Net Zero Teesside Project

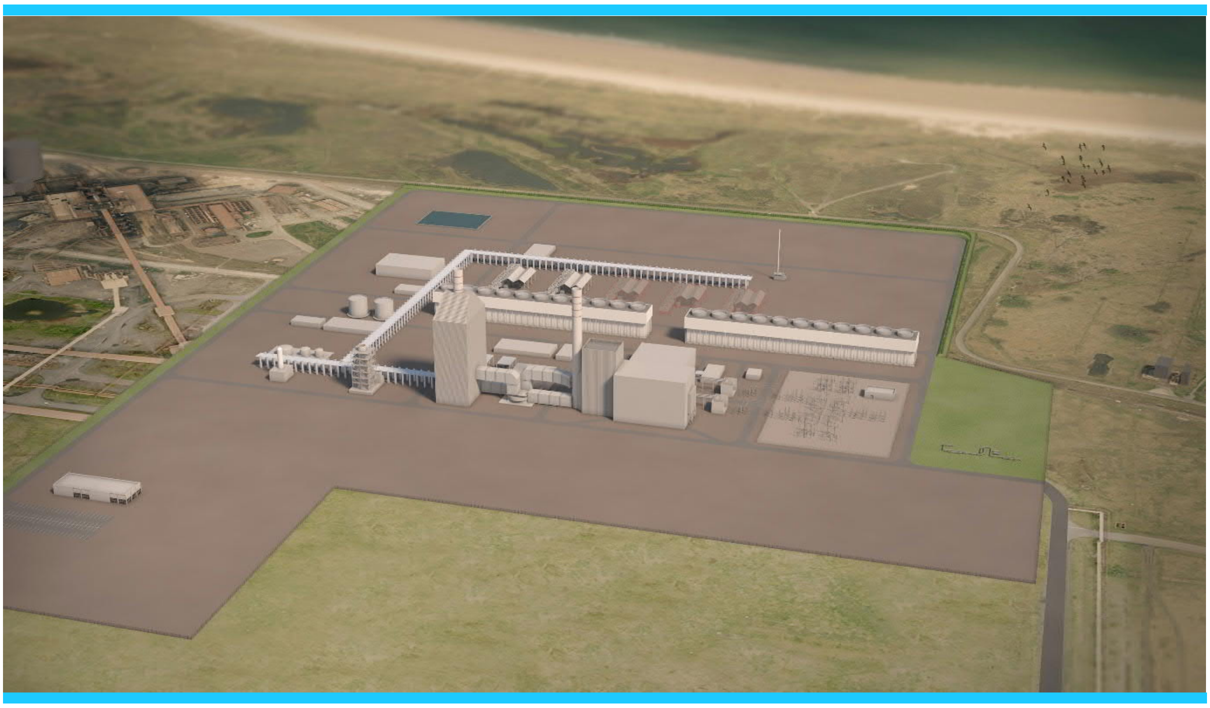
Planning Inspectorate Reference: EN010103

Land at and in the vicinity of the former Redcar Steel Works site in Stockton-on-Tees, Teesside

The Net Zero Teesside Order

Document Reference: 5.8 Combined Heat and Power Readiness Assessment

The Planning Act 2008
The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 – Regulation 5(2)(q)



Applicants: Net Zero Teesside Power Limited (NZT Power Ltd) & Net Zero North Sea Storage Limited (NZNS Storage Ltd)

Date: October 2021

DOCUMENT HISTORY

Document Ref	5.8 Combined Heat and Power Readiness Assessment		
Revision	2.0		
Author	J Calvert		
Signed		Date	October 2021
Approved By	R Lowe		
Signed		Date	October 2021
Document Owner	AECOM Ltd		

GLOSSARY

Abbreviation	Description
AOD	Above Ordnance Datum
BEIS	Department for Business, Energy and Industrial Strategy
BAT	Best Available Technology
CCGT	Combined Cycle Gas Turbine
CCP	Capture Compression Plant
CCUS	Carbon Capture, Usage and Storage
CHP	Combined Heat and Power
CHP-R	Combined Heat and Power – Ready
CO_2	Carbon Dioxide
DCO	Development Consent Order
ES	Environmental Statement
Ha	Hectare
IP	Intermediate Pressure
LP	Low Pressure
MLWS	Mean Low Water Spring
Mt	Million tonnes
MWe	Mega Watts (electrical)
MWth	Mega Watts (thermal)
NPS	National Policy Statements
NZNS	Net Zero North Sea Storage Limited
NZT	Net Zero Teesside
NZT Power	Net Zero Teesside Power Limited
Order	Net Zero Teesside Order
PES	Primary Energy Saving
SoS	Secretary of State
STDC	South Tees Development Corporation

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1.0 EXECUTIVE SUMMARY

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

1.1.2 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 will be demonstrated by applying the three 'BAT Tests' outlined in the 'CHP Ready Guidance for Combustion and Energy from Waste Power Plants' (2013, the 'CHP-R Guidance').

1.1.3 Following an assessment of the feasibility for heat extraction, three 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.

1.1.4 The CHP Assessment has indicated that there are a number of theoretical identified heat users within a 15 km radius of the Proposed Development. Techno-economic factors and commercial risks have been considered throughout the examination of the three main heat demand clusters South Bank, Kirkleatham and Redcar as well as the future developments in Teesworks.

1.1.5 Based on this discussion, none of the current heat demand clusters have been considered further for the available heat from the Proposed Development. However, there is potential to provide Teesworks with available waste heat as the peak heat demand lies within the CHP envelope of the Proposed Development and the Teesworks site is on land adjacent to the Proposed Development, reducing the cost of the necessary heat distribution pipework.

1.1.6 As these developments are not yet built, CHP is therefore not proposed to be installed from the outset, however the Proposed Development will be considered Combined Heat and Power - Ready with sufficient space allocated for future retrofit of a heat offtake within its footprint should that be required.

1.1.7 The Applicant is therefore 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.

2.0 INTRODUCTION

2.1 Overview

2.1.1 This Combined Heat and Power Readiness (CHP-R) assessment (Document Ref. 5.8) has been prepared on behalf of Net Zero Teesside Power Limited and Net Zero North Sea Storage Limited (the 'Applicants'). 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 'PA 2008').

2.1.2 The Applicants are seeking development consent for the construction, operation and maintenance of the Net Zero Teesside Project ('NZT'), including associated development (together the 'Proposed Development') on land at and in the vicinity of the former Redcar Steel Works site, Redcar and in Stockton-on-Tees, on Teesside (the 'Site'). The former Steel Works site, along with other land required for the Proposed Development, lies within the boundary of the land controlled by the South Tees Development Corporation ('STDC'), which is now known as 'Teesworks'.

2.1.3 A DCO is required for the Proposed Development as it falls within the definition and thresholds for a 'Nationally Significant Infrastructure Project' (a 'NSIP') under Sections 14(1)(a) and 15 of the PA 2008, associated development under Section 115(1)(b) and by direction under Sections 35(1) and 35ZA of the same Act. The DCO, if made by the SoS, would be known as the 'Net Zero Teesside Order' (the 'Order').

2.1.4 The Proposed Development will be the UK's first commercial scale, full chain Carbon Capture, Usage and Storage project and will initially capture up to 4 million tonnes (Mt) of carbon dioxide (CO_2) emissions per annum. It will comprise a number of elements, including a new gas-fired Electricity Generating Station with post-combustion carbon capture plant; gas, water and electricity connections (for the generating station); a CO_2 pipeline network (a 'gathering network') for collecting CO_2 from a cluster of local industries on Teesside; a CO_2 compressor station (for the compression of the CO_2) and a CO_2 export pipeline.

2.1.5 The CO_2 captured from the Electricity Generating Station and local industries will be compressed and then transported (via the export pipeline) for secure storage within the Endurance saline aquifer located 145 kilometres offshore from Teesside under the North Sea. The export pipeline has the capacity to carry up to 10Mt of CO_2 per annum. The Proposed Development will therefore make a significant contribution toward the UK reaching its greenhouse gas emissions target by 2050.

2.2 The Applicants

2.2.1 NZT encompasses proposals to both decarbonise electricity generation and a cluster of carbon intensive industries on Teesside. In line with the CCUS business models published by BEIS in December 2020, there will be separate entities who will be responsible for:

- electricity generation with post-combustion carbon capture (including the gas, water and electricity connections);

- CO_2 gathering (from industrial emitters), CO_2 compression and CO_2 export and storage; and
- industrial (including hydrogen production) carbon capture and connections to the CO_2 gathering network.

