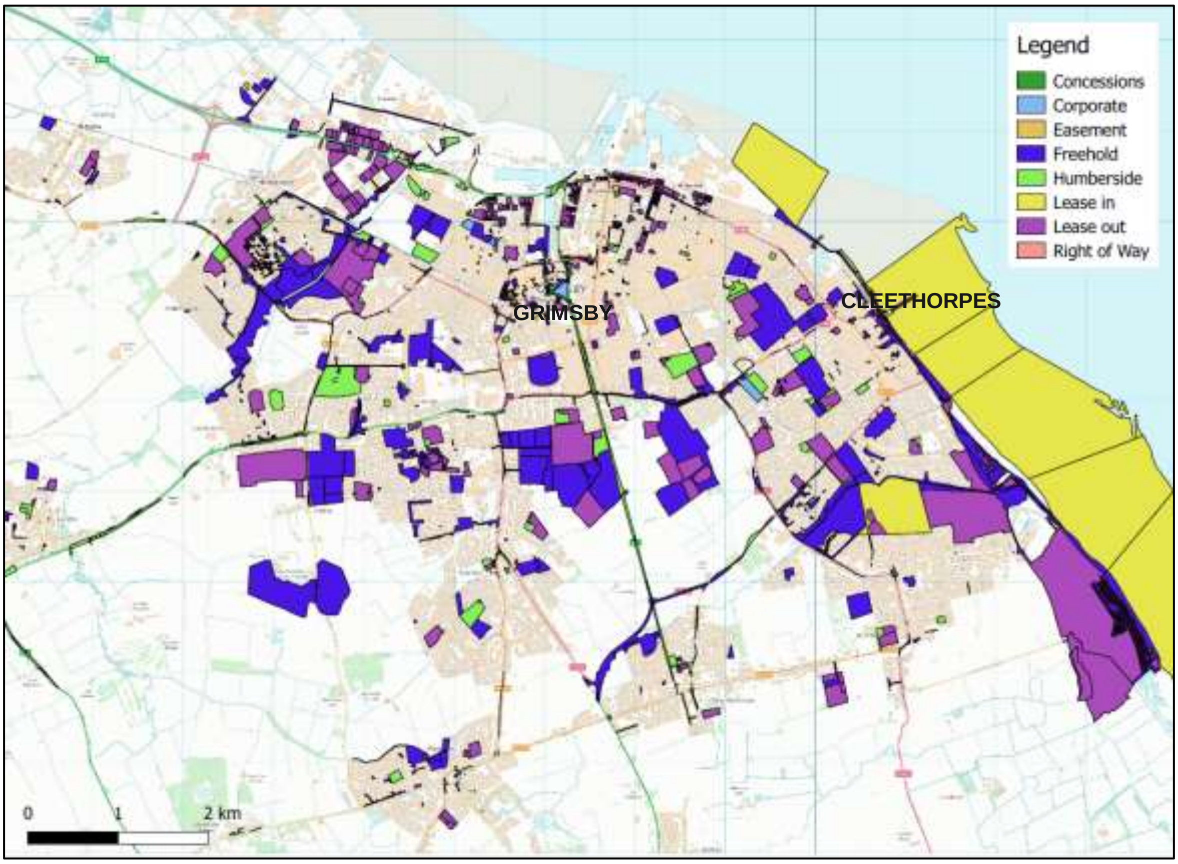
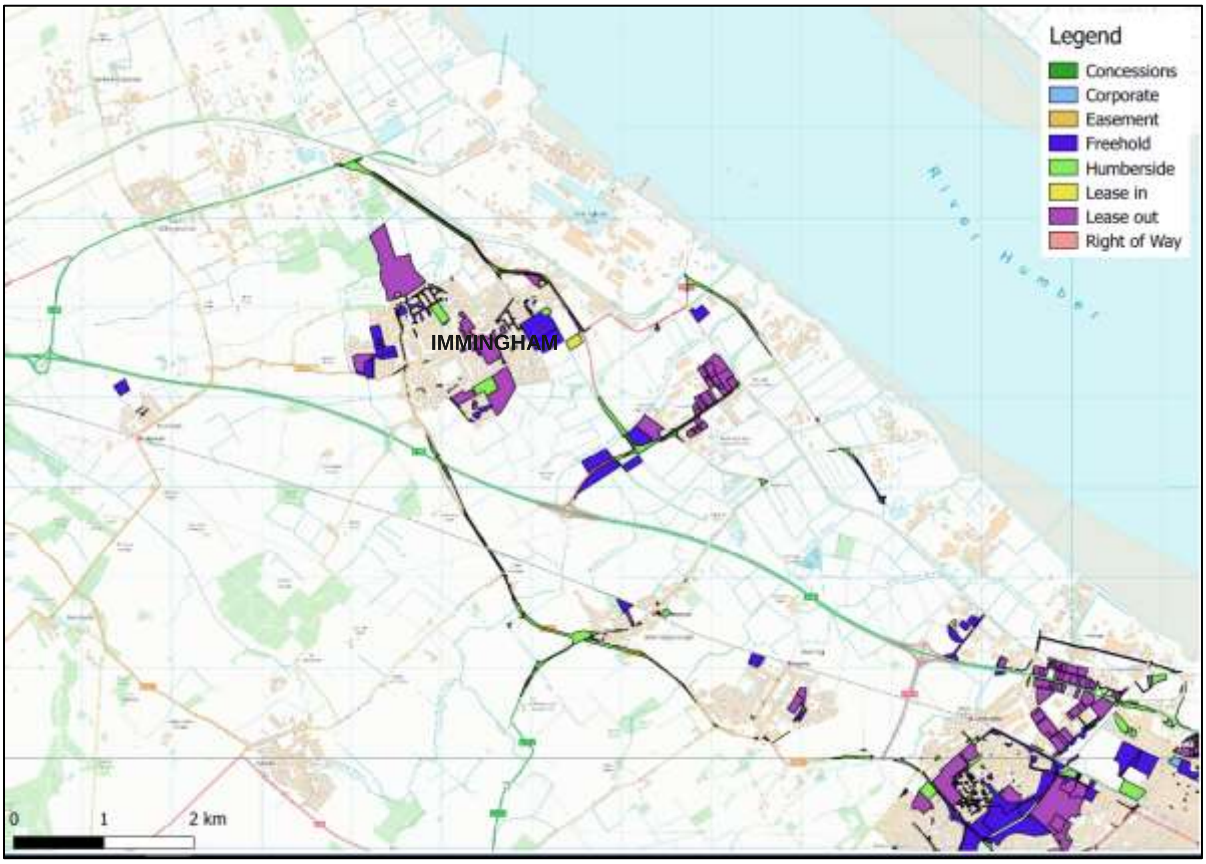


Figure 4-14: Council adopted land (2 of 2)



5 Cluster Assessment and Selection

A longlist of clusters was defined based on the findings of the mapping exercises. For example, 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, 26 separate clusters were defined. Their indicative boundaries are shown in Figure 5-1 and Figure 5-2.

Given the large number of clusters (a result of the large initial study area), it was necessary at this stage to filter down the longlist of clusters under consideration and to select a tractable number to take forward to the technical and economic assessment.

The clusters were therefore assessed in a semi-quantitative way through careful consideration of each cluster in relation to the key characteristics of areas suitable for a heat network, as presented previously in Table 4-1. Each cluster was scored on a scale of 1 to 3 for each characteristic, as shown in Table 5-1. The characteristics were assigned weighting factors on the basis of a judgement on their relative importance, and overall scores for each cluster thus derived. The overall scores for each cluster are presented in Table 5-2.

Following this procedure, a workshop was held with NELC in order to agree on which clusters to take forward to the technical and economic assessment. The decision was based predominantly on the assessment procedure described above, but also incorporated NELC’s view on the areas of key strategic interest.

The outcome of this process was the selection of the following five clusters. A brief summary of the rationale for the selection of these clusters is given below; the clusters are described in much greater detail in Section 6.

1. Diana, Princess of Wales (DPoW) Hospital and around

The high energy demand of the hospital provides a highly suitable potential anchor load. Considering the nearby academy, care home, other non-domestic loads and residential buildings, the cluster contains a good mix of user types. Substantial new development is also expected in this cluster, including an extension to the hospital, staff and student accommodation. The area is bordered by a major road and a conservation area, but there is also substantial adopted land in the area potentially suitable for an energy centre, and the Hospital itself may be able to house the heat supply plant.

2. Grimsby Institute (GIFHE) and around

The cluster contains several suitable potential anchor heat loads, including Grimsby Institute, Franklin College, Ormiston Maritime Academy and The Academy Grimsby. There is a relatively high overall heat density, and the potential for the network to expand to serve the surrounding residential buildings. The development of several hundred new residential units is planned in the area. There is a region of adopted Council land northwest of the Institute which could host the energy centre, which could also potentially be housed at the Institute. The cluster is separated from the DPoW hospital cluster by a major road, and bordered by the same conservation area.

3. Cromwell Road and Great Coates Industrial Estate

There are several public and private sector buildings in this cluster which, individually or in combination, could act as anchor heat loads; these include Grimsby Leisure Centre, the fire station, the police station and several large coldstores (which could be supplied with heat from the network to drive low temperature absorption chillers). The development of at least 250 residential units is planned in the area. Notable constraints due to the railway and river suggest that two split schemes should be considered as options within this cluster, but there are approaches to crossing those features which could allow a single scheme serving the cluster. This cluster is also somewhat closer than the DPoW and GIFHE clusters to the various potential sources of waste heat in the South Humber Bank area. Finally, there is a significant amount of adopted land in the area.

4. Immingham Town

While the heat demand density in this cluster is somewhat lower than for the above clusters, and potential anchor loads are somewhat smaller (including a leisure centre, several schools and a hotel), there is excellent potential for connecting to nearby existing and planned sources of waste heat. A substantial amount of new residential development is planned, including approximately a thousand new homes. These factors lend this cluster additional strategic interest to NELC.

5. Stallingborough Enterprise Zone

This area, currently largely greenfield, has been identified as key in terms of economic development and inward investment by NELC. Internal stakeholders have identified this site as having the most interest from large energy users in the commercial and manufacturing sectors considering moving into the area. It has been suggested by NELC that this site will be developed ahead of the Europarc Enterprise Zone, which is the reason for the selection of this cluster rather than cluster 17. Since the site is largely greenfield, scenarios were studied for the future user mix on the site. The cluster also contains several existing buildings including HCF Catch, an industrial training facility, and a fire station. The area is close to the existing waste heat sources in the region, and the site could potentially host one of the planned Energy-from-Waste facilities itself. Since the development is likely to be commercial//industrial in nature, there are many suitable locations for the energy centre on site.

Figure 5-1: Indicative cluster boundaries (1 of 2)

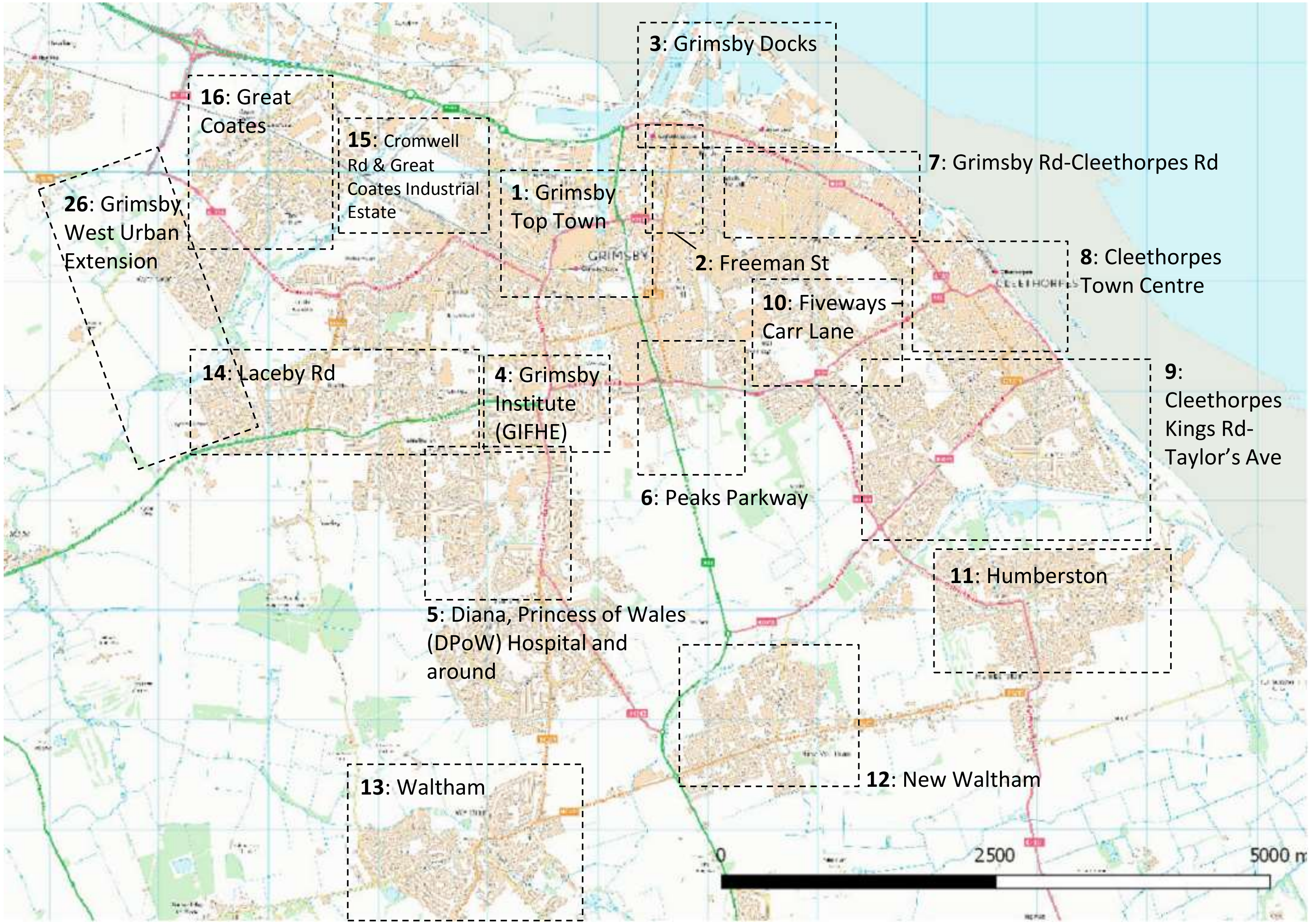


Figure 5-2: Indicative cluster boundaries (2 of 2)

Table 5-1: Cluster assessment against key characteristics

ID	Cluster	Existing heat demand	Potential anchor customers	Mix of users	New development	Heat sources	Constraints and dig	Land ownership	Site for energy centre
	Weighting factor	*3*	*3*	*2*	*2*	*1*	*1*	*1*	*1*
1	Grimsby Top Town	3	2	3	2	1	1	1	1
2	Freeman St	3	1	2	2	1	2	2	3
3	Grimsby Docks	1	2	1	1	1	2	2	2
4	Grimsby Institute and around	3	3	3	2	1	1	2	1
5	DPoW Hospital and around	3	3	3	2	1	2	2	1
6	Peaks Parkway	3	1	2	3	1	2	3	3
7	Grimsby Rd-Cleethorpes Rd	3	1	2	1	1	2	1	1
8	Cleethorpes Town Centre	3	2	2	2	1	1	1	1
9	Cleethorpes Kings Rd-Taylor's Ave	2	1	2	1	1	3	3	3
10	Old Clee	2	1	1	2	1	1	2	2
11	Humberston	2	1	1	1	1	3	2	2
12	New Waltham	1	1	1	1	1	3	2	2
13	Waltham	1	1	1	1	1	3	2	2
14	Laceby Rd	2	1	2	2	1	3	2	3
15	Cromwell Rd and Great Coates Industrial Estate	2	2	3	2	2	1	3	3
16	Great Coates	2	2	2	1	2	1	2	3
17	Europarc Enterprise Zones	2	2	2	3	3	3	3	3
18	Stallingborough Village	1	1	1	1	2	2	2	2
19	Stallingborough Enterprise Zone	1	2	2	3	3	3	3	3
20	Healing	1	1	1	1	2	3	2	2
21	South Humber Bank – Moody Lane	2	1	1	2	3	3	2	2
22	South Humber Bank – Hobson Way-Laporte Rd	2	1	1	2	3	3	2	2
23	Immingham Town	2	2	2	2	2	3	2	2
24	Immingham Port	2	1	1	1	2	3	2	2
25	Killingholme	2	1	1	1	3	3	2	2
26	Grimsby West Urban Extension	1	1	2	3	1	3	3	3

Table 5-2: Cluster assessment summary

ID	Cluster	Weighted score	ID	Cluster	Weighted score
5	Diana, Princess of Wales Hospital and around	34	22	South Humber Bank – Hobson Way/Laporte Rd	25
17	Europarc Enterprise Zones	34	21	South Humber Bank – Moody Lane	25
4	Grimsby Institute and around	33	9	Cleethorpes Kings Rd/Taylor's Ave	25
19	Stallingborough Enterprise Zone	31	25	Killingholme	23
15	Cromwell Road and Great Coates Industrial Estate	31	7	Grimsby Rd-Cleethorpes Rd	23
6	Peaks Parkway	31	24	Immingham Port	22
23	Immingham Town	29	11	Humberston	21
1	Grimsby Top Town	29	10	Fiveways – Carr Lane	21
2	Freeman St	28	3	Grimsby Docks	20
8	Cleethorpes Town Centre	27	20	Healing	19
26	Grimsby West Urban Extension	26	18	Stallingborough Village	18
16	Great Coates	26	13	Waltham	18
14	Laceby Rd	26	12	New Waltham	18

6 Scheme Options Appraisal

6.1 Technical and economic assessment approach

The technical and economic assessment has been undertaken for each of the five selected clusters. For each cluster, a series of scheme options have been specified in detail, differing in the extent of the network and the assumption of which customers connect to the scheme. In general terms, the scheme options progress from a ‘core scheme’ including a small number of anchor customers, to more extensive schemes incorporating a greater number of customers, often including smaller heat users and residential customers. At this stage it is assumed that all existing buildings served within each scheme connect from the outset. The extension of a ‘core scheme’ to a more extensive scheme over time should be considered during detailed feasibility. 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 2, 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 A.

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 with a 10% discount applied[14]; potential revenue from electricity sales for the case of Gas CHP, based on either on-site/private wire sale of electricity and/or grid export; potential revenue from the Renewable Heat Incentive, for the case of biomass, heat pumps and geothermal; and a developer connection charge (for new builds only) based on the lifetime value of CO_2 savings. Key assumptions used in the economic assessment, including all costs and revenues are provided in Appendix B. It is assumed that existing buildings connect to the heat network at the start, whereas new developments are phased in as they are completed. If existing buildings do not connect to the heat network at the start, the economics are worse as the revenues from heat and electricity sales are reduced but the capital cost of the network remains the same. It is therefore vital that all potential customers are encouraged to connect to the heat network from the outset; a relatively high discount of 10% is therefore applied to the heat sale price versus the counterfactual. Key assumptions used in the economic assessment are provided in Appendix B.

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[15], lifetime CO_2 emissions savings and the ‘funding gap’ to project viability.

A discussion of the potential delivery models for a heat network in NE Lincolnshire is provided in Section 7. Some of the potential delivery models include a key role for NELC in funding all or part of the upfront cost of the heat network. Discussions with NELC have suggested that a public sector-led scheme could be viable, and possibly preferred, in this case. In such a scenario, it has been suggested that NELC would seek a minimum IRR of approximately 6%, although this figure is only

[14] The counterfactual price of heat, expressed in p/kWh, is the price the customer would have paid for heat in the counterfactual case of no heat network. The price includes not only the unit fuel price but also the marginal standing charge, marginal annualised replacement cost, and marginal operating cost. See appendix B for worked examples of the heat sale price calculation.

[15] The lifetime cost of heat supply is the project NPV excluding heat sales (25 yrs at 6%) divided by the heat provided (also discounted at 6%)

indicative at this stage and would be determined on a case by case basis following detailed feasibility. For this reason, our economic assessment focuses on the funding gap (if any) for viability of a public sector-led delivery model. The relevant funding gap is determined as the NPV of the project using a 6% discount rate, where this is negative (where it is positive, there is no funding gap).

Where a funding gap at 6% is identified, we consider whether and what level of grant support under HNDU's Heat Network Investment Programme (HNIP) could be used to bridge the gap. In particular, we determine the funding gap (i.e. the required HNIP grant) in two cases:

- RHI is taken up (where available)
- RHI is not taken up

These two cases are studied because, under State Aid rules, the generation plant component of a heat network may not be supported both by the RHI and by capital support under HNIP. In the case that the RHI is taken up, only the network infrastructure component may be supported by HNIP funding, resulting in a lower maximum level of grant support. It may therefore need to be assessed on a case by case basis whether the most suitable business case results from taking up the RHI or not, once the implied allowable level of HNIP grant is included.

We also consider at a high level whether the required level of HNIP grant support could be available, or whether the required level of support is above the limit imposed by the HNIP rules. The terms of eligibility and available level of funding are described in the HNIP Guidance document[16].

In all cases, the required level of HNIP support is lower than the 'notification threshold' of £20m. The maximum level of support available for the generation plant component, as defined in the Guidance document, is therefore 45% of the difference between the capital cost of the proposed generation plant for the heat network, and the capital cost of the counterfactual plant. The maximum level of support for the network infrastructure component is 100% of the difference between the capital cost of the network and the lifetime operating profit expected for the network operator. As such, an absolute upper limit for the level of support available is 45% of the capital cost of the generation plant (i.e. assuming a negligible cost of counterfactual generation plant) plus 100% of the capital cost of the network infrastructure (i.e. assuming no operating profit for the network operator in the absence of HNIP support). We therefore present the level of HNIP support required to reach the 6% hurdle rate provided it is within this absolute upper limit. Where the required grant is greater than this upper limit, it is noted that a grant is not applicable and the project will not be viable. It is likely that any HNIP grant awarded will have to be spent by March 2021; this is compatible with all of the scheme options as modelled, since it is assumed for the purposes of this analysis that all generation and network infrastructure would be installed from the outset.

[16] https://www.salixfinance.co.uk/system/public_files/hnip_pilot_full_applicant_guidance_2.0.pdf (Accessed July 2017)

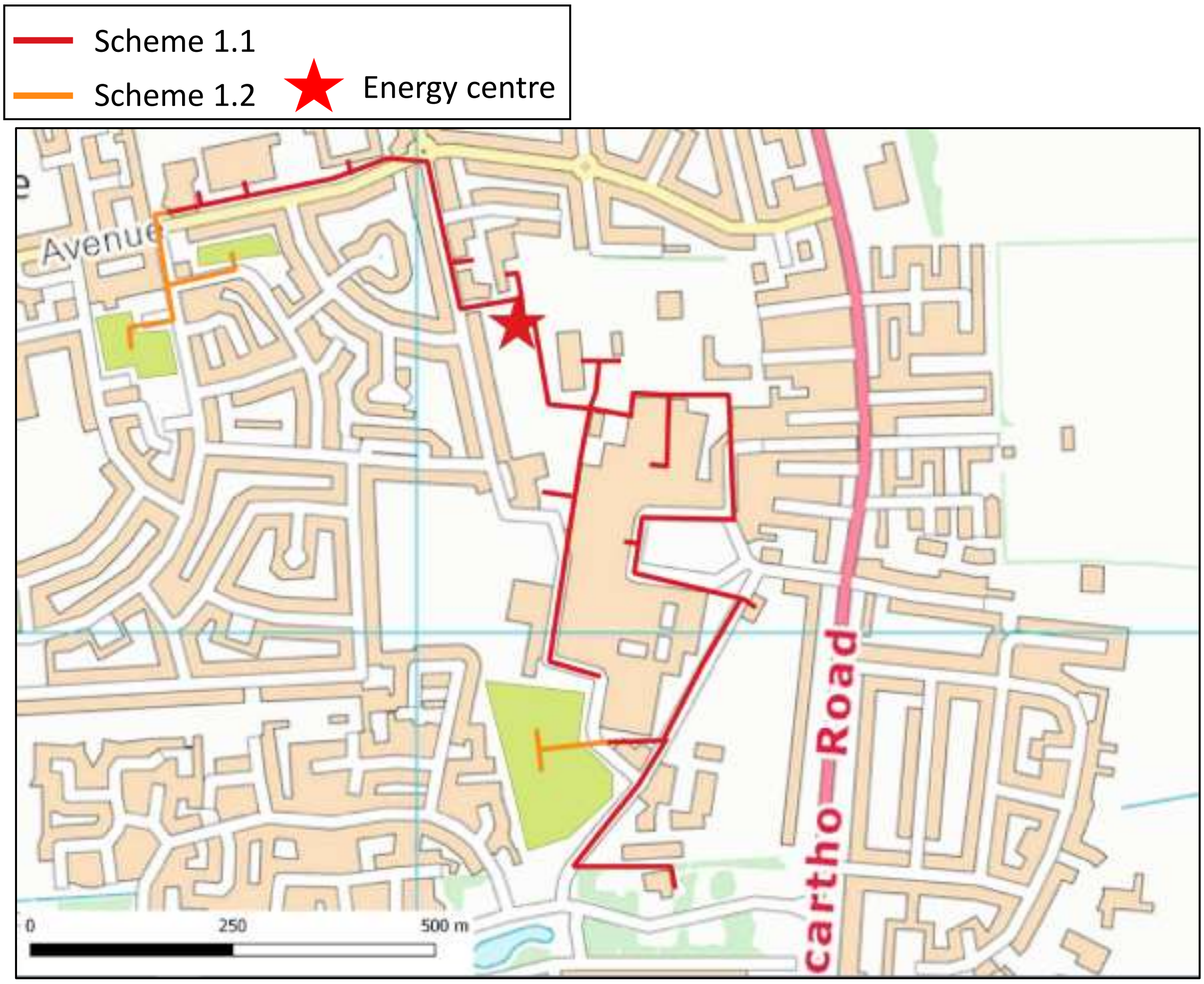
6.2 Technical and economic assessment results

6.2.1 Cluster 1 – DPoW Hospital and around

The network routes for the two scheme options considered for the DPoW Hospital cluster are presented in Figure 6-1, and the customers connected in each case are shown in Table 6-1. The hospital site itself forms the core of the scheme in both scheme options.

In S1.1, the network also serves a day nursery, a children's centre, several schools, 90 units of assisted housing, a care home and a student accommodation block. The extended scheme, S1.2, includes the new development expected surrounding the hospital, including residential units, staff accommodation, retirement and assisted living units. It is expected that the hospital could host the energy centre, as the majority of the heat generated would be used by the hospital site.

Figure 6-1: Scheme network routes for Cluster 1 – DPoW Hospital and around



The current energy service providers to the hospital, Centrica, have been engaged to understand the energy demand of the site, the nature of the incumbent heating system and the potential for a new heat network to serve the site. The hospital has recently installed a Gas CHP serving part of the site. This system was designed to provide the majority of the hospital's 800 kWe base electricity load. The CHP also provides approximately 500 kW of useful heating, and operates almost continuously for around 95% of the year. However, the annual average heat demand for the hospital site is 2.4 MW.

The remaining 1.9 MW of heating demand not met by the CHP unit is provided by gas boilers. There is therefore the potential for a new heat network to serve the remaining 1.9 MW of heating demand currently met by gas boilers.

An important constraint for a heat network at the hospital site is that the heating system is currently based on steam distribution. As such, a heat pump or geothermal-based system is unlikely to be suitable at the site, as it would not be able to reach the high temperatures required. Centrica have advised that de-rating the system to low temperature hot water (LTHW) was considered recently, but this was not found to be economically viable. Therefore, the heat supply options studied for this cluster include a further Gas CHP unit, and a Biomass boiler system.

A further consequence of the existing Gas CHP facility is that there is limited remaining potential for electricity generated on-site to be used on-site. The hospital has an annual average of 1,060 kWe electricity demand, of which only around 260 kWe is not already met by the existing CHP. Therefore, the majority of the electricity generated by a new Gas CHP plant feeding a heat network would likely need to be exported to the grid. This would generate a lower revenue than on-site consumption, and so will have an adverse impact on the project economics.

Table 6-1: Scheme customers in Cluster 1 – DPoW Hospital and around

Customer	S1.1	S1.2
Diana, Princess of Wales (DPoW) Hospital	✓	✓
Day Nursery	✓	✓
Nunsthorpe and Bradley Park Children's Centre	✓	✓
Oasis Academy Nunsthorpe	✓	✓
Assisted housing (90 resi units)	✓	✓
Nunsthorpe Community School	✓	✓
The Orchard – Grimsby Manor care home (94 resi units)	✓	✓
Scartho Hall student accommodation (35 resi units)	✓	✓
Sevenhills Academy	✓	✓
Scartho Top/Second Avenue (19 resi units)		✓
Hospital site (233 resi units)		✓
Sutcliffe/Second Avenue (100 resi units)		✓
Winchester Avenue (60 resi units)		✓

A summary of the technical assessment for the DPoW cluster is shown in Table 6-2. The hospital makes up the majority of the heat demand in each case (note that we only include the heat demand for the part of the hospital not being served by the existing Gas CHP), with the total heat demand 19.4 GWh/yr for S1.1 and 20.9 GWh/yr for S1.2. The primary heating plant (Gas CHP or Biomass boiler) is sized at 2.8 MW in each case. The total network length, including the main distribution network and the service pipe serving individual buildings, is 3.9 km in the case of S1.1, and 8.7 km in the case of

S1.2 (we do not consider connecting to a waste heat source, as the nearest known source is 8.7 km away). The linear heat density is found to be 5.0 GWh/yr/km for S1.1, and 2.4 GWh/yr/km for S1.2.

