Carbon Alternatives

Central Lincolnshire Local Plan: Climate Change Evidence Base

Task J – Decentralised Energy Networks

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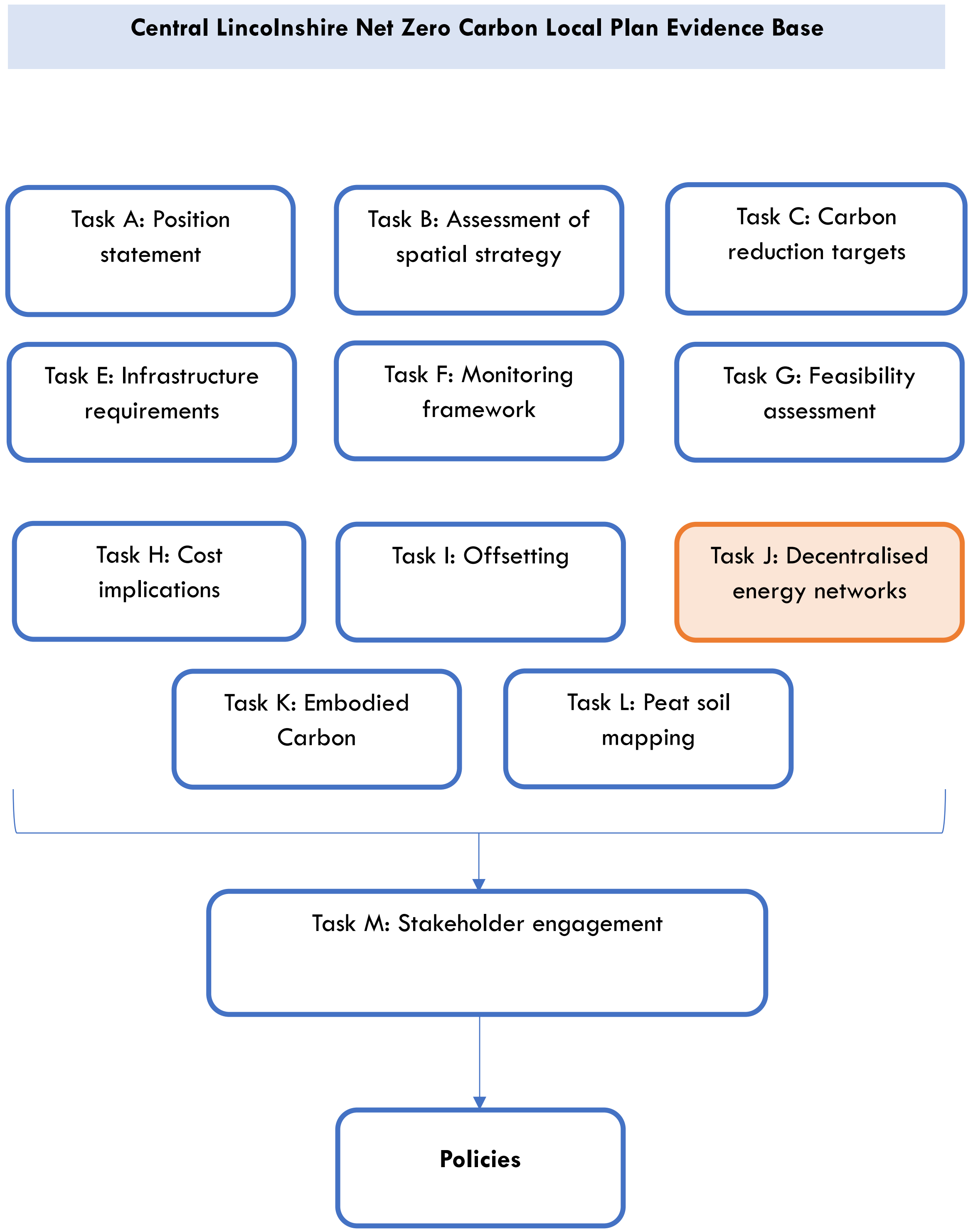
Our work on Task E (infrastructure requirements) has outlined the strategic direction for Central Lincolnshire to decarbonise electricity and heat. Part of the answer involves the development of heat networks for existing estates. This report focuses on the opportunity for heat networks across the region.

The assessment of the potential for heat networks has been based on data from the hotmaps.eu tool. The number of currently operating heat networks has been drawn from the most up to date estimates published by BEIS.

This is part of a wider set of analyses (shown in diagram to the right) to support the relevant local authorities in their stated commitments to combat climate emergency by transitioning their entire areas to net zero carbon by 2030 (Lincoln and North Kesteven) or no later than 2050 along with the national legislated goal (West Lindsey, and Lincolnshire County Council). It is also relevant to Lincolnshire County Council's Green Masterplan[i].



1 Overview of findings and recommendations

1.1 Heat networks are most able to reduce carbon emissions and costs when implemented for the benefit of existing building stock, rather than for thermally efficient new buildings, which have a much lower heat demand.

1.2 A key focus on heat networks should be in conservation areas, where maintenance of the building character makes additional insulation hard and in off-gas grid areas where heating fuels are more expensive and produce higher carbon emissions than natural gas.

1.3 That said, where renewable heat is already available nearby to new development then heat networks should be considered. Examples of available renewable heat sources situated nearby to proposed new development are the energy from waste plant in Lincoln and the biomass power station at Sleaford.

