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PRELIMINARY FEASIBILITY ASSESSMENT FOR ROLLING OUT 5GDHC TECHNOLOGY IN 7 FOLLOWER REGIONS

EAST MIDLANDS

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1. Introduction

Activities in the Long-term work package aim to sustain and roll out D2Grids outputs to a wide variety of target groups, including policymakers, financial investors, professionals, SMEs and other companies in the DHC industry, as well as to new territories ("follower regions"). Transnational roll-out beyond pilot sites will be facilitated by assessing replication potential of 5GDHC in these follower regions and preparing specific local action plans. The regional vision development and preliminary feasibility assessment for rolling out 5GDHC technology is carried in this deliverable for each of the 7 follower regions defined for this project, namely: Parkstad Limburg (NL); North-East France; Luxembourg; Flanders (BE); Ruhr-area (DE); Scotland; East Midlands (UK). It aims to define ambitions for low-carbon heating & cooling and to assess the feasibility and potential of 5GDHC's roll-out.

The D2Grids project, has ambitious goals for the future. Five years after the project ends, 2 million m^2 of floor area in North-West Europe should be served by 5GDHC, of which 1.5 million m^2 by scaling up the D2Grids pilots and 0.5 million m^2 by rolling out into the follower regions. The overall capacity of these 5GDHC systems should be 180,000 MWh/a, including 100,000 MWh/a additional renewable energy source capacity. 10 years after the end of D2Grids, the total floor area should be 5 million m^2 and the overall capacity 450,000 MWh/a. This document presents a template for regional vision development, which describes ambitions of each of the follower regions on how the region can contribute towards this goal of 0.5 million m^2 of floor area after 5 years. To inform this regional vision, a preliminary feasibility assessment is conducted first (see D.LT.1.1).

The goal of the feasibility assessment is to find the potential of deploying 5GDHC in the follower regions within 5 years after the project ends, as well as finding possible longer-term opportunities. This is done by mapping strengths, weaknesses, barriers and opportunities of 5GDHC for each of the follower regions. The assessment consists of 5 categories: renewable sources; existing infrastructure and planned developments; thermal demand & supply profiles; legal & policy framework; financing options.

UK Context

"The UK was the first major economy to create a legally binding target to bring greenhouse gas emissions to net zero by 2050. This target was set considering the latest scientific evidence and was recommended by the Climate Change Committee (CCC), the UK's independent climate advisory body. The net zero target also responds to the overwhelming public support for acting on climate change. In recent surveys of the UK public, 80% of participants expressed concern about climate change."

UK National Policy References

- HM Government, Industrial Strategy
- HM Government, The Clean Growth Strategy: Leading the way to a low carbon future
- Ten Point Plan for a Green Industrial Revolution (2020)
- Net Zero Strategy – Build Back Greener (2021).
- Energy Security Bill (including provision for Heat Network Zoning)

Key policies:

- An ambition that by 2035, no new gas boilers will be sold.
- A new £450 million three-year Boiler Upgrade Scheme will see households offered
- grants of up to £5,000 for low-carbon heating systems so they cost the same as a gas boiler now.
- A new £60 million Heat Pump Ready programme that will provide funding for pioneering heat pump technologies and will support the government's target of 600,000 installations a year by 2028.
- Delivering cheaper electricity by rebalancing of policy costs from electricity bills to gas bills this decade
- Further funding for the Social Housing Decarbonisation Scheme and Home Upgrade Grants, investing £1.75 billion. Additional funding of £1.425 billion for Public Sector Decarbonisation, with the aim of reducing emissions from public sector buildings by 75% by 2037.

- Launching a Hydrogen Village trial to inform a decision on the role of hydrogen in the heating system by 2026

Heat networks – policy statement

"Under the £338 million Heat Network Transformation Programme, we will launch the £270 million Green Heat Network Fund to grow the market for low carbon heat networks. We will also pass new legislation to regulate the sector for consumers, give heat networks the statutory powers they need to build, and regulate the carbon emissions of projects from the early 2030s. We will also deliver new heat networks zones in England by 2025 where heat networks are the default solution for decarbonising heating. Finally, we will work with industry to increase the capacity and capability of the UK supply chain to support the sector to reach its growth potential and look to improve performance of legacy networks through the Heat Network Efficiency Scheme." P145

Heat Pumps – policy statement

"We will grow the UK heat pump market to support 600,000 installations per year by 2028. As part of this, and working with industry to do so, we will aim for cost parity between heat pumps and gas boilers by 2030 with significant cost reductions of at least 25-50% by 2025. To achieve this, we will introduce a range of new policies to support heat pump deployment, including a new £450 million Boiler Upgrade Scheme over 2022/23 to 2024/25 with grants of £5,000 for an air source heat pump." P145

2. Characterising the region

East Midlands Region – UK

The East Midlands is one of nine designated regions of England (see map below). It consists of the counties of:

- Derbyshire
- Leicstershire
- Nottinghamshire
- Lincolnshire
- Rutland
- Northamptonshire

Figure 1. East Midlands Region

The Region includes the major cities of;

- Nottingham
- Derby
- Leicester
- Mansfield
- Northampton
- Lincoln

There is **no** East Midlands Region governing organisation.

Local government is provided by elected Councils. Larger cities are usually 'Unitary Authorities' meaning that they provide a single layer of local government, answerable directly to Parliament. Other areas typically consist of County Councils under which are District Councils, a double tier in which both have decision-making powers.

Local Enterprise Partnerships

Alongside elected Councils are Local Enterprise Partnerships. These are private sector run and have responsibility for regional economic development for a number of local councils; they are not elected but decision-making bodies include representation from elected Councillors.

The five LEPs in the East Midlands area are;

- D2N2 - Derby and Derbyshire, Nottingham and Nottinghamshire
- GLLEP – Greater Lincolnshire
- LLEP – Leicester and Leicestershire
- SEMLEP – South East Midlands
- GCGP – Greater Cambridge and Greater Peterborough

The Sheffield City Region LEP used to include parts of the East Midlands but a boundary change has resulted in these areas moving to D2N2.

UK LEP Regions

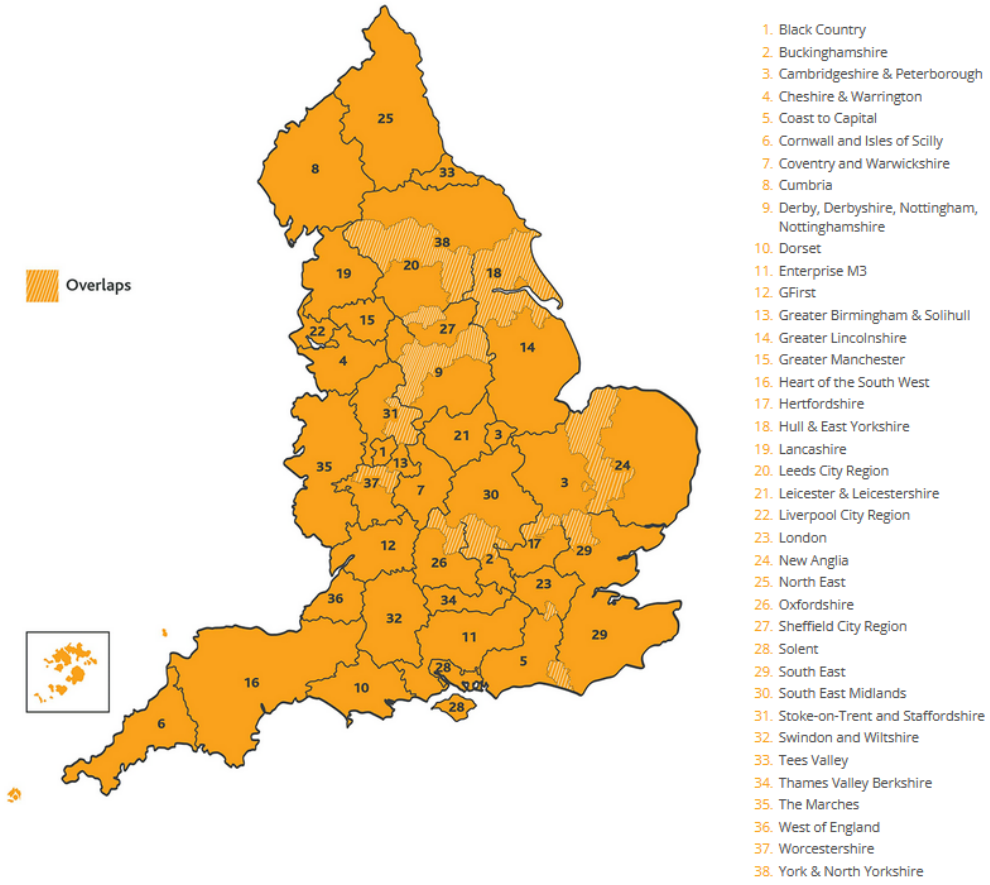

Figure 2. UK Local Enterprise Partnership (LEP) Regions

D2N2 LEP

D2N2 is the largest LEP area in the East Midlands Region and the fourth largest in England outside London. Encompassing Derby, Derbyshire, Nottingham and Nottinghamshire, it has a population of around 2.2 million and GVA of around £46 billion.

Economic scale and productivity

D2N2's total GVA is around £46 billion. This is equivalent to around £21,250 per capita – roughly 80% of the UK's per capita GVA figure. Across D2N2, GVA per head of population is strongest in Derby and Nottingham, where it is (in both cases) above the national average, reflecting both cities' functions as major centres of economic activity.

Productivity in D2N2 is about 12% below that of the UK overall, at around £28.60 per hour worked. This is broadly comparable with neighbouring LEP areas: the productivity deficit is a regional challenge, not just one for D2N2.

Reflecting its scale, the area is diverse, including the major urban centres of Nottingham and Derby (and their associated stock of commercial, educational and public sector assets), a number of significant sub-regional centres and areas of deep rurality and high environmental quality, including the Peak District National Park.

