Net Zero Teesside Project

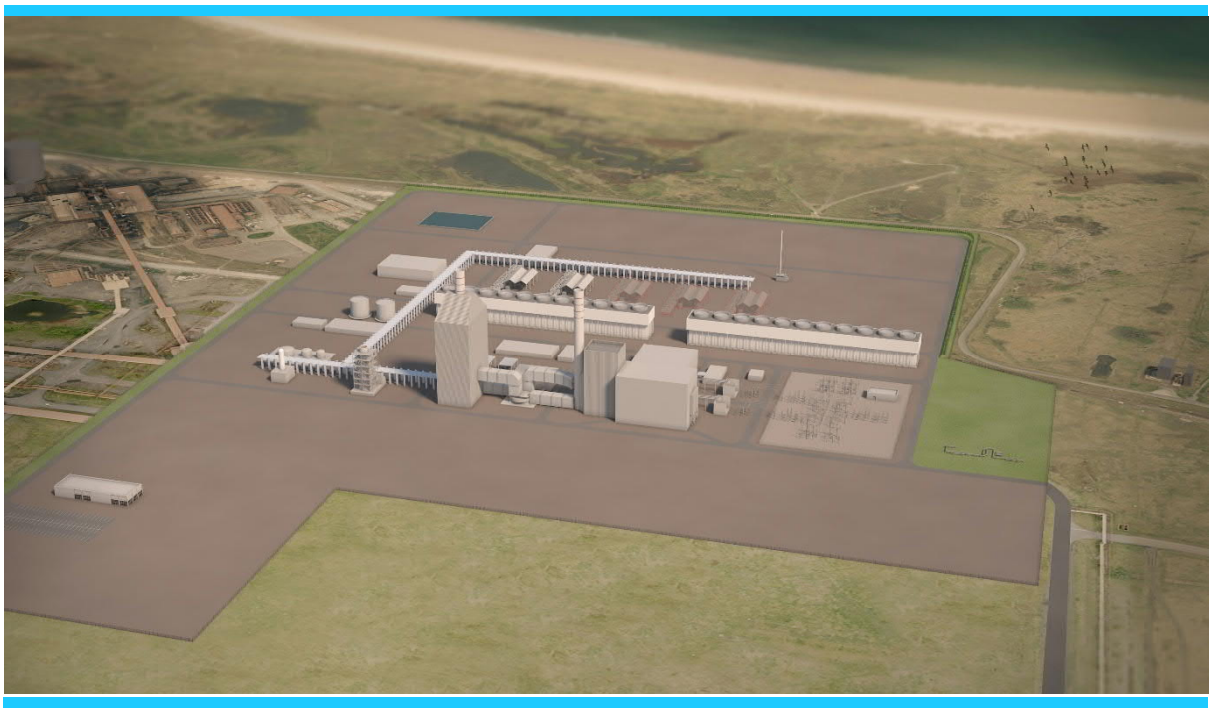
Planning Inspectorate Reference: EN010103

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

The Net Zero Teesside Order

Document Reference: 5.7 Carbon Capture Readiness Assessment

The Planning Act 2008
The Infrastructure Planning (Applications: Prescribed Forms and Procedures) 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: May 2021

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GLOSSARY

Abbreviation	Description
AOD	Above Ordnance Datum
BEIS	Department for Business, Energy and Industrial Strategy
BGS	British Geological Survey
CCGT	Combined Cycle Gas Turbine
CCP	Capture and Compression Plant
CCR	Carbon Capture Readiness / Ready
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Usage and Storage
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
COMAH	Control of Major Accident Hazards Regulations 1999
DCC	Direct Contact Cooler
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
DTI	Department of Trade and Industry
EPC	Engineering, Procurement and Construction
ES	Environmental Statement
EU	European Union
GGH	Gas to Gas Heat
ha	Hectare
HSC	Hazardous Substance Consent
HSE	Health & Safety Executive
IED	Industrial Emissions Directive
LCP	Large Combustion Plant Directive
MAHP	Major Accident Hazard Pipeline
MAPP	Major Accident Hazard Prevention Policy
MLWM	Mean Low Water Mark
Mt	Million tonnes

Abbreviation	Description
MWe	Mega Watt Electrical Mega Watts
NEP	Northern Endurance Partnership
NSIP	Nationally Significant Infrastructure Project
NZNS Storage	Net Zero North Sea Storage Limited
NZT	Net Zero Teesside
NZT Power	Net Zero Teesside Power Limited
Order	Net Zero Teesside Order
PA2008	The Planning Act 2008
PSR	Pipeline Safety Regulations 1996
SNS	Southern North Sea
SoS	Secretary of State
STDC	South Tees Development Corporation
TEG	Triethylene Glycol
WTP	Water Treatment Plant

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1.0 EXECUTIVE SUMMARY

1.1.1 The purpose of this document is to demonstrate that it is technically feasible to incorporate Carbon Capture technology within the Proposed Development and therefore that it is Carbon Capture Ready in accordance with the Carbon Capture Readiness (Electricity Generating Stations) Regulations 2013.

1.1.2 This document has been produced in accordance with the requirements of the Department of Energy and Climate Change November 2009 guidance 'Carbon Capture Readiness (CCR) – A Guidance Note for Section 36 Electricity Act 1989 consent applications.'

1.1.3 Following a technical feasibility assessment of the proposed Carbon Capture and Storage ('CCS') technology, the likely sizing and utility demand has been established. The site layout for Proposed Development shows that there is sufficient space for the carbon capture technology within the site based on this assessment.

1.1.4 The storage location proposed for the Proposed Development is the Endurance saline aquifer, with a storage capacity capable of accepting the carbon output from the Proposed Development over its design life. It is intended that the CO_2 captured from the Proposed Development will be transported to the storage site via pipeline and a separate but related consent for the routing, construction and operation of the offshore pipeline is being progressed by Northern Endurance Partnership.

1.1.5 Economic viability of power with Carbon Capture, Usage and Storage ('CCUS') has been demonstrated through the 'System Value to the UK Power Market of Carbon Capture and Storage' report published by NZT in June 2020. The analysis estimated that inclusion of power with CCUS in the UK market could reduce the total UK system cost of reaching net zero by 2050 by £19bn versus a system without power with CCUS. Specific project terms will be negotiated following a successful application in line with the Department of Business, Energy and Industrial Strategy ('BEIS') cluster selection process and based on the Dispatchable Power Agreement as described by BEIS in its report 'An update on business models for Carbon Capture, usage and Storage' published in December 2020.

1.1.6 It is likely that the onshore and offshore CO_2 transport from the Site will be in a 'dense phase' and that the pipeline would therefore be considered to be a Major Accident Hazard Pipeline. It is considered that the risks of any dense phase carbon pipeline can be appropriately mitigated through the routing and design of the pipeline, and that potential significant effects of accident scenarios can be mitigated at the detailed design phase of the CO_2 transport network.

1.1.7 It is envisaged that the Proposed Development will come under the hazardous substance consenting regime and may trigger the need for lower tier Control of Major Accident Hazard ('COMAH') licensing. This will be determined at the detailed design stage.

