

Keadby Next Generation Power Station

Environmental Permit Application

Appendix F – Combined Heat and Power Readiness Assessment

The Environmental Permitting (England and Wales) Regulations 2016

Operator: Keadby Next Generation Limited

Date: December 2025

Document History

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Glossary

| Abbreviation | Description |
|--------------|--|
| BAT | Best Available Techniques - the available techniques which are the best for preventing or minimising emissions and impacts on the environment. BAT is required for operations involving the installation of a facility that carries out industrial processes. Techniques can include both the technology used and the way an installation is designed, built, maintained, operated and decommissioned. |
| BEIS | Department for Business, Energy and Industrial Strategy (now DESNZ). |
| CBA | Cost-benefit analysis - involves analysing the benefits of a course of action and comparing against the costs associated with it. |
| CCGT | Combined Cycle Gas Turbine – a highly efficient form of electricity generation technology. An assembly of heat engines work in tandem using the same source of heat to convert it into mechanical energy which drives electrical generators and consequently generates electricity. |
| CCP | Carbon Capture Plant – plant used to capture carbon dioxide (CO ₂) emissions produced from the use of fossil fuels in electricity generation and industrial processes. |
| CHP | Combined Heat and Power - process that captures and utilizes the heat that is a by-product of the electricity generation process |

| Abbreviation | Description |
|--------------|--|
| CHPQA | Combined Heat and Power Quality Assurance - a government initiative providing a practical, determinate method for assessing all types and sizes of Combined Heat and Power (CHP) schemes throughout the UK. |
| CHP-R | Combined Heat and Power – Ready – refers to a power generation station which is designed to be ready, with minimum modification, to supply heat in the future. |
| DCO | Development Consent Order – made by the relevant Secretary of State pursuant to The Planning Act 2008 to authorise a Nationally Significant Infrastructure Project. A DCO can incorporate or remove the need for a range of consents which would otherwise be required for a development. A DCO can also include rights of compulsory acquisition. |
| DECC | Department of Energy and Climate Change (now DESNZ) |
| DESNZ | Department for Energy Security and Net Zero |
| DTI | Department of Trade and Industry (now DESNZ) |
| HCA | Homes and Communities Agency - non-departmental public body that funded new affordable housing in England (now Homes England). |
| HP | High Pressure |
| HRSG | Heat Recovery Steam Generation - an energy recovery heat exchanger that recovers heat from a hot gas stream. It produces steam that can be used in a process (cogeneration) or used to drive a steam turbine (combined cycle). |
| IP | Intermediate Pressure |
| LEP | Local Enterprise Partnerships - business-led partnerships between local authorities and local private sector businesses. |
| LP | Low Pressure |
| MW | Megawatt – unit of power |
| MWth | Megawatts thermal – thermal power |
| NLC | North Lincolnshire Council |

| Abbreviation | Description |
|--------------|---|
| NSIP | Nationally Significant Infrastructure Project – defined by the Planning Act 2008 and cover projects relating to energy (including generating stations, electric lines and pipelines); transport (including trunk roads and motorways, airports, harbour facilities, railways and rail freight interchanges); water (dams and reservoirs, and the transfer of water resources); wastewater treatment plants and hazardous waste facilities. These projects are only defined as nationally significant if they satisfy a statutory threshold in terms of their scale or effect. |
| OEM | Original Equipment Manufacturer |
| PES | Primary Energy Saving – the reduction in non-converted energy available by implementing a combined heat and power scheme compared to the proposed installation. It quantifies the energy efficiency gains by utilising waste heat from power generation, which would otherwise be lost, thereby lowering overall fuel use and emissions. |
| SoS | Secretary of State - title typically held by Cabinet Ministers in charge of Government Departments |

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1. Introduction

1.1. Overview

This Combined Heat and Power Readiness Assessment has been prepared by AECOM on behalf of Keadby Next Generation Limited ('the Operator') which is a subsidiary of SSE plc. It forms part of the application for an Environmental Permit, submitted to the Environment Agency under the Environmental Permitting Regulations (England and Wales) 2016 (as amended).

The Keadby Next Generation Power Station ('the Proposed Installation') is a new CCGT electricity generating station with a capacity of up to 910MW electrical output. The Proposed Installation will be designed to run on 100% hydrogen and capable of operating on 100% natural gas from the start of operations. When hydrogen becomes available and operation with hydrogen firing is commercially viable, the Proposed Installation will be upgraded to operate on a blend of natural gas and hydrogen or 100% hydrogen.

The Proposed Installation will be located on land to the west of Keadby 1 and Keadby 2 Power Stations. The Proposed Installation includes connections for cooling water, electricity, hydrogen and natural gas, and construction laydown areas and other associated development.

1.2. The Proposed Installation

The Proposed Installation would comprise a high efficiency gas fired power station with an electrical output capacity of up to 910MWe and associated buildings, structures and plant.

The Proposed Installation will include:

- a new-build CCGT electricity generating station fuelled by hydrogen and/or natural gas with a power output of up to 910MW (Work No. 1) including:
 - a CCGT plant;
 - cooling infrastructure;
 - natural gas and hydrogen blending equipment (for the Operator's infrastructure);
- supporting facilities including administration and control buildings, workshops, storage buildings, effluent treatment facilities, fire water storage tank(s), demineralised water treatment plant including storage tank(s), and permanent laydown areas for operation and maintenance activities;

- a hydrogen supply pipeline, including a gas compound for the hydrogen supplier's apparatus and a hydrogen gas compound for the Operator's apparatus;
- a natural gas supply pipeline including a compound for the natural gas supplier's apparatus and a natural gas compound for the Operator's apparatus.
- electrical connection works for the export and import of electricity to and from the generating station and the existing 400kV National Grid Electricity Transmission (NGET) substation located adjacent to the Keadby Power Station site, including works within the substation (which would be undertaken by NGET).
- water supply connection works to provide cooling and make-up water to the generating station, including intake structures and an underground and/or overground water supply pipeline running between the generating station and the Stainforth and Keadby Canal;
- connections to and use of an existing outfall and associated pipework for the discharge of used cooling water, surface water and treated effluent to the River Trent;
- public water connection pipeline from a new connection on Chapel Lane to provide potable water to the generating station;
- an allocation of land to meet the requirements of the Carbon Capture Readiness (Electricity Generating Stations) Regulations 2013.

The Operator will be responsible for the construction, operation (including maintenance) and eventual decommissioning of the Proposed Installation including the on-site connections to electricity, cooling water, hydrogen and natural gas supplies.

The Proposed Installation will be capable of operating 24 hours per day, 7 days per week with programmed offline periods for maintenance.

The route for the hydrogen supply pipeline to the Proposed Installation has not yet been confirmed. The supply pipeline is not included in the Proposed Installation and will be progressed by a third party under a separate consent. In line with Government policy, it is recognised that developments such as the Proposed Installation are needed to stimulate investment in the development of hydrogen production and supply infrastructure.

1.3. The Proposed Installation Site

The Site is located within and near to the existing Keadby Power Station site near Scunthorpe, Lincolnshire and lies within the administrative boundary of North Lincolnshire Council (NLC). The majority of land is within the ownership or control of the Operator (or SSE associated companies) and is centred on national grid reference 482351, 411796.

The existing Keadby Power Station site currently encompasses the operational Keadby 1 and Keadby 2 Power Station sites, including the Keadby 2 Power Station Carbon Capture and Readiness reserve space.

1.4. The Purpose of CHP

CHP is the generation of electrical power and usable heat in a single process. This is also known as co-generation. CHP beneficially utilises a greater proportion of the fuel energy, reducing the energy wasted as low-grade heat when generating electrical or mechanical power.

Inherent to the design of combined cycle combustion power plant is the efficient use of 'waste' heat within the combined cycle technology. The waste heat from the gas turbine is recovered by a heat recovery steam generator and steam at high, intermediate and low pressures used to generate electricity within the steam turbine. Steam can be extracted from the steam turbine to provide heat to offsite heat loads. Utilising high pressure steam for electricity generation is more efficient, as it maximises the extraction of useful energy by the steam turbine. Low pressure steam, which has already delivered much of its energy, is more suitably employed in CHP applications. Moreover, the temperature of low-pressure steam is more suited to typical heat demand profiles, making it a favourable option for CHP.

Where carbon capture readiness is also required as an alternative to hydrogen-fired operation as a decarbonisation approach the steam provision required in the CCP is obtained from the CCGT; this is primarily used to generate the heat necessary to separate the captured carbon dioxide from the rich amine within the carbon dioxide stripper.

1.5. The Purpose and Structure of this Document

The purpose of this document is to comply with Section 4.8 of the 'Overarching National Policy Statement for Energy (EN-1)' (DESNZ) and Paragraph 1.6.2 of the 'National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2)' (DESNZ), which require developers promoting thermal generating stations to consider the opportunities for the implementation of CHP. In addition, it fulfils the requirements of the 'CHP Ready Guidance for Combustion and Energy from Waste Power Plants' (Environment Agency, 2013) (the 'CHP-R Guidance'). The document is structured as follows:

- Section 2 describes the policy context and assessment methodology;
- Section 3 assesses the feasibility of heat extraction from the Proposed Installation based on the current design;
- Section 4 identifies potential heat users in the vicinity of the Proposed Installation Site;
- Section 5 presents the assessment of the Proposed Installation against the three Best Available Technique ('BAT') Tests described in the CHP-R Guidance; and
- Section 6 presents the conclusions of this CHP assessment.

2. Policy Context and Assessment Methodology

National Policy Statements

The National Policy Statements (NPS) for energy infrastructure form the policy framework for applications for new generating stations of greater than 50MW capacity in England and 350MW in Wales. The NPS of most relevance to the Proposed Installation (and this CHP assessment) are EN-1 and EN-2.

Section 4.8 of EN-1 deals with the consideration of CHP. Paragraph 4.8.3 states that CHP is technically feasible for many types of thermal generating stations, including gas-fired, nuclear, energy from waste and biomass. Paragraph 4.8.4 goes on to state that the use of CHP reduces emissions, and that the Government is therefore committed to promoting 'Good Quality CHP', which denotes CHP that has been certified as highly efficient under the CHP Quality Assurance ('CHPQA') programme.

Paragraph 4.8.6 of EN-1 recognises that, to be economically viable as a CHP plant, a generating station needs to be located close to industrial or domestic customers with heat demands. The distance will vary according to the size of the generating station and the nature of the heat demand.

Paragraph 4.8.8 of EN-1 highlights that under guidelines issued by the Department of Trade and Industry (DTI) in 2006 (DTI4, 2006), any application to develop a thermal generating station under Section 36 of the Electricity Act 1989 must either include CHP or contain evidence that possibilities for CHP have been fully explored to inform the consideration of the application by the SoS. The paragraph goes on to confirm that the same principle now applies to any thermal generating station that is the subject of an application for development consent under the 2008 Act and that the SoS should have regard to the DTI guidance, or any successor to it, when considering the CHP aspects of applications for thermal generating stations.

Paragraph 4.8.9 and 4.8.10 of EN-1 state that:

'In developing proposals for new thermal generating stations, applicants should consider both the current and future opportunities for CHP from the start and it should be adopted as a criterion when considering potential locations for a project. Given how important liaison with potential customers for heat is, applicants should not only consult those potential customers they have identified themselves but also Local Authorities, obtaining their advice on opportunities. Further advice is contained in the 2006 DTI guidance and applicants should also consider relevant information in regional and local energy and heat demand mapping.'

According to the Paragraph 4.8.12 of EN-1, the utilisation of useful heat that can replace conventional fossil-fuel based heat generation is encouraged, and the proposals include CHP will be given substantial weight. Applicants proposing thermal generation without CHP should ensure that they address the following points:

- explain why CHP is not economically or practically feasible;
- provide details of any potential future heat requirements in the area that have been considered and the reasons the station could not meet them;
- detail the provisions in the proposed scheme for ensuring any potential heat demand in the future can be exploited; and
- provide an audit trail of dialogue between the applicant, prospective customers, the local area energy team in local government and district heating energy supplies companies.

Paragraph 4.8.17 of EN-1 states that, if not satisfied with the evidence that has been provided, the SoS may wish to investigate this with one or more bodies such as the Local Authorities. According to paragraph 4.8.18 of EN-1, if the SoS identify a potential heat customer that has not been explored, the applicant should be requested to pursue this.