Table 6-2: Summary of technical assessment for Cluster 1 – DPoW Hospital and around

		Unit	S1.1	S1.2
Annual heat demand at full build-out	Domestic	GWh/yr	0.3	1.9
	Non-domestic		19.1	19.1
	Total		19.4	20.9
Peak heat demand	Total	MW	7.0	7.6
Number of connections	Domestic	#	219	631
	Non-domestic	#	12	12
	Total	#	231	643
Heat supply capacity	Main supply	MW	2.8	2.8
	Auxiliary boilers		7.7	8.5
Network route length	Distribution	km	3.6	6.3
	Service		0.3	2.4
	Distance to closest source of waste heat		8.7	8.7
Network temperature	Network flow/return temperature	ºC	120/70	
	Network delta T		30	
Linear heat density		GWh/yr/km	5.0	2.4

As described above, the high temperature steam distribution system means that heat pumps and geothermal are not suitable for the heat supply for this scheme. The nearest known source of waste heat is more than 8 km away, so this is not considered a viable option for this cluster. The scheme options considered for the DPoW cluster are:

- S1.1 with Gas CHP
- S1.1 with Biomass boiler
- S1.2 with Gas CHP
- S1.2 with Biomass boiler

The results of the economic assessment are presented below. Figure 6-2 presents the capital cost of each scheme option. This ranges from £5.8m to £10.2m, with the network representing a majority of the cost in each case.

The project IRR is presented in Figure 6-3, and the NPV at 6% discount rate in Figure 6-4. In the figures shown, revenue from the RHI is included for the Biomass case. It can be seen that the NPV is negative for all scheme options, with only S1.1 with Gas CHP providing a positive IRR, which is very low at 0.2%.

Figure 6-5 presents the breakdown of the NPV into various cost and revenue components. In the case of Gas CHP, a key reason for the poor economic performance is the high fraction of electricity generated which is exported to the grid (for the reasons described above), assumed to be 80%. This attracts a lower value than on-site consumption, and has a large impact on project economic viability. In the case of Biomass boilers, the RHI tariff is not found to be sufficient to offset the cost, particularly, of the fuel and the network. Large (>1MW) biomass systems currently attract a relatively low tariff of 2.1 p/kWh, which is significantly lower than the typical biomass fuel price assumed of 4.0 p/kWh.

Figure 6-2: Capital cost of scheme options for Cluster 1 – DPoW Hospital and around

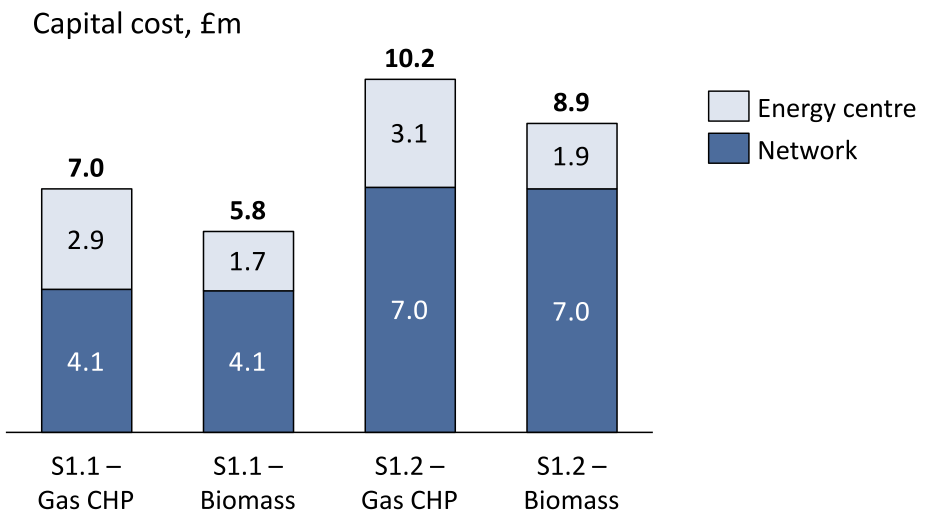


Figure 6-3: IRR summary for Cluster 1 – DPoW Hospital and around

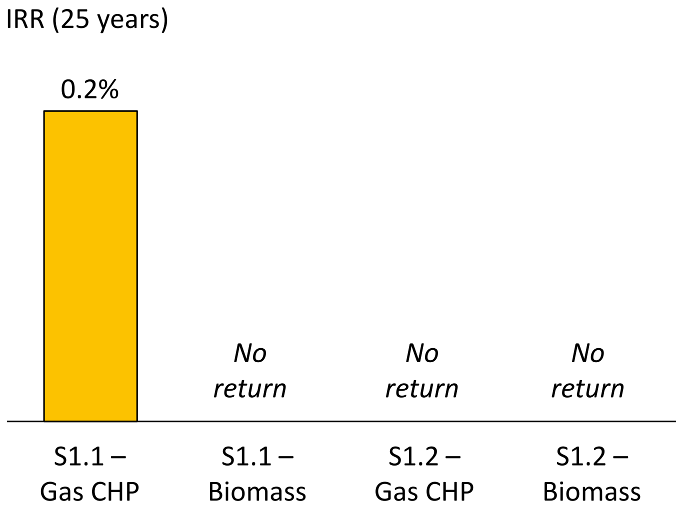


Figure 6-4: Net present value summary for Cluster 1 – DPoW Hospital and around

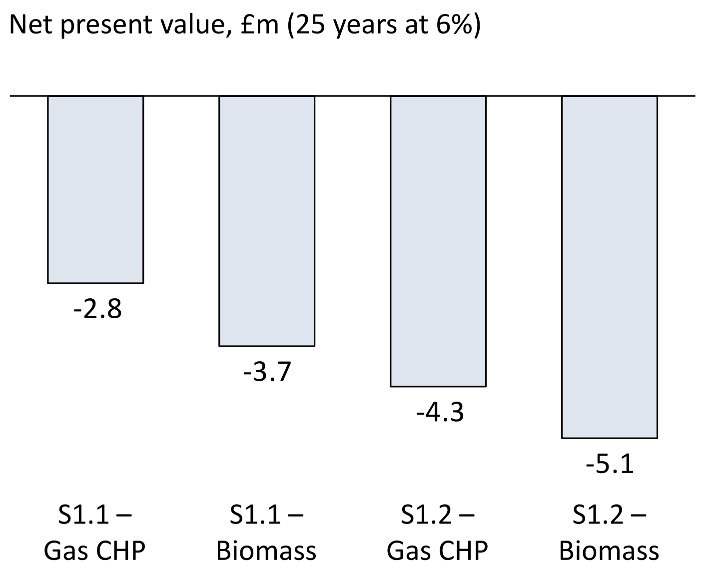
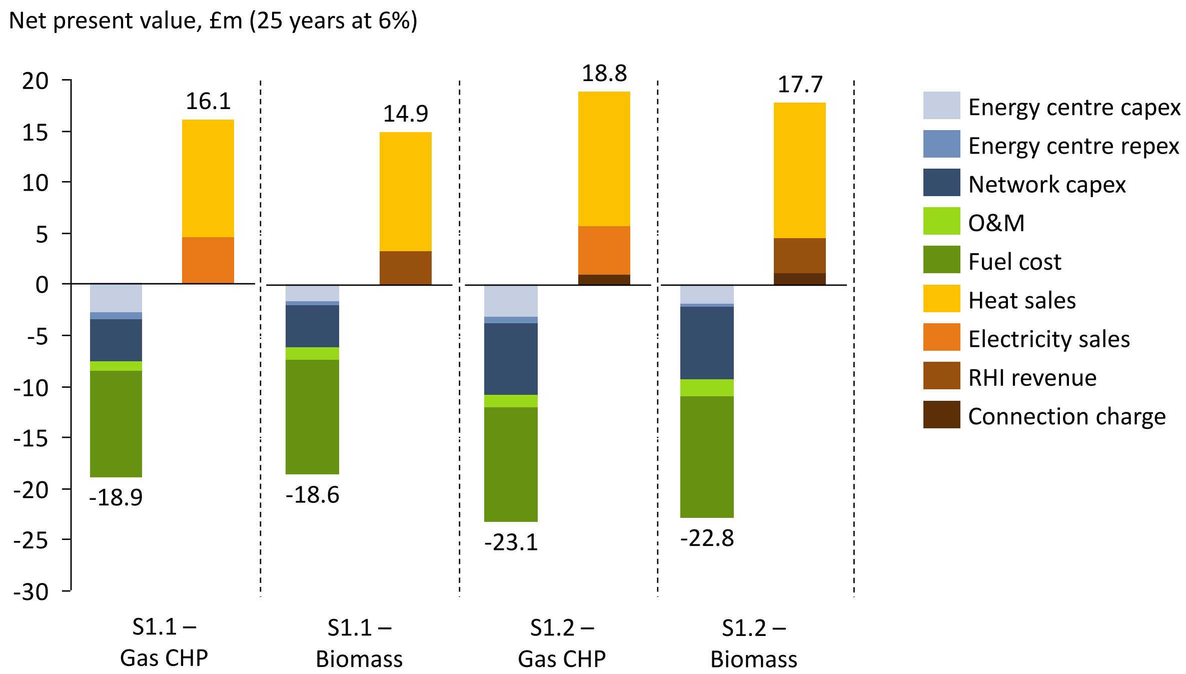


Figure 6-5: Cost and revenue components for Cluster 1 – DPoW Hospital and around



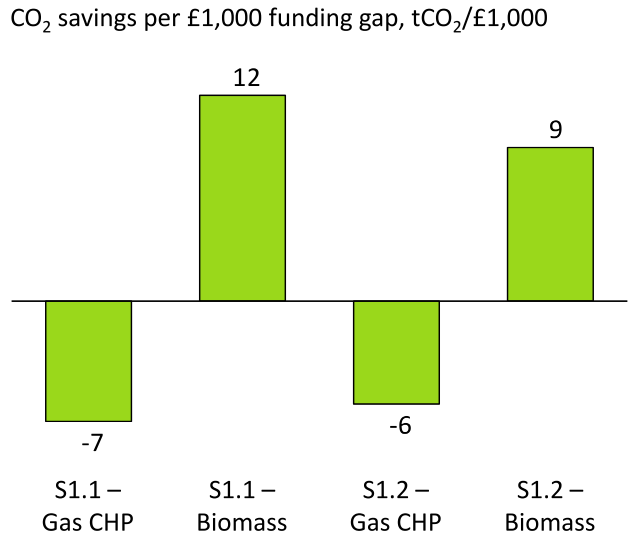
A summary of the economic assessment for the DPoW cluster is shown in Table 6-3. The CO_2 savings over the 20-year lifetime of the heating plant are shown for each scheme option. For Gas CHP, as explained in Section 3.3, the lifetime CO_2 savings are found to be negative (i.e. increase CO_2 emissions versus the counterfactual of gas boilers). For the Biomass boiler schemes, lifetime CO_2 savings are substantial, at 46-48 $ktCO_2$.

As described in Section 6.1, the minimum required HNIP grant to achieve NELC's typical hurdle rate of 6% has been determined, and the carbon savings value for money calculated. The Biomass boiler schemes would require a minimum grant of £3.7m and £5.1m for S1.1 and S1.2 respectively, and would lead to CO_2 savings of 12 tCO_2 per £1,000 grant and 9 tCO_2 per £1,000 grant respectively.

Table 6-3: Summary of economic assessment for Cluster 1 – DPoW Hospital and around

Scheme	Capital cost, £m	NPV, £m (25 yrs at 6%)	IRR (25 years)	NPV, £m (40 yrs at 6%)	IRR (40 years)	Lifetime cost of heat supply, p/kWh	Funding gap at 6%, £m	Funding gap at 6% excluding RHI, £m	Minimum HNIP grant to achieve 6% IRR	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	CO_2 savings per £1,000 HNIP grant, tCO_2/£1,000
S1.1 – Gas CHP	7.0	-2.8	0.2%	-2.0	3.4%	5.8	2.8	2.8	2.8	-21	-7
S1.1 – Biomass	5.8	-3.7	N/A	-3.2	1.3%	6.2	3.7	7.0	3.7	46	12
S1.2 – Gas CHP	10.2	-4.3	N/A	-3.3	2.8%	6.7	4.3	4.3	4.3	-25	-6
S1.2 – Biomass	8.9	-5.1	N/A	-4.3	1.7%	7.0	5.1	8.6	5.1	48	9

Figure 6-6: Carbon savings value for money for Cluster 1 – DPoW Hospital and around



6.2.2 Cluster 2 – GIFHE and around

The network routes for the three scheme options considered for the Grimsby Institute (GIFHE) cluster are presented in Figure 6-7, and the customers connected in each case are shown in Table 6-4.

The core scheme, S2.1, includes GIFHE, two schools, a sixth form college and a day nursery. The first extended scheme, S2.2, includes two further schools, 154 existing residential units and approximately 450 residential units expected to form part of several new developments. The largest scheme, S1.3, also incorporates 644 existing residential units, which are relatively low density semi-detached and terraced properties. There are several options for the energy centre location, including on the site of GIFHE. The location shown in Figure 6-7 corresponds to a largely undeveloped area of Council adopted land.

Figure 6-7: Scheme network routes for Cluster 2 – GIFHE and around

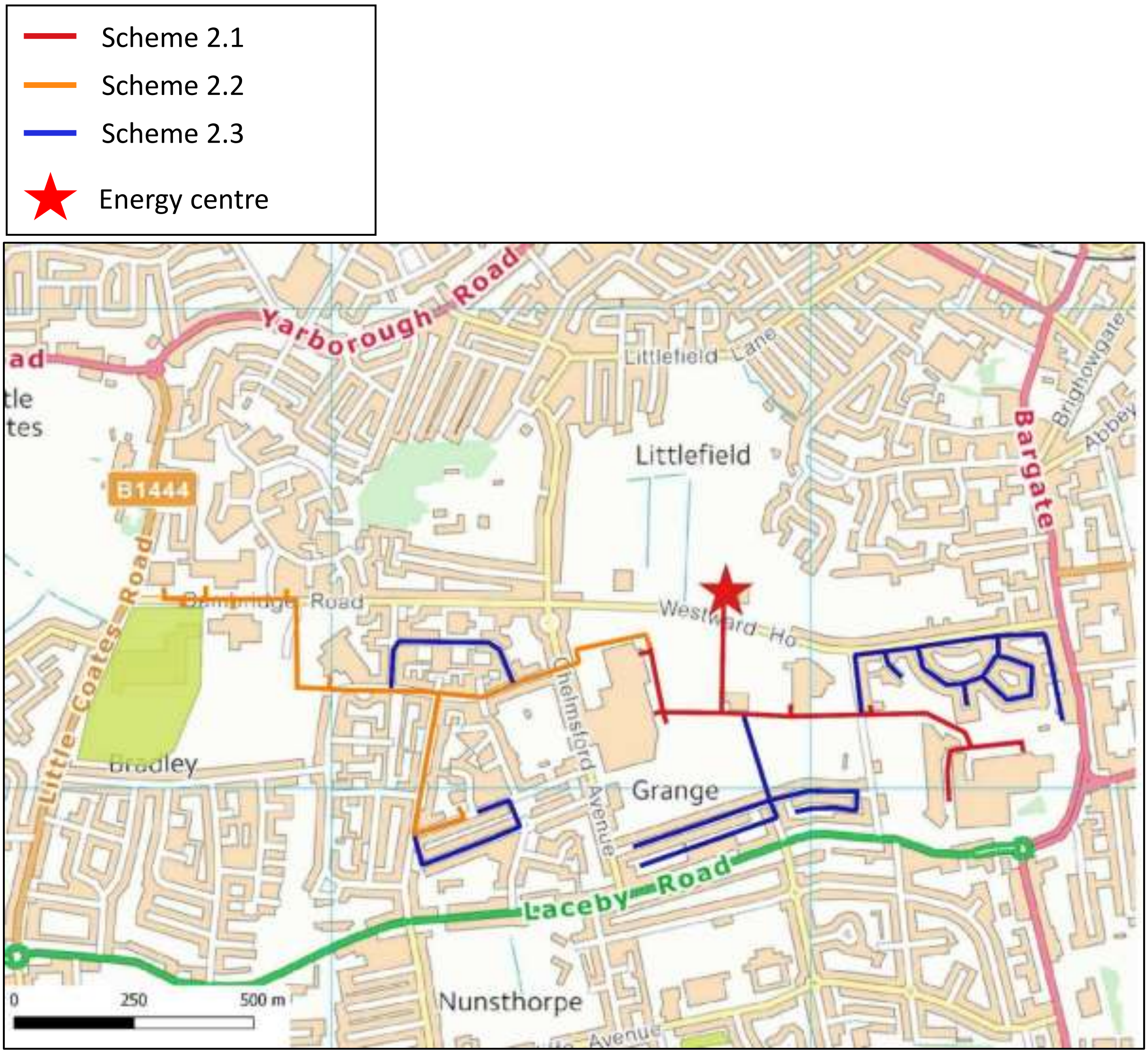


Table 6-4: Scheme customers in Cluster 2 – GIFHE and around

Customer	S2.1	S2.2	S2.3
Grimsby Institute for Further and Higher Education (GIFHE)	✓	✓	✓
Franklin College	✓	✓	✓
The Academy Grimsby	✓	✓	✓
Ormiston Maritime Academy	✓	✓	✓
Little Stars Nursery	✓	✓	✓
Grange Primary School		✓	✓
The Cambridge Park Academy		✓	✓
Fairways Care Home (50 resi units)		✓	✓
Masonic Hall House (104 resi units)		✓	✓
Cherry Blossom Court (32 resi units)		✓	✓
Former Western School site (425 resi units, 3 non-resi)		✓	✓
Existing residential (644 houses)			✓

A summary of the technical assessment for the GIFHE cluster is shown in Table 6-5.

The core scheme S2.1 serves 5.9 GWh/yr heat demand, rising to 8.9 GWh/yr in S2.2 and 15.2 GWh/yr in S2.3. The network length, including the main distribution network and the service pipe serving individual buildings, is found to be 2.0 km in the case of S2.1, rising to 7.5 km for S2.2 and 14.8 km in S2.3. The larger network length for S2.2 and S2.3 are a result of the addition of relatively low density residential customers. In line with this, the linear heat density of the scheme falls from 2.9 GWh/yr/km for S2.1, to 1.2 GWh/yr/km for S2.2 and 1.0 GWh/yr/km for S2.3.

No high temperature steam distribution systems have been identified in the GIFHE cluster. As such, and given that low carbon sources are of greatest interest, we focus primarily in this cluster on scheme options supplied by WSHPs. Biomass is not considered desirable for this area given the prevalence of residential and educational buildings and the corresponding environmental impacts (mainly noise and air quality), and the unsuitability of the residential roads for HGV movements. The greenfield area indicated as a possible energy centre location is sufficiently large that a borehole array for a WSHP could be sited there, if the groundwater there were found suitable for abstraction (this would need to be considered in more detail at detailed feasibility stage). Similarly to the DPoW cluster, the nearest known source of waste heat is approximately 8 km away, and so this is not considered a viable option for this cluster. Gas CHP is also studied as an alternative heat supply option.

The scheme options considered for the GIFHE cluster are:

- S2.1 with WSHP
- S2.2 with WSHP
- S2.2 with Gas CHP
- S2.3 with WSHP

Table 6-5: Summary of technical assessment for Cluster 2 – GIFHE and around

		Unit	S2.1	S2.2	S2.3
Annual heat demand at full build-out	Domestic	GWh/yr	-	1.9	8.1
	Non-domestic		5.9	7.0	7.1
	Total		5.9	8.9	15.2
Peak heat demand	Total	MW	2.4	3.3	6.0
Number of connections	Domestic	#	-	428	1,072
	Non-domestic	#	5	11	13
	Total	#	5	439	1,085
Heat supply capacity	Main supply	MW	1.5	2.4	4.1
	Auxiliary boilers		2.6	3.9	7.7
Network route length	Distribution	km	1.9	6.2	10.3
	Service		0.1	1.3	4.5
	Distance to closest source of waste heat		7.7	7.7	7.7
Network temperature	Network flow/return temperature	ºC		80/50	
	Network delta T			30	
Linear heat density		GWh/yr/km	2.9	1.2	1.0

The results of the economic assessment are presented below. Figure 6-8 presents the capital cost of each scheme option. This ranges from £3.0m for the core scheme S2.1 to £17.1m for the largest scheme S2.3 with WSHP. The network contributes around half of the total capital cost for S1.1, but more than two-thirds of the cost for the other scheme options. The WSHP carries a higher capital cost than the Gas CHP system for S2.2, at £2.6m as compared with £1.7m.

The project IRR is presented in Figure 6-9, and the NPV at 6% discount rate in Figure 6-10. In the figures shown, revenue from the RHI is included for the WSHP case. It can be seen that the NPV is negative in all cases, consistent with the fact that the IRR is below 6% for each scheme option. The highest IRR is achieved for S2.1 with WSHP, at 3.4%. Positive returns of 1.7% and 2.4% are achieved for WSHP and Gas CHP respectively for S2.2, which includes two additional schools and around 600 residential units, the majority of which will form part of a new development. S1.3 with WSHP does not achieve a positive return.

Figure 6-8: Capital cost of scheme options for Cluster 2 – GIFHE and around

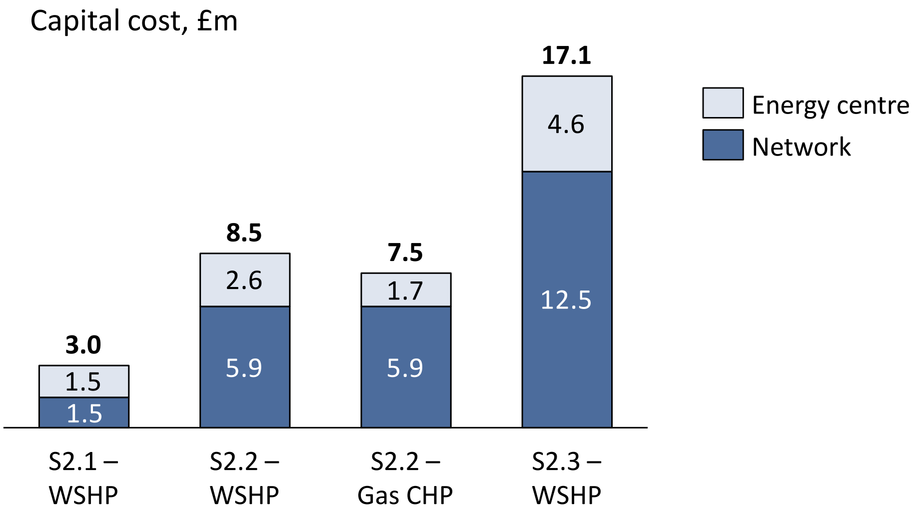


Figure 6-9: IRR summary for Cluster 2 – GIFHE and around

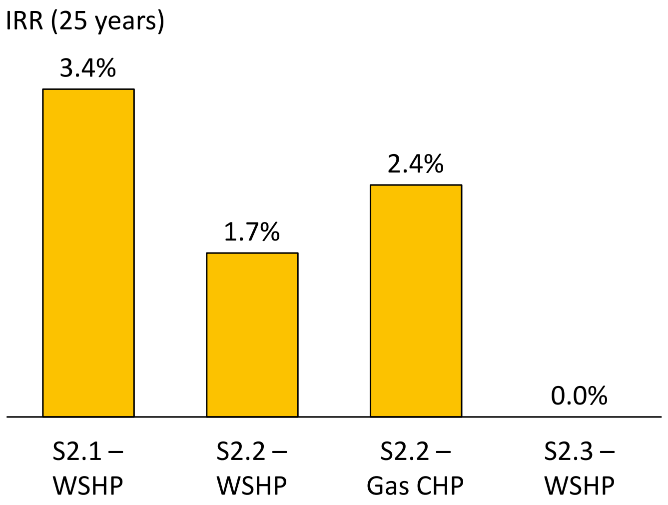


Figure 6-10: Net present value summary for Cluster 2 – GIFHE and around

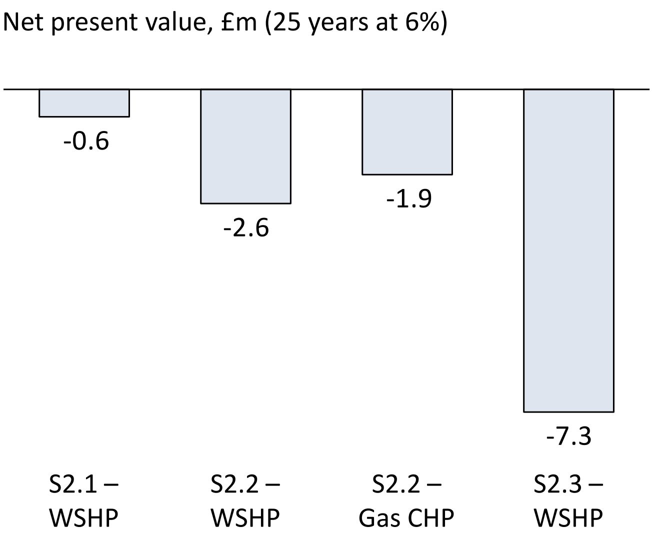


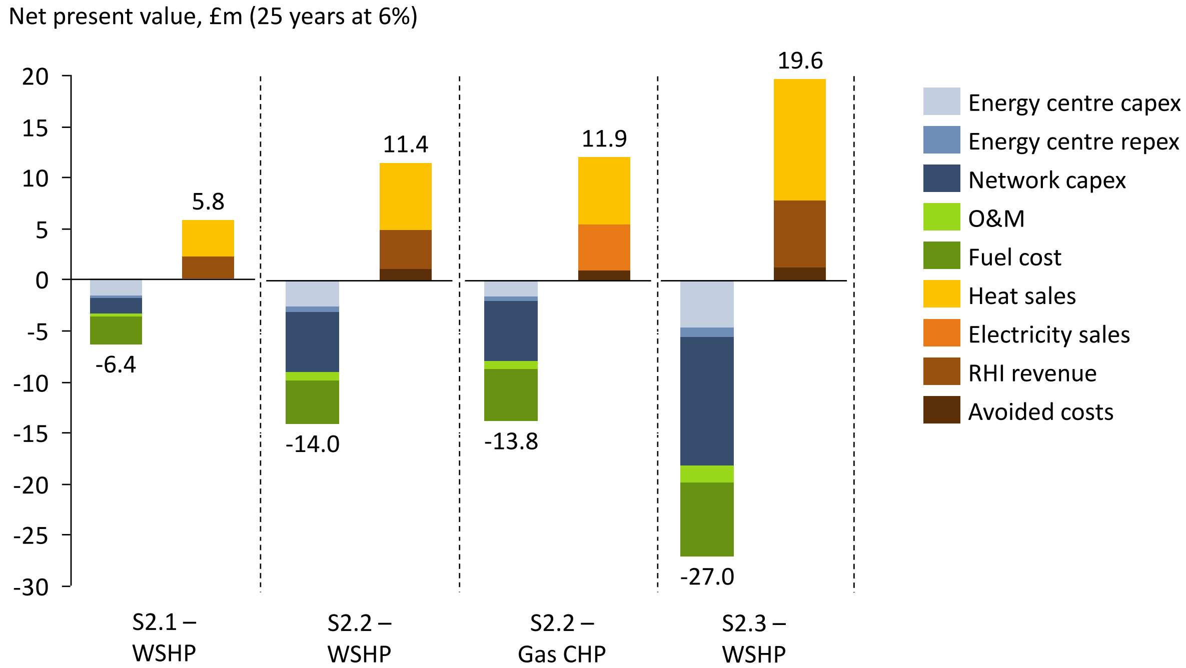
Figure 6-11 presents the breakdown of the NPV into various cost and revenue components. It can be seen that in S2.1, which achieves the highest IRR in this cluster, the share of the costs associated with the network capex is smaller than for the other scheme options. This reflects the higher linear heat density of S2.1, meaning that a smaller length of network can be built for every unit of heat supplied.

The second highest IRR in this cluster is achieved by S2.2 with Gas CHP. The S2.2 Gas CHP scheme performs significantly better than the S1.2 Gas CHP scheme for the DPoW cluster despite the lower linear heat density of S2.2, largely as a result of the higher electricity price available to the developer. In this case (and unlike for the DPoW case) it is expected that the majority of the electricity generated can be used on-site, rather than exported to the grid, generating a substantially higher value.

Scheme S2.2 with WSHP carries a slightly lower IRR and NPV than the corresponding Gas CHP scheme. This is due to the balance of various components of the NPV. The WSHP has lower fuel costs due to the higher fuel efficiency, and an additional revenue stream from the RHI; however, the Gas CHP has a slightly lower energy centre capital cost and an additional revenue stream from the electricity sales. These components almost balance, but result in a slightly higher value for the Gas CHP case.

Figure 6-11 also indicates the reason for the absence of a positive return for S2.3 with WSHP. It can be seen that the increase in the network capex versus the other schemes in this cluster is not offset by the increase in revenue from heat sales and RHI payments, and the total NPV is substantially more negative.