1.1.8 In conclusion, the Proposed Development demonstrates and commits to including a carbon capture plant integrated to a gas-fired power generation plant in one facility from the outset and is therefore CCR compliant. In addition, the project compliments

renewable energy by being dispatchable and helps to decarbonise the electricity grid when operating by reducing the need for unabated power supplies.

2.0 INTRODUCTION

2.1 Overview

2.1.1 This Carbon Capture Readiness (CCR) Assessment (Document Ref. 5.7) 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:

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 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 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 2.2.5 The CO2 gathering network, CO2 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

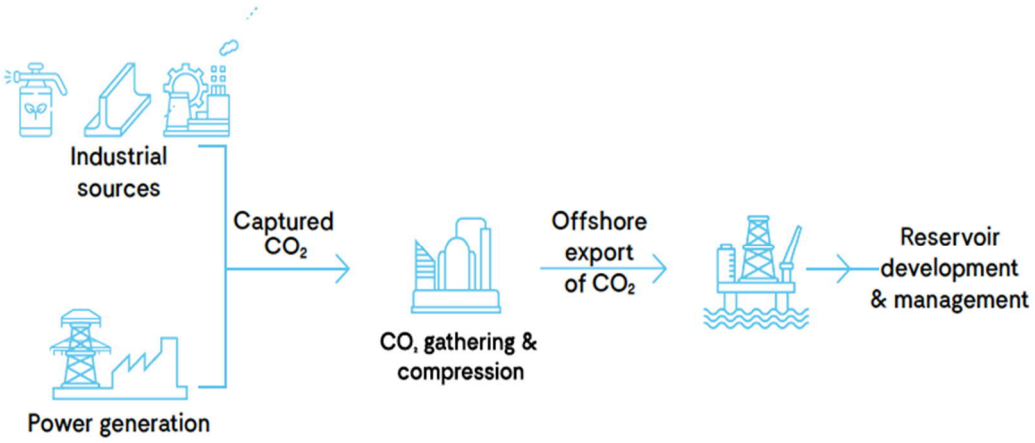
gathering network and the onshore section of the CO_2 export pipeline (these are all within the scope of the DCO Application).

2.2.6 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.

2.2.7 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



2.2.8 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.

2.2.9 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.

2.3 The Site

2.3.1 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.

2.3.2 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.

2.3.3 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.

2.3.4 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).

2.4 The Proposed Development

2.4.1 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.

2.4.2 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.

2.4.3 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.

2.4.4 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.

2.4.5 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).

2.5 The Purpose and Structure of this Document

2.5.1 The purpose of this document is to demonstrate that it is technically feasible to incorporate CCUS technology within Proposed Development and therefore that the Proposed Development is ‘Carbon Capture Ready’ without any additional works (‘CCR’).

2.5.2 Given that the main purpose of the Proposed Development is to be the UK’s first full chain CCUS project incorporating power (a gas-fired power station) and an industrial network, it has specifically been designed and sized to include CCUS technology from the outset. Nevertheless, CCR needs to be demonstrable for all new combustion plant with a generating capacity at or over 300MWe and of a type covered by the EU

Industrial Emissions Directive[1], as set out in the Carbon Capture Readiness (Electricity Generating Stations) Regulations 2013, Section 4.7 of the 'Overarching National Policy Statement for Energy (EN-1)'[2], and Chapter 3 of Part 1 of the Energy Act 2008 and other EU-derived domestic legislation which transposed Directive 2009/31/EC on the geological storage of carbon dioxide in relation to England and Wales[3].

2.5.3 This document has been produced in accordance with the requirements of the Department of Energy and Climate Change (DECC) November 2009 carbon capture guidance 'Carbon Capture Readiness (CCR) – A Guidance Note for Section 36 Electricity Act 1989 consent applications.'

2.5.4 The document is structured as follows:

- Section 1: Executive Summary;
- Section 2: Introduction;
- Section 3: Legislative Background;
- Section 4: Description of the Proposed Development;
- Sections 5 and 6: Technical and Economic Feasibility Assessments;
- Section 7: Health and Safety Assessment; and
- Section 8: Discussion of the proposed periodic review of this CCR Assessment.

2.6 Approach to demonstrating CCR compliance

2.6.1 The following approach has been used for this CCR Assessment:

- A gas-fired power station with an 'unabated' (no CCUS) net power output of between 750 and 860MWe is proposed by the Applicants. The power station is expected to be able to supply electricity for approximately 8,000 hours per year and consists of one CCGT unit. In practice the power station is likely to run in dispatchable mode for much of the time, to support the use of intermittent renewables supplying electricity to the UK transmission system. For this CCR Assessment, the largest H-Class gas turbine technology currently available has been used to generate the approximate values for the various plant requirements.
- Based on a high-level conceptual design for the Proposed Development, a preferred CC technology has been identified, based on thermal and process modelling, and current carbon capture technology availability;

[1] To be interpreted as per Paragraph 6 of Schedule 1A to the Environmental Permitting (England and Wales) (Amendment) (EU Exit) Regulations 2019
[2] Whilst the National Policy Statements refer to the Large Combustion Plant Directive, this Directive was superseded by Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive).
[3] Change of reference to the EU Directive on the Geological Storage of Carbon Dioxide, as prescribed by Paragraph 6(29)(d) of Schedule 1A to Schedule 1A to the Environmental Permitting (England and Wales) (Amendment) (EU Exit) Regulations 2019

- The sizing and utility demand of the main carbon capture plant required has been established using thermal and process modelling. Site layouts have been prepared to show that the equipment would fit into the land currently identified to be used for CC purposes;
- Geological storage sites with storage capacities capable of accepting the carbon output from the Proposed Development over its design life were identified, utilising a study from the (former) Department of Trade and Industry (DTI)[4] (the 'DTI Study'), However, the Endurance store has been designated for use by the Proposed Development through the Northern Endurance Partnership (NEP) and this is the store that has been considered in this Assessment;
- Potential routes to transport the captured CO_2 from the Site to the Endurance store have been identified by the NEP; a pipeline route is being separately consented to support the Proposed Development;
- A statement is provided to the economic viability of the CCS plant, as prepared under the proposed business model for the project between the Applicants and the government-owned Low Carbon Contracts Company, recognizing that commercial discussions are ongoing between the Applicants and Government on the financing of the Proposed Development; and
- A high-level assessment of the Health and Safety issues associated with the CC plant was undertaken.

[4] Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK, 2006

3.0 LEGISLATIVE BACKGROUND

3.1 The Carbon Capture Readiness (Electricity Generating Stations) Regulations 2013

3.1.1 The Carbon Capture Readiness (Electricity Generating Stations) Regulations 2013 (the CCR Regulations) came into force on 25 November 2013. These regulations were made in transposition of Article 36 of the EU Industrial Emissions Directive (see box below).