Paragraph 4.8.19 of EN-1 states that: 'The Secretary of State may also be aware of potential developments (for example from the applicant or a third party) which could utilise heat from the plant in the future, for example planned housing, and which is due to be built within a timeframe that would make the supply of heat cost-effective. Where it may be reasonably possible for the applicant to reach agreement with a potential heat customers during the lifetime of the station, the Secretary of State may wish to impose requirements to ensure that generating station is CHP-ready and designed in order to allow heat supply at a later date.'

NPS EN-2 reiterates the requirements of EN-1, to either include CHP or present evidence in the application that the possibilities for CHP have been fully explored (paragraph 1.6.2).

DESNZ published revised drafts of some of the energy NPS (including EN-1 but not EN-2) for consultation in late April 2025. Following public consultation revised drafts were issued in November 2025 and these are due to be adopted in late December 2025. The provisions around CHP remain largely unchanged from those detailed above.

2.1. CHP Guidance

The requirements for the assessment of the feasibility of CHP in relation to thermal generating stations are set out in the 'Guidance on Background Information to Accompany Notifications Under Section 14(1) of the Energy Act 1976 and Applications under Section 36 of the Electricity Act 1989' (the 'CHP Guidance') (DTI, 2006). A driving principle behind the guidance – and the broader philosophy of CHP – is the reduction of losses in the power generation process, associated improvements in efficiency and ultimately, therefore a reduction in CO₂ emissions.

Paragraph 8 of the CHP Guidance states that the Government expects developers to explore opportunities to use CHP fully when developing proposals for new thermal generating stations and provide evidence to show the steps taken to assess the viability of CHP opportunities. However, it does recognise that in some cases CHP will not be an economic option.

Paragraph 12 of the CHP Guidance lists what must be included with applications where CHP is not to be included. This includes:

- the basis for the developer's conclusion that it is not economically feasible to exploit existing regional heat markets;
- a description of potential future heat requirements in the area; and
- the provisions in the proposed scheme for exploiting any potential heat demand in the future.

Paragraphs 13 - 17 provide guidance on exploring opportunities for local users to make use of heat. Developers should fully explore opportunities for existing and likely local users of heat across a range of sectors, including industry, housing and community users. They should also engage with Government agencies, have regard to heat mapping and contact regional and local bodies to identify potential heat users.

Paragraph 19 stresses that where heat opportunities have been identified, developers should carry out detailed studies on the economic feasibility of these. Paragraphs 20 - 22 provide further guidance on economic feasibility.

2.2. CHP-R Guidance

In 2013, the Environment Agency published detailed guidance on CHP-readiness assessments required for thermal generating stations (the 'CHP-R Guidance'), to be used by developers and Environment Agency officers as part of the Environmental Permitting regime.

The Environment Agency requires applications for Environmental Permits to demonstrate BAT is implemented at any new 'installation'. BAT applies to a number of operational criteria, including energy efficiency.

In accordance with the CHP-R Guidance, the Environment Agency requires that developers satisfy three BAT tests in relation to CHP. The first involves considering and identifying opportunities for the use of heat off-site. Where this is not technically or economically possible and there are no immediate opportunities, the second test involves ensuring that the plant is built to be 'CHP - Ready'. The third test involves carrying out periodic reviews to see if the situation has changed and there are opportunities for heat use off-site.

Where development consent is granted for a new plant without CHP, the associated application for an Environmental Permit should build on the conclusions of the CHP

assessment and contain sufficient information to demonstrate the new plant will be built 'CHP - Ready' ('CHP-R') (for the chosen location and design). The Environment Agency requires that:

'all applications for Environmental Permits for new installations regulated under the Environmental Permitting (England and Wales) Regulations 2010⁵ demonstrate the use of BAT for a number of criteria, including energy efficiency. One of the principal ways in which energy efficiency can be improved is through the use of Combined Heat and Power (CHP). With respect to the use of CHP, there are three BAT tests which should be applied [...].'

The three BAT tests are summarised below:

First BAT Test:

'The Environment Agency considers that BAT for energy efficiency for new combustion power plant or Energy from Waste (EfW) plant is the use of CHP in circumstances where there are technically and economically viable opportunities for the supply of heat from the outset.

The term CHP in this context represents a plant which also provides a supply of heat from the electrical power generation process to either a district heating network or to an industrial/ commercial building or process.

However, it is recognised that opportunities for the supply of heat do not always exist from the outset (i.e. when a plant is first consented, constructed and commissioned).'

Second BAT Test:

In cases where there are no immediate opportunities for the supply of heat from the outset, the Environment Agency considers that BAT is to build the plant to be CHP-Ready (CHP-R) to a degree which is dictated by the likely future opportunities which are technically viable and which may, in time, also become economically viable.

The term 'CHP-R' in this context represents a plant which is initially configured to generate electrical power only, but which is designed to be ready, with minimum modification, to supply heat in the future. The term 'minimum modification' represents an ability to supply heat in the future without significant modification of the original plant / equipment. Given the uncertainty of future heat loads, the initial electrical efficiency of a CHP-R plant (before any opportunities for the supply of heat are realised) should be no less than that of the equivalent non-CHP-R plant.'

Third BAT Test:

Once an Environmental Permit has been issued for a new CHP-R plant, the operator should carry out periodic reviews of opportunities for the supply of heat to realise CHP. Such opportunities may be created both by new heat loads being built in the vicinity of

the plant, and/ or be due to changes in policy and financial incentives which improve the economic viability of a heat distribution network for the plant being CHP.

The CHP-R Guidance reiterates the need for applications for development consent involving generating stations to be supported by a CHP assessment in line with Section 4.6 of EN-1. The CHP-R Guidance (Section 3.2) states that a CHP assessment should contain details on:

- *‘an explanation of their choice of location, including the potential viability of the site for CHP;*
- *a report on the exploration carried out to identify and consider the economic feasibility of local heat opportunities and how to maximise the benefits from CHP;*
- *the results of that exploration; and*
- *a list of organisations contacted.’*

If the proposal is for generation without CHP, the CHP assessment should also contain:

- *‘the basis for the developer’s conclusion that it is not economically feasible to exploit existing regional heat markets;*
- *a description of potential future heat requirements in the area; and*
- *the provisions in the proposed scheme for exploiting any potential heat demand in the future.’*

The CHP-R Guidance states at Section 3.3 that:

‘The primary focus of this CHP-R Guidance is on the demonstrations required in an application for an Environmental Permit for new plants under the Environmental Permitting (England and Wales) Regulations 2010. However, the principles contained within this CHP-R Guidance may also have implications on consent applications (i.e. Planning Permission (under the Town and Country Planning Act 1990) or a DCO (under the Planning Act 2008)) for the new plant. Indeed, the Environment Agency will be consulted on these applications, as well as applications for extensions of/ variations to existing plants.’

The Environment Agency (2012) ‘Guidelines for Developments requiring Planning Permission and Environmental Permits’ set out the role of the Environment Agency in the planning process. The 2012 guidelines also set out the approach that the Environment Agency will take to responding to applications for developments which will also require an Environmental Permit. These Guidelines recognise that there may be some interdependencies between planning and permitting requirements and recommend early engagement with the Environment Agency via their planning pre-application service.

Therefore, it is recommended that the CHP-R Guidance (and the requirements for CHP-R) is considered prior to making a consent application for a new plant, in particular

because the first and second BAT tests may affect the layout, space requirements and building design for the implementation of CHP (or CHP-R).

Accordingly, the Environment Agency recommend that the requirement for new plants to be CHP or CHP-R be discussed at the earliest possible stage, ideally during planning the pre-application period. In any case, where a DCO is required, the operator will have to make similar demonstrations under both the planning and permitting applications in terms of suitability of the location for CHP, potential opportunities for heat supply and CHP-R. When consulted by the planning authorities on relevant consent applications for new plants, the Environment Agency will highlight the need for the plant to be CHP or CHP-R and will make reference to the CHP-R Guidance.

The CHP-R guidance states that:

'The Environment Agency will not object to applications for new plants where they are located in areas where there are no opportunities for heat supply. However, where relevant, the Environment Agency will highlight the lack of opportunities to the Planning Authorities, and this may influence the Planning Authority in its consideration of the suitability of the proposed location.'

2.3. Note on the Implementation of the Energy Efficiency Directive

In addition to the requirements of the CHP-R Guidance, the Energy Efficiency Directive has been implemented in the UK initially through the Environmental Permitting (England and Wales) (Amendment) Regulations 2015 (UK Gov., 2015). Since March 2015, these Regulations have required operators of certain combustion plants to carry out a cost-benefit analysis ('CBA') where opportunities for 'Good Quality CHP' schemes (or high efficiency co-generation) are identified. These schemes are those which achieve at least a 10 per cent saving in primary energy consumption ('primary energy saving' or 'PES').

2.4. Assessment Methodology

This CHP assessment has been undertaken in accordance with the methodology prescribed by the CHP-R Guidance, the stages of which are summarised below:

- identify whether the plant is required to provide CHP or be CHP-R;
- identify if there are opportunities for the supply of heat from the plant;
- where opportunities are identified, select the most appropriate heat loads for further consideration;
- determine the 'CHP envelope' to confirm if the plant is capable of serving the selected heat loads;
- identify the impacts on plant operation of supplying heat to the serviceable loads;
- identify the provisions required (e.g. on-site space) to supply heat to the serviceable loads; and

- undertake a CBA for the serviceable loads.

3. Heat Export Feasibility Study

3.1. Introduction

This section assesses the feasibility for heat extraction and export from the Proposed Installation for comparison with the identified CHP heat load presented in Section 4. The Proposed Installation includes a combined cycle gas turbine (CCGT) power station with electrical generating capacity up to 910 MW.

This analysis has been based on thermal modelling of the CCGT plant during part and full load scenarios as well as heat and material balance calculations from pre-FEED work. The largest gas turbine unit currently commercially available has been used as the power generation technology within the plant model to determine heat available from the Proposed Installation.

The Proposed Installation is intended to operate in dispatchable mode and as such may not be operating when required by potential heat users which presents a significant barrier to operation as a viable CHP installation.

Both part and full load scenarios have been considered within this study to produce a complete CHP envelope from minimum and maximum electrical power generation, respectively. It is difficult to predict the future operating regime of the Proposed Installation. There may be significant periods where the Proposed Installation is not operating at full load (or at all) under a flexible dispatchable regime; any heat made available for potential CHP is therefore likely to be intermittent, which does affect the viability of CHP provision.

3.2. Heat Extraction Options

The high efficiency observed in modern CCGTs, such as the model evaluated, is primarily achieved by minimising losses and maximising the integration of 'waste' heat within the plant itself. Useful heat is recovered from the gas turbine's exhaust gas through the Heat Recovery Steam Generator (HRSG). This heat is used to produce steam, at various pressures, which generates further power via a separate steam turbine.

The main heat extraction option considered is the extraction of steam from the electricity generating cycle. Within the scope of the Proposed Installation, the utilisation of low pressure (LP) steam offtake from the CCGT has been assessed in the context of CHP readiness. Utilisation of high pressure steam could also be considered but was discounted on an efficiency basis.

The exhaust gas exiting the HRSG through the main stack may still contain a certain amount of recoverable thermal energy and would not have a significant effect on the

CCGT unit, however as a minimum level of temperature is required for dispersion, impacting material selection and air quality, this option is discounted. Therefore, only the LP steam CHP-R design has been evaluated further here.

In order to be designed as CHP-R, it is expected that the design of the CCGT unit would be identical to conventional CCGT units with the inclusion of the following additional items:

- Accessible tie-in location in low pressure (LP) steam turbine inlet
- A steam turbine condenser design that would allow for integration with a heat pump to supply a district heat network
- Control systems allow for future integration with the heat offtake connections. (i.e. capable of accommodating a future heat offtake module and providing sufficient inputs/outputs capacity.)

The existing CHP guidance does not address heat pump opportunities or the comparison between power plant integration schemes and localised conventional heat pump schemes for district heat network and so is not developed as part of this CHP-R assessment.

The CHP envelope is based on the largest, current commercially available gas turbine unit. However, it should be noted that, in recognising the evolution of gas turbine technology, there is potential for further efficiency and output improvements to be made prior to or during the detailed design of the Proposed Installation. Therefore, the applications are seeking to allow and retain flexibility to adapt to future circumstances. In such circumstances, this could extend the boundaries of CHP envelopes.

3.3. Identification of the CHP Envelope

The following assumptions have been made to be used in the CHP envelope calculations.