It enjoys generally good strategic connectivity via the Midland Mainline (rail) and the M1, A1 and A50, as well as via East Midlands and Doncaster Sheffield airports located just beyond its boundaries. Connectivity will be further improved following the completion of the High Speed 2 rail line (HS2) after 2030

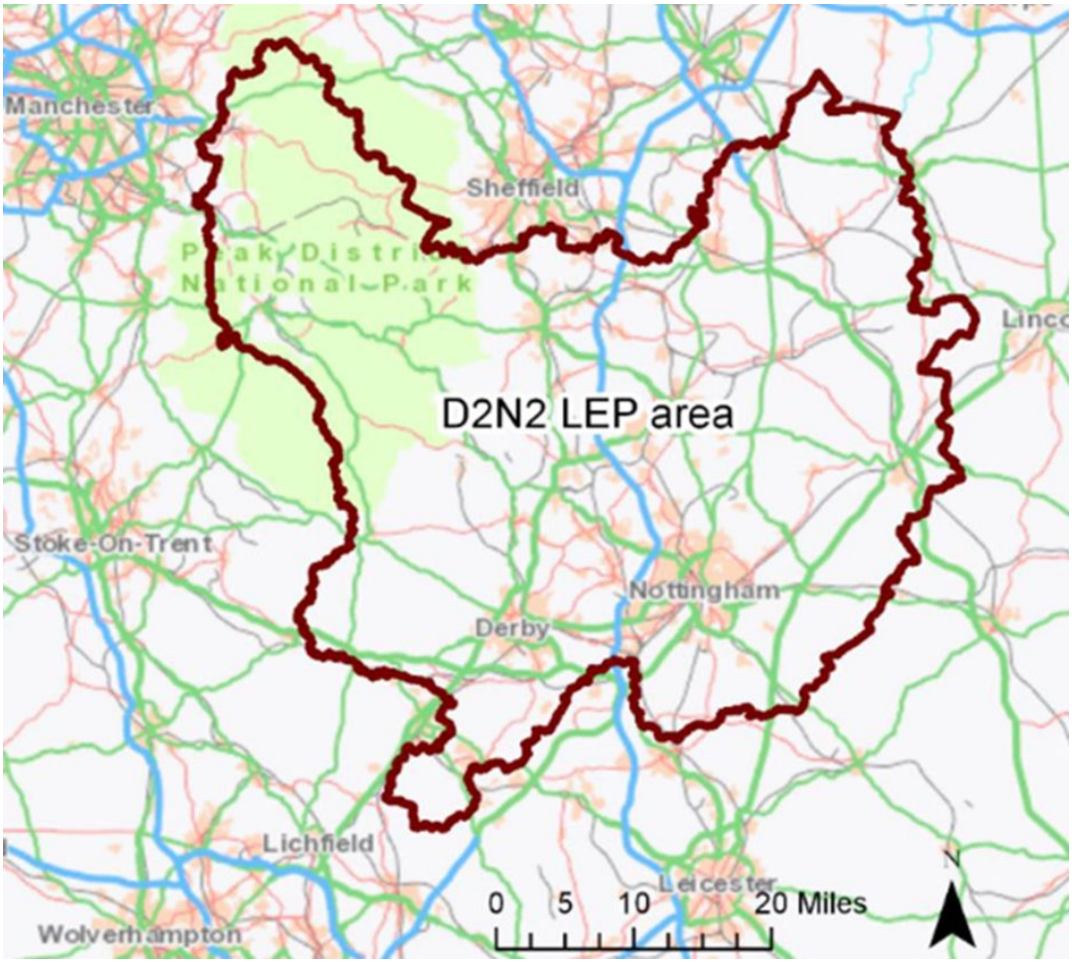

Figure 3. D2N2 LEP Region

Net Zero Hubs

In 2010 the UK government created a further layer by designating 5 'Energy Hubs' across the UK. More recently the Hubs have been renamed 'Net Zero Hubs' to reflect a broadening of their remit - to support and address critical net zero transition issues.

The East Midlands Region largely, but not completely, lies within the Midlands Energy Hub. The D2N2 LEP is within the Midlands Energy Hub.

The lack of precise alignment between the political and economic organisational layers can be an obstacle to the development of infrastructure projects.

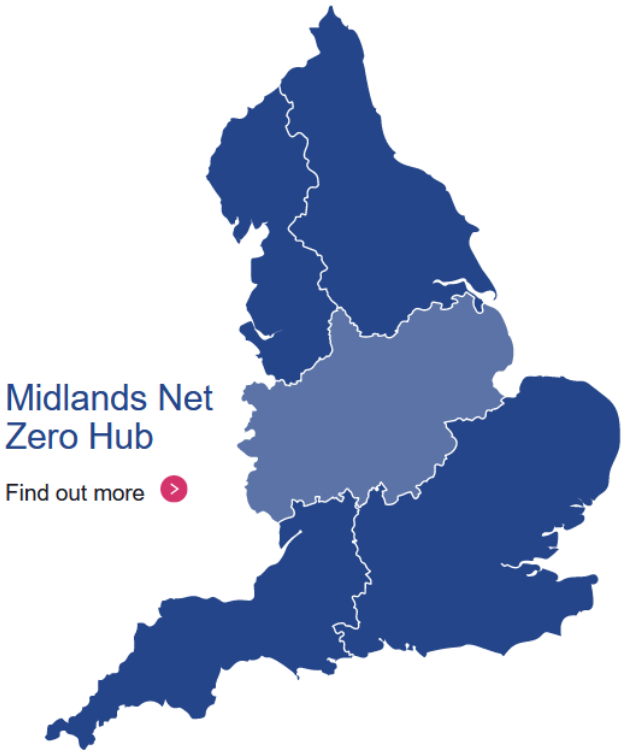

Figure 4. Midlands Net Zero Hub Region

To understand the opportunity for 5GDHC in the East Midlands we have developed an interactive model built on building level data and information such as energy consumption, EPC certificates and fuel types. This will be made available to public organisations and investors to assist in their technical and commercial evaluation of potential 5GDHC projects.

Geography

Most of the East Midlands region is relatively flat. The only higher ground is the South Pennine hills to the west.

Major rivers, that could provide significant 5GDHC opportunities are:

- Trent
- Nene
- Soar
- Welland

Much of the East Midlands region is situated above one of the UK's principle aquifers – map source – British Geological Survey (BGS) See below.

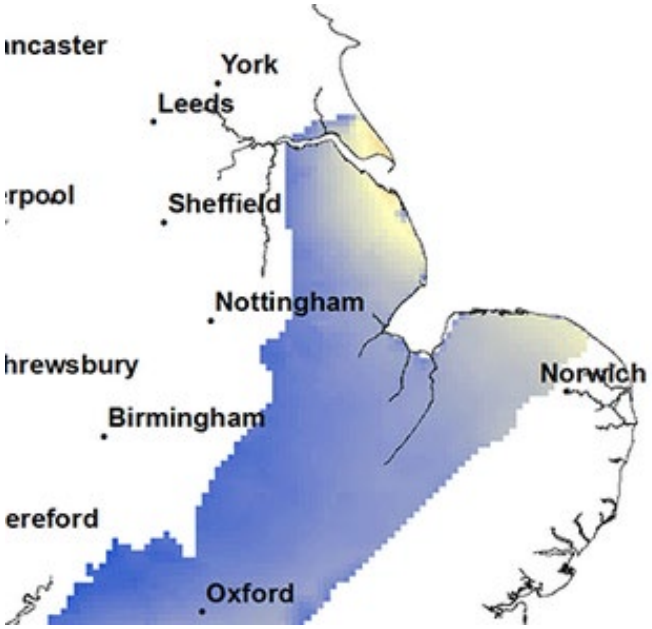

Figure 5. Aquifer below East Midlands Region

3. Analysis

3.1. Heating regime

3.1.1. Current dominant heating technology or carrier in the region

The predominant heating fuel used in the UK is Natural Gas. Over 70% of the domestic, industry and service sectors are heated in this way. Electric Heating (both direct and heat pumps), non-gas fuels such as oil, solid fuel, bio-energy and waste make up the remaining 30%.

Remote areas are least likely to have a gas connection. Domestic connections in these areas make up the majority of the UK non-gas heating market.

Heat networks are estimated to deliver approximately 2% of overall heat demand nationally with expectation that this will rise to 20% by 2050. The East Midlands region is predominantly served by mains gas, historically this has been difficult to displace due to its low cost. Figure 6 shows the percentage of domestic buildings using particular heat sources in the East Midlands.