EU DIRECTIVE
Some types of EU legislation, such as Directives, are indirectly applicable, meaning domestic legislation is required by EU member states to become law. In the UK this was often achieved via Statutory Instruments rather than passing primary legislation. The UK government has made the EU Withdrawal Act 2018 which maintains established environmental principles and ensures that existing EU environmental law will continue to have effect in UK law. The European Union (EU) published the Directive on the Geological Storage of Carbon Dioxide (Directive 2009/31/EC) ("the Directive") in the Official Journal of the European Union on 5 June 2009, with the Directive coming into force on 25 June 2009. Article 21 of the Directive requires that necessary measures are taken to allow access to transport networks and storage sites for geological storage of produced and captured CO_2. Article 33 of the Directive requires an amendment to Directive 2001/80/EC (commonly known as the Large Combustion Plants Directive ("LCP")), via Article 9a, such that operators of all combustion plants with an electrical output of 300 MW or more (and for which the construction / operating license was granted after the date of the Directive) are required to carry out a study to assess: • Whether suitable storage sites for CO_2 are available; • Whether transport facilities to transport CO_2 are technically and economically feasible; and • Whether it is technically and economically feasible to retrofit for the capture of CO_2 emitted from the power station; This may be known as a 'CCR Feasibility Study', to be determined by the competent authority. The Industrial Emissions Directive ("IED", Directive 2010/75/EU) entered into force in January 2011 and was to be transposed into national legislation by Member States by January 2013. The IED brought together seven existing directives, including the LCP. Article 36 of the IED replicates the requirements of Article 9a of Directive 2001/80/EC (LCP) and the above requirement for a CCR Feasibility Study.

3.1.2 The CCR Regulations provide that no order for development consent (in England and Wales) may be made in relation to a combustion plant with a capacity at or over 300MWe unless the relevant authority has determined (on the basis of an assessment carried out by the applicant) whether it is technically and economically feasible to retrofit the equipment necessary to capture the carbon dioxide that would otherwise be emitted from the plant, and to transport such carbon dioxide from the site to an appropriate long term geological store.

3.1.3 The CCR Regulations summarise the need for a 'CCR Feasibility Study' and state (at Regulation 2(1)) that a: ""CCR Assessment", in relation to a combustion plant, means an assessment as to whether the CCR Conditions are met in relation to that plant."

3.1.4 In terms of the 'CCR Conditions', CCR Regulation 2(2) states that:

> *"for the purposes of these Regulations, the CCR Conditions are met in relation to a combustion plant, if, in respect of all of its expected emissions of CO_2 –*

a) *Suitable storage sites are available;*

b) *It is technically and economically feasible to retrofit the plant with the equipment necessary to capture that CO_2; and*

c) *It is technically and economically feasible to transport such captured CO_2 to the storage sites referred to in sub-paragraph (a)"*

3.1.5 Furthermore, CCR Regulation 3(1) states that:

> *"The Secretary of State must not make a relevant consent order unless the Secretary of State has determined whether the CCR Conditions are met in relation to the combustion plant to which the consent order relates".*

3.1.6 CCR Regulation 3(3) states that:

> *"If the Secretary of State –*
>
> a) *determines that the CCR Conditions are met in relation to a combustion plant; and*
>
> b) *decides to make a relevant consent order in respect of that plant,*
>
> *the Secretary of State must include a requirement in the relevant consent order that suitable space is set aside for the equipment necessary to capture and compress all of the CO_2 that would otherwise be emitted from the plant."*

3.2 Planning Policy

3.2.1 Under Section 104(3) of the Planning Act 2008, Development Consent Order ('DCO') applications for NSIPs are required to be determined by the relevant Secretary of State ('SoS') in accordance with policy set out in the relevant National Policy Statements (NPS), subject to the exceptions set out in that Section. As stated in the Overarching National Policy Statement For Energy (EN-1):

> *"All applications for new combustion plant which are of generating capacity at or over 300MW and of a type covered by the EU's Large Combustion Plant Directive (LCPD) should demonstrate that the plant is 'Carbon Capture Ready' (CCR) before consent may be given. The [Secretary of State] must not grant consent unless this is the case."*

3.2.2 In this regard, NPS EN-1 also states that:

> *"In order to assure the [Secretary of State] that a proposed development is CCR, applicants will need to demonstrate that their proposal complies with guidance issued ... in November 2009 or any successor to it."*

3.2.3 The guidance referred to above is discussed in the following section.

3.3 CCR Guidance

3.3.1 The Department of Energy and Climate Change ('DECC') (now Department of Business, Energy and Industrial Strategy) published guidance (the 'CCR Guidance') on

CCR in November 2009[5]. The guidance makes it clear that, under the Government's CCR Policy, as part of their DCO application, applicants are required to:

- Demonstrate that sufficient space is available on or near the site to accommodate carbon capture equipment in the future;
- Undertake an assessment into the technical feasibility of retrofitting CCS equipment;
- Propose a suitable area of deep geological storage offshore for the storage of captured CO_2;
- Undertake an assessment into the technical feasibility of transporting the captured CO_2 to the proposed storage area;
- Assess the likelihood that it will be economically feasible within the power station's lifetime to link it to a full CCS chain, covering retrofitting of capture equipment, transport and storage; and
- If necessary, apply for and obtain Hazardous Substance Consent ('HSC') when applying for consent.

3.4 Assessment Methodology

3.4.1 This CCR Assessment has therefore been prepared to fulfil the requirements of the CCR Guidance as set out below:

- Allocation of Space for CC Equipment: An assessment of appropriate space set aside to accommodate the CC Plant is provided in Section 5.1 of this Assessment.
- Technical Assessment of Feasibility of CC Equipment Retrofit: Annex C of the CCR Guidance provides a detailed advisory checklist of the information to be included in a CCR Feasibility Study Report on the technical assessment of the feasibility of retrofitting CCS equipment for a new natural gas combined cycle power station using post-combustion carbon capture. It is noted that a specific checklist for the technology intended for the Proposed Development is not provided by the CCR Guidance, however, for the purposes of this CCR Assessment, Section 5.2 deals with the technical response to the requirements of Annex C, as being of most relevance to the Proposed Development.
- Technical Feasibility of Storage of Captured CO_2: In accordance with the guidance, at least two fields or aquifers with an appropriate CO_2 storage capacity, which have been listed in either the "valid" or "realistic" categories in the DTI Study, should be proposed as suitable CO_2 storage locations for the Proposed Development. Such sites are identified in Section 5.3.

[5] Department of Energy and Climate Change (DECC) (November 2009) 'Carbon Capture Readiness (CCR) – A Guidance Note for Section 36 Electricity Act 1989 consent applications'

- Technical Feasibility of Transport of Captured CO_2: The CCR Guidance states that the feasibility of any proposed site for a new combustion plant will be influenced by the availability of transport routes to the proposed storage area. The technical feasibility of transporting the captured CO_2 to the storage area proposed for the Proposed Development (Endurance) is assessed in Section 5.4. Whilst it is recognised that the CCR Guidance states that an applicant may not assume, at the CCR stage, that they will be able to outsource onshore CO_2 transport and storage arrangements (such as to a cluster network), the Applicants consider that the project scope, coupled with the commitment from Government to supporting the establishment of CCUS in four industrial clusters including Teesside (BEIS, Energy White Paper, December 2020) demonstrates that such links are justified within this DCO application.
- Economic Assessment of the Feasibility of CCS: The CCR Guidance states that the main aim of the economic assessment is to provide an indication of the future likelihood of a retrofit of CCS equipment, CO_2 transport and storage of CO_2 being economically feasible at some stage during the proposed combustion plant's operational lifetime. This is developed in Section 6, recognising the position of the Proposed Development, which is to have CCUS from day one (not retrofitted).
- Health and Safety Analysis: An analysis of Health and Safety issues associated with the Capture plant including consideration of whether a HSC may be required for the plant for the Proposed Development is provided in Section 7.

