The Keadby 3 Low Carbon Gas Power Station Project

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The Keadby 3 (Carbon Capture Equipped Gas Fired Generating Station) Order

Land at and in the vicinity of the Keadby Power Station site, Trentside, Keadby, North Lincolnshire

Combined Heat and Power Readiness Assessment

The Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 – Regulation 5(2)(q)

Applicant: Keadby Generation Limited

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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
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 energy 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 utilises the heat that is a by-product of the electricity generation process
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.

Abbreviation	Description
DECC	Department of Energy and Climate Change (now BEIS)
DTI	Department of Trade and Industry (now BEIS)
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	Megawatts - unit of energy.
MWth	Megawatts thermal – thermal energy
NLC	North Lincolnshire Council
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); waste water 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.
PES	Primary energy saving - schemes which achieve at least a 10 per cent saving in primary energy consumption
SoS	The Secretary of State - title typically held by Cabinet Ministers in charge of Government Departments.

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EXECUTIVE SUMMARY

Keadby Generation Limited (the 'Applicant') is seeking development consent for the construction, operation and maintenance of a new low carbon Combined Cycle Gas Turbine (CCGT) Generating Station ('the Proposed Development'). The Proposed Development is a new gas fired electricity generating station of up to 910 megawatts (MW) of gross electrical output with state-of-the art carbon capture technology and including cooling water, electrical, gas and utility connections, construction laydown areas and other associated works on land to the west of the existing Keadby 2 Power Station, under construction. The Proposed Development will therefore make a significant contribution toward the UK reaching its Net Zero greenhouse gas emissions target by 2050.

The purpose of this document is to comply with Section 4.6 of the 'Overarching National Policy Statement for Energy (EN-1)' (Department for Energy and Climate Change (DECC), 2011a) and Section 2.33 of the 'National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2)' (DECC, 2011b), which require developers promoting thermal generating stations to consider the opportunities for the implementation of Combined Heat and Power ('CHP').

The assessment demonstrates that the Applicant has explored the potential for the plant to operate in CHP mode, i.e. exporting heat to off-site users. In order to examine the CHP potential, the use of Best Available Techniques ('BAT') for the Proposed Development has been demonstrated by applying the three 'BAT Tests' outlined in the 'CHP Ready Guidance for Combustion and Energy from Waste Power Plants' (Environment Agency, 2013) (the 'CHP-R Guidance').

Following an assessment of the feasibility for heat extraction, two potential heat loads capable of producing hot water for district heating were identified. From these loads, there is approximately up to 39 MWth and 80 MWth of heat available from the Proposed Development running at minimum electrical power (part load) and maximum electrical power (full load) respectively. However, the Proposed Development is also primarily expected to operate in dispatchable mode (intermittently) rather than baseload (all the time).

The CHP assessment has indicated that there are a number of theoretical identified heat users within a 15km radius of the Proposed Power and Carbon Capture ('PCC') Site. Although there are large heat loads which relate to domestic, small industrial and education uses 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 of commercial operation of the Proposed Development. However, the Proposed Development will be designed to be CHP-Ready in accordance with the BAT Tests of the CHP-R Guidance.

1.0 INTRODUCTION

1.1 Overview

1.1.1 This Combined Heat and Power ('CHP') Assessment (**Application Document Ref. 5.7**) has been prepared by AECOM on behalf of Keadby Generation Ltd (the 'Applicant') which is a wholly owned subsidiary of SSE plc. It forms part of the application (the 'Application') for a Development Consent Order (a 'DCO') that has been submitted to the Secretary of State (the 'SoS') for Business, Energy and Industrial Strategy, under section 37 of 'The Planning Act 2008' (the '2008 Act').

1.1.2 The Applicant is seeking development consent for the construction, operation and maintenance of a new low carbon Combined Cycle Gas Turbine (CCGT) Generating Station ('the Proposed Development') on land at, and in the vicinity of, the existing Keadby Power Station, Trentside, Keadby, Scunthorpe DN17 3EF (the 'Proposed Development Site').

1.1.3 The Proposed Development is a new electricity generating station of up to 910 megawatts (MW) gross electrical output, equipped with carbon capture and compression plant and fuelled by natural gas, on land to the west of Keadby 1 Power Station and the (under construction) Keadby 2 Power Station, including connections for cooling water, electrical, gas and utilities, construction laydown areas and other associated development. It is described in **Chapter 4:** The Proposed Development of the Environmental Statement (ES) (ES Volume I - **Application Document Ref. 6.2**).

1.1.4 The Proposed Development falls within the definition of a 'Nationally Significant Infrastructure Project' (NSIP) under Section 14(1)(a) and Sections 15(1) and (2) of the 2008 Act, as it is an onshore generating station in England that would have a generating capacity greater than 50MW electrical output (50MWe). As such, a DCO application is required to authorise the Proposed Development in accordance with Section 31 of the 2008 Act. The DCO, if made by the SoS, would be known as 'The Keadby 3 (Carbon Capture Equipped Gas Fired Generating Station) Order' ('the Order').

1.2 The Applicant

1.2.1 The Applicant, Keadby Generation Limited, is the freehold owner of a large part of the Proposed Development Site and is a wholly owned subsidiary of the FTSE 100-listed SSE plc, one of the UK's largest and broadest-based energy companies, and the country's leading developer of renewable energy generation. Over the last 20 years, SSE plc has invested over £20bn to deliver industry-leading offshore wind, onshore wind, CCGT, energy from waste, biomass, energy networks and gas storage projects. The Applicant owns and operates the adjacent Keadby 1 Power Station and is in the process of constructing Keadby 2 Power Station. SSE operates the Keadby Windfarm which lies to the north and south of the Proposed Development Site and

generates renewable energy from 34 turbines, with a total installed generation capacity of 68MW.

1.2.2 SSE has produced a 'Greenprint' document (SSE plc, 2020a) that sets out a clear commitment to investment in low carbon power infrastructure, working with government and other stakeholders to create a net zero power system by 2040. This includes investment in flexible sources of electricity generation and storage for times of low renewable output which will complement other renewable generating sources, using low carbon fuels and/ or capturing and storing carbon emissions. SSE is working with leading organisations across the UK to accelerate the development of carbon capture, usage and storage ('CCUS') clusters, including Equinor and National Grid Carbon.

1.2.3 The design of the Proposed Development demonstrates this commitment. The Applicant would not build the CCGT without the Carbon Capture Plant ('CCP'); the Proposed Development will be built with a clear route to decarbonisation, being equipped with post-combustion carbon capture technology, consistent with SSE's commitment to reduce the carbon intensity of electricity generated by 60% by 2030, compared to 2018 levels (SSE plc, 2020b). It is intended that the Proposed Development will connect to infrastructure that will be delivered by the Zero Carbon Humber (ZCH) Partnership[1] and Northern Endurance Partnership (NEP)[2] for the transport and offshore geological storage of carbon dioxide.

1.3 What is Carbon Capture, Usage and Storage?

1.3.1 CCUS is a process that removes carbon dioxide emissions at source, for example emissions from a power station or industrial installation, and then compresses the carbon dioxide so that it can be safely transported to secure underground geological storage sites. It is then injected into layers of solid rock filled with interconnected pores where the carbon dioxide becomes trapped and locked in place, preventing it from being released into the atmosphere. Plate 1 shows what is involved in the process.