Figure 6-11: Cost and revenue components for Cluster 2 – GIFHE and around



A summary of the economic assessment for the GIFHE cluster is shown in Table 6-6. The CO_2 savings over the 20-year lifetime of the heating plant are also shown for each scheme option. For the WSHP schemes, lifetime CO_2 savings range from 12 $ktCO_2$ for S2.1 to 29 $ktCO_2$ for S2.2. Lifetime CO_2 savings for S2.2 with Gas CHP are negative relative to the gas boiler counterfactual, at -18 $ktCO_2$.

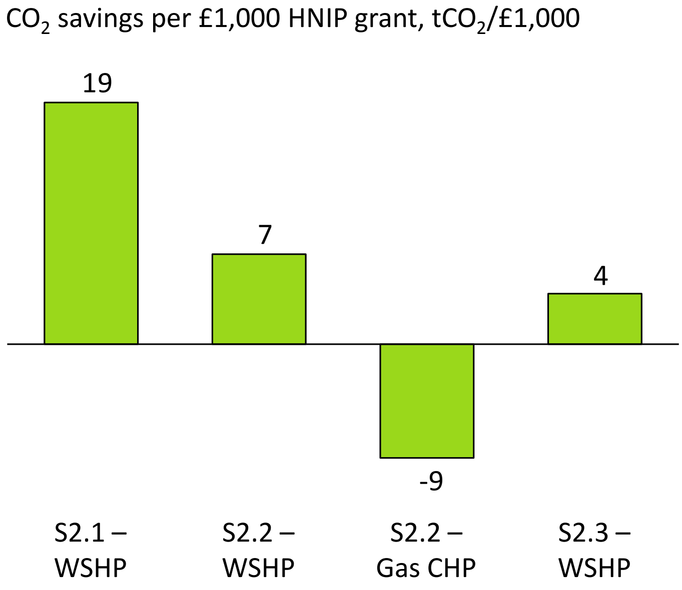
The minimum required HNIP grant to achieve NELC's indicative hurdle rate of 6% has been determined for each scheme. This is found as £0.6m for S2.1 with WSHP and £2.6m for S2.2 with

WSHP. In terms of carbon savings value for money, this represents 19 tCO_2 per £1,000 grant for S2.1 and 7 tCO_2 per £1,000 grant for S2.2. Scheme S2.3 with WSHP, which was found to be significantly less cost-effective than the other scheme options, is found to require a minimum grant of £7.3m, representing a lower value of carbon savings of 4 tCO_2 per £1,000 grant.

Table 6-6: Summary of economic assessment for Cluster 2 – GIFHE and around

Scheme	Capital cost, £m	NPV, £m (25 yrs at 6%)	IRR (25 years)	NPV, £m (40 yrs at 6%)	IRR (40 years)	Lifetime cost of heat supply, p/kWh	Funding gap at 6%, £m	Funding gap at 6% excluding RHI, £m	Minimum HNIP grant to achieve 6% IRR	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	CO_2 savings per £1,000 HNIP grant, tCO_2/£1,000
S2.1 – WSHP	3.0	-0.6	3.4%	-0.1	5.6%	5.5	0.6	2.8	0.6	12	19
S2.2 – WSHP	8.5	-2.6	1.7%	-1.5	4.4%	8.0	2.6	6.4	2.6	18	7
S2.2 – Gas CHP	7.5	-1.9	2.4%	-1.0	4.6%	7.5	1.9	1.9	1.9	-18	-9
S2.3 – WSHP	17.1	-7.3	0.0%	-5.5	3.1%	9.9	7.3	13.9	7.3	29	4

Figure 6-12: Carbon savings value for money for Cluster 2 – GIFHE and around

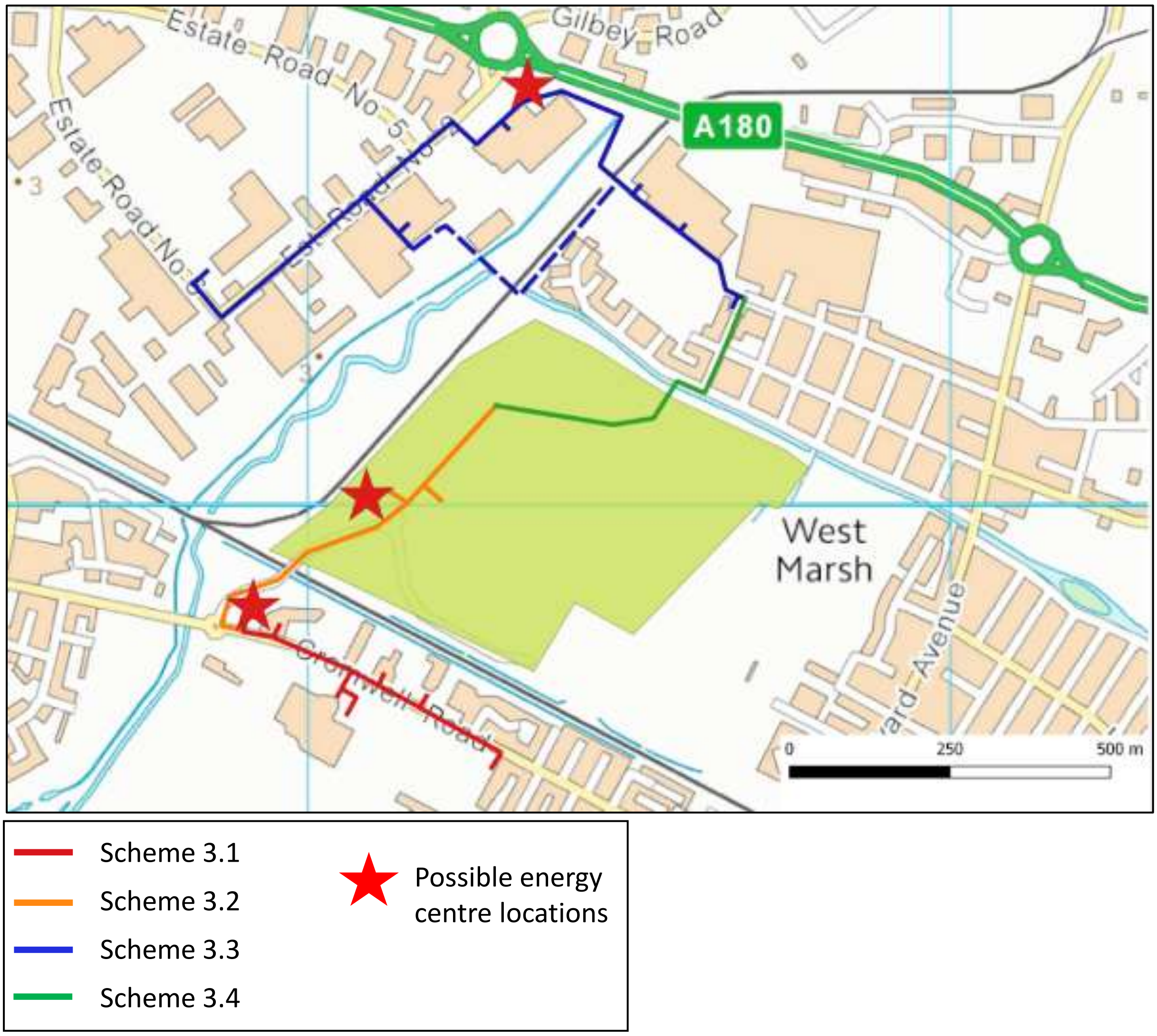


6.2.3 Cluster 3 – Cromwell Rd and Great Coates Industrial Estate

Figure 6-13 presents the network routes for the four scheme options considered for the Cromwell Rd and Great Coates Industrial Estate cluster, and the customers connected in each case are shown in Table 6-7.

The railway lines and River Freshney present significant constraints in this cluster. We have therefore considered two separate core schemes for the cluster, as well as a scheme option which combine these by crossing the railways and river, likely at the locations indicated on the map.

Figure 6-13: Scheme network routes for Cluster 3 – Cromwell Rd



The first core scheme, S3.1, incorporates the range of public sector buildings on Cromwell Rd, southwest of one of the railway lines. This includes the Grimsby swimming pool and leisure centre, a primary care centre and several other customers. Scheme S3.2 extends S3.1 across one of the railway lines to incorporate a significant development site of approximately 250 new residential units. For these schemes, potential energy centre locations include the Council adopted land off Cromwell Rd or on the new development site.

The second core scheme, S3.3, is comprised of four large coldstore and seafood manufacturing facilities, three west and one east of the Freshney and the railway, and a primary school. This core scheme entails a railway and river crossing, but two opportunities have been identified at Gilbey Rd pedestrian and cycle bridge, and the railway bridge crossing the Freshney. The final scheme option, S3.4, combines all these customers into a single scheme.

Table 6-7: Scheme customers in Cluster 3 – Cromwell Rd

Customer	S3.1	S3.2	S3.3	S3.4
Grimsby Swimming pool - New	✓	✓		✓
Grimsby Leisure Centre	✓	✓		✓
Grimsby Auditorium	✓	✓		✓
Cromwell Road Fire and Rescue Service	✓	✓		✓
Local Police Team Base	✓	✓		✓
Resource Centre	✓	✓		✓
Private Care Centre	✓	✓		✓
Land off Macaulay Street Grimsby (250 resi units)		✓		✓
HSH and SAL - Coldstores			✓	✓
ACS & T - Coldstores			✓	✓
DFDS - Coldstores			✓	✓
Icelandic Seachill - Coldstores			✓	✓
Littlecoates Primary Academy			✓	✓

A summary of the technical assessment for the Cromwell Rd and Great Coates Industrial Estate cluster is shown in Table 6-8. The Cromwell Rd core scheme S3.1 serves an annual heat demand of 4.0 GWh/yr, and including the new residential development in S3.2 increases this to 5.0 GWh/yr. The Great Coates Industrial Estate core scheme S3.3 serves 14.5 GWh/yr of heat demand, largely supplying absorption chillers for the large coldstores, as well as the primary school heating demand. The combined scheme S3.4 serves a total of 19.5 GWh/yr. The peak heat demand ranges from 2.0 MW for S3.1 to 10.9 MW for S3.4.

The network lengths for the core scheme S3.1 is 1.1 km, increasing to 3.1 km when the new residential development is connected in S3.2. The second core scheme S3.3 has a network length of 2.1 km. The length of the whole network supplying all customers in S3.4 is 6.2 km. The linear heat density ranges from 1.7 GWh/yr/km for S3.2 to 7.0 GWh/yr/km for S3.3, and is 3.2 GWh/yr/km for the entire scheme S3.4.

The nature of this cluster is that a wide range of technologies could be suitable for heat provision. The nearest known source of waste heat is below 6 km away; the viability of waste heat as an option is therefore considered. It is expected that a WSHP could also be suitable for the site, given that moderate to low delivery temperatures would be sufficient to supply the key anchor customers including the leisure centre, the coldstores and the new residential development. Furthermore, there are several nearby greenfield areas that could be suitable for a groundwater borehole array (the Freshney is another potential source that could be considered, but this is not expected to have sufficient heat capacity). Biomass-based heat supply is also a more viable option in the case that the energy centre is located in the industrial area of Great Coates Industrial Estate. We also consider high temperature and low temperature deep geothermal, as well as Gas CHP, as potential heat supply options.

Table 6-8: Summary of technical assessment for Cluster 3 – Cromwell Rd

		Unit	S3.1	S3.2	S3.3	S3.4
Annual heat demand at full build-out	Domestic	GWh/yr	-	1.0	-	1.0
	Non-domestic		4.0	4.0	14.5	18.6
	Total		4.0	5.0	14.5	19.5
Peak heat demand	Total	MW	2.0	2.2	8.7	10.9
Number of connections	Domestic	#	0	250	0	250
	Non-domestic	#	7	7	5	12
	Total	#	7	257	5	262
Heat supply capacity	Main supply	MW	0.6	0.7	2.9	3.2
	Auxiliary boilers		2.1	2.5	9.3	12.5
Network route length	Distribution	km	0.9	2.9	2.0	5.9
	Service		0.2	0.2	0.1	0.3
	Distance to closest source of waste heat		5.9	5.9	5.7	5.7
Network temperature	Network flow/return temperature	ºC	80/50			
	Network delta T		30			
Linear heat density		GWh/yr/km	3.6	1.7	7.0	3.2

The scheme options considered for the cluster are:

- S3.1 with WSHP
- S3.2 with WSHP
- S3.3 with WSHP
- S3.4 with WSHP
- S3.4 with Gas CHP
- S3.4 with Biomass boiler
- S3.4 with Low T geothermal
- S3.4 with High T geothermal
- S3.4 with Waste heat

The results of the economic assessment are presented below. Figure 6-14 presents the capital cost of each scheme option. For the schemes based on WSHP, the capital cost ranges from £1.9m for S3.1 to £13.0m for S3.4, reflecting both the larger energy centre and more extensive network required. For the various heat supply options for S3.4, the capital cost ranges from £9.7m for Biomass boilers, £11.5m for Gas CHP, £13.0m for WSHP, £16.7m for Waste heat (for the assumption of a 5.9 km connection to the waste heat source) to £20.1m for low T and high T Geothermal.

The 25-year project IRR is presented in Figure 6-15, and the 25-year NPV at 6% is presented in Figure 6-16. All scheme options studied have a negative NPV at 6%, and hence achieve an IRR below 6%. The four schemes based on WSHP achieve a positive IRR, with the highest return for S3.1 at 4.1%, returns of 2.7% and 3.6% for S3.2 and S3.3 respectively, and 0.9% for S3.4. The other heat supply technologies do not achieve a positive IRR when serving S3.4.

Figure 6-17 and Figure 6-18 show the breakdown of the NPV for various cost and revenue components. For the four scheme options served by WSHP, the main variation relates to the network capital cost relative to the heat sales. A comparison of the different heat supply options for S3.4 shows that the Gas CHP scheme option has an only slightly lower overall NPV than the WSHP. The trend between these two technologies is reversed from the case for S2.2 in the GIFHE cluster; this is due to a lower assumed fraction of on-site consumption of electricity demand for S3.4. This is mainly attributable to the imbalance of heat and electricity demand for the coldstores; if the storage cooling demand was served using heat (via absorption chillers), the remaining electricity would be substantially smaller than the heat demand. In the case of CHP, this means that the demand for heat and electricity generated is likely to be imbalanced, leading to a surplus of electricity which would need to be exported to the grid. This results in a lower overall value of electricity sales.

The geothermal cases result in a large negative NPV, due mainly to the high capital cost of the deep borehole, combined with the heat pump required in both the low T and high T cases (in neither case is the temperature expected to be sufficient to supply all customers on the network).

The lifetime cost for the Waste heat option is dominated by the cost of the network infrastructure, largely relating to the assumed 5.9 km connection to the waste heat source. An important caveat here is that, should a new Energy-from-Waste facility be constructed closer to this cluster – which is a feasible outcome – the NPV of this option could be much improved. This option should therefore be kept under review should a new heat source be planned within several km of the site.

Figure 6-14: Capital cost of scheme options for Cluster 3 – Cromwell Rd

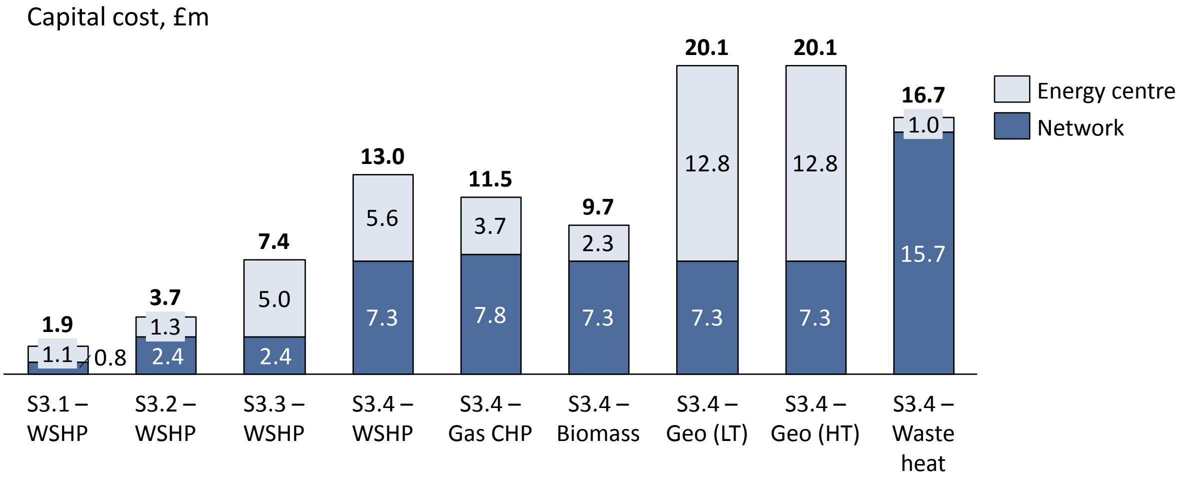


Figure 6-15: IRR summary for Cluster 3 – Cromwell Rd

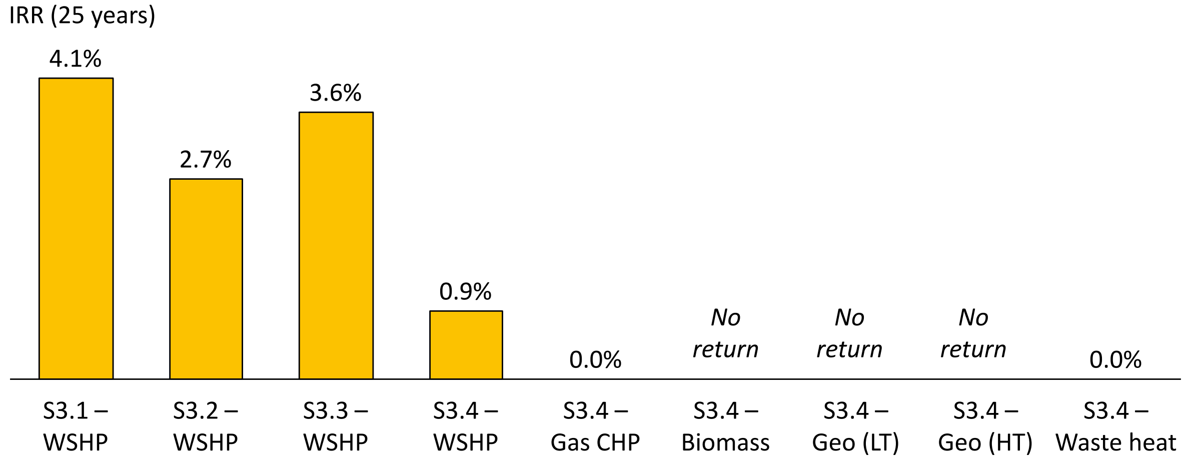


Figure 6-16: Net present value summary for Cluster 3 – Cromwell Rd

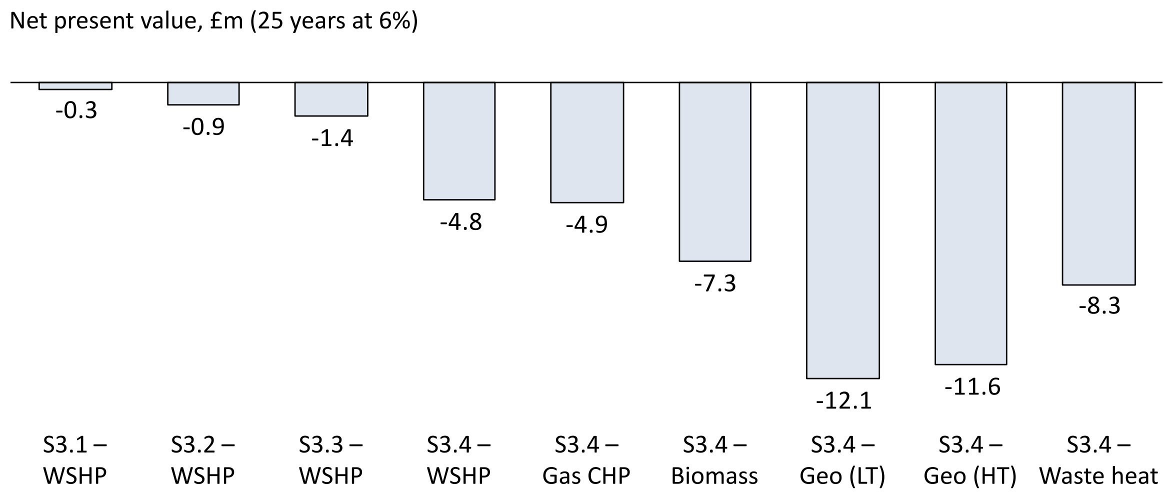


Figure 6-17: Cost and revenue components for Cluster 3 – Cromwell Rd (schemes using WSHP)

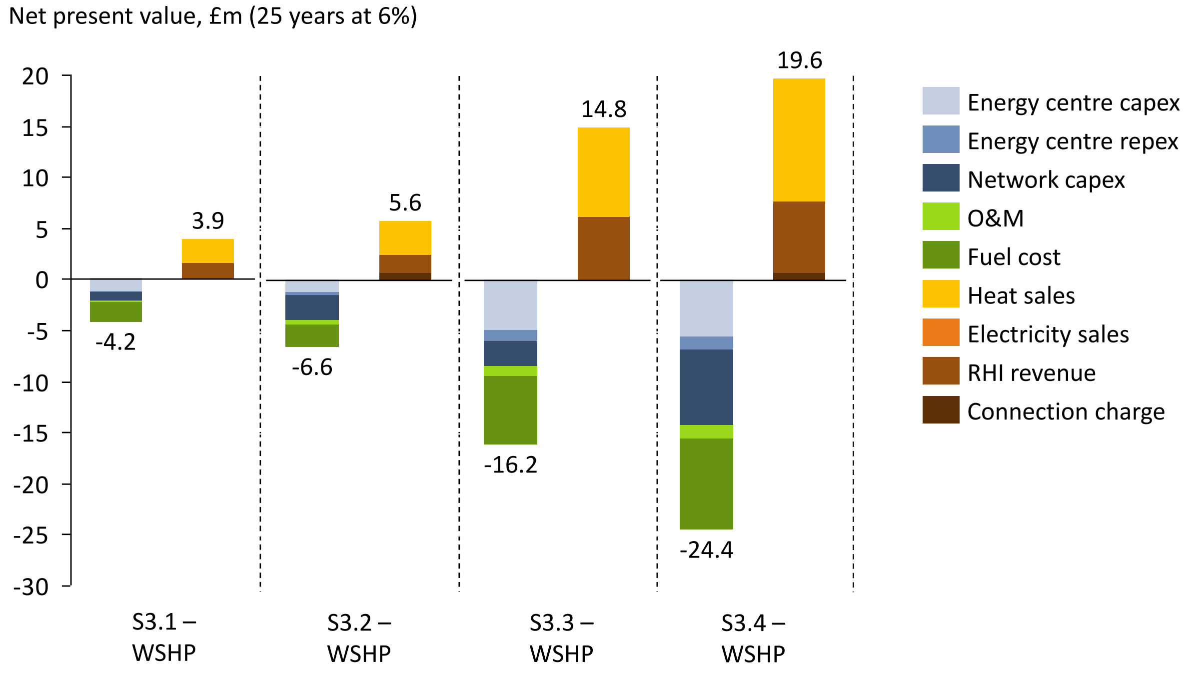
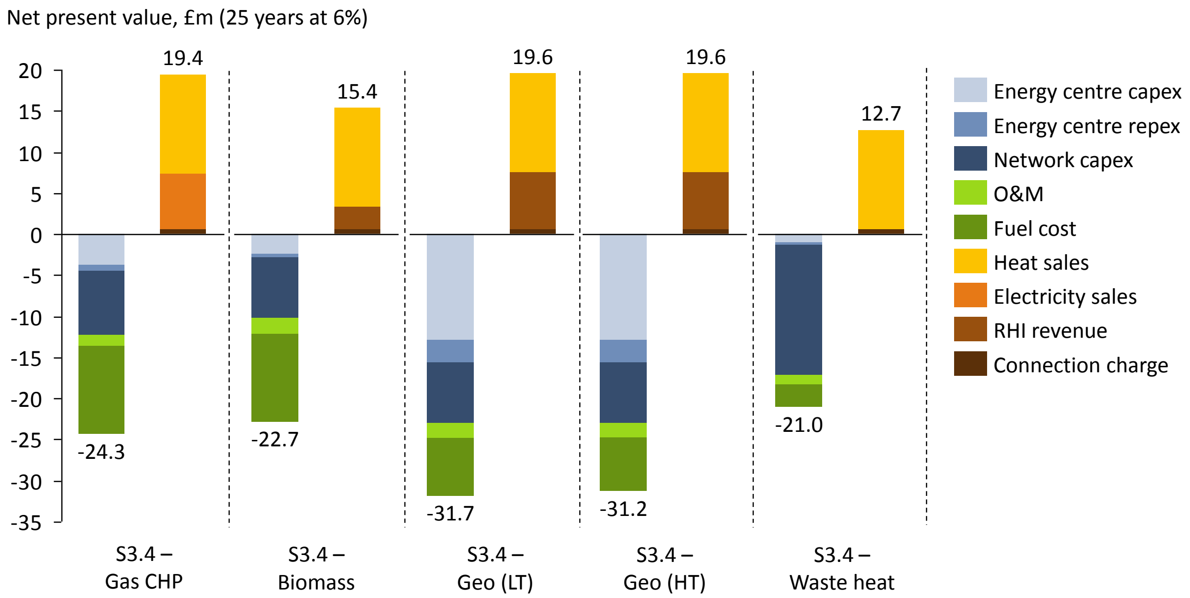


Figure 6-18: Cost and revenue components for Cluster 3 – Cromwell Rd (schemes using other technologies)



A summary of the economic assessment and carbon savings potential for the Cromwell Rd and Great Coates Industrial Estate cluster is shown in Table 6-9. For the WSHP schemes, lifetime CO_2 savings range from 8 ktCO_2 for S3.1 to 31 ktCO_2 for S3.4. Lifetime CO_2 savings for S3.4 with Biomass boiler are 35 ktCO_2, with low T and high T Geothermal saving 35-36 ktCO_2, and Waste heat (assumed to require almost no gas boiler backup) saving 75 ktCO_2.

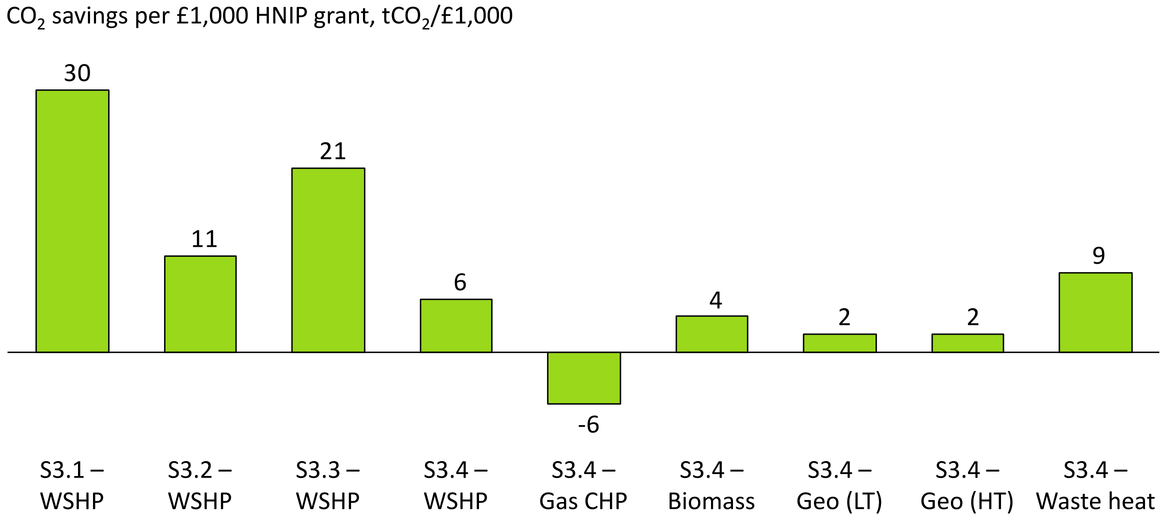
The minimum required HNIP grant to achieve NELC's typical hurdle rate of 6% has been determined for each scheme. This is found as £0.3m for S3.1 with WSHP, corresponding to a carbon savings value for money of 30 tCO_2 per £1,000 grant. For S3.2 with WSHP, a grant of £0.9m could lead to carbon savings of 11 tCO_2 per £1,000 grant. For the entire scheme S3.4 with WSHP, a £4.8m grant could achieve carbon savings of 6 tCO_2 per £1,000 grant.

A comparison of the different heat supply options for S3.4 shows that, due to the more negative NPV, a substantially higher grant is required for the Waste heat option versus the WSHP option, at £8.3m versus £4.8m. However, due to the greater lifetime CO_2 savings of the Waste heat option, the carbon savings value for money is actually higher than for the WSHP, at 9 tCO_2 per £1,000 grant. Waste heat is thereby found to represent the best carbon savings value for money of all the heat supply options studied. The Biomass boiler option achieves savings of 5 tCO_2 per £1,000 grant, slightly lower than the WSHP option. For the Geothermal options, the required grant is larger than the combined cost of the network and 45% of the generation plant cost, and would thus not be allowable under the terms of HNIP.