4.0 DESCRIPTION OF THE PROPOSED DEVELOPMENT

4.1 Location

4.1.1 The Site boundary of the Proposed Development covers a wide area located within the administrative boundaries of Redcar and Cleveland Borough Council (RCBC) to the south of the River Tees (South Bank and Dormanstown Wards) and in Stockton-on-Tees Borough Council (STBC) to the north of the River Tees (Billingham South Ward). A portion of the Site to the south of the Tees also lies within the Teesworks area.

4.1.2 The area surrounding the Site is characterised by industrial land uses. The nearest main settlements are the towns of Redcar, Eston and Middlesbrough. There is a concentration of industrial land uses around the mouth of the River Tees. The power station and CC plant site is remote from residential receptors, although there are areas of public/private amenity close to its northern and eastern boundary. The nearest residential settlement is the town of Redcar (approximately 1.8 km east) including the suburb of Dormanstown (approximately 1.4 km to the south east). The village of Warrenby is approximately 0.7 km to the south east and consists of the Warrenby Industrial Estate and a single residential property (Marsh House Farm)

4.1.3 To the north of the Site lie the coastal areas of South Gare and Coatham Sands, that are local environmental and community assets and are incorporated in the Teesmouth and Cleveland Coast SPA/Ramsar and the Teesmouth and Cleveland Coast SSSI.

4.1.4 The Teesside Wind Farm is located off-shore approximately 2.4 km north east of the Site and is oriented north-west to south-east, parallel with the shoreline at Coatham Sands.

4.2 Combustion Plant Description

4.2.1 The CCR Assessment addresses the power station and its readiness to address its own carbon dioxide emissions. The CCR Assessment does not consider the capture of emissions from industrial users that would be collected by the proposed CO_2 Gathering Network. Current BEIS guidance is based upon unabated plant capacity and therefore the largest H-Class gas turbine technology currently available has been used as the basis for approximate values for the various plant requirements.

4.2.2 The power station is likely to initially provide baseload electrical generation and assumed to operate for approximately 8,000 hours annually for the purposes of this CCR Assessment.

4.2.3 The power station will be designed to operate for up to 25 years, after which ongoing operation and market conditions will be reviewed. If it is not appropriate to continue operating after that time, it will be decommissioned.

4.3 Carbon Capture and Storage Technology

4.3.1 The Proposed Development is to be the UK's first full chain CCUS project incorporating power (a gas-fired power station) and an industrial network. The

current Emissions Performance Standard ('EPS') set by the UK Government for new electricity generating stations is set at a level (450 g CO_2/kWh)[6]. This EPS is proposed by UK Government to be maintained for consented plants until 2045.

4.3.2 There are three alternative carbon capture technologies available, namely:

- Pre-combustion carbon capture;
- Post combustion carbon capture; and
- Oxy-combustion carbon capture.

4.3.3 This CCR Assessment has focused on the use of post-combustion carbon capture, as this is the chosen technology included as part of the Proposed Development. No further discussion is presented in this Assessment on the alternative technologies as that decision has been made.

4.3.4 The feasibility of CCS for the Proposed Development has therefore been assessed on the basis of the best currently available post-combustion carbon capture technology which, for carbon capture from combustion flue gases, would use an amine-based solution as the absorption medium.

4.4 Process Design Basis

4.4.1 The conceptual design in this Assessment has been based upon the post-combustion modelling developed using industry standard process modelling software, using heat cycle data from a combustion plant with similar configuration. 95% CO_2 capture efficiency has been used as the basis for the equipment design in the concept design plot layouts and in this CCR Assessment.

4.4.2 This Assessment has been developed for a single carbon capture train processing the mass flow rate of flue gas from the largest H-Class gas turbine technology currently available.

4.4.3 Potential operational issues related to implementation of flexible CCS cycles can be achieved using one of the techniques discussed in the BEIS Study published in 2020[7].

[6] Energy Act 2013 (c.32), Part 2 Electricity Market Reform, Chapter 8 – Emissions performance standard
[7] Start-up and Shut-down times of power CCUS facilities, AECOM study for the Department of Business, Energy & Industrial Strategy, May 2020

5.0 TECHNICAL ASSESSMENT

5.1 Space

5.1.1 An indicative layout of the Site, including the power station and capture plant, has been developed as part of the initial engineering design work conducted.

5.1.2 The carbon capture plant incorporates all the major equipment items described in following subsection (Section 5.2) with appropriate areas for ductwork, piping, access and maintenance available.

5.1.3 DCO Drawing shows the indicative Site layout with the areas of the power station, CCS plant and overall Site to show that it meets the requirements outlined for CCR purposes.

Footprint Comparison

5.1.4 The CCR Guidance[8]; provides an indicative CCR space requirement based on a 500MWe (net) combustion plant. For a CCGT power station with post-combustion carbon capture, the indicative CCR space requirement was initially provided at 3.75ha for 500MWe, which equates to 75m^2/MW.

5.1.5 However, following the publication of the CCR Guidance, the indicative CCR space requirement was reviewed by Imperial College, London. The Imperial College review[9] concluded that the footprint estimates presented in the CCR Guidance were overly conservative and recommended the reduction of the indicative CCR space requirement for a CCGT power station with post-combustion capture by 36%. Therefore, the corrected indicative CCR space requirement is 2.4ha for 500MWe. This equates to 48m^2/MW.

5.1.6 In addition, the review by Imperial College further detailed additional scope for a reduction in the indicative CCS space requirement by 50% to 1.875ha (including the reduction of 36%) considering technology advances and layout optimisation. This equates to 37.5m^2/MW. However, the Imperial College review also states that such a reduction can only be justified following a detailed engineering design rather than only a linear scaling of this value.

5.1.7 The allocated carbon capture site area for the Proposed Development, of circa 51,685m^2, corresponds to 60.0m^2/MW when considering the unabated net power output of the power station is 860MWe. This figure is greater than the corrected CCR minimum space requirement and therefore meets the CCR Guidance requirements. This is due to a combination of reasons:

[8] Carbon Capture Readiness (CCR) – A guidance note for Section 36 Electricity Act 1989 consent application, Department of Energy & Climate Change, November 2009
[9] Assessment of the validity of —Approximate minimum land footprint for some types of CO2 capture plant‖ provided as a guide to the Environment Agency assessment of Carbon Capture Readiness in DECC's CCR Guide for Applications under Section 36 of the Electricity Act 1989, Imperial College

- the conceptual design has considered 95% capture rates that lead to larger equipment sizes;
- the conceptual design carried out a full constructability review to assess equipment maintenance and laydown needs which has resulted in larger areas being required in between equipment items, partly to account for underground services (pipes and cables) as well as large electrical substations;
- The conceptual design has carried out safety assessments for layout of equipment and this has led to different spacing conclusions to the previous studies.

5.1.8 Proposed Development is a 'First Of A Kind' CCS project on a gas-fired generating station and space optimization progressively occurs as the technology matures through implementation on multiple sites ("Nth Of A Kind").

5.1.9 The Proposed Development has identified and secured a land option on a conservative space allocation of over 500,000 m^2. This land is available for laydown if required.