2 Decentralised Energy Networks

Introduction

2.1 Heat networks are systems that supply heat from a source (or multiple sources) to buildings, which is used for space heating and the generation of domestic hot water. This heat is generated in a central plant (see examples in Figure 1) and distributed through insulated pipework that is typically buried underground. Larger heat networks are known as district heating, while smaller networks are known as community heating.

Benefits

2.2 Heat Networks (HN) are beneficial in that they enable large existing sources of heat to be put to use over a wide area- e.g., waste heat from a power station.

2.3 HN are also beneficial because their operation - which can be more complex to optimise than traditional heating technologies- is undertaken by an expert HN operator. The end user is not involved in the technical and economic aspects of their energy, resulting in higher overall system efficiency. HNs also allow for a much faster shift to decarbonised heat generation than individual housing energy retrofits- such as replacing gas boilers in hundreds of homes for heat pumps- as a single change to the central HN plant can switch the heat source for hundreds of buildings. Figure 1 provides an overview of heat networks.

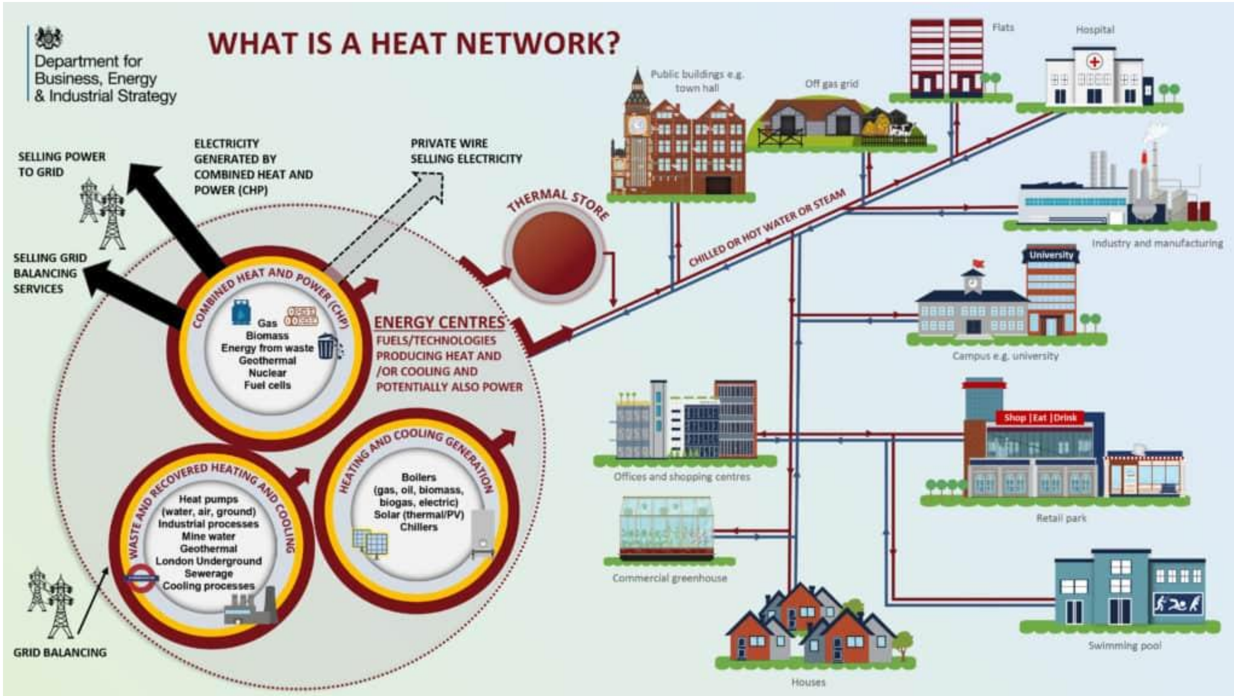


Figure 1 Introduction to Heat Networks source: BEIS

Adoption

2.4 While adopted on a smaller scale in the UK than many European countries[1], HNs are growing in popularity, with over 17,000 currently in operation[2]. For example, 10 Downing St is heated from a HN, and perhaps most notably, all buildings on the 2012 Olympic Park in East London. In response to the oil crisis in the early 1970s, the UK adopted natural gas (initially from the North Sea) to heat our homes. As of 2018, 85% of UK homes were heated with gas[3]. The Danish response to the same oil crisis was to develop HNs, and now 65% of Danish homes are heated from HNs[4] . The high adoption in the Danish energy system has allowed a rapid increase in the proportion of heat from renewables, reaching 59% by 2017[5]. This energy is sourced from waste plants, biomass, solar thermal, heat pumps and surplus wind generation.

Viability

2.5 The pipe infrastructure for HNs is expensive to install, so to make an economic case for a HN, the heat demand for a geographical area must be high. The 'heat density' maps below (Figure 3 and Figure 4) show the heat density in MWh / ha for the Central Lincolnshire area. The areas of highest heat density tend to be the historic centres of cities, towns and villages- places that are often conservation areas to preserve the character and heritage of the buildings. The importance of maintaining the character of such buildings makes any retrofitting options that would impact their visual appearance difficult. This includes, for example, external insulation/cladding, energy-efficient glazing, and interior wall insulation. Additionally, ground or air source heat pumps in such locations can also be challenging due to space constraints and visual impact. As such, HNs with a low carbon heat source can be the optimal route to the decarbonisation in the absence of many other alternatives. The second set of maps (Figure 6 and Figure 7) indicate the conservation areas within the Lincolnshire Combined Authority area, which correlate highly with the areas of high heat density. New residential developments, built to good energy efficiency standards, will require energy of around 50 MWh/ha, which is low compared to the heat demand densities of existing built-up area.