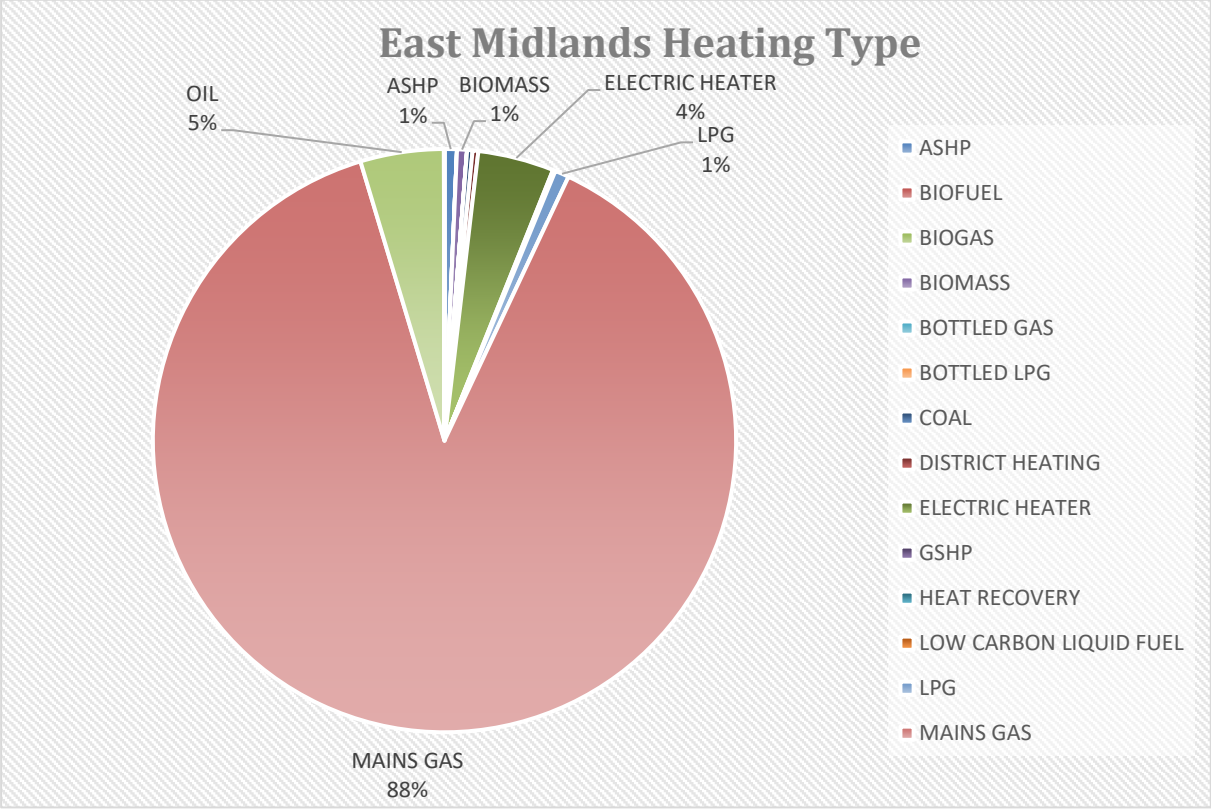

Figure 6. Heating Sources – East Midlands Buildings

3.1.2. Main Suppliers of energy for heating in the East Midlands

National Grid logo	The National grid is a public utility that is responsible for the transmission mains of both gas and electrical networks. It primarily deals with large scale power and gas transportation
Cadent	Responsible for smaller scale distribution of gas.
FCC	Operates erf that supplies heat to EM largest heat network
NCC	Operates the largest heat network in the UK, suppling ~5000 domestic dwellings and 100 commercial entities.
Western Power	Electricity distributed network operator, provides electrical infrastructure for electrical heating
Resellers	A Number of resellers who purchase electricity and gas for resale on the open market

3.1.3. Legal Framework

The Gas act 1989 (as amended) and the Electricity Act 1989 (as amended) prohibit certain activities unless the undertaking party are licensed, unless they are license exempt (which is typically bound by class acts) or, in the instance of the gas act, eligible for exception to the prohibition of licensed activities.

There are a set of licensed activities and industry codes that suppliers will need to sign up and adhere to.

For gas the following apply:

- Transmission
- Interconnector
- Shipper

- Supplier

For electricity the following apply

- Transmissions
- Offshore Transmission
- Interconnector
- Distribution
- Generation
- Supply

Heat networks are currently only regulated via the Heat Metering and Billing Regulations and health and safety legislation.

While heat networks remain largely unregulated in comparison with electricity and gas networks, the Competition and Markets Authority have advised that regulation should be introduced. This is currently in development – see details in section 4.1.5.

3.1.4. Competition in the market

Following the liberalisation of energy markets, customers remained with their regional supplier for electrictity and national supplier for gas. The intention was that customers would switch to save money and a competitive market would form.

Six major suppliers consolidated the market and switching fell below desired outcomes. The Competition and Markets Authority launched an investigation in 2014 and concluded that many customers were being charged on 'default' tariffs and therefore paying more than they should. The 'overcharging' was assessed to be in region of £1.4 Billion. This led to market reforms that improved tariff arrangements and delivered more value to consumers. A 'safeguard tariff cap' was introduced to prevent high 'default' tariffs.

The exit from Covid combined with Russia's invasion of Ukraine has led to a dramatic increase in wholesale gas prices. This has removed any competition in the electrical and gas markets as the UK government 'price cap' now delays the passing-on of new market pricing to domestic consumers. For the time being, switching tariffs would be disadvantageous for the consumer.

Heat networks are not covered by the government price cap and so networks that rely on gas have the potential to be considerably more expensive. In contrast, non-gas networks are currently in a favourable market position. For example, Nottingham's district heating network which primary fuel type is waste, is now able to deliver superb value energy to its customers.

3.1.5. Developments in heating policy and market contexts

The UK government created the Heat Network Development Unit (HNDU) to galvanise and support heat network growth. This scheme has enabled local authorities to spend approximately £30m on heat network project developments. into local authorities.

The funding is for feasibility studies and/or detailed project development that paves the way for construction financial support from the Green Heat Network Fund.

The Competition and Markets Authority has conducted an assessment of heat network operational practices in the UK and judged that the vast majority are typically charging consumers a fair market price. Those deemed to be overcharging were judged to be operating a poorly performing.

The UK has developed a code of practice for heat networks (CP1) to try to prevent poor operational practice. The Competition and Markets Authority recommended the sector should be regulated in line with other utility providers.

The Heat Network Market Framework is being developed to regulate heat networks with the primary goals of enabling sector growth whilst providing protections to consumers. The framework finished its consultation in February 2022.

In a major strategy development, the UK government has introduced legislation establishing heat network zones across the UK by 2025. Under the right technical, environmental and commercial conditions, this will mandate the connection of all buildings (except for individual homes) within designated zones to local heat networks and thereby significantly reduce the commercial risks currently faced by heat network developers.

3.2. Position of district heating

1.1.1. Regulation of district heating providers and 5GDHC

Heat networks in the England have only delivered heat to a small proportion of English dwellings. The heat network market remained unregulated until the introduction of the Heat Networks (Metering and Billing) Legislation in 2014. Its aims were to drive energy efficiency and reduce carbon emissions via a 3 stage process:

1. Heat Network Operators submit notifications of heat supply from their network to customers
2. Installation of Metering devices
3. Billing based on consumption

More legislation is expected to follow through the zoning programme and market framework. This regulation will also cover 5GDHC networks.

1.1.1. Ownership and operation of district heating systems

Heat networks within the UK are driven forward by a project sponsor and project operator. The relationship between them is governed by contractual and funding structures. The five most comment structures are:

- **3rd Party ESCo** – The project sponsor enters into an energy services agreement with a 3rd Party who will deliver the Heat network through an Energy Service Company (ESCo)
- **Concession** – The project sponsor forms a concencession agreement with a 3rd Party ESCo to deliver the Heat Network
- **Project Sponsor ESCo** – The Project Sponsor establishes a wholly owned ESCo to deliver the heat network
- **Joint Venture ESCo** – The Project Sponsor jointly establishes an ESCo with a Joint venture partner to deliver the heat network
- **In-House Delivery** – The Project Sponsor develops the heat network without establishing a stand-alone delivery vehicle. This is the operating model for the Nottingham District Heating Network.

1.1.2. Regulation of the price setting

The price setting for heat networks is not currently regulated. The Competition and Markets Authority has indicated that heat networks currently deliver fair value for the vast majority of consumers. Heat networks' pricing is largely competitive when considered holistically, that is beyond the price per kWh.

Following the rise in gas prices largely caused by the war in Ukraine, customers supplied by district heating networks run by gas have experienced very high price rises in 2022 as they are not protected by the UK price cap.

3.2.1. Role of building owners and building occupants

In the UK, building owners are responsible for infrastructure and costs associated with utility provision, including district heating. The tenant or occupier is typically responsible for paying for the energy used during its occupation. This can make

district heating rollout challenging because the interests of owners and tenants are not necessarily aligned. Value needs to be added to both parties which can be particularly challenging in retrofit situations.

Local authorities are able to impose planning rules for new developments that favour of low carbon systems including district heating. Many local authorities are reluctant to force connection as it could be seen as a deterrent for certain developers who then may take their capital and development prospects to a different local authority. The planned heat network zoning legislation will mandate connection which should resolve this question.

Part L building regulations set out standards for building fabric and efficiency. These standards are progressively being strengthened. With improved energy efficiency, buildings can run their heating systems at lower operating temperatures which improves opportunities for developing 5GDHC networks.

3.2.2. Financing and subsidies

Financing heat networks in the East Midlands has been challenging historically due to the low-cost counterfactual of gas. New schemes would typically need to achieve hurdle rates of 6% for public investment and 12% for private systems.

The government Green Heat Network Fund supports commercialisation and capital investment to uplift IRR's to investible propositions. The main goal of the fund is to act as a lever for private investment.

Figure 7. gives a summary of financing options that could be explored

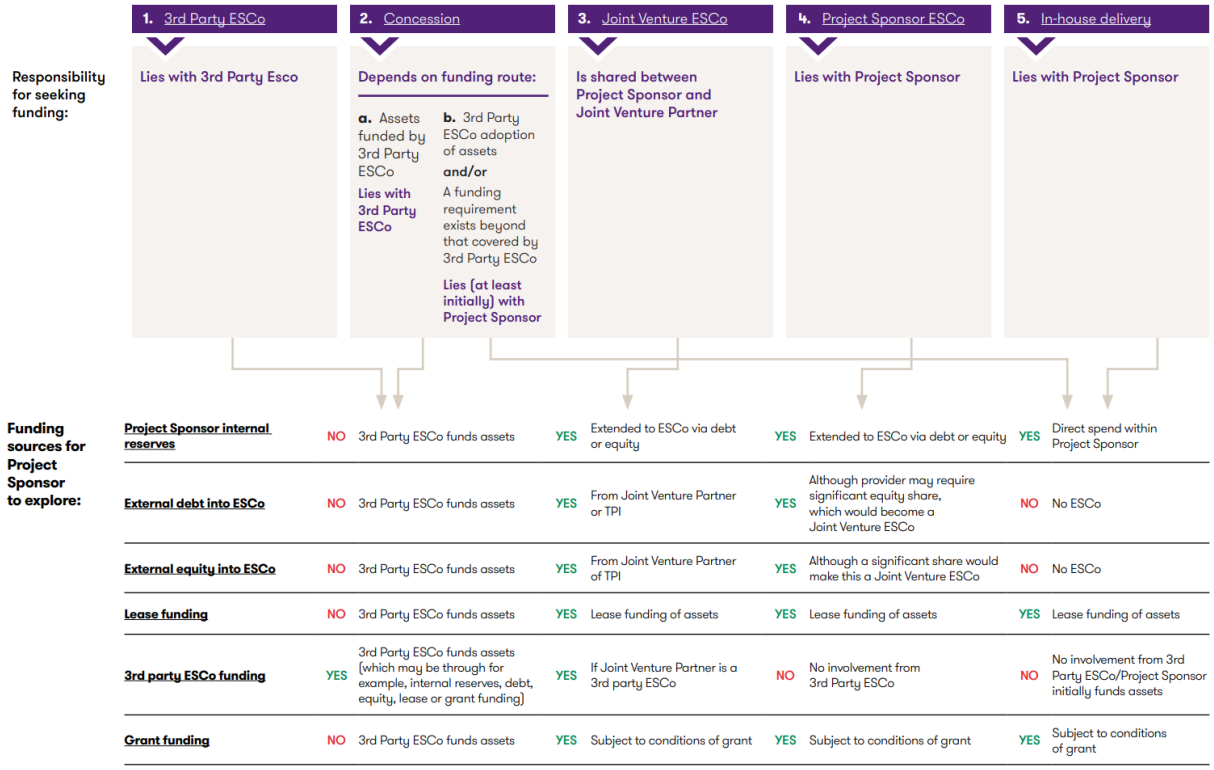

Figure 7. Financing Options

3.3. Available Energy Sources

For the development of 5GDHC, it is important that each region gains insights in other (possibly low temperature) heat sources which are available today or in the future. As part of the work in D2Grids, a preference scale of energy sources has been developed (see D.T1.1.4 generic 5G technology model). The structure of this section reflects this ranking, with the

highest ranking forms of energy mentioned first. These sources are in most cases not only relevant for 5GDHC development. When there are many high or medium temperature sources available in a region, the case of 4GDH might be better than for 5GDHC. Currently, we have no way of quantitatively saying what the shares of low grade sources would be in order to make a decent 5GDHC business case. At the time of writing, D.T1.1.4 has not been finalized.