2.2.2 The entities are set out in Table 2.1 below:

Table 2.1: NZT Entities

Onshore works scope	Partnership	NZT Entity	Within the scope of the DCO Application?
Electricity Generating Station with post-combustion carbon capture (including the gas, water and electricity connections)	bp*, Eni, Equinor and Total	Net Zero Teesside Power Limited	Yes
CO_2 gathering network, CO_2 compression and the onshore section of CO_2 export pipeline	bp*, Eni, Equinor, National Grid, Shell and Total	Net Zero North Sea Storage Limited	Yes
Industrial and hydrogen production carbon capture and connection to the CO_2 gathering network	Individual industrial emitters	N/A	No

*Operator on behalf of the relevant Partnership

2.2.3 NZT is being promoted by Net Zero Teesside Power Limited ('NZT Power') and Net Zero North Sea Storage Limited ('NZNS Storage'). NZT Power and NZNS Storage (together the Applicants for the purposes of the DCO Application) have been incorporated on behalf of bp as operator of the two Partnerships.

2.2.4 The electricity generation with post-combustion carbon capture Partnership comprises bp, Eni, Equinor and Total, with bp leading as operator. NZT Power will be responsible for the Proposed Development in so far as it relates to the construction, operation and eventual decommissioning of the Electricity Generating Station together with its carbon capture plant (both within the scope of the DCO Application).

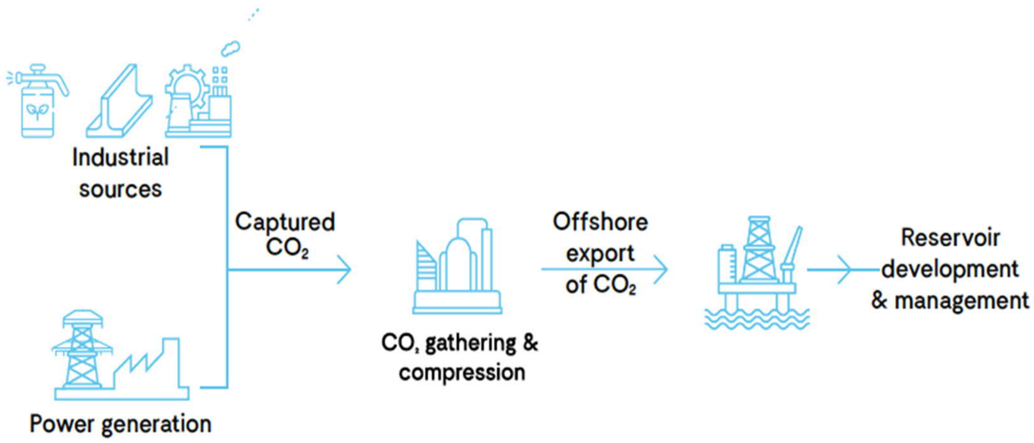
2.2.5 The CO_2 gathering network, CO_2 compression and onshore section of CO_2 export pipeline Partnership comprises bp, Eni, Equinor, National Grid, Shell and Total, with bp leading as operator. NZNS Storage will be responsible for the Proposed Development in so far as it relates to the construction, operation and eventual decommissioning of the equipment required for the high-pressure compression of CO_2 from the electricity generating station and industrial emitters via the CO_2 gathering network and the onshore section of the CO_2 export pipeline (these are all within the scope of the DCO Application).

2.2.6 NZNS Storage will also be responsible for the offshore elements of NZT, comprising the offshore section of the CO_2 export pipeline (below Mean Low Water Springs ('MLWS')) to a suitable offshore geological CO_2 storage site under the North Sea, CO_2 injection wells and associated infrastructure. The offshore elements of NZT (with the exception of the gas and CO_2 pipeline crossings of the River Tees and the water outfall from the Electricity Generating Station) do not form part of the DCO Application.

2.3 What is Carbon Capture, Usage and Storage?

2.3.1 Carbon Capture, Usage and Storage ('CCUS') is a process that removes CO_2 emissions at source, for example emissions from an Electricity Generating Station or industrial installation, and then compresses the CO_2 so that it can be safely transported to secure underground storage sites. It is then injected into layer of solid rock filled with interconnected pores where the CO_2 becomes trapped and locked in place, preventing it from being released into the atmosphere. Figure 2.1 below shows what is involved in the process.

Figure 2.1: CCUS Process



2.3.2 The technologies used in CCUS are proven and have been used safely across the World for many years. Storage sites are located several kilometres underground and are subject to stringent tests to ensure that they are geologically suitable. In the UK, it is expected that the storage sites will be located offshore, in areas such as the North Sea.

2.3.3 CCUS is one of a number of technologies that are crucial to reducing CO_2 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.

2.4 The Site

2.4.1 The Site lies within the administrative boundaries of both Redcar and Cleveland Borough Council and Stockton-on-Tees Borough Council. It also partly lies within the boundary of the Teesworks area that is controlled by the STDC.

2.4.2 Most of the Site lies within the administrative area of Redcar and Cleveland Borough Council, although parts of Site (for the Electricity Generating Station's gas supply connection to the National Transmission System for gas and the CO_2 gathering network) cross the River Tees into the administrative area of Stockton-on-Tees Borough Council. At this location, the River Tees is tidal. In addition, there are elements of the Site which extend into South Gare, Coatham Sands and the North Sea. Those sections of the Site that are below MLWS are outside the jurisdiction of either local authority being part of the UK marine area.

2.4.3 The Site extends to approximately 462 hectares ('ha') in area. Much of it comprises previously developed (including part of the former Redcar Steel Works Site) and existing industrial land, some of which was reclaimed from the Tees Estuary in the late C19th and during the C20th. The Site is relatively flat and low-lying and sits at a level of between sea level and approximately 9 metres Above Ordnance Datum ('AOD'). The area surrounding the Site is largely characterised by industrial and commercial uses, although there are open areas of land to the north in the form of South Gare and Coatham Sands, which are used for recreational purposes and that are of nature conservation importance.

2.4.4 A more detailed description of the Site and its surroundings is provided at Chapter 3 'Description of the Existing Environment' in the Environmental Statement ('ES') Volume I (Document Ref. 6.2).

2.5 The Proposed Development

2.5.1 The Proposed Development will work by capturing CO_2 from the Electricity Generating Station in addition to a cluster of local industries on Teesside and transporting it via a CO_2 export pipeline to the Endurance saline aquifer under the North Sea. The Proposed Development will initially capture and transport up to 4Mt of CO_2 per annum, although the CO_2 export pipeline has the capacity to accommodate up to 10Mt of CO_2 per annum thereby allowing for future expansion.

2.5.2 The Proposed Development comprises the following elements:

- a combined cycle gas turbine ('CCGT') Electricity Generating Station with an electrical output of between 750 and 860 megawatts and post-combustion carbon capture plant;
- cooling water, gas and electricity grid connections and infrastructure for the Electricity Generating Station;
- a CO_2 gathering network (including connections under the tidal River Tees) to collect and transport the captured CO_2 from industrial emitters to a CO_2

compressor station (the industrial emitters using the gathering network will be responsible for consenting their own carbon capture plant and connections to the gathering network);

- a high-pressure CO_2 compressor station to receive and compress the captured CO_2 from the Electricity Generating Station and gathering network before it is transported offshore; and
- a dense phase CO_2 export pipeline for the onward transport of the captured and compressed CO_2 to the Endurance saline aquifer under the North Sea.

2.5.3 The Electricity Generating Station, its post-combustion carbon capture plant and the CO_2 compressor station will be located on part of the STDC Teesworks area (on part of the former Redcar Steel Works Site). The CO_2 export pipeline will also start in this location before heading offshore. The Electricity Generating Station connections and the CO_2 gathering network will require corridors of land within both Redcar and Stockton-on-Tees, including crossings beneath the River Tees.

2.5.4 All of the above elements are included in the scope of the DCO Application, with the exception of the CO_2 export pipeline, where only the onshore section of pipeline above MLWS is included. The CO_2 export pipeline below MLWS and the CO_2 storage site under the North Sea (the Endurance saline aquifer) will be the subject of separate consent applications, including under the Petroleum Act 1998 and the Energy Act 2008. These applications will be supported by an Offshore Environmental Statement.