2.6 A heat network will be more environmentally and economically beneficial where the existing heating infrastructure/fuels are expensive and/or higher carbon. Typically, this is the case in off-gas grid areas where LPG (liquid petroleum gas), electricity or oil are used. Such areas should also be a focus for the consideration of HNs.

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[1] https://post.parliament.uk/research-briefings/post-pn-0632/
[2] https://www.theade.co.uk/assets/docs/resources/Heat%20Networks%20in%20the%20UK_v5%20web%20single%20pages.pdf
[3] Decarbonising Heat BEIS 2018
[4] https://www.euroheat.org/knowledge-hub/district-energy-denmark
[5] https://www.euroheat.org/knowledge-hub/district-energy-denmark

2.7 The final piece in the HN jigsaw is determining the most viable low carbon or renewable heat source for an area. Until recently, the preferred low carbon heat source for HNs were gas-fired combined heat and power (CHP) plants, as these systems generated high return-on-investment, and the heat and power produced less carbon emissions than traditional fossil-fuel energy. But as the UK energy grid has decarbonised in recent years, the CO2 saving arising from gas-fired CHP has reduced. As the grid continues to decarbonise (see Figure 2), a gas-fired CHP HN will no longer provide an overall carbon saving over the lifetime of equipment, when compared with other renewable sources of heat.

2.8 For the study, we have reviewed available data to identify potential heat sources that could be used to provide heat to a heat network. As the economic viability of HNs improve with scale, opportunities to heat more than 200 houses are more likely to be feasible.

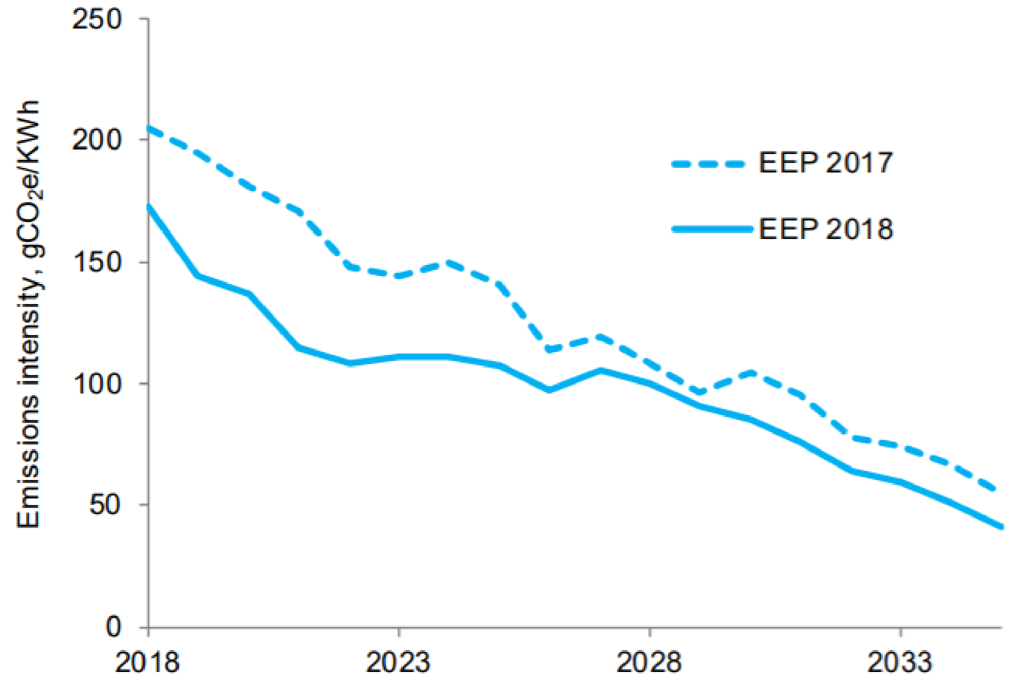


Figure 2 Projected emissions trajectory for Electricity in the UK (BEIS, 2019)