- As the OEM has not yet been selected, a thermodynamic performance model representative of a generic H class machine has been used;
- It is assumed that standard LP turbine sizing with IP-LP crossover pressure control valve is used;
- LP delivery pressure is 4 bar(a) and temperature is 155°C;
- Condensate return temperature is 75°C;
- 25% of steam turbine exhaust flow from 100% load is considered the approximate limit to prevent LP last-stage blade buffeting;
- Thermal input LHV: 1387 MW for 100% load, 610 MW for min load;
- Thermodynamic performance on natural gas, hydrogen or natural gas - hydrogen blends are similar;
- For the purposes of assessing carbon capture impacts, a post combustion non-proprietary amine based solvent is assumed.

The following calculations have been performed to determine the CHP envelope. The envelope limits are defined as follows:

- A – Minimum Stable Load with No Heat Extraction;
- B – Minimum Stable Load with Maximum Heat Extraction;
- C – Maximum Electrical Power (100% Full Load) with Maximum Heat Extraction;
- and
- D – Maximum Electrical Power (100% Full Load) with No Heat Extraction.

The CHP efficiency (η_{CHP}) is defined as:

$$\eta_{CHP} = \frac{\text{Net Process Heat Output} + \text{Net Power Output}}{\text{Fuel Input}}$$

Based on the values of heat load and the expected electrical power output of the Proposed Installation, the CHP envelope can be produced as shown in **Plate 1**.

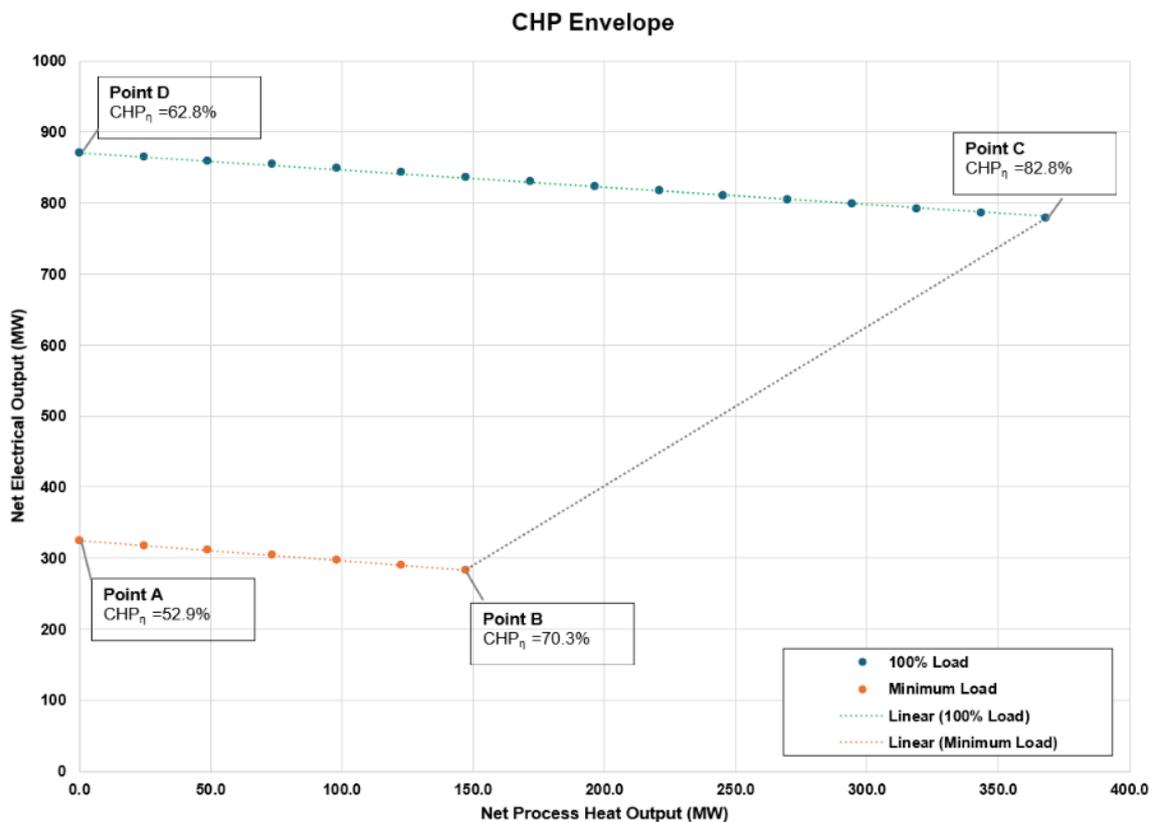


Plate 1: Indicative CHP Envelope (without CCP)

Table 1 shows that the primary energy saving (PES) associated with the Proposed Installation in CHP mode during full load would be approximately 16%, achieving a CHP efficiency of approximately 82.8%. During minimum load, the approximate primary saving, and CHP efficiency of the Proposed Installation would be 12% and 70.3%, respectively.

Table 1: Indicative CHP Envelope (without CCP)

| Description | Min. Elec. Power | Min. Elec. Power | Max. Elec. Power | Max. Elec. Power |
|---------------------------------|------------------|------------------|------------------|------------------|
| | No Heat Load | Max Heat Load | Max Heat Load | No Heat Load |
| Reference Point | A | B | C | D |
| Thermal Input, MWth | 610 | 610 | 1387 | 1387 |
| Net Power Output, MWe | 323 | 281 | 780 | 870 |
| Heat Load, MWth | 0 | 147 | 368 | 0 |
| CHP Net Efficiency, % | 52.9 | 70.3 | 82.8 | 62.8 |
| Primary Energy Saving, % | 0 | 12 | 16 | 0 |

The Proposed Installation does not include a carbon capture plant; it is being designed to run on 100% hydrogen and capable of operating on 100% natural gas from the start of operations. When hydrogen becomes available and operation with hydrogen firing is commercially viable, the Proposed Installation will be upgraded to operate on a blend of natural gas and hydrogen or 100% hydrogen. Therefore, a decarbonisation route via hydrogen firing is expected to be available. In order to comply with the Carbon Capture and Storage Regulations, sufficient space has been allocated for carbon capture and storage (CCS) infrastructure. However, it is a requirement to demonstrate Carbon Capture Readiness, which is recorded in CHP-R Guidance and which, if installed would impact the heat available for CHP.

In the event a carbon capture plant is installed and operational, the availability of steam energy for other off-takers is evaluated in **Table 2** below. Approximately 270 MWth of energy would be required for a future CCP in maximum load mode, and 123 MWth of energy would be required for the CCP in minimum load mode. Consequently, the energy yield from the steam cycle for the off-takers will be reduced. At maximum load, the energy available to off-takers after CCP would be 98 MWth, while this capacity reduces to 24 MWth at minimum load. In this case, the PES value is calculated as 4.5% for max load and 2% for min load. PES is lower at minimum load relative to maximum load because both heat and electrical efficiencies decline at reduced load. This efficiency drop is primarily caused by the steam cycle becoming increasingly sub-optimal as the load decreases.

CHP Envelope

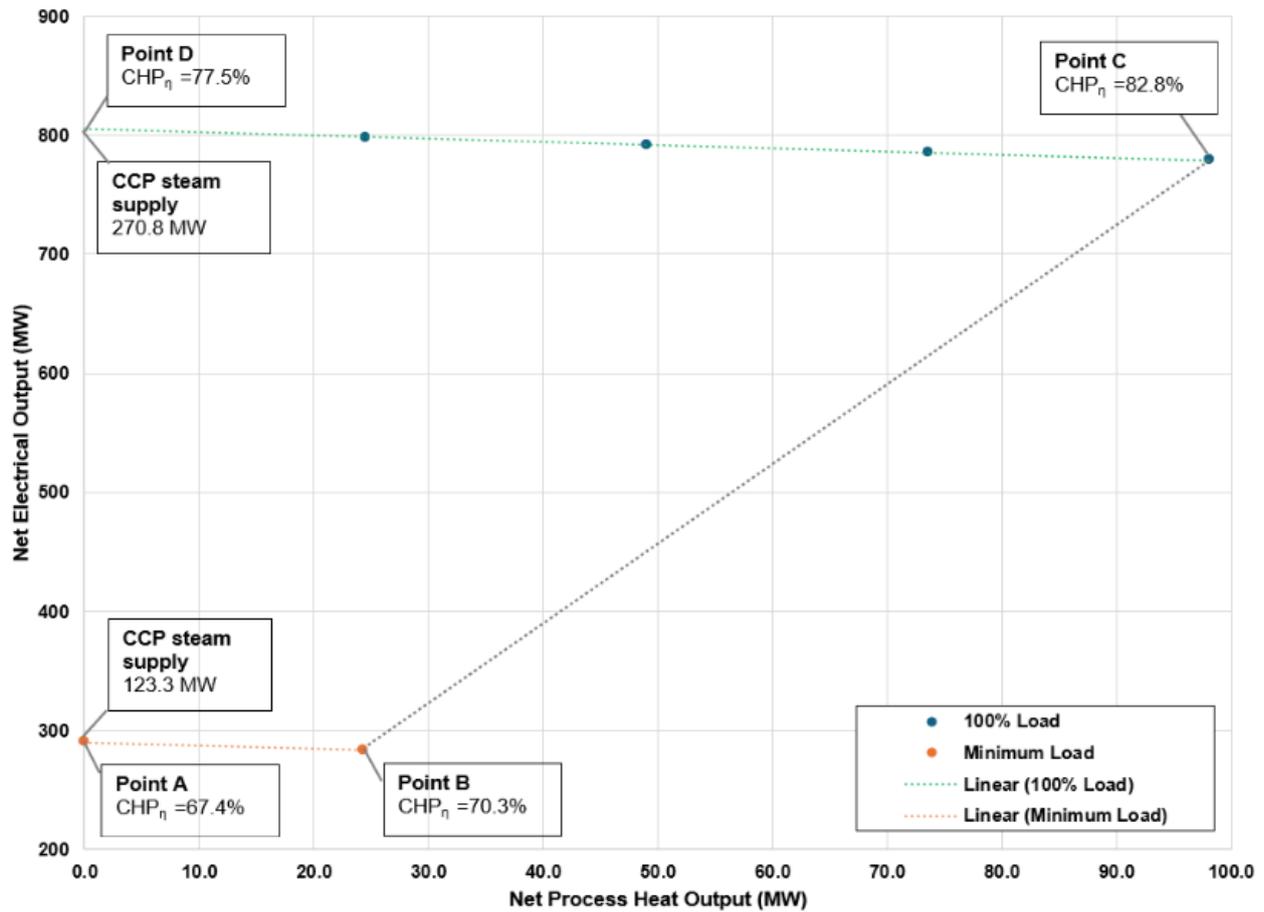


Plate 2: Indicative CHP Envelope (with CCP)

Table 2 Indicative CHP Envelope (with CCP)

| Description | Min. Elec. Power | Min. Elec. Power | Max. Elec. Power | Max. Elec. Power |
|-------------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|
| | No Heat Load for offtakers | Max Heat Load for offtakers | Max Heat Load for offtakers | No Heat Load for offtakers |
| Reference Point | A | B | C | D |
| Thermal Input, MWth | 610 | 610 | 1387 | 1387 |
| Net Power Output, MWe | 288 | 281 | 780 | 805 |
| Heat Load for CCP, MWth | 123 | 123 | 270 | 270 |
| Heat Load for offtakers, MWth | 0 | 24 | 98 | 0 |
| CHP Net Efficiency, % | 67.4 | 70.3 | 82.8 | 77.5 |

| Description | Min. Elec. Power | Min. Elec. Power | Max. Elec. Power | Max. Elec. Power |
|---------------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|
| | No Heat Load for offtakers | Max Heat Load for offtakers | Max Heat Load for offtakers | No Heat Load for offtakers |
| Primary Energy Saving, % | 18.3 | 2 | 4.5 | 17.8 |

The performance of the Proposed Installation (i.e. the indicative heat and power envelope data) is presented in Appendix A to this document, in the format defined by the CHP-R Guidance (Environmental Agency, 2013).

In the case of heat export from the CCGT to offtakers, as illustrated in **Plate 3**, while the produced net power decreases, plant CHP efficiency is enhanced, resulting in primary energy savings. Referring to the figure below, sourced from Environmental Agency’s CHP Ready Guidance, the system’s heat loss when the CCGT and a hypothetical standalone boiler individually meet power and heat demands is greater than the heat loss value of the CHP system. In this scenario, primary energy savings are achieved.