2.5.5 The ancillary development required in connection with and subsidiary to the above elements of the Proposed Development is detailed in Schedule 1 of the draft DCO (Document Ref. 2.1). A more detailed description of the Proposed Development is provided at Schedule 1 'Authorised Development' of the draft DCO and Chapter 4 'The Proposed Development' in ES Volume I (Document Ref. 6.2) and the areas within which each of the main elements of the Proposed Development are to be built are denoted by the coloured and hatched areas on the Works Plans (Document Ref. 4.4).

2.6 The Purpose and Structure of this Document

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

2.6.2 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 will be demonstrated by applying the three 'BAT Tests' outlined in the 'CHP Ready Guidance for Combustion and Energy from Waste Power Plants' (2013, the 'CHP-R Guidance').

2.6.3 Details of the above CHP guidance are presented in Section 3.1 of this document.

2.6.4 The remainder of this report is structured as follows:

- Section 3 describes the policy context;
- Section 4 assesses the feasibility of heat extraction from the Proposed Development based on the current design;
- Section 5 identifies potential heat users in the vicinity of the Proposed Development;
- Section 6 presents the assessment of the Proposed Development against the BAT tests described in the CHP-R Guidance; and
- Section 7 presents the conclusions of this CHP assessment.

3.0 POLICY CONTEXT AND ASSESSMENT METHODOLOGY

3.1 National Policy Statements

3.1.1 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.

3.1.2 The National Policy Statements (NPS) for energy infrastructure form the policy framework for applications for new generating stations of greater than 50 MW capacity in England and Wales. The NPS of most relevance to the Proposed Development (and this CHP Assessment) are the *'Overarching National Policy Statement on Energy (EN-1)' and the 'National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2)'.*

3.1.3 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.

3.1.4 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.

3.1.5 Paragraph 4.6.6 of EN-1 highlights that under guidelines[1] issued by the Department for Energy and Climate Change ('DECC'[2]), any application to develop a thermal generating station under Section 36 of the Electricity Act 1989 must have either included CHP or contain evidence that possibilities for CHP had 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 PA 2008 and that the SoS should have regard to the DECC guidance, or any successor to it, when considering the CHP aspects of application for thermal generating stations.

3.1.6 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,*

[1] *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'*

[2] In 2016, the functions of DECC were merged into the Department for Business, Energy and Industrial Strategy ('BEIS')

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

3.1.7 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.

3.1.8 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.

3.1.9 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.

3.1.10 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.

3.1.11 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).

3.2 CHP Guidance

3.2.1 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'*, Ref. 2-1).

3.2.2 Paragraph 8 of the CHP Guidance states that the Government expects developers to explore opportunities to use CHP fully, including community heating, when developing proposals for new thermal generating stations. However, it does recognise that in some cases CHP will not be an economic option.

3.2.3 Paragraph 12 of the 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.

3.2.4 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.

3.2.5 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.

3.3 CHP-R Guidance

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

3.3.2 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.

3.3.3 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.

3.3.4 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' (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 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* [...]’.

3.3.5 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 […]'.

3.3.6 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 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.

3.3.7 If the proposal is for generation without CHP:

- 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.

3.3.8 The CHP-R Guidance states 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'

3.3.9 The Environment Agency 'Guidelines for Developments requiring Planning Permission and Environmental Permits' set out the role of the Environment Agency in the planning process; the 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.

3.3.10 These Guidelines recognise that there may be some interdependencies between planning and permitting requirements. In the case of such interdependencies, the Guidelines recommend early engagement with the Environment Agency via their planning pre- application service.

3.3.11 Therefore, it is recommended that this 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).

3.3.12 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.

3.3.13 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.

3.3.14 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'.

3.4 Note on the Implementation of the Energy Efficiency Directive

3.4.1 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. Since March 2015, these Regulations have required operators of certain combustion installations 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').

3.5 Assessment Methodology

3.5.1 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 be CHP or 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 to operation of the plant of the supply of 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.

4.0 HEAT EXPORT FEASIBILITY STUDY

4.1 Introduction

4.1.1 This Section assesses the feasibility for heat extraction and export from the site for comparison with the identified CHP heat load from Section 3.6. The Proposed Development comprises one H-class combined cycle gas turbine (CCGT) power station and post-combustion carbon capture plant (CCP) with site cooling provided through mechanical draft cooling towers. The selection of the turbine and CCGT supplier has not yet been made and will be subject to a procurement process at the end of the Front-End Engineering Design (FEED) stage. However, for the purposes of this CHP assessment, the largest H-class gas turbine technology currently commercially available has been used as the basis for approximate heat loads available from the site with a net unabated power output of approximately 860MWe.

4.1.2 This analysis has been based on generic thermal cycle modelling undertaken by AECOM, based on simulation of a single train of H-Class CCGT combined with post-combustion capture using open-art MEA solvent. An H-Class CCGT was chosen as it is the largest gas turbine currently available on the market and represents the largest quantity of heat potentially available for recovery, while the generic MEA-based capture process configuration would the most opportunity for waste heat recovery from the capture process. Therefore, the study basis has identified the largest boundary of the envelope of waste heat that could potentially be utilised for CHP with present technology. Note that other technology choices (such as future selection of the CCGT OEM, or choice of licensed capture process) may reduce the amount of heat available for CHP. The scope of this study is to identify the most favourable scenario for availability of heat for CHP and does not extend to selection of a specific CCGT OEM nor use of a licensed process.

4.1.3 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. The operating regime of the Proposed Development is expected to change to dispatchable after a period of baseload operation to support the penetration of renewable energy sources supplying the UK transmission system. As a result, there may be significant periods where the Proposed Development is not operating at full load or not operating at all.

4.1.4 Due to the dispatchable nature of the facility, any heat available for a potential CHP design is likely to be intermittent, which would affect the viability of any CHP scheme.

4.2 Heat Extraction Options

4.2.1 One primary factor contributing to the high efficiency of the CCGT is re-use 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.

4.2.2 There are several existing measures in place to re-use heat within the CCP as well as the CCGT. Most of the steam provision required in the CCP is used to generate the heat necessary to separate the captured CO_2 from the rich amine within the CO_2 stripper.

4.2.3 Some reheat of the treated flue gas may also be required to aid dispersion and this would therefore re-use some waste heat within the plant reducing availability for export.

4.2.4 This results in a significant amount of waste heat already being utilised within the Proposed Development. The Proposed Development CHP Readiness assessment takes into account the steam requirement for the carbon capture plant 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 operate in isolation from the carbon capture plant. It is likely that waste heat from the CCGT would be used as a priority within the carbon capture plant where feasible. As a consequence, the CHP readiness assessment appraises opportunities to use heat rejection at a suitable temperature from the CCP to feed either the site cooling network or a District Heating rather than using direct LP steam offtake from the CCGT. Note that licensors will optimise heat recovery within the CCP to minimise parasitic load and this will be undertaken at the detailed design stage. As a consequence, available heat for CHP may be further reduced accordingly. However, there are two potential areas of waste heat availability considered for offsite use during the integrated operation of the CCGT and CCP (i.e. abated operation). These comprise:

- Extraction from the CO_2 stripper overhead stream;
- Extraction from the low pressure (LP) condensate leaving the CO_2 stripper reboiler.

4.2.5 Waste heat recovery from the CO_2 compressors has been considered but is not of sufficient heat quality for further investigation and has not been considered further in this report.

4.2.6 The Proposed Development is assumed to be running with the capture plant in operation for the majority of its design lifetime. Therefore, the following sections and CHP-R Assessment Form (Appendix 1) have only considered the CHP potential during the running of the CCGT with carbon capture.

CO_2 Stripper Overhead Stream

4.2.7 From analysis of the stream temperatures across the post-combustion carbon capture plant during the available heat and material balance calculations for a similar plant configuration, the CO_2 stripper overhead stream was identified as a potential source of heat extraction.

4.2.8 Based on a generic design, the CO_2 overhead stream could exit the top of the CO_2 stripper column at a temperature of 109°C before heading into the CO_2 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.

4.2.9 With the use of a suitable heat exchanger, heat from the CO_2 overhead stream could be extracted by reducing the temperature of this stream before the CO_2 stripper condenser. Assuming the CO_2 overhead stream temperature exiting the heat exchanger is 70°C, there is approximately up to 62MWth of heat available from the site running at maximum electrical power (full load).

