Intended for

Gateway Energy Centre Limited

Document Type

Report

Date

20 June 2019

GATEWAY ENERGY CENTRE

2019 UPDATED CCR FEASIBILITY STUDY

RAMBOLL

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Project Name:	**GATEWAY ENERGY CENTRE** **2019 Updated CCR Feasibility Study**
Project No.:	**1620002349-018**
Document Type:	**Report**
Document ID:	**1097375-2**
Document Version:	**3 (FINAL)**
Date:	**20 June 2019**
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LIST OF ABBREVIATIONS

AC	alternating current
ACC	air cooled condenser
BAT	Best Available Techniques
BEIS	Department for Business, Energy and Industrial Strategy
BESS	Battery Energy Storage System
CCGT	combined cycle gas turbine
CCR	Carbon Capture Readiness
CCS	Carbon Capture and Storage
CO_2	carbon dioxide
CRH	cold re-heat
DC	direct current
DCS	Distributed Control System
ES FID	Environmental Statement Further Information Document
EU ETS	European Union Emissions Trading Scheme
GEC	Gateway Energy Centre
GECL	Gateway Energy Centre
ha	hectares
HRSG	heat recovery steam generator
HSC	Hazardous Substances Consent
IED	Industrial Emissions Directive
LCV	lower calorific value
MEA	monoethanolamine
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
OCGT	open cycle gas turbine
SNS	South North Sea

1. INTRODUCTION

1.1 Overview

1.1.1 In August 2011, the Original Consent was granted for the Gateway Energy Centre (GEC) under Section 36 of the Electricity Act 1989. Subsequently, in November 2014 and August 2016, the consent was varied (the 2014 Varied Consent and the 2016 Varied Consent, respectively) under Section 36C of the Electricity Act 1989. The 2016 Varied Consent is the existing consent for GEC.

1.1.2 Gateway Energy Centre Limited (GECL) is submitting the 2019 Variation Application under Section 36C of the Electricity Act 1989, to the Secretary of State for Business, Energy and Industrial Strategy (the Secretary of State) via the Department for Business, Energy and Industrial Strategy (BEIS), to vary the existing consent for GEC (the Development or the Proposed Development).

1.1.3 This Section provides a summary of the relevant consenting history for GEC, a description of the relevant aspects of the 2019 Variation Application and the associated purpose of this document.

1.2 Relevant Consenting History for Gateway Energy Centre

1.2.1 Condition 2 of the existing consent provides that: "*the Development shall be up to 1250 MW capacity and comprise:*

(a) either:

(i) Up to two Combined Cycle Gas Turbine (CCGT) units (including for each CCGT unit: a gas turbine; a heat recovery steam generator; steam turbine plant; and, associated equipment); or,

(ii) (1) One CCGT unit (including: a gas turbine; a heat recovery steam generator; steam turbine plant; and, associated equipment), and

(2) One or more Open Cycle Gas Turbine (OCGT) units with the OCGT units having a combined rated electrical output of less than 300 MW[1] (including for each OCGT unit: a gas turbine; and, associated equipment).

(d) air cooled condensers and auxiliary cooling;

(e) gas receiving facility;

(f) one or more electrical switchyards;

(g) ancillary plant and equipment; and,

(h) the necessary buildings (including administration offices) and civil engineering works".

1.2.2 To ensure enforceability, Condition 4(1A) of the existing consent provides that: "*the Company shall notify the Secretary of State and Thurrock Council (as the relevant planning authority) which one of the gas turbine technology options in paragraph 2(a) of this consent has been selected prior to the commencement of the Development and provide details of the capacity of each gas turbine technology to be used*".

1.2.3 With regards to Carbon Capture Readiness (CCR), within the existing consent:

- Condition 4(3)(c) provides that the 'current Carbon Capture and Storage (CCS) proposal' means the CCS proposal set out in the Feasibility Study and assessed in accordance with the requirements of 'Carbon Capture Readiness (CCR): A Guidance Note for Section 36 Electricity Act 1989 Consent Applications'[2] (the CCR Guidance);

[1] 300 MW refers to the OCGT(s) and not the CCGT and the OCGT(s).
[2] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/43609/Carbon_capture_readiness_-_guidance.pdf

- Condition 4(3)(e) provides that 'Feasibility Study' means the 2010 CCR Feasibility Study, the 2014 Updated CCR Feasibility Study, and the 2014 Assessment of the CCR Compliance of the Proposed Gateway Energy Centre Report; and,
- Condition 4(3)(d) provides that: "*'designated site' means the land hatched yellow on FIGURE 3-B* ['Illustrative Site Plan with Carbon Capture Areas' dated 16/02/2010] *as the area where the Company proposes to locate the capture equipment*".

1.3 Relevant Aspects of the 2019 Variation Application

1.3.1 Amongst other variations, the 2019 Variation Application seeks to vary Condition 2(a) to provide that GEC shall remain up to 1250 MW generating capacity, but shall comprise either (*green italic text added to highlight proposed variation*):

(i) *Development Option (i)*, comprising:

Up to two CCGT units (including for each CCGT unit: a gas turbine; a Heat Recovery Steam Generator (HRSG); steam turbine plant; and, associated equipment); or,

(ii) *Development Option (ii)*, comprising:

(1) One CCGT unit with a rated electrical output of up to 630 MW (including: a gas turbine, HRSG; steam turbine plant; and, associated equipment);

(2) One or more OCGT units, with the OCGT units having a combined rated electrical output of less than 300 MW (including for each OCGT unit: a gas turbine; and, associated equipment); and,

(3) A Battery Energy Storage System (BESS) with a rated electrical output of up to 320 MW (including: batteries; associated enclosures; control and protection systems; temperature control systems; and, power conversion systems).

1.3.2 The 2019 Variation Application also seeks to vary Condition 4(1A) to provide that (*green italic text added to highlight proposed variation*) GECL shall notify the Secretary of State and Thurrock Borough Council which one of the ~~*gas turbine technology*~~ *Development Options* in paragraph 2(a) has been selected prior to commencement of GEC and provide details of the capacity of each of each ~~*gas turbine*~~ technology to be used.

1.3.3 With regards to CCR, the 2019 Variation Application seeks to vary (*green italic text added to highlight proposed variations*):

- Condition 4(3)(d) to provide that:
  - *'CCS site for Development Option (i)' and 'CCS site for Development Option (ii)' mean the areas of land hatched green on FIGURE 1620002349-018-00004 (P02) and FIGURE 1620002349-018-00005 (P02) respectively allocated to the Development Options in paragraph 2(a);* and,
  - *'designated site' means, following notification to the Secretary of State and Thurrock Borough Council which one of the Development Options in paragraph 2(a) has been selected, the area of land allocated to that Development Option as the area where GECL proposes to locate the capture equipment.*

1.3.4 The rationale for the variation of Condition 4(3)(d) is to allow GECL, at the time of notification to the Secretary of State and Thurrock Borough Council which one of the Development Options in paragraph 2(a) has been selected, to dispose of the CCS site associated with the Development Option not selected.

1.4 The Purpose of this Document

1.4.1 To accompany the 2019 Variation Application, GECL is providing the following information to BEIS:

- The 2019 Environmental Statement Further Information Document (2019 ES FID); and,

- The 2019 Updated CCR Feasibility Study.

1.4.2 This document is the 2019 Updated CCR Feasibility Study.

1.4.3 The purpose of this 2019 Updated CCR Feasibility Study, in combination with the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study (as independently verified by Imperial College in the 2014 Assessment of the CCR Compliance of the Proposed Gateway Energy Centre Report), is to demonstrate that it remains feasible to retrofit a carbon dioxide (CO_2) capture chain to GEC within its 35 year operating lifetime, and that GEC remains compliant with the requirements of the CCR Guidance. Electronic versions of the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study (as independently verified by Imperial College in the 2014 Assessment of the CCR Compliance of the Proposed Gateway Energy Centre Report) can be downloaded free of charge from the GEC website:

http://www.intergen.com/development-opportunities-portfolio/gateway-energy-centre-downloads

1.4.4 Furthermore, the purpose of this document is to support the proposed variation of Condition 4(3)(d) by:

- Presenting the CCS site for Development Option (i) and the CCS site for Development Option (ii); and,
- Providing the supporting information for Development Option (i) and Development Option (ii) to assess the proposals in accordance with the requirements of the CCR Guidance.

1.4.5 Within this 2019 Updated CCR Feasibility Study, where information provided in the 2010 CCR Feasibility Study the 2014 Updated CCR Feasibility Study remains valid and appropriate, this is stated, and the information is referenced but not repeated.

The Structure of this 2019 Updated CCR Feasibility Study

1.4.6 Based on the purpose, this 2019 Updated CCR Feasibility Study is structured as follows:

- ***Section 1***: Provides a brief summary of the relevant consenting history for GEC, a description of the relevant aspects of the 2019 Variation Application and the associated purpose of this document;
- ***Section 2***: Summarises the context and the assessment methodology for this 2019 Updated CCR Feasibility Study;
- ***Section 3***: Presents a description of the Proposed Development, and a summary of the assessment scenarios;
- ***Section 4***: Presents a description of the proposed CO_2 capture process, and estimated CO_2 capture / storage requirements;
- ***Section 5***: Provides the technical assessment regarding the space requirement;
- ***Section 6***: Provides the technical assessment regarding the retrofitting and integration of the CO_2 capture plant technology;
- ***Section 7***: Provides the technical assessment regarding CO_2 storage sites;
- ***Section 8***: Provides the technical assessment regarding CO_2 transport;
- ***Section 9***: Provides the economic assessment;
- ***Section 10***: Provides the discussion on Hazardous Substances Consent (HSC); and,
- ***Section 11***: Presents the conclusions of this 2019 Updated CCR Feasibility Study.