[1] https://www.zerocarbonhumber.co.uk/the-vision/

[2] https://www.zerocarbonhumber.co.uk/news/northern-endurance-partnership/

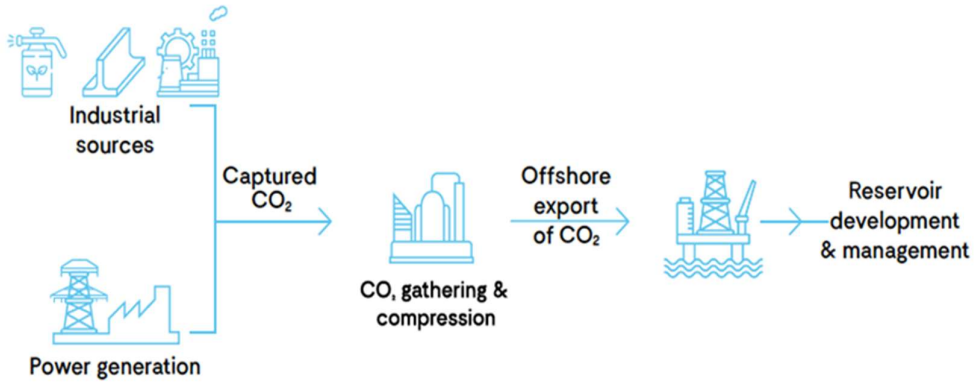


Plate 1: Illustration of the Carbon Capture, Usage and Storage

1.3.2 The technologies used in CCUS are proven and have been used safely across the world for many years. Geological storage sites are located far underground and are subject to stringent tests to ensure that they are geologically suitable. It is expected that the storage sites will be located offshore, in areas such as the North Sea. The NEP has been formed to develop the offshore infrastructure to transport and store carbon dioxide emissions in the North Sea.

1.3.3 CCUS is crucial to reducing carbon dioxide emissions and combatting global warming. The UK Government has committed to achieving Net Zero in terms of greenhouse gas emissions by 2050. This is a legally binding target. UK Government policy further states that the '*deployment of power CCUS projects will play a key role in the decarbonisation of the electricity system at low cost'* (HM Government, 2020a, page 47).

1.3.4 The Proposed Development will provide up to 910MWe (gross) of dispatchable capacity and will be designed to be capable of capturing over 90% of the carbon dioxide emitted from the generating station, with an average capture rate of around 90%. At full load, this could equate to a capture of just over two million tonnes of CO_2 per year, dependent upon the turbine equipment chosen and the dispatch load factor of the power plant. The Proposed Development could be up and running by the mid-2020s and will facilitate the timely development of a major CCUS cluster in the Humber region, making an important contribution towards the achievement of Net Zero by 2050.

1.4 The Proposed Development

1.4.1 The Proposed Development will work by capturing carbon dioxide emissions from the gas-fired power station and connecting into the ZCH Partnership export pipeline and gathering network for onward transport to the Endurance saline aquifer under the North Sea.

1.4.2 The Proposed Development would comprise a low carbon gas fired power station with a gross electrical output capacity of up to 910MWe and associated buildings, structures and plant and other associated development defined in the

Schedule 1 of the draft DCO (**Application Document Ref. 2.1**) as Work No. 1 – 11 and shown on the Works Plans (**Application Document Ref. 4.3**).

1.4.3 At this stage, the final technology selection cannot yet be made as it will be determined by various technical and economic considerations and will be influenced by future UK Government policy and regulation. The design of the Proposed Development therefore incorporates a necessary degree of flexibility to allow for the future selection of the preferred technology in the light of prevailing policy, regulatory and market conditions once a DCO is made. Justification for the need to retain flexibility in certain parameters is outlined in this chapter and also in **Chapter 6**: Consideration of Alternatives (ES Volume I – **Application Document Ref. 6.2**)

1.4.4 The Proposed Development will include:

- a carbon capture equipped electricity generating station including a CCGT plant (**Work No. 1A**) with integrated cooling infrastructure (**Work No. 1B**), and carbon dioxide capture plant (CCP) including conditioning and compression equipment, carbon dioxide absorption unit(s) and stack(s) (**Work No. 1C**), natural gas receiving facility (**Work No. 1D**), supporting uses including control room, workshops, stores, raw and demineralised water tanks and permanent laydown area (**Work No. 1E**), and associated utilities, various pipework, water treatment plant, wastewater treatment, firefighting equipment, emergency diesel generator, gatehouse, chemical storage facilities, other minor infrastructure and auxiliaries/ services (all located in the area referred to as the 'Proposed Power and Carbon Capture (PCC) Site' and which together form **Work No. 1**);
- natural gas pipeline from the existing National Grid Gas high pressure (HP) gas pipeline within the Proposed Development Site to supply the Proposed PCC Site including connection to National Grid Gas's apparatus (**Work No. 2A**) and the Applicant's apparatus (**Work No. 2B**) (the 'Gas Connection Corridor');
- electrical connection works to and from the existing National Grid 400kV Substation for the export of electricity (**Work No. 3A**) (the 'Electrical Connection Area to National Grid 400kV Substation');
- electrical connection works to and from the existing Northern Powergrid 132kV Substation for the supply of electricity at up to 132kV to the Proposed PCC Site, and associated plant and equipment (**Work No. 3B**) (the 'Potential Electrical Connection to Northern Powergrid 132kV Substation');
- Water Connection Corridors to provide cooling and make-up water including:
  - underground and/ or overground water supply pipeline(s) and intake structures within the Stainforth and Keadby Canal, including temporary cofferdam (**Work No. 4A**) (the 'Canal Water Abstraction Option');
  - in the event that the canal abstraction option is not available, works to the existing Keadby 1 power station cooling water supply pipelines and

intake structures within the River Trent, including temporary cofferdam (**Work No. 4B**) (the 'River Water Abstraction Option');
- works to and use of an existing outfall and associated pipework for the discharge of return cooling water and treated wastewater to the River Trent (**Work No. 5**) (the 'Water Discharge Corridor');

- towns water connection pipeline from existing water supply within the Keadby Power Station to provide potable water (**Work No. 6**);
- above ground carbon dioxide compression and export infrastructure including deoxygenation, dehydration, staged compression facilities, outlet metering, and electrical connection (**Work No. 7A**) and connection infrastructure into National Grid Carbon's apparatus (**Work No. 7B**);
- new permanent access from A18, comprising the maintenance and improvement of an existing private access road from the junction with the A18 including the western private bridge crossing of the Hatfield Waste Drain (**Work No. 8A**) and installation of a layby and gatehouse (**Work No. 8B**), and an emergency vehicle and pedestrian access road comprising the maintenance and improvement of an existing private track running between the Proposed PCC Site and Chapel Lane, Keadby and including new private bridge (**Work No. 8C**);
- temporary construction and laydown areas including contractor facilities and parking (**Work No. 9A**), and access to these using the existing private roads from the A18 and the existing private bridge crossings, including the replacement of the western existing private bridge crossing known as 'Mabey Bridge') over Hatfield Waste Drain (**Work No. 9B**) and a temporary construction laydown area associated with that bridge replacement (**Work No. 9C**);
- temporary retention, improvement and subsequent removal of an existing Additional Abnormal Indivisible Load Haulage Route (**Work No. 10A**) and temporary use, maintenance, and placement of mobile crane(s) at the existing Railway Wharf jetty for a Waterborne Transport Offloading Area (**Work No. 10B**);
- landscaping and biodiversity enhancement measures (**Work No. 11A**) and security fencing and boundary treatments (**Work No. 11B**);
- associated development including: surface water drainage systems; pipeline and cable connections between parts of the Proposed Development Site; and
- hard standings and hard landscaping; soft landscaping, including bunds and embankments; external lighting, including lighting columns; gatehouses and weighbridges; closed circuit television cameras and columns and other security measures; site preparation works including clearance, demolition, earthworks, works to protect buildings and land, and utility connections; accesses, roads, roadways and vehicle and cycle parking; pedestrian and cycle routes; and temporary works associated with the maintenance of the authorised development.