4.2.10 During minimum electrical power operation (part load), the heat available will be reduced due to the reduced flow rate of the CO_2 overhead stream. For this operating mode, there is approximately up to 30MWth of heat available in the form of 90°C hot water.

CO_2 Stripper Reboiler Condensate Return

4.2.11 After supplying heat to the stripper amine within the CO_2 stripper reboiler, the LP steam condenses within the reboiler, leaving at a temperature that could be up to 144°C based on a generic design, but this would be lower for specific solvents. This LP condensate requires further cooling before returning to the CCGT's condenser; this can be used to pre-heat boiler feedwater for example, thereby minimising heat rejection to cooling water.

4.2.12 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.

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

4.2.14 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

4.2.15 A review of the two potential heat extraction locations was conducted to assess the quantity of heat available to potential users within the local area. These extraction locations include: the inlet of the CO_2 stripper condenser, and the low pressure condensate return leaving the stripper reboiler.

4.2.16 The total potential heat available in the form of district heating is up to 80 MWth at full load, whereas at part load up to 39 MWth is available.

4.3 Identification of the CHP Envelope

4.3.1 Based on the assumption of extraction from section above, the following calculations have been performed to determine the heat and power envelope. The envelope limits are defined as follows:

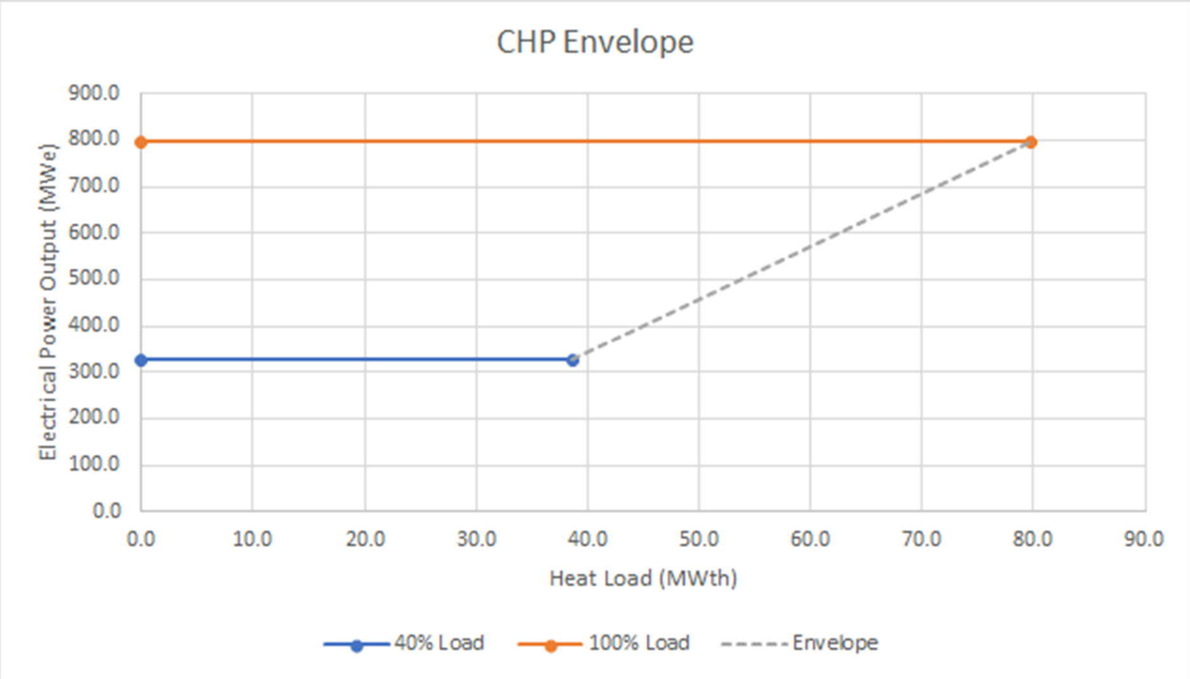
- A – Minimum Stable Load with no Heat Extraction
- B – Minimum Stable Load with maximum Heat Extraction
- C – Maximum Electrical Power (100% Full Load) with maximum Heat Extraction
- D – Maximum Electrical Power (100% Full Load) with no Heat Extraction

4.3.2 The CHP efficiency (ηCHP) is defined as:

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

4.3.3 Based on the values of heat load presented in the previous section and the expected electrical power output of the site, the CHP envelope can be produced as shown in Figure 4.1.

Figure 4.1: Indicative CHP Envelope



4.3.4 The performance of the site (i.e. the indicative heat and power envelope data) is presented in Appendix 1 to this document, in the format defined by the CHP-R Guidance.

4.3.5 Table 4.1 shows that the primary energy saving associated with the Proposed Development operating 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 site is 7.2% and 57.4% respectively.

Table 4.1: 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	649	649	1,371	1,371
Net Power output, MWe	327	327	796	796
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

4.4 Further Consideration and Potential Challenges of CHP

4.4.1 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.

4.4.2 It would be necessary to install tie-in points to facilitate the future installation of the equipment required for the CHP opportunity identified.

4.4.3 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.

4.4.4 Other potential challenges may result from the operating regime not being compatible with the requirements of the heat load. The Proposed Development is expected to start as a baseload plant but move to operate in dispatchable mode to support renewables penetration supplying the UK transmission system. This will 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 ultimate running regime and load of the CCGT units may not coincide with the requirements of the identified heat load, and this incompatibility may affect the viability and effectiveness implementing any CHP scheme.

4.5 Economic Assessment

4.5.1 As outlined in the EED, a cost-benefit analysis is only required where the CHP opportunity has the potential to be 'high efficiency' (i.e. achieve a PES of 10% or greater).

4.5.2 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 site), this section of the document will be updated accordingly.

5.0 IDENTIFICATION OF HEAT USERS

5.1 Introduction

5.1.1 A review of the potential heat demand within a 15km radius of the Proposed Development 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.

5.1.2 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 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 has taken place to date.

5.2 CHP Opportunities

5.2.1 The Tees Estuary area hosts many heavy industrial plants as well as several towns with residential, commercial and light industrial buildings. In the last decade several feasibility studies have been undertaken to assess the potential for district heat networks in the area. These studies have considered the potential to take waste heat from one or more of the many industrial processes which already exist around the estuary. The analysis in the report draws on the most recent of these studies which covers the area around the Proposed Development.

5.2.2 While district heating has been deployed in the UK since the 1950s, it has achieved only a low market penetration and currently provides less than 2% of the UK heat demand. This is in stark contrast to the position in many other European countries; in Finland and Denmark for example, district heating is the dominant heat source, accounting for 49% and 60% of total heat supply respectively. Even where district heating makes a lower overall contribution to heat supply, it is often a major source of heat in larger cities. For example, district heating is responsible for only 18% of total heat supply in Austria, but in Vienna it provides 36% of the city's heat, including over 270,000 domestic households and with plans to extend the system.[3]

5.2.3 Generally, district heating systems are only installed in urban areas where a higher density of heat demand improves the cost effectiveness, however networks can also be developed to link large industrial consumers with low-carbon heat sources.