1.4.7 The Appendices provide associated supporting information.

2. CONTEXT AND METHODOLOGY

2.1 Context

2.1.1 The context provided in Section 2 of the 2010 CCR Feasibility Study and Section 2 of the 2014 Updated CCR Feasibility Study remains valid and appropriate.

2.1.2 In summary:

- At a European Union level, the requirement for a CCR Feasibility Study is provided the CCS Directive[3], more recently, by the Industrial Emissions Directive (IED)[4]; and,
- In the UK:
  - The requirements of the Directives are implemented via the Carbon Capture Readiness (Electricity Generating Stations) Regulations 2013[5] (the CCR Regulations); and,
  - The CCR Guidance provides the required content of a CCR Feasibility Study.

2.2 Assessment Methodology

2.2.1 The assessment methodology provided in Section 2 of the 2010 CCR Feasibility Study and Section 2 of the 2014 Updated CCR Feasibility Study remains valid and appropriate.

[3] Directive 2009/31/EC on the geological storage of carbon dioxide. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF
[4] Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control). Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:en:PDF
[5] Available at: http://www.legislation.gov.uk/uksi/2013/2696/made

3. THE PROPOSED DEVELOPMENT / SUMMARY OF ASSESSMENT SCENARIOS

3.1 Gateway Energy Centre (the Development or the Proposed Development)

3.1.1 GEC will have an operational lifetime of approximately 35 years.

Development Options

3.1.2 The 2019 Variation Application seeks to vary Condition 2(a) to provide that GEC shall remain up to 1250 MW generating capacity, but shall comprise either:

- Development Option (i), comprising:

  Up to two CCGT units with a rated electrical output of up to 1250 MW; or,

- Development Option (ii), comprising:

  (1) One CCGT unit with a rated electrical output of up to 630 MW;

  (2) One or more OCGT units having a combined rated electrical output of less than 300 MW; and,

  (3) A BESS with a rated electrical output of up to 320 MW.

Development Option Technologies

The CCGT Unit(s)

3.1.3 Under the varied Condition 2(a):

- For Development Option (i), there would be up to two CCGT units with a rated electrical output of up to 1250 MW; or,
- For Development Option (ii), there would be one CCGT unit with a rated electrical output of up to 630 MW.

3.1.4 Each CCGT unit will comprise: a gas turbine; a HRSG; steam turbine plant; and, associated equipment.

3.1.5 Within each CCGT unit, the natural gas will be burnt in the combustion chamber of the gas turbine from where the resulting hot gases will expand through the turbine section to generate sufficient power to drive the air compressor section and generator to produce electrical power. The hot exhaust gases still contain recoverable energy and will therefore be used in a HRSG to generate steam, which will be expanded in steam turbine plant to produce additional electrical power.

3.1.6 The steam exhausting the steam turbine plant will pass to an air cooled condenser (ACC) where it will be condensed. The resulting condensate will be returned to the HRSG to continue the steam cycle.

3.1.7 The flue gases will be discharged via a dedicated stack.

3.1.8 The use of a combined gas and steam cycle increases the overall fuel efficiency of the generating station. As such, the CCGT unit(s) will be capable of generation in combined cycle mode with an overall electrical generation efficiency of approximately 57 to 60.5% based on the lower calorific value (LCV) of the fuel.

OCGT Units

3.1.9 Under the varied Condition 2(a):

- For Development Option (ii), there would be one or more OCGT(s) unit having a combined rated electrical output of less than 300 MW.

3.1.10 Each CCGT unit will comprise: a gas turbine; and, associated equipment. Indeed, in essence, an OCGT unit comprises the prime driver of a CCGT unit, which is the gas turbine.

3.1.11 Within each OCGT unit (and as with a CCGT unit), the natural gas will be burnt in the combustion chamber of the gas turbine from where the resulting hot gases will expand

through the turbine section to generate sufficient power to drive the air compressor section and generator to produce electrical power.

3.1.12 As there is no steam cycle, there is no condensing of steam and associated cooling requirement. Whilst auxiliary cooling is still required, this is significantly lower for an OCGT unit than for a CCGT unit.

3.1.13 The flue gases will be discharged via a dedicated stack. The stack normally contains a silencer to reduce noise emissions. Due to the higher stack exit temperature, the stacks for OCGT units are generally shorter than those for CCGT units.

3.1.14 The OCGT unit(s) will have an electrical generation efficiency between approximately 36 to 41.5% based on the LCV of the fuel.

The Battery Energy Storage System

3.1.15 Under the varied Condition 2(a):

- For Development Option (ii), there would be a BESS with a rated electrical output of up to 320 MW.

3.1.16 The BESS will comprise:

- Batteries, housed in enclosures, also including:
- Control and protection systems;
- Chillers / cooling systems (to ensure temperature control); and,
- A power conversion system (to convert alternating current (AC) into direct current (DC) during energy charging, or to convert DC into AC during energy discharging).
- Transformers and switchgear.

3.1.17 Although the battery types may be varied throughout the Proposed Development's operational lifetime, it is currently envisaged that lithium-ion batteries will be used during the initial operational phase[6].

Proposed Development Location

3.1.18 GEC will be located within the overall red-line boundary (see Figure 63114-PBP-0025 associated with the existing consent (Appendix A provides this Figure)). The overall red-line boundary covers a total area of approximately 29.1 hectares (ha) (71.9 acres). This includes:

- The GEC site, which covers an area of approximately 11.3 ha (27.9 acres) and includes the current designated site (the land hatched yellow on FIGURE 3-B 'Illustrative Site Plan with Carbon Capture Areas' from the 2010 CCR Feasibility Study, dated 16/02/2010, associated with the existing consent (Appendix A provides this Figure)); and,
- Land to the north and west which is intended to be used during construction for temporary laydown and storage.

3.1.19 The overall red-line boundary, and the GEC site, is located on the north bank of the Thames Estuary on land within the DP World® London Gateway Logistics Park.

3.2 Assessment Scenarios

3.2.1 Based on the development options technologies and the maximum proposed rated electrical output of each technology, Table 3.1 summarises the requirement for these to be assessed in this 2019 Updated CCR Feasibility Study. With regards to the requirement for these to be assessed, consideration is given to:

[6] Regarding other battery types, it is understood that lithium-ion batteries will continue to be the battery chemistry of choice for the foreseeable future, largely due to the upfront investment in this battery chemistry from the automotive industry in large-scale manufacturing capacity for the electric vehicle market.

- Whether the development option technology meets the definition of a 'combustion plant'[7]; and,
- Whether the maximum proposed rated electrical output of each technology meet or exceeds the 'capacity threshold for CCR'[8], taken to be at or over a rated electrical output of 300 MW.

TABLE 3.1: SUMMARY OF REQUIREMENT FOR DEVELOPMENT OPTION TECHNOLOGIES TO BE ASSESSED

Development Option	*Development Option Technology*	*Proposed Rated Electrical Output*	*Does the Development Option Technology meet the definition of a 'Combustion Plant'?*	*Does the maximum proposed rated electrical output of the technology meet or exceed the 'Capacity Threshold for CCR'?*	*Is the Development Option Technology required to be assessed?*
(i)	CCGT	1250	Yes	Yes	Yes
(ii)	CCGT	630	Yes	Yes	Yes
	OCGT	<300	Yes	No	No
	BESS	320	No	N / A	No

Summary of Assessment Scenarios

3.2.2 Based on Table 3.1, the assessment scenarios for this 2019 Updated CCR Feasibility Study comprise:

- For Development Option (i), assessment of two CCGT units with a rated electrical output up to 1250 MW; and,
- For Development Option (ii), assessment of one CCGT unit with a rated electrical output up to 630 MW.

3.2.3 No further discussion is provided for the Development Option (ii) OCGT or BESS technologies in the remainder of this 2019 Updated CCR Feasibility Study.

[7] The CCR Regulations apply to 'combustion plants' and defines a combustion plant as: "*any technical apparatus in which fuels are oxidised in order to use the heat thus generated…*".

[8] The CCR Guidance states (on page 4) that it applies to "*applications for* [electricity generating combustion plants] *with an electrical generating capacity at or over 300 MW and of a type covered by the* [LCPD, now IED]. *This capacity threshold* […] *is based on the capacity of the new* [overall electricity generating combustion plant] *as a whole, rather than on the individual capacity of each of the* [electricity generating combustion plant] *units which make up the* [overall electricity generating combustion plant]. *However, where an application for a variety of* [electricity generating combustion plant] *unit types is received (for example combined cycle and open cycle gas turbines), the threshold is applied to the new units of the same type on the site".*

4. PROPOSED CO_2 CAPTURE PROCESS AND ESTIMATED CO_2 CAPTURE / STORAGE REQUIREMENTS

4.1 Proposed CO_2 Capture Process

4.1.1 The current understanding is that CO_2 capture will not be installed until CO_2 capture is either mandated or economically beneficial. A number of CO_2 capture technologies currently exist, and at the time of eventual installation, it is highly probable that this number will have increased.