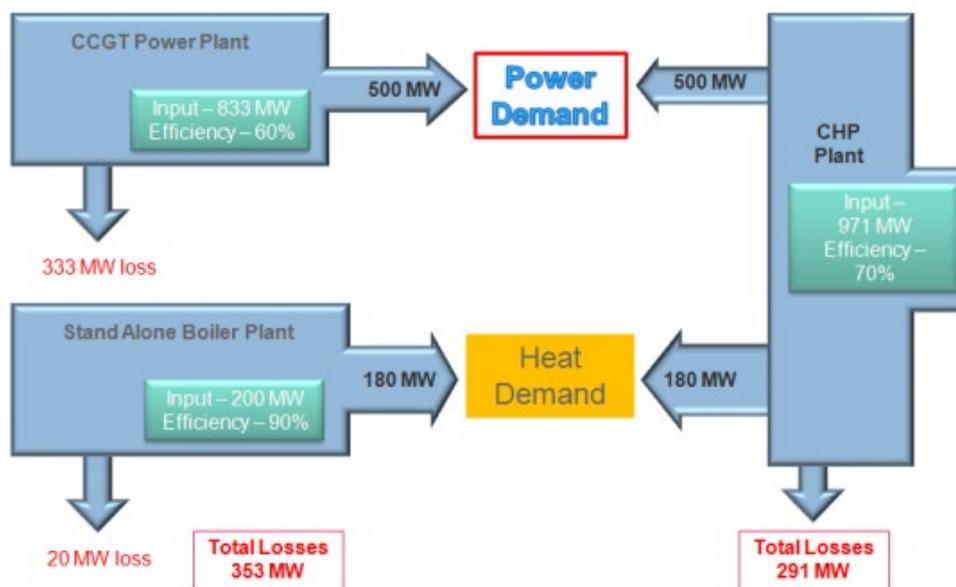


Plate 3: Generic Illustration of the Primary Energy Savings Resulting from the CHP

In the case presented in **Plate 3**, the key point to note is that the power supplied to the grid remains the same whether the CCGT and standalone boiler operate separately or as part of a CHP system. When heat extraction is carried out from the CCGT, the fuel input must be increased in order to maintain the same power output, which is not a possible scenario for the Proposed Installation discussed in this report as the base case is already based on 100% fuel input value. In this case, the reduction in power output due to the heat extraction must be balanced by increased generation from another equivalent CCGT operating on the grid. However, this report does not consider an assessment of the efficiency of such an external CCGT plant.

Plate 4 and **Plate 5** respectively present the loss calculation used to determine the primary energy saving % under maximum and minimum load conditions of the Proposed Installation. At maximum load with maximum heat extraction PES is calculated to be 16%; under minimum load with maximum heat extraction, PES is found to be 12%. As outlined in the Energy Efficiency Directive (Directive 2012/27/EU of the European Parliament and of the Council of 25 October), a CBA is only required where the CHP opportunity has the potential to be “high efficiency” that means where the PES achieves 10% or greater. However, the PES calculation must also be performed based on the heat demand selected within a 15 km radius, as this will determine whether an economic analysis is required. The details of calculation and results are provided in Section 4.

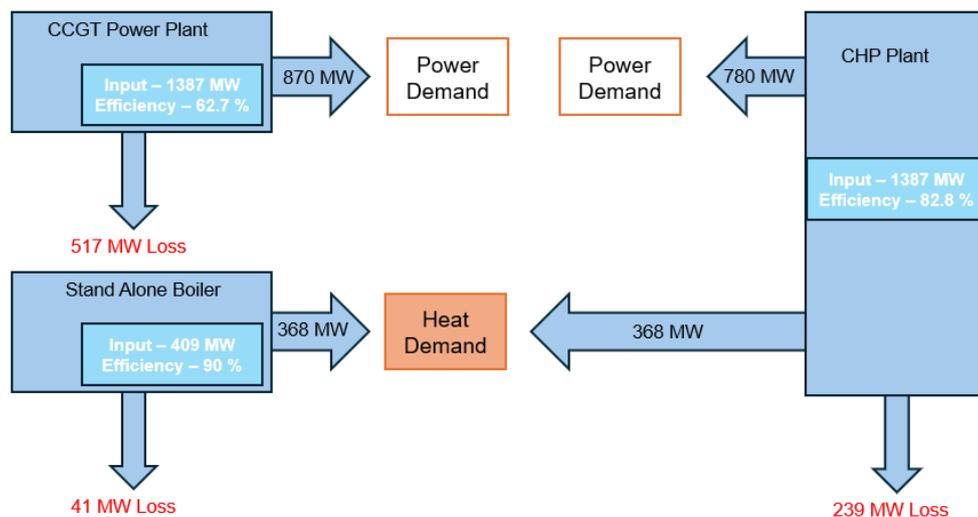


Plate 4: Illustration of the Primary Energy Savings Resulting from the CHP for power station Maximum Load

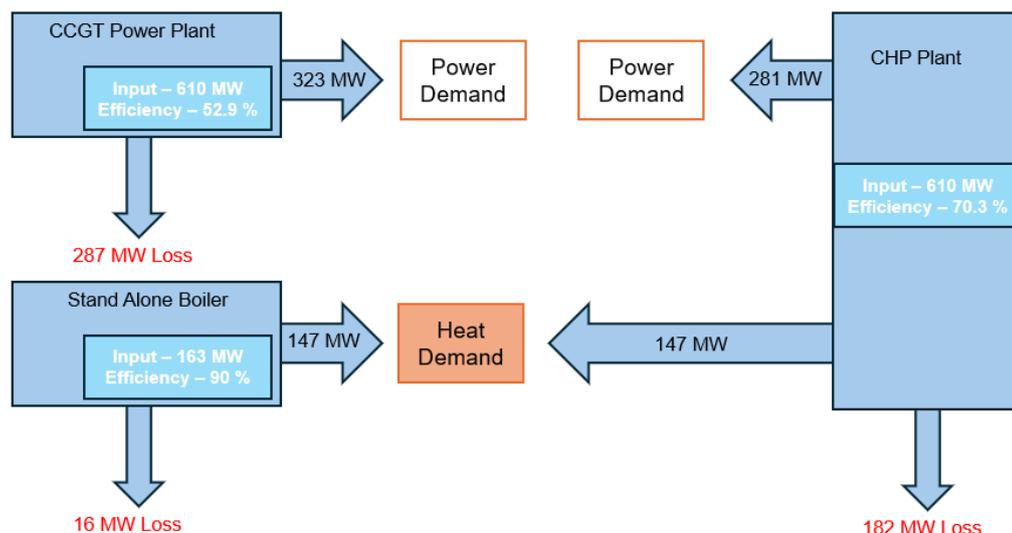


Plate 5: Illustration of the Primary Energy Savings Resulting from the CHP for power station Minimum Load

4. Identification of Potential Heat Users and Viability Assessment

4.1. Introduction

A review of the potential heat demand within a 15km radius of the centre of the Proposed Installation has been undertaken to assess potential known or consented future developments that may require heat and to identify any existing major heat consumers, i.e. to identify potential heat loads.

Potential heat loads were identified using publicly available datasets, including regional fuel use data, the UK CHP Development Map, Ordnance Survey (OS) mapping, satellite imagery, and aerial photographs from Google Earth. (see Appendix B). The CHP-R Guidance states that heat loads used in the CHP-R assessment should be agreed with the Environment Agency. This will be carried out during the Environmental Permit determination period if any potentially viable CHP opportunities are identified.

4.2. CHP Opportunities

In line with the CHP Guidance, CHP assessments consider data from the UK CHP Development Map (BEIS, 2021). An assessment using this updated resource was conducted for a 15 km radius centred on the Proposed Site. The findings are presented in **Plate 6**.

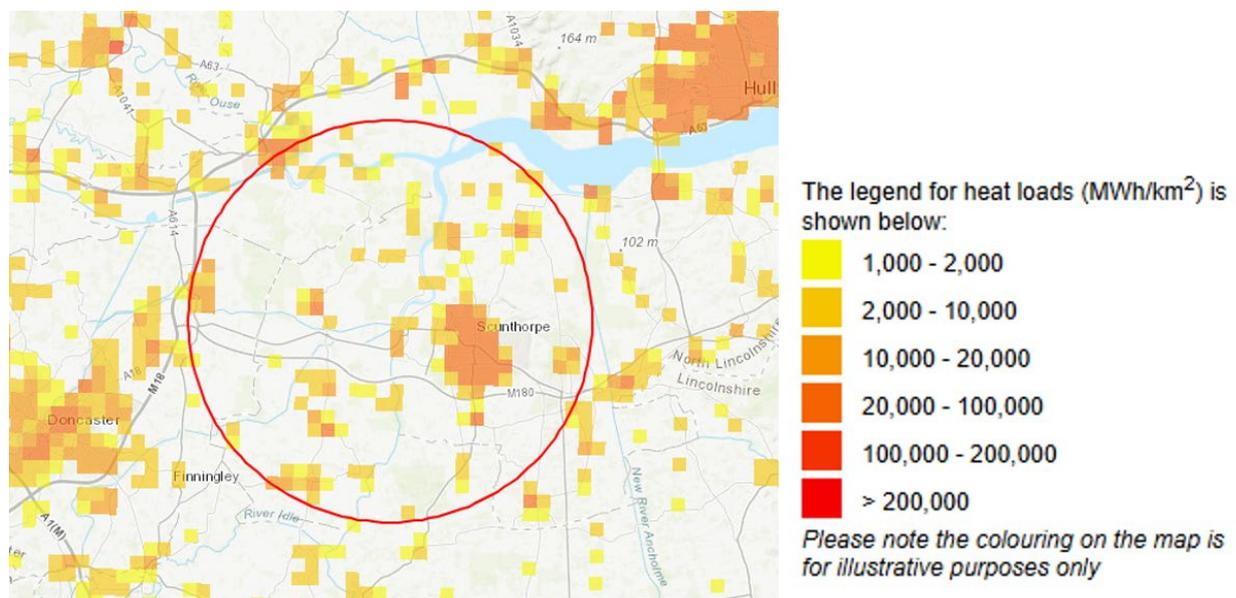


Plate 6: (Appendix B) Results from the examination of the UK CHP Development Map: Total heat demand map

4.3. CHP Viability

Plate 6 indicates that the area of highest heat demand within the study boundary is Scunthorpe, approximately 8-11km away from the site. This presents a potential opportunity for the deployment of a district heating network. Developing a heat network to serve such a wide area would involve substantial logistical and economic challenges, especially given the predominance of low-density, detached and semi-detached housing in the area. A single district heating main extending from the Keadby Power Station to Scunthorpe would therefore represent the most technically and economically feasible option, as constructing multiple pipelines in different directions would substantially increase capital expenditure (CAPEX) and reduce overall viability.

Based on the operational cases and CCGT modelling, two heat extraction threshold values have been identified at which the PES exceeds 10%. It has been calculated that if the heat demand within the 15 km radius surpasses these thresholds, the PES value will exceed 10%. The heat extraction amounts capable of exceeding the 10% of PES threshold at both minimum and maximum gas turbine loads are provided below:

- Gas Turbine at Maximum Load: At 221 MWth heat offtake, the PES > 10%.
- Gas Turbine at Minimum Load: At 123 MWth heat offtake, the PES also > 10%.

Using a plant utilisation factor of around 40% of the year, total annual heat energy available ranges between 429,000 MWh and 773,000 MWh. Comparing these heat quantities with the totals shown in Appendix B, these are greater than the total heat demand for all non-domestic buildings within a 15km radius. The non-domestic buildings have a calculated load of 120,000 MWh/yr which falls below 10% PES scenarios.

For the 10% PES to be exceeded all non-domestic buildings in the 15km radius and approximately 21 % of the domestic buildings that are scattered within 15km radius would need to be connected to the network. If only the non-domestic load of 120,000 MWh/yr was to be accounted for maximum and minimum gas turbine load scenarios this would have PES value of 2% for minimum and 4.5% for maximum.

A potential district heating network would serve only non-commercial buildings in this initial assessment. This is due to the comparatively simpler and less complex connection process for non-commercial users, making them more suitable for early-phase evaluations. Based on this limited scope, the heat load estimated does not result in a Primary Energy Saving (PES) greater than 10%. According to the Energy Efficiency Directive (Directive 2012/27/EU of the European Parliament and of the Council of 25 October), cost-benefit analysis is required for high-efficiency cogeneration installations that exceeds PES of 10%. Therefore, since the PES does not exceed this threshold, no further detailed financial modelling has been conducted at this stage. However, the heat load potential in Scunthorpe (the areas of highest heat demand identified), particularly if extended to commercial buildings or future developments might warrant further investigation in future.