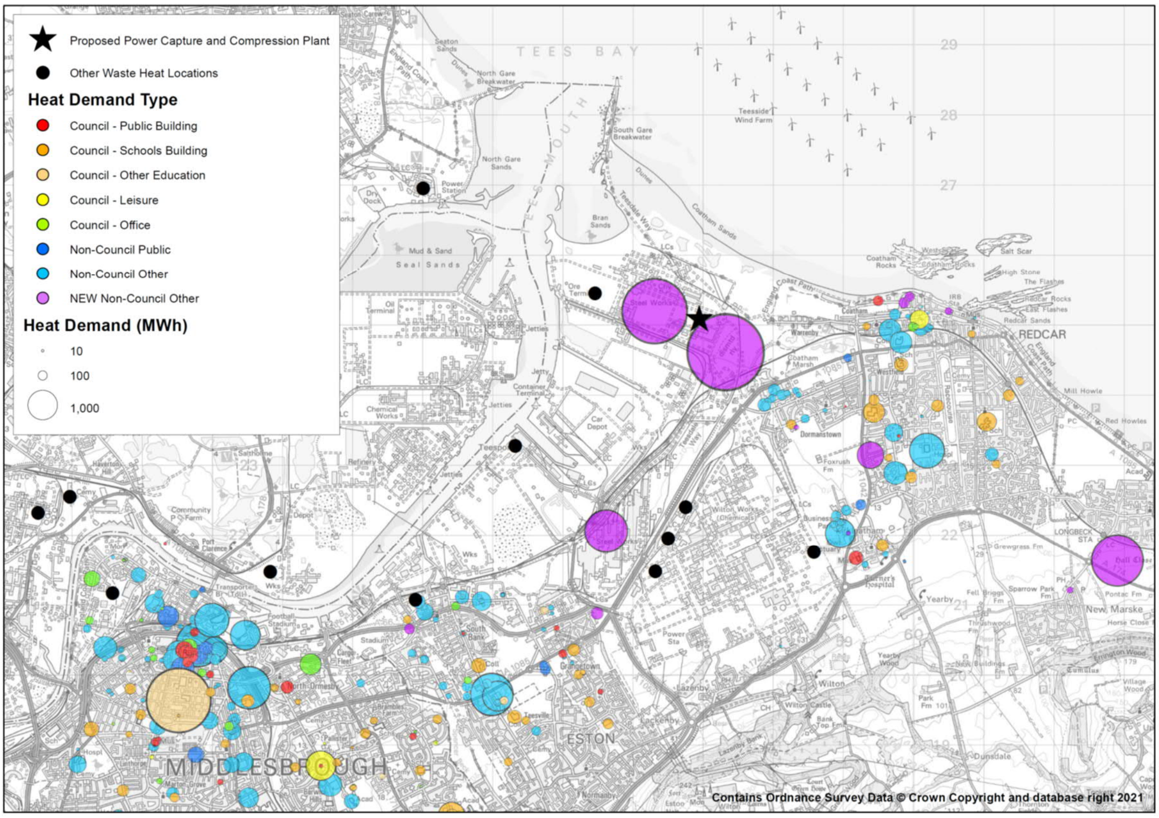
5.2.4 District heating will require continuous availability of heat. The Proposed Development is expected to start as a baseload plant but move to operate in dispatchable mode to support renewables penetration supplying the UK transmission system. This will result in the plant periodically not operating in response to the grid demands as well as maintenance requirements. Therefore, a

[3] "*The Potential and Costs of District Heating Networks*"
http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/distributed_en_heat/District_heat/District_heat.aspx

back-up source of heat may also be required to supply and district heat network. This back-up plant could take the form of a gas boiler, electric boiler, heat pump and/or heat from another industrial process.

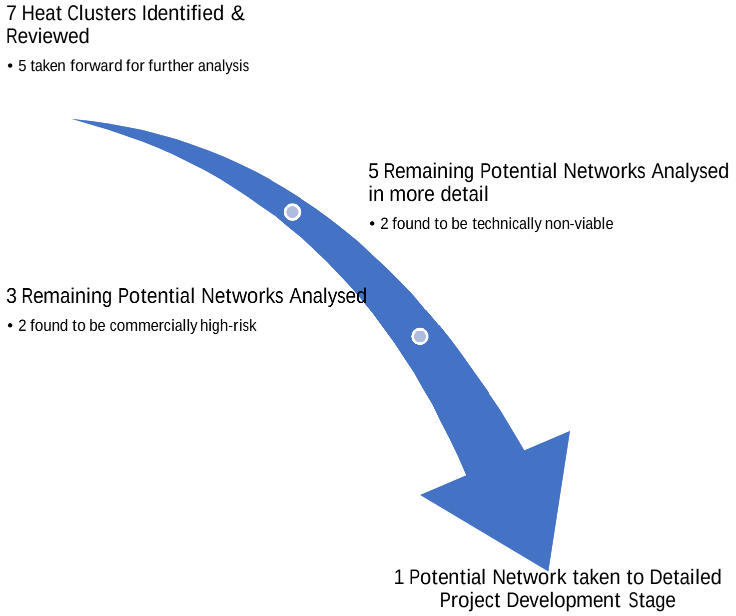
5.2.5 In 2016 AECOM undertook a heat mapping and master planning study for the Tees Valley Combined Authority. This study mapped potential sources of heat and over 200 heat demands in South Tees covering the area from Middlesbrough through to Redcar. For the purposes of this report AECOM has updated this mapping based on publicly available information for new developments that have either been built or proposed since 2016. Figure 5.1 shows the location of the Proposed Development, the mapped heat demands, and 14 other potential heat sources identified through this process. Mapped heat demands are represented as coloured circles where the diameter of the circle is proportional to the size of the annual heat demand. This approach to mapping shows clusters of heat demands in several locations generally around urban centres or industrial zones.

Figure 5.1: Map showing local heat demands identified by previous heat mapping study, additional heat demands identified for this study, the location of the Proposed Development and locations of other industrial process heat sources



5.2.6 The 2016 heat mapping and feasibly study identified seven heat clusters which showed the potential to form the basis of a district heat network. Five of these seven clusters were identified as being sufficiently promising to be further analysed through initial technoeconomic modelling and stakeholder engagement. After this stage, two networks were identified as non-viable and three networks were taken forward for a more detailed technoeconomic assessment. Two of the remaining networks were found to be technically feasible but commercially high risk; the one remaining network was progressed to detailed project development stage but is yet to be delivered. This progressive refinement process is illustrated in Figure 5.2:

Figure 5.2: Illustration of the refinement of opportunities previously identified by the 2016 study



5.2.7 To appraise the feasibility of supplying heat from the Proposed Development to local off-takers, the following section assesses the potential to supply the nearest three of the seven clusters previously identified as well as new heat demands that have been identified. In each instance, the viability has been compared to that of the twelve other industrial heat sources shown in Figure 5.1.

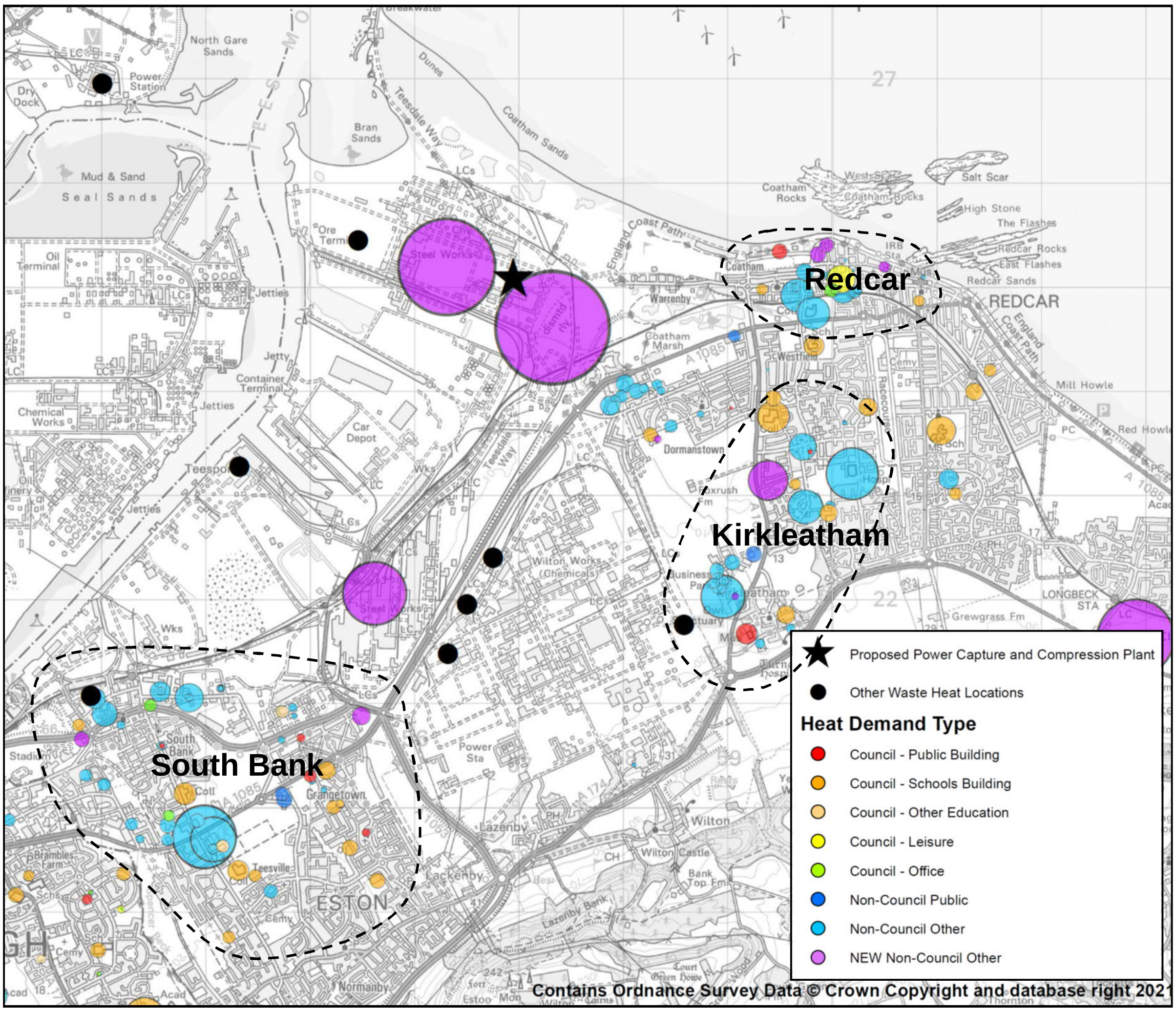
5.2.8 The three heat clusters to be considered are:

- South Bank;
- Kirkleatham;
- Redcar.