Depending on the region and the country, there are different energy sources and storages. This can mostly be attributed to the different topography and available natural resources. For the development of 5GDHC it is relevant to know the different energy sources and storages. This allows planning from which source energy is to be drawn or whether another grid variant/generation such as 4GDHC is more advantageous. The main focus is on renewable energies. However, the potential of fossil fuels is also considered.

The number of heat networks in the East Midlands region is small. The major cities such as Leicester and Nottingham have heat networks, but the penetration is still small compared with other European countries. Natural Gas is the most common heat source for heat networks in the UK.

Electricity generating assets have significant potential to be able supply heat to heat networks. The figure below shows key electrical generation assets within the East Midlands.

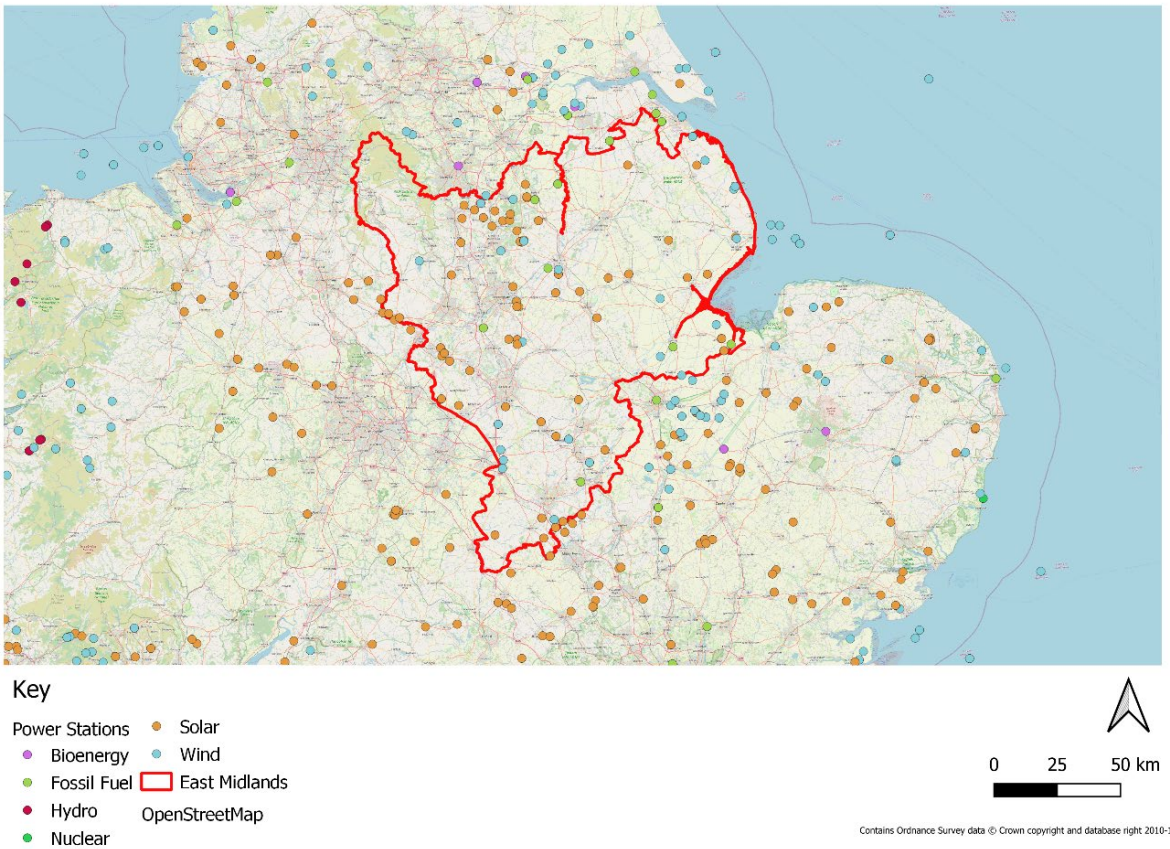

Figure 8. Electricity Generation Assets – East Midlands

3.3.1. Reuse of thermal energy, by exchange between heating and cooling demands

One of the core principles of 5GDHC is to facilitate energy exchanges between local buildings. For instance, if one building is producing heat for its own consumption, it automatically also creates cold which ideally could be supplied to another nearby building.

Analysing the potential of such energy exchange is, however, not currently possible on a regional scale because the detailed energy consumption data, for different time periods is not available. The potential for energy exchange also depends on the design of the network and the type of users involved. Ideally, a good mix of consumers should be present, so that their energy flows and needs are complementary.

Nordic Energy has published an online tool that enables the detailed assessment of energy exchange potential. The model covers almost all buildings within the East Midlands and presents information via an interactive map enabling users to better understand the buildings and their energy demand. It therefore also enables users to identify the area-based potential for 5GDHC.

The regional demand opportunities are presented in the following diagram for the East Midlands.

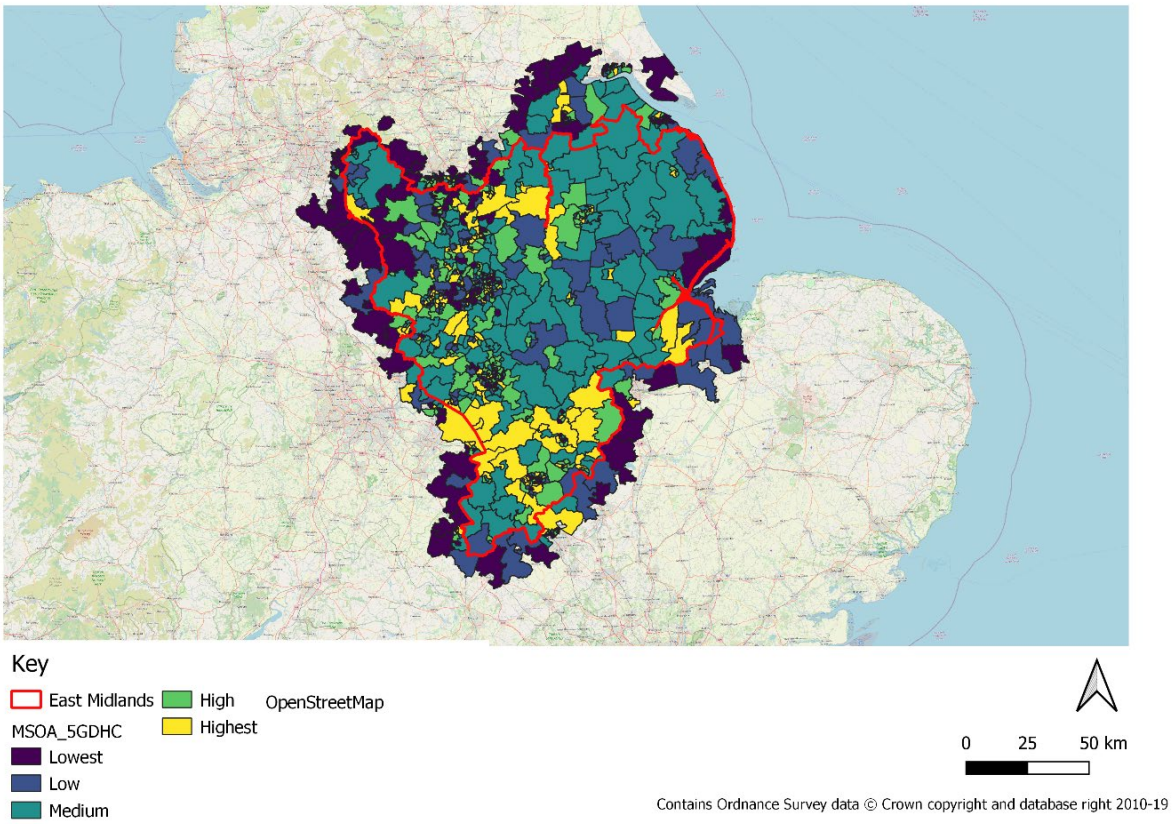

Figure 9. Comparative 5GDHC potential in the East Midlands (demand led)