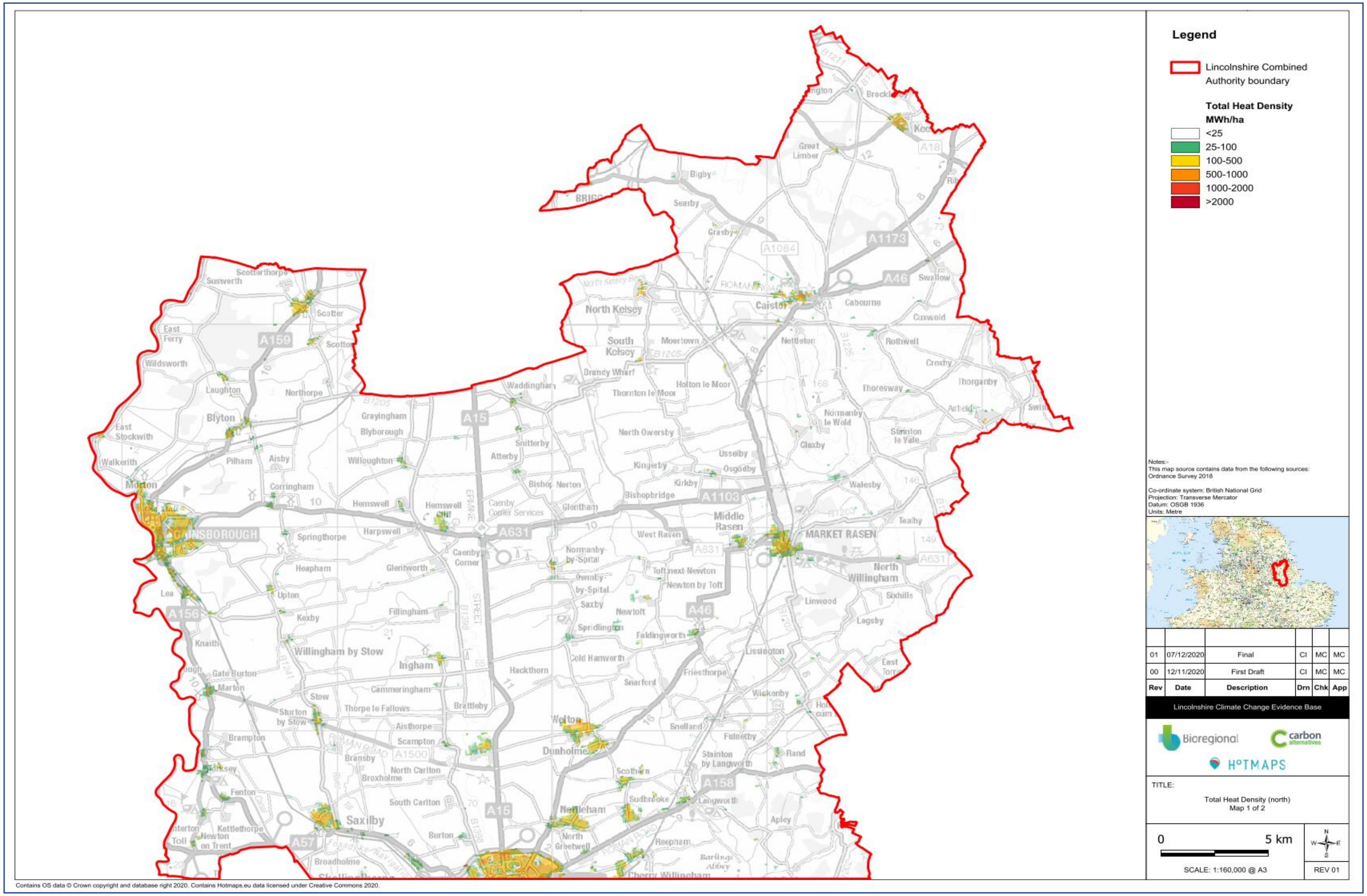


Figure 3 Heat Demand Density (MWh/ha) for the northern part of Central Lincolnshire