Table 6-9: Summary of economic assessment for Cluster 3 – Cromwell Rd

Scheme	Capital cost, £m	NPV, £m (25 yrs at 6%)	IRR (25 years)	NPV, £m (40 yrs at 6%)	IRR (40 years)	Lifetime cost of heat supply, p/kWh	Funding gap at 6%, £m	Funding gap at 6% excluding RHI, £m	Minimum HNIP grant to achieve 6% IRR	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	CO_2 savings per £1,000 HNIP grant, tCO_2/£1,000
S3.1 – WSHP	1.9	-0.3	4.1%	0.0	6.2%	5.2	0.3	1.8	0.3	8	30
S3.2 – WSHP	3.7	-0.9	2.7%	-0.4	5.1%	7.1	0.9	2.7	0.9	10	11
S3.3 – WSHP	7.4	-1.4	3.6%	-0.0	5.9%	5.4	1.4	7.4	1.4	29	21
S3.4 – WSHP	13.0	-4.8	0.9%	-3.1	3.9%	6.9	4.8	11.8	4.8	31	6
S3.4 – Gas CHP	11.5	-4.9	0.0%	-3.7	3.1%	6.9	4.9	4.9	4.9	-28	-6
S3.4 – Biomass	9.7	-7.3	N/A	-6.7	N/A	7.9	7.3	10.1	7.3	35	5
S3.4 – Geo (LT)	20.1	-12.1	N/A	-10.1	1.2%	9.8	12.1	19.1	N/A	35	N/A
S3.4 – Geo (HT)	20.1	-11.6	N/A	-9.5	1.6%	9.6	11.6	18.6	N/A	36	N/A
S3.4 – Waste heat	16.7	-8.3	0.0%	-6.6	2.7%	8.3	8.3	8.3	8.3	75	9

Figure 6-19: Carbon savings value for money for Cluster 3 – Cromwell Rd



6.2.4 Cluster 4 – Immingham Town

Error! Reference source not found. presents the network routes for the three scheme options considered for the Immingham Town cluster, and the customers connected in each case are shown in **Error! Reference source not found.**.

The core scheme, S4.1, includes a number of public sector customers including the Immingham Leisure Centre, two schools, the Stark Lincolnshire and Goole Hospital, a primary care home with 38 residential units and the police station, as well as a hotel. The first extension to this scheme, S4.2, includes another school and 612 new homes across three new developments. The final extension, S4.3, includes a further 257 new homes across two new developments.

The potential energy centre location indicated on the map corresponds to a large area of Council adopted land, currently a park. Other sites could be suitable.

Figure 6-20: Scheme network routes for Cluster 4 – Immingham Town

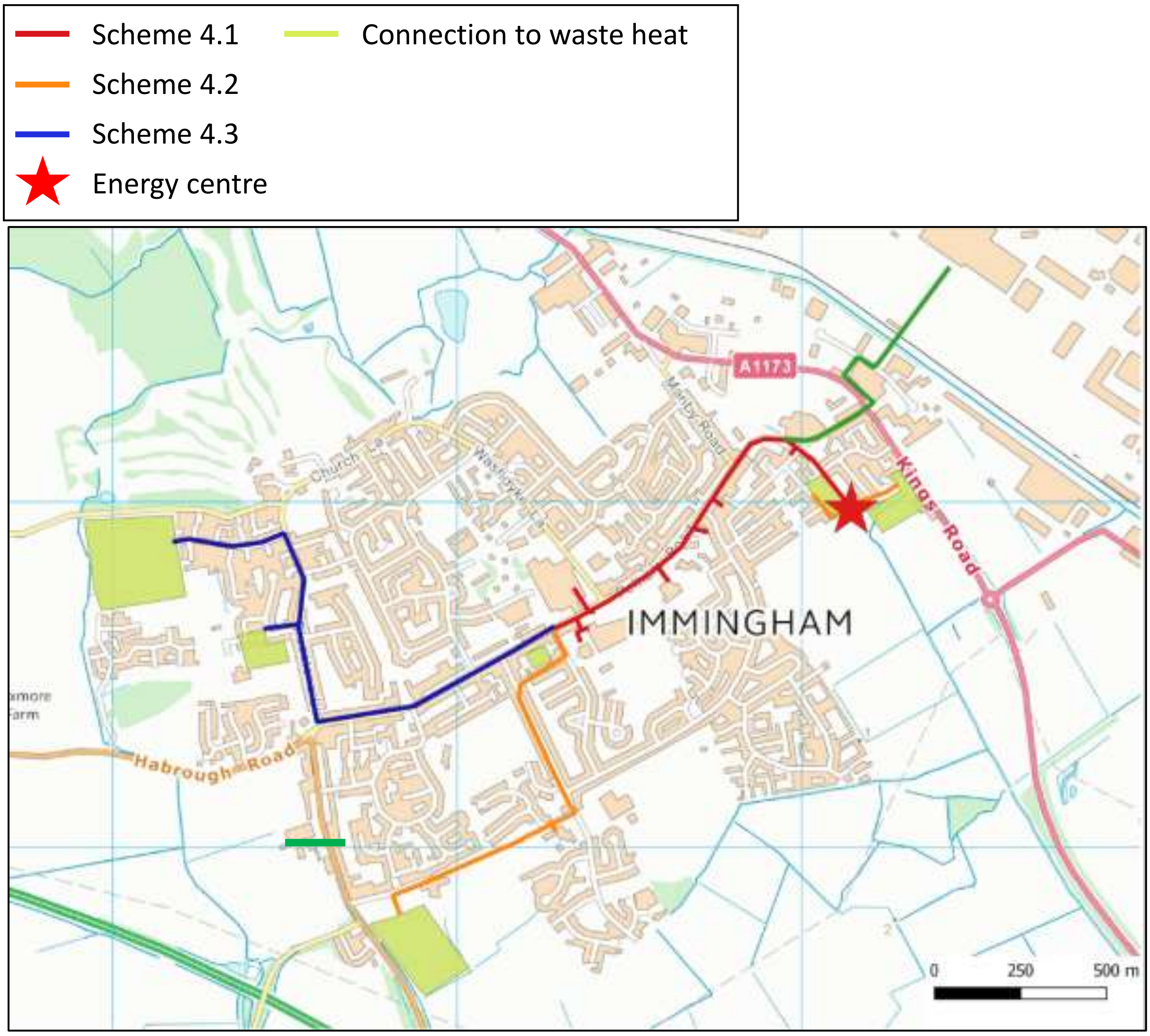


Table 6-10: Scheme customers in Cluster 4 – Immingham Town

Customer	S4.1	S4.2	S4.3
Oasis Immingham	✓	✓	✓
Immingham Leisure Centre	✓	✓	✓
Stark Lincolnshire and Goole Hospital	✓	✓	✓
Canon Peter Hall CE Primary School	✓	✓	✓
Humberside Police Station	✓	✓	✓
County Hotel	✓	✓	✓
Havenmere Care Home (38 resi units)	✓	✓	✓
Eastfield Primary Academy		✓	✓
Craik Hill Car Park, Humberville Road (22 resi units)		✓	✓
Waterworks Street (32 resi units)		✓	✓
Land to the east of Stallingborough Road (540 resi units)		✓	✓
Trenchard Close (18 resi units)		✓	✓
Roval Drive (79 resi units)			✓
West of Pilgrims Way (178 resi units)			✓

A summary of the technical assessment for the Immingham Town cluster is shown in **Error! Reference source not found.**. The core scheme S4.1 serves 3.8 GWh/yr of heat demand. The first extension, S4.2, adds substantial residential heat demand, and serves 6.3 GWh/yr overall. The largest scheme studied for this cluster, S4.3, serves 7.3 GWh/yr of heat demand.

The network length increases from 2.2 km for S4.1 to 10.6 km for S4.2. The large increase is associated with the network required to serve the 612 homes connected to the scheme, which are expected to be relatively low density semi-detached and terraced in nature. The additional network length required to serve these homes was estimated based on the network length that would be required to serve a similar number of buildings of a similar density in the surrounding area. For S4.3, the total network length is estimated at 15.8 km.

The heat density of the Immingham Town cluster is somewhat lower than for the clusters studied above. The linear heat density ranges from 1.7 GWh/yr/km for S4.1, to 0.6 GWh/yr/km and 0.4 GWh/yr/km. These relatively low linear heat density values will provide a challenge in designing an economically viable heat network scheme. However, a key potential opportunity for this cluster is the availability of a waste heat source in the near vicinity of the town, likely across the railway bordering the Immingham Port. While no such source is currently operational, discussions with stakeholders have raised the possibility of a new Energy-from-Waste facility in this area. We have therefore examined the potential viability of heat network schemes served by a waste heat source less than 1 km from the network, to understand whether this could present good value in terms of carbon savings whilst meeting NELC's other strategic priorities. We also study the potential to serve scheme S4.1 using WSHP and Gas CHP.

Table 6-11: Summary of technical assessment for Cluster 4 – Immingham Town

		Unit	S4.1	S4.2	S4.3
Annual heat demand at full build-out	Domestic	GWh/yr	0.3	2.7	3.8
	Non-domestic		3.4	3.5	3.5
	Total		3.8	6.3	7.3
Peak heat demand	Total	MW	1.5	2.3	2.8
Number of connections	Domestic	#	1	613	870
	Non-domestic	#	6	7	7
	Total	#	7	620	877
Heat supply capacity	Main supply	MW	0.8	1.4	1.9
	Auxiliary boilers		1.7	3.0	4.1
Network route length	Distribution	km	1.9	7.2	11.1
	Service		0.3	3.4	4.7
	Distance to closest source of waste heat		0.8	0.8	0.8
Network temperature	Network flow/return temperature	ºC		80/50	
	Network delta T			30	
Linear heat density		GWh/yr/km	1.7	0.6	0.4

The list of scheme options studied for this cluster is:

- S4.1 with Waste heat
- S4.1 with WSHP
- S4.1 with Gas CHP
- S4.2 with Waste heat
- S4.3 with Waste heat

The results of the economic assessment are presented below. **Error! Reference source not found.** presents the capital cost of each scheme option. For the schemes based on Waste heat at nearby Immingham Port (assuming here a connection distance of less than 1 km), the capital cost ranges from £3.1m for S4.1 to £10.6m for S4.3, reflecting the extent of the network required to distribute heat to the customers in the larger schemes. In each case, the network cost dominates the capital cost, as the energy centre does not include costly primary heating plant, but only low cost backup gas boilers and auxiliary plant.

Figure 6-21: Capital cost of scheme options for Cluster 4 – Immingham Town

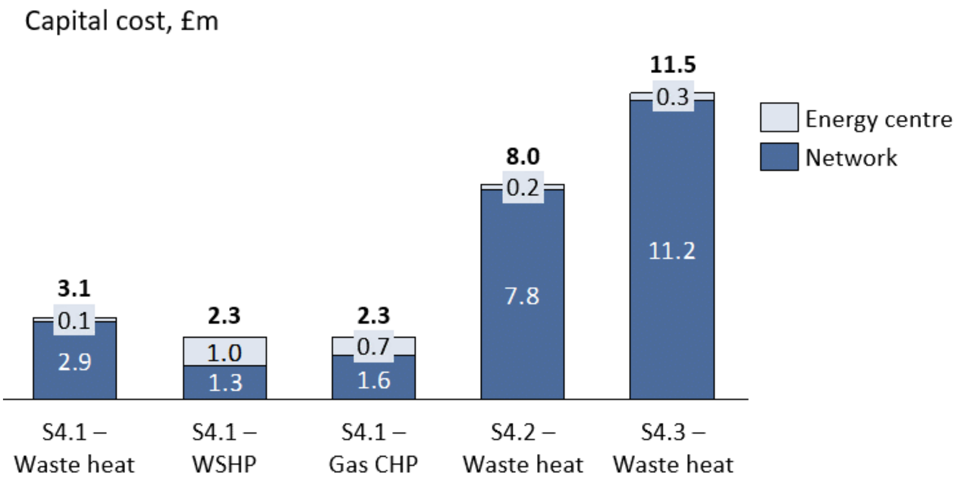


Figure 6-22: IRR summary for Cluster 4 – Immingham Town

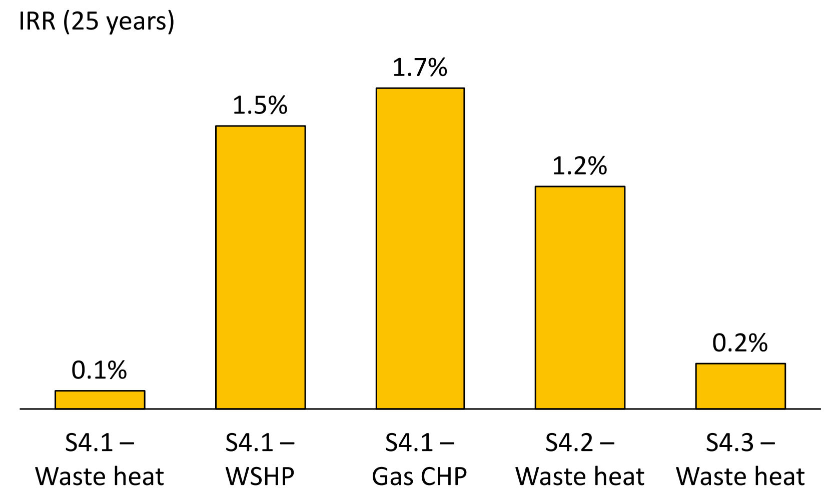
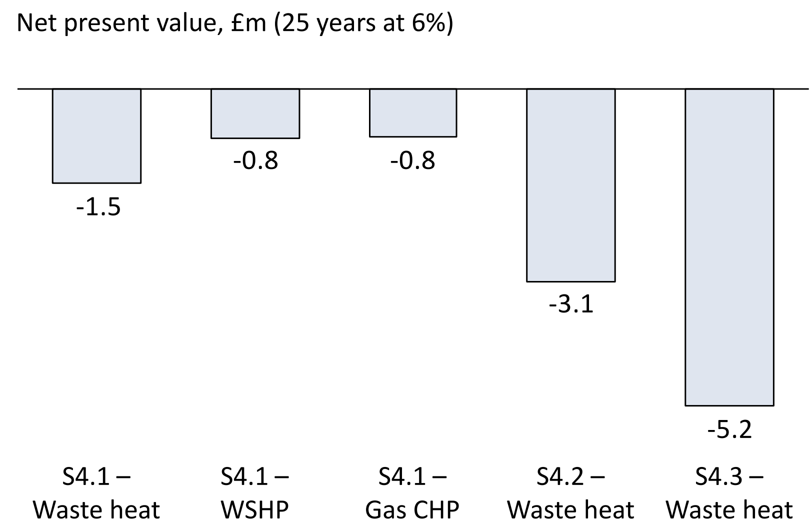


Figure 6-23: Net present value summary for Cluster 4 – Immingham Town

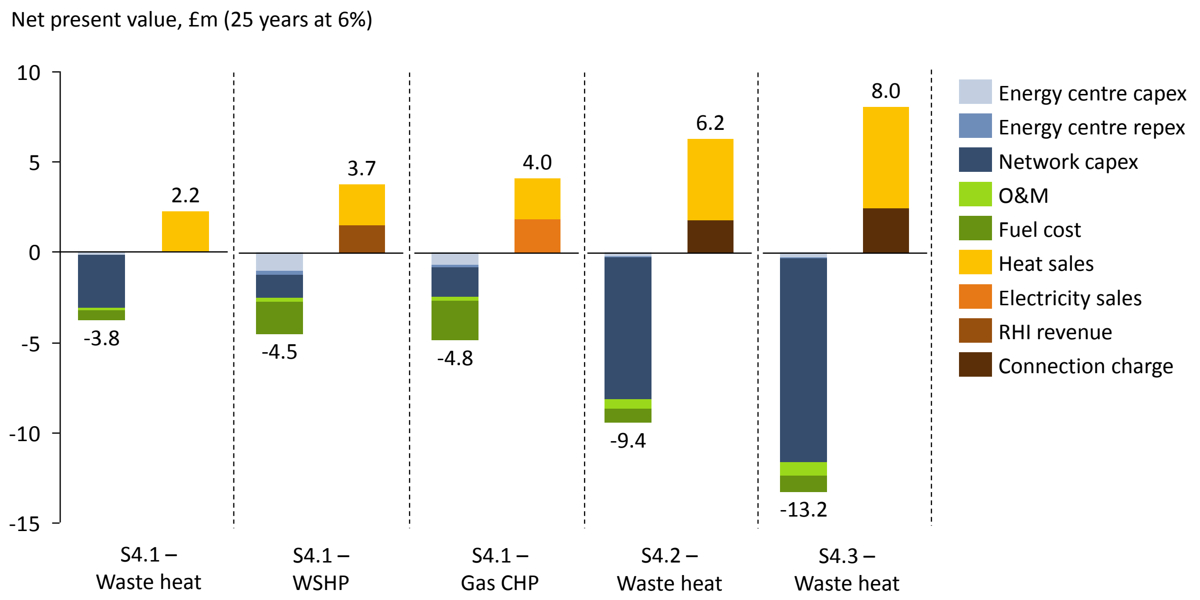


It can be seen that the capital cost of scheme S4.1 with Waste heat is the higher than that of the alternatives, even with the relatively low connection distance of 0.8 km to the waste heat source. For both the WSHP and the Gas CHP option, the capital cost is £2.3m. In the case of Gas CHP, the network cost includes the estimated cost of a private wire to deliver the electricity generated to several of the anchor customers.

The 25-year project IRR is presented in **Error! Reference source not found.**, and the 25-year NPV at 6% is presented in **Error! Reference source not found.**. All scheme options studied have a negative NPV at 6%, and hence achieve an IRR below 6%. The highest IRR is achieved for scheme S4.1 with Gas CHP, at 1.7%. The same scheme S4.1 with WSHP achieves a similar IRR of 1.5%, while the same scheme S4.1 with Waste heat achieves an IRR of only 0.1%. Scheme S4.2 with Waste heat performs somewhat better, with an IRR of 1.2%, the highest of the schemes based on Waste heat. Scheme S4.3 with Waste heat achieves an IRR of 0.2%.

Error! Reference source not found. presents the breakdown of the NPV according to the various cost and revenue components. The lifetime cost for the schemes based on Waste heat are dominated by the capital cost of the network infrastructure, which is not fully compensated by the value of heat sales and any developer connection charge. For schemes S4.1 with WSHP and with Gas CHP, the largest component of the lifetime cost is in each case the fuel cost, followed by the network cost and then the energy centre cost. In each case, these costs are not fully compensated by the value of heat sales in combination with the RHI for the WSHP case, and electricity sales in the Gas CHP case.

Figure 6-24: Cost and revenue components for Cluster 4 – Immingham Town



A summary of the economic assessment and carbon savings potential for the Immingham Town cluster is shown in **Error! Reference source not found.**.

For the Waste heat-based schemes, lifetime CO_2 savings range from 15 ktCO_2 for S4.1 to 26 ktCO_2 for S4.3. Lifetime CO_2 savings for S4.1 with WSHP are around half of that for the same scheme using Waste heat, at 8 ktCO_2. Lifetime CO_2 savings for S4.1 with Gas CHP are negative, at -5 ktCO_2.

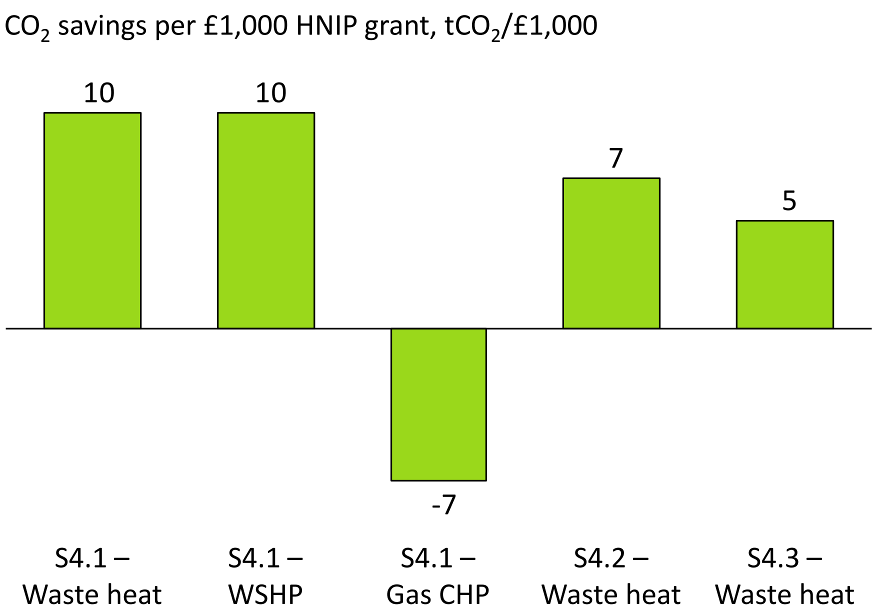
The minimum required HNIP grant to achieve NELC's typical hurdle rate of 6% has been determined for each scheme. For scheme S4.1 with Waste heat, this is found as £1.5m, corresponding to a carbon savings value for money of 10 tCO_2 per £1,000 grant. For the same scheme S4.1 with WSHP, a smaller grant of £0.8m is sufficient, and this achieves almost the same carbon savings value for money of 10 tCO_2 per £1,000 grant – albeit achieving only half the lifetime carbon savings. The same scheme S4.1 with Gas CHP could also be viable with a £0.8m grant, but this would not lead to positive lifetime CO_2 savings.

The first extended scheme S4.2, which adds more than 600 homes and a school to the customers connected in S4.1, could achieve a 6% IRR using Waste heat with a £3.1m grant. This would achieve carbon savings of 7 tCO_2 per £1,000 grant. Also using Waste heat, the second extended scheme S4.3, which serves a further 257 new homes, requires a grant of £5.2m, achieving carbon savings of 5 tCO_2 per £1,000 grant.

Table 6-12: Summary of economic assessment for Cluster 4 – Immingham Town

Scheme	Capital cost, £m	NPV, £m (25 yrs at 6%)	IRR (25 years)	NPV, £m (40 yrs at 6%)	IRR (40 years)	Lifetime cost of heat supply, p/kWh	Funding gap at 6%, £m	Funding gap at 6% excluding RHI, £m	Minimum HNIP grant to achieve 6% IRR	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	CO_2 savings per £1,000 HNIP grant, tCO_2/£1,000
S4.1 – Waste heat	3.1	-1.5	0.1%	-1.2	2.7%	7.8	1.5	1.5	1.5	15	10
S4.1 – WSHP	2.3	-0.8	1.5%	-0.5	4.2%	6.3	0.8	2.3	0.8	8	10
S4.1 – Gas CHP	2.3	-0.8	1.7%	-0.5	4.1%	6.3	0.8	0.8	0.8	-5	-7
S4.2 – Waste heat	8.0	-3.1	1.2%	-2.1	3.8%	10.9	3.1	3.1	3.1	22	7
S4.3 – Waste heat	11.5	-5.2	0.2%	-3.9	3.1%	13.5	5.2	5.2	5.2	26	5

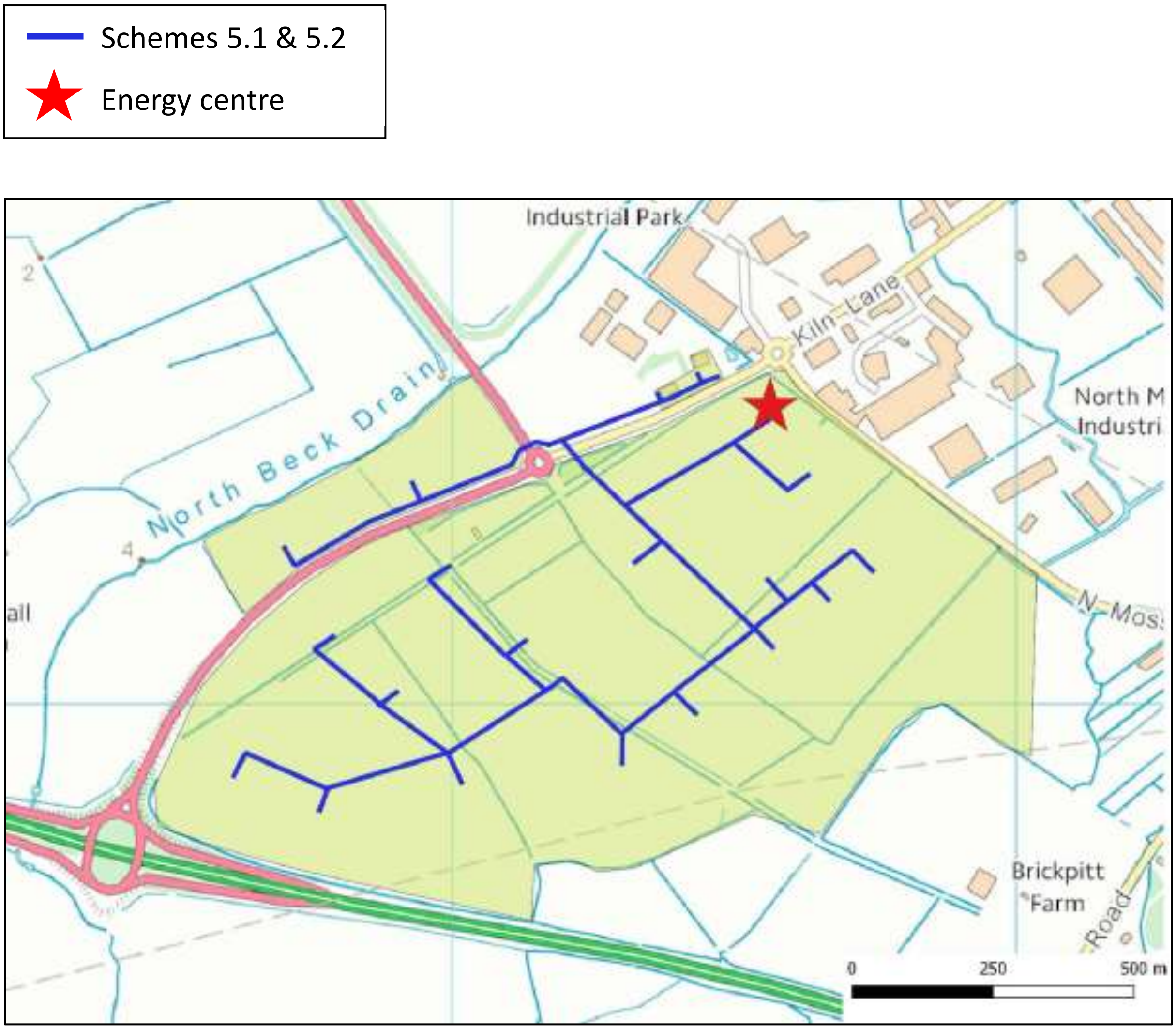
Figure 6-25: Carbon savings value for money for Cluster 4 – Immingham Town



6.2.5 Cluster 5 – Stallingborough Enterprise Zone

The Stallingborough Enterprise Zone cluster is somewhat different from the other clusters studied in that the cluster is based almost entirely around anticipated new commercial and industrial development. The Enterprise Zone is a 64 hectare greenfield site owned by NELC, and is currently greenfield.

Figure 6-26: Scheme network routes for Cluster 5 – Stallingborough EZ



Due to the location, offering good access to the A180 and the port, it is expected to be particularly attractive to logistics and distribution companies associated with the nearby manufacturing businesses or the freight passing through the port of Immingham. The site is thus expected to attract a mix of B1 (offices, R&D and light industry), B2 (general industrial) and B8 (storage and distribution) employment space.

A key potential advantage of the cluster in relation to heat network development is the possibility of the future construction of an Energy-from-Waste plant on or near the Enterprise Zone. While there are no firm plans for this at the current time, discussion with stakeholders has highlighted this as a possibility. As such, we study this is a heat supply option for this cluster.

The customers assumed to be connected to the scheme are shown in Table 6-13. In the cluster, we also include two neighbouring existing buildings, including HCF CATCH, an industrial training facility, and Immingham East Fire station.

Given the greenfield nature of the Enterprise Zone, the majority of the network route shown in Figure 6-26 is indicative only, except for the connections to the two existing buildings which are located at the northwest edge of the site across Kiln Lane. The indicative network route is based on the proposed phasing for the site in the *Local Growth Fund Round 1 Business Case* document[17] prepared by NELC in 2016.

Table 6-13: Scheme customers in Cluster 5 – Stallingborough EZ

Customer	S5.1	S5.2
HCF CATCH	✓	✓
Immingham East Fire Station	✓	✓
Stallingborough Enterprise Zone ≈135,000 m^2 of B1, B2 and B8 (Two scenarios for heat demand considered)	✓	✓

A summary of the technical assessment for the Stallingborough Enterprise Zone cluster is shown in Table 6-14. Given the predominantly greenfield nature of the site, we have studied a sensitivity on the energy demand of the site at full build-out. The two scheme studied, S5.1 and S5.2, represent the same scheme in terms of the customers connected, but two different scenarios for the overall energy demand of those customers.

The energy demand served in S5.1 is based on the *Local Growth Fund Round 1 Business Case*, combined with energy demand benchmarks for appropriate activity types as described in 2.2. In S5.1, it is assumed that the general industrial facilities are not heat intensive.

In S5.2, the high heat demand sensitivity, a scenario is studied where a greater proportion of the site is occupied by more heat intensive industry. This could include activities such as food manufacturing, coldstores for seafood processing (supplied using heat via absorption chillers), heated greenhouses for agriculture, shellfish aquaculture or some other heat intensive process. Such heat intensive users could be attracted to the area on the basis of low heat prices resulting from a successful heat network. In this scenario, the overall heat demand is nearly three times higher than in the low demand scenario S5.1.