1.4.5 The Applicant will be responsible for the construction, operation (including maintenance) and eventual decommissioning of the Proposed Development, with the exception of the National Grid Gas compound works (**Work No. 2A**), the works within the National Grid Electricity Transmission 400kV substation (part of **Work No. 3A**), the works within the Northern Powergrid 132kV substation (part of **Work No. 3B**), and the National Grid Carbon compound works (**Work No. 7B**), which will be the responsibility of those named beneficiaries.

1.4.6 The Proposed Development includes the equipment required for the capture and compression of carbon dioxide emissions from the generating station so that it is capable of being transported off-site. ZCH Partnership will be responsible for the construction, operation and decommissioning of the carbon dioxide gathering network linking onshore power and industrial facilities including the Proposed Development in the Humber Region. The carbon dioxide export pipeline does not, therefore, form part of the Proposed Development and is not included in the Application but will be the subject of separate consent applications by third parties, such as the Humber Low Carbon Pipeline DCO Project by National Grid Carbon[3].

1.4.7 The Proposed Development will operate 24 hours per day, 7 days per week with programmed offline periods for maintenance. It is anticipated that in the event of CCP maintenance outages, for example, it may be necessary to operate the Proposed Development without carbon capture, with exhaust gases from the CCGT being routed via the Heat Recovery Steam Generator (HRSG) stack.

1.4.8 Various types of associated and ancillary development further required in connection with and subsidiary to the above works are detailed in Schedule 1 'Authorised Development' of the draft DCO (**Application Document Ref. 2.1**). This along with **Chapter 4:** The Proposed Development in the ES Volume I (**Application Document Ref. 6.2**) provides further description of the Proposed Development. The areas within which each numbered Work (component) of the Proposed Development are to be built are defined by the coloured and hatched areas on the Works Plans (**Application Document Ref. 4.3**).

1.5 The Proposed Development Site

1.5.1 The Proposed Development Site (the 'Order Limits') 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 Applicant (or SSE associated companies) and is centred on national grid reference 482351, 411796.

[3] https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/humber-low-carbon-pipelines/

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

1.5.3 The Proposed Development Site encompasses an area of approximately 69.4 hectares (ha). This includes an area of approximately 18.7ha to the west of Keadby 2 Power Station in which the generating station (CCGT plant, cooling infrastructure and CCP) and gas connection will be developed (the Proposed PCC Site).

1.5.4 The Proposed Development Site includes other areas including:

- Previously developed land, along with gas, towns water and other connections, and access routes, within the Keadby Power Station site;
- the National Grid 400kV Substation located directly adjacent to the Proposed PCC Site, through which electricity generated by the Proposed Development will be exported;
- Emergency Vehicle Access Road and Potential Electrical Connection to Northern Powergrid Substation, the routes of which utilise an existing farm access track towards Chapel Lane and land within the existing Northern Powergrid substation on Chapel Lane;
- Water Connection Corridors:
  1 Canal Water Abstraction Option which includes land within the existing Keadby Power Station site with an intake adjacent to the Keadby 2 Power Station intake and pumping station and interconnecting pipework;
  2 River Water Abstraction Option which includes a corridor that spans Trent Road and encompasses the existing Keadby Power Station pumping station, below ground cooling water pipework, and infrastructure within the River Trent; and
  3 a Water Discharge Corridor which includes an existing discharge pipeline and outfall to the River Trent and follows a route of an existing easement for Keadby 1 Power Station;
- an existing river wharf at Railway Wharf (the Waterborne Transport Offloading Area) and existing temporary haul road into the into the existing Keadby 1 Power Station Site (the 'Additional Abnormal Indivisible Load (AIL) Route');
- a number of temporary Construction Laydown Areas on previously developed land and adjoining agricultural land; and
- land at the A18 Junction and an existing site access road, including two existing private bridge crossing of the Hatfield Waste Drain lying west of Pilfrey Farm (the western of which is known as Mabey Bridge, to be replaced, and the eastern of which is termed Skew Bridge) and an existing temporary gatehouse, to be replaced in permanent form.

1.5.5 In the vicinity of the Proposed Development Site the River Trent is tidal, therefore parts of the Proposed Development Site are within the UK marine area. No harbour works are proposed.

1.5.6 Further description of the Proposed Development Site and its surroundings is provided in **Chapter 3:** The Site and Surrounding Area in ES Volume I (**Application Document Ref. 6.2**).

1.6 The Development Consent Process

1.6.1 As a NSIP project, the Applicant is required to obtain a DCO to construct, operate and maintain the generating station, under Section 31 of the 2008 Act. Sections 42 to 48 of the 2008 Act govern the consultation that the promoter must carry out before submitting an application for a DCO and Section 37 of the 2008 Act governs the form, content and accompanying documents that are required as part of a DCO application. These requirements are implemented through the Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended) ('APFP Regulations') which state that an application must be accompanied by an ES, where a development is considered to be 'EIA development' under the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the EIA Regulations).

1.6.2 An application for development consent for the Proposed Development has been submitted to the Planning Inspectorate (PINS) acting on behalf of the Secretary of State. Subject to the Application being accepted (which will be decided within a period of 28 days following receipt of the Application), PINS will then examine it and make a recommendation to the Secretary of State, who will then decide whether to make (grant) the DCO.

1.7 The Purpose and Structure of this Document

1.7.1 The purpose of this document is to comply with Section 4.6 of the 'Overarching National Policy Statement for Energy (EN-1)' (DECC, 2011a) and Section 2.33 of the 'National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2)' (DECC, 2011b), which require developers promoting thermal generating stations to consider the opportunities for the implementation of CHP.

1.7.2 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.

1.7.3 Inherent to the design of the Proposed Development is the efficient use of 'waste' heat within the Proposed PCC Site. By way of example, 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. Whilst appreciating this existing balance of power (electricity) and heat, this document considers if there

are additional opportunities for implementation of CHP. 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 Development based on the current design;
- Section 4 identifies potential heat users in the vicinity of the Proposed Development Site;
- Section 5 presents the assessment of the Proposed Development against the three Best Available Technique ('BAT') Tests described in the 'CHP Ready Guidance for Combustion and Energy from Waste Power Plants' (Environment Agency, 2013) (the 'CHP-R Guidance'); and
- Section 6 presents the conclusions of this CHP assessment.

2.0 POLICY CONTEXT AND ASSESSMENT METHODOLOGY

2.1 National Policy Statements

2.1.1 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 Wales. The NPS of most relevance to the Proposed Development (and this CHP assessment) are EN-1 and EN-2.

2.1.2 Section 4.6 of EN-1 deals with the consideration of CHP. Paragraph 4.6.2 states that CHP is technically feasible for all types of thermal generating stations, including gas-fired, nuclear, energy from waste and biomass. Paragraph 4.6.3 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.

2.1.3 Paragraph 4.6.5 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.

2.1.4 Paragraph 4.6.6 of EN-1 highlights that under guidelines issued by the Department of Trade and Industry (DTI) in 2006 (DTI[4], 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.