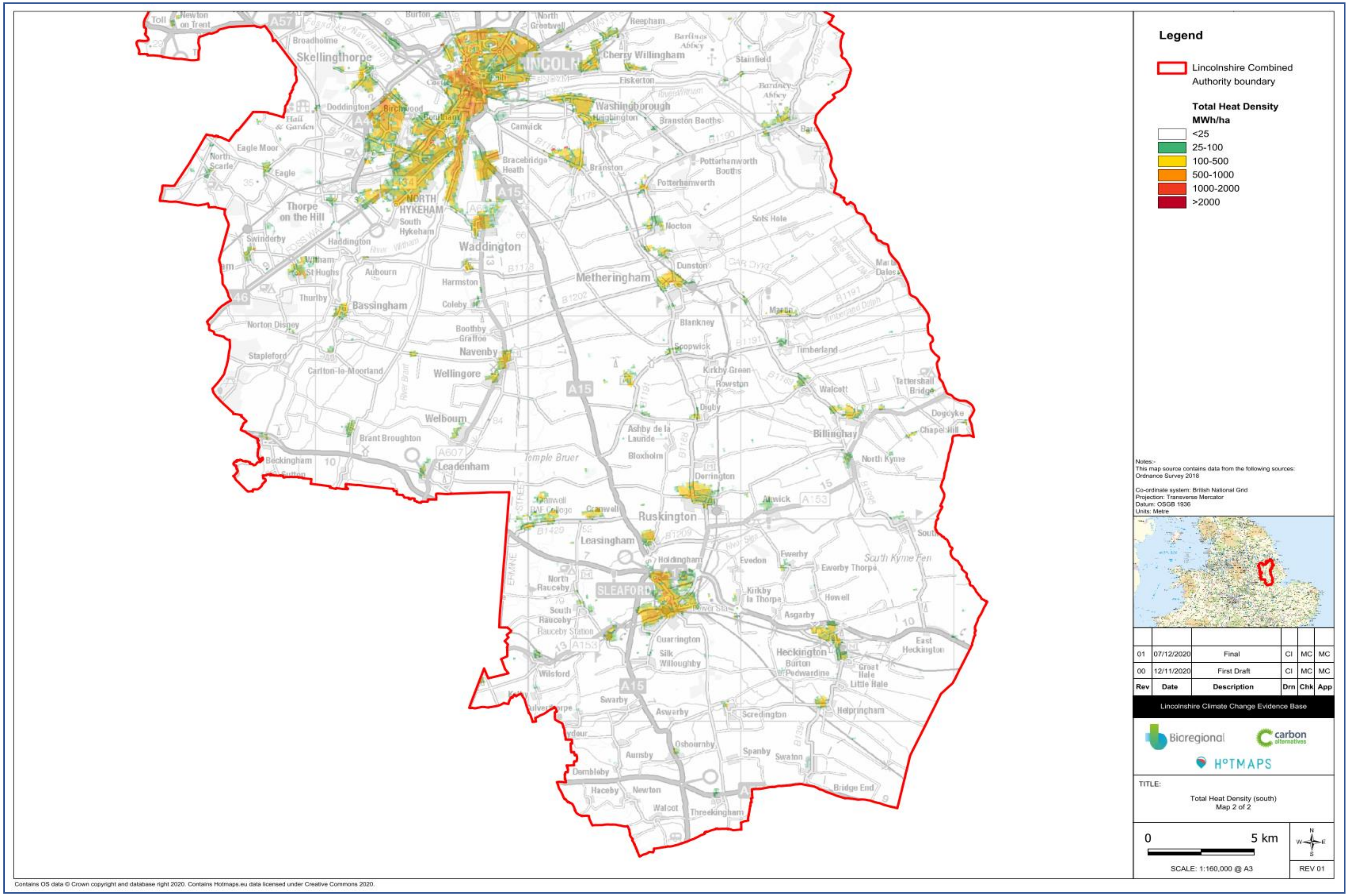


Figure 4 Heat Demand Density (MWh/ha) for the southern part of Central Lincolnshire

3 Identified available low carbon heat sources

3.1 Air source and ground source heat pumps use heat sources that are readily available everywhere, i.e. transferring heat from underground, or from the surrounding air, into a building. Biomass being transportable is similarly possible anywhere, but the fuel costs and sustainability credentials will vary with the type of fuel used and the delivery distance, and there are issues with impact to air quality particularly in more urban settings. The 2011 Aecom Central Lincolnshire Energy Study indicated a large biomass resource. Based on the relatively low uptakes of the Renewable Heat Incentive (RHI) (as of October 2020 there are only 908 domestic biomass boilers receiving RHI in the whole of the East Midlands) it is assumed much of this resource remains available. In more rural areas, where land is available, solar thermal can be used to supply heat to heat networks. This is fairly common in Denmark, (see Figure 5- note the heat network energy centre and thermal storage visible in the background).

3.2 However, the localised heat sources identified in Figure 6 and Figure 7 are typically cheaper to access and /or are higher temperature and so have lower heat generation costs. As such heat networks utilising these localised sources are likely to lead to lower lifecycle costs and higher carbon savings.

3.3 The following section highlights the possibility of the identified sources for generating renewable heat within the Lincolnshire Combined Authority.

Figure 5 Solar thermal for town heat network in Denmark. Source: Carbon Alternatives.