Scheme S5.1 thus serves 9.0 GWh/yr of heat demand, while S5.2 serves 24.6 GWh/yr. It is estimated based on the indicative network route developed that the total network length required to serve all customers would be approximately 7.9 km (of which 6.7 km is the distribution network and 1.2 km is associated with service pipes connecting to each individual building).

As noted above, discussion with stakeholders has highlighted the possibility – though there are no firm plans at this stage – of the construction of an Energy-from-Waste facility on or near the Enterprise Zone. Since this could have a large impact on the viability of a heat network at this site, we study this as one of the heat supply options for this cluster. For the purpose of the assessment, we assume a connection distance of 0.4 km, corresponding to an Energy-from-Waste facility on the site. We also study the case of a WSHP, since there is substantial space on the site for development of a groundwater borehole array.

[17] https://www.nelincs.gov.uk/wp-content/uploads/2015/12/Local-Growth-Fund-Business-Case.pdf (Accessed July 2017)

Table 6-14: Summary of technical assessment for Cluster 5 – Stallingborough EZ

		Unit	S5.1	S5.2
Annual heat demand at full build-out	Domestic	GWh/yr	-	-
	Non-domestic		9.0	24.6
	Total		9.0	24.6
Peak heat demand	Total	MW	5.4	15.0
Number of connections	Domestic	#	-	-
	Non-domestic	#	46	46
	Total	#	46	46
Heat supply capacity	Main supply	MW	1.5	3.5
	Auxiliary boilers		7.3	17.9
Network route length	Distribution	km	6.7	6.7
	Service		1.2	1.2
	Distance to closest source of waste heat		0.4	0.4
Network temperature	Network flow/return temperature	ºC	80/50	
	Network delta T		30	
Linear heat density		GWh/yr/km	1.1	3.1

The list of scheme options studied for this cluster is:

- S5.1 with Waste heat
- S5.2 with Waste heat
- S5.2 with WSHP

The results of the economic assessment are presented below. Figure 6-27 presents the capital cost of each scheme option. For the two schemes based on Waste heat on-site (assuming here a connection distance of 0.4 km), the capital cost is £7.6m for S5.1 and £11.1m for S5.2, with the cost dominated by the network cost. The network cost for the two scheme options is different despite the network length being the same in each case. This is due to the larger pipe diameter required in S5.2, since the scheme serves a larger heat demand and hence requires a larger volume of water to be distributed across the site.

Scheme S5.2 with WSHP carried a capital cost of £14.7m, substantially higher than for the same scheme using Waste heat. This reflects the high cost of the WSHP plant and borehole array, which is not offset by the reduction in network cost versus the Waste heat case associated with connection to the waste heat source.

Figure 6-27: Capital cost of scheme options for Cluster 5 – Stallingborough EZ

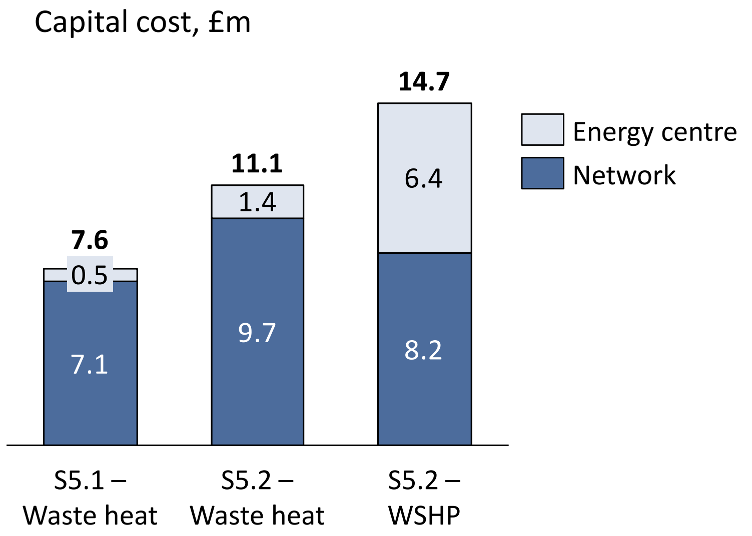


Figure 6-28: IRR summary for Cluster 5 – Stallingborough EZ

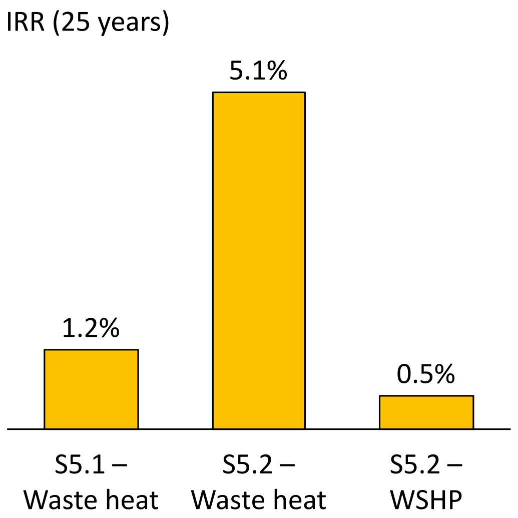
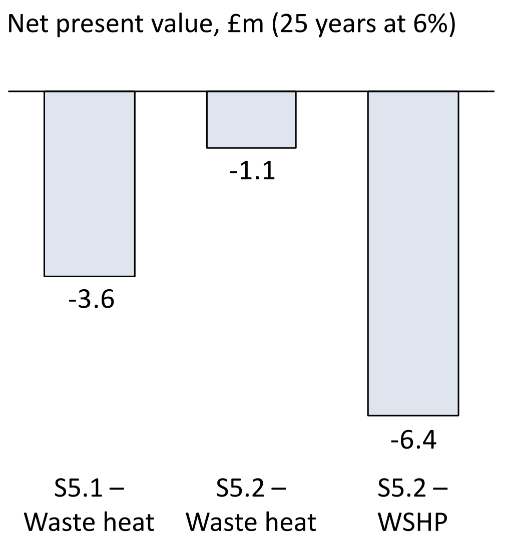


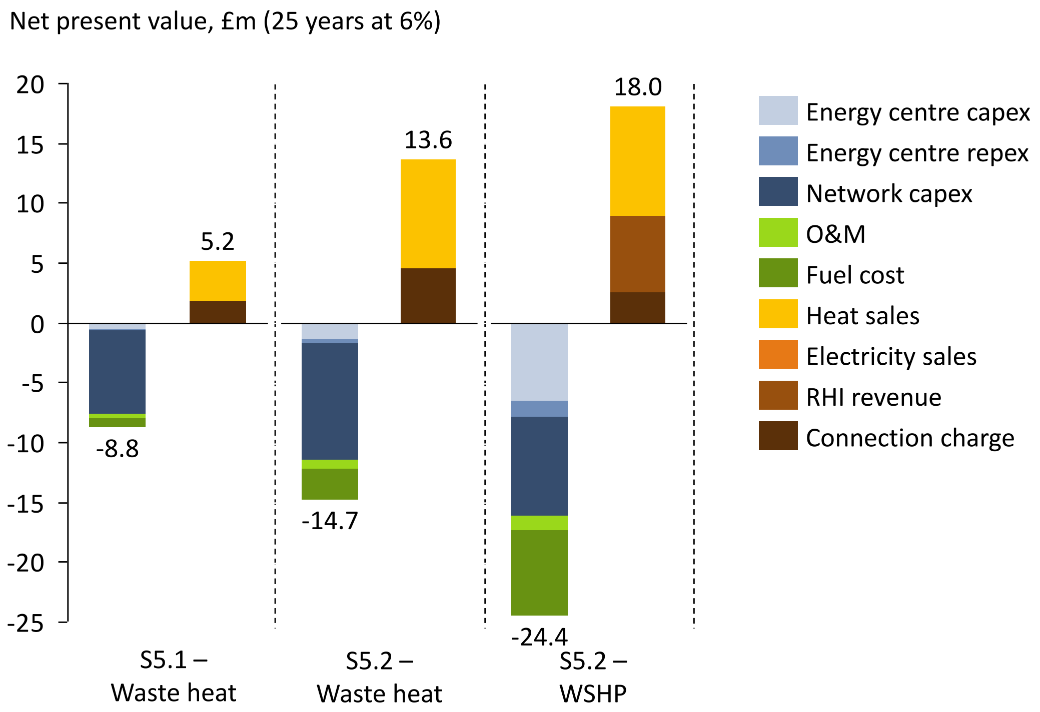
Figure 6-29: Net present value summary for Cluster 5 – Stallingborough EZ



The 25-year project IRR is presented in Figure 6-28 and the 25-year NPV at 6% is presented in Figure 6-29. The low heat demand scenario, scheme S5.1, achieves a low IRR of 1.2% using Waste heat. However, the high heat demand scenario, scheme S5.2, achieves an IRR of 5.1% with Waste heat. Since this is the highest IRR achieved for any scheme across all clusters; it is important to emphasise that this value is achieved only under the scenario of heat intensive businesses being attracted to the Enterprise Zone. Scheme S5.2 with WSHP achieves an IRR of 0.5%. The NPV ranges from -£1.1m for S5.2 with Waste heat to -£6.4m for S5.2 with WSHP.

Figure 6-30 presents the breakdown of the NPV for the various cost and revenue components. It can be seen that, for the low heat demand scenario S5.1 with Waste heat, the revenue from heat sales is not sufficient to offset the network capex. For the high heat demand scenario S5.2 with Waste heat, the revenue from heat sales is much greater and, when combined with the revenue from the developer connection charge, nearly offsets the costs, which are associated mainly with the network. For S5.2 with WSHP, the revenue from heat sales and the RHI are not sufficient to offset the costs, which include a greater contribution from the energy centre cost and ongoing fuel costs.

Figure 6-30: Cost and revenue components for Cluster 5 – Stallingborough EZ



A summary of the economic assessment and carbon savings potential for the Stallingborough Enterprise Zone cluster is shown in Table 6-15.

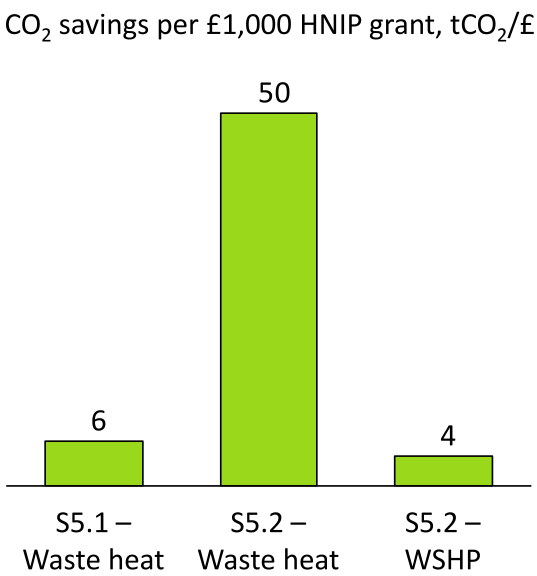
For the Waste heat-based schemes, lifetime CO_2 savings are 23 ktCO_2 for S5.1 and 56 ktCO_2 for S5.2. Lifetime CO_2 savings for S5.2 with WSHP are around half of that for the same scheme using Waste heat, at 23 ktCO_2.

The minimum required HNIP grant to achieve NELC's typical hurdle rate of 6% is found, for scheme S5.1 with Waste heat, to be £3.6m, corresponding to a carbon savings value for money of 6 tCO_2 per £1,000 grant. However, for scheme S5.2 with Waste heat, the required grant is only £1.1m, and leads to carbon savings of 50 tCO_2 per £1,000 grant. The same scheme S5.2 using WSHP requires a grant of £6.4m, leading to carbon savings of 4 tCO_2 per £1,000 grant.

Table 6-15: Summary of economic assessment for Cluster 5 – Stallingborough EZ

Scheme	Capital cost, £m	NPV, £m (25 yrs at 6%)	IRR (25 years)	NPV, £m (40 yrs at 6%)	IRR (40 years)	Lifetime cost of heat supply, p/kWh	Funding gap at 6%, £m	Funding gap at 6% excluding RHI, £m	Minimum HNIP grant to achieve 6% IRR	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	CO_2 savings per £1,000 HNIP grant, tCO_2/£1,000
S5.1 – Waste heat	7.6	-3.6	1.2%	-2.0	4.3%	10.3	3.6	3.6	3.6	23	6
S5.2 – Waste heat	11.1	-1.1	5.1%	2.8	7.4%	5.6	1.1	1.1	1.1	56	50
S5.2 – WSHP	14.7	-6.4	0.5%	-3.9	4.0%	8.5	6.4	12.7	6.4	23	4

Figure 6-31: Carbon savings value for money for Cluster 5 – Stallingborough EZ



6.3 Summary of economic assessment

The results of the economic assessment for all scheme options studied, across the five selected clusters, is presented below in Table 6-16.

Table 6-16: Summary of economic assessment results

	Scheme	Capital cost, £m	NPV, £m (25 yrs at 6%)	IRR (25 years)	NPV, £m (40 yrs at 6%)	IRR (40 years)	Lifetime cost of heat supply, p/kWh	Funding gap at 6%, £m	Funding gap at 6% excluding RHI, £m	Minimum HNIP grant to achieve 6% IRR	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	CO_2 savings per £1,000 HNIP grant, tCO_2/£1,000
DPoW	S1.1 – Gas CHP	7.0	-2.8	0.2%	-2.0	3.4%	5.8	2.8	2.8	2.8	-21	-7
	S1.1 – Biomass	5.8	-3.7	N/A	-3.2	1.3%	6.2	3.7	7.0	3.7	46	12
	S1.2 – Gas CHP	10.2	-4.3	N/A	-3.3	2.8%	6.7	4.3	4.3	4.3	-25	-6
	S1.2 – Biomass	8.9	-5.1	N/A	-4.3	1.7%	7.0	5.1	8.6	5.1	48	9
GIFHE	S2.1 – WSHP	3.0	-0.6	3.4%	-0.1	5.6%	5.5	0.6	2.8	0.6	12	19
	S2.2 – WSHP	8.5	-2.6	1.7%	-1.5	4.4%	8.0	2.6	6.4	2.6	18	7
	S2.2 – Gas CHP	7.5	-1.9	2.4%	-1.0	4.6%	7.5	1.9	1.9	1.9	-18	-9
	S2.3 – WSHP	17.1	-7.3	0.0%	-5.5	3.1%	9.9	7.3	13.9	7.3	29	4
Cromwell Rd	S3.1 – WSHP	1.9	-0.3	4.1%	0.0	6.2%	5.2	0.3	1.8	0.3	8	30
	S3.2 – WSHP	3.7	-0.9	2.7%	-0.4	5.1%	7.1	0.9	2.7	0.9	10	11
	S3.3 – WSHP	7.4	-1.4	3.6%	-0.0	5.9%	5.4	1.4	7.4	1.4	29	21
	S3.4 – WSHP	13.0	-4.8	0.9%	-3.1	3.9%	6.9	4.8	11.8	4.8	31	6
	S3.4 – Gas CHP	11.5	-4.9	0.0%	-3.7	3.1%	6.9	4.9	4.9	4.9	28	-6
	S3.4 – Biomass	9.7	-7.3	N/A	-6.7	N/A	7.9	7.3	10.1	7.3	35	5
	S3.4 – Geo (LT)	20.1	-12.1	N/A	-10.1	1.2%	9.8	12.1	19.1	N/A	35	N/A
	S3.4 – Geo (HT)	20.1	-11.6	N/A	-9.5	1.6%	9.6	11.6	18.6	N/A	36	N/A
	S3.4 – Waste heat	16.7	-8.3	0.0%	-6.6	2.7%	8.3	8.3	8.3	8.3	75	9
Immingham	S4.1 – Waste heat	3.1	-1.5	0.1%	-1.2	2.7%	7.8	1.5	1.5	1.5	15	10
	S4.1 – WSHP	2.3	-0.8	1.5%	-0.5	4.2%	6.3	0.8	2.3	0.8	8	10
	S4.1 – Gas CHP	2.3	-0.8	1.7%	-0.5	4.1%	6.3	0.8	0.8	0.8	-5	-7
	S4.2 – Waste heat	8.0	-3.1	1.2%	-2.1	3.8%	10.9	3.1	3.1	3.1	22	7
	S4.3 – Waste heat	11.5	-5.2	0.2%	-3.9	3.1%	13.5	5.2	5.2	5.2	26	5
Stalling-borough	S5.1 – Waste heat	7.6	-3.6	1.2%	-2.0	4.3%	10.3	3.6	3.6	3.6	23	6
	S5.2 – Waste heat	11.1	-1.1	5.1%	2.8	7.4%	5.6	1.1	1.1	1.1	56	50
	S5.2 – WSHP	14.7	-6.4	0.5%	-3.9	4.0%	8.5	6.4	12.7	6.4	23	4

6.4 Comparison of key scheme options against critical success factors

During the course of the project, a range of stakeholders within NELC were engaged in order to define the critical success factors for heat network development. The critical success factors are the metrics chosen by NELC to reflect the Council's strategic objectives and priorities for heat network development.

The critical success factors selected by NELC were:

- Reduced energy costs
- Meeting climate targets
- Impact on households
- Gross value added to the region
- Impact on fuel poor households
- Impact on the local air quality

These factors, and the metrics chosen to represent them, are explained further in Table 6-17. As indicated in the table, each critical success factor was assigned equal weighting.

The critical success factors were used to compare all scheme options considered in the technical and economic assessment. The aim of this process is to help NELC to identify the scheme options most closely aligned with their objectives, and to assist in the selection of the preferred options to take forward to detailed feasibility stage.

The performance of each scheme option considered against the individual critical success factors is presented in Table 6-18. An overall score for each scheme option was determined using a 'swing weighting' approach. In this approach, the scheme option(s) performing best against each individual critical success factor was awarded a score of 100% and the scheme option(s) performing worst was awarded a score of zero. All other scheme options were awarded a score between zero and 100% according to the performance of the scheme option versus the worst and best performing scheme options (using a linear scale). The individual scores against each critical success factor are then multiplied by the weighting for each factor and summed to obtain an overall score.

Table 6-17: Description of critical success factors

Critical success factor	Metric	Units	Weighting (0-100)
Reduced energy costs	Lifetime cost of heat supply	p/kWh	100
Meeting climate targets	Lifetime CO_2 emissions reduction	tCO_2	100
Impact on households	Number of households served	#	100
Gross value added (GVA) to the region	Likely impact on GVA (Higher score for likelihood of reducing business energy bills; attracting new commercial heat users; using local sources of waste heat and increasing investment in EfW and/or biomass)	Qualitative assessment (1-10)	100
Impact on fuel poor households	Number of fuel poor households served	#	100
Impact on local air quality	Likely impact on air quality (Higher score for greater reduction in gas combustion, so waste heat highest, followed by WSHP; lowest score for biomass as likely to have most negative impact; higher score for improving air quality in densely populated areas and vice versa)	Qualitative assessment (1-10)	100

Table 6-18: Summary of scheme performance against critical success factors

	Scheme	Lifetime cost of heat supply, p/kWh	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	Number of households served	Gross value added to the region (Qualitative assessment 1-10)	Number of fuel poor households served	Impact on the local air quality (Qualitative assessment 1-10)
DPoW	S1.1 – Gas CHP	5.8	-21	219	4	0	4
	S1.1 – Biomass	6.2	46	219	4	0	1
	S1.2 – Gas CHP	6.7	-25	631	4	0	4
	S1.2 – Biomass	7	48	631	4	0	1
GIFHE	S2.1 – WSHP	5.5	12	0	4	0	6
	S2.2 – WSHP	8	18	614	4	0	7
	S2.2 – Gas CHP	7.5	-18	614	4	0	4
	S2.3 – WSHP	9.9	29	1258	4	79	8
Cromwell Rd	S3.1 – WSHP	5.2	8	0	4	0	5
	S3.2 – WSHP	7.1	10	250	4	0	6
	S3.3 – WSHP	5.4	29	0	5	0	7
	S3.4 – WSHP	6.9	31	250	5	0	7
	S3.4 – Gas CHP	6.9	28	250	5	0	4
	S3.4 – Biomass	7.9	35	250	5	0	2
	S3.4 – Geo (LT)	9.8	35	250	5	0	7
	S3.4 – Geo (HT)	9.6	36	250	5	0	7
	S3.4 – Waste heat	8.3	75	250	7	0	9
Immingham	S4.1 – Waste heat	7.8	15	38	6	0	9
	S4.1 – WSHP	6.3	8	38	4	0	7
	S4.1 – Gas CHP	6.3	-5	38	4	0	4
	S4.2 – Waste heat	10.9	22	650	5	0	10
	S4.3 – Waste heat	13.5	26	907	6	0	10
Stalling-borough	S5.1 – Waste heat	10.3	23	0	8	0	9
	S5.2 – Waste heat	5.6	56	0	10	0	9
	S5.2 – WSHP	8.5	23	0	8	0	7

The overall score of each scheme option considered against the critical success factors is shown in Figure 6-32. The five highest scoring scheme options are:

- GIFHE and around: S2.3 with WSHP
- Stallingborough Enterprise Zone: S5.4 with Waste heat
- Cromwell Rd and Great Coates Industrial Estate: S3.4 with Waste heat
- Immingham Town: S4.3 with Waste heat
- Immingham Town: S4.2 with Waste heat

The highest scoring scheme option is S2.3 with WSHP in the GIFHE cluster. This is the most extended scheme in the cluster and includes more than 1,000 households, as well as the Institute itself, a number of schools and a care home. NELC data estimates that an average of 12% of existing households in this area are at-risk of fuel poverty; this suggests that approximately 79 of the 644 existing households in this scheme could be fuel poor households. The large number of households, and potentially fuel poor households, served is the key reason for the high score of this scheme option, with the associated carbon savings and air quality impact also scoring well.

The Stallingborough high heat density scenario S5.2 using Waste heat also scores highly on a number of metrics, particularly CO_2 savings, the lifetime cost of heat supply, GVA to the region and impact on air quality. The carbon and air quality impacts are large, since Waste heat leads to the lowest impact of all heat supply options against these metrics. The scheme scores well on GVA since it would be expected to attract inward investment into the region both in terms of customers and potentially an Energy-from-Waste developer. The cost of heat for the scheme is low since the heat density in this scenario is high. It is important to note that this outcome is dependent on relatively heat intensive users moving into the Enterprise Zone, and the low heat density scenario S5.1 scores substantially lower.

The Cromwell Rd and Great Coates Industrial Estate scheme S3.4 with Waste heat, incorporating a range of public buildings including a leisure centre, 250 new homes and several coldstores, achieves the third highest overall score. The Waste heat option scores more highly than the other heat options, including WSHP, despite the lower IRR (and hence higher lifetime cost of heat supply), due to the higher CO_2 savings of the Waste heat option and the greater GVA impact associated with potentially attracting a further EfW development to the region. Scheme S3.4 also scores well due to the relatively large number of households served and the positive air quality impact in the area, which includes residential buildings, a leisure centre and other public buildings. It is also worth noting that all the scheme options in this cluster using WSHP score relatively well in terms of the cost of heating (and hence the funding gap to deliverability). As such, this cluster could be relatively robust to one or more customers 'dropping out' of the scheme.

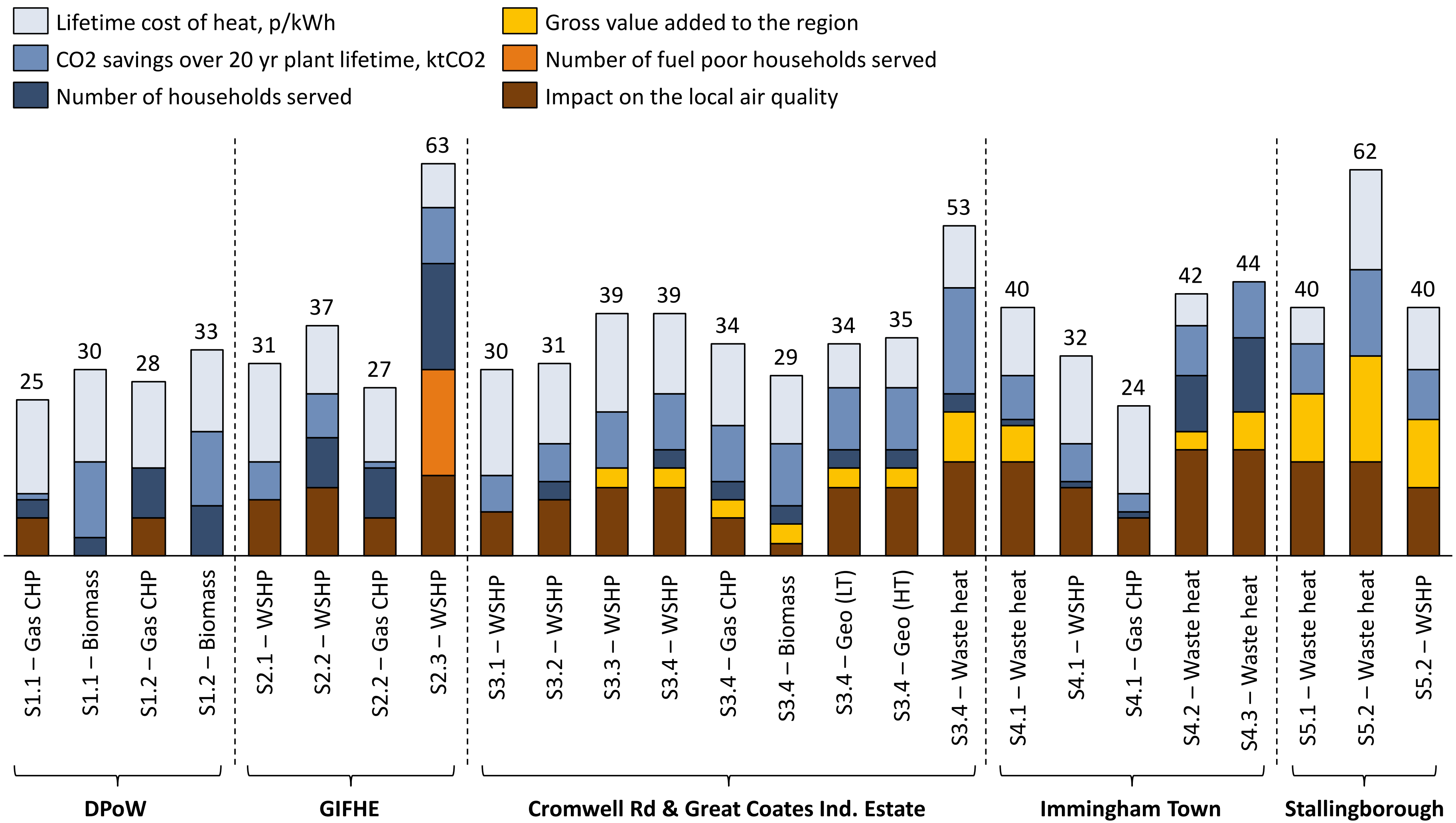
The Immingham Town cluster provides the fourth and fifth highest scoring scheme options with S4.3 and S4.2 respectively, in both cases using Waste heat. These schemes score well due to the positive air quality impacts in this residential area, the large carbon savings and the large number of households served, at 907 households in the case of S4.3 and 650 for S4.2.

The DPoW Hospital cluster does not contain any schemes that score highly, as a result of the negative carbon savings in the case of Gas CHP, the impact on the local air quality in the case of Biomass and the relatively low gross value added to the region. Despite not scoring highly against the critical success factors at this stage, the DPoW Hospital has the potential to be a good anchor customer due to its high heat demand. A heat network in this area should be reconsidered in the future once the existing Gas CHP unit reaches the end of its life, if a source of waste heat is developed closer to the hospital, if the development plans are expanded, or if a large electricity-only customer is identified in the vicinity. The Council should continue to engage with the hospital and revisit this cluster should an opportunity arise in the future.

It is important to note that, while the lifetime cost of heat supply (representing the cost-effectiveness of the scheme) is one of the critical success factors, the cost of heat is relatively high for some of the highest scoring scheme options described above. This is particularly the case for the Immingham Town schemes S4.2 and S4.3, and the GIFHE scheme S2.3. The critical success factors are intended to highlight which scheme options align most closely with NELC's strategic objectives, but this does not necessarily mean that the highest scoring options will be deliverable.

We therefore examine the deliverability of the scheme options in the following section.

Figure 6-32: Weighted score of key scheme options against critical success factors



7 Delivery Models and Roles for NELC

7.1 Description of delivery models

There are a range of potential delivery models and financing structures that could be used to deliver a heat network in North East Lincolnshire. The delivery models that are typically employed for heat networks involve contractual arrangements between a project sponsor (for example a developer or local authority) and one or more service providers, which provide the various elements of design, construction and operation of the system[18]. The most appropriate model will depend on the circumstances of a particular scheme, including the balance of existing and new build buildings expected to connect to the system, the strength of the business case (e.g. the rate of return on investment in the scheme) and the appetite of various stakeholders to engage with delivery of the scheme.

The most commonly used contractual arrangement can be summarised as follows[19]:

- **Energy service company (ESCO) / utility** – An expert provider, such as an ESCO or utility, undertakes to design, build, finance and operate the heat network and to supply heat to customers within the area that become connected to the network.
- **Wholesale supply of energy (design, build and operate contract)** – A project sponsor contracts with a single provider to design, build, own and operate the heat network and to sell wholesale energy to the sponsor. The sponsor sells energy on to retail consumers (and may be a consumer itself).
- **Network delivery and operation** – The project sponsor contracts with multiple providers to design, build, operate and maintain a heat network, but the sponsor remains the owner of the assets. The sponsor enters into heat (and potentially electricity) supply agreements with consumers and may also handle fuel purchasing.