Developing a heat network to serve a wide area comprising thousands of buildings, including individual homes, presents substantial logistical and economic challenges. District heating becomes financially viable primarily in high-density residential areas (e.g. flats or terraced housing). In contrast, most dwellings in the vicinity are semi-detached or detached, making decentralised options like individual air source heat pumps more economically attractive for these users.

However, this could change in the future, as, recent Heat network zoning regulation (DESNZ, 2024) concerning district heating schemes require new buildings, non-domestic buildings above an agreed size and energy use threshold and buildings that are already communally heated within a defined proximity of a heat network to connect, where feasible. According to the Heat network zoning regulation, to identify potential heat network zones in towns and cities, a methodology is being developing, and the proposed methodology is being tested in the pilot projects now. Then, national standards will be set. Once the pilot studies are concluded and the necessary standards are formally established under this regulation, it is expected that heat demand in Scunthorpe could increase accordingly.

4.4. Economic Assessment

The Economic Assessment is a requirement when the calculated Primary Energy Saving (PES) exceeds 10%. In this case, while the technical assessment identified potential maximum heat loads, the serviceable (or realistically usable) heat load is significantly lower due to local demand constraints. As a result, the calculated PES falls below the 10% threshold, and a full Economic Assessment has not been prepared. As the Proposed Installation is intended to operate in dispatchable mode it may not be operating when required by potential heat users and additional heat generating equipment such as standalone boilers might be required to address this.

4.5. Further Consideration and Potential Challenges of CHP

Within the defined CHP envelope and based on the selected heat demand value of 120,000 MWh within a 15 km radius, the calculated PES does not exceed 10%. As outlined in Section 4.4, under such circumstances a CBA is not required. However, should the heat demand or the plant's operational profile change in the future, the CHP scheme may become economically viable. In such a case, it is essential that the plant, being CHP-R, is capable of supplying heat with minimal modifications. Therefore, the system must be designed to be compatible with the potential future implementation of CHP infrastructure. This includes, but not limited to, provisions such as accessible tie-in locations, control system requirements, as summarized in paragraph 3.2.4.

5. BAT Assessment

5.1. Introduction

The CHP-R Guidance states that the Environment Agency require applications for Environmental Permits to demonstrate BAT for a number of criteria, including energy efficiency. Aside from the selection of efficient turbines, one of the principal ways of improving energy efficiency is through the use of CHP. The Environment Agency therefore requires developers to satisfy three BAT tests in relation to CHP.

The first involves considering and identifying opportunities for the use of heat off-site. Where this is not technically or economically possible and there are no immediate opportunities, the second test involves ensuring that the plant is built to be 'CHP - Ready'. The third test involves carrying out periodic reviews to see if the situation has changed and there are opportunities for heat use off-site.

The CHP-R Guidance BAT requirements have been fulfilled for the Proposed Installation, as outlined in this section.

5.2. Plant Description

As detailed within Section 1, the Proposed Installation consists of a CCGT plant.

Details of the plant energy production and potential heat loads are identified in Sections 3 and 4 respectively and summarised within the CHP-R Assessment Form presented in Appendix A.

5.3. BAT Tests

The following section describes how the Proposed Installation addresses the three BAT Tests identified within Section 2.3.

First BAT Test

As illustrated in Section 3 and summarised in the CHP-R Assessment Form in Appendix A, the Proposed Installation has up to 368 MWth and 147 MWth of heat available for supplying to heat off-takers at full and part load respectively. This is illustrated in the CHP envelope identified in Section 3 and demonstrates that the Proposed Installation has the capacity to produce a significant quantity of hot water should there be demand for local district heating.

The Proposed Installation is in excess of the 300MWe threshold identified in the Environment Agency's CHP-R Guidance (2013) and is expected to operate primarily as

a dispatchable plant over its 25-year design life. As such the operating profile of the Proposed Installation may not be operating when required by potential heat users and as such is not well suited to the local heat demands from potential offtakers.

The assessment undertaken in Section 3 has identified that the maximum theoretical heat output for the plant represents a PES of approximately 12% for minimum load and 16% for maximum load which are above the 10% threshold identified by the Energy Efficiency Directive for high efficiency co-generation.

The heat demand within a 15km radius of the plant has been identified and is considered technically feasible. Section 5 above discusses the potential heat users within this area. The total selected non-domestic heat demand has been estimated at 120,000 MWh. Based on this evaluation, the resulting Primary Energy Saving (PES) has been determined to be below 10%, indicating that it is not economically viable. As such, a CBA has not been prepared due to the limited serviceable demand and the dispatchable nature of the plant, which means that the theoretical heat is unlikely to be consistently available in practice for the expected operating profile of the Proposed Installation.

Second BAT Test

Whilst no current heat demand has been identified that is economically viable, there is the potential for a number of neighbouring opportunities to be developed that could provide a viable heat demand. To this extent, the extraction option from the steam cycle has been evaluated. In the case of Carbon Capture Plant integration, potential heat extraction options within the CCP could also be considered.

The Proposed Installation, in accordance with Second BAT Test, will be built to be 'CHP Ready'. To account for the possibility that future heat loads may become economically viable, the detailed design phase will include an assessment of potential design provisions that could allow for the implementation of the required infrastructure.

In accordance with the second BAT Test of the Environment Agency's CHP-R Guidance (2013), this assessment assumes that, given the uncertainty of future heat loads and the fact that it is not technically or economically feasible to install CHP from Commercial Operation Date, the initial electrical efficiency of the 'CHP Ready' Proposed Installation is no less than that of the equivalent non-CHP Ready plant. This may impact the extent of "CHP-Readiness" of the installation.

The Proposed Installation will be built to be CHP-Ready, incorporating the necessary provisions summarized in paragraph 3.2.4, in addition to the features of a conventional CCGT unit.

Third BAT Test

Once the Proposed Installation is operating as a 'CHP Ready' plant, the Operator will also carry out an ongoing review of CHP potential, including:

- carrying out regular reviews to determine if there have been sufficient changes in circumstances (e.g. due to changes in policy and/ or financial incentives that make it more economically viable) to warrant new technical and economic assessments; and
- carrying out regular review of operating profile of the power plant and impact on technical and economic viability
- re-visiting the technical and economic assessments within 12 months of the Commercial Operation Date and at least every 5 years thereafter or when a change in circumstances warrant.

6. Conclusions

In line with the requirements of NPS EN-1 and EN-2 (DECC, 2011a and 2011b) and the CHP-R Guidance (Environment Agency, 2013), this CHP assessment has been undertaken to support the application for a DCO and meet the BAT requirements of the CHP-R Guidance.

The Proposed Installation is intended to operate in dispatchable mode and as such may not be operating when required by potential heat users which presents a significant barrier to operation as a viable CHP installation.

The CHP assessment has indicated that there are a number of theoretical identified heat users within a 15km radius of the Proposed Installation Site. Although there are large heat loads which relate to domestic, small industrial and education within this search area, none of these offer economically viable opportunities for a heat network.

CHP is therefore not proposed to be installed from the outset; however, the Proposed Installation will be CHP-Ready with sufficient space allocated for future retrofit of a heat offtake within the Proposed Installation Site should that be required. This is considered to be BAT for plant such as the Proposed Installation.

Under maximum CHP operation (i.e. full load), the plant achieves an electrical output of approximately 780 MWe while extracting up to 368 MWth of heat. In this mode, the CHP net efficiency is estimated at ~82.8%, resulting in a Primary Energy Saving (PES) of approximately 16%. At minimum stable generation, the plant operates at around 281 MWe with approximately 147 MWth of heat extraction. In this condition, the CHP net efficiency is ~70.3%, and the corresponding PES is estimated at 12%. Both operating scenarios exceed the 10% PES threshold defined in the Energy Efficiency Directive, which means that an economic analysis would normally be required under the Directive. However, as explained in Section 4.3, in order for the PES value to exceed 10%, the heat extraction must reach approximately 221 MWth at maximum load and exceed 123 MWth at minimum load. However, the current analysis has identified the non-domestic heat demand within 15 km to be 120,000 MWh annually. Assuming 3,500 hours of operation per year, the CHP system would need to extract 773,000 MWh at full load and 429,000 MWh at partial load, both of which significantly exceed the current demand (120,000 MWh). Consequently, the PES target of 10% cannot be met under current conditions. Therefore, there is not required to conduct economic analysis. To achieve PES > %10, all non-domestic users plus approximately 21 percent of domestic buildings would need to connect. However, local housing density (predominantly semi-detached/detached) makes individual air-source heat pumps more viable than a district heating network at present.

If a Carbon Capture Plant (CCP) were to be installed on the CCGT, available heat offtake drops to ~98 MWth (full load) and ~24 MWth (minimum load), yielding PES well below

10 %. In this operating mode, while the non-domestic heat demand can still be met at maximum load, it cannot be fully satisfied during minimum load operation.

The PES assessments conducted for operation with CCP are based on the assumption that heat will be extracted from the steam cycle. Other potential heat extraction points within the potential CCP may also exist and could warrant further evaluation.

The Operator is committed to carrying out a periodic ongoing review of CHP potential. This commitment will be secured through an appropriately worded requirement in Schedule 2 to the draft DCO.

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Annex A

A.1 CHP-R Assessment Form

| # | Description | Units | Notes/Instructions |
|--|---|-------|---|
| Requirement 1: Plant, Plant Location and Potential Heat Loads | | | |
| 1.1 | Plant Name | | Keadby Next Generation Power Station |
| 1.2 | Plant description | | <p>A combined cycle gas turbine (CCGT) power station with a gross capacity of approximately 910 megawatts (MWe).</p> <p>The Proposed Installation will be designed to run on 100% hydrogen and capable of operating on 100% natural gas from the start of operations. When hydrogen becomes available and operation with hydrogen firing is commercially viable, the Proposed Installation will be upgraded to operate on a blend of natural gas and hydrogen or 100% hydrogen.</p> <p>The CCGT will comprise an H-class gas turbine, heat recovery steam generator and steam turbine.</p> <p>Site cooling will be supplied through hybrid cooling technology and operation will be at UK ambient conditions.</p> |
| 1.3 | Plant Location (Postcode / Grid Ref) | | Keadby, Scunthorpe (DN17 3EF / SE820120) |
| 1.4 | Factors influencing selection of plant location | | Ongoing development of an existing power generation site (Keadby 1 and 2) and close to a proposed Humber Cluster |

| | | | |
|-----|--|----|--|
| 1.5 | Operation of plant | | |
| a) | Proposed operational plant load | % | 100 Single train design (one gas turbine, one HRSG and one steam turbine) |
| b) | Thermal input at proposed operational plant load | MW | 1,387 |
| c) | Net electrical output at proposed operational plant load | MW | 870 |
| d) | Net electrical efficiency at proposed operational plant load | % | 62.7 |
| e) | Maximum plant load | % | 100 |
| f) | Thermal input at maximum plant load | MW | 1,387 |
| g) | Net electrical output at maximum plant load | MW | 870 |
| h) | Net electrical efficiency at maximum plant load | % | 62.7 |
| i) | Minimum stable plant load | % | 37 |
| j) | Thermal input at minimum stable plant load | MW | 610 |
| k) | Net electrical output at minimum stable plant load | MW | 335 |
| l) | Net electrical efficiency at minimum stable plant load | % | 52.9 |
| 1.6 | Identified Potential Heat Loads | | See details presented in Section 4. |
| 1.7 | Selected Heat Loads | | |
| a) | Category (e.g. industrial / district heating) | | Non-domestic |
| b) | Maximum heat load extraction required | | 120,000 GWh (assuming 3500 hours annual) 34 MWth |

| | | | |
|--|---|----------|---|
| 1.8 | Export and return requirements of heat load | | |
| a) | Description of heat load extraction | | LP steam extraction |
| b) | Description of heat load profile | | Intermittent flow (depending on seasonal heat demand) |
| c) | Export pressure | bar a | Not available (tbd in the subsequent project phase) |
| d) | Export temperature | °C | Not available (tbd in the subsequent project phase) |
| e) | Export flow | t/h | Not available (tbd in the subsequent project phase) |
| f) | Return pressure | bar a | Not available (tbd in the subsequent project phase) |
| g) | Return temperature | °C | Not available (tbd in the subsequent project phase) |
| h) | Return flow | t/h | Not available (tbd in the subsequent project phase) |
| Requirement 2: Identification of CHP Envelope | | | |
| 2.0 | Comparative efficiency of a standalone boiler for supplying the heat load | 90 % LHV | 90 |
| 2.1 | Heat extraction at 100% plant load | | |
| a) | Maximum heat load extraction at 100% plant load | MW | 368 |
| b) | Maximum heat extraction export flow at 100% plant load | t/h | 540 |
| c) | CHP mode net electrical output at 100% plant load | MW | 780 |
| d) | CHP mode net electrical efficiency at 100% plant load | % | 56.2 |