4.1.2 However, similar to the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, this 2019 Updated CCR Feasibility Study focuses on currently available technology closest to commercial deployment rather than speculating on future developments that may be available at the time of eventual installation. Whilst many of these future developments are likely, it would be difficult to demonstrate technical and economic feasibility based on such uncertain and unproven future developments.

4.1.3 Therefore, similar to the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, the technical and economic assessment is based on the assumption of the best currently available technology which, for CO_2 capture from flue gases of CCGT units, is a post-combustion CO_2 capture process via chemical absorption.

4.1.4 This CO_2 capture process may be regarded as commercially available, but has not yet been commercially proven and deployed for large-scale combustion plant applications. However, it is the belief of Ramboll that no technical barriers exist to extending existing experience to a scale appropriate for GEC.

Development Option (i)

4.1.5 For Development Option (i), the proposed CO_2 capture process and equipment described in Section 4 of the 2014 Updated CCR Feasibility Study is the basis for the assessment and the associated description remains valid.

4.1.6 In summary:

- To support the 2014 Updated CCR Feasibility Study, GECL commissioned Siemens to undertake a specific engineering investigation[9] to verify whether the designated site was sufficient for two CCGT units with a rated electrical output up to 1250 MW;
- The assessment is based on a post-combustion CO_2 capture process via chemical absorption used an amino acid salt; and,
- The post-combustion CO_2 capture process comprises: flue gas cooling; flue gas blowing; a CO_2 absorption section; a CO_2 desorption section; a CO_2 compressor section; a solvent reclaimer section; and, a storage and unloading section.

Development Option (ii)

4.1.7 For Development Option (ii), the proposed CO_2 capture process and equipment described in Section 4 of the 2010 CCR Feasibility Study is the basis for the assessment and the associated description remains valid.

4.1.8 In summary:

- The assessment is based on a post-combustion CO_2 capture process via chemical absorption using amines (typically based on monoethanolamine (MEA), diamine or sterically hindered amine); and,
- The post-combustion CO_2 capture process comprises: flue gas cooling; a CO_2 absorption section; a CO_2 stripping / desorption section; and, a CO_2 compression and discharge section.

[9] The Siemens engineering investigation was based on a Siemens PostCap™ reference project, containing the results of a full process simulation including equipment dimensioning. The results of the Siemens engineering investigation, and the 2014 Updated CCR Feasibility Study, were independently verified by Imperial College London in the 2014 Assessment of the CCR Compliance of the Proposed Gateway Energy Centre Report.

Summary of Proposed CO_2 Capture Processes

4.1.9 The main stages for the proposed CO_2 capture processes for Development Option (i) and Development Option (ii) are almost identical. The main difference is the solvent used (e.g. an amino acid salt verses an amines).

4.2 Estimated CO_2 Capture / Storage Requirements

Percentage of CO_2 Capture

4.2.1 Within the CCR Regulations, reference to:

- In Regulation 2(2), "*all of its expected emissions of CO_2*"; and,
- In Regulation 6(3), "*all of the CO_2*";

indicates that a CCR Feasibility Study should consider all of the CO_2 emissions from a relevant combustion plant, rather than just a certain percentage of it (i.e. 50% or 20%). This is likely derived from the spirit of the CCS Directive (which the CCR Regulations transpose), which does not cover a fraction of the CO_2, but in principle relates to all of the CO_2.

4.2.2 Therefore, within this 2019 Updated CCR Feasibility Study (as with the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study), "*all of its expected emissions of CO_2*" and "*all of the CO_2*" is assumed to be the CO_2 emissions which can be captured using Best Available Techniques (BAT). This is considered to be in line with the CCR Guidance which (at paragraph 11) states: "*applicants should explain what percentage of these CO_2 emissions they consider will be captured by their proposed capture technology, in keeping with the principle of best practice*".

CO_2 Capture Steam Generation Options Considered

4.2.3 The CO_2 capture process will require steam to regenerate the liquid solvent.

4.2.4 The 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study noted two main steam generation options comprising:

- Option A, where steam is extracted from the steam cycle of the CCGT unit(s); and,
- Option B, where steam is generated by auxiliary boilers.

4.2.5 For these steam generation options, the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study noted:

- Option A would impose a greater requirement in terms of retrofitting if a CO_2 capture process is installed. For example, if a largely standard CCGT unit was installed, then after retrofitting, the CCGT unit may be less efficient then if a 'non-standard CO_2 capture optimised' CCGT unit is installed. However, a 'non-standard CO_2 capture optimised' CCGT unit would likely incur an efficiency penalty during pre-retrofitting operation.
- Option B would require minimal changes to be made in terms of retrofitting if a CO_2 capture process is installed. However, additional natural gas would be required for the auxiliary boilers which could increase the CO_2 capture requirement if the additional CO_2 in the auxiliary boilers flue gas was combined with the flue gases from the CCGT unit(s), prior to entering the CO_2 capture process.

4.2.6 Therefore, whilst both Option A and Option B remain available for the CCGT unit(s), Option A remains the focus of this 2019 Updated CCR Feasibility Study (as with the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study).

Development Option (i)

4.2.7 For Development Option (i), the estimated CO_2 capture and storage requirements described in Section 3 of the 2014 Updated CCR Feasibility Study remain valid and appropriate.

4.2.8 For Development Option (i), Table 4.1 provides a summary of the CO_2 capture and storage requirements.

TABLE 4.1: DEVELOPMENT OPTION (i) ESTIMATED CO_2 CAPTURE AND STORAGE REQUIREMENTS

Component		*Estimated Requirement*	
		'Design Case'	*'Specific Case'*
Flue Gas Flow	t/hr	7,623	6,143
CO_2 Consent of Flue Gas Flow	%vol	3.7	4.6
CO_2 Generated	kg/s	121.4	113.1
	t/hr	437	407
On-Site CO_2 Capture Process Requirements (Assuming 90% CO_2 Capture)	t/hr	393	366
	t/day	9,432	8,784
CO_2 Storage Site Requirement (Assuming 75% capacity factor)	Mt/yr	-	2.4
Total CO_2 Storage Site Requirement (Assuming operational lifetime of 35 years)	Mt	-	84.2

4.2.11 Within Table 4.1:

- The 'Design Case' is based on the Siemens engineering investigation and uses three Siemens SGT5-4000F gas turbines modelled in single shaft configuration; and,
- The 'Specific Case' is based on the likely configuration of GEC under Development Option (i) and uses two Siemens SGT5-8000H gas turbines modelled in single shaft configuration.

4.2.12 The 2014 Updated CCR Feasibility Study noted that the estimated CO_2 capture requirements for the 'Design Case' were larger than the 'Specific Case', and therefore if the sizing of the space requirement and the on-site CO_2 capture process requirements were sufficient for the 'Design Case' they would be sufficient for the 'Specific Case'. Accordingly, within the 2014 Updated CCR Feasibility Study, the 'Design Case' was used for the sizing of the space requirement and the on-site CO_2 capture process requirements. The 'Specific Case' was used for the estimated CO_2 storage site requirements.

Development Option (ii)

4.2.13 For Development Option (ii), CO_2 and flue gas intensity factors were modelled assuming one single shaft CCGT unit, comprising: one gas turbine; one steam turbine with a triple pressure re-heat steam cycle; and, ACCs. As the manufacturer has not been selected, the modelling exercises were undertaken using a range of different 'H' Class gas turbine models currently commercially available. Table 4.2 provides the CO_2 and flue gas intensity factors (alongside the power ratios[10]).

TABLE 4.2: CO_2 AND FLUE GAS INTENSITY FACTORS FOR DIFFERENT 'H' CLASS GAS TURBINE MODELS

	CO_2 Intensity (t/MWh)	*Flue Gas Intensity (t/MWhr)*	*Power Ratio*
Model A	0.34	5.3	1.02
Model B	0.34	5.0	1.02

4.2.14 Based on Table 4.2, the maximum values of the factors, as applied to the maximum rated electrical output of the CCGT unit, were used for the sizing of the space requirement and the on-site CO_2 capture process requirements. The average values of the factors were used for the estimated CO_2 storage site requirement.

[10] The power ratio is used to determine the maximum flow rates using the average flow rates. The power ratio is the difference between the total electrical output of the CCGT unit at typical site rated conditions (10°C) and the total electrical output of the CCGT unit at reduced atmospheric temperature conditions (5°C, selected to simulate the effect of anti-icing equipment). Accordingly, the power ratio is used to determine the maximum flow rates which could be expected from the CCGT unit under worst case conditions.

4.2.15 For Development Option (ii), Table 4.3 presents the CO_2 capture and storage requirements.

TABLE 4.3: DEVELOPMENT OPTION (ii) ESTIMATED CO_2 CAPTURE AND STORAGE REQUIREMENTS

Component		***Estimated Requirements***	
		Maximum	***Average***
CO_2 Generated	kg/s	59.9	58.7
	t/hr	215.7	211.4
On-Site CO_2 Capture Process Requirements (Assuming 90% CO_2 Capture)	t/hr	194.1	190.3
	t/day	4658.3	4567.0
CO_2 Storage Site Requirement (Assuming 75% capacity factor)	Mt/yr	-	1.3
Total CO_2 Storage Site Requirement (Assuming operational lifetime of 35 years)	Mt	-	43.8

5. TECHNICAL ASSESSMENT – SPACE REQUIREMENT

5.1 Requirements of the CCR Guidance

5.1.1 The requirement for this technical assessment is to provide an illustrative site layout ("*outline plot level plan*") which is sufficiently detailed to show:

- The footprint of the Proposed Development;
- The location of the CO_2 capture plant technology;
- The location of any CO_2 compression technology;
- The location of any chemical storage facilities; and
- The exit point of the CO_2 pipeline.