The role of the local authority within these delivery models can also take a variety of forms. These include:

- **Heat consumers** – local authority controlled buildings can provide significant heat demand. By agreeing to connect its buildings within a particular area to a heat network the local authority can help to provide the minimum guaranteed heat demand needed for the heat network business case to be viable.
- **Convening and influencing** – the local authority can influence developers, landlords and tenants to connect to the heat network using the range of planning and development control powers at its disposal, as well as influence as a land and property owner.
- **Contracting party** – the local authority can be more directly involved in driving establishment of a heat network. This could include provision of project finance in some form (see below) or by contracting with an ESCO that provides a full design, build, finance and operate (DBFO) solution (even in the latter case, although the local authority maintains no ownership of heat network assets, it may provide some form of financial contribution).
- **Joint venture** – the local authority could invest in a special purpose vehicle as a corporate joint venture, alongside an existing ESCO or other investors. The project delivery vehicle will then deliver the heat network (potentially contracting elements out to third parties) and supply heat and power to consumers.

A number of the roles for the local authority described above involve provision of a financial contribution of some form. Broadly the options for how a local authority, or other public sector bodies, could apply funding can be categorised as follows:

[18] See Appendix C for case studies of heat network delivery models involving local authorities.
[19] Based on 'District heating manual for London', GLA (2013)

- Grant funding (could be provided by the local authority or other public sector body, including national government or European Commission funding sources)
- Direct expenditure on public assets (e.g. buildings or land), including provision (sale or lease) of land and buildings
- Debt finance, in the form of low interest rate loans
- Equity investment in project vehicles

The Council should explore potential delivery models and financing options between now and the detailed feasibility stage. As part of the feasibility, the potential delivery model for each scheme option will be considered in more detail.

7.2 Deliverability of preferred scheme options

7.2.1 Public sector-led versus Private sector-led delivery

The economic assessment shows that none of the scheme options studied achieves an IRR of 6% or above without additional support from HNIP funding (or similar). A private sector-led scheme is likely to require a substantially higher IRR than this, typically at least 10% and possibly higher. As such, it appears likely that for the schemes to be deliverable, NELC will need to take a prominent role in funding the heat network, although this does not preclude private sector involvement. As presented in the economics analysis, even in this case a substantial level of support is likely to be required through HNIP or another source.

Nonetheless, discussions with NELC suggest that there is appetite within the Council to take a leading role in delivery of the scheme, and HNIP funding is available for the purpose of bridging the funding gap. As such, several of the scheme options studied could be deliverable under a Council-led approach.

An NELC-led delivery model could take any of the contracting arrangements described in the prior section, albeit that the lack of a commercially viable IRR means that a majority of public sector investment is likely to be required in all cases. It also seems reasonable to assume that a model which transfers the technical delivery and operational risk from the Council is likely to be preferred, although a delivery model in which the Council takes on a technical delivery and operational role should also be considered at detailed feasibility stage.

7.2.2 Required level of HNIP funding

An upper limit to the allowable level of HNIP funding was described in Section 6.1. To recap, the maximum level of support available for the generation plant component of the scheme is 45% of the difference between the capital cost of the proposed generation plant for the heat network, and the capital cost of the counterfactual plant. The maximum level of support for the network infrastructure component is 100% of the difference between the capital cost of the network and the lifetime operating profit expected for the network operator. In the case that the RHI is taken up, only the network infrastructure component may be supported by HNIP funding.

In order to understand whether the required level of HNIP funding to achieve a 6% IRR – and hence for the scheme to be potential deliverable under a NELC-led model – we have tested whether the required HNIP grant is within the upper limit for the allowable support. Table 7-2 presents the required HNIP grant as a fraction of the relevant capital cost; i.e. where RHI is also taken up, the capital cost of the network only; where no RHI is available, the capital cost of the generation plant and network infrastructure.

It can be seen that in all cases, the required HNIP grant is less than (or in one case equal to) the capital cost of the network infrastructure. Since none of the schemes achieve an IRR above 6% in the absence of HNIP funding, it could be assumed that the operating profit of the network operator would, in the absence of HNIP funding, be zero. On this basis, **the required funding to achieve a 6% IRR is within the allowable limit for all scheme options**.

It is important to note that this does not imply that HNIP would definitely be provided. The application for HNIP funding is via a competitive process, and the application would be assessed on a range of metrics including the short-term and long-term carbon savings, the carbon savings value for money, the social net present value and others. At this stage, we are able to comment on which scheme options provide the largest carbon savings and the best carbon savings value for money, and as such which may carry the highest likelihood of being funded through HNIP. All scheme options are based on a heat price that provides a 10% reduction on the counterfactual. The value of each heat network project to society as a whole is outside of the scope of this study. A comparison of the performance of each of the 5 selected schemes against the HNIP assessment criteria, is presented below in Table 7-1.

Table 7-1: Performance against HNIP assessment criteria

Scheme	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	CO_2 savings per £1,000 HNIP grant, tCO_2/£1,000	Heat price comparison
S2.3 – WSHP	29	4	10% reduction on counterfactual
S3.4 – Waste heat	75	9	
S4.2 – Waste heat	22	7	
S4.3 – Waste heat	26	5	
S5.2 – Waste heat	56	50	

Among the five highest scoring scheme options using the critical success factors aligning with NELC's strategic objectives, the lifetime carbon savings range from 22 $ktCO_2$ for Immingham Town scheme S4.2 with Waste heat to 75 $ktCO_2$ for the Cromwell Rd scheme S4.3 with Waste heat. In terms of carbon savings value for money, these are in the range 4 to 9 $ktCO_2$ per £1,000 grant for four of the schemes, and 50 $ktCO_2$ per £1,000 for the Stallingborough scheme S5.2 with Waste heat.

It is notable that for the GIFHE, Cromwell Rd and Immingham Town clusters, some of the less extensive schemes, which scored lower overall against the critical success factors, achieve a higher carbon savings value for money than the highest scoring scheme options (highlighted in green in Table 7-2). These less extensive schemes could provide a means of de-risking the heat network development project at detailed feasibility stage as they represent less ambitious, but potentially more deliverable, alternative scheme designs. At the detailed feasibility stage the phased expansion of less extensive scheme options into the more extensive schemes that score highly against the critical success factors should be fully assessed.

Table 7-2: Required HNIP grant as fraction of relevant capital costs

	Scheme	Total capital cost, £m	Network capital cost, £m	Funding gap at 6% including RHI, £m	Funding gap at 6% excluding RHI, £m	Minimum HNIP grant to achieve 6% IRR	CO_2 savings over 20 yr plant lifetime, $ktCO_2$	CO_2 savings per £1,000 HNIP grant, tCO_2/£1,000	No RHI: Grant as fraction of total capital cost (%)	With RHI: Grant as fraction of network capital cost (%)
DPoW	S1.1 – Gas CHP	7.0	4.1	2.8	2.8	2.8	-21	-7	40%	
	S1.1 – Biomass	5.8	4.1	3.7	7.0	3.7	46	12		90%
	S1.2 – Gas CHP	10.2	7	4.3	4.3	4.3	-25	-6	42%	
	S1.2 – Biomass	8.9	7	5.1	8.6	5.1	48	9		73%
GIFHE	S2.1 – WSHP	3.0	1.5	0.6	2.8	0.6	12	19		40%
	S2.2 – WSHP	8.5	5.9	2.6	6.4	2.6	18	7		44%
	S2.2 – Gas CHP	7.5	5.9	1.9	1.9	1.9	-18	-9	25%	
	S2.3 – WSHP	17.1	12.5	7.3	13.9	7.3	29	4		58%
Cromwell Rd	S3.1 – WSHP	1.9	0.8	0.3	1.8	0.3	8	30		38%
	S3.2 – WSHP	3.7	2.4	0.9	2.7	0.9	10	11		38%
	S3.3 – WSHP	7.4	2.4	1.4	7.4	1.4	29	21		58%
	S3.4 – WSHP	13.0	7.3	4.8	11.8	4.8	31	6		66%
	S3.4 – Gas CHP	11.5	7.8	4.9	4.9	4.9	28	-6	43%	
	S3.4 – Biomass	9.7	7.3	7.3	10.1	7.3	35	5		100%
	S3.4 – Geo (LT)	20.1	7.3	12.1	19.1	N/A	35	N/A	N/A	N/A
	S3.4 – Geo (HT)	20.1	7.3	11.6	18.6	N/A	36	N/A	N/A	N/A
	S3.4 – Waste heat	16.7	15.7	8.3	8.3	8.3	75	9	50%	
Immingham	S4.1 – Waste heat	3.1	2.9	1.5	1.5	1.5	15	10	48%	
	S4.1 – WSHP	2.3	1.3	0.8	2.3	0.8	8	10		62%
	S4.1 – Gas CHP	2.3	1.6	0.8	0.8	0.8	-5	-7	35%	
	S4.2 – Waste heat	8.0	7.8	3.1	3.1	3.1	22	7	42%	
	S4.3 – Waste heat	11.5	11.2	5.2	5.2	5.2	26	5	49%	
Stalling-borough	S5.1 – Waste heat	7.6	7.1	3.6	3.6	3.6	23	6	47%	
	S5.2 – Waste heat	11.1	9.7	1.1	1.1	1.1	56	50	10%	
	S5.2 – WSHP	14.7	8.2	6.4	12.7	6.4	23	4		78%

8 Summary of Opportunities, Risks and Recommendations

This assessment **has identified several potentially deliverable heat network scheme options** based on heat supply options including Waste heat, WSHP and Gas CHP. These schemes provide the opportunity to deliver multiple benefits across the region, including reduced energy costs to consumers, substantial carbon emissions reduction, improved local air quality and increased inward investment and local economic growth.

All scheme options studied achieve, in the absence of additional support, a **moderate to low IRR of 5% or below**. This suggests that the **most likely delivery model would be an approach led by NELC** investment, **supported by funding under HNIP** or a comparable source.

NELC have expressed a strong appetite for investment and leadership in heat network projects, providing they are aligned with the Council's wider objectives. It is understood that NELC investment in such projects is likely to require a return on investment of at least 6%. An analysis of the funding gap for the scheme options studied – that is, the amount of upfront funding required to achieve a 6% IRR overall – suggests that the level of support required is within the allowable limits for HNIP support. As such, a number of heat network projects could be viable, and have the potential to bring large benefits in terms of carbon savings, air quality impacts, affordable warmth and gross value added to the region.

The scheme options scoring highest in an assessment against NELC's critical success factors, and hence most closely aligned with the Council's strategic objectives, include the following:

- **GIFHE and around**: S2.3 with WSHP
- **Stallingborough Enterprise Zone**: S5.2 with Waste heat
- **Cromwell Rd and Great Coates Industrial Estate**: S3.4 with Waste heat
- **Immingham Town**: S4.3 with Waste heat
- **Immingham Town**: S4.2 with Waste heat

These scheme options, their potential benefits, the associated risks and our recommendations, are considered in turn below. A summary of the key risks is presented in Appendix F; a detailed assessment of the potential risks of each scheme option should be carried out during detailed feasibility.

8.1.1 GIFHE and around

Scheme S2.3, based on WSHP, has the **potential to reduce the heating costs of more than 1,000 households, of which nearly 80 are estimated to be at risk of fuel poverty**. The scheme could deliver lifetime **carbon savings of 29 $ktCO_2$** and contribute to local air quality improvement. For these reasons, this scheme option scores highest against NELC's critical success factors.

The **key risk for this scheme option is its deliverability**. The capital cost of the scheme is estimated to be £17.1m, and achieving a 6% project IRR would require HNIP grant support in the region of £7.3m. While this is within the allowable limits of HNIP support (as discussed in Section 7.2), this scheme option does not offer the same value for money as several of the other schemes studied here. As an indicator of this, the carbon savings value for money is 4 $ktCO_2$ per £1,000 grant, several times smaller than for a number of other schemes presented in Table 7-2. This suggests that an HNIP application for funding for this scheme option may be less competitive, and carries a higher risk of not being awarded the funding.

A way of de-risking this aspect of the scheme, and a **key recommendation, is to carry the less extensive scheme options for this cluster, S2.1 and S2.2 with WSHP, through to detailed feasibility stage**, as well as S2.3. These schemes, while scoring less highly against NELC's critical success factors than S2.3, carry a higher IRR and hence are **more likely to be deliverable**. They also offer better value for money for an HNIP grant in terms of carbon savings, achieving savings of 19 $ktCO_2$ and 7 $ktCO_2$ per £1,000 grant respectively.

A **further risk relates to the RHI**. Since this cluster is far from any existing source of waste heat, and biomass heating is not preferred due to the air quality impacts in this urban environment, WSHPs are the most suitable low carbon option. The economic case shown relies on the receipt of substantial RHI support. The continued availability and level of the RHI should be reviewed in the subsequent stages of feasibility study.

In addition, it is imperative that the **potential customers for the scheme, including GIFHE, continue to be engaged** by NELC and partners following this study and throughout the subsequent feasibility stages. At this early stage, the appetite for customers to connect to the heat network is not well-established, carrying a substantial risk relating to the demand for heat. In the later feasibility stages, greater certainty over the demand for connection to the network will need to be gained and the heat price discount required to ensure sufficient demand will need to be further investigated.

In order to maximise the likelihood of connection of any new residential developments, the Council should **leverage its position as land-owner (where relevant) in future negotiations with developers**, to ensure that commitments to connect buildings into any district heating network available on the site are stipulated in the contractual terms.

8.1.2 Stallingborough Enterprise Zone

The economic assessment suggested that a heat network at Stallingborough Enterprise Zone could, in the case that heat intensive users are attracted to the site (case S5.2), provide the most cost-effective option for a heat network of all those studied, with an IRR before HNIP support above 5%. This scheme could bring lifetime **carbon savings of 56 $ktCO_2$** and contribute to **significant inward investment** and improved industrial competitiveness. Grant support of £1.1m, to bridge the funding gap to 6% IRR, could bring excellent carbon savings value for money of 50 $ktCO_2$ per £1,000 grant.

The **key risk for this scheme option is that the businesses moving to the site do not provide the level of heat assumed** in the high heat demand scenario. The low heat demand scenario, S5.1 – which is more closely in line with the heat demand at the existing Europarc Business Park, an analogous development – was found to achieve a lower IRR of 1.2%. While this could still be deliverable with HNIP support, it would be more marginal.

In addition, the 5% IRR assumes the presence of a **waste heat source on the site** itself. This is deemed to be a realistic scenario on the basis of discussions with NELC and other stakeholders, but the failure of such a source to materialise represents an additional risk. The same scheme based on a WSHP is a potentially viable alternative, but this would also make the economic case marginal.

A further risk is that the **phasing** of the site is too gradual, reducing the heat sales over the lifetime of the network and impacting negatively on the economic case. In this initial analysis, we assume that the site is built out over several years only; a significantly slower build-out rate would lead to a reduced IRR.

The viability of this scheme is therefore in part **dependent on ongoing activity to encourage heat intensive users to the site** on the basis of (among the site's wider benefits) the potential for low cost energy. Where an Energy-from-Waste plant can be attracted to the site, this could provide a further pull factor for heat intensive users.

In terms of next steps, it is recommended that **further feasibility work for this scheme option is undertaken at such time that the site development plans are further progressed**, as the uncertainty relating to the energy demand at the current time precludes a more detailed analysis.

8.1.3 Cromwell Rd and Great Coates Industrial Estate

Scheme S3.4, based on Waste heat from the South Humber Bank area, could serve **250 new households**, bringing lifetime **carbon savings of 75 ktCO_2** and improving local air quality. A relatively large grant of £8.3m towards an overall capital cost of £16.7m could bring carbon savings of **9 ktCO_2 per £1,000 grant**.

Key risks to the deliverability of this scheme include the level of storage cooling demand among the **coldstores**, the counterfactual system type and operating cost and whether there are any constraints around the use of heat absorption chillers to provide that demand. Despite several attempts, it was not possible to engage the coldstores to explore these questions.

An additional risk relates to the **requirement to cross the railway** (twice) using the bridges highlighted in Section 6.2. It is strongly recommended that the implications of this are examined further in any further feasibility work.

A further risk relates to the **availability of a suitable waste heat source**. However, the waste heat source was assumed in the economic assessment to be within 6 km, including a fairly wide area stretching almost as far as the Port of Immingham in the direction of the South Humber Bank. It is therefore feasible that a suitable heat source such as a new EfW plant could be located closer to this scheme, which would improve the economic case and reduce the funding gap relative to the case shown here.

Similarly to the case for the GIFHE cluster, it is the case for the Cromwell Rd cluster that the less extensive schemes achieve a higher IRR, and are thus more likely to be deliverable, than scheme S3.4. This scheme achieves the highest score against NELC's critical success factors since it is more extensive and hence brings greater carbon savings and air quality impacts, and since the use of waste heat encourages greater investment in the area from EfW plant or other sources. However, the level of HNIP funding required is substantial, and it may be less likely to be receive the required support than the other scheme options in the cluster. Therefore, **it is recommended that the less extensive schemes in this cluster, S3.1, S3.2 and S3.3**, including the options supplied by a WSHP, **are also carried forward** along with S3.4 in any detailed feasibility study undertaken for this cluster.

Finally, the general risk that customers will not connect to the scheme applies here. It is helpful that many of the potential customers in this scheme are either public sector or new build homes on Council land, where the Council should be able to leverage its position as landowner to ensure connection to any heat network. However, these stakeholders should continue to be engaged ahead of and during the subsequent stages of feasibility work.

8.1.4 Immingham Town

Two schemes in Immingham Town, S4.3 and S4.2 based on Waste heat, were found to score highly against NELC's critical success factors. The most extensive scheme, S4.3, could provide heat to more than **900 households** and deliver lifetime **carbon savings of 26 ktCO_2**, if supported by a grant of **£5.2m**. Scheme S4.2 could serve **650 households** and deliver **carbon savings of 22 ktCO_2**, with a lower grant of **£3.1m**.

There is a risk to the deliverability of this scheme in that the analysis **assumes a suitable waste heat source (likely an EfW plant) is built within 1 km of the network**, based on discussions with the Council and key stakeholders. If a suitable heat source is not built within this distance, these scheme options are not likely to be viable.

However, an **alternative option for this cluster is a WSHP** serving the core scheme, S4.1. While this serves many fewer households and achieves lower carbon savings, due to its smaller extent, this represents a potentially viable alternative should the nearby waste heat source not materialise. Scheme S4.1 is also more likely to be deliverable than schemes S4.2 and S4.3 due to the smaller funding gap of £0.8m and higher carbon savings value for money in the case of HNIP support of 10

$ktCO_2$ per £1,000 grant. It is therefore **recommended that the core scheme S4.1, served by WSHP, is also taken forward** to any detailed feasibility stage work.

8.1.5 Summary

In summary, **each of the four clusters described above presents a viable opportunity** to deliver a heat network in North East Lincolnshire under a **public sector-led** delivery model, **provided that HNIP support can be obtained** to bridge the funding gap.

It is therefore recommended that all four clusters – GIFHE and around, Cromwell Rd and Great Coates Industrial Estate, Immingham Town and Stallingborough Enterprise Zone – could be taken forward to detailed feasibility stage. As noted above, however, it is expected that there would be value in progressing the analysis for Stallingborough Enterprise Zone at a later date, once there is a greater level of certainty over the development plans for the site.

As the selection of particular schemes for further study is made, it will be important for the right **balance** to be found between **alignment of the schemes with NELC's wider objectives** and the **deliverability** of the scheme. As described above, the schemes most closely aligned with NELC's critical success factors carry a greater risk of non-deliverability than less extensive schemes in the same cluster.

Given that there has only been one pilot round of HNIP funding, there is little information available to 'benchmark' the scheme options presented here against other schemes in terms of value of money for HNDU, and hence to inform the decision of which schemes to focus on. As such, it is recommended that NELC **engage with HNDU** to assist in making this decision, in order to find the right balance between ambition and likelihood of delivery in selecting the preferred scheme options to carry forward. Where possible, it is **recommended that both the more extensive and the less extensive (generally more deliverable) schemes be carried forward** in the analysis, in order to minimise the risk that no deliverable project materialises.

In any case, it will be imperative for NELC, and any consultants undertaking further work, to **continue to engage the relevant stakeholders** – whether potential customers, heat suppliers, railways, utilities, and others – to further **reduce uncertainty** and gather the information required to develop the detailed feasibility case.

9 Appendix A – Technical Assumptions

Table 9-1: Summary of technical assumptions

Item	Value	Unit	Comment
Efficiency			
Gas boiler	85%	%	
Gas CHP – electrical	28%	%	
Gas CHP – heat	52%	%	
WSHP	330%	%	
Geothermal – Low T (40ºC)	530%	%	
Geothermal – High T (55ºC)	650%	%	
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	50%	%	
Geothermal	50%	%	
Biomass boiler	50%	%	
Gas CHP	75%	%	
Capacity of auxiliary boiler and thermal storage			
Gas boiler	120%	% of peak demand	
Thermal storage	3 hours	Hours of annual average heat demand	
Carbon intensity			
Gas	185	gCO_2/kWh	
Waste heat	0	gCO_2/kWh	Assumed zero
Biomass	16	gCO_2/kWh	
Grid electricity – 2020	198	gCO_2/kWh	
Grid electricity – 2025	174	gCO_2/kWh	
Grid electricity – 2030	107	gCO_2/kWh	
Grid electricity – 2040	48	gCO_2/kWh	
Grid electricity – 2050	25	gCO_2/kWh	

10 Appendix B – Economic and Financial Assumptions

Table 10-1: Summary of economic and financial assumptions

Item	Value	Unit	Comment
Capital costs			
Gas boiler – Commercial and network-scale	72	£/kWth	
Gas boiler – Domestic	1,500	£/dwelling	
Gas CHP	844	£/kWth	
WSHP	1,440	£/kWth	
Geothermal	3,663	£/kWth	
Biomass boiler	402	£/kWth	
Thermal storage	962	£/m3	
Network: "A" factor (steel)	10,000	£/m^2	Cost per metre Ar + B, where r is the radius of the pipe
Network: "B" factor (steel)	250	£/m	
Network: "A" factor (plastic)	7,500	£/m^2	Cost per metre Ar + B, where r is the radius of the pipe
Network: "B" factor (plastic)	188	£/m	
Network: additional insulation cost	9	£/m	
Heat interface unit and heat meter – Domestic	1,630	£/dwelling	
Heat interface unit and heat meter – Non-domestic	2,878	£/connection	
Private wire infrastructure	300	£/m	
Plant replacement			
Generation plant – Lifetime	20	yrs	
Generation plant – Replacement cost	70%	% of initial cost	
Network			No replacement
Operating and maintenance costs			
Gas boiler	5%	% of capex/yr	
Gas CHP	1%	% of capex/yr	
WSHP	1%	% of capex/yr	
Geothermal	1%	% of capex/yr	
Biomass boiler	5%	% of capex/yr	
Network	0.4%	% of capex/yr	
Heat interface unit and heat meter – Domestic	4%	% of capex/yr	
Heat interface unit and heat meter – Non-domestic	4%	% of capex/yr	
Administrative and billing	11	£/MWh/yr	
Fuel purchase prices			

Gas – Domestic (2020)	36	£/MWh	Varies by year according to BEIS projections
Gas – Commercial/Public (2020)	24	£/MWh	
Gas – Industrial (2020)	17	£/MWh	
Electricity – Domestic (2020)	170	£/MWh	
Electricity – Commercial/Public (2020)	100	£/MWh	
Electricity – Industrial (2020)	100	£/MWh	
Electricity – Wholesale (2020)	53	£/MWh	
Gas – Domestic (2030)	45	£/MWh	
Gas – Commercial/Public (2030)	40	£/MWh	
Gas – Industrial (2030)	31	£/MWh	
Electricity – Domestic (2030)	187	£/MWh	
Electricity – Commercial/Public (2030)	130	£/MWh	
Electricity – Industrial (2030)	130	£/MWh	
Electricity – Wholesale (2030)	69	£/MWh	
Biomass	40	£/MWh	Fixed over time
Waste heat	Varies		Value of electricity foregone assuming Z-factor of 7 (varies over time)
Heat sales			
Heat sale price[20]	Varies		Calculated separately for each customer as 10% discount on counterfactual price of heat (assumed to be gas boilers)
Electricity sales			
Private wire	Varies		Unless otherwise stated assumed 80% of CHP electricity sales by private wire to Commercial/Public customers, 20% grid export. Private wire sale price equal to retail price. Typically £90-120/MWh.
Grid export	Varies		Equal to wholesale electricity price (varies over time). Typically £50-70/MWh.
Connection charges			
Developer connection charge	Varies		Calculated as the lifetime value of CO_2 savings (varies by time, supply option)
Avoided costs – Domestic gas boiler	1,500	£/dwelling	
Avoided costs – Domestic gas connection	550	£/dwelling	
Financial assumptions			
Economic lifetime	25	yrs	
Discount rate	6%	%	Typical hurdle rate for NELC investment
RHI tariffs			

[20] See worked example of the heat sale price below

Biomass boiler	2.08	p/kWh	All correspond to Large commercial biomass as >1 MWth
WSHP (Tier 1)	9.09	p/kWh	
WSHP (Tier 2)	2.71	p/kWh	

10.1.1 Worked examples - Heat sale price for 2017

Example heat sale price calculations for a typical domestic and non-domestic customer are shown in Table 10-2 and Table 10-3 respectively.

Table 10-2: Example domestic heat sale price calculation

	Item	Value	Unit
Heat demand	Annual heat demand	15	MWh/yr
Fixed cost	*Boiler Opex*	86	£/yr
	Fixed Standing Charge	76	£/yr
	Fixed Annualised Replacement Cost	128	£/yr
	Total fixed costs divided by heat demand	1.9	p/kWh
Variable cost	*Gas Unit Cost*	3.8	p/kWh
	Unit cost of heat (assuming 85% boiler efficiency)	4.5	p/kWh
Total cost	**Counterfactual price of heat**	**6.4**	**p/kWh**
	Discounted price of heat (10% discount)	**5.7**	**p/kWh**

Table 10-3: Example non-domestic heat sale price calculation

	Item	Value	Unit
Fixed cost	Marginal Boiler Opex	0.2	p/kWh
	Marginal Standing Charge	1.0	p/kWh
	Marginal Annualised Replacement Cost	0.1	p/kWh
Variable cost	*Gas Unit Cost*	1.8	p/kWh
	Unit cost of heat (assuming 85% boiler efficiency)	2.1	p/kWh
Total cost	**Counterfactual price of heat**	**3.4**	**p/kWh**
	Discounted price of heat (10% discount)	**3.0**	**p/kWh**

11 Appendix C – Sensitivity results

Table 11-1: Sensitivity results: heat demand, capex and opex, heat sale price and electricity sale price

		NPV, £m (25 yrs at 6%)				
	Scheme	**Central case**	**20% reduction in heat demand**	**30% increase in capex and opex**	**20% decrease in heat sale price**	**Assume all electricity is sold at wholesale price**
DPoW	S1.1 – Gas CHP	-2.8	-4.0	-5.3	-5.1	-3.4
	S1.1 – Biomass	-3.7	-3.9	-6.0	-6.1	N/A
	S1.2 – Gas CHP	-4.3	-5.8	-7.9	-7.0	-5.0
	S1.2 – Biomass	-5.1	-5.5	-8.4	-7.7	N/A
GIFHE	S2.1 – WSHP	-0.6	-0.8	-1.7	-1.3	N/A
	S2.2 – WSHP	-2.6	-3.1	-5.5	-3.9	N/A
	S2.2 – Gas CHP	-1.9	-3.2	-4.5	-3.2	-3.8
	S2.3 – WSHP	-7.3	-8.4	-13.3	-9.7	N/A
Cromwell Rd	S3.1 – WSHP	-0.3	-0.4	-1.0	-0.8	N/A
	S3.2 – WSHP	-0.9	-1.2	-2.2	-1.6	N/A
	S3.3 – WSHP	-1.4	-1.8	-4.2	-3.1	N/A
	S3.4 – WSHP	-4.8	-5.6	-9.5	-7.2	N/A
	S3.4 – Gas CHP	-4.9	-6.7	-9.0	-7.3	-5.5
	S3.4 – Biomass	-7.3	-7.7	-10.9	-9.7	N/A
	S3.4 – Geo (LT)	-12.1	-13.2	-19.5	-14.5	N/A
	S3.4 – Geo (HT)	-11.6	-12.8	-19.0	-14.0	N/A
	S3.4 – Waste heat	-8.3	-10.3	-13.8	-10.7	N/A
Immingham	S4.1 – Waste heat	-1.5	-1.9	-2.5	-2.0	N/A
	S4.1 – WSHP	-0.8	-0.9	-1.6	-1.3	N/A
	S4.1 – Gas CHP	-0.8	-1.2	-1.6	-1.2	-1.2
	S4.2 – Waste heat	-3.1	-3.9	-5.7	-4.0	N/A
	S4.3 – Waste heat	-5.2	-6.2	-8.9	-6.3	N/A
Stalling-borough	S5.1 – Waste heat	-3.6	-4.2	-6.0	-4.3	N/A
	S5.2 – Waste heat	-1.1	-2.5	-4.8	-2.9	N/A
	S5.2 – WSHP	-6.4	-6.8	-11.5	-8.2	N/A

Table 11-2: NPV discounted at 3.5% social discount rate for the five highest scoring scheme options

Cluster	Scheme	NPV, £m (25 yrs at 3.5%)	NPV, £m (40 yrs at 3.5%)
GIFHE	S2.3 – WSHP	-5.3	-1.3
Cromwell Rd	S3.4 – Waste heat	-5.8	-2.0
Immingham	S4.2 – Waste heat	-1.8	0.3
Immingham	S4.3 – Waste heat	-3.5	-0.8
Stallingborough	S5.2 – Waste heat	2.6	11.1

Of the five highest scoring scheme options, only S5.2 with Waste heat achieves a positive NPV at the 3.5% social discount rate based on a 25 yr project lifetime without a grant.