5.2 Indicative Process Description

Introduction

5.2.1 The Proposed Development has been assessed based on a nominal unabated capacity of 860MWe for the power station, against the criteria presented in Annex C of the CCR Guidance[10]. as follows:

Power Plant Location

5.2.2 The exit point for the captured CO_2 from the Site will be located within the northern part of the Site and will leave it via the high-pressure CO_2 compressor station directly to the proposed offshore geological storage site beneath the North Sea.

5.2.3 Pipe racks will be used to transfer the compressed and dehydrated CO_2 to the defined exit point. Based on initial studies, the preliminary size of the CO_2 pipe connecting the Capture plant and the HP CO_2 compressor station is estimated to be 16" (406mm) in diameter.

5.2.4 Further information on the transport and storage of captured CO_2 off-site is provided in Sections 5.3 and 5.4.

Space Requirements

5.2.5 The indicative layout of the Site, as discussed in Section 5.1, demonstrates that space has been allocated for the following:

[10] Carbon Capture Readiness (CCR) – A guidance note for Section 36 Electricity Act 1989 consent application, Department of Energy & Climate Change, November 2009

- CO_2 capture equipment, including any flue gas pre-treatment, and CO_2 drying and compression;
- Space for routing flue gas duct to the CO_2 capture equipment;
- Any extensions or additions to the balance of plant on the gas turbine units where necessary to cater for the additional requirements of the capture equipment;
- Maintenance and operational vehicle movement;
- Space for storage and handling of amines and handling of CO_2, including space for infrastructure to transport CO_2 to the plant boundary; and
- Major plant deliveries and access around the Site.

5.2.6 In terms of the land required for laydown during construction of the Capture plant, the additional land within the Proposed Development Site boundary to the immediate south would be used. This would be developed further in a detailed Construction Environmental Management Plan as part of the EPC Contractor's procurement and site management responsibility. There is sufficient land availability within the Site to be used for laydown.

Gas Turbine Operation

5.2.7 The design for the CC plant accounts for any backpressure in the flue gas flow path (primarily in the absorbers, direct contact cooler and dampers).

5.2.8 Based on the flue gas flow rate of around 1,022kg/s with a nominal pressure rise of 140mbar a power demand of approximately 16.4MWe, has been included in the carbon capture plant power requirement, based on a generic design.

Flue Gas System

5.2.9 The flue gas system has been developed based on the concept and pre-FEED design of the for CCGT post-combustion capture and includes similar design elements. The following flue gas system is proposed for the carbon capture plant.

Isolation and Bypass Dampers

- The flue gas exiting the prime movers is routed to a bypass or diverter damper, from where it will be directed to the Capture Plant for normal operations. It may be directed to a HRSG stack (e.g. during start up or fault conditions).

Flue Gas Cooling

- The absorption process requires a blower to overcome frictional losses in the ducting and capture plant equipment plus a flue gas cooler to lower the flue gas temperature to enhance the CO_2 chemical absorption and to minimise amine degradation. The blower may be upstream of the DCC or downstream of the DCC depending upon vendor design.
- The flue gas is routed to a direct contact cooler ('DCC'), which quenches the flue gas to an acceptable temperature for absorption. A small slipstream of the circulating cooling water is routed through the DCC Water Filter to remove

particulate build-up. A portion of this particulate free stream is returned to the DCC; the other portion is directed to a wastewater treatment plant. Cool, saturated, flue gas from the DCC is extracted and then passes to the Absorber.

CO_2 Absorber

- The cooled flue gas from the DCC is fed to the bottom of the counter current Absorber where CO_2 in the flue gas is absorbed by the solvent. Flue gas enters near the bottom of the Absorber and flows upward through packed beds. CO_2 reacts chemically with the solvent and is absorbed into the bulk solution. Rich solvent leaves the bottom of the Absorber and is transferred to the Stripper by the Rich Solvent Pump.
- Stripped flue gas, trace amounts of vaporized amine-based solution and water travels through a chimney tray and enters the top packed bed. This packed bed is the wash section of the column, where wash water is used to recover the vaporized amine and water. A Wash Water Circulating Pump circulates the wash water between the Absorber and Wash Water Cooler.
- Treated (CO_2 Lean) flue gas is vented to the atmosphere via the stack on top of each Absorber. An early evaluation of the potential visible plumes has been undertaken and a full assessment will be evaluated at the detailed design stage and if required appropriate mitigation employed.

CO_2 Stripper

- Rich solvent leaves the bottom of the Absorber and is routed to the rich to lean amine solution cross heat exchanger which increases the efficiency of the process by heating the rich amine to >100°C using the heat in the lean amine stream from the Stripper. The preheated rich amine enters the Stripper below the wash section of the column through a liquid distributor and flows down through the packed beds counter-current to the vapour from the Reboiler releasing the absorbed CO_2. The lean amine from the bottom of the Stripper is transferred to the rich to lean solution cross heat exchanger, where it is cooled against the rich amine from the absorber train.

5.2.10 Stripper Overhead Condenser

- The overhead vapour from the Stripper is cooled in the overhead Condenser, condensing some of the water content. The two-phase enters the separation drum (separating the product gas which is routed to the CO_2 Compression / Dehydration unit).

5.2.11 Amine Reclaimer

- The amine-based solution degrades in the presence of different elements that lead to amine oxidation to salts, thus a purification stage is necessary to prevent the accumulation of such heat stable salts. The generic design assumes that the reclaimer is a kettle-type reboiler where this purification process takes place. There is a feed of steam, water and sodium hydroxide to feed the reactions and processes required to allow for the recovery of part of the degraded amine-based

solvent. The reclaimer is expected to operate on an intermittent basis when the content of dissolved salts exceeds a predefined value.

CO_2 Compressor

5.2.12 The wet CO_2 from the Stripper Reflux Drum is routed to an intercooled LP CO_2 Compressor. The captured CO_2 is compressed to meet the delivery pressure required for the onshore gathering network entry specification.

Dehydration Unit

- A dehydration package is included to reduce the water content in the CO_2 stream to 50ppm (wt.) to assure that condensation in the CO_2 pipeline does not occur. At this concentration, the dew point is at approximately -46°C, which makes condensation unlikely.

Steam Cycle

5.2.13 A supply of the order of 109kg/s of low pressure steam (244MW heat) is assumed for the amine regeneration process within the generic design.

Cooling System

5.2.14 The amine-based capture process has a considerable cooling duty, which is estimated at 360-390MWth. The carbon capture plant will use mechanical draft cooling towers to address main cooling demands within the CCS process which comprise:

- Flue gas DCC cooler;
- Lean solution to absorber cooler;
- Stripper overhead cooler; and
- CO_2 compression intercoolers.

5.2.15 Space has been allocated for the cooling towers needed to meet both the cooling demand of the CCGT and CC plant.

Compressed Air system

5.2.16 Space has been allocated for the supply of instrument air and general service air to the CC plant.

Water Treatment

Raw Water

- The CC plant will have a calculated make-up raw water demand of approximately 676 t/h based on a generic design. This water shall make up for evaporative losses within the mechanical draft cooling towers as well as cooling water blowdown.
- The increment on raw water abstracted by the site to supply the CC plant in addition to the CCGT operating alone has been included in the water demand assessment. The level of water treatment necessary for the CC plant, including

filtration and chemical dosing, will depend on the water quality at the abstraction site.