2.1.5 Paragraph 4.6.7 of EN-1 states that:

'In developing proposals for new thermal generating stations, developers should consider the opportunities for CHP from the very earliest point 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 bodies such as the Homes and Communities Agency (HCA), Local Enterprise Partnerships (LEPs) and Local Authorities and obtain their advice on opportunities for CHP. Further advice is contained in the 2006 DECC guidelines

[4] DTI became the Department for Energy and Climate Change (DECC) and its functions were then merged into the Department for Business, Energy and Industrial Strategy ('BEIS') in 2016.

and applicants should also consider relevant information in regional and local energy and heat demand mapping.'

2.1.6 Paragraph 4.6.8 of EN-1 also states that to encourage proper consideration of CHP, substantial additional weight should be given by the SoS to applications incorporating CHP. If a proposal is for thermal generation without CHP, the applicant should:

- explain why CHP is not economically or practically feasible;
- provide details of any future heat requirements in the area that the generating station could meet; and
- detail the provisions for ensuring any potential heat demand in the future can be exploited.

2.1.7 Paragraph 4.6.10 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 HCA, LEPs and Local Authorities. According to paragraph 4.6.11 of EN-1, should the SoS identify a potential heat customer that has not been explored, the applicant should be requested to pursue this. If agreement cannot be reached with the potential customer, the applicant should provide evidence demonstrating why this was not possible.

2.1.8 Paragraph 4.6.12 of EN-1 states that the SoS may wish to impose requirements within any DCO to ensure that the generating station is 'CHP Ready' to facilitate the potential future export of heat, should demand be identified.

2.1.9 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 (paragraphs 2.3.2 - 3).

2.2 CHP Guidance

2.2.1 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 CO_2 emissions.

2.2.2 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.

2.2.3 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.

2.2.4 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.

2.2.5 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.

2.3 CHP-R Guidance

2.3.1 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.

2.3.2 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.

2.3.3 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.

2.3.4 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 2010[5] demonstrate the use of BAT for a number of criteria, including energy efficiency.

[5] Now the Environmental Permitting (England and Wales) Regulations 2016

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 […]'.

2.3.5 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 applicant/ 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.'

2.3.6 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*.'

2.3.7 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*.'

2.3.8 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'

2.3.9 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.

2.3.10 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).

2.3.11 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 applicant 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.

2.3.12 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.'

2.4 Note on the Implementation of the Energy Efficiency Directive

2.4.1 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').

2.5 Assessment Methodology

2.5.1 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.

3.0 HEAT EXPORT FEASIBILITY STUDY

3.1 Introduction

3.1.1 This Section assesses the feasibility for heat extraction and export from the Proposed Development for comparison with the identified CHP heat load presented in Section 4. The Proposed Development includes a combined cycle gas turbine (CCGT) power station and post-combustion carbon capture plant (CCP) with cooling provided through hybrid cooling towers.

3.1.2 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 gather the approximate heat loads available from the Proposed Development. This is comparable with the CCGT installed for the adjacent Keadby 2 Power Station (under construction) and is within the environmental parameters relied on in the ES.

3.1.3 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 Development and in particular when it would be expected to change to dispatchable mode from baseload operation in the future power market. As a result, there may be significant periods where the Proposed Development is not operating at full load or not operating 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

3.2.1 One primary factor contributing to the high efficiency of modern CCGTs such as the model evaluated is re-use of large amounts of the ‘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.

3.2.2 The carbon capture process uses steam from the steam turbine. Most of the steam provision required in the CCP is used to generate the heat necessary to separate the captured carbon dioxide from the rich amine within the carbon dioxide stripper.

3.2.3 Some reheat of the treated flue gas may also be required to aid dispersion and this would therefore use some additional waste heat within the Proposed Development, further reducing availability for export.

3.2.4 This results in a significant amount of heat from the CCGT already being utilised within the Proposed Development. This CHP-R Assessment takes into account

the steam requirement for the CCP and its provision from the CCGT before any residual waste heat is then appraised for CHP purposes. It is not envisaged that the CCGT would routinely operate in isolation from the carbon capture plant, although there are circumstances that this could be necessary (refer to paragraph 3.2.6).

3.2.5 In order to reduce the loss in available power in abated mode, waste heat from the CCGT would be used as a priority within the CCP where feasible. As a consequence, the CHP readiness assessment appraises opportunities to use heat rejection at a suitable temperature from the CCP, rather than using direct low pressure (LP) steam offtake from the CCGT. It is noted that licensors will optimise heat recovery within the CCP to minimise parasitic loads and this will be undertaken at the detailed design stage. As a consequence, available heat for CHP may be further reduced accordingly. However, two potential options for extracting heat from the Proposed Development have been considered during full operation with both the CCGT and CCP running (i.e. abated operation). These comprise:

- extraction from the carbon dioxide stripper overhead stream; and
- extraction from the LP condensate leaving the carbon dioxide stripper reboiler.

3.2.6 During normal (abated) operation, the flue gases will enter the integrated CCP. However, during outages of the CCP, it will be possible to discharge exhaust gases through a dedicated stack above the HRSG building, which will be fitted with CEMS instrumentation. As the Proposed Development is expected to operate with the CCP for the majority of its design lifetime, the following sections and CHP-R Assessment Form (Appendix A) have only considered the CHP potential from the abated CCGT (operating with carbon capture).

Carbon Dioxide Stripper Overhead Stream

3.2.7 From analysis of the stream temperatures across the CCP within heat and material balance calculations, the carbon dioxide stripper overhead stream was identified as a potential source of heat extraction.

3.2.8 The carbon dioxide overhead stream exits the top of the carbon dioxide stripper column at a temperature of around 109°C before transferring into the carbon dioxide stripper condenser where the stream is reduced to 26°C using the site cooling water. At this elevated temperature, it is possible to heat hot water using the available waste heat to approximately 90°C, the typical requirement for district heating.

3.2.9 With the use of a suitable heat exchanger, heat from the carbon dioxide overhead stream can be extracted by reducing the temperature of this stream before the carbon dioxide stripper condenser. Assuming the carbon dioxide overhead stream temperature exiting the heat exchanger is 70°C, there is

approximately up to 62MWth of heat available from the Proposed Development running at maximum electrical power (full load).

3.2.10 During minimum electrical power operation (part load), the heat available will be reduced due to the reduced flow rate of the carbon dioxide overhead stream. For this operating mode, there is approximately up to 30MWth of heat available in the form of 90°C hot water.

Carbon Dioxide Stripper Reboiler Condensate Return

3.2.11 After supplying heat to the rich amine within the carbon dioxide stripper reboiler, the LP steam condenses within the reboiler, leaving at a temperature that could be up to approximately 144°C based upon a generic design. This LP condensate requires further cooling before returning to the CCGT's condenser.

3.2.12 Therefore, there is potential to utilise this available excess heat from the LP condensate to heat water for district heating using a water-water heat exchanger before the condensate cooler.

3.2.13 Based on the model's condensate cooler duty, approximately up to 18MWth of heat can be extracted when running at full load and used to supply 90°C hot water for district heating.

3.2.14 During part load, the CCP requires a lower demand of LP steam and therefore the amount of heat which can be extracted is lower than at full load. For this operating mode, there is approximately up to 9MWth of heat available in the form of 90°C hot water.

Summary

3.2.15 The total potential heat available in a form that could be suitable for district heating is up to 80 MWth at full load, whereas at part load up to 39 MWth is available.