Gas CHP optimisation

This assessment assumes a single Gas CHP sized to the heat demand and appropriate run hours. When the unit is not running at full load, there is a small reduction in the electrical efficiency. It may therefore be preferable to install two smaller Gas CHP units, such that in the summer months, one unit can be turned off and the other run at a higher load, and hence at a higher efficiency. The additional cost of installing two smaller units would need to be balanced with the increase in electrical efficiency. By installing two smaller units rather than one large, the capex is likely to increase by around 10%[21] . Assuming the smaller unit can be run at full capacity for an additional 2,000 hrs, the average annual electrical efficiency is likely to increase from 28% to 30%. The increased electrical efficiency results in additional 6.6% electricity production and hence a 6.6% increase in revenues from electricity sales (assuming the same proportion is sold via private wire). The effect on the project economics is shown below for two scheme options. For these examples, the additional capex is outweighed by the additional revenues from electricity sales, although this has a small impact on the overall project economics. The optimal Gas CHP sizing and number of units should be considered further as part of the detailed feasibility stage should any of the selected scheme options be supplied by Gas CHP.

Table 11-3: Comparison of single CHP unit versus two CHP units – Immingham Town S4.1

	NPV (25 yrs at 6%), £m		
Customer	**Single 0.6 MW CHP unit**	**Two 0.3 MW CHP units**	**Difference**
Gas CHP capex	-0.51	-0.56	-0.05
Gas CHP replacement	-0.11	-0.12	-0.01
Electricity sales revenue	1.81	1.93	0.12
Total project NPV	-0.76	-0.70	**0.06**

[21] Bespoke Gas CHP Policy – Cost curves and Analysis of Impacts on Deployment, Ricardo-AEA for DECC, 2014

Table 11-4: Comparison of single CHP unit versus two CHP units – Cromwell Road S3.4

	NPV (25 yrs at 6%), £m		
Customer	**Single 3.2 MW CHP unit**	**Two 1.6 MW CHP units**	**Difference**
Gas CHP capex	-2.70	-3.00	-0.30
Gas CHP replacement	-0.59	-0.65	-0.06
Electricity sales revenue	6.90	7.35	0.45
Total project NPV	-4.87	-4.78	**0.9**

12 Appendix D – Breakdown of key capital costs and upfront revenues

Table 12-1: Breakdown of capital costs

		Capex, £m										Upfront revenue, £m		
	Scheme	Primary plant (excluding replacement)	Back-up boiler (excluding replacement)	Land costs	Connection to waste heat plant	Thermal storage	HIUs	Private wire	Distribution pipes (including link to waste heat)	Service pipes	Total capex	Developer connection charge	Avoided counterfactual capex	Total upfront revenue
DPoW	S1.1 – Gas CHP	2.2	0.6	0.03	N/A	0.18	0.04	0.06	3.7	0.1	7.0	N/A	N/A	N/A
	S1.1 – Biomass	1.1	0.6	0.03	N/A	0.18	0.04	N/A	3.7	0.1	5.8	N/A	N/A	N/A
	S1.2 – Gas CHP	2.4	0.7	0.03	N/A	0.20	0.7	0.06	5.6	0.5	10.2	N/A	0.9	0.9
	S1.2 – Biomass	1.2	0.7	0.03	N/A	0.20	0.7	N/A	5.6	0.5	8.9	0.2	0.9	1.1
GIFHE	S2.1 – WSHP	1.3	0.2	0.03	N/A	0.06	0.01	N/A	1.3	0.1	3.0	N/A	N/A	N/A
	S2.2 – WSHP	2.3	0.3	0.03	N/A	0.08	0.7	N/A	4.5	0.5	8.5	0.2	0.9	1.1
	S2.2 – Gas CHP	1.3	0.3	0.03	N/A	0.08	0.7	0.20	4.5	0.5	7.5	N/A	0.9	0.9
	S2.3 – WSHP	4.1	0.6	0.03	N/A	0.14	1.8	N/A	9.6	1.0	17.1	0.2	1.0	1.1
Cromwell Rd	S3.1 – WSHP	0.9	0.2	0.03	N/A	0.04	0.02	N/A	0.6	0.1	1.9	N/A	N/A	N/A
	S3.2 – WSHP	1	0.2	0.03	N/A	0.05	0.4	N/A	1.7	0.3	3.7	0.1	0.5	0.6
	S3.3 – WSHP	4.2	0.8	0.03	N/A	0.14	0.02	N/A	2.2	0.1	7.4	N/A	N/A	N/A
	S3.4 – WSHP	4.6	1.0	0.03	N/A	0.18	0.4	N/A	6.3	0.4	13.0	0.1	0.5	0.6

	Scheme	Capex, £m										Upfront revenue, £m		
		Primary plant (excluding replacement)	Back-up boiler (excluding replacement)	Land costs	Connection to waste heat plant	Thermal storage	HIUs	Private wire	Distribution pipes (including link to waste heat)	Service pipes	Total capex	Developer connection charge	Avoided counterfactual capex	Total upfront revenue
Cromwell Rd	S3.4 – Gas CHP	2.7	1.0	0.03	N/A	0.18	0.4	0.44	6.3	0.4	11.5	N/A	0.5	0.5
	S3.4 – Biomass	1.3	1.0	0.03	N/A	0.18	0.4	N/A	6.3	0.4	9.7	0.1	0.5	0.6
	S3.4 – Geo (LT)	11.7	1.0	0.03	N/A	0.18	0.4	N/A	6.3	0.4	20.1	0.1	0.5	0.6
	S3.4 – Geo (HT)	11.7	1.0	0.03	N/A	0.18	0.4	N/A	6.3	0.4	20.1	0.1	0.5	0.6
	S3.4 – Waste heat	N/A	1.0	0.03	1.0	0.18	0.4	N/A	13.7	0.4	16.7	0.2	0.5	0.7
Immingham	S4.1 – Waste heat	N/A	0.1	0.03	1.0	0.04	0.02	N/A	1.9	0.1	3.1	N/A	N/A	N/A
	S4.1 – WSHP	0.9	0.1	0.03	N/A	0.04	0.02	N/A	1.2	0.1	2.3	N/A	N/A	N/A
	S4.1 – Gas CHP	0.5	0.1	0.03	N/A	0.04	0.02	0.34	1.2	0.1	2.3	N/A	N/A	N/A
	S4.2 – Waste heat	N/A	0.2	0.03	1.0	0.06	1.0	N/A	5.0	0.7	8.0	0.4	1.3	1.7
	S4.3 – Waste heat	N/A	0.3	0.03	1.0	0.07	1.4	N/A	7.8	0.9	11.5	0.6	1.9	2.5
Stalling-borough	S5.1 – Waste heat	N/A	0.5	0.03	1.0	0.10	0.13	N/A	5.6	0.2	7.6	1.3	0.5	1.8
	S5.2 – Waste heat	N/A	1.4	0.03	1.0	0.28	0.13	N/A	8.0	0.2	11.1	3.2	1.3	4.5
	S5.2 – WSHP	5.1	1.4	0.03	N/A	0.28	0.13	N/A	7.6	0.2	14.7	1.3	1.3	2.6

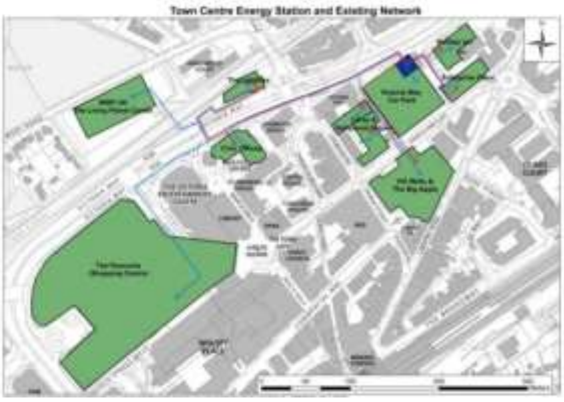
13 Appendix E – Case studies

13.1.1 Case study 1: Thameswey (Woking Borough Council)

- Set up by Woking Borough Council in 1999 as an Energy & Environmental Services Group
- Thameswey has set-up two ESCOs to deliver energy projects in Woking and Milton Keynes

Thameswey Energy Ltd (Woking)

- Set-up in 2000 to build and operate decentralised energy in Woking
- Heat network provides heat to > 170 commercial & domestic customers using Gas CHP
- Also supplies cooling and electricity



Thameswey Central Milton Keynes Ltd

- Set-up in 2005 to provide heat and electricity to central Milton Keynes
- Currently serves approx. 1,000 domestic customers

13.1.2 Case study 2: Southampton Geothermal Heating Company

- Set-up in 1986 to supply a heat network with heat from a geothermal borehole
- Local Authority played key role to facilitate development of the scheme, although the heat network company is wholly owned by a private company (ENGIE)
- Now the largest commercially developed heat network scheme in the UK:
    - 8 MW CHP engines plus boiler capacity
    - Absorption chillers for cooling
    - 14 km of pipework
    - Supplies over 1,000 residential customers, several large office buildings, a hospital, health clinic, university, large shopping centre, supermarket, hotels, sports complex etc.
- £5m in energy sales per annum
- £12m capital cost to-date
- 11,000 tonnes CO_2 saved per annum

13.1.3 Case study 3: Northern Gateway (Colchester Borough Council)

- A heat network supplied by WSHP is currently being developed at the Colchester Northern Gateway development

- The project has been successful in securing HNIP funding
- Colchester Borough Council (CBC) will establish a wholly council-owned SPV to deliver the district heating scheme.
- The SPV will be financed by the council’s Prudential Borrowing, a capital grant from the Heat Network Investment Project (HNIP) and council equity investment.
- The SPV will engage a contractor to construct the scheme under a design and build contract.
- The SPV will own the plant and network assets and is expected to also operate the scheme, although the council may explore the option of contracting O&M and billing functions to a third-party.

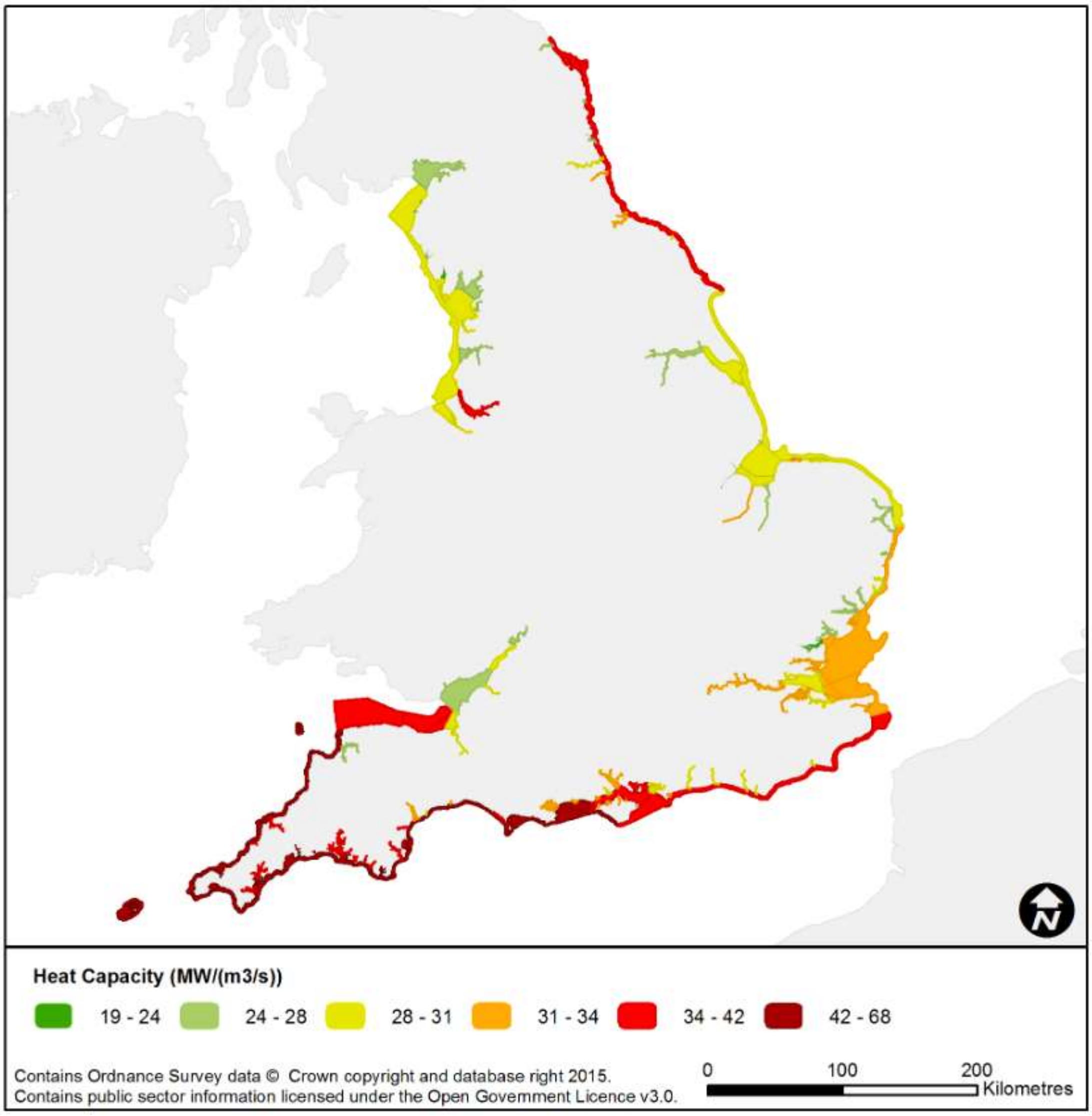
14 Appendix F – Summary of key risks

Table 14-1: Summary of key risks

Risk	Comment
Ability to attract customers to connect to heat network	In order to ensure sufficient heat sales to cover the high capital expenditure of installing a heat network, customers need to be willing to connect. This is particularly imported for the 'anchor' customers. A 10% reduction in heat sale price versus the counterfactual is included in the economic assessment to encourage potential customers to connect. Stakeholders have been engaged with throughout this process and discussions with potential anchor customers will continue throughout the detailed feasibility phase
Phasing of connections	It has been assumed that existing buildings will connect to the network from the outset and new builds will connect as they are completed. A delay in the connection of one or more buildings will result in reduced heat sale revenues and could impact the economic viability of the scheme. Potential connection dates should be discussed with relevant stakeholders at the earliest opportunity
Viability of potential heat sources	There are a number of potential existing and proposed sources of waste heat in the area however the viability and location of these sources is uncertain. Consultations have been held with a number of potential waste heat providers and there is a lot of interest in this area. Continued engagement with these stakeholders will be key to ensure all potential opportunities are considered fully. The viability of WSHP in each cluster area needs to be explored fully during detailed feasibility. At this stage, there is no reason to suggest WSHP will not be viable
Availability and level of the RHI	The economic viability of the schemes that are eligible for the RHI (WSHP, Biomass boiler and Geothermal) strongly depends on the availability and level of the RHI support. Of the five highest scoring scheme options, only GIFHE and around: S2.3 with WSHP is eligible for the RHI
Securing of grant funding	All of the scheme options assessed require a grant in order to reach a 6% project IRR. The ability to secure grant funding is therefore essential. The Council are working closely with HNDU to ensure the scheme options put forward offer the best chance of being awarded HNIP funding
Uncertainty over capital costs	It is difficult to predict the capital costs precisely at this stage. A sensitivity with capital and operating costs increased by 30% is shown in appendix D. At the detailed feasibility stage a project contingency should be included in the assessment

15 Appendix G – Water source and groundwater protection maps

Figure 15-1: Heat capacity per unit abstraction for coastal and transitional waterbodies[22]



[22] National Heat Map: Water source heat map layer, DECC (2015)

Figure 15-2: Lower Greensand aquifer map[23]

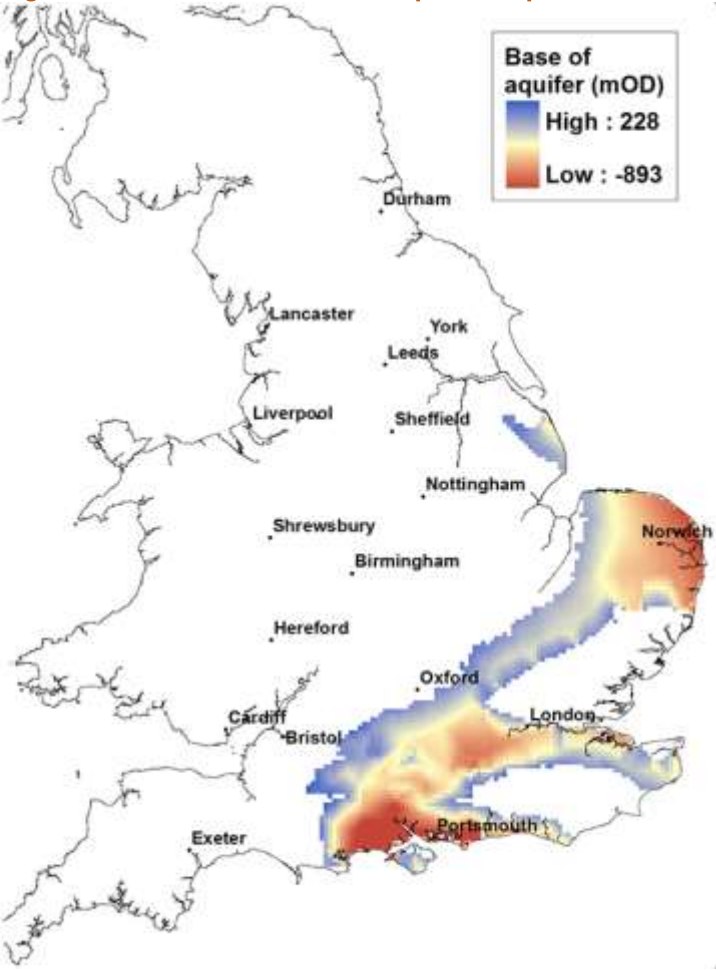
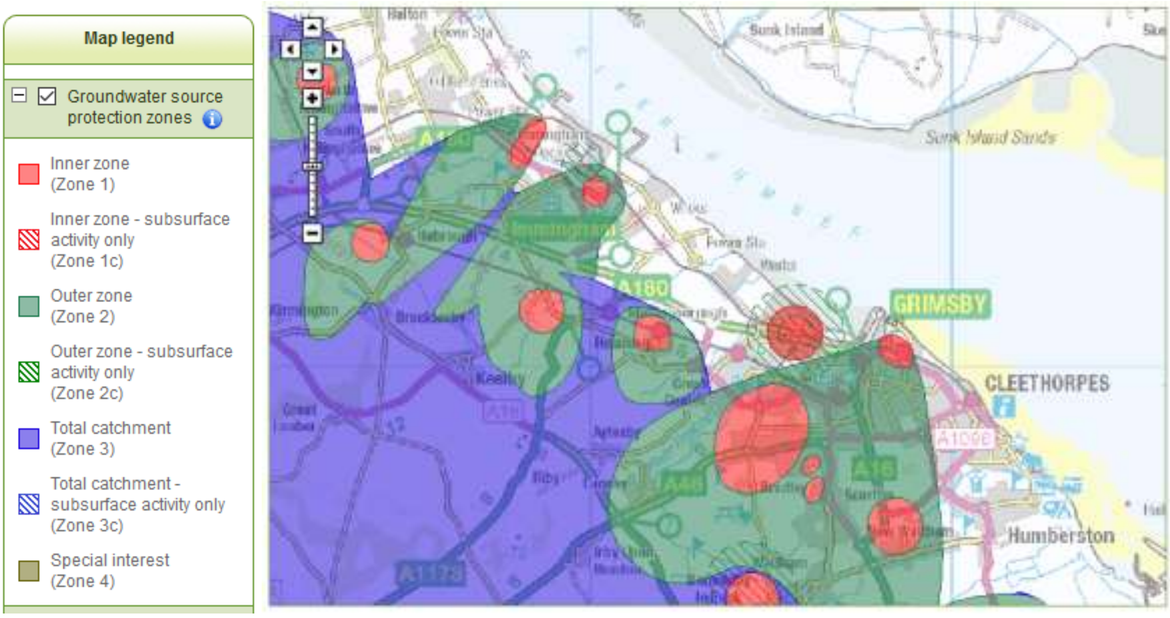


Figure 15-3: Groundwater source protection zones[24]



[23] British Geological Society
[24] Environment Agency

16 Appendix H – Combined heat source and heat demand figures

Figure 16-1: Heat demand and potential heat sources map for Grimsby and Cleethorpes and around

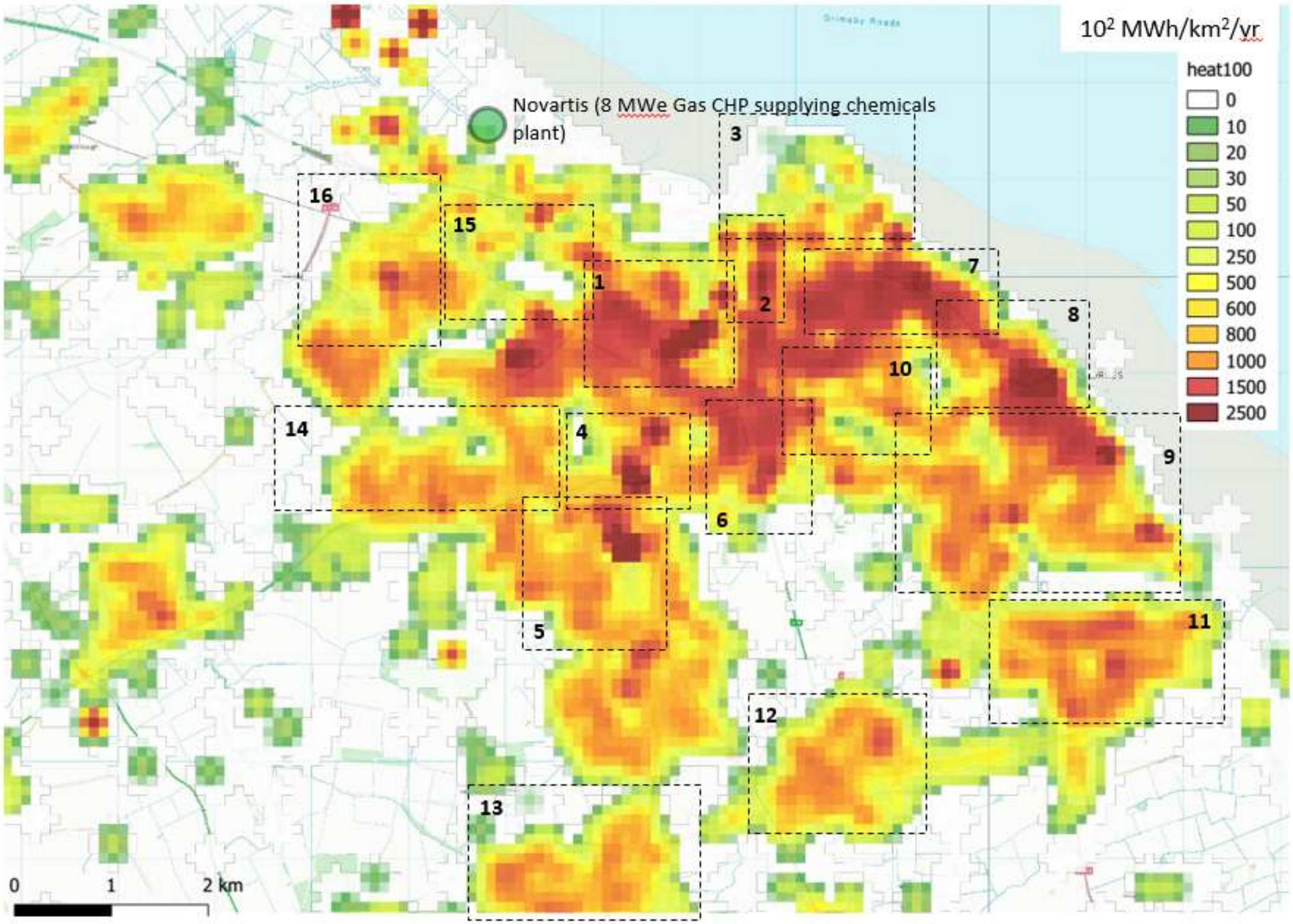
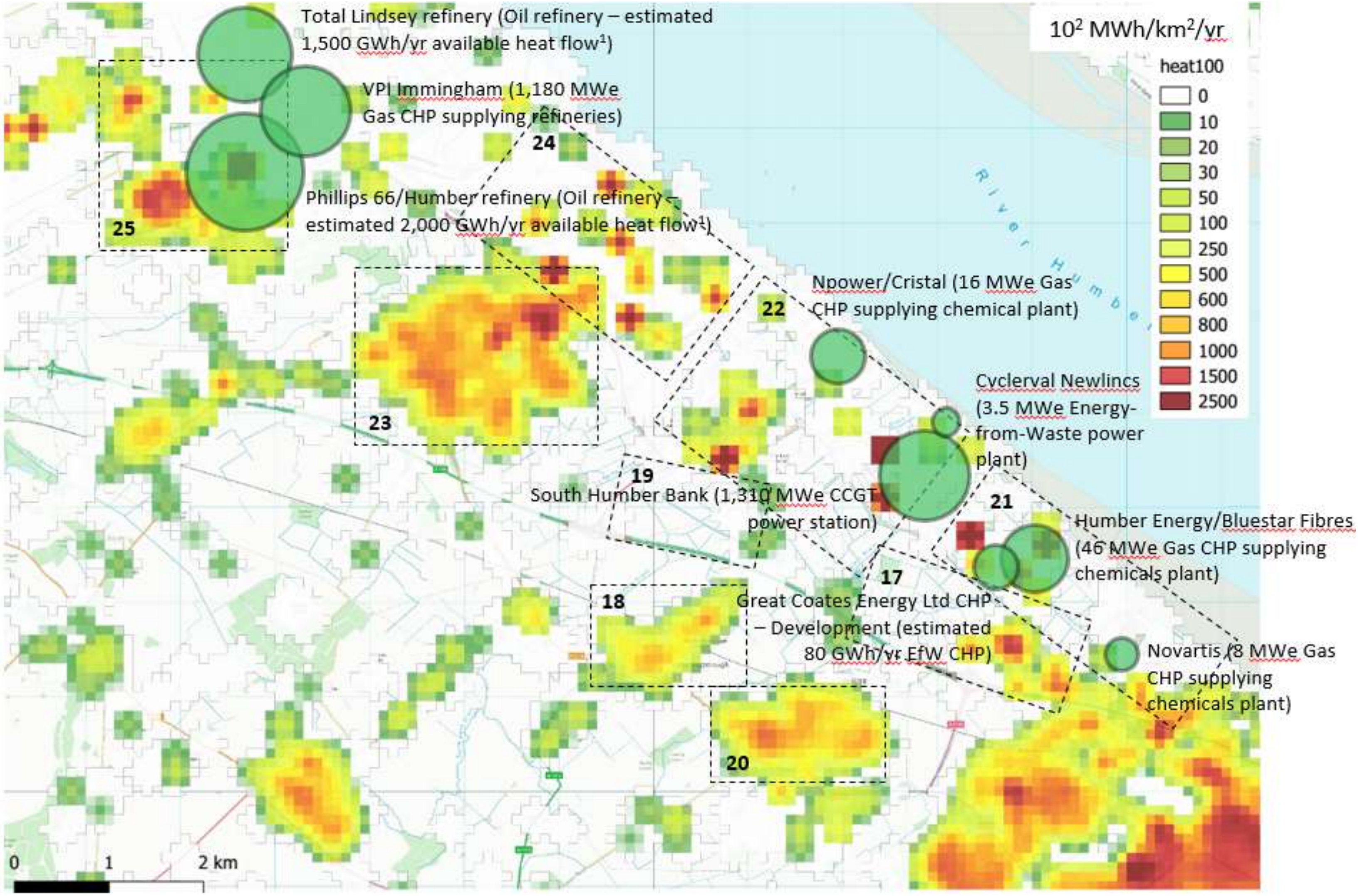