5.1.2 Informing this technical assessment, Table 1 of the CCR Guidance ('Approximate minimum land footprint for some types of CO_2 capture plant') provides indicative space requirements, including for CCGT units with post-combustion CO_2 capture, "*based on net plant capacities of around 500 MW*" (original space requirement).

5.1.3 Following the publication of the CCR Guidance, this original space requirement was reviewed by Imperial College London[11] which resulted in the correction of the indicative space requirement for CCGT units with post-combustion CO_2 capture (corrected space requirement). In addition, this review detailed additional scope for a further reduction of the indicative space requirement for CCGT units with post-combustion CO_2 capture based on technology advances and layout optimisation (further reduced space requirement).

5.2 Technical Assessment

5.2.1 Table 5.1 presents a summary of these space requirements for both Development Option (i) and Development Option (ii).

TABLE 5.1: SUMMARY OF SPACE REQUIREMENTS, BASED ON CCR GUIDANCE AND IMPERIAL COLLEGE LONDON REVIEW

Basis	***Space Requirement***	
	For Development Option (i) (Two CCGT Units, up to 1250 MW)	***For Development Option (ii)*** (One CCGT Unit, up to 630 MW)
Original Space Requirement[12] (ha)	9.4	4.7
Corrected Space Requirement[13] (ha)	6.0	3.0
Further Reduced Space Requirement[14] (ha)	4.7	2.4

5.2.2 Within the existing consent, Condition 4(3)(d) provides that the current 'designated site' means the: "*land hatched yellow on FIGURE 3-B* [('Illustrative Site Plan with Carbon Capture Areas' from the 2010 CCR Feasibility Study, dated 16/02/2010]". This designated site currently comprises an area of 4.7 ha.

Development Option (i)

5.2.3 For Development Option (i):

- Figure 1620002349-018-00004 (P02) provides the 'CCS site for Development Option (i)', with the CCS site shown as the area of land hatched green. The total area is approximately 4.72 ha.
- Figure 1620002349-018-00006 (P02) provides the associated illustrative site layout, which covers an area of approximately 4.5 ha. The CO_2 terminal point has

[11] Available at: http://www.decc.gov.uk/en/content/cms/meeting_energy/consents_planning/electricity/electricity.aspx
[12] Based on 3.75 ha for a 500 MW (net) CCGT unit with post-combustion CO_2 capture.
[13] Based on 2.4 ha for a 500 MW (net) CCGT unit with post-combustion CO_2 capture.
[14] Based on 1.875 ha for a 500 MW (net) CCGT unit with post-combustion CO_2 capture.

been placed to match the most likely CO_2 transport option (i.e. via on-shore pipeline).

5.2.4 There are no changes to the illustrative site layout for Development Option (i). Therefore, the technical assessment in Section 5 of the 2014 Updated CCR Feasibility Study remains valid and appropriate. The technical assessment was based on the Siemens engineering investigation. The Siemens engineering investigation (including the associated illustrative site layout), and the 2014 Updated CCR Feasibility Study, were independently verified by Imperial College London in the 2014 Assessment of the CCR Compliance of the Proposed Gateway Energy Centre Report. The 2014 Updated CCR Feasibility Study stated that, as the illustrative site layout area was smaller than the further reduced space requirement, the designated site remained valid and appropriate.

Development Option (ii)

5.2.5 For Development Option (ii):

- Figure 1620002349-018-00005 (P02) provides the 'CCS site for Development Option (ii)', with the CCS site shown as the area of land hatched green. The total area is approximately 3.03 ha.
- Figure 1620002349-018-00007 (P02) provides the illustrative site layout, which covers an area of approximately 2.4 ha. The CO_2 terminal point has been placed to match the most likely CO_2 transport option (i.e. via on-shore pipeline).

5.2.6 For the illustrative site layout, in the absence of technology / specific data, professional judgement was used to make the various assumptions required. The sizing of the internal dimensions of the main CO_2 capture plant technology has been based on the FluorDaniel Study 1999[15]. Using these sizings, likely worst case estimates of the external dimensions of the main CO_2 capture plant technology has been based on the Fluor-Statoil Study 2005[16]. The balance of plant items are also based on the Fluor-Statoil Study 2005. The sizing of cooling plant / equipment is based on information from the software modelling.

The 2019 Variation Application

5.2.7 With regards to designated sites, the 2019 Variation Application seeks to vary (*green italic text added to highlight proposed variations*):

- Condition 4(3)(d) to provide that:
  - *'CCS site for Development Option (i)' and 'CCS site for Development Option (ii)' mean the areas of land hatched green on FIGURE 1620002349-018-00004 (P02) and FIGURE 1620002349-018-00005 (P02) respectively allocated to the Development Options in paragraph 2(a);* and,
  - *'designated site' means, following notification to the Secretary of State and Thurrock Borough Council which one of the Development Options in paragraph 2(a) has been selected, the area of land allocated to that Development Option as the area where GECL proposes to locate the capture equipment.*

5.2.8 The rationale for the variation of Condition 4(3)(d) is to allow GECL, at the time of notification to the Secretary of State and Thurrock Borough Council which one of the Development Options in paragraph 2(a) has been selected, to dispose of the CCS site associated with the Development Option not selected.

5.3 Future Considerations

5.3.1 As part of the Status Reports, this technical assessment will be reviewed.

5.3.2 With regards to the Status Reports, within the existing consent Condition 4(5)(a), the first Status Report is required within 3 months of the commissioning of GEC. The 2019 Variation Application seeks to vary Condition 4(5)(a) to provide that (*green italic text added to highlight proposed variation*) the first Status Report is required within 3 months

[15] 'Recovery of CO_2 from Flue Gases: Commercial Trends' (FluorDaniel, dated October 1999).
[16] 'Study and Estimate for CO_2 Capture Facilities for the proposed 800 MW Combined Cycle Power Plant – Tjeldbergodden, Norway' (Fluor-Statoil, dated April 2005).

of the commissioning of ~~*GEC*~~ *the CCGT units(s)*. Subsequent Status Reports would then be required every two years.

6. TECHNICAL ASSESSMENT – RETROFITTING AND INTEGRATION

6.1 Requirements of the CCR Guidance

6.1.1 The requirement for this technical assessment is to demonstrate that, for both Development Option (i) and Development Option (ii), the CCGT unit(s) can been designed in such a way to enable retrofitting and integration of the CO_2 capture plant technology.

6.2 Technical Assessment

6.2.1 For CO_2 capture from flue gases of CCGT units using a post-combustion CO_2 capture process, the technical assessment is to be made against Annex C ('Environment Agency Verification of CCS Readiness New Natural Gas Combined Cycle Power Station using Post Combustion Solvent Scrubbing') of the CCR Guidance.

C1: Design, Planning Permissions and Approvals

6.2.2 For both Development Option (i) and Development Option (ii), this 2019 Updated CCR Feasibility Study, used in combination with the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, shows that it is technically feasible to retrofit and integrate CO_2 capture plant technology to the CCGT unit(s).

6.2.3 For Development Option (i), Figure 1620002349-018-00006 (P02) provides the illustrative site layout, which covers an area of approximately 4.5 ha. For Development Option (ii), Figure 1620002349-018-00007 (P02) provides the illustrative site layout, which covers an area of approximately 2.4 ha.

C2: Power Plant Location

6.2.4 For both Development Option (i) and Development Option (ii), this 2019 Updated CCR Feasibility Study, used in combination with the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, demonstrates that a feasible on-shore and off-shore route exists from the GEC site to the identified CO_2 storage sites.

6.2.5 In terms of the CO_2 terminal point, this has been placed to match the most likely CO_2 transport option (i.e. via on-shore pipeline). Therefore, for both Development Option (i) and Development Option (ii), the CO_2 terminal point is located on the eastern boundary of the GEC site.

C3: Space Requirements

6.2.6 Within Figure 1620002349-018-00006 (P02) (for Development Option (i)) and Figure 1620002349-018-00007 (P02) (for Development Option (ii)), the provision of space is shown for:

- The main items of CO_2 capture plant technology (including flue gas pre-treatment and CO_2 drying and compression);
- New duct work to allow interconnection of the CCGT unit(s) flue gas system with the CO_2 capture plant technology;
- Additional plant infrastructure (including roads in reasonable proximity to the key items of plant / equipment and the loading / unloading area and solvent storage); and,
- Loading and unloading solvent, and solvent storage.

6.2.7 In terms of the CO_2 terminal point, this has been placed to match the most likely CO_2 transport option (i.e. via on-shore pipeline). Therefore, for both Development Option (i) and Development Option (ii), the CO_2 terminal point is located on the eastern boundary of the GEC site.