Demineralised Water

- At present this is assumed to be approximately 75.7 t/hr based on conservative assumptions from the generic design. Should demineralised water quality be required, there is enough space in the proposed layout to include a dedicated water treatment plant.

Waste Water

- The detailed design of the PCC including the carbon capture plant will include appropriate surface water drainage systems including oil interceptors as necessary, consistent with surface water drainage systems for power stations and chemical plants in general. Space provision for site drainage e.g. surface water and process water drains has been included in the footprint allocation for the capture plant.
- Waste water will be generated from the cooling of the flue gas resulting in partial condensation of water vapour within the direct contact cooler. The volume of wastewater generated will vary with ambient conditions but is not likely to exceed 250 t/h. The waste water treatment requirements identified below:

Table 5.1: Average Estimated Waste Water Output

PARAMETER	VALUE
Drain Water from CO_2 compression CC plant / kg/s	0.8
DCC blowdown / kg/s	30.2
Cooling Tower Blowdown / kg/s	37.5

5.2.17 The waste water drain will be relatively clean although may have a slightly elevated pH. It is envisaged it will be routed to an effluent treatment plant prior to discharge.

Hazardous Waste Streams

- The standard amine-based process includes a reclaimer for recovery of amine-based solution and removal of degradation products, solids and salts formed in the carbon capture process. This operation will generate a low volume effluent stream which will require treatment offsite via a licensed waste contractor.
- Activated carbon is also consumed in the active carbon filters for the circulating amine-based solution. A slip-stream is constantly directed to a mechanical prefilter and then to the active carbon filter for removal of solids delaying the reclaiming activity. It is estimated that 0.08kg of carbon per tonne of captured CO_2 shall be consumed. This solid waste material shall be disposed of for off-site regeneration/recycling via a licensed waste contractor.

Electrical

5.2.18 In addition to the utilities described previously, the CO_2 capture system will require the following utilities.

- Electrical Power Distribution System; and
- Fire Protection and Monitoring System.

5.2.19 The total power requirement of the CC plant is approximately 50.1MWe. Further detail of individual users is presented in Table 5 2.

Table 5.2: CC Estimated Plant Electrical Power Consumption

CC EQUIPMENT ITEMS	ESTIMATED ELECTRICAL CONSUMPTION (MWe)
CO_2 Compressor	19.1
Solvent Recirculation Pumps	2.0
Booster Fan	16.4
Cooling Tower Fan Motors	1.4
Cooling Water Circulation Pumps	8.3
DCC Water Pump	1.4
Miscellaneous	1.6
Total	50.1

5.2.20 It is currently understood that the electrical demand of the CC plant is taken directly from the output of the power plant, reducing the export capacity to National Grid accordingly.

5.3 CO_2 Storage

5.3.1 The maximum theoretical volume of CO_2 anticipated to be captured during the lifetime of the Proposed Development is 50.7 million tonnes (2.0 million tonnes per year for a 25-year period for the power station).

5.3.2 The UK's major potential sites for the long-term geological storage of CO_2 are offshore depleted hydrocarbon (oil and gas) fields and offshore saline water-bearing reservoir rocks / aquifers.

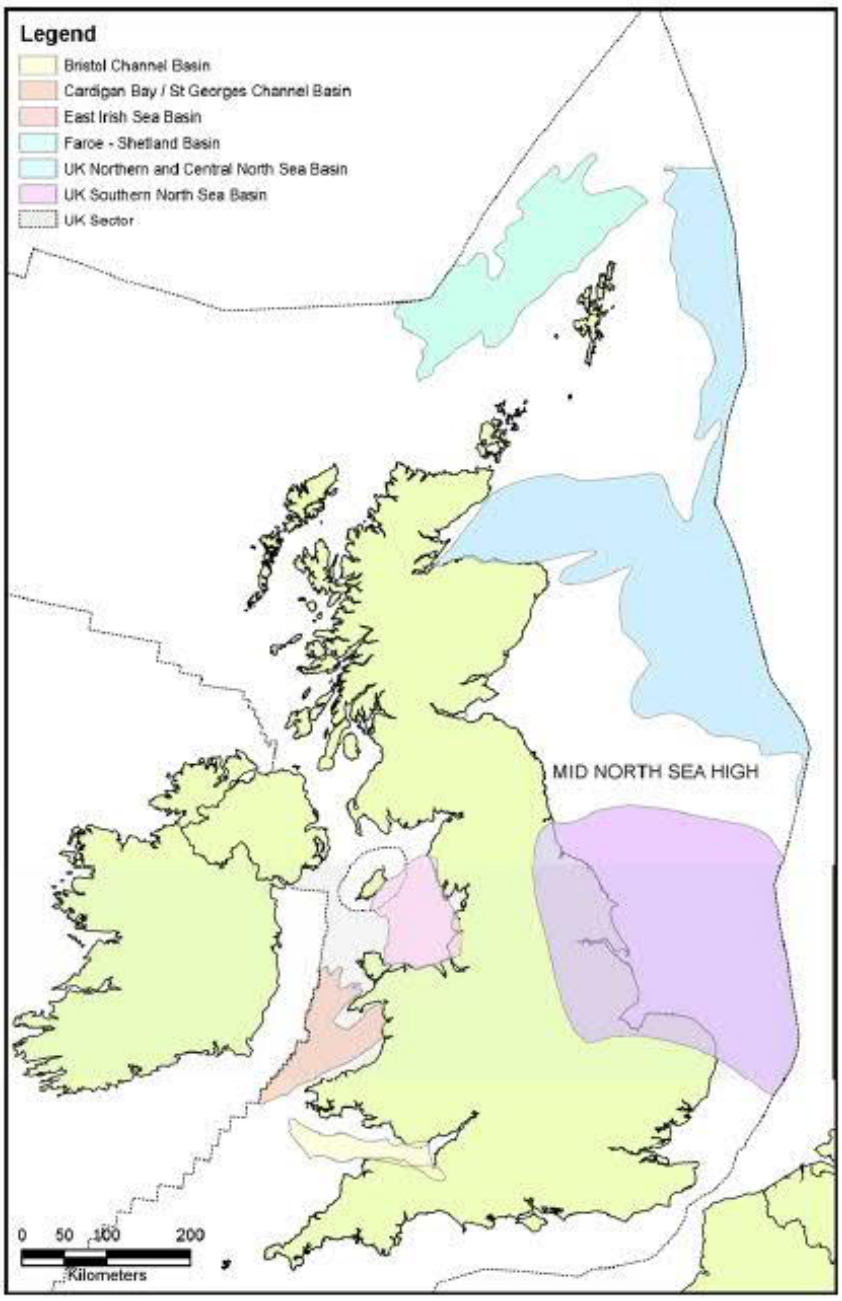
5.3.3 Oil and gas fields and saline aquifers are regarded as prime potential sites for CO_2 storage for the following reasons:

- they have a proven seal which has retained buoyant fluids, in many cases for millions of years; and
- often a large body of knowledge and data regarding their geological and engineering characteristics has been acquired during the exploration and production phases of development.