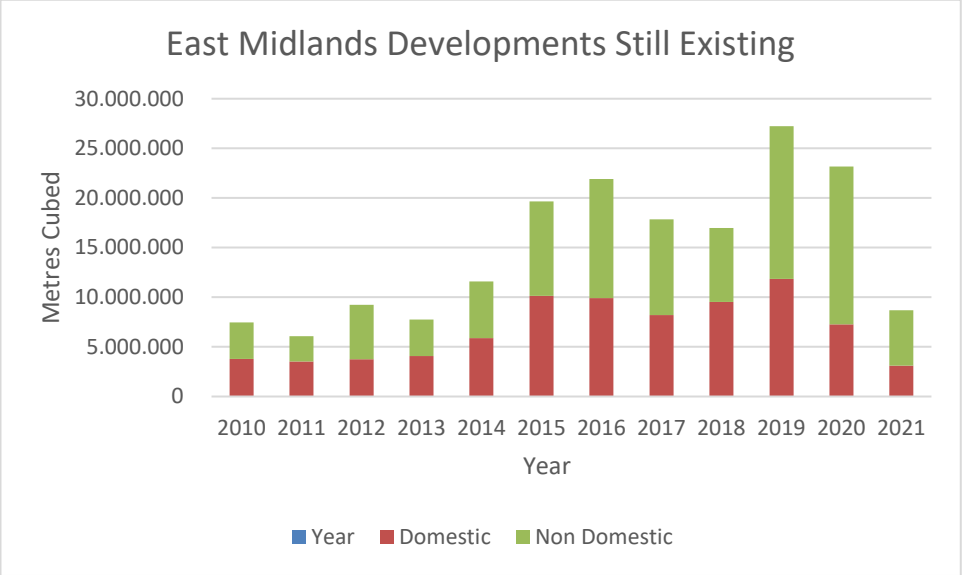

Figure 10. New Build developments in the East Midlands

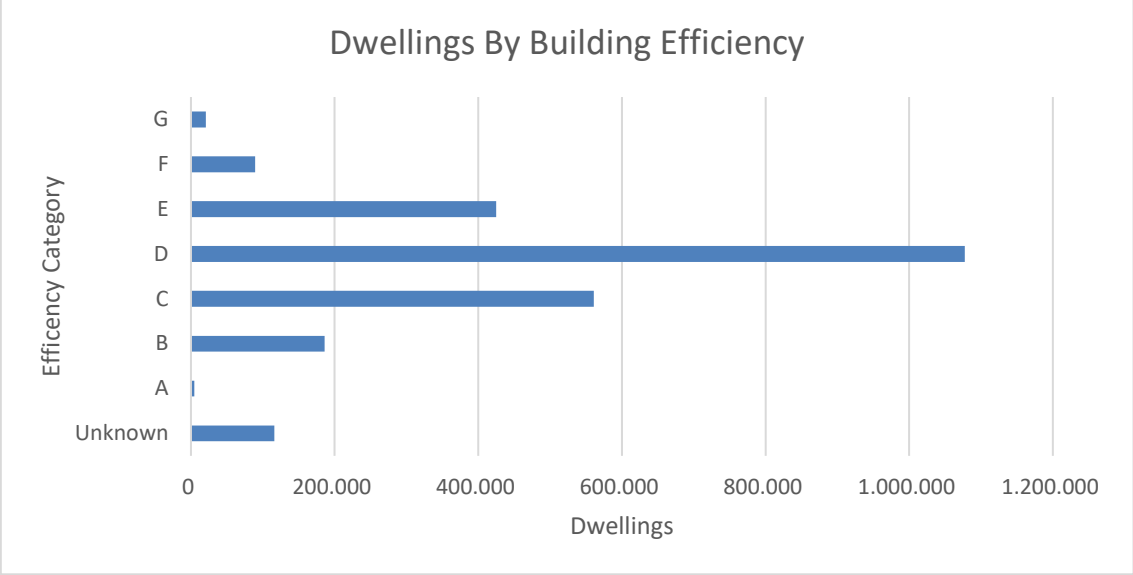

Figure 11. Current energy efficiency of building stock within the East Midlands.

The challenge of connecting existing buildings to 5GDHC networks is achieving good commercial returns given the efficiency improvements needed when heat is supplied at lower temperatures. Weather optimisation goes some way to improve this but until the gap between gas and electricity prices increases the commercial outlook remains challenging.

3.3.2. Ambient thermal sources from soil, water, air, and low temperature solar heat & low grade thermal storage possibilities

(Bertermann et al., 2015) analysed the pan-European very shallow geothermal energy potentials. Very Shallow Geothermal Potential, both BTES and ATES, is basically solar heat that is stored in the shallow underground (up to 10 metre depth).

The map below shows there are some areas with a very high heat conductivity potential in the East Midlands. Nevertheless, in some of these areas there are also limitations or restrictions for the implementation of shallow geothermal energy (see stripes in the background). Such limitations are caused, for instance, by protected zones, unsuitable soil types (Histosols, Cryosols, Leptosols, Gleysols, Planosols) or soil slopes >15°C.

Heat conductivity is expressed in Watts per meter*Kelvin. Red zones are 'highly suitable' and orange zones are 'very suitable'. Yellow zones are 'suitable', which is still better than the blue zones which are 'limited suitable' or 'less suitable'. For the East Midlands it shows that there are significant areas of opportunity for shallow geothermal energy.

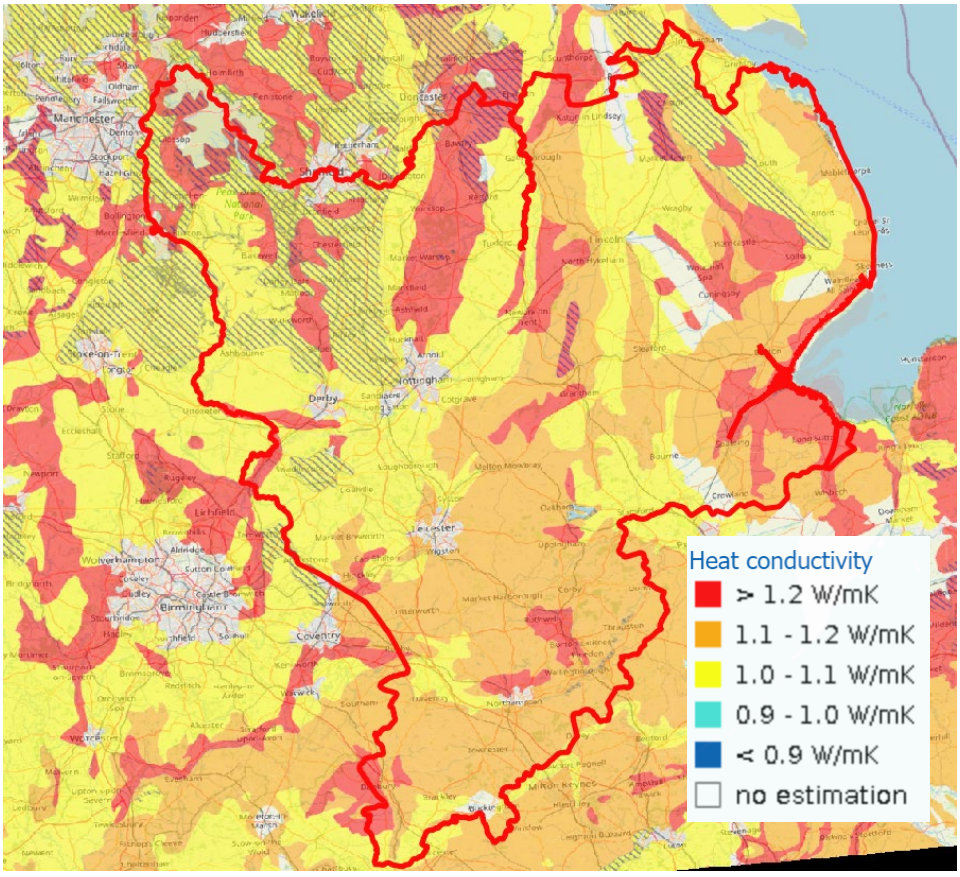

Figure 12. ThermoMap East Midlands (Red Border East Midlands)

Mine Energy

Minewater is another strong potential heat source in the East Midlands. The region has a significant history of coal mining in the areas represented by the Coal Authority's map below, numbered, 8,9,10 and 11.

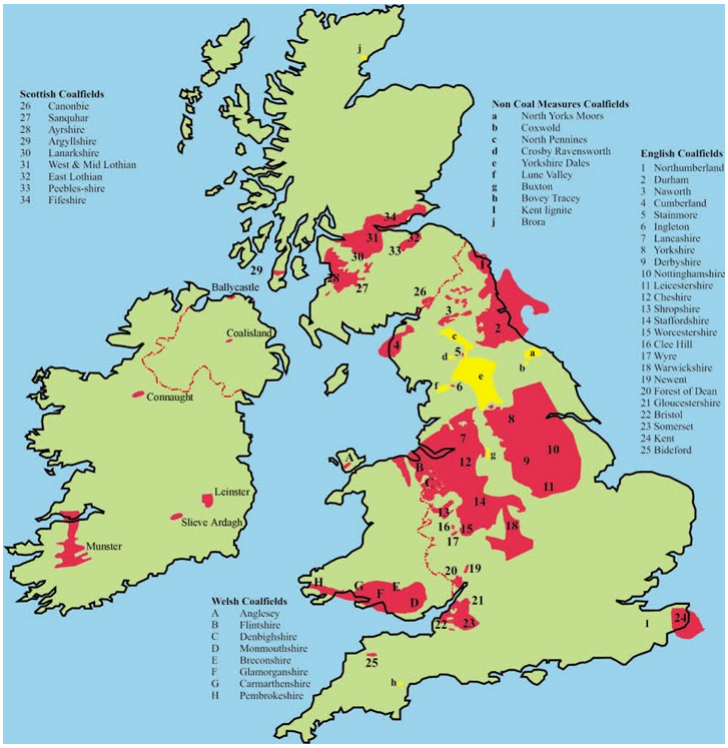

Figure 13. Coal Reserves in the UK

Since the mines closed, the Coal Authority has been managing legacy issues emanating from them such as preventing eruptions of mine water to the surface that would pollute water supplies.

The Coal Authority are also supporting projects that use the warm water that has filled the former coal seams to provide low temperature heat for district heating networks. The potential for mine energy in the East Midlands has not been fully explored due to the cost associated with procuring this information from the Coal Authority. The data is available to view on a non-commercial basis here (https://mapapps2.bgs.ac.uk/coalauthority/home.html).

Advantages of Mine Energy projects include:

- Substantial network of mine workings in a large area of the East Midlands
- Many Mine Workings in the East Midlands readily accessible via boreholes – between 100m and 300m below surface e.g. around Nottingham
- Potential storage opportunity, particularly in any mine shafts that have not been filled up after closure of the mine
- Most mine workings are close to population centres and therefore heating/cooling demands
- Most mine workings are also close to industrial sites and therefore can be integrated with heat recovery projects from industry

Former mining areas have lower than average economic and social/health indicators

- Job density below average
- Unemployment well above average
- Business activity well below average
- Ill-health double the level of South East England

Ref "The State of the Coalfields" – Foden, Forthergill and Gore, 2014 – Sheffield Hallam University

Therefore another advantage of mine energy schemes is the economic and social/health uplift that they bring to former mining communities that have strong cultural identities.