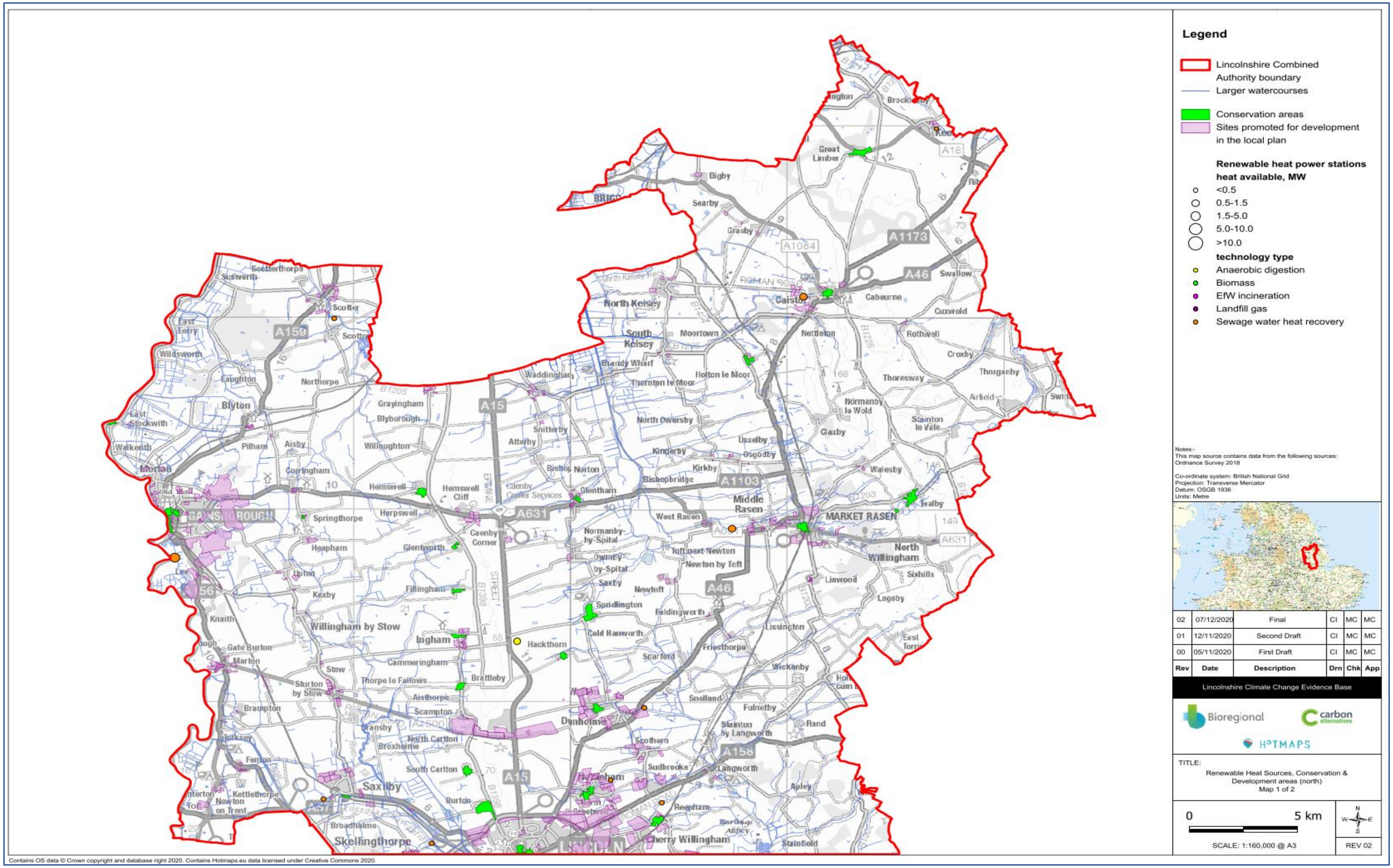


Figure 6 Renewable heat sources, proposed development areas and conservation areas in the northern area of Central Lincolnshire

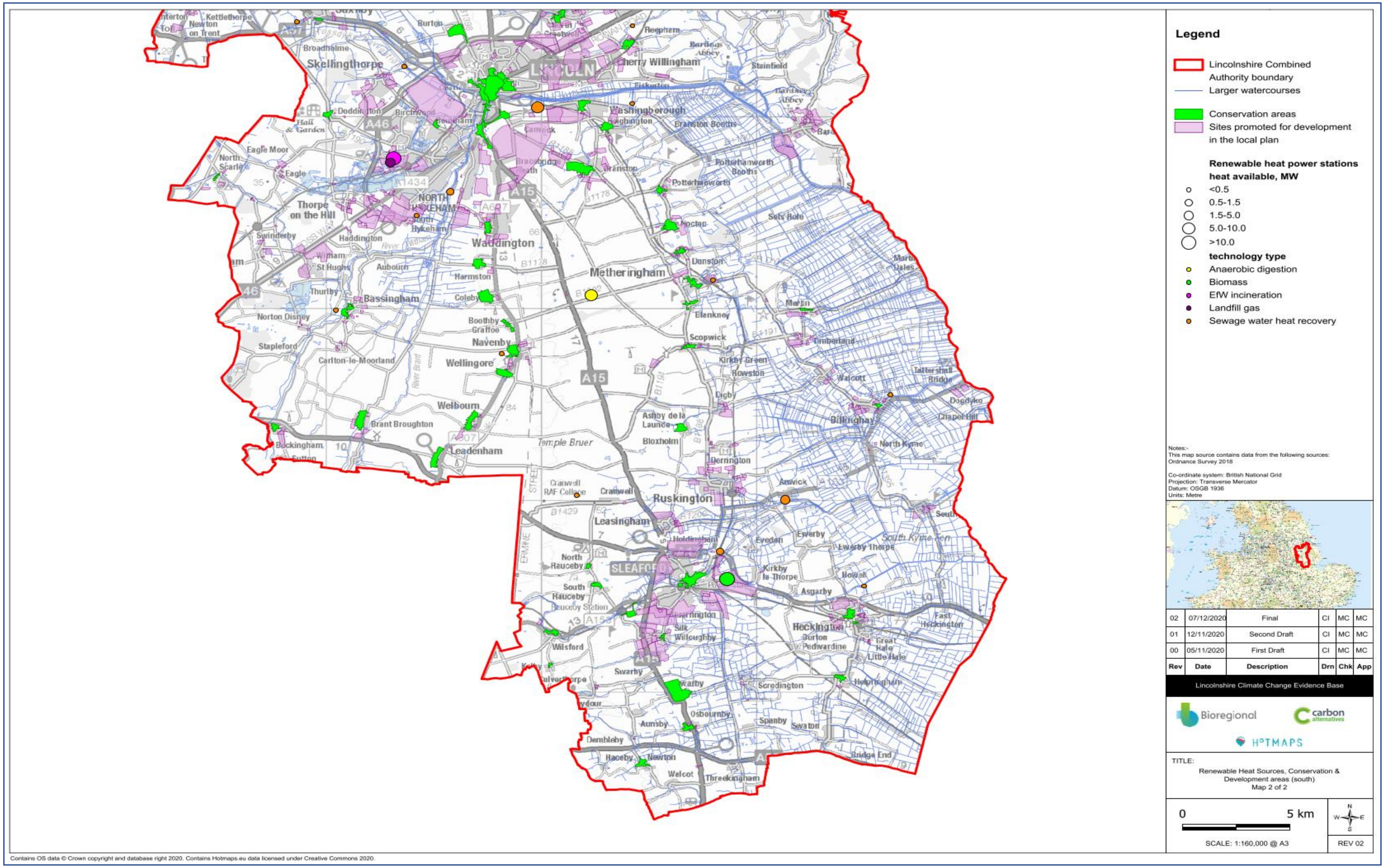


Figure 7 Renewable heat sources, proposed development areas and conservation areas in the southern area of Central Lincolnshire