3.3 Identification of the CHP Envelope

3.3.1 Based on the assumption of extraction as per Section 3.2 above, the following calculations have been performed to determine the heat and power envelope. The envelope limits are defined as follows:

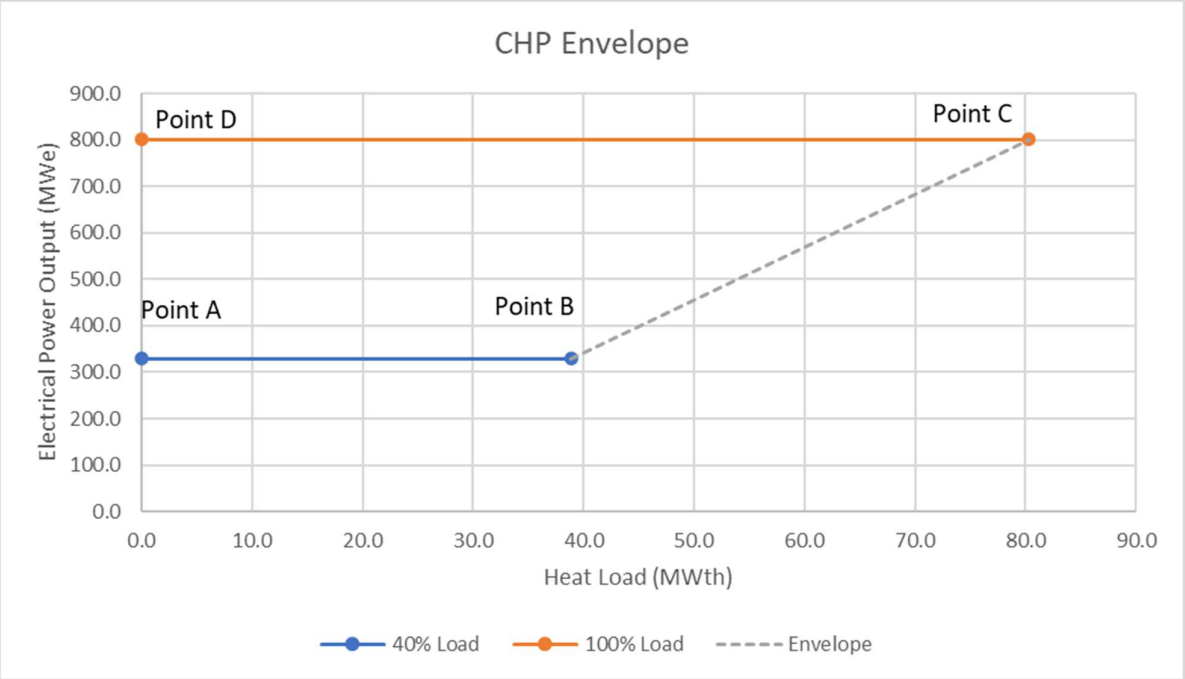
- A – Minimum Stable Load with No Heat Extraction;
- B – Minimum Stable Load with Maximum Heat Extraction;
- C – Maximum Electrical Power (100% Full Load) with Maximum Heat Extraction; and
- D – Maximum Electrical Power (100% Full Load) with No Heat Extraction.

3.3.2 The CHP efficiency (ηCHP) is defined as:

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

3.3.3 Based on the values of heat load presented in Section 3.2 above and the expected electrical power output of the Proposed Development, the CHP envelope can be produced as shown in Figure 1.

Figure 1: Indicative CHP Envelope



3.3.4 The performance of the Proposed Development (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 (Environment Agency, 2013).

3.3.5

3.3.6 Table 1 shows that the primary energy saving associated with operating the Proposed Development in CHP mode during full load would be approximately 7.1%, achieving a CHP efficiency of approximately 64.9%. During part load, the approximate primary saving, and CHP efficiency of the Proposed Development would be 7.2% and 57.4% respectively.

Table 1: Indicative CHP Envelope during abated operation

Description	Min. Elec. Power No Heat Load	Min. Elec. Power Max Heat Load	Max. Elec. Power Max Heat Load	Max. Elec. Power No Heat Load
Reference Point	A	B	C	D
Thermal Input, MWth	654	654	1,381	1,381
Net Power output, MWe	329	329	801	801
Heat Load, MWth	0	39	80	0
CHP Net Efficiency, %	50.4	57.4	64.9	58.0
Primary Energy Saving, %	0.0	7.2	7.1	0.0

3.4 Further Consideration and Potential Challenges of CHP

3.4.1 To allow the identified (and any additional future) potential CHP opportunities to be realised, should it be economic to do so, modifications to the Proposed Development would be needed to incorporate a number of appropriate provisions to allow for the future implementation of CHP.

3.4.2 It would be necessary to install the equipment required for the CHP opportunity identified. This would include the necessary heat exchangers for the carbon dioxide stripper overhead stream, LP and IP condensate streams as well as the required pipework and connections to export heat from the Proposed Development Site to the user.

3.4.3 If the quantity of process heat output from one or more of the two heat extraction locations is deemed economically viable and will be of use off-site, the detailed design (yet to be undertaken) will be developed to demonstrate that the heat exchangers can be installed in the required positions. This will also include an assessment of the routing options to determine the technical feasibility of heat export to the identified demand.

3.4.4 Other potential challenges may result from the operating regime not being compatible with the requirements of the heat load. It is difficult to predict the future operating regime of the Proposed Development at this stage but is expected to be run in dispatchable mode to match the anticipated intermittency of renewable power in the future power market. This is likely to result in the plant periodically not operating in response to the grid demands as well as maintenance requirements. In contrast, a primary requirement of a viable and effective CHP scheme is that it should be capable of meeting the requirements of the identified heat load that is likely to be steady and consistent over the majority of the year, particularly for district heating schemes or steady state industrial processes. As a result, the running regime and load of the Proposed Development may not coincide with the requirements of the identified heat load(s), and this incompatibility may affect the viability and effectiveness of implementing the CHP opportunity.

3.5 Economic Assessment

3.5.1 As outlined in the Energy Efficiency Directive, a CBA is only required where the CHP opportunity has the potential to be 'high efficiency' (i.e. achieve a PES of 10% or greater). No such opportunities have been identified.

3.5.2 Where opportunities are identified in the future (through the periodic review of this CHP assessment, anticipated as a condition to the Environmental Permit for the Proposed Development), this section of the document will be updated accordingly.

4.0 IDENTIFICATION OF POTENTIAL HEAT USERS

4.1 Introduction

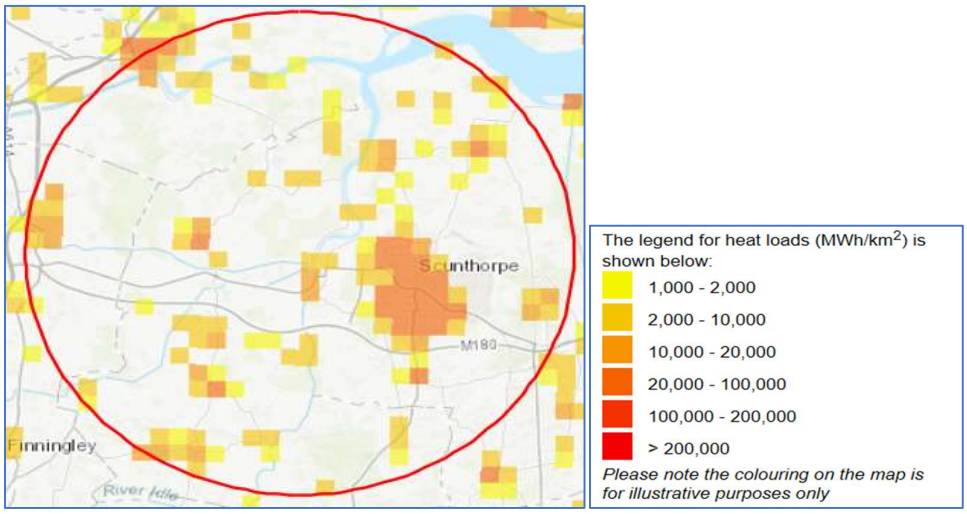
4.1.1 A review of the potential heat demand within a 15km radius of the centre of the Proposed PCC Site has been undertaken to assess potential known or consented future developments that may require heat and to identify any existing major heat consumers; i.e. to identify potential heat loads.