5.2.9 The general synopsis is that the Tees Estuary hosts several heavy industrial processes, many of which have large quantities of surplus heat. A small number of the industrial operations in the area require heat but their requirements tend to be for higher grade heat (i.e. steam) than is available from heat loads from other local industrial facilities. This trend applies to both sides of the Tees Estuary. The north bank heat demand is purely industrial from the point closest to the Proposed Development extending upstream as far as Port Clarence (around 5km to the south west). If it is to become the basis of a heat network, the heat from the Proposed Development will need to be more economically viable than all the other potential sources of heat in the area. This economic viability could be achieved by either having a lower operational cost (i.e. the cost of extracting the heat including any power reduction) and/or being lower capital cost (this is primarily a function of the distance between the Proposed Development and the prospective off-takers). The location of the Proposed Development on the former steelworks site places it further from the vast majority of the off-takers than the other potential heat sources.

5.2.10 Figure 5.3 shows a section of Figure 5.1 with three heat clusters identified during the 2016 study.

Figure 5.3: Map clusters of heat demands, Proposed Development and other industrial process heat sources

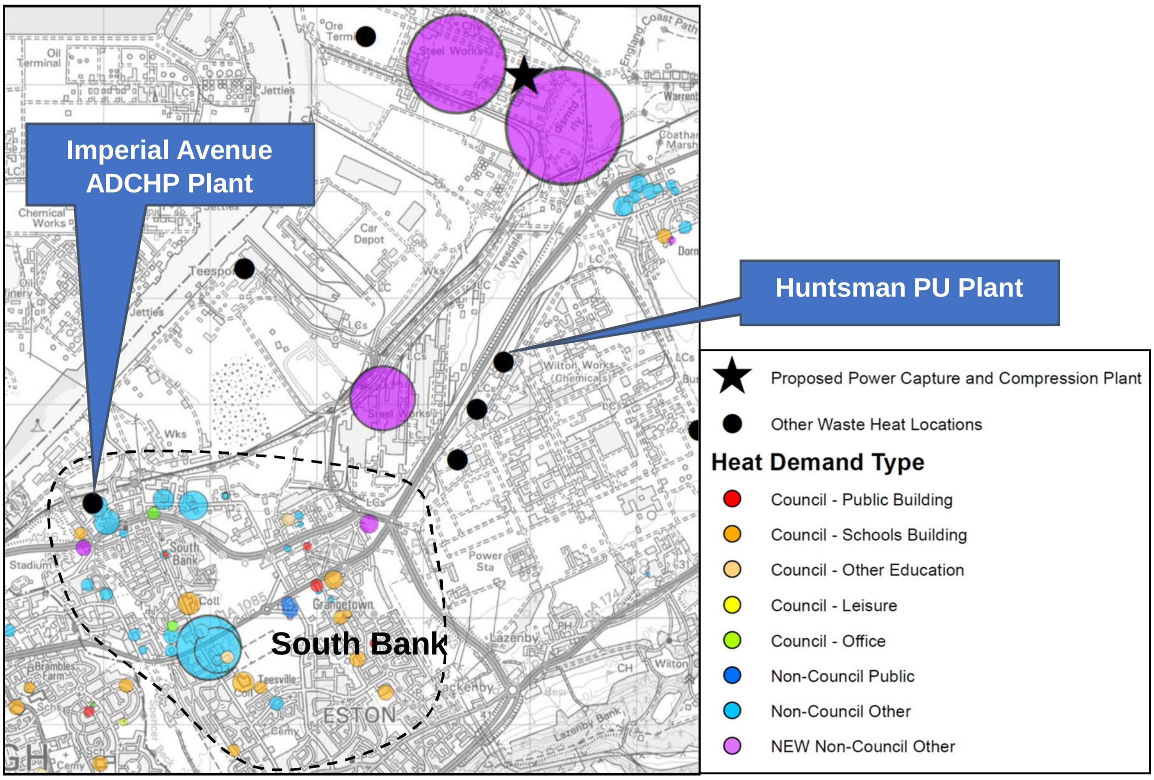


5.2.11 The following sections discuss the viability of supplying heat to the nearest three heat clusters identified in the previous study and the newly identified heat demands shown in purple in Figure 5.3.

5.3 South Bank Cluster

5.3.1 The South Bank heat demand cluster was identified during the 2016 heat mapping exercise and progressed through two stages of techno-economic modelling. The first round of modelling considered two heat sources; waste heat from the Huntsman PU plant on the Wilton site and an anaerobic digestion combined heat and power (ADCHP) plant on Imperial Avenue, see Figure 5.4.

Figure 5.4: South Bank heat demand cluster



5.3.2 The initial round of modelling established that the long distance between the largest loads and the Huntsman PU plant made the use of this heat source less attractive than the nearer ADCHP plant. Subsequent techno-economic modelling concluded that there was potential for a technically viable heat network served by the ADCHP. The economically optimal network was estimated to have a peak heat demand of around 8.3MW and an annual demand of around 10.9GWh.

5.3.3 However, the identified heat off-takers are almost entirely private businesses, (mostly light industry and retail) stakeholder engagement showed that the level of enthusiasm for the proposed network was low and the commercial risks were further elevated by the relatively short-term commitments each organisation was willing to consider. Moreover, the economic viability of the network relied heavily on the sales of electricity form the ADCHP plant through a private wire network.

5.3.4 Drawing on the findings of this earlier analysis, it is unlikely that providing heat to this cluster from the Proposed Development would prove to be more viable than the ADCHP plant because:

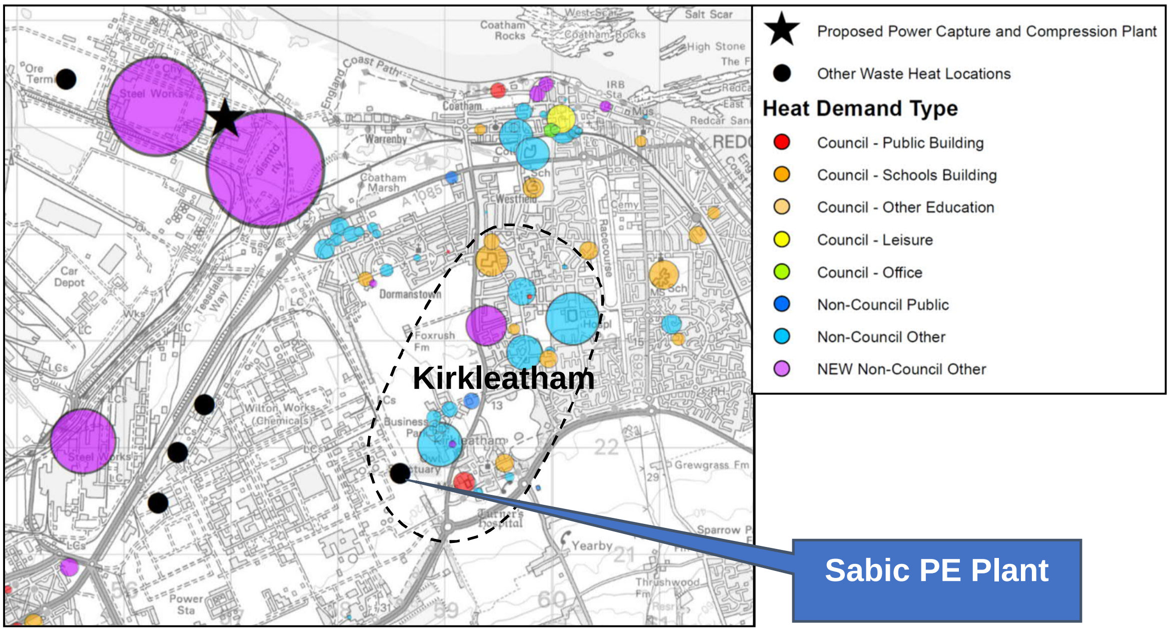
- The capital costs of a heat network delivering heat from the Proposed Development to the cluster would be much greater than that required to link to the ADCHP plant. The Proposed Development is approximately 5km further from the cluster than the ADCHP.