| | | | |
|--|--|-----|------|
| e) | CHP mode net CHP efficiency at 100% plant load | % | 82.8 |
| f) | Reduction in primary energy usage for CHP mode at 100% plant load | % | 16 |
| 2.2 Heat extraction at minimum stable plant load | | | |
| a) | Maximum heat load extraction at minimum stable plant load | MW | 147 |
| b) | Maximum heat extraction export flow at minimum stable plant load | t/h | 216 |
| c) | CHP mode net electrical output at minimum stable plant load | MW | 281 |
| d) | CHP mode net electrical efficiency at minimum stable plant load | % | 46 |
| e) | CHP mode net CHP efficiency at minimum stable plant load | % | 70.3 |
| f) | Reduction in primary energy usage for CHP mode at minimum stable plant load | % | 12 |
| 2.3 | Can the plant supply the selected identified potential heat load (i.e. is the identified potential heat load within the 'CHP envelope')? | | Yes |
| Requirement 3: Operation of the Plant with the Selected Identified Heat Load (120,000 GWh /34 MW) | | | |
| 3.1 | Proposed operation of plant with CHP | | |
| a) | CHP mode net electrical output at proposed operational plant load | MW | 863 |

| | | | |
|----|--|------|-----|
| b) | CHP mode net electrical efficiency at proposed operational plant load | % | 62 |
| c) | CHP mode net CHP efficiency at proposed operational plant load | % | 65% |
| d) | Reduction in net electrical output for CHP mode at proposed operational plant load | % | 0.8 |
| e) | Reduction in net electrical efficiency for CHP mode at proposed operational plant load | %pts | 0.7 |
| f) | Reduction in primary energy usage for CHP mode at proposed operational plant load | % | 1.8 |
| g) | Z ratio | | 4.9 |

Requirement 4: Technical provision and space requirements

| | | | |
|-----|--|--|---|
| 4.1 | Description of likely suitable extraction points | | Extraction of LP steam from steam turbine inlet. |
| 4.2 | Description of potential options which could be incorporated in the plant, should a CHP opportunity be realised outside the 'CHP envelope' | | N/A |
| 4.3 | Description of how the future costs and burdens associated with supplying the identified heat load / potential CHP opportunity have been minimised through the implementation of an appropriate CHP-R design | | Future costs of the CHP technology could be minimised by implementing the necessary connections to the appropriate heat extraction point during the installation phase, in order to avoid any disruption to power plant operations at a later stage. This includes conducting detailed engineering analyses and |

| | | | |
|---|---|-------|--|
| | | | installing the required equipment in advance. |
| 4.4 | Provision of site layout of the plant, indicating available space which could be made available for CHP-R | | Suitable provision will be included in the detailed design of the plant. |
| Requirement 5: Integration of CHP and carbon capture | | | |
| 5.1 | Is the plant required to be CCR? | | Yes – because electrical power output is greater than 300 MW. |
| 5.2 | Export and return requirements identified for carbon capture | | |
| | <u>100% plant load</u> | | |
| a) | Heat load extraction for carbon capture at 100% plant load | MW | 271 |
| b) | Description of heat export (e.g. steam / hot water) | | Low Pressure (LP) Steam |
| c) | Export pressure | bar a | 4 |
| d) | Export temperature | °C | 155 |
| e) | Export flow | t/h | 396 |
| f) | Return pressure | bar a | Pressure loss will be calculated in detailed design phase. |
| g) | Return temperature | °C | 75 |
| h) | Return flow | t/h | 396 |
| i) | Likely suitable extraction points | | LP/ Intermediate Pressure (IP) crossover |
| | <u>Minimum stable plant load</u> | | |
| j) | Heat load extraction for carbon capture at minimum stable plant load | MW | 123 |
| k) | Description of heat export (e.g. steam / hot water) | | Low Pressure (LP) Steam |
| l) | Export pressure | bar a | 4 |

| | | | |
|-----|--|-------|--|
| m) | Export temperature | °C | 155 |
| n) | Export flow | t/h | 180 |
| o) | Return pressure | bar a | Pressure loss will be calculated in detailed design phase. |
| p) | Return temperature | °C | 75 |
| q) | Return flow | t/h | 180 |
| r) | Likely suitable extraction points | | LP/ Intermediate Pressure (IP) crossover |
| 5.3 | Operation of plant with carbon capture (without CHP) | | |
| a) | Maximum plant load with carbon capture | % | 100 |
| b) | Carbon capture mode thermal input at maximum plant load | MW | 1,387 |
| c) | Carbon capture mode net electrical output at 100% plant load | MW | 805 |
| d) | Carbon capture mode net electrical efficiency at maximum plant load | % | 58 |
| e) | Minimum stable plant load with CCS | % | 37 |
| f) | Carbon capture mode thermal input at minimum stable plant load | MW | 610 |
| g) | Carbon capture mode net electrical output at minimum stable plant load | MW | 288 |
| h) | Carbon capture mode net electrical efficiency at minimum stable plant load | % | 47 |
| 5.4 | Heat extraction for CHP at 100% plant load with carbon capture | | |

| | | | |
|-----|--|-----|------|
| a) | Maximum heat load extraction at 100% plant load with carbon capture | MW | 98 |
| b) | Maximum heat extraction export flow at 100% plant load with carbon capture | t/h | 144 |
| c) | Carbon capture and CHP mode net electrical output at 100% plant load | MW | 780 |
| d) | Carbon capture and CHP mode net electrical efficiency at 100% plant load | % | 56.2 |
| e) | Carbon capture and CHP mode net CHP efficiency at 100% plant load | % | 63.2 |
| f) | Reduction in primary energy usage for carbon capture and CHP mode at 100% plant load | % | 4.5 |
| 5.5 | Heat extraction at minimum stable plant load with carbon capture | | |
| a) | Maximum heat load extraction at minimum stable plant load with carbon capture | MW | 24 |
| b) | Maximum heat extraction export flow at minimum stable plant load with carbon capture | t/h | 36 |
| c) | Carbon capture and CHP mode net electrical output at minimum stable plant load | MW | 281 |
| d) | Carbon capture and CHP mode net electrical efficiency at minimum stable plant load | % | 46 |

| | | | |
|--|---|---|---|
| e) | Carbon capture and CHP mode net CHP efficiency at minimum stable plant load | % | 50 |
| f) | Reduction in primary energy usage for carbon capture and CHP mode at minimum stable plant load | % | 2 |
| 5.6 | Can the plant with carbon capture supply the selected identified potential heat load (i.e. is the identified potential heat load within the 'CHP and carbon capture envelope')? | | No, available heat extraction capacity is 24 MW, selected load is 34 MW. |
| 5.7 | Description of potential options which could be incorporated in the plant for useful integration of any realised CHP system and carbon capture system | | Not available |
| Requirement 6: Economics of CHP-R | | | |
| 6.1 | Economic assessment of CHP-R | | Not considered economically viable to develop a district heat network as the primary energy saving does not meet the 10%. |
| BAT Assessment | | | |
| | Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)? | | No – selected load is not economically viable. |
| | If not, is the new plant a CHP-R plant at the outset? | | Yes |
| | Once the new plant is CHP-R, is it BAT? | | Yes |

Annex B

B.1 Review of CHP Development Map

The CHP Guidance requires that CHP assessments examine the information available on the Online Industrial Heat Map to identify potential CHP opportunities. Since the publication of the CHP Guidance, the Online Industrial Heat Map has been replaced with the UK CHP Development Map (Department for Business, Energy & Industrial Strategy (BEIS), 2021). The results from the examination of the UK CHP Development Map, covering a search area of 15km centred on the Proposed Installation, are shown in **Plate B.1**.

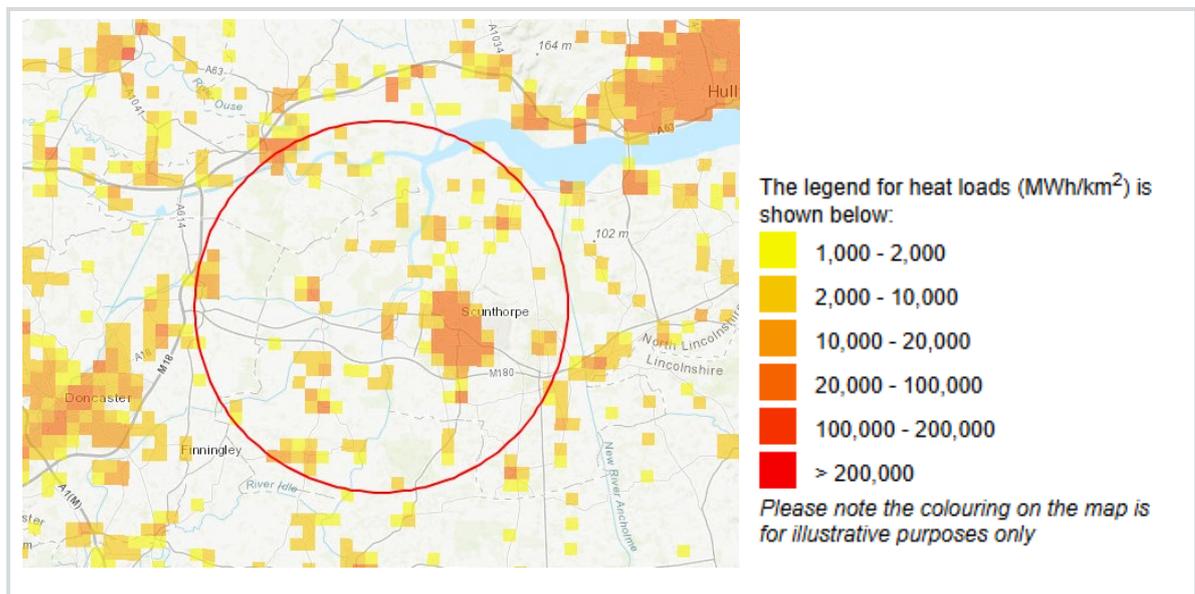


Plate B1: Results from the Examination of the UK CHP Development Map: Total Heat Demand Map

The breakdown of the results from the review of the UK CHP Development Map across the full 15km radius is shown in **Table B.1**. Results from the examination of the UK CHP Development Map: Heat demand by sector

Table B.1: Results from the Examination of the UK CHP Development Map: Heat Demand by Sector

| Sector | % share of total load identified | Total heat load (MWh) |
|------------------------------|----------------------------------|-----------------------|
| Communications and Transport | 0.04% | 708 |
| Commercial Offices | 0.27% | 4,256 |
| Domestic | 93.26% | 1,488,307 |
| Education | 1.54% | 24,644 |

| Sector | % share of total load identified | Total heat load (MWh) |
|--|----------------------------------|-----------------------|
| Government Buildings | 0.28% | 4,423 |
| Hotels | 0.22% | 3,572 |
| Large Industrial | 0.00% | 0 |
| Health | 0.33% | 5,220 |
| Other | 0.07% | 1,135 |
| Small Industrial | 3.23% | 51,545 |
| Prisons | 0.00% | 0 |
| Retail | 0.53% | 8,536 |
| Sport and Leisure | 0.15% | 2,365 |
| Warehouses | 0.08% | 1,225 |
| District Heating | 0.00% | 0 |
| Total potential heat load within 15 km of Proposed Installation | | 1,595,937 |

From **Table B.1**, the largest potential heat loads within the CHP search area (15 km radius from Proposed Installation), relate to:

- Domestic (93.3%),
- Small industrial (3.2%), and
- Education (1.5%).

The following figures illustrate these heat loads within the CHP search area.