Rivers/water sources

3.3 Water is a powerful source of heat as it is easier to extract large quantities of heat from water than from the air. At the coldest times of the year, where space heating demand is highest, surface water in the environment is typically warmer than the air. This increases the efficiency of water source heat pumps over air source heat pumps. All the watercourses in Central Lincolnshire are marked on the maps above (Figure 6 and Figure 7), but the key opportunities for water source heat pumps are:

- River Witham passing through Lincoln
- River Trent passing through Gainsborough
- River Slea passing through Sleaford

Waste heat sources

3.4 Waste heat sources are typically at higher than ambient temperatures and so allow for higher efficiency heat pump operation. In rare instances, the waste heat is available at temperatures that are sufficient to use directly in a heat network. Available datasets that identify potential industrial waste heat sources- Hot Maps and work by Durham University[6]- identified no industrial sources in the study area. The potential sources below were found whilst reviewing other data. They are all examples of heat provided by all-year-round refrigeration loads.

- Moy Park Chicken – Anwick - possible refrigeration loads are a waste heat source, and
- Tulip Meat Ruskington possible refrigeration loads are a waste heat source
- Large supermarket refrigeration is a viable heat source.

3.5 Another positive effect of heat use from refrigeration systems is that the collection of waste heat improves the efficiency of the refrigeration plant. This increases carbon savings and produces an economic benefit to the host site.

Energy from Waste (EfW) plants

3.6 Lincoln EfW (Figure 8) is located 5 km south-west from the centre of Lincoln. It generates 16.4MW of electricity, resulting in over 30MW of available heat. This is sufficient to heat over 20,000 dwellings - around half the homes in Lincoln. Therefore implementing a EfW HN is not a question of the availability of heat, but rather the economics and acceptability of the HN from this source. Lincoln's EfW plant is listed as being 'CHP enabled' which means the plant has been designed with the possibility of extracting some heat. The design approach typically extracts steam which offers high-temperature heat but at the cost of a small reduction in electricity generation.

The landfill site on which the Lincoln EfW has been constructed has 2MWe of generation that uses the gases generated by the decomposition of the waste in the landfill. A typical 1MWe (the 'e' referring to the equivalent electrical output) landfill gas typically generates 700kW of heat from the engine, that has to be rejected (like the radiator for a car engine) and another 700kW in the exhaust. The addition of a heat exchanger would allow the heat in the exhaust to be collected for use. The engine heat is all at a temperature that can be directly used in a heat network. Over time the generation of landfill gases from the waste decreases and so this is not a long term source of heat after the landfill stops having new waste added, but the heat is free and easily connected and the 2MWe of generation could provide up to 3MW of heat.

Figure 8 Lincoln Energy from Waste (EfW) facility Source: FCC Environment

Power stations

3.7 Sleaford Renewable Energy Plant is 650m from the eastern edge of Sleaford. The plant burns straw and generates 40MW of electricity, resulting in over 50MW of heat being potentially available. This heat could supply in excess of the heat demands of the 9,500 houses, and the non-domestic heat loads in Sleaford. The station supplies heat to several buildings in the town centre already making this an easier opportunity for increasing the number of buildings supplied by a HN.

Sewage

3.8 Sewers are warmer than ambient temperatures and their flow provides a continuous stream of available heat. Both factors make sewage works a suitable heat source for heat pumps, which can then supply a HN. There are 22 sewage works where heat recovery may be possible in Central Lincolnshire. These are marked up in Figure 6 and Figure 7 with their approximate size.

[6] www.mygridgb.co.uk/waste-heat-map/

Anaerobic Digestion (AD) plants

Anaerobic Digestion is the process by which organic matter such as animal or food waste is broken down to produce biogas and biofertilizer. Commonly the biogas generated is then used in a generator to generate electricity and heat. Some of the generated heat is needed for the AD process, but commonly there is surplus heat which could be directly used in a heat network. Two AD plants have been identified and are shown in Figure 6 and Figure 7. In the main the heat available is small and the locations quite distant from heat loads that could be served by a heat network.

Extension of existing heat networks

3.9 The extension of an existing network is the lowest cost route to expanding the number of buildings served by a HN, as the cost and risks of building and operating an energy centre are avoided. Additionally, with a heat network already operating in the neighbourhood, the unfamiliarity and uncertainty of becoming a heat network customer is lessened. The number of heat networks that are currently operating is estimated in Table 1. Most of the networks only serve a single building and so probably have less capacity to expand, although this is not always the case as often the plant installed for a newer network is significantly oversized. The expansion of an existing network may also create an opportunity to decarbonise the currently operating heat network. New renewable heat plants can be installed to serve both the new and existing HN and the older, most probably gas-fired plant, retained as a back-up heat source for the enlarged network. Such a development could benefit both the new and the existing HNs.