6.2.8 In combination with the above, it should be noted that the tender specifications for the CCGT unit(s) will include the following:

- The provision of space within the CCGT unit(s) for the future addition of flue gas off-take ducting, flue gas diversion mechanisms and access for retrofit / maintenance;

- The provision of space within the CCGT unit(s) for new duct work to allow interconnection of the existing flue gas system with the CO_2 capture plant technology;
- The provision of space within the CCGT unit(s) for additional pipe work / pipe work support (likely to be beneath the new duct work);
- The provision of space within the turbine hall of the CCGT unit(s) to allow for steam off-take, including space surrounding blanked-off off-take ports for addition of off-take pipe work (including isolation and bypass valves) and access for retrofit / maintenance;
- The provision of space within the CCGT unit(s) for the return pipe work / pipe work support (i.e. for condensate to the feedwater system); and,
- The provision of space to allow for additional raw water requirements, additional demineralised water requirements, additional waste water treatment requirements and additional compressed air requirements.

C4: Gas Turbine Operation with Increased Exhaust Pressure

6.2.9 Based on the introduction of CO_2 capture plant technology within each CCGT unit, the gas turbine (and upstream ducting / HRSG) may be subject to increased back pressure unless a booster fan is provided.

6.2.10 Within Figure 1620002349-018-00006 (P02) (for Development Option (i)) and Figure 1620002349-018-00007 (P02) (for Development Option (ii)), the provision of space is shown for booster fans. For each CCGT unit, the use of a booster fan will ensure that there is no pressure increase at the upstream CCGT unit stack, and therefore no increase in back pressure on the gas turbine.

6.2.11 For each CCGT unit, the booster fan will likely be constructed of stainless steel / coated carbon steel, and would be designed for a flue gas flow rates between approximately 2,500 to 3,415 t/hr.

6.2.12 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to the retrofitting and integrating of CO_2 capture plant technology in terms of gas turbine operation with increased exhaust pressure.

C5: Flue Gas System

6.2.13 Within Figure 1620002349-018-00006 (P02) (for Development Option (i)) and Figure 1620002349-018-00007 (P02) (for Development Option (ii)), the provision of space is shown for new duct work to allow interconnection of the CCGT unit(s) flue gas system with the CO_2 capture plant technology.

6.2.14 Also, as noted in the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, Selective Catalytic Reduction (SCR) is not deemed to be required as the IED limits for nitrogen oxides (NO_x) will result in a flue gas containing a concentration of nitrogen dioxide (NO_2) that will not impact on the CO_2 capture plant technology.

6.2.15 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of the flue gas system.

C6: Steam Cycle

6.2.16 The CO_2 capture process will require steam to regenerate the liquid solvent. Information from vendors covers a range of condensing temperatures (and therefore pressures) for this steam, and a range of specific energy requirements for the regeneration of the liquid solvent. Thus, requirements would ultimately depend on the technology and vendor selected.

6.2.17 For Development Option (i), based on the Siemens engineering investigation, the requirements are:

- Steam Pressure – 4.6 bar a;

- Steam Flow – 502 t/h; and,
- Steam Temperature – 148.7°C.

6.2.18 For Development Option (ii), estimated using information provided by vendors, the requirements are:

- Steam Pressure – 4.5 bar a;
- Steam Flow – 224 t/h; and,
- Specific Energy Consumption – 2.7 GJ/t CO_2.

6.2.19 Based on implementing Option A, where steam is extracted from the steam cycle of the CCGT unit(s), several off-take options exist. As with the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, steam extraction is from the cold re-heat (CRH) as this considered to be the most universally retrofittable option for CCGT unit(s). In terms of retrofitting and integrating, steam extraction from the CRH would require space for an off-take port on each CRH line as well as increasing the de-superheating capability. If this is employed, steam extraction could be undertaken at any pressure up to the CRH pressure.

6.2.20 For Development Option (i), the illustrative performance results are:

- Without CO_2 capture plant technology:
  - Net output: 1160 MW
  - LHV efficiency: 59.5%
- With CO_2 capture plant technology:
  - Net output: 1010 MW
  - LHV efficiency: 51.8%

6.2.21 For Development Option (ii), the illustrative performance results are:

- Without CO_2 capture plant technology:
  - Net output: 584 MW
  - LHV efficiency: 59.4%
- With CO_2 capture plant technology (steam extracted from CRH):
  - Net output: 549 MW
  - LHV efficiency: 55.8%

6.2.22 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of the steam cycle of the CCGT unit(s).

C7: Cooling Water System

6.2.23 An additional cooling duty would be imposed by the CO_2 capture plant technology. This additional cooling duty would be required for:

- Cooling the flue gases to absorber temperature (flue gas cooling);
- Cooling the lean solvent before entry into the absorber (process cooling);
- Cooling the CO_2 and condensing of water in the CO_2 product before and between compression stages (inter-cooling); and,
- Cooling of the CO_2 capture ancillary plant / equipment.

6.2.24 Because of the high auxiliary cooling load of the CO_2 capture plant technology, water cooling would be a better option if available. Water cooling generally provides a lower temperature sink, and much smaller and less expensive heat exchangers. However, as it cannot be assumed that water cooling will be available in the future, as noted in the 2010

CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, air-cooling (via A-frame fin-fan coolers) has been assumed.

6.2.25 For Development Option (i), the additional cooling duty, based on the Siemens engineering investigation, is approximately 672 MJ/s. For Development Option (ii), the additional cooling duty, estimated using information provided by vendors and from Thermoflex software modelling, is approximately 249 MJ/s.

6.2.26 Per MJ/s of cooling duty, the fin-fan cooler space requirement is approximately 16 m^2. For Development Option (i), the air-cooling space requirement is approximately 10,800 m^2. For Development Option (ii), the air-cooling space requirement is approximately 3,900 m^2. There would be no continuous make up water requirements for this cooling system. Within Figure 1620002349-018-00006 (P02) (for Development Option (i)) and Figure 1620002349-018-00007 (P02) (for Development Option (ii)), the provision of space for fin-fan coolers is shown.

6.2.27 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of additional cooling duty.

C8: Compressed Air System

6.2.28 Compressed air would be required for the instrument air system of the CO_2 capture plant. For Development Option (i), this is estimated to be approximately 750 Nm^3/hr. For Development Option (ii), this is estimated to be approximately 375 Nm^3/hr.

6.2.29 The provision of space for this additional compressed air requirement would be provided within the Compressed Air System at for the CCGT unit(s). The requirement for the provision of this space will be included in the tender specifications for the CCGT unit(s).

6.2.30 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of additional compressed air requirements.

C9: Raw Water Pre-Treatment Plant

6.2.31 For both Development Option (i) and Development Option (ii), the additional water requirements for the CO_2 capture plant technology are estimated to be minimal.

6.2.32 However, the provision of space for raw water storage and treatment will be provided with the Water / Firewater Storage Tank for GEC and the Water Treatment Plant for the CCGT unit(s). The requirement for the provision of this space will be included in the tender specifications.

6.2.33 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of additional raw water requirements.

C10: Demineralisation / Desalination Plant

6.2.34 For both Development Option (i) and Development Option (ii), additional demineralised water would be required to replace water removed during the solvent reclaiming process. For Development Option (i), this is estimated to be approximately 1 m^3/hr. For Development Option (ii), this is estimated to be approximately 0.5 m^3/hr.

6.2.35 The provision of space for this additional demineralised water requirement will be provided within the Water Treatment Plant for the CCGT unit(s). The requirement for the provision of this space will be included in the tender specifications for the CCGT unit(s).

6.2.36 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of additional demineralised water requirements.

C11: Waste Water Treatment Plant

6.2.37 For both Development Option (i) and Development Option (ii), it is currently anticipated that the waste water generated by the CO_2 capture plant technology would be treated in the Water Treatment Plant for the CCGT unit(s). The resulting effluent would be discharged into the DP World® London Gateway Logistics Park drainage system swale. Alternatively, the waste water will be directly discharged into the DP World® London Gateway Logistics Park drainage system swale. All waste water will be treated to control concentrations of various compounds to within the limits prescribed by an Environmental Permit.

6.2.38 Therefore, the provision of space for any additional waste water generated will be provide within the Water Treatment Plant for the CCGT unit(s) and the DP World® London Gateway Logistics Park drainage system swale. The requirement for the provision of this space will be included in the tender specifications for the CCGT unit(s).

6.2.39 In addition, for both Development Option (i) and Development Option (ii), the final design of the CO_2 capture plant technology will include provisions for surface water drainage, contaminated surface water drainage (which will initially drain to oil interceptors) and process water drainage. This will also be discharged into the DP World® London Gateway Logistics Park drainage system swale.

6.2.40 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of additional waste water.

C12: Electrical

6.2.41 For both Development Option (i) and Development Option (ii), the gas turbine and steam turbine generators of the CCGT unit(s), and any associated step-up transformers, will be sized for maximum generator output. Similarly, the outgoing high voltage (HV) electrical connection to National Grid Electricity Transmission System (and associated systems) will also be designed for the maximum electrical power output of GEC.

6.2.42 However, the retrofitting and integration of CO_2 capture plant technology will lead to an estimated electrical requirement of:

- For Development Option (i), approximately 93 MW; or
- For Development Option (ii), approximately 40 MW.

6.2.43 At this stage it is suggested that this electrical requirement is met by a reduction in the electrical output from the CCGT unit(s) to the National Grid Electricity Transmission System using auxiliary transformers.