Figure 16-2: Heat demand and potential heat sources map for Immingham and around



17 Appendix I – Stakeholder Consultation Data

Building Name	Building Use	Internal Floor Area (m2)	Heating demand (kWh/yr)	Supply Plant Description	Fuel Type	Electricity demand (kWh/yr)	Total Gas spend (£/yr)	Total Electricity spend (£/yr)	Total Other fuel spend (£/yr)	Specify Other fuel	Data collection method	Confidence rating for data robustness (1=lowest, 4=highest)
Diana, Princess of Wales Hospital	Hospital		21,024,000	Gas CHP (800 kW electricity, 500 kW heat avg.) and Gas boilers (1.9 MW heat avg.), steam distribution	Gas	18,109,481					Building Owner (or Agent) Supplied Information	4
Grimsby Institute of Further & Higher Education	College		2,978,588			3,250,328	95,107	342,090			Building Owner (or Agent) Supplied Information	3
Grimsby Leisure Centre	Leisure Facility	3,215	1,251,884			748,679	72,995	101,213			Metered data from bills - provided by NELC/ENGIE	4
Immingham Leisure Centre	Leisure Facility	163	1,155,525			183,649	44,476	19,459			Metered data from bills - provided by NELC/ENGIE	4
Grimsby Swimming Pool - New	Leisure Facility	1,925	1,135,750			462,000		56			Metered data from bills - provided by NELC/ENGIE	4
Cleethorpes Leisure Centre	Leisure Facility	1,850	1,090,015			439,194	40,838	41,023			Metered data from bills - provided by NELC/ENGIE	4
Oasis Academy Immingham	School (Academy)	10,023	1,085,891	Multiple boilers / air conditioners	Gas	962,606	32,425	95,646			Building Owner (or Agent) Supplied Information	
Holy Family Catholic Academy	Comprehensive School	5,882	846,310			218,299	34,275	21,306			Metered data from bills - provided by NELC/ENGIE	4
Humberston Academy	School (Academy)		841,704			320,000						
Grimsby Crematorium	Cemeteries and Crematoria	384	839,528			84,611	31,451	9,235			Metered data from bills - provided by NELC/ENGIE	4

Tollbar Academy	Comprehensive School	12,591	827,414			925,874	32,304	89,023			Metered data from bills - provided by NELC/ENGIE	4
Grimsby Auditorium	Leisure Facility	2,591	781,976			254,413	31,974	30,391			Metered data from bills - provided by NELC/ENGIE	4
Healing School - A Science Academy	Comprehensive School	5,020	667,231			219,108	27,054	22,673			Metered data from bills - provided by NELC/ENGIE	4
Nunsthorpe and Bradley Park Children's Centre	Childrens Centre	754	491,841			72,371	19,440	7,880			Metered data from bills - provided by NELC/ENGIE	4
Cleethorpes Academy	Comprehensive School	6,192	458,744			435,716	18,564	42,769			Metered data from bills - provided by NELC/ENGIE	4
Market Hall	Market	3,247	449,751			510,165	18,215	49,807			Metered data from bills - provided by NELC/ENGIE	4
Civic Offices	Administrative Office	2,267	436,389			614,562	17,660	60,146			Metered data from bills - provided by NELC/ENGIE	4
Old Clee Primary Academy	Primary School	2,491	424,190			174,094	16,114	18,060			Metered data from bills - provided by NELC/ENGIE	4
Immingham Resource Centre	Community Resource Centre	1,435	378,912			84,695	15,355	9,788			Metered data from bills - provided by NELC/ENGIE	4
Welholme Academy	Primary School	2,488	377,256			158,703	15,297	16,142			Metered data from bills - provided by NELC/ENGIE	4
Signhills Academy	Junior School	1,791	345,474			140,608	13,190	15,572			Metered data from bills - provided by NELC/ENGIE	4
Thrunscoe Primary and Nursery Academy	Primary School	1,495	333,712			121,425	12,972	13,654			Metered data from bills - provided by NELC/ENGIE	4
HCF CATCH	Other Educational		332,582	Multiple gas boilers for heating, gas boilers for hot water and gas heaters in engineering workshop	Gas, and Elec for cooling	415,728	19,600	36,000			Current energy bills	4
Western Primary School	Primary School	1,738	327,532			82,976	13,273	8,977			Metered data from bills - provided by NELC/ENGIE	4
Cromwell House	Respite Care	297	327,093			72,596	13,197	7,900			Metered data from bills - provided by NELC/ENGIE	4
Scartho Infants' School and Nursery	Infant School	1,040	317,602			71,532	12,807	7,785			Metered data from bills - provided by NELC/ENGIE	4
Fairfield Academy	School (Academy)		302,931									

Waltham Leas Primary Academy	Primary School	1,701	287,187			166,301	10,947	17,052			Metered data from bills - provided by NELC/ENGIE	4
The Cambridge Park Academy	Special School	2,255	273,266			194,427	10,597	18,840			Metered data from bills - provided by NELC/ENGIE	4
Grimsby Town Hall	Administrative Office	1,451	270,603			80,485	10,922	8,681			Metered data from bills - provided by NELC/ENGIE	4
Yarborough Academy	Primary School	2,070	268,604			174,492	10,887	19,304			Metered data from bills - provided by NELC/ENGIE	4
Innovation Centre	Business and Enterprise Centre	2,448	266,063			213,958	10,770	22,631			Metered data from bills - provided by NELC/ENGIE	4
Lisle Marsden C of E Primary Academy	Primary School	2,818	261,642			177,837	9,973	17,758			Metered data from bills - provided by NELC/ENGIE	4
Reynolds Academy	Primary School	1,830	261,061			199,153	10,573	21,537			Metered data from bills - provided by NELC/ENGIE	4
Fairfield Academy	Primary School	1,708	251,539			116,332	10,181	12,557			Metered data from bills - provided by NELC/ENGIE	4
William Barcroft Junior School	Junior School	1,216	244,580			92,829	9,912	10,080			Metered data from bills - provided by NELC/ENGIE	4
Elliston Primary Academy	Primary School	1,914	241,834			96,001	11,243	10,755			Metered data from bills - provided by NELC/ENGIE	4
Lisle Marsden C of E Primary Academy	School	3,309	241,109	Gas central heating		177,438					Building Owner (or Agent) Supplied Information	3
Grange Primary School	Primary School	2,534	240,205			97,888	9,734	10,431			Metered data from bills - provided by NELC/ENGIE	4
Springfield Primary School (Academy)	Primary School	1,847	225,844			80,717	9,147	8,989			Metered data from bills - provided by NELC/ENGIE	4
Humberston Park Special School	Special School	1,426	223,173			161,606	8,496	17,171			Metered data from bills - provided by NELC/ENGIE	4
Oasis Academy Nunsthorpe	School (Academy)	3,554	214,914	5 x commercial boilers for heating 2 x andrews water heaters for hot water supply	Gas	182,076					Other	
Edward Heneage Primary Academy	Primary School	1,605	206,366			26,686	7,986	2,910			Metered data from bills - provided by NELC/ENGIE	4
Laceby Acres Academy	Primary School	1,493	197,047			78,027	7,983	8,487			Metered data from bills - provided by NELC/ENGIE	4

Allerton Primary School	Primary School	1,636	186,539			69,647	7,544	7,587			Metered data from bills - provided by NELC/ENGIE	4
Fishing Heritage Centre	Museum	1,089	185,080			114,268	7,483	12,209			Metered data from bills - provided by NELC/ENGIE	4
William Molson Centre	Administrative Office	742	181,569			49,329	9,261	5,384			Metered data from bills - provided by NELC/ENGIE	4
St Peter's C of E Primary	Primary School	1,220	180,990			65,289	7,318	7,062			Metered data from bills - provided by NELC/ENGIE	4
Edward Hennage Primary Academy	School (Academy)		177,270			160,000						
Municipal Offices	Administrative Office	2,385	164,200			223,425	6,650	23,171			Metered data from bills - provided by NELC/ENGIE	4
Humber Seafood Institute (HSI)	Business and Enterprise Centre	2,513	163,596			582,906	6,616	57,222			Metered data from bills - provided by NELC/ENGIE	4
Littlecoates Primary Academy	Primary School	1,317	153,889			73,351	6,213	8,016			Metered data from bills - provided by NELC/ENGIE	4
Queen Mary Avenue Infant & Nursery School	Infant and Nursery School	1,218	145,649			72,531	5,900	7,893			Metered data from bills - provided by NELC/ENGIE	4
Woodlands Academy	Primary School	1,753	130,241			112,380	5,267	10,866			Metered data from bills - provided by NELC/ENGIE	4
Coomb Briggs Primary School	Primary School	883	129,437			40,427	5,248	4,438			Metered data from bills - provided by NELC/ENGIE	4
Havelock Academy	School (Academy)		126,958			1,007,780						
Doughty Road Depot	Works Depot	3,243	126,643			269,665	5,123	26,503	27,814	Oil	Metered data from bills - provided by NELC/ENGIE	4
Thrunscoe Centre	Administrative Office	887	122,760			297,008	4,934	31,504			Metered data from bills - provided by NELC/ENGIE	4
The Humberston Church of England Primary School	Primary School	1,334	115,565			58,966	4,402	6,427			Metered data from bills - provided by NELC/ENGIE	4
Phoenix Park Academy (Phoenix House site)	Special School	904	111,235			23,385	4,493	2,599			Metered data from bills - provided by NELC/ENGIE	4
Healing Primary Academy	Primary School	1,220	107,058			104,229	4,328	12,188			Metered data from bills - provided by NELC/ENGIE	4
Allerton Primary School		2,301	15,854 m3 of gas	Natural Gas boiler		72,724	1.821 p/kWh	11.8250 p/kWh			Building Owner (or Agent) Supplied Information	3

Humberston Park Special School	School	2,743	144,536 oil, 279,882 gas	Main heating source is oil		161,261					Building Owner (or Agent) Supplied Information	3
The Elms (vacated)	Administrative Office	481	101,190			27,622	4,091	2,997			Metered data from bills - provided by NELC/ENGIE	4
Cleethorpes Library and TIC	Library	595	97,723			50,054	3,953	5,471			Metered data from bills - provided by NELC/ENGIE	4
Immingham West Fire and Rescue	Fire station	1,462	96,096	oil		105,438		11,404				
Stanford Junior & Infant School (Laceby)	Junior and Infant School	1,155	92,366			62,919	3,719	6,862			Metered data from bills - provided by NELC/ENGIE	4
Middlethorpe Primary Academy	Primary School	986	84,780			63,911	3,428	6,966			Metered data from bills - provided by NELC/ENGIE	4
Enfield Academy of New Waltham	Primary School	763	83,656			44,825	3,368	5,895			Metered data from bills - provided by NELC/ENGIE	4
Bradley Pitches	Parks and Open Spaces	0	83,196			107,173	4,219	12,099			Metered data from bills - provided by NELC/ENGIE	4
Poplar Road Business Units	Business and Enterprise Centre	2,498	80,449			157,315	4,072	16,499			Metered data from bills - provided by NELC/ENGIE	4
44 Heneage Road (vacated)	Administrative Office	281	78,876			20,611	3,186	2,298			Metered data from bills - provided by NELC/ENGIE	4
Alexandra Dock Business Centre	Business and Enterprise Centre	202	74,563			57,954	3,001	6,356			Metered data from bills - provided by NELC/ENGIE	4
The Knoll	Administrative Office	413	67,547			30,722	2,717	3,345			Metered data from bills - provided by NELC/ENGIE	4
Waltham Library	Library	309	64,262			25,458	2,584	2,778			Metered data from bills - provided by NELC/ENGIE	4
Broadway Childrens Centre	Childrens Centre	201	62,219			34,010	2,500	3,700			Metered data from bills - provided by NELC/ENGIE	4
Stallingborough C of E Primary School	Primary School	595	50,223			36,964	2,021	4,065			Metered data from bills - provided by NELC/ENGIE	4
St Joseph's Catholic Primary Voluntary Academy	Primary School	841	48,852			50,467	1,968	5,517			Metered data from bills - provided by NELC/ENGIE	4

Scartho Nursery School	Nursery School	515	43,238			27,639	2,174	3,051			Metered data from bills - provided by NELC/ENGIE	4
Doughty Learning Centre	Training / Conference Centre	131	42,392			5,732	1,703	695			Metered data from bills - provided by NELC/ENGIE	4
East Marsh Family Hub	Childrens Centre	304	40,785			32,635	2,058	3,551			Metered data from bills - provided by NELC/ENGIE	4
3 Town Hall Square	Administrative Office	217	38,536			19,208	1,935	2,147			Metered data from bills - provided by NELC/ENGIE	4
Unit 5 Acorn Business Park (Vacated)	Administrative Office	610	37,882			23,303	1,861	2,674			Metered data from bills - provided by NELC/ENGIE	4
419 Cromwell Road - Academy	Special School	289	37,323			20,992	1,505	2,344			Metered data from bills - provided by NELC/ENGIE	4
31 Heneage Road	Residential Home	146	34,904			23,359	1,738	2,649			Metered data from bills - provided by NELC/ENGIE	4
29 Heneage Road	Residential Home	124	31,274			15,407	1,560	1,759			Metered data from bills - provided by NELC/ENGIE	4
80 Cambridge Road	Respite Care	102	29,638			2,585	1,345	336			Metered data from bills - provided by NELC/ENGIE	4
3a Town Hall Square	Administrative Office	132	28,870			6,125	1,142	737			Metered data from bills - provided by NELC/ENGIE	4
Sevenhills Academy	Special School	847	28,523			48,949	1,160	5,252			Metered data from bills - provided by NELC/ENGIE	4
Eastfield Primary Academy	Primary School	1,464	26,180			116,742	1,291	12,673	8,132	Oil	Metered data from bills - provided by NELC/ENGIE	4
Great Coates Village Nursery School	School	422	26,000	Main heating system gas / electric mix	Gas and electric	31,000					Building Owner (or Agent) Supplied Information	3
507 Grimsby Road	Residential Home	116	25,381			11,601	1,252	1,381			Metered data from bills - provided by NELC/ENGIE	4
25 Scartho Road	Residential Home	0	24,641			8,537	1,198	990			Metered data from bills - provided by NELC/ENGIE	4
Whitgift Bungalow	Respite Care	69	22,946			4,959	1,115	589			Metered data from bills - provided by NELC/ENGIE	4
Great Coates Village Nursery School	Nursery School	278	22,513			30,005	1,113	3,315			Metered data from bills - provided by NELC/ENGIE	4
New Waltham Academy	Primary School	1,166	20,756			90,950	1,009	9,877	5,535	Oil	Metered data from bills - provided by NELC/ENGIE	4

139 Central Promenade	Administrative Office	32	19,069			5,863	927	739			Metered data from bills - provided by NELC/ENGIE	4
74 Second Avenue	Residential Service	75	13,511			1,891	657	294			Metered data from bills - provided by NELC/ENGIE	4
Education Development Centre	Surplus Property	1,095	11,162			20,293	415	2,509			Metered data from bills - provided by NELC/ENGIE	4
Trin Youth Centre (Closed)	Youth and Community Centre	277	10,223			9,773	508	1,088			Metered data from bills - provided by NELC/ENGIE	4
100 Saltergate	Residential Service	108	8,518			1,734	394	240			Metered data from bills - provided by NELC/ENGIE	4
The Elms Bungalow (vacated)	Surplus Property		8,414			623	409	104			Metered data from bills - provided by NELC/ENGIE	4
Bert Boyden Centre	Day Centre	374	6,844			43,208	853	4,648			Metered data from bills - provided by NELC/ENGIE	4
53 Whitgift Way	Residential Service	44	5,462			4,427	318	526			Metered data from bills - provided by NELC/ENGIE	4
St James House	Administrative Office	330	4,510			970	184	186			Metered data from bills - provided by NELC/ENGIE	4
Discovery Centre	Gallery	260	358			156,672	19	16,873			Metered data from bills - provided by NELC/ENGIE	4
Matthew Humberstone Voluntary Controlled C of E Lower School (former)	Surplus Property	3,388	175			10,369	9	1,702			Metered data from bills - provided by NELC/ENGIE	4
Archives Office	Administrative Office	438	0			48,550	0	4,362			Metered data from bills - provided by NELC/ENGIE	4
Welholme Galleries	Storage	214	0			3,414	0	446			Metered data from bills - provided by NELC/ENGIE	4
Bursar Primary Academy	Primary School	990	0			47,876	0	5,314			Metered data from bills - provided by NELC/ENGIE	4
Grimsby Central Library	Library	1,370	0			350,343	0	36,937			Metered data from bills - provided by NELC/ENGIE	4
Willowdene (incl Bungalow and Pine Lodge)	Respite Care	810	0			95,341	0	10,431			Metered data from bills - provided by NELC/ENGIE	4
Roval Drive Playing Fields/Sports Ground	Parks and Open Spaces	2	0			4,673	0	557			Metered data from bills - provided by NELC/ENGIE	4

Unit 5 Moss Road Industrial Estate	Industrial Unit	261	0			6,933	85	794			Metered data from bills - provided by NELC/ENGIE	4
Laceby Library (now run by Laceby Stanford School - as of 17-03-15)	Library	247	0			4,054	0	514			Metered data from bills - provided by NELC/ENGIE	4
Centre4 (Resource Centre)	Commercial Lease	2,913	0			107,625	0	11,527			Metered data from bills - provided by NELC/ENGIE	4
42 Alexandra Road	Surplus Property	117	0			818	0	123			Metered data from bills - provided by NELC/ENGIE	4
Poplar Road Offices	Surplus Property	250	0			2,282	0	281			Metered data from bills - provided by NELC/ENGIE	4
NEWLincs	Commercial Offices	420	0	Electric radiators	Electric						Building Owner (or Agent) Supplied Information	1
NEWLincs	Industrial	2,500	0	EfW CHP plant - Air cooled condensers (ACC) are used for recovery of steam turbine exhaust steam into condensate, the byproduct of this process is low-grade waste heat current not used, potentially this could be used for district heating.	Combusts 56,000 tonnes of municipal solid waste per year. Runs for 8000 hrs per year						Building Owner (or Agent) Supplied Information	1
Great Coates Primary School	School (Academy)	1,829	0	Natural Gas		Electricity Network	not yet known	not yet known			Assumptions Used	2
Springfield Primary Academy		3,092	0								Assumptions Used	2
Stallingborough C of E Primary School			0	Gas central heating							Estimated from bills	3
37 Campbell Grove	Residential Service	68				4,427		526			Metered data from bills - provided by NELC/ENGIE	4

14 Town Hall Street	Commercial Lease	85				37		86			Metered data from bills - provided by NELC/ENGIE	4
King George V Stadium	Leisure Facility	385				84,751		8,866			Metered data from bills - provided by NELC/ENGIE	4
Saint Mary's Catholic Primary Academy	Primary School	1,092				69,377		7,553	4,661	Oil	Metered data from bills - provided by NELC/ENGIE	4
Barretts Recreation Ground	Parks and Open Spaces	201				700		436			Metered data from bills - provided by NELC/ENGIE	4
Cleethorpes Business Centre	Business and Enterprise Centre	1,097				203,289		21,523			Metered data from bills - provided by NELC/ENGIE	4
Immingham Library (former)	Miscellaneous Lease	161				30,566		2,788			Metered data from bills - provided by NELC/ENGIE	4
East Ravendale Church of England Primary School	Primary School	524				37,268		4,095			Metered data from bills - provided by NELC/ENGIE	4
The Cedars (vacated)	Administrative Office	349				3,728		483			Metered data from bills - provided by NELC/ENGIE	4
Laceby Acres Primary - Caretakers House	Service Tenancy	66				0		46			Metered data from bills - provided by NELC/ENGIE	4
Poplar Road Former Depot	Surplus Property	890				41,953		4,603			Metered data from bills - provided by NELC/ENGIE	4
Humberston Cloverfields Academy	Primary School	1,179				43,625		5,008	395	Oil	Metered data from bills - provided by NELC/ENGIE	4
Boating Lake Car Park Toilets	Public Convenience	0				9,407		1,095			Metered data from bills - provided by NELC/ENGIE	4
Sussex Recreation Ground	Parks and Open Spaces	93				15,550		2,004			Metered data from bills - provided by NELC/ENGIE	4
Town Hall Square Toilets (closed)	Surplus Property	0				1,428		191			Metered data from bills - provided by NELC/ENGIE	4
Gilbey Road Depot	Works Depot	2,212				223,028		20,668	2,774	Oil	Metered data from bills - provided by NELC/ENGIE	4
Clee Youth Centre (former)	Miscellaneous Lease	339				59,576		6,517			Metered data from bills - provided by NELC/ENGIE	4
King George V Playing Fields - Taylors Avenue	Parks and Open Spaces	20				443		120			Metered data from bills - provided by NELC/ENGIE	4

Garibaldi Street Toilets	Public Convenience	31				6,712		778			Metered data from bills - provided by NELC/ENGIE	4
Poplar Road Playing Fields	Parks and Open Spaces	38				228		106			Metered data from bills - provided by NELC/ENGIE	4
Sea Road Toilets	Public Convenience	0				25,295		2,764			Metered data from bills - provided by NELC/ENGIE	4
Boating Lake	Parks and Open Spaces	105				74,521		8,302			Metered data from bills - provided by NELC/ENGIE	4
Grimsby Cemetery	Cemeteries and Crematoria	259				15,045		1,749			Metered data from bills - provided by NELC/ENGIE	4
Duke of York Gardens	Parks and Open Spaces	25				314		115			Metered data from bills - provided by NELC/ENGIE	4
Peoples Park	Parks and Open Spaces	116				68,753		8,232			Metered data from bills - provided by NELC/ENGIE	4
Abbey Walk Multistorey Car Park	Car Park (Multi-storey)	27				135,464		14,694			Metered data from bills - provided by NELC/ENGIE	4
Butt Lane Playing Fields	Parks and Open Spaces	78				1,424		235			Metered data from bills - provided by NELC/ENGIE	4
Mount Pleasant Playing Field	Parks and Open Spaces	30				1,019		273			Metered data from bills - provided by NELC/ENGIE	4
Land at Kings Road, Immingham	Off Road Motorbike Course					7,045		794			Metered data from bills - provided by NELC/ENGIE	4
Garibaldi Street Car Park	Car Park (Uncovered)	0				15,039		1,690			Metered data from bills - provided by NELC/ENGIE	4
Littlecoates Allotments	Allotments	10				2,561		353			Metered data from bills - provided by NELC/ENGIE	4
Cleethorpes Cemetery	Cemeteries and Crematoria	121				4,373		550			Metered data from bills - provided by NELC/ENGIE	4
Greenlands Open Space	Parks and Open Spaces	46				2,495		350			Metered data from bills - provided by NELC/ENGIE	4
Chapel Lane Playing Fields	Parks and Open Spaces	0				18		84			Metered data from bills - provided by NELC/ENGIE	4
Haverstoe Park	Parks and Open Spaces	69				1,333		225			Metered data from bills - provided by NELC/ENGIE	4

Jubilee Park	Parks and Open Spaces	48				492		135			Metered data from bills - provided by NELC/ENGIE	4
Cleethorpes Showground Caravan Park	Miscellaneous Lease	16				110,865		11,799			Metered data from bills - provided by NELC/ENGIE	4
Sidney Park	Parks and Open Spaces	41				1,015		191			Metered data from bills - provided by NELC/ENGIE	4
Hardys Recreation Ground	Parks and Open Spaces	0				314		69			Metered data from bills - provided by NELC/ENGIE	4
Heritage Centre Bandstand	Public Amenity	33				4,647		532			Metered data from bills - provided by NELC/ENGIE	4
65 Central Promenade	Commercial Lease					46,731		5,070			Metered data from bills - provided by NELC/ENGIE	4
Grant Street Public Toilets	Public Convenience	0				80		85			Metered data from bills - provided by NELC/ENGIE	4
Kingsway Toilets	Public Convenience	0				20,669		2,304			Metered data from bills - provided by NELC/ENGIE	4
St Peters Avenue Toilets	Public Convenience	56				9,919		1,146			Metered data from bills - provided by NELC/ENGIE	4
Grimsby Business Centre	Business and Enterprise Centre	1,535				185,243		19,727			Metered data from bills - provided by NELC/ENGIE	4
South Quay Business Units	Business and Enterprise Centre	350				59,076		6,323			Metered data from bills - provided by NELC/ENGIE	4
Nunsthorpe Business Units	Business and Enterprise Centre	355				44,732		4,902			Metered data from bills - provided by NELC/ENGIE	4
Watersports Centre	Miscellaneous Lease	133				166		53			Metered data from bills - provided by NELC/ENGIE	4
Scartho Junior Academy	Junior School	1,227				56,808		6,198			Metered data from bills - provided by NELC/ENGIE	4
Immingham Business Units	Business and Enterprise Centre	68				41,111		4,510			Metered data from bills - provided by NELC/ENGIE	4

Pumping Station at Doughty Road	Highway Infrastructure	0				5,539		632			Metered data from bills - provided by NELC/ENGIE	4
Pumping Station at Boulevard Avenue	Highway Infrastructure	0				1,765		190			Metered data from bills - provided by NELC/ENGIE	4
Pumping Station at Ellis Way	Highway Infrastructure	0				2,030		254			Metered data from bills - provided by NELC/ENGIE	4
Pumping Station at Catherine Street	Highway Infrastructure	0				490		133			Metered data from bills - provided by NELC/ENGIE	4
Pumping Station at Haycroft Avenue	Highway Infrastructure	0				2,288		328			Metered data from bills - provided by NELC/ENGIE	4
Origin 2 (Two)	Administrative Office	925				154,131		16,184			Metered data from bills - provided by NELC/ENGIE	4
Macaulay Childrens Centre (West Marsh)	Childrens Centre	148				24,901		2,710			Metered data from bills - provided by NELC/ENGIE	4
Pumping Station at Pasture Street	Highway Infrastructure	0				1,211		212			Metered data from bills - provided by NELC/ENGIE	4
Pumping Station at Patrick Street	Highway Infrastructure	0				865		175			Metered data from bills - provided by NELC/ENGIE	4
Units 1 and 2 Pyewipe Place	Storage					37,908		4,162			Metered data from bills - provided by NELC/ENGIE	4
Newby Centre	Commercial Lease	86				14,858		1,636			Metered data from bills - provided by NELC/ENGIE	4
Cleethorpes Craft Centre	Commercial Lease	351				4,039		470			Metered data from bills - provided by NELC/ENGIE	4
Meridian Park Events Arena	Leisure Facility	43				63,554		6,944			Metered data from bills - provided by NELC/ENGIE	4
Welholme Road/Peaks Parkway Junction	Highway Infrastructure					130		38			Metered data from bills - provided by NELC/ENGIE	4
Weelsby Road/Peaks Parkway Junction	Highway Infrastructure					0		35			Metered data from bills - provided by NELC/ENGIE	4
Victoria Street/Peaks Parkway Junction	Highway Infrastructure					323		61			Metered data from bills - provided by NELC/ENGIE	4
Victor Street/Cleethorpe Road Junction	Highway Infrastructure					746		114			Metered data from bills - provided by NELC/ENGIE	4

Tomline Street CCTV	Highway Infrastructure					341		72			Metered data from bills - provided by NELC/ENGIE	4
St Peter's Church - Clock only	Maintenance Liability					0		35			Metered data from bills - provided by NELC/ENGIE	4
Riby Square Junction	Highway Infrastructure					0		35			Metered data from bills - provided by NELC/ENGIE	4
Pollution Monitoring Unit - Woodlands Avenue	Highway Infrastructure	0				3,395		401			Metered data from bills - provided by NELC/ENGIE	4
Hainton Square Junction - 1	Highway Infrastructure					15,384		1,693			Metered data from bills - provided by NELC/ENGIE	4
Hainton Square Junction - 2	Highway Infrastructure					0		35			Metered data from bills - provided by NELC/ENGIE	4
Fryston Corner Junction (CCTV)	Highway Infrastructure					301		67			Metered data from bills - provided by NELC/ENGIE	4
Freeman Street/Strand Street Junction	Highway Infrastructure					204		57			Metered data from bills - provided by NELC/ENGIE	4
Freeman Street/Nelson Street Junction	Highway Infrastructure					414		79			Metered data from bills - provided by NELC/ENGIE	4
Freeman Street/Kent Street Junction	Highway Infrastructure					184		55			Metered data from bills - provided by NELC/ENGIE	4
Freeman Street/Duncombe Street Junction	Highway Infrastructure					194		56			Metered data from bills - provided by NELC/ENGIE	4
Cartergate/Frederick Ward Way Junction (CCTV)	Highway Infrastructure					56		32			Metered data from bills - provided by NELC/ENGIE	4
Freeman Street/Railway Street Junction	Highway Infrastructure					194		56			Metered data from bills - provided by NELC/ENGIE	4
Scartho Road/Scartho Park Junction	Highway Infrastructure					0		35			Metered data from bills - provided by NELC/ENGIE	4
Deansgate Bridge/Baxtergate Junction	Highway Infrastructure					25		37			Metered data from bills - provided by NELC/ENGIE	4
Deansgate Bridge/Bargate Junction	Highway Infrastructure					341		72			Metered data from bills - provided by NELC/ENGIE	4

Cleethorpes Country Park Toilets (closed to public)	Public Convenience	7				1,837		280			Metered data from bills - provided by NELC/ENGIE	4
Pumping Station at Wintringham Road	Highway Infrastructure	0				5,193		622			Metered data from bills - provided by NELC/ENGIE	4
Victoria Street Fountain	Maintenance Liability					4,712		589			Metered data from bills - provided by NELC/ENGIE	4
Riverhead Exchange	Public Amenity					249,351		25,760			Metered data from bills - provided by NELC/ENGIE	4
Pier Gardens	Parks and Open Spaces	0				0		82			Metered data from bills - provided by NELC/ENGIE	4
Central Promenade	Amenity Open Space					22,245		2,444			Metered data from bills - provided by NELC/ENGIE	4
Corporation Road Bridge	Highway Infrastructure	0				0		342			Metered data from bills - provided by NELC/ENGIE	4
Europarc Pond and Walkway (incl fountain)	Amenity Open Space					8,036		943			Metered data from bills - provided by NELC/ENGIE	4
Cartergate House	Commercial Leased	2,607				76,097						
St Mary’s Catholic Primary Voluntary Academy		1,944		Main heating system is oil		69,377					Assumptions Used	2