5.3.4 As shown in Figure 5.1 most of the UK's large offshore oil fields are mainly in the Northern and Central North Sea Basin. The UK's offshore gas fields occur mainly in

two areas: the Southern North Sea (SNS) Basin and the East Irish Sea Basin. The CCR Guidance suggests that the simplest and most appropriate means of demonstrating there are "no known barriers" to CO_2 storage is by delineating on a map a suitable storage area in either the North Sea or Irish Sea (Morecambe Bay). Within this delineated area, there should be at least two fields or aquifers, with an appropriate CO_2 storage capacity, which have been listed in either the "valid" or "realistic" categories in the DTI's 2006 Study of UK Storage Capacity 'Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK', October 2006 (DTI Study), which is provided in Annex 1D of the CCR Guidance.

Figure 5.1: Major sedimentary basins on the UK Continental Shelf[11]



5.3.5 The Proposed Development is located in Redcar, Teesside and therefore the nearest hydrocarbon fields and saline aquifers are located in the SNS Basin.

[11] British Geological Survey (BGS) (October 2006) Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK (DTI/Pub URN 06/2027), prepared for the UK Department of Trade and Industry, now the Department of Business Enterprise and Regulatory Reform.)

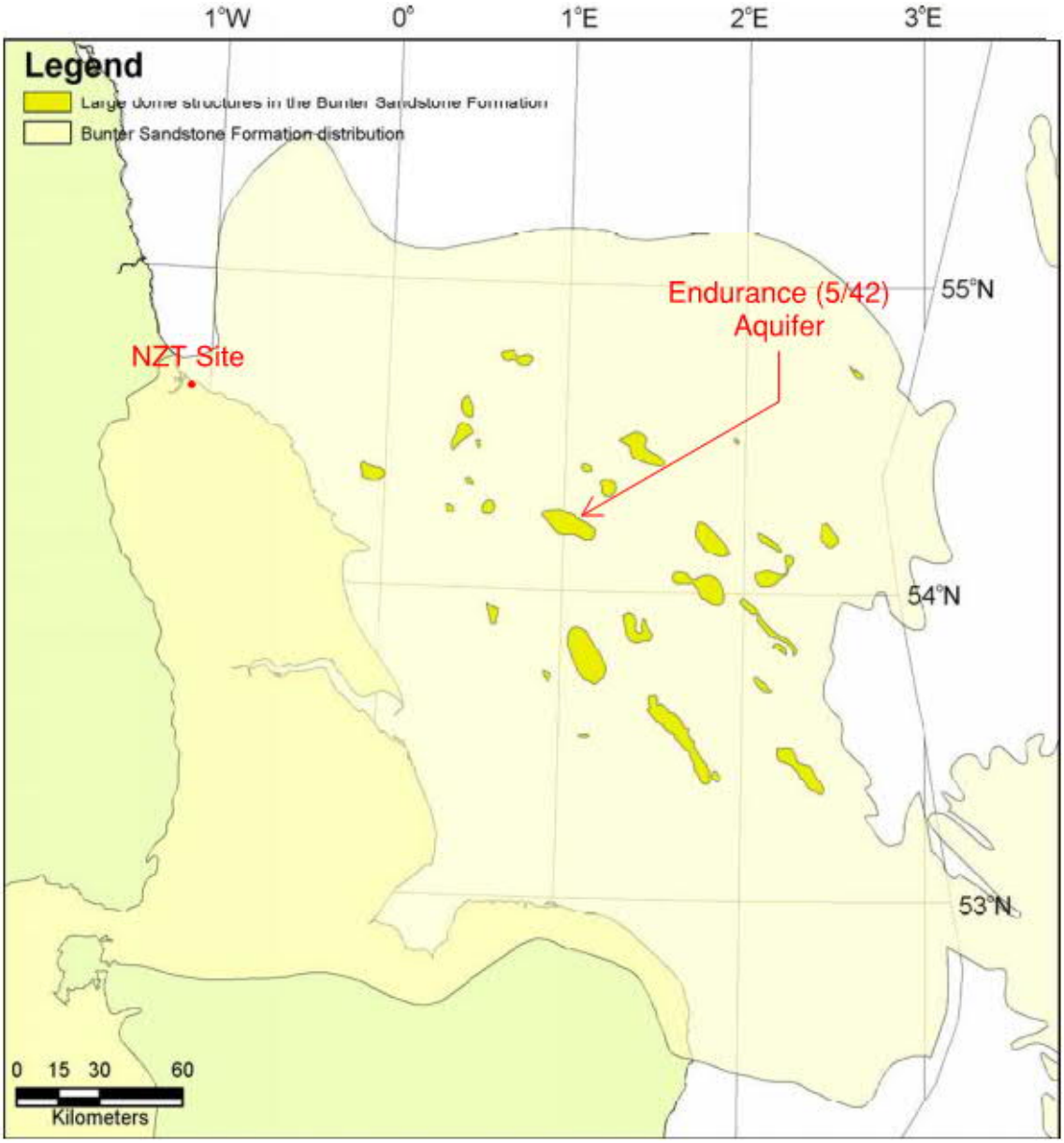
5.3.6 The storage location currently proposed for the Proposed Development is the Endurance saline aquifer within the Bunter Sandstone Formation in the SNS basin (formally identified as 5/42). The estimated total storage capacity of this storage location is approximately 2,700 million tonnes based on the examination as part of the Field Development Report for the White Rose CCS project[12].

5.3.7 Based on the total CO_2 storage requirements of the Site (50.7 million tonnes), the Site will use approximately 2.0% of the overall capacity of the Endurance Saline Aquifer.

5.3.8 The location of the Endurance Saline Aquifer is illustrated on Figure 5.2.

[12] White Rose Project - K43: Field Development Report (February 2016), prepared for the Department of Energy and Climate Change

Figure 5.2: Map of storage sites within the Bunter Sandstone Formation with the location of the Endurance Aquifer annotated[13]



5.3.9 In accordance with the DECC Guidance, the Bunter Sandstone Formation aquifer above is identified as having great potential as a CO_2 storage location in the DTI Study.

[13] (British Geological Survey (BGS) (October 2006) Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK (DTI/Pub URN 06/2027), prepared for the UK Department of Trade and Industry, now the Department of Business Enterprise and Regulatory Reform.)

5.3.10 Under the CCR Guidance, the storage assessment should be reviewed on an ongoing basis as part of the two-yearly Status Reports, with a view to incorporating developments in the updated design for the carbon capture plant. The Applicants are intending that the Proposed Development is to be the first user of the Endurance store therefore the ongoing review is not considered necessary in this case.

5.4 CO_2 Transport

Overall Route

5.4.1 There are various options available for transporting CO_2 from point of capture to final geological storage, including on and offshore transportation by pipeline and offshore transportation by pipeline or shipping.

5.4.2 It is intended that the CO_2 captured from the Proposed Development will be transported to the storage site via pipeline and a separate but related consent for the routing, construction and operation of the offshore pipeline is being progressed by NEP. Shipping is not considered viable for the transport of dense phase CO_2.

Predominantly Onshore Transport prior to transition

5.4.3 The selected option identified for the Proposed Development is a pipeline leaving the Site to the north, before heading south east towards the offshore storage sites in the Southern North Sea Basin. This is the preferred potential route which is focused on in this CCR Assessment.