4.1.2 The potential heat loads have been identified using a review of publicly available datasets on fuel use in the region - the UK CHP Development Map, available ordnance survey (OS) data, satellite imagery and aerial photographs from Google Earth. The CHP-R Guidance requires that the heat loads used in a CHP-R assessment be agreed with the Environment Agency. At this stage, no detailed consultation with the Environment Agency regarding CHP has taken place to date.

4.2 CHP Opportunities

4.2.1 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 PCC Site, are shown in Figure 2.

Figure 2: Results from the Examination of the UK CHP Development Map



4.2.2 The breakdown of the results from the review of the UK CHP Development Map across the full 15km radius is shown in Table 2.

Table 2: Results from the Examination of the UK CHP Development Map

Sector	% Share of Total Load Identified	Total Mwh[6]
Communications and Transport	0.04%	718
Commercial Offices	0.27%	4,268
Domestic	93.25%	1,489,652
Education	1.54%	24,644
Government Buildings	0.28%	4,422
Hotels	0.22%	3,572
Large Industrial	0%	0
Health	0.33%	5,220
Other	0.07%	1,136
Small Industrial	3.24%	51,717
Prisons	0%	0
Retail	0.53%	8,532
Sport and Leisure	0.15%	2,378
Warehouses	0.08%	1,292
District Heating	0%	0
Total potential heat load within 15 km		1,597,551

4.2.3 From Table 2, it can be seen that the largest potential heat loads within the CHP search area relate to:

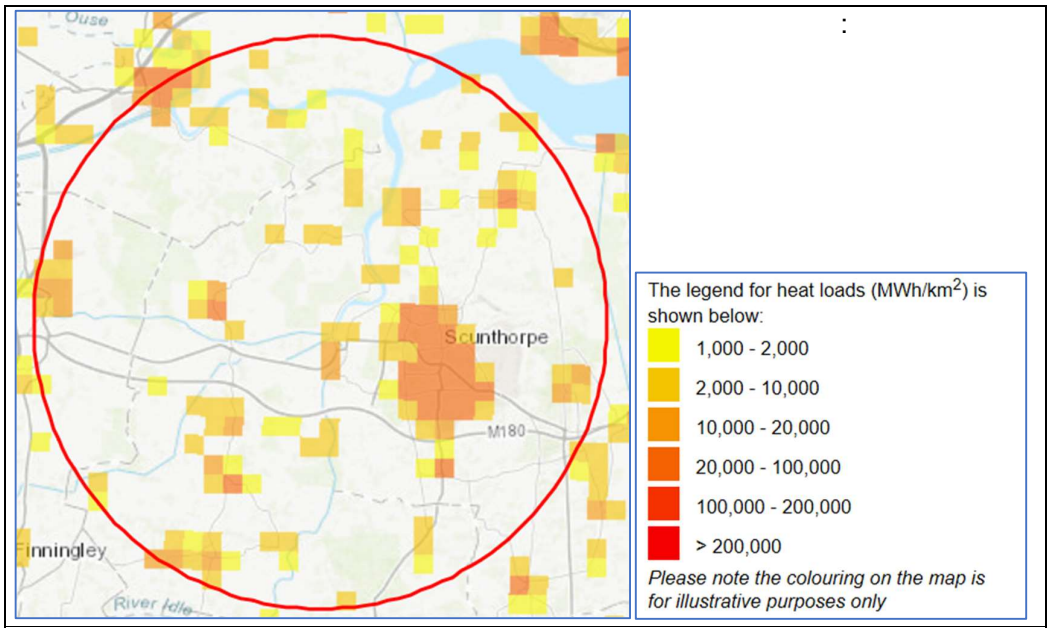
- domestic;
- small industrial; and
- education.

Domestic

4.2.4 In terms of the domestic heat loads within the CHP search area, the results from the UK CHP Development Map are shown in Figure 3.

[6] Estimated average instantaneous loads Identified.

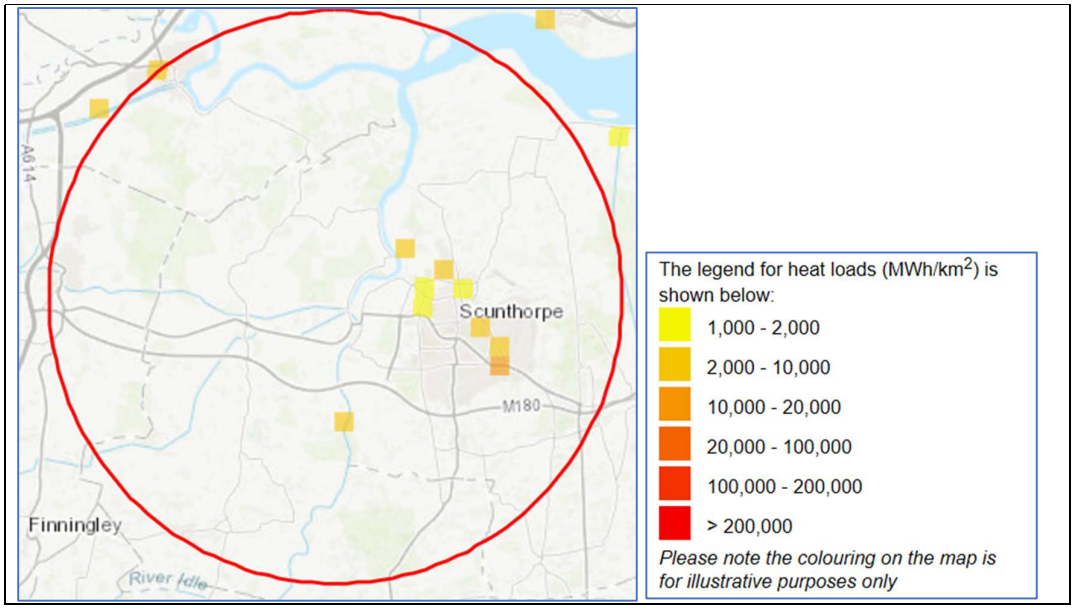
Figure 3: Domestic Heat Loads



Small Industrial

4.2.5 In terms of the small industrial heat loads within the CHP search area, the results from the UK CHP Development Map are shown in Figure 4.