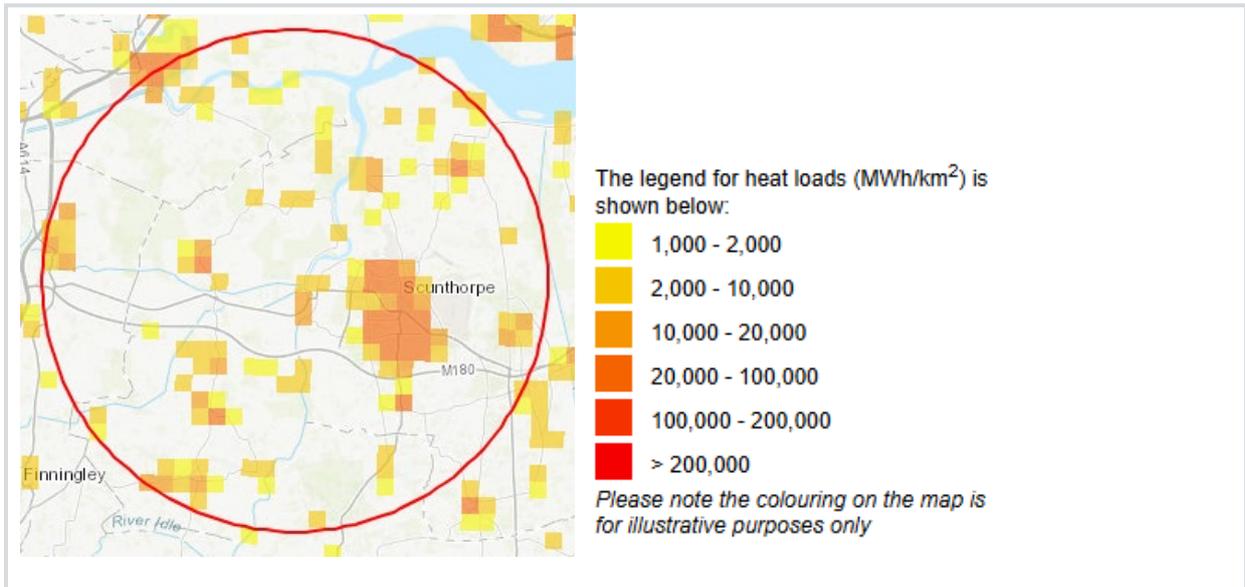


Plate B.2: Results from the Examination of the UK CHP Development Map: Domestic Heat Loads

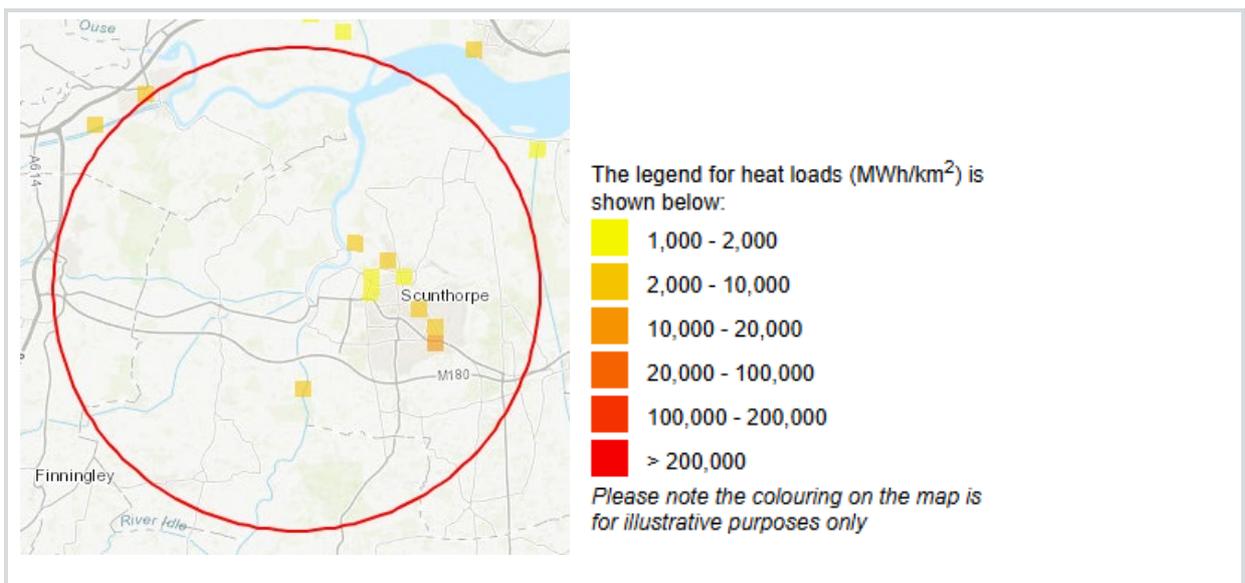


Plate B.3 Results from the Examination of the UK CHP Development Map: Small Industrial Heat Loads

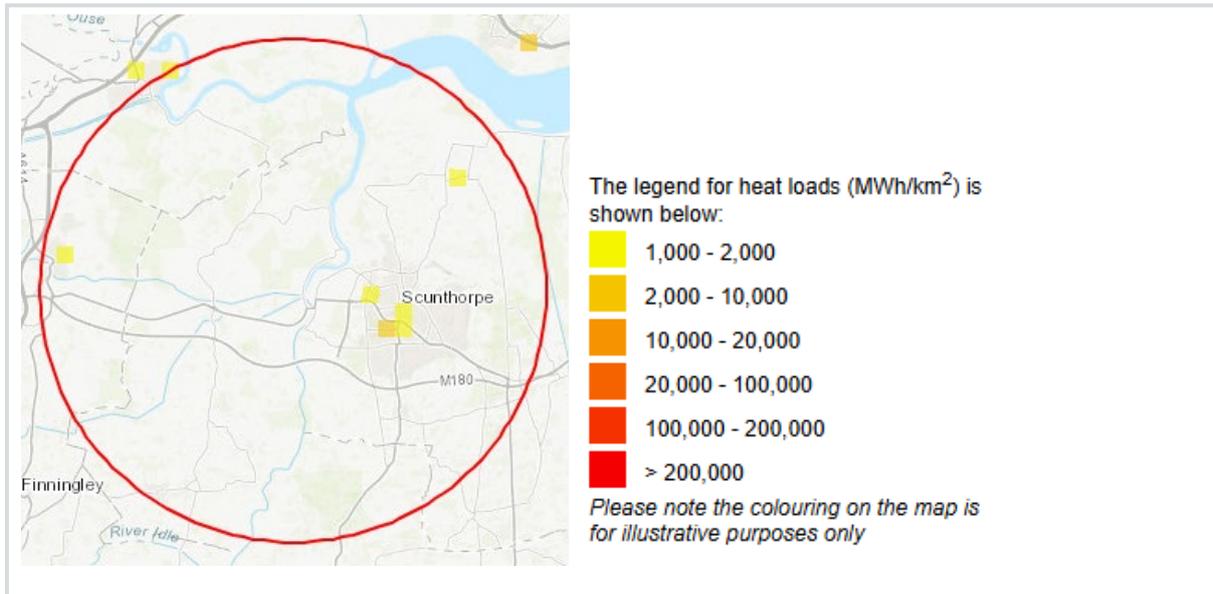


Plate B.4 Results from the Examination of the UK CHP Development Map: Education Heat Loads

B.2 Review of Healthcare Data

NHS England publish the cost of “providing and maintaining the NHS Estate including buildings, maintaining and equipping hospitals, the provision of services e.g. laundry and food, and the costs and consumption of utilities” in the Estates Return Information Collection (ERIC).

The ERIC summary results for 2023/24 have been reviewed to identify the healthcare heat loads within a 15 km radius of the Proposed Installation, as summarised in **Table B.2**.

Table B.2 ERIC Data Healthcare Sites - a 15 km Radius of Proposed Installation

| Site Name | Post Code | Gross internal floor area (m ²) | Distance from Proposed Installation (km) [1] | Gas consumed (kWh) | Oil consumed (kWh) |
|---|-----------|---|--|--------------------|--------------------|
| New Beacon House | DN17 1BS | 1,805 | 5.4 | Not Applicable | Not Applicable |
| Global House (North Lincolnshire College) | DN17 1AJ | 1,145 | 5.7 | Not Applicable | Not Applicable |

| Site Name | Post Code | Gross internal floor area (m ²) | Distance from Proposed Installation (km) [1] | Gas consumed (kWh) | Oil consumed (kWh) |
|--------------------------------|-----------|---|--|--------------------|--------------------|
| Scunthorpe General Hospital | DN15 7BH | 64,434 | 5.3 | 19,129,429 | 36,760 |
| Ironstone Centre | DN15 6HX | 1,005 | 6.3 | Not Applicable | Not Applicable |
| St. Nicholas House, Scunthorpe | DN15 6NU | 734 | 6.4 | 116,174 | 0 |
| Great Oaks Inpatient Unit | DN16 2JX | 3,003 | 7.9 | 713,328 | 0 |
| Nth Lincs - Talking Shop | DN15 6SS | 503 | 6.8 | 53,699 | 0 |

[1] Distance measured as the crow flies.

Source: Estates Returns Information Collection, Summary page and dataset for ERIC 2023/24

Seven NHS sites within 15 km, as the crow flies, from the Proposed Installation have been identified, as listed in Table B.2. Three of these sites (New Beacon House, Global House and Ironstone Centre) do not have consumption data recorded within the ERIC data; therefore, the Display Energy Certificate (DEC) online database has been reviewed to obtain any additional information for these sites; summarised below in **Table B.3**.

Table B.3 DEC Energy Data for Selected Healthcare Sites - 15 km Radius of Proposed Installation

| Site Name | Post Code | Gross internal floor area (m ²) | Distance from Proposed Installation (km) [1] | Gas consumed (kWh) | Oil consumed (kWh) |
|----------------------|-----------|---|--|--------------------|--------------------|
| New Beacon House | DN17 1BS | 1,805 | 5.4 | Not available | Not available |
| Global House (North) | DN17 1AJ | 1,145 | 5.7 | 278,246 | Not applicable |

| Site Name | Post Code | Gross internal floor area (m ²) | Distance from Proposed Installation (km) [1] | Gas consumed (kWh) | Oil consumed (kWh) |
|-----------------------|-----------|---|--|--------------------|--------------------|
| Lincolnshire College) | | | | | |
| Ironstone Centre | DN15 6HX | 1,005 | 6.3 | 326,509 | Not applicable |

[1] Distance measured as the crow flies.

Source: Display Energy Certificate database, <https://www.gov.uk/find-energy-certificate>

The last site, New Beacon House, does not have consumption data recorded within the ERIC dataset or have a valid DEC available online. The online CIBSE Benchmarking Tool has been used to estimate the building's gas consumption.

Table B.4 Benchmarked Energy Data for Selected Healthcare Sites - 15 km Radius of Proposed Installation

| Site Name | Post Code | Gross internal floor area (m ²) | Distance from Proposed Installation (km) [1] | Gas consumed (kWh) | Oil consumed (kWh) |
|------------------|-----------|---|--|--------------------|--------------------|
| New Beacon House | DN17 1BS | 1,805 | 5.4 | 267,140 [2] | Not applicable |

[1] Distance measured as the crow flies.

[2] Benchmarked energy consumption using CIBSE Energy Benchmarking Dashboard, for typical practice fossil fuel consumption for health centres.

Source: CIBSE Energy Benchmarking Dashboard, <https://www.cibse.org/knowledge-research/knowledge-resources/knowledge-toolbox/energy-benchmarking-dashboard/>

The above noted gas consumption data has been converted into heat demand by accounting for an assumed boiler efficiency of 85%, representative of existing boiler performance. **Table B.5** records the heat demands from the identified healthcare buildings.

Table B.5 Total Potential Healthcare Heat Load

| Site Name | Total fossil fuel consumption (kWh) | Total heat demand (kWh) | Total heat demand (MWh) |
|-----------|-------------------------------------|-------------------------|-------------------------|
| | | | |

| | | | |
|---|------------|------------|----------|
| New Beacon House | 267,140 | 227,069 | 227.1 |
| Global House (North Lincolnshire College) | 278,246 | 236,509 | 236.5 |
| Scunthorpe General Hospital | 19,166,189 | 16,291,261 | 16,291.3 |
| Ironstone Centre | 326,509 | 277,533 | 277.5 |
| St. Nicholas House, Scunthorpe | 116,174 | 98,748 | 98.7 |
| Great Oaks Inpatient Unit | 713,328 | 606,329 | 606.3 |
| Nth Lincs - Talking Shop | 53,699 | 45,644 | 45.6 |
| Total potential healthcare heat load within 15 km radius of proposed Keadby Next Generation Power Station | | 17,783,092 | 17,783.1 |

B3. Review of Proposed Future Developments

A high-level desktop review of significant potential future developments in the vicinity of the Proposed Installation has been undertaken; with the proposed Lincolnshire Lakes development presenting the greatest opportunity.