5.4.4 Due to the Proposed Development's deliberate siting adjacent to the UK's eastern coastline, there will be a very short onshore pipeline before using an offshore pipeline heading towards the storage site.

5.4.5 Developing networks where clusters of power stations or other heavy industry adopting CCUS could use the same pipeline infrastructure is the most cost-effective solution for CCUS deployment compared to each installation building its own separate pipeline.

Predominantly Offshore Transport

5.4.6 The offshore pipeline would run south eastwards, heading directly towards the Endurance storage site as the proposed CO_2 storage location.

5.4.7 A sub-sea pipeline would typically be laid using specialist trenching and laying barges. Where the level of disruption to the environmentally sensitive areas (which is typically caused by trenching) is deemed to be unacceptable, other techniques such as thrust boring or directionally drilled boreholes may be feasible. Both boring methods avoid the need to disturb existing habitats. If these alternative boring techniques are not feasible it is envisaged that construction would be planned around breeding and migration seasons or consider species and habitat relocation. This would be established and considered at all stages of the outline design, EIA and subsequent detailed design of the offshore infrastructure.

5.4.8 Navigation of wind farm sites and associated cabling, dredging areas, existing pipeline infrastructures and disposal sites via the proposed route would be feasible.

Experience gained by Applicants in the laying of the natural gas and oil pipelines in the SNS Basin would provide the techniques and expertise required to accomplish this.

5.4.9 The routes of shipping lanes are not anticipated to be a significant barrier to this form of transport, because the pipeline would run along the seabed at a depth sufficient to allow ships free passage. The impacts of the offshore CO_2 pipeline would be minimised by keeping the route of the pipeline a sufficient distance away from the shore so as not to impact any designated coastline. It is therefore considered that a feasible route exists to remove the captured CO_2 from the Proposed Development to the storage sites identified.

6.0 ECONOMIC ASSESSMENT

6.1 Overview

6.1.1 Gas-fired power with carbon capture projects will operate under the Dispatchable Power Agreement[14] currently under development by BEIS. The proposed business model as set out in December 2020 includes an agreement between the Applicants and the government-owned Low Carbon Contracts Company (LCCC). The agreement will provide the Proposed Development with payments consisting of an availability and variable payment, with consumer subsidy supplementing revenue from wholesale and balancing markets and ancillary services.

6.1.2 Initial power CCS projects will be selected as part of the proposed CCUS Cluster Sequencing process[15] from October 2021, with bilateral negotiations to agree a Dispatchable Power Agreement. Final project economics will be subject to the outcome of these negotiations.

6.1.3 Economic viability of power with CCUS has been demonstrated through the 'System Value to the UK Power Market of Carbon Capture and Storage' report published by NZT in June 2020[16]. The analysis estimated that inclusion of power with CCUS in the UK market could reduce the total UK system cost of reaching net zero by 2050 by £19bn versus a system without power with CCUS. Specific project terms will be negotiated following a successful application in line with the BEIS cluster selection process and based on the Dispatchable Power Agreement as described by BEIS in its update on CCUS business models in December 2020[17].

[14] https://www.gov.uk/government/publications/carbon-capture-usage-and-storage-ccus-business-models
[15] https://www.gov.uk/government/consultations/carbon-capture-usage-and-storage-market-engagement-on-cluster-sequencing
[16] https://www.netzeroteesside.co.uk/wp-content/uploads/2020/06/System_Value_to_UK_Power_Market_of_Carbon_Capture_and_Storage_June20.pdf
[17] https://www.gov.uk/government/publications/carbon-capture-usage-and-storage-ccus-business-models

7.0 HEALTH AND SAFETY

7.1 Pipeline

7.1.1 It is likely that the onshore and offshore CO_2 transport from the Site will be in a 'dense phase', i.e. at a pressure greater than 73.9 bar.

7.1.2 Current UK experience of designing and operating CO_2 pipelines is limited and only some pipeline design codes include it as a relevant fluid within their scope. European Standards implemented in the UK as British Normative Standards (BS EN series) and supported by published documents (such as the British Standards PD series) provide a sound basis for the design of pipelines.

7.1.3 The CCR Guidance states that, until the Health and Safety requirements of pipelines conveying dense phase CO_2 have been considered in more depth, such pipelines should be considered as conveying 'dangerous fluids' under the Pipeline Safety Regulations 1996 (PSR), and 'dangerous substances' under the Control of Major Accident Hazards Regulations 1999 (as amended) (COMAH).

7.1.4 The 'Comparison of risks from carbon dioxide and natural gas pipelines' (Health and Safety Executive, 2009) concluded that a loss of containment event from a dense or supercritical phase CO_2 pipeline presents a similar level of risk to a release from a high-pressure natural gas pipeline. As such, designers of CO_2 pipelines should consider applying a similar fluid hazard categorisation (chosen from an established pipeline design code) to that applied to high pressure natural gas pipelines.

7.1.5 The pipeline would therefore be considered to be a Major Accident Hazard Pipeline (MAHP).

7.1.6 Therefore, when undertaking the detailed design of the pipeline route, it is recognised that the pipeline operator must pay due attention to the following potential requirements:

- Installation and frequency of emergency shut-down valves;
- The preparation of a Major Accident Hazard Prevention Policy (MAPP); and
- Ensuring the appropriate emergency procedures, organisation and arrangements are in place.

7.1.7 In addition, the Local Authority, which would be notified by the HSE of a MAHP, must prepare an Emergency Plan.

7.1.8 The Net Zero Teesside Project location has been selected to deliberately minimise the extent of on-shore high-pressure pipeline, and to maximise distance from sensitive receptors and other industrial operations so as to prevent the harmful consequences of any major accidents. In particular, the siting of the high-pressure CO_2 Compressor close to the shoreline minimises the risk of any high-pressure CO_2 release from impacting off-site receptors, particularly given the prevailing wind direction. The Hazard Assessment undertaken for the Project, based on HSE

modelling[18] has informed the consultation distances. Potential accident scenarios will be evaluated, and potentially significant effects will be mitigated; these would be undertaken at the detailed design phase of any CCUS transport network.

7.2 On-site

7.2.1 There is the potential for dense phase CO_2 to be present in pipework on site once it has been captured and compressed prior to offshore transport, recognising that the low-pressure compression facility and CO_2 pipeline represent a lower hazard than the high-pressure pipeline. Whilst CO_2 is not currently classified as hazardous, BEIS and the HSE recognise that an accidental release of large quantities of CO_2 (particularly, dense-phase CO_2) could result in a major accident.

7.2.2 No bulk storage of dense or gaseous phase CO_2 is proposed for the Proposed Development. The only 'stored' CO_2 on site would therefore be the inventory in the capture plant and on-site pipework, and this is envisaged to be considerably less than five tonnes. It is envisaged that the Proposed Development will come under the hazardous substance consenting regime and may trigger the need for lower tier COMAH licensing. This will be determined at the detailed design stage.

[18] HSE (2011). Assessment of the major hazard potential of carbon dioxide (CO2)

8.0 CCR REVIEW

8.1.1 As the Proposed Development is carbon capture enabled and will be built as a CCUS project, it is considered that there is no need to undertake regular reviews of CCR status in the future.

APPENDIX 1: INDICATIVE CCR LAYOUT