- The commercial risks associated with the types of potential off-takers are unlikely to have reduced.

5.4 Kirkleatham Cluster

5.4.1 The Kirkleatham heat demand cluster was identified during the 2016 heat mapping exercise and progressed through two stages of techno-economic modelling. This modelling considered the viability of supplying demands with heat from the Sabic PE plant, see Figure 5.5. The economically optimal network was estimated to have a peak heat demand of around 21.5MW and an annual demand of around 19.1GWh.

Figure 5.5: Kirkleatham heat demand cluster



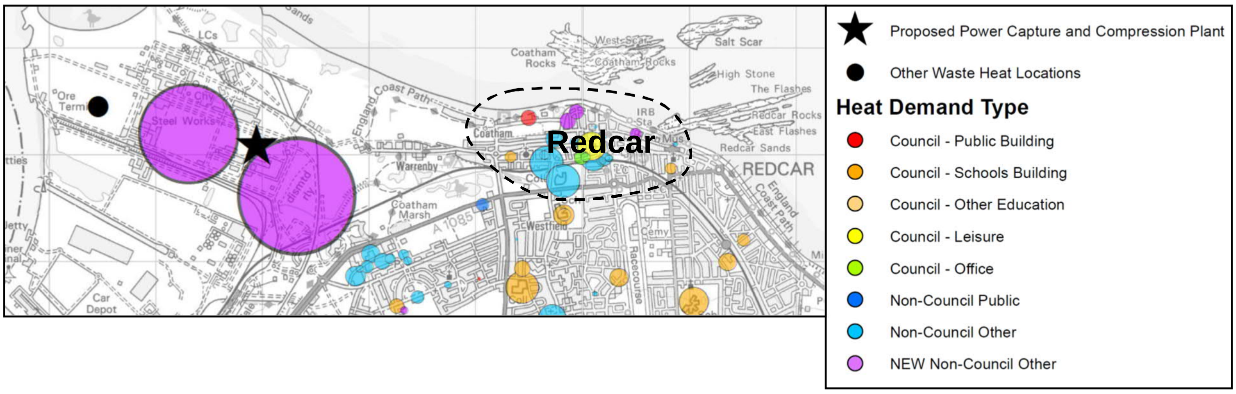
5.4.2 The potential heat off-takers in this cluster include a small hospital, a proposed housing development and a small business park. The business park is currently host to around 14 businesses (light industrial and commercial). Techno-economic modelling considered serving all of these as well as the proposed expansion of this park to around twice its current size. This modelling suggested that a technically and economically viable heat-only network could be developed if the park was largely built out within a few years. However, the client team concluded that the commercial risks associated with relying on this rapid build-out were too high.

5.4.3 The business park has not substantially expanded in the last four years, so it is reasonable to conclude that the previously identified commercial risks remain an impediment to the development of a network in this locality.

<u>Redcar Cluster</u>

5.4.4 The Redcar heat demand cluster was identified during the 2016 heat mapping exercise and went through two rounds of techno-economic modelling. This analysis considered the viability of supplying demands with a purpose-built gas-CHP plant to be located in an existing plant room in one of the off-taker buildings, see Figure 5.6.

Figure 5.6: Redcar heat demand cluster



5.4.5 The systematic techno-economic modelling tool that AECOM used considered every permutation of off-taker buildings that could be connected. This process concluded that the economically optimal network consisted of just four buildings with a peak demand of around 2.5MW and an annual demand of 3.1GWh.

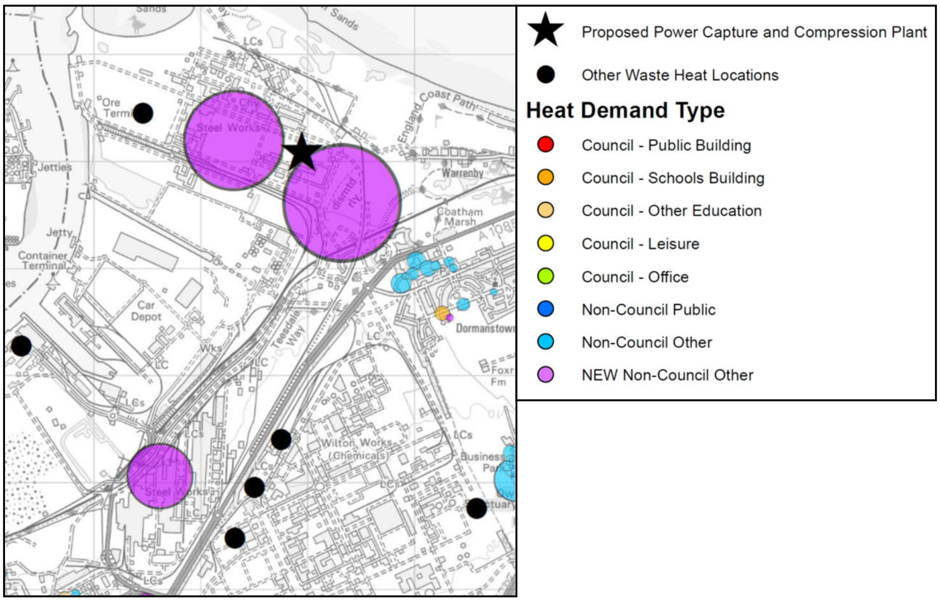
5.4.6 The economic viability of the network was found to be marginal despite taking several steps to refine and optimise the design by making us of an existing plant room and existing boilers etc.

5.4.7 The previous analysis concluded that the very small network opportunity in central Redcar was not economically viable. The cost of running a pipe from the Proposed Development to central Redcar would be many times greater than the capital cost of the gas-CHP previously considered as the primary heat source; it is therefore unlikely that the Proposed Development would prove to be more economically viable than the scheme previously considered.

5.5 Newly Identified Heat Demands

5.5.1 Figure 5.3 above shows the 14 heat demands that have been indented through analysis of planning applications and other development plans for the area around the Proposed Development. Most of the 14 identified heat demands are small and/or remote from the Proposed Development, however Figure 5.7 shows the three largest and nearest heat demands, these are significantly larger and nearer than the majority of the other heat demands identified.

Figure 5.7: Large newly identified heat demands near to the Proposed Development



5.5.2 Table 5.1 summarises these three potential heat demands. It can be seen that these are all proposed, rather than pre-existing, developments. Table 5.1 and Figure 5.7 show benchmarked heat demands for these three sites based on the publicly available information about the size and nature of the proposals.

Table 5.1: Three largest and nearest newly identified heat demands

Development Name	Purpose	Size (ft²)	Timescales	Benchmarked Heat Demand (kWh_{th}/yr)
Lackenby	Commercial uses - manufacturing, logistics and distribution	1,000,000 ft²	Works commence Mar '21	4,368,030
Long Acres	Commercial; office and incubator space	2,000,000 ft²for manufacturing; 430,000 ft² office	Site prep work ongoing	14,262,082
The Foundry	Commercial	5,000,000 ft²	Consenting process ongoing, site prep expected Apr '21	10,223,048

5.5.3 The two largest demands (Long Acres and The Foundry) are on adjacent Teesworks plot to the Proposed Development so the costs of heat distribution pipework would be much less than the other potential off-takers considered in this report.

5.5.4 Since the annual heat demand from Long Acres and The Foundry is approximately $24.5GWh_{th}$ and the peak demand is assumed to be up to 30MW, the Proposed Development has sufficient heat available to meet this heating demand as this is within the CHP envelope.

5.5.5 As these developments are not yet built, there may be an opportunity to engage with the developers to discuss and assess the viability of supplying heat from the Proposed Development.

6.0 BAT ASSESSMENT

6.1 Introduction

6.1.1 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 and choice of cooling method, 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.

6.1.2 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.

6.1.3 The Environment Agency CHP Guidance BAT Requirements have been fulfilled for the Proposed Development, as outlined in this section.

6.2 Plant Description

6.2.1 As detailed within Section 2, the Proposed Development consists of a CCGT plant and associated auxiliary equipment with a gross electrical output between 750-860MWe. The plant will also include a post-combustion carbon capture plant and compression station for the collection and onward transportation of captured CO_2 for offshore geological storage.

6.2.2 The CCGT plant will be fuelled by natural gas and will comprise of a H-class gas turbine, heat recovery steam generator and steam turbine. The plant has been designed to operate with carbon capture throughout its design life.

6.2.3 Site cooling will be supplied through mechanical draft cooling technology with operation at UK ambient conditions.

6.2.4 The CCGT plant is being developed for dispatchable operation with a baseload period for the first 1-3 years of operation. As more renewable capacity becomes available, the CCGT plant mode of operation will revert to being increasingly dispatchable. This flexibility is being accommodated within the CCGT and Capture plant design.

6.2.5 Details of the plant energy production and potential heat loads are identified in Section 4 and 5 respectively and summarised within the CHP-R Assessment Form presented in Appendix 1.

6.2.6 The Proposed Development is located on land at and in the vicinity of the former Redcar Steel Works site, Redcar, although parts of the CO_2 gathering network and the power station's gas supply connection to the National Transmission System for gas are in Stockton-on-Tees, on Teesside.

6.3 BAT Tests

6.3.1 The following text describes how the Proposed Development addresses the three BAT Tests identified within Section 3.3.

First BAT Test

6.3.2 As the Proposed Development is expected to have an availability of 8,000 hours per year during the majority of its 25-year design life, it has the potential to supply baseload heat capacity in the event that there is a significant demand for heat.

6.3.3 As illustrated in Section 4 and summarised in the CHP-R Assessment Form in Appendix 1, 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. This is illustrated in the CHP envelope identified in Section 4 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.

6.3.4 As the CCGT plant is in excess of the 300MWe threshold identified in the EA CHP-R Guidance, heat demand within a 15km radius of the plant is considered technically feasible. Section 5 has discussed the existing heat demand (based on a heat mapping exercise undertaken in 2016) within this locale and has concluded that, although there are heat demand clusters at South Bank (8.3MW peak heat demand); Kirkleatham (21.5MW peak heat demand); and Redcar (2.5MW peak heat demand), none of these offer economically viable opportunities for a heat network.

6.3.5 An assessment of recent planning applications and development plans for the area have identified two large potential heat demands that may benefit from the inclusion of a heat network as part of the Teesworks development. As can be seen from Figure 5.7, they are in relatively close proximity to the Proposed Development. However, they are at various stages in the development process so do not offer a current and existing outlet for the supply of heat. In the event that these are developed, it is estimated that they will have a peak heat demand up to 30MWth (28,853 MWhth/y), which is well within the CHP Envelope of the Proposed Development as identified in Section 4.

6.3.6 The assessment undertaken in Section 4 has identified that the PES would be approximately 7.2% which is below the 10% threshold identified by the EED for high efficiency co-generation. As the PES does not meet the 10% threshold a CBA is not required by the EED.

6.3.7 Based on the above discussion the Proposed Development will not be operated as a CHP plant at the outset of commercial operation, because as outlined in Section 5, the Teesworks developments are not yet built and the developers have not been consulted

Second BAT Test

6.3.8 As illustrated in the previous section, 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. This has identified two potential options which are listed below:

- Extraction from the CO_2 stripper overhead stream;

- Extraction from the low pressure (LP) condensate leaving the CO_2 stripper reboiler.

6.3.9 In the event that the plant does operate as a baseload plant or 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. This will ensure that the Proposed Development is designed and built to allow for the future implementation of CHP if the identified or potential future heat loads become economically viable.

6.3.10 In accordance with the second BAT Test of the EA CHP Ready Guidance, 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-R plant.

6.3.11 Sufficient space will be allocated for future retrofit of a heat offtake within the Proposed Development footprint, should that be required. Potential routes for water or steam pipelines to the boundary of the Proposed Development would be feasible and will be maintained within the plant design, although since no specific CHP opportunity has been identified, no route corridor has been determined.

Third BAT Test

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

- Instigate 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 to warrant a new technical and financial assessment; and
- Re-visiting the technical and economic assessments at least every 5 years or when a change in circumstances warrants.

7.0 CONCLUSIONS

7.1.1 In line with the requirements of NPS EN-1 and EN-2 and the CHP-R Guidance, this CHP Assessment has been undertaken to support the application for a DCO and meet the BAT requirements of the CHP-R Guidance.

7.1.2 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 the identified heat loads become economically viable.

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

7.1.4 Techno-economic factors and commercial risks have been considered throughout the further examination of the three main heat demand clusters South Bank, Kirkleatham and Redcar within the 15km radius. Based on this discussion, none of the heat demand clusters have been considered further for the potential usage of available heat from the Proposed Development at this stage.

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

7.1.6 It remains the case that there are several opportunities for re-use of "waste" heat within the Proposed Development itself, notably associated with the cooling of the CO_2 stream and cooling of the amine processing condensate stream; these efficiencies will be refined as the design of the Proposed Development progresses.

7.1.7 There are a number of large newly identified heat demands near to the Proposed Development yet to be built including two potential users in Teesworks, adjacent to the site. There may be an opportunity to engage with the developers to discuss and assess the viability of supplying heat from the Proposed Development as the heat demand requirements are within the CHP envelope of the Proposed Development.

7.1.8 The Applicant is therefore 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.

APPENDIX 1: CHP-R ASSESSMENT FORM

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant location and Potential heat loads			
1.1	Plant name		Net Zero Teesside
1.2	Plant description		A combined cycle gas turbine (CCGT) power station and post-combustion carbon capture plant with a gross output of approx. 860 megawatts (MWe). (The largest H-class gas turbine technology currently available has been used in the following potential heat load calculation which has a net power output of 860MWe.) A generic design has been assumed for the CCP. 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 mechanical draft technology and operation will be at UK ambient conditions.
1.3	Plant location (Postcode / Grid Ref)		Redcar, North Yorkshire (TS10 5NX / NZ568252)
1.4	Factors influencing selection of plant location		These include: availability of sufficient brownfield land; location suitable for CCS as it is situated in a coastal area with potential industrial CO_2 producers.
1.5	Operation of plant		Initially baseload but reverting to dispatchable operation. 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 of this form
a)	Proposed operational plant load	%	100 (initial stage of operation)

#	Description	Units	Notes / Instructions
b)	Thermal input at proposed operational plant load (generic design)	MW	1371
c)	Net electrical output at proposed operational plant load (generic design)	MW	796
d)	Net electrical efficiency at proposed operational plant load LHV	%	58.0
e)	Maximum plant load	%	100
f)	Thermal input at maximum plant load	MWth	1371
g)	Net electrical output at maximum plant load	MW	796
h)	Net electrical efficiency at maximum plant load LHV	%	58.0
i)	Minimum stable plant load	%	40
j)	Thermal input at minimum stable plant load	MW	649
k)	Net electrical output at minimum stable plant load	MW	327
l)	Net electrical efficiency at minimum stable plant load	%	50.4
1.6	Identified Potential Heat Loads		See details presented in Section 5
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
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

#	Description	Units	Notes / Instructions
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	2280
c)	CHP mode net electrical output at 100% plant load	MW	796
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
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	1103
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

#	Description	Units	Notes / Instructions
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
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: CO_2 stripper overhead stream, and CO_2 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

#	Description	Units	Notes / Instructions
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 will be minimised by incorporating space provision and an offtake within the detailed design of the plant to facilitate the supply of heat or steam to the site boundary.
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 – plant has CCS included, based on a generic design
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)		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/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
p)	Return temperature	°C	144
q)	Return flow	t/h	168

#	Description	Units	Notes / Instructions
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	1371
c)	Carbon capture mode net electrical output at 100% plant load	MW	796
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	649
g)	Carbon capture mode net electrical output at minimum stable plant load	MW	327
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	2280
c)	Carbon capture and CHP mode net electrical output at 100% plant load	MW	796
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	%	7.1

#	Description	Units	Notes / Instructions
	CHP mode at 100% plant load		
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	1103
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 capture and CHP mode at minimum stable plant load	%	7.2
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')?		N/A
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

#	Description	Units	Notes / Instructions
			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