6.2.44 For both Development Option (i) and Development Option (ii), the provision of space for additional electrical plant / equipment associated with specific power plant / CO_2 capture plant items (i.e. pumps / fans) will be provided within the respective plant item areas. This additional electrical plant / equipment is small in size and could be readily accommodated.

6.2.45 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of electrical, subject to detailed design being carried out.

C13: Plant Pipe Racks

6.2.46 Within Figure 1620002349-018-00006 (P02) (for Development Option (i)) and Figure 1620002349-018-00007 (P02) (for Development Option (ii)), the provision of space is shown for plant pipe racks to allow interconnection of the CCGT unit(s) and the CO_2 capture plant technology. The requirement for the provision of this space will be included in the tender specifications.

6.2.47 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical

barriers to retrofitting and integration of the CO_2 capture plant technology in terms of plant pipe racks.

C14: Control and Instrumentation

6.2.48 For both Development Option (i) and Development Option (ii), the control and instrumentation system for the CO_2 capture plant technology is anticipated to be incorporated into the Distributed Control System (DCS) for the CCGT unit(s) / GEC (i.e. would be within the Control Building for the CCGT units(s) / GEC).

6.2.49 Therefore, the provision of space for the control and instrumentation system will comprise that to be used for the routing of cabling to / from and the installation of equipment within the Control Building for the CCGT units(s) / GEC. The requirement for the provision of this space will be included in the tender specifications for the CCGT units(s) / GEC.

6.2.50 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of control and instrumentation.

C15: Plant Infrastructure

6.2.51 Within Figure 1620002349-018-00006 (P02) (for Development Option (i)) and Figure 1620002349-018-00007 (P02) (for Development Option (ii)), the provision of space for plant infrastructure (i.e. the CO_2 capture plant technology) is shown. In addition, the design basis for the CCGT unit(s) / GEC ensures that offices and stores are sufficiently sized for the additional requirements of the CO_2 capture plant technology.

6.2.52 Furthermore, the GEC site is accessible from the existing road network, and is not considered to have any access constraints which could impede future construction / operational activities.

6.2.53 Therefore, subject to detailed design being carried out for both Development Option (i) and Development Option (ii), it is considered that there are no foreseeable technical barriers to retrofitting and integration of the CO_2 capture plant technology in terms of plant infrastructure.

6.3 Future Considerations

6.3.1 As part of the Status Reports, this technical assessment will be reviewed.

7. TECHNICAL ASSESSMENT – CO_2 STORAGE SITES

7.1 Requirements of the CCR Guidance

7.1.1 The requirement for this technical assessment is to:

- Provide the estimated CO_2 storage requirement;
- Identify a possible CO_2 storage site, including delineating the geological extent of that site, and identify within that site at least two oil or gas/gas condensate fields (or saline aquifers) listed in the range of geological formations identified as "viable" or "realistic" in 'Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK'[17] (October 2006); and,
- Provide an estimate of the potential total CO_2 which could be stored in the CO_2 storage site.

7.2 Technical Assessment

7.2.1 Based on Table 4.1 (for Development Option (i)) and Table 4.3 (for Development Option (ii)), Table 7.1 provides the estimated CO_2 storage requirements over a 35 year period.

TABLE 7.1: ESTIMATED CO_2 STORAGE REQUIREMENTS

		Development Option (i)	*Development Option (ii)*
Total CO_2 Storage Site Requirement (Assuming operational lifetime of 35 years)	Mt	84.2	43.8

7.2.4 Both the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study identified the Hewett (L Bunter) gas field and the Leman gas field, within the South North Sea (SNS) region, as possible CO_2 storage sites. Both gas fields are identified as "viable" or "realistic" in 'Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK' (October 2006), with CO_2 storage capacities of 237 Mt of CO_2 and 1,203 Mt of CO_2 respectively.

7.2.5 FIGURE 4 'Indicative Location of Storage Areas and Off-Shore Pipeline Route' from the 2010 CCR Feasibility Study, dated 23/09/09, delineated the extent of these CO_2 storage sites. Appendix A provides this Figure.

7.2.6 Based on Table 7.1, Table 7.2 provides the estimated percentage CO_2 storage requirements over a 35 year period for the identified gas fields.

TABLE 7.2: ESTIMATED PERCENTAGE CO_2 STORAGE REQUIREMENTS

		Development Option (i)	*Development Option (ii)*
Total CO_2 Storage Site Requirement (Assuming operational lifetime of 35 years)	Mt	84.2	43.8
Hewett (L Bunter) Gas Field (CO_2 Storage Capacity of 237 Mt of CO_2)	%	35.5	18.5
Leman Gas Field (CO_2 Storage Capacity of 1,203 Mt of CO_2)	%	7.0	3.6

7.2.9 It is noted that on the BEIS Website[18], that the Hewett gas field (both L Bunter and U Bunter) has a CO_2 storage capacity of 359 Mt of CO_2, and has three potential users (Damhead Creek 2 (84 Mt of CO_2), Willington C (200 Mt of CO_2) and GEC[19] (74 Mt of CO_2)) and a remaining CO_2 storage capacity of 1 Mt of CO_2. Therefore, using the Hewett gas field for Development Option (i) would result in its CO_2 storage capacity being

[17] Available at: https://webarchive.nationalarchives.gov.uk/+/http:/www.berr.gov.uk/files/file35684.pdf
[18] 'CO_2 storage sites – areas identified for potential use in CCR Feasibilities Studies'. Available at: https://itportal.beis.gov.uk/EIP/pages/c02.htm
[19] Based on the 2010 CCR Feasibility Study.

exceeded. Accordingly, it is proposed that the preferred CO_2 storage site for GEC is changed to the Leman gas field.

7.2.10 In addition, it is noted that in the future it is likely that there may be competing interest for these identified CO_2 storage site as other CCS projects become operational. However, there are clearly a large number of additional CO_2 storage site which exist in the SNS region that are capable of meeting the estimated CO_2 storage requirements of GEC. Indeed, Table 7.3 lists CO_2 storage sites available in the SNS region that can meet the maximum estimated CO_2 storage requirement of GEC[20].

TABLE 7.3: CO_2 STORAGE SITES IN THE SNS REGION

Field Name	***CO_2 Storage Capacity (Mt of CO_2)***
Barque	108
Galleon	137
Hewett L Bunter	237
Hewett U Bunter	122
Indefatigable	357
Leman	1,203
Ravenspurn North	93
V Fields	143
Viking	221
Windermere	143
Total	**2,764**

7.2.11 Therefore, whilst the decision as to which specific CO_2 storage site to use will not be made until eventual retrofitting and integration of the CO_2 capture technology, Table 7.3 shows that the potential CO_2 storage sites in the SNS region (which are capable of meeting the maximum estimated CO_2 storage requirement of GEC) have a total CO_2 storage capacity in excess of 2,700 Mt of CO_2. The maximum estimated CO_2 storage requirement of GEC is less than 3.1% of this total CO_2 storage capacity.

7.2.12 Also, as noted in the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, at the time of eventual retrofitting and integration of the CO_2 capture technology there may be an available 'CO_2 Network' in the region such that captured CO_2 from GEC, and other combustion plants in the region, would be delivered to a 'central hub'. From this 'central hub', the captured CO_2 would be delivered to a number of different CO_2 storage sites.

7.3 Future Considerations

7.3.1 As part of the Status Reports, this technical assessment will be reviewed.

[20] There are other CO_2 storage sites with smaller CO_2 storage capacities than that required to satisfy the maximum estimated CO_2 storage requirements of GEC. However, these CO_2 storage sites have not been listed here.

8. TECHNICAL ASSESSMENT – CO_2 TRANSPORT

8.1 Requirements of the CCR Guidance

8.1.1 The requirement for this technical assessment is to:

- Demonstrate that a feasible on-shore and off-shore route exists from the Proposed Development site to the CO_2 storage site;
- Identify, for the first 10 km surrounding the Proposed Development site, a 1 km wide corridor for the route; and,
- Identify, after the first 10 km from the Proposed Development site, a 10 km wide corridor for the route (including both the on-shore and off-shore route).

8.2 Technical Assessment

8.2.1 For both Development Option (i) and Development Option (ii), the CO_2 transport technical assessment in Section 8 of the 2010 CCR Feasibility Study and Section 8 of the 2014 CCR Feasibility Study remains valid and appropriate.

8.2.2 FIGURE 5 'Indicative On-Shore / Near Shore Pipeline Route' from the 2010 CCR Feasibility Study, dated 22/09/09, identified a 1 km wide corridor for the route, and FIGURE 4 ''Indicative Location of Storage Areas and Off-Shore Pipeline Route' from the 2010 CCR Feasibility Study, dated 23/09/09, identified a 10 km wide corridor for the route. Appendix A provides these Figures.

8.3 Future Considerations

8.3.1 As part of the Status Reports, this technical assessment will be reviewed.

9. ECONOMIC ASSESSMENT

9.1 Requirements of the CCR Guidance

9.1.1 The requirements for the economic assessment are to demonstrate the full range of costs and benefits associated with the deployment of the CO_2 capture plant technology, CO_2 transport and CO_2 storage, and discuss: "*the likelihood that it will be economically feasible within the power station's lifetime to link it to the full CCS chain, covering retrofitting of carbon capture equipment, transport and storage*".

9.2 Introduction

9.2.1 This section presents the results of the economic assessment which investigates the feasibility of retrofitting and integration of the CO_2 capture plant technology. The economic assessment tests a number of key industry and market sensitivities, and is consistent with the assessments completed for the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, as well as other CCR Feasibility Studies.

9.2.2 In terms of undertaking an economic assessment the CCR Guidance notes (at paragraph 68) a wide range of parameters, including:

- Assumed £ / € exchange rate;
- Future fuel prices (both absolute and relative to other fuels);
- Electricity price levels;
- Carbon price;
- Output with / without CO_2 capture, transport and storage;
- Lifetime load factor;
- CO_2 emitted with / without CO_2 capture, transport and storage;
- Estimations of costs of retrofitting CO_2 capture equipment (construction and operation);
- Estimations of costs of transport (construction and operation);
- Estimations of costs of storage (permitting and operation); and,
- Reasonable estimations of when these costs would be incurred.

9.2.3 With regards to these parameters, the estimations of costs used in this economic assessment are based on CO_2 capture, transport and storage technologies available in 2014 / 2015, updated where more recent studies are available. These costs are expected to reduce in time, bearing in mind the recent and likely future developments in technology.

9.3 Approach / Assessment Methodology

9.3.1 For both Development Option (i) and Development Option (ii), an economic model has been developed to calculate the lifetime cost of electricity, expressed in p/kWh, over an assumed 35 year economic lifetime. As per the requirements of the CCR Guidance, the economic model includes the likely costs of CO_2 capture, transport and storage. However, the economic model does not include the effects of taxation.

9.3.2 Using the economic model, the economic feasibility was assessed by varying the price of EU Allowances under the EU Emissions Trading Scheme (EU ETS) / UK Carbon Floor Price (carbon price) whilst the remaining parameters remained constant. Carbon prices ranged from €0/t CO_2 to €200/t CO_2. This allowed for the identification of the carbon price where CO_2 capture, transport and storage would become economically feasible.

9.3.3 Insert 9.1 presents the approach / assessment methodology.

INSERT 9.1: ECONOMIC ASSESSMENT METHODOLOGY

Step 1

- The economic model calculates the cost of electricity generation (p/kWh) over the proposed operational lifetime without the addition of CO_2 capture, transport and storage.
- This assumes that allowances must be purchased for 100% of the residual CO_2 emissions.

Step 2

- The economic model calculates the costs of electricity generation (p/kWh) over the proposed operational lifetime with the addition of CO_2 capture, transport and storage (for a number of different Scenarios).
- Again, this assumes that allowances must be purchased for 100% of the residual CO_2 emissions.

Step 3

- The Base Case assumptions are subjected to a sensitivity analysis to identify potential ranges for the carbon price for the different Scenarios.

Step 4

- The range of costs of electricity generation (p/kWh) for the different Scenarios are plotted graphically to present the range of carbon prices within which retrofitting CO_2 capture, transport and storage would be economically feasible.

9.4 Estimations / Assumptions

9.4.1 Table 9.1 presents the estimations and assumptions.

TABLE 9.1: CENTRAL ESTIMATIONS / ASSUMPTIONS

Variable	***Assumption***
Assumed First Year of Operation	2021
£:€ Exchange Rate[21]	1.1594
Nominal Discount Rate	10%
Gas Price	52 p/therm[22]
Carbon Allocations	None (Full Purchase)
Development Option (i): Impact of CO_2 Capture, Transport and Storage	
Net Output	1246 MW
Net Output with CCS[23]	1050 MW
Lifetime capacity factor	75%
CO_2 emitted before retrofitting CO_2 capture	330 kg/MWh
CO_2 emitted after retrofitting CO_2 capture	Approximately 37 kg/MWh
Development Option (ii): Impact of CO_2 Capture, Transport and Storage	
Net Output	616 MW
Net Output with CCS[23]	520 MW
Lifetime load factor	75%
CO_2 emitted by before retrofitting CO_2 capture	Approximately 331 kg/MWh
CO_2 emitted after retrofitting CO_2 capture	Approximately 37 kg/MWh

9.5 Economic Assessment Scenarios

9.5.1 For both Development Option (i) and Development Option (ii), the economic model runs three possible scenarios relating to the readiness level of the CO_2 capture technology and the possible transport and storage infrastructure options. These three possible scenarios are:

- Scenario A: First of a Kind Plant, with dedicated Transport and Storage

  Scenario A assumes that the CCGT unit(s) will be the first to be fitted with CO_2 capture, transport and storage amongst the CCR CCGT unit fleet. This means that the construction cost will be relatively high because of the lack of experience.

  In addition, within Scenario A, it is assumed that all of the on-shore and off-shore transport and storage infrastructure will be based on new assets. This infrastructure will be sized to the CCGT unit(s) and would be 'dedicated'.

- Scenario B: First of a Kind Plant, with dedicated Transport and Reused Storage

  Similar to Scenario A, Scenario B assumes that the CCGT unit(s) will be the first to be fitted with CO_2 capture, transport and storage amongst the CCR CCGT unit fleet. This means that the construction cost will be relatively high because of the lack of experience.

  However, within Scenario B, it is assumed that both on-shore and off-shore transport pipelines are based on new assets that would be sized to SEE, but that the storage infrastructure can be re-used. Storage site re-use will allow for a reduction in storage costs.

[21] Exchange rate taken on 29 April 2019.
[22] Based on the Higher Heating Value (HHV).
Source:
https://www.utilityhelpline.co.uk/latest-news/wholesale-energy-prices-update-08-02-2019
[23] Includes additional auxiliary power for CO_2 compression and fin-fan coolers, and lost generation because of steam extraction for CO_2 capture.

- Scenario C: Nth of a Kind Plant, with shared Transport and Storage

  Scenario C assumes that the CCGT unit(s) will be fitted with CO_2 capture, transport and storage after the majority of the CCR CCGT unit fleet. This means that the construction cost will be relatively lower due to learning curve effects.

  Within Scenario C, it is assumed that a CO_2 network with several other emitters will be used. To recognise this possibility, the economic model has been run for a case where the transport and storage system (and associated costs) is shared[24]. Within this economic assessment, associated costs allocated to the CCGT unit(s) have been assumed to be approximately 16%.

9.6 Sensitivity Analysis

9.6.1 For each of the economic assessment scenarios, the economic model has the capability to vary the three sensitivities listed below:

- Discount Rate

  Whilst a nominal 10% discount rate is considered to be a reasonable value for a base case analysis for a CCGT unit project, the retrofitting of CO_2 capture, transport and storage at some time in the future is considered to present an additional risk to developers. Therefore, a higher risk-adjusted discount rate of 12.5% has been added to reflect this risk.

- Gas Price

  Volatility in the gas market (assuming continued linkage with oil) in the UK in recent years has shown that there remains significant uncertainty in the longer-term forward gas price. Therefore, the economic assessment has modelled what is considered to be outlying possibilities for the gas price with a ±30% uncertainty range.

- Capital Cost

  The capital cost for the CCGT unit(s) has been stressed with a ±10% uncertainty range. This uncertainty is applied to the CCGT unit(s) and the CO_2 capture, transport and storage.

9.6.2 Based on these three sensitivities, the economic model runs illustrated in this economic assessment show the cumulative effects of factors increasing the cost of electricity (high gas price, high capital cost, high discount rate), and of factors decreasing the cost of electricity (low gas price, low capital cost). Table 9.2 describes the high and low sensitivity runs for each economic assessment scenario.

TABLE 9.2: SENSITIVITY ANALYSIS RUNS

	Discount Rate	***Gas Price***	***Capital Costs***
High	12.5%	+30%	+10%
Low	10%	-30%	-10%

9.7 Economic Assessment

Development Option (i)

9.7.1 Insert 9.2 and Insert 9.3 present the variation of generation costs with carbon price. The generation costs (in p/kWh) is shown on the y-axis and the carbon price is shown on the x-axis. Solid lines represent the central case for each Scenario and the dotted lines represent the 'high' and 'low' sensitivity analysis runs.

9.7.2 Insert 9.2 compares the results of the economic model for the Base Case (black line) with Scenario A (blue line) and Scenario B (green line). Insert 9.2 shows that for carbon prices in the range €0/tonne to €200/tonne:

[24] Whilst the CCR Guidance states that outsourcing transport and storage cannot be assumed in a CCR Feasibility Study, such an option is included for comparative purposes.

- For the Base Case (i.e. without CO_2 capture, transport and storage), the lifetime cost of electricity ranges between 4.92 p/kWh and 8.85 p/kWh;
- For Scenario A:
  - The lifetime cost of electricity ranges between 7.66 p/kWh and 8.14 p/kWh; and,
  - The break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario A) is approximately €159/t CO_2.
- For Scenario B:
  - The lifetime cost of electricity ranges between 7.57 p/kWh and 8.05 p/kWh; and,
  - The break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario B) is approximately €154/t CO_2.

9.7.3 Insert 9.3 compares the results of the economic model for the Base Case (black line) with Scenario C (red line). Insert 9.3 shows that for carbon prices in the range €0/tonne to €200/tonne:

- For Scenario C:
  - The lifetime cost of electricity ranges between 6.81 p/kWh and 7.28 p/kWh; and,
  - The break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario C) is approximately €109/t CO_2.

9.7.4 Insert 9.4 provides a comparison of the break-even carbon prices.

Development Option (ii)

9.7.5 Insert 9.5 and Insert 9.6 present the variation of generation costs with carbon price. The generation costs (in p/kWh) is shown on the y-axis and the carbon price is shown on the x-axis. Solid lines represent the central case for each Scenario and the dotted lines represent the 'high' and 'low' sensitivity analysis runs.

9.7.6 Insert 9.5 compares the results of the economic model for the Base Case (black line) with Scenario A (blue line) and Scenario B (green line). Insert 9.5 shows that for carbon prices in the range €0/tonne to €200/tonne:

- For the Base Case (i.e. without CO_2 capture, transport and storage), the lifetime cost of electricity ranges between 4.94 p/kWh and 8.87 p/kWh;
- For Scenario A:
  - The lifetime cost of electricity ranges between 8.02 p/kWh and 8.50 p/kWh; and,
  - The break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario A) is approximately €179/t CO_2.
- For Scenario B:
  - The lifetime cost of electricity ranges between 7.93 p/kWh and 8.41 p/kWh; and,
  - The break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario B) is approximately €173/t CO_2.

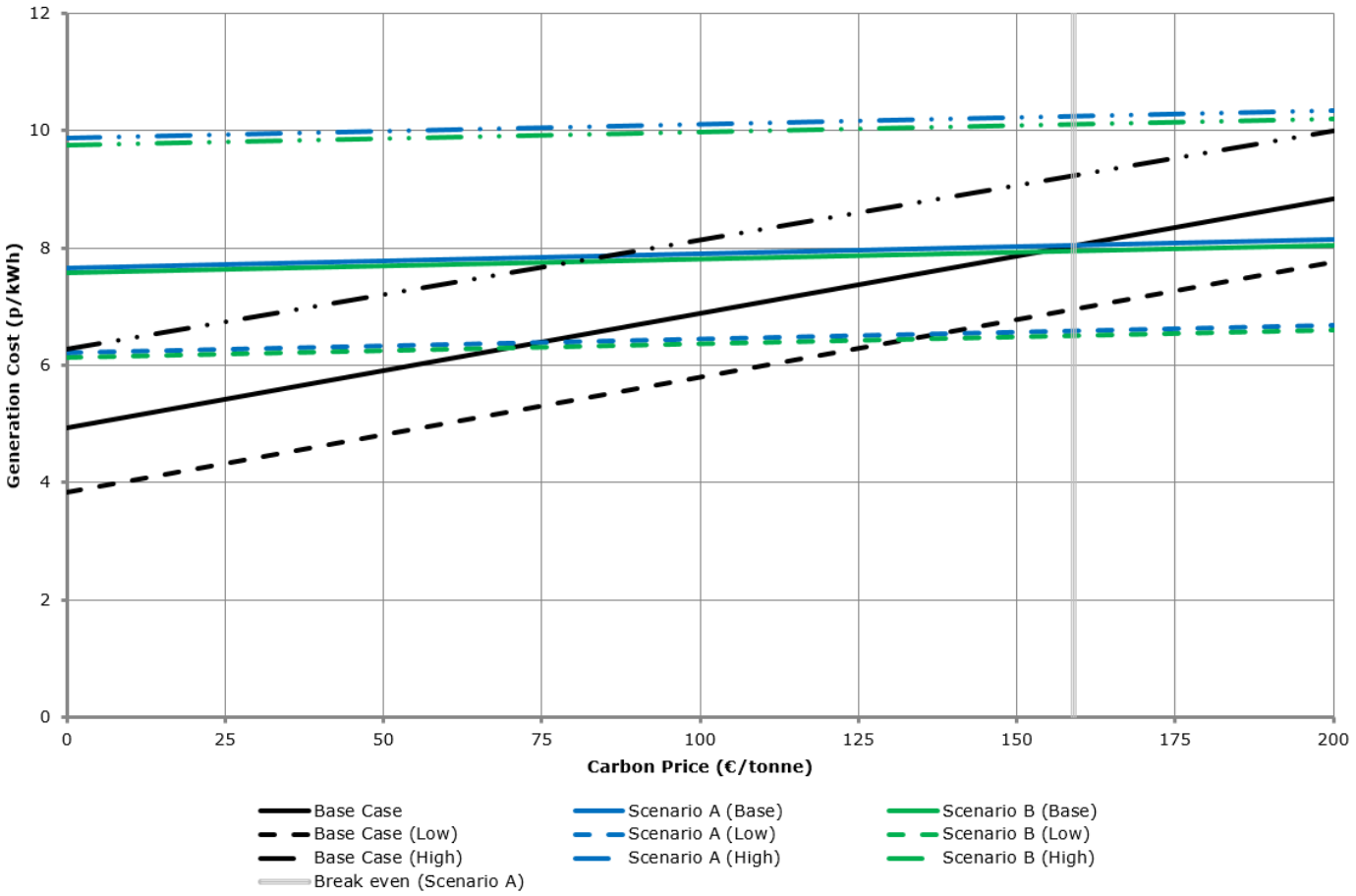
9.7.7 Insert 9.6 compares the results of the economic model for the Base Case (black line) with Scenario C (red line). Insert 9.6 shows that for carbon prices in the range €0/tonne to €200/tonne:

- For Scenario C:
  - The lifetime cost of electricity ranges between 7.04 p/kWh and 7.52 p/kWh; and,

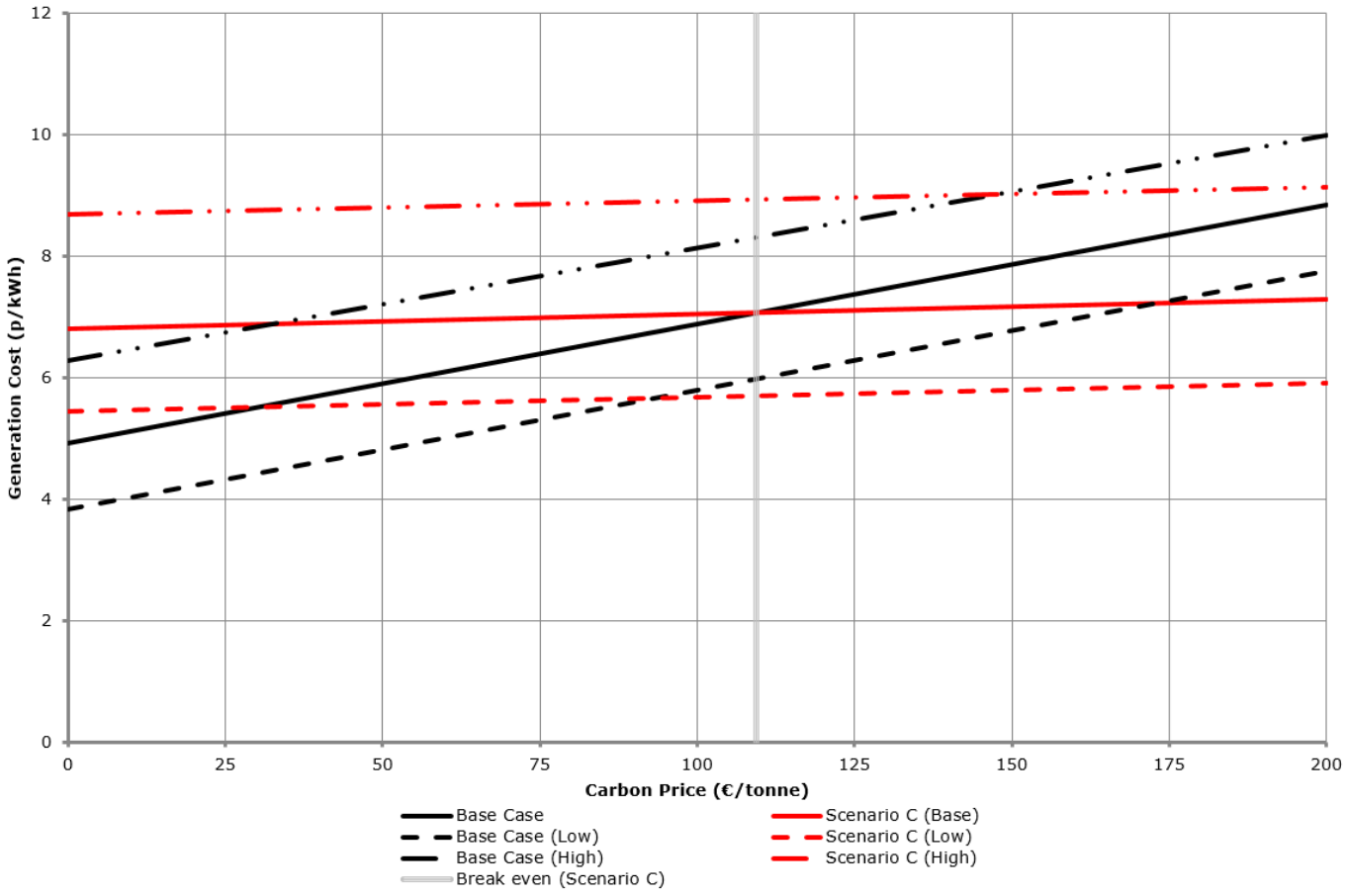
- The break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario C) is approximately €122/t CO_2.

9.