Mine energy as a heat source is still in its infancy. A number of innovative mine energy projects are underway which will help understand the mine water delivery potential in the UK. Some of the mine energy opportunities and issues are identified below;

- Data for geothermal energy assessments is not readily accessible
- There is a shortage of geothermal energy experts in the UK
- Mine energy projects are most suited to serving new build housing that is energy efficient
- Older housing needs energy efficiency retrofit measures to be undertaken prior to 5GDHC connection
- Low grade storage is becoming more utilised as technology develops but take up is low

Ambient Heat Sources and Heat Pumps

Over the past 3 years there has been a near 100% rise in the sales of heat pumps in the UK (35,000 in 2019 to 67,000 in 2021) as the demand for the technology increases. The domestic 'Renewable Heat Incentive' (RHI) has been a major policy driver in the rollout of heat pumps, although that scheme has now closed. The scheme supported 6,134 Air source heat pumps and 1,065 Ground source heat pumps since its inception in the East Midlands.

The Boiler Upgrade scheme is the new policy driver to support homeowners in their move to greener technologies, including heat pumps. This provides a grant of £5,000 towards replacement of a gas boiler with an air source heat pump and £6,000 for ground or water source heat pump.

Geothermal storage systems, both BTES and ATES, are increasingly being progressed in the UK but it is not yet widely established. The East Midlands region is suitable for both An assessment of the geology and soil, such as provided by the British Geological Survey (semi-public organisation) is necessary for these applications.

3.3.3. Higher temperature renewable sources like geothermal, solar heat

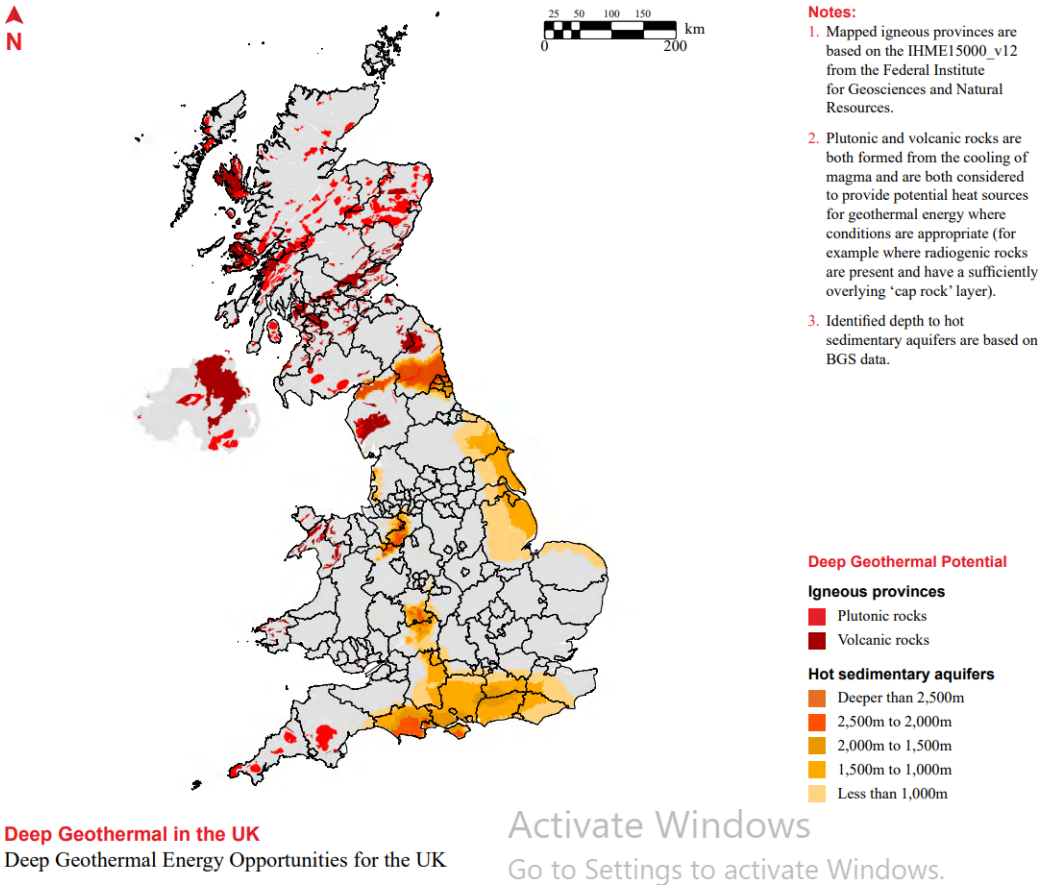

Figure 14. Deep Geothermal Energy Opportunities in the UK
Source : https://www.r-e-a.net/wp-content/uploads/2021/05/Deep-Geothermal-Energy-Opportunities-for-the-UK.pdf

A recent study by ARUP and REA has explored the potential for Deep Geothermal in the UK. The UK has only recently deployed its first deep geothermal project located in Cornwall. The united downs project produces temperatures of 188C at its 5km base. The project budget is £30M and made possible through the European Regional Development Fund.

Deep geothermal is in its infancy within the UK, with government support growth is expected to accelerate a number of projects. From current knowledge the East Midlands opportunity is there but limited when compared to other regions in the UK

Solar Heat

The vast majority of large solar projects in the UK are PV rather than heat. This is because the commercial case historically has favoured electrical production owing to the high price of electricity and the low price of gas. Small scale solar thermal typically covers around 40-60% of the household hot water consumption over a year.

3.3.4. Higher temperature industrial waste heat, otherwise rejected in the environment

Waste heat is the energy that is generated through processes which is not put into any practical use and is lost, through waste or dumping into the environment. Waste heat recovery technologies can be deployed to recover this valuable energy source and reduce the overall energy consumption. Excess recovered heat can be transported through district heating networks to consumers.

Below is map providing a broad estimate of waste heat availability across the UK.

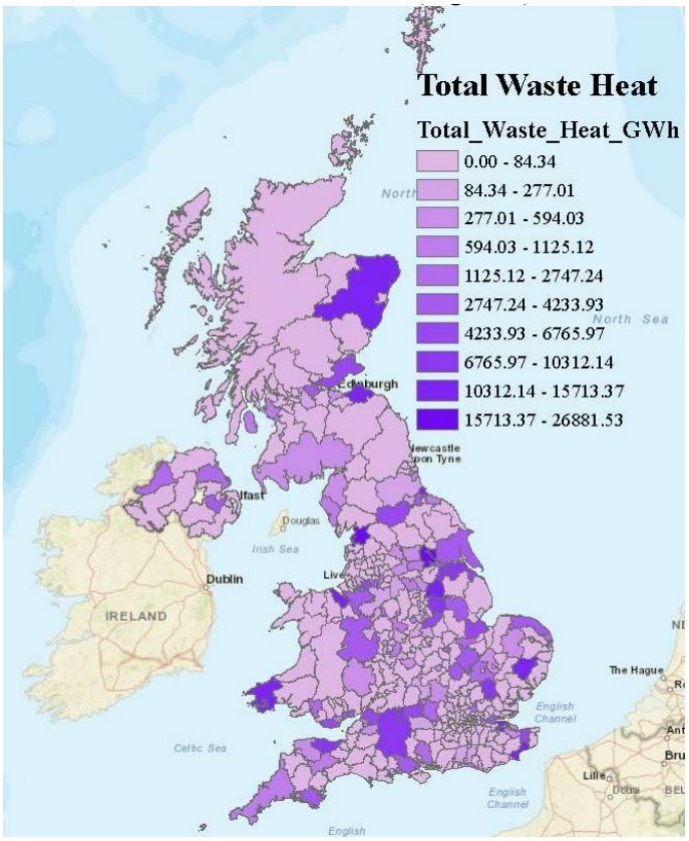

Figure 15. Distribution of estimated total waste heat in the UK (source : *Waste Heat Mapping: A UK Study* - *http://www.mygridgb.co.uk/waste-heat-map/*)

The potential for recovering waste heat in the East Midlands is significant. Across the UK, industrial waste heat has been estimated to be 391,000 GWh. However, UK industry has been tended to focus on improving processes as a means of improving productivity and efficiency rather than optimising resource management such as heat recovery. Progress, therefore in harvesting waste heat to then supply into heat networks has been limited.

3.3.5. Renewable electricity from local sources like wind, sun

The UK has seen an unprecedented rollout of solar and wind energy over recent years with a particular emphasis on off-shore wind, a significant proportion of which is near the East Midlands coastline. The Energy Security Bill, introduced to parliament in July 2022, reinforces the prioritisation of local renewable energy generation, the impact of which can be seen in the diagram and map below.