Local Authority Name	Estimated number of heat networks
North Kesteven	5
Lincoln	25
West Lindsey	7
Total	48
Estimate of single building communal heating systems	41
Estimate multi-building heat networks	7

Table 1 Estimated number of heat networks in Central Lincolnshire

Recommendations: Heat network target areas

3.10 New developments, especially as proposed in this plan, need little heat and so the high infrastructure cost of HNs leads to a high cost for the carbon saved. Where possible the money would be more effectively spent on installing HNs to existing buildings. We suggest the focus for HNs should consider the following:

3.10.1 Off gas grid areas where the alternative fuels (oil, LPG, electricity) are used, at a higher cost and carbon.

3.10.2 Conservation and similar areas where historic building types are hard to insulate without impacting on character. Hence low carbon heat from a HN is one of the limited number of options for this predominantly solid wall and high heat demand stock. These are identified in Figure 6 and Figure 7 in green.

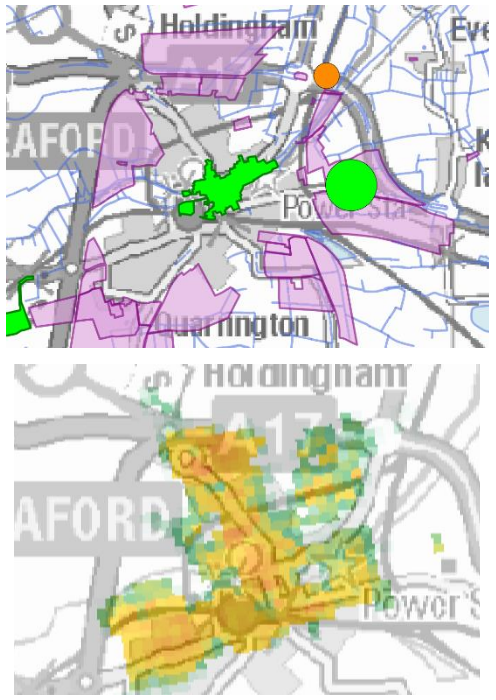
3.10.3 Where there are easily available renewable heat sources eg close to EfW plant, biomass power station and industrial waste heat sources (eg food factories with large refrigeration). Figure 6 and Figure 7 identify such heat sources.

3.10.4 Extension of existing HNs into neighbouring areas. This could be retrofitting or for new developments.

3.10.5 HN to new development should only be considered when the development is in close proximity to an identified low carbon heat source and the development is larger than 100 homes. In this case, the lower cost of the heat source may offset the higher cost of the HN pipework to the new development. We suggest HN connection is considered where the distance between the heat source and the heat load is less than c.500m. The most relevant identified heat sources are the Lincoln EfW plant and Sleaford Renewable Energy Plant, both of which produce high-temperature heat that might be able to be used directly in a heat network. The attractiveness of a HN is also increased when supplied to mixed-use development which should have a more continuous heat demand profile.

Example area for focus

3.11 As an example, the town of Sleaford has been picked to show the possible heat demands, heat sources and tool for further assessment.



Map detailing possible renewable heat sources. The green spot indicates the possible heat recovery from a Biomass Power Station, the orange dot is a sewage treatment location. Also identified are conservation areas (green) and potential new development areas (purple) where

Heat demand density map, showing heat demand around the centre of town, which gives an indication of the possible viability of heat networks across all areas of the town

Figure 9 Maps detailing potential renewable heat sources and heat demand density for the town of Sleaford, Central Lincolnshire.

Other relevant datasets

3.12 Other datasets are available at http://www.domesticenergymap.uk/ which indicate the areas of highest fuel poverty, lowest EPC rating and highest gas use. Such data sets can be used to help focus on the consideration of HNs in the areas of greatest need.

3.13 The potential for HNs and the economic limits to their extent can be assessed at a high level by the online tool Thermos https://www.thermos-project.eu/home/. Thermos assesses the economics of the connection of every building by estimating the capital cost of connection and heat sales value of each building and designs a network that achieves the required economic returns. Where data is known (e.g., specific building heat demands, heat generation costs, etc.) this can be entered into Thermos to improve the accuracy of the assessment.

4 Recommendations

5.1 An in-house 'champion' and dedicated staff resource is needed to drive the opportunities identified forward. The economics are complex with ever-shifting grant opportunities and other support mechanisms for HNs and renewable heat sources, and the opportunity factors are not just technical.

5.2 Apply for BEIS/HNDU funding to explore the feasibility of HNs based on:

- the Lincoln EfW plant
- the Sleaford Power Station

5.3 The above two options are the most viable heat sources, and the Sleaford Power Station already serves a HN. In Sleaford, connection to the existing HN should be encouraged at every opportunity. Whilst these studies are conducted, outputs from the BEIS pilot heat network zoning will start to become known and a similar approach could be adopted for Lincoln and Sleaford.

5.4 Use of Thermos to identify other locations where heat networks have higher viability - guided by the recommendations in this document. BEIS is currently developing an improved database of waste heat sources which would improve this analysis.

5.5 Potential Local Plan policy wording on HNs could include: "The use of heat networks providing heating will be encouraged in new developments within the threshold criteria set out below":

- "Within 500m of an existing district heat network"
- "Within 1km of renewable or waste heat source"

5.6 If these criteria are met, a feasibility assessment for HN will be required for:

- All residential developments for 100 dwellings (including off-gas areas)
- All applications for non-domestic developments above 1000m2 floor space"

[i] Lincolnshire County Council (2020), *Environment and Planning: Green Masterplan.* https://www.lincolnshire.gov.uk/green-masterplan