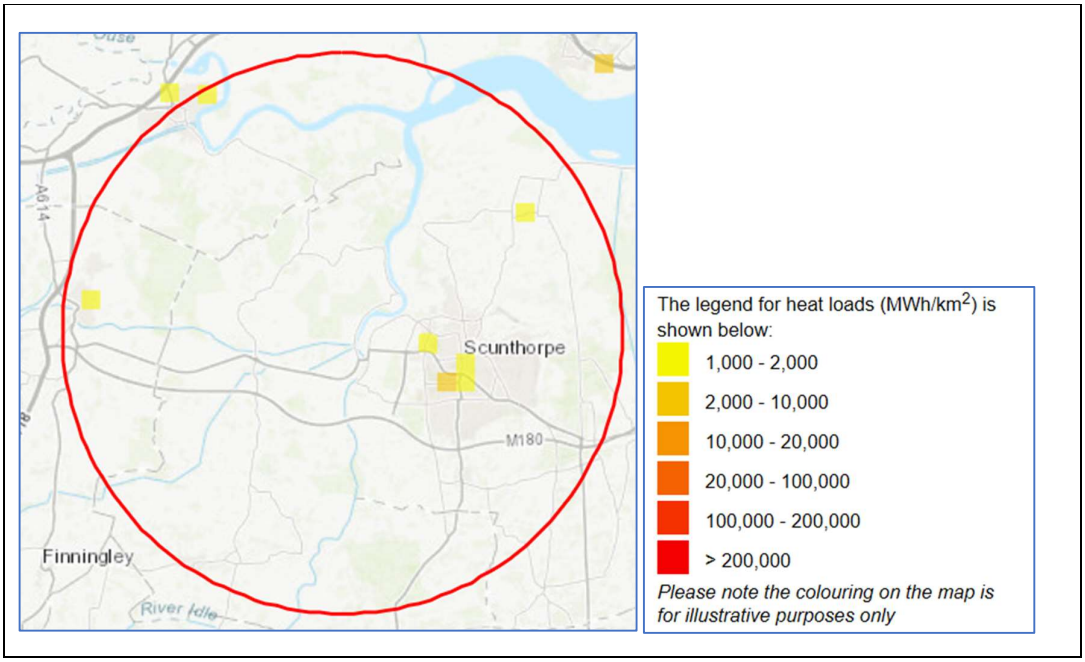
Figure 4: Small Industrial Heat Loads



Education

4.2.6 In terms of the education heat loads within the CHP search area, the results from the UK CHP Development Map are shown in Figure 5.

Figure 5: Education Heat Loads



4.3 CHP Viability

Domestic Loads

4.3.1 The CHP Development Map outputs within Figure 3 indicate that the domestic heat load within the search area is 1,489,652MWh (approximately 93% of the total heat load within the search area). As indicated by Figure 3, the heat load is spread across the CHP search area with the highest heat loads located within the settlements of Scunthorpe and Bottesford.

4.3.2 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* […]'

4.3.3 Whilst the domestic heat loads present within the CHP search area are in excess of 200MWth, the overall load comprises numerous individual loads

associated with individual disparate settlements. 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.

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

Small Industrial

4.3.5 The CHP Development Map outputs within Figure 4 indicate that the small industrial heat load within the search area is 51,717MWh (approximately 3% of the total heat load within the search area). As indicated by Figure 4, the heat loads are broadly split between industrial facilities surrounding Scunthorpe and some limited industrial activity at West and East Butterwick. Notable small industrial facilities locally include Queensway Industrial Estate, Midland Road Industrial Estate, Foxhills Industrial Estate, Normanby Enterprise Park, Shipping Dale Industrial Estate and Flixborough Industrial Estate.

4.3.6 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 Development which itself would have a highly variable output in dispatchable mode.

4.3.7 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 […]'*.

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

Education

4.3.9 The CHP Development Map outputs within Figure 5 indicates that the education heat load within the search area is 24,644MWh (approximately 1.5% of the total heat load within the search area). As indicated by Figure 5, the heat loads are split between Scunthorpe and two separate locations at Thorne (to the west) and Winerton (to the north-east). 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.

5.0 BAT ASSESSMENT

5.1 Introduction

5.1.1 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.

5.1.2 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.

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

5.2 Plant Description

5.2.1 As detailed within Section 1, the Proposed Development consists of a CCGT plant, CCP and associated auxiliary equipment.

5.2.2 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

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

First BAT Test

5.3.2 As the Proposed Development is expected to have an availability of up to 8,000 hours per year during the majority of its 25-year design life, it theoretically has the potential to supply baseload heat capacity in the event that there is a significant demand for heat, recognising that its primary role is expected to be as a dispatchable plant.

5.3.3 As illustrated in Section 3 and summarised in the CHP-R Assessment Form in **Appendix A**, the Proposed Development has up to 80 MWth and 39 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 Development has the capacity to produce a significant quantity of hot water should there be demand for local district heating.

5.3.4 As the CCGT plant is in excess of the 300MWe threshold identified in the Environment Agency's CHP-R Guidance (2013), heat demand within a 15km radius of the plant is considered technically feasible. Section 4 above discusses the potential heat users within this locale and concludes that, although there are large heat loads which related to domestic, small industrial and education, none of these offer economically viable opportunities for a heat network.

5.3.5 The assessment undertaken in Section 3 has identified that the PES would be approximately 7.2% which is below the 10% threshold identified by the Energy Efficiency Directive for high efficiency co-generation. As the PES does not meet the 10% threshold, a CBA is not required by the Energy Efficiency Directive.

5.3.6 Based on the above discussion, the Proposed Development will not be operated as a CHP plant at the outset of commercial operation as there is no current heat demand within the technically feasible radius that is considered economically viable.

Second BAT Test

5.3.7 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, an assessment of heat extraction options from the Proposed Development has been undertaken that has identified two potential options:

- extraction from the carbon dioxide stripper overhead stream; and
- extraction from the LP condensate leaving the carbon dioxide stripper reboiler.

5.3.8 For the period that the Proposed Development does operate as a baseload plant or that the variable heat demand could be supplemented by other nearby proposed heat sources at the time of development, the Proposed Development will be built to be 'CHP Ready'. The final heat export capacity provided will be determined at detailed design stage and will reflect the load potential available at that time. The Proposed Development will be designed and built to allow for the future implementation of CHP if the identified or potential future heat loads become economically viable.

5.3.9 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, the initial electrical efficiency of the 'CHP Ready' Proposed Development is no less than that of the equivalent non-CHP Ready plant.

5.3.10 Sufficient space will be allocated for future retrofit of a heat offtake within the Proposed Development Site, should that be required. Potential routes for water or steam pipelines to the boundary of the Proposed Development Site would be feasible.

Third BAT Test

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

- instigating an action plan;
- maintaining a dialogue with key heat users as set out in the proposed action plan;
- 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
- re-visiting the technical and economic assessments at least every 5 years or when a change in circumstances warrants.

6.0 CONCLUSIONS

6.1.1 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.

6.1.2 This CHP assessment demonstrates that the Proposed Development meets the BAT tests outlined in the CHP-R Guidance. It therefore will be designed and built as 'CHP-Ready' to supply any identified viable heat load up to a potential maximum of 80 MWth based on the heat export feasibility study. This will allow for the future implementation of CHP if and when identified heat loads become economically viable when considered alongside the proposed operating regime of the Proposed Development.

6.1.3 The CHP assessment has indicated that there are a number of theoretical identified heat users within a 15km radius of the Proposed Development 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.

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

6.1.5 It remains the case that the primary way to maximise energy efficiency within the Proposed Development is through the use of steam and heat from the CCGT within the CCP. These efficiencies will be refined as the design of the Proposed Development progresses.