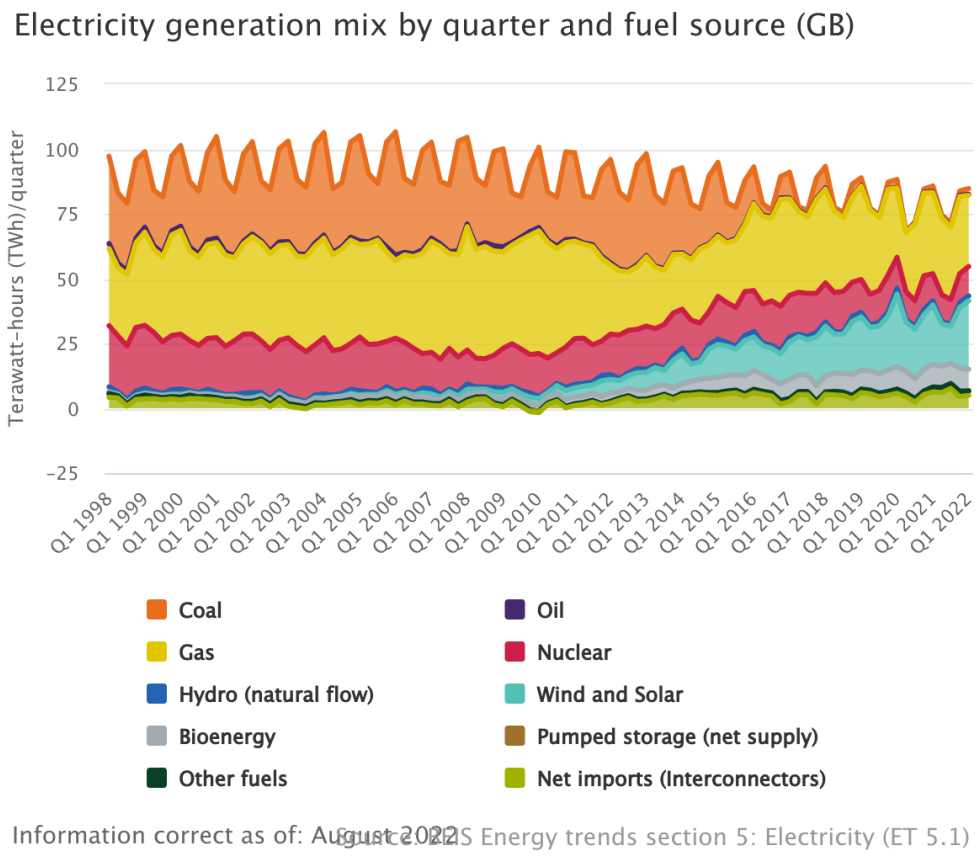

Figure 16. Electricity Generation mix by quarter and fuel source

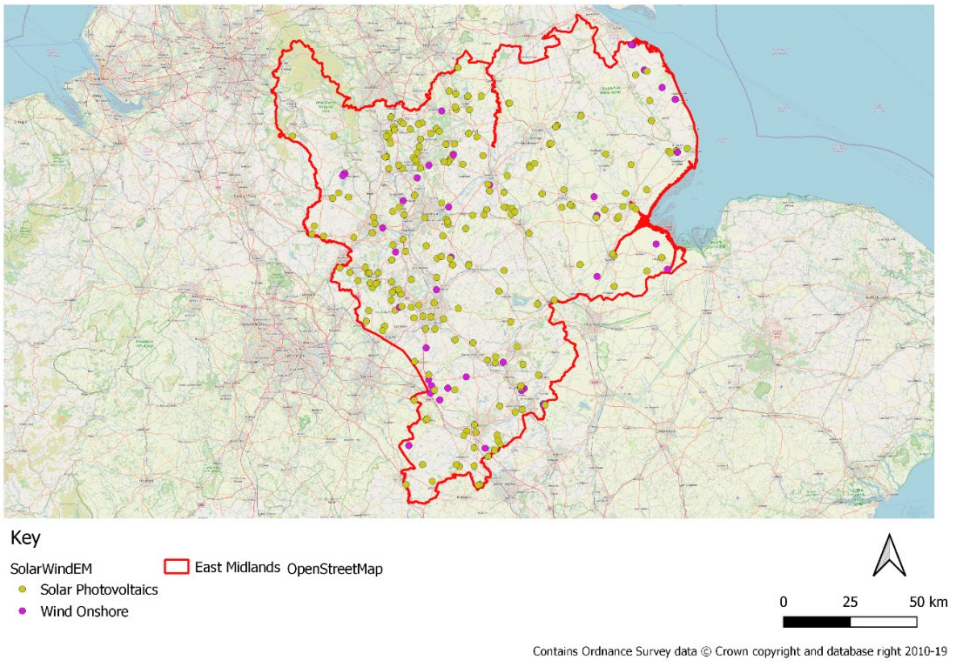

Figure 17. Solar and Wind Installations over 150 kW in East Midlands

Solar and wind installations (both operation and under construction) over 150kW in the East Midlands (*DBEIS Renewable energy planning database monthly extract*)

The East Midlands solar and on-shore wind electricity output is currently 2.5GW (2GW Solar, and 0.5GW Wind).

The off-shore wind electricity output is shown on the map below

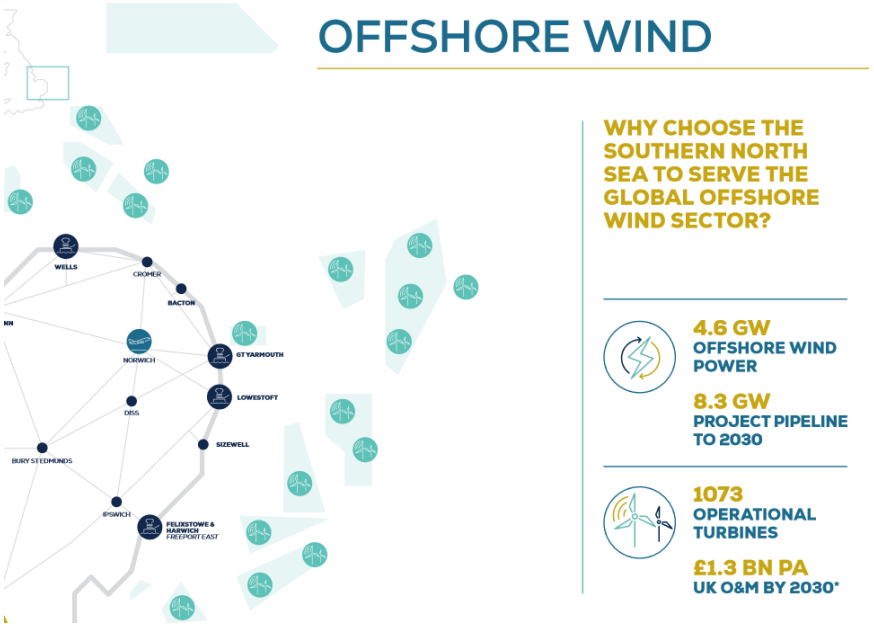

Figure 18. Norfolk and Suffolk All Energy Industry Council

3.3.6. Electricity use at times of renewable overproduction, e.g. when spot price is low

The electricity grid is evolving with the increased rollout of renewable energy and other factors such as the electrification of transport. Electricity is generated, transported, delivered and used continuously in real-time, and supply must always match demand as electricity cannot be stored at scale yet.

Although the generation, transportation, delivery and usage of electricity is continuous, for the purposes of determining consumption and organising payments, it is measured in half hour chunks called 'settlement periods'.

The electricity grid Balancing Mechanism uses the Electrical Supply Operators Primary Tool to balance supply and demand in settlement periods. If the electricity grid predicts there will be a difference between the amounts of electricity produced and consumed they may accept a 'bid' or 'offer' ('spot price') to increase or decrease, generation or consumption.

This creates pricing optimisation opportunities. Octupus energy, for example, offers 'Agile Tariff's that fluctuate according to market conditions in each settlement period. Other pricing mechanisms enable users of all scales to take part in low spot price trading if they have the flexibility to do so.

The graph below demonstrates the variation in potential future electricity demand in the East Midlands over a 24 hour period.

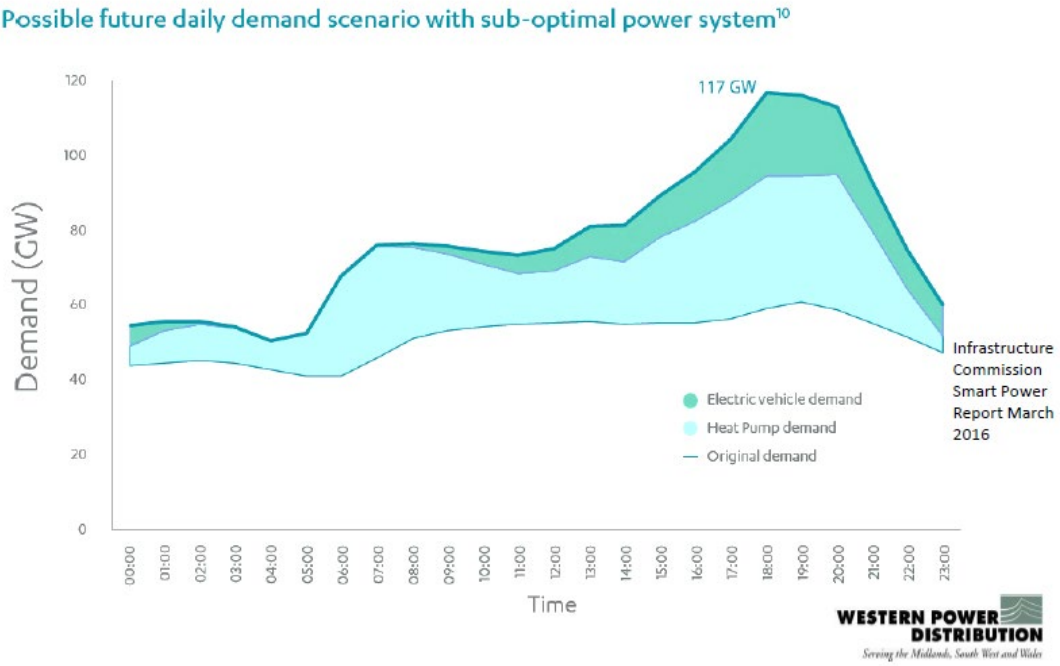

Figure 19. Potential future electricity demand over 24 hour period in East Midlands

The graph above also demonstrates the challenge from a changing demand profile with the introduction of heat pumps and electric vehicles. 5GDHC has a strong opportunity to support these demand challenges on aging electrical infrastructure with its ability to absorb electricity at specific times using the flexibility of its assets and operation.

3.3.7. High temperature heat from burning biofuels, biogas, biomass

In the East Midlands, 13,000 domestic properties use biomass as their primary source of heating, which constitutes approximately 0.5% of all domestic buildings. These are typically in rural areas. Biomass systems are becoming more financially appealing given the rise in wholesale gas and electricity prices. Biomass can be sourced from many different areas and provide market resilient heating. To address air quality issues, legislation imposes strict standards on the type of fuel which can be burned.

The table below gives an overview of the biomass technologies that operate with a generation capacity of over 150kWe in the East Midlands.