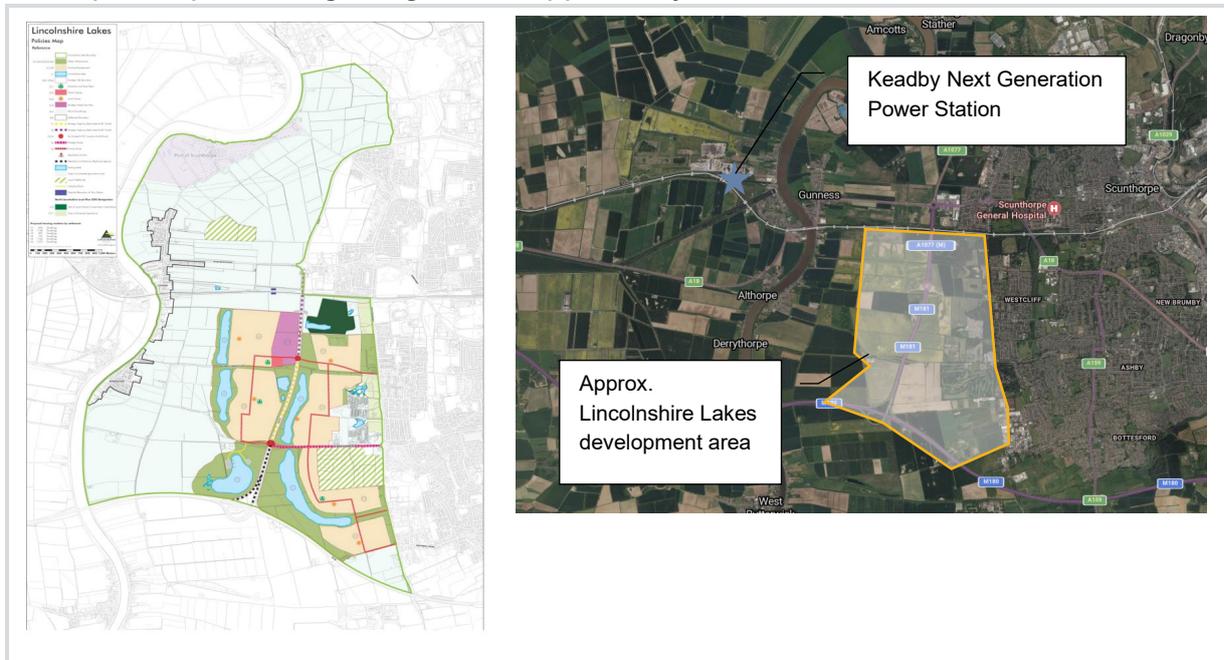


Plate B.5 Lincolnshire Lakes Development

Source: Lincolnshire Lakes Strategic Design Guide PART A: Analysis and Framework Plans, August 2016¹ and Aerial image from bing.com

Table B.6 Strategic Site Allocations taken from the Lincolnshire Lakes Area Action Plan

| Reference | Summary description of relevant features |
|-----------|--|
| SSA1 | Mixed use area and district centre, including: <ul style="list-style-type: none"> • 23 ha strategic mixed-use area • 2.15 ha district centre |
| SSA2 | Villages 1 and 2, and Lake 1 <ul style="list-style-type: none"> • Village 1: approximately 690 dwellings, with 300 m² local centre (shopping) • Village 2: approximately 1,188 dwellings, with 500 m² local centre (shopping) |
| SSA3 | Villages 3 and 4, and Lake 2 <ul style="list-style-type: none"> • Village 3: approximately 987 dwellings, with 400 m² local centre (shopping) and primary school • Village 4: approximately 769 dwellings, with 300 m² local centre (shopping) |
| SSA4 | Lake 5 and surrounding area |
| SSA5 | Village 5 and Lake 3 <ul style="list-style-type: none"> • Village 5: approximately 1,100 dwellings, with 300 m² local centre (shopping) and primary school |
| SSA6 | Village 6 and Lake 4 <ul style="list-style-type: none"> • Village 6: approximately 1,570 dwellings, with 500 m² local centre (shopping) and primary school |

Source: Lincolnshire Lakes Area Action Plan, Adopted May 2016²

Benchmarks have been used to calculate the overall heat demand that the Lincolnshire Lakes development may present, as illustrated below in **Table B.7**.

¹ <https://democracy.northlincs.gov.uk/wp-content/uploads/2017/03/Lincolnshire-Lakes-Strategic-Design-Guide1.pdf>

² https://m.northlincs.gov.uk/public/planningreports/LincolnshireLakes/Adoption/Lincolnshire_Lakes_AAP_2016.pdf

Table B.7 Potential Heat Demands from Lincolnshire Lakes Development

| Sector | % share of load identified | Potential future heat load (MWh) |
|--|-----------------------------------|---|
| Communications and Transport | 0.00% | - |
| Commercial Offices | 0.00% | - |
| Domestic | 73.91% | 24,295 |
| Education | 0.63% | 208 |
| Government Buildings | 0.00% | - |
| Hotels | 0.00% | - |
| Large Industrial | 0.00% | - |
| Health | 0.00% | - |
| Other | 0.00% | - |
| Small Industrial | 0.00% | - |
| Prisons | 0.00% | - |
| Retail | 25.46% | 8,369 |
| Sport and Leisure | 0.00% | - |
| Warehouses | 0.00% | - |
| District Heating | 0.00% | - |
| Total potential heat load within Lincolnshire Lakes development | | 32,872 |

Annex C

C1 CHP Viability Study

Domestic Loads

The CHP Development Map outputs within **Plate B.2** indicate that the existing domestic heat load within the search area is 1,488,306 MWh (approximately 93% of the total heat load within the search area). As indicated by **Plate B.2**, the heat load is spread across the CHP search area with the highest heat loads located within the settlements of Scunthorpe and Bottesford.

This may be further increased by the Lincolnshire Lakes development, which at its maximum extent may have a domestic heat load of 24,295 MWh. At the time of writing (March 2025), there are five projects within the Lincolnshire Lakes development within the planning process; but the anticipated timelines for construction are not known.

Reporting undertaken historically for DECC (Pöyry and Faber Maunsell, 2009) suggests that a district heating network using waste heat from a generating station would potentially be cost-effective where heat demand exceeds 200MWth within 15km. Notwithstanding, NPS EN-1 (at paragraph 4.6.5) recognises the challenges associated with retrofitting CHP:

“[...] the provision of CHP is most likely to be cost-effective and practical where it is included as part of the initial design and is part of a mixed-use development. For example, retrofitting a district heating network to an existing housing estate may not be efficient [...]”

Whilst the domestic heat loads present within the CHP search area are in excess of 200 MWth, the overall load comprises numerous individual loads associated with individual disparate settlements.

The largest domestic heat loads are to the east of the River Trent which would therefore necessitate the construction of pipework crossing the river to connect the Proposed Power Station to any network.

Owing to the technical complexities and engineering challenges of multiple export networks, as well as the lack of any clear and stable revenue stream, the costs and benefits of including it as part of any initial design cannot be realised.

On this basis, the domestic heat load is not considered to be a viable CHP opportunity.

Small Industrial Loads

The CHP Development Map outputs within **Plate B.3** indicate that the small industrial heat load within the search area is 51,545 MWh (approximately 3% of the total heat load

within the search area). As indicated by **Plate B.3**, the heat loads are broadly split between industrial facilities surrounding Scunthorpe and some limited industrial activity at West Butterwick. Notable small industrial facilities locally include Queensway Industrial Estate, Grange Lane Industrial Estate, Midland Road Industrial Estate, Sawcliffe Industrial Estate, Foxhills Industrial Estate and Flixborough Industrial Estate.

However, it should be noted that industrial heat demands are particularly difficult to benchmark accurately because the use (and therefore the heat demand) of industrial units varies widely. A relatively high proportion of industrial units are not heated or heated to low temperatures (frost protection). Conversely some industrial processes require large quantities of heat. Therefore, the benchmarked heat demand for this category of building is particularly uncertain and should be validated with site-specific data prior to further development of heat network design.

Although the individual small industrial sites could potentially present some heat loads, all of the small industrial users are located on the eastern side of the River Trent which presents challenges in terms of transporting any potential waste heat to industrial users. In addition, there is no single small industrial load and instead, there are a number of multiple disparate users. As well as leading to increased cost and technical complexity in installing a network for export of heat, balancing multiple (variable) loads is predicted to be prohibitive against the context of the Proposed Installation which itself would have a highly variable output in dispatchable mode.

Furthermore, as there is no single heat load, there would be greatly increased legal and financial complexity – and ultimately risk – associated with establishing contracts for supply of ‘waste’ heat to multiple users. This is a specific issue highlighted within reporting undertaken for DECC in 2009 which notes that “[...] *achieving a satisfactory base load heat demand will be risky if it relies on securing commitments from a large number of private sector users [...]*”.

Owing to the factors discussed above, the small industrial heat loads are not considered to be a viable CHP opportunity.

Education Loads

The CHP Development Map outputs within **Plate B.4** indicates that the existing education heat load within the search area is 24,644 MWh (approximately 1.5% of the total heat load within the search area). As indicated by **Plate B.4**, the heat loads are split between Scunthorpe and two separate locations at Thorne (to the west) and Winerton (to the north-east).

This load may be further increased by the construction of the Lincolnshire Lakes development which may add a further 208 MWh of education heat load.

The barriers associated with education are as per those discussed above for small industrial heat loads and on this basis, education is not considered to be a viable CHP opportunity.

Healthcare Loads

The CHP Development Map outputs indicates that the healthcare heat load within the search area is 5,220MWh (approximately 0.3% of the total heat load within the search area).

A subsequent review of the ERIC dataset indicates that the healthcare heat load is approximately 17,780 MWh, within which the largest heat load is Scunthorpe General Hospital with a total heat demand of 16,291MWh. The other healthcare heat loads are distributed across Scunthorpe and are generally associated with smaller primary healthcare settings.

The barriers associated with healthcare are as per those discussed above for small industrial heat loads and on this basis, education is not considered to be a viable CHP opportunity.

Heat Demand Summary

Table C.1 shows a summary of the calculated heat demands as described in the previous sections. These show a total annual heat demand of circa 1.63 million MWh per year. Non-domestic heat demands total annual heat demand is around 120,400 MWh per year.

Table C.1 Summary of Calculated Heat Demand - 15km of Proposed Installation

| Head Demand Category | Calculated Heat Demand (GWh/yr) | Data source |
|------------------------------|---------------------------------|----------------------------------|
| Domestic existing | 1,488 | CHP Development Map |
| Domestic future development | 24 | Planning application & Benchmark |
| Small Industrial existing | 52 | CHP Development Map |
| Education existing | 25 | CHP Development Map |
| Education future development | 0.2 | Planning application & Benchmark |
| Healthcare existing | 18 | CHP Development Map |
| Other | 26 | CHP Development Map |
| Total | 1,634 | |
| Non-domestic total | 120 | |

Supply & Demand Balance

Analysis of the Proposed Installation plant has been undertaken to assess the calculated Primary Energy Saving (PES) from the potential heat off-take. This has established that the PES is less than 10% when the heat offtake is low. The minimum heat offtake at which a 10% PES is achieved has been calculated to be 123MWth when the plant is operating at minimum electrical output and 221MWth when the plant is operating at maximum output.

Taking account of these minimum thresholds the heat demand analysis, summarised in the previous sections, has been reviewed to establish what scale of heat network might be needed to use this minimum quantum of heat.

The projected annual run-time for the plant is understood to be 3,500 hours per year. This equates to around 40% of the year. Taking account of this utilisation factor, total annual heat available ranges between 429,000 MWh and 773,000 MWh. Comparing these heat quantities with the totals shown in **Table C.1**, these are greater than the total heat demand for all non-domestic buildings within a 15km radius, including future developments, but lower than the total including all dwellings (existing and future development).

Developing a heat network to serve a large area, with many thousands of buildings including a large number of individual dwellings, would be extremely challenging in many ways. The economics of supplying individual houses via DHNs typically only becomes viable when the dwelling density is high (e.g. terraced housing or flats). However, most dwellings in the area are either semi-detached or detached and so supplying heat in this way is likely to be less economically viable, for a heat network developer, than supplying them with individual air source heat pumps.