6.1.6 The Applicant 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.

7.0 REFERENCES

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APPENDIX A: CHP-R ASSESSMENT FORM

#	Description	Units	Notes/ Instructions
Requirement 1: Plant, Plant Location and Potential Heat Loads			
1.1	Plant name		Keadby 3 Power Station
1.2	Plant description		A combined cycle gas turbine (CCGT) power station with a gross capacity of approximately 910 megawatts (MWe) and post-combustion carbon capture plant. The power station will be fuelled by natural gas and the CCGT will comprise an H-class gas turbine, heat recovery steam generator and steam turbine. Site cooling will be supplied through hybrid cooling technology and operation will be at UK ambient conditions.
1.3	Plant location (Postcode / Grid Ref)		Keadby, Scunthorpe (DN17 3ER / 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		Note: plant is expected to operate with carbon capture through its design life and so answers to Section 1.5 correspond to values given in Requirement 5
a)	Proposed operational plant load	%	100
b)	Thermal input at proposed operational plant load	MW	1,381
c)	Net electrical output at proposed operational plant load	MW	801

#	Description	Units	Notes/ Instructions
d)	Net electrical efficiency at proposed operational plant load	%	58.0
e)	Maximum plant load	%	100
f)	Thermal input at maximum plant load	MW	1,381
g)	Net electrical output at maximum plant load	MW	801
h)	Net electrical efficiency at maximum plant load	%	58.0
i)	Minimum stable plant load	%	40
j)	Thermal input at minimum stable plant load	MW	654
k)	Net electrical output at minimum stable plant load	MW	329
l)	Net electrical efficiency at minimum stable plant load	%	50.4
1.6	Identified Potential Heat Loads		See details presented in Section 4
1.7	Selected Heat Loads		
a)	Category (e.g. industrial / district heating)		N/A
b)	Maximum heat load extraction required	MW	N/A
1.8	Export and return requirements of heat load		
a)	Description of heat load extraction		N/A
b)	Description of heat load profile		N/A
c)	Export pressure	bar a	N/A
d)	Export temperature	°C	N/A

#	Description	Units	Notes/ Instructions
e)	Export flow	t/h	N/A
f)	Return pressure	bar a	N/A
g)	Return temperature	°C	N/A
h)	Return flow	t/h	N/A
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		Note: plant is expected to operate with carbon capture through its design life and so answers to Section 2.1 correspond to values given in Requirement 5
a)	Maximum heat load extraction at 100% plant load	MW	80
b)	Maximum heat extraction export flow at 100% plant load	t/h	2295
c)	CHP mode net electrical output at 100% plant load	MW	801
d)	CHP mode net electrical efficiency at 100% plant load	%	58.0
e)	CHP mode net CHP efficiency at 100% plant load	%	64.9
f)	Reduction in primary energy usage for CHP mode at 100% plant load	%	7.1
2.2	Heat extraction at minimum stable plant load		Note: plant is expected to operate with carbon capture through its design life and so answers to Section 2.1 correspond to values given in Requirement 5

#	Description	Units	Notes/ Instructions
a)	Maximum heat load extraction at minimum stable plant load	MW	39
b)	Maximum heat extraction export flow at minimum stable plant load	t/h	1110
c)	CHP mode net electrical output at minimum stable plant load	MW	327
d)	CHP mode net electrical efficiency at minimum stable plant load	%	50.4
e)	CHP mode net CHP efficiency at minimum stable plant load	%	57.4
f)	Reduction in primary energy usage for CHP mode at minimum stable plant load	%	7.2
2.3	Can the plant supply the selected identified potential heat load (i.e.is the identified potential heat load within the 'CHP envelope')?		N/A – no viable heat users identified
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed operation of plant with CHP		
a)	CHP mode net electrical output at proposed operational plant load	MW	N/A – no viable heat users identified
b)	CHP mode net electrical efficiency at proposed operational plant load	%	N/A – no viable heat users identified
c)	CHP mode net CHP efficiency at proposed operational plant load	%	N/A – no viable heat users identified

#	Description	Units	Notes/ Instructions
d)	Reduction in net electrical output for CHP mode at proposed operational plant load	MW	N/A – no viable heat users identified
e)	Reduction in net electrical efficiency for CHP mode at proposed operational plant load	%	N/A – no viable heat users identified
f)	Reduction in primary energy usage for CHP mode at proposed operational plant load	%	N/A – no viable heat users identified
g)	Z ratio		N/A – no viable heat users identified
Requirement 4: Technical provisions and space requirements			
4.1	Description of likely suitable extraction points		Extraction of waste heat to provide district heating from: carbon dioxide stripper overhead stream, and carbon dioxide stripper reboiler condensate return stream .
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 accurately sizing the various heat exchangers at the specified extraction points to allow the maximum amount of heat to be extracted.
4.4	Provision of site layout of the plant, indicating available space which		Suitable provision will be included in the detailed design of the plant.

#	Description	Units	Notes/ Instructions
	could be made available for CHP-R		
Requirement 5: Integration of CHP and carbon capture			
5.1	Is the plant required to be CCR?		Yes – plant has CCS included
5.2	Export and return requirements identified for carbon capture		
	100% plant load		
a)	Heat load extraction for carbon capture at 100% plant load	MW	203
b)	Description of heat export (e.g. steam / hot water)		Low Pressure (LP) steam
c)	Export pressure	bar a	4.5
d)	Export temperature	°C	148
e)	Export flow	t/h	342
f)	Return pressure	bar a	4.0
g)	Return temperature	°C	144
h)	Return flow	t/h	342
i)	Likely suitable extraction points		LP/ Intermediate Pressure (IP) crossover
	Minimum stable plant load		
j)	Heat load extraction for carbon capture at minimum stable plant load	MW	100
k)	Description of heat export (e.g. steam / hot water)		LP steam
l)	Export pressure	bar a	4.5
m)	Export temperature	°C	148
n)	Export flow	t/h	168
o)	Return pressure	bar a	4.0

#	Description	Units	Notes/ Instructions
p)	Return temperature	°C	144
q)	Return flow	t/h	168
r)	Likely suitable extraction points		LP/ 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	1,381
c)	Carbon capture mode net electrical output at 100% plant load	MW	801
d)	Carbon capture mode net electrical efficiency at maximum plant load	%	58.0
e)	Minimum stable plant load with CCS	%	40
f)	Carbon capture mode thermal input at minimum stable plant load	MW	654
g)	Carbon capture mode net electrical output at minimum stable plant load	MW	329
h)	Carbon capture mode net electrical efficiency at minimum stable plant load	%	50.4
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	80
b)	Maximum heat extraction export flow at 100% plant load with carbon capture	t/h	2295

#	Description	Units	Notes/ Instructions
c)	Carbon capture and CHP mode net electrical output at 100% plant load	MW	801
d)	Carbon capture and CHP mode net electrical efficiency at 100% plant load	%	58.0
e)	Carbon capture and CHP mode net CHP efficiency at 100% plant load	%	64.9
f)	Reduction in primary energy usage for carbon capture and CHP mode at 100% plant load	%	7.1
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	39
b)	Maximum heat extraction export flow at minimum stable plant load with carbon capture	t/h	1110
c)	Carbon capture and CHP mode net electrical output at minimum stable plant load	MW	327
d)	Carbon capture and CHP mode net electrical efficiency at minimum stable plant load	%	50.4
e)	Carbon capture and CHP mode net CHP efficiency at minimum stable plant load	%	57.4
f)	reduction in primary energy usage for carbon	%	7.2

#	Description	Units	Notes/ Instructions
	capture and CHP mode at minimum stable plant load		
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')?		N/A – no viable heat users identified
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		N/A
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 saving is not significant (less than 10%). Further investigation is required to assess whether potential heat users would seek to develop a district heating network and the additional commercial factors associated within the development.
BAT Assessment			
Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?			No – currently no viable heat users identified to use the district heat export and the development of a district heating network in the area 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