Technology	No CHP Installed Capacity (MWe)	Number	Yes CHP Installed Capacity (MWe)	Number	Total Installed Capacity (MWe)	Total Number
Anaerobic Digestion	17.4	7	20.5	10	37.9	17

Biomass (dedicated)	34.8	3	64.4	7	99.2	10
Grand Total	**52.2**	**10**	**84.9**	**17**	**137.1**	**27**

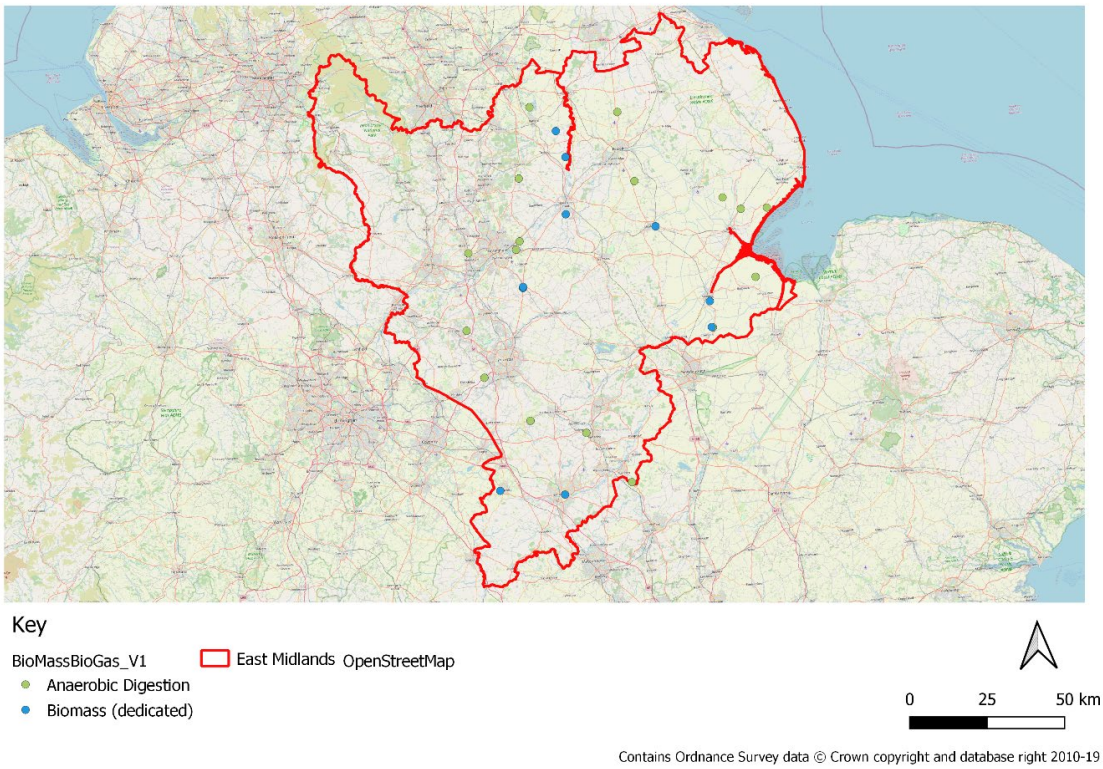

Figure 20. Sources of High Temperature Heat from Burning Bio Fuels – East Midlands

3.3.8. High temperature heat from burning fossil fuels

Coal

There are three coal-fired power stations still in operation in the UK, two of these stations are within the East Midlands region, 'West Burton A' and 'Ratcliffe on Soar'. Both of these power stations can generate 2GW but are scheduled to be decommissioned in the coming years. The timeframe is currently uncertain given the energy security issues the UK government is currently grappling with. Radcliffe on Soar currently operates as a 'peaker' plant to address periods of very high demand on the national grid.

Gas

There are five active gas-fired power stations within the East Midlands;

- West Burton B with a capacity of 1.33 GW
- Corby with a capacity of 0.41GW
- Cottam Development Centre with a capacity of 0.45GW
- Spalding with a capacity of 0.95GW
- Staythorpe C with a capacity of 1.77GW

On the domestic level its estimated that 88% of all homes and businesses in the East Midlands use Natural gas as a primary means of heating and hot water. There are drivers and support schemes to encourage residents to move and switch to a non-fossil based heating system.

4. SWOT analysis

Analyse SWOT	
Strengths	**Weaknesses**
- Heat network growth is being supported by government investment and policy - Private investment market is well developed in the UK - Market for non-fossil fuel based heating is substantial as most heating is currently from fossil fuel sources - Anticipated high level of house building growth - Technical regulations in the building industry becoming more advantageous – higher standards - Region has multiple sources of low temperature heat e.g. mine water, sea, waste water, aquifers, canals and rivers - Proven capability to develop renewable energy programmmes such as off-shore wind roll-out	- Gas network dominates heat supply in the East Midlands, creating a major obstacle for alternative heat suppliers - Heat offtakers expect to have control of their own heating infrastructure – gas boiler + radiators - District Heating is relatively new to a lot of customers/developers – resistance to change - High capital upfront costs - High Proportion of older buildings that are energy inefficient and difficult to connect to low temperature networks - Lack of sample projects as examples
Opportunities	**Threats**
- Government is supporting heat network growth with legislation such as Heat Network Zoning and funding such as HNDU and Green Heat Network Fund - Essential building fabric improvements aligns with 5GDHC needs - Proven inter-seasonal storage technologies ATES and BTES have high potential but currently under-developed - Opportunities for waste heat recovery growth, thereby strengthening security of energy supplies and improving revenues for industry - Using return temperatures on existing and new higher temperature networks could help facilitate 5GDHC - Expected introduction of regulation enabling DH to carry same utility rights as electricity and gas. - Good synergy with growing renewable electricity infrastructure – particularly off-shore wind	- UK heat market dominated by gas supplied by an operator with a monopoly - Poor UK economic conditions reducing investment appetite – government and private sector - High cost of UK electricity - heating costs rising beyond the means of customers - Adoption of the technology without ensuring a balance of heating and cooling - Future construction of ‘passive’ buildings that have limited heating and cooling needs

5. Regional vision

5.1. High potential areas and potential pilot sites

To develop a 5GDHC vision for the East Midlands, Nordic Energy has developed an Interactive Model which facilitates greater understanding of potential locations for 5GDHC.

The Interactive Model provides unprecedented detail regarding the current East Midlands building stock, circa 2.8million buildings. Data, largely comprising real (as opposed to modelled) data, provides the substance behind a 3D map covering the whole of the East Midlands region. Viewers can zoom in from a map of the whole region down to individual buildings. Hovering the mouse cursor over a building results in a pop-up box containing key information about the building such as its age, sources of energy, energy consumption and EPC certificate.

Two screenshots from Nordic Energy's interactive model are below, which can be accessed through their website (www.nordic.energy)

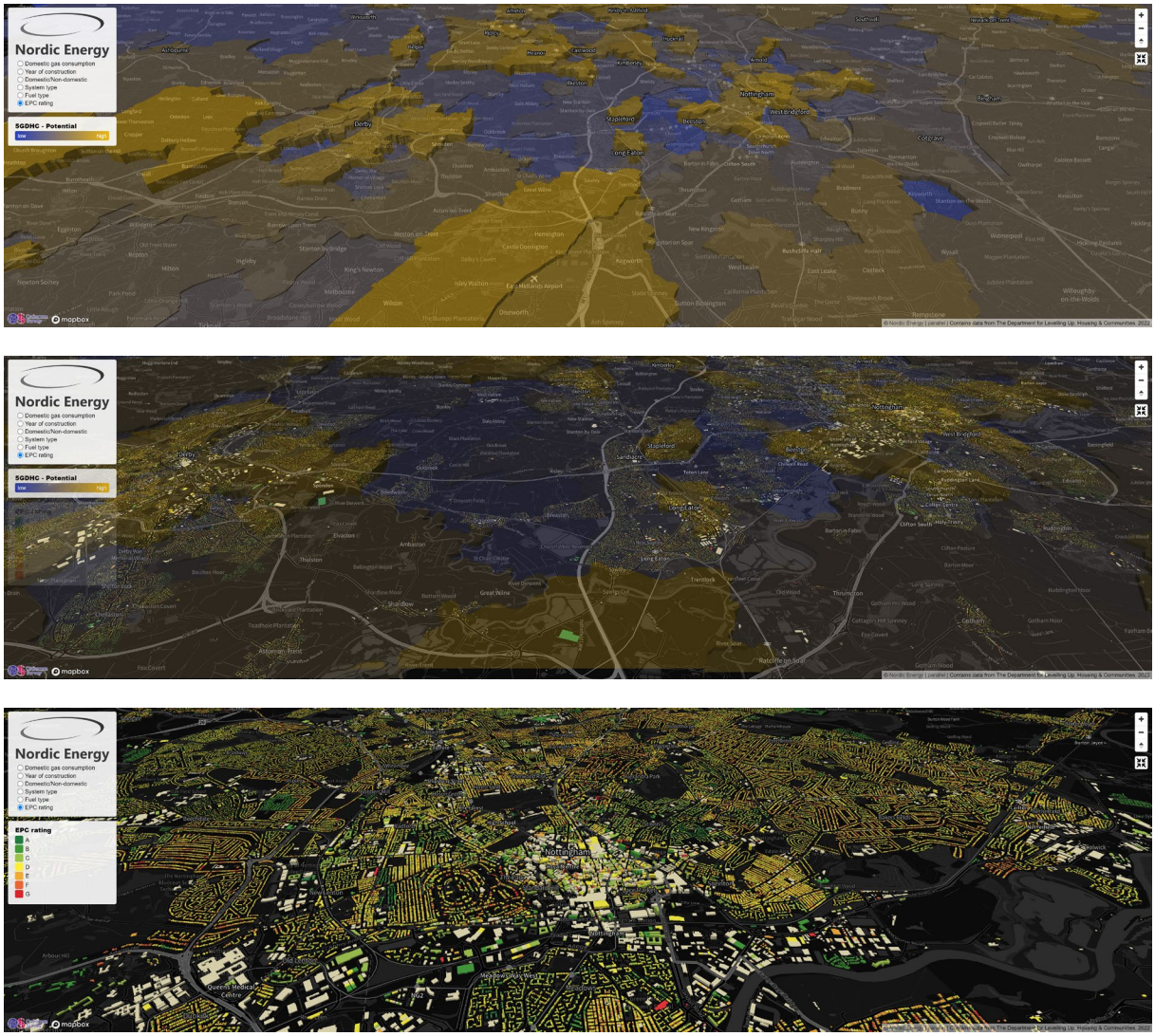

Figure 21. Screenshots of the interactive Model

DH networks are usually enabled by local authorities which can make it difficult to tie this in with a regional strategy and vision as the approach is very patchwork. BEIS has formed 'Net Zero Hubs' to help facilitate these regional developments.

Nordic Energy is in the process of sharing the Interactive Model with the Midlands Net Zero Hub (covering a similar area to the East Midlands) with a view to assisting the identification of optimal 5GDHC opportunities.

6. References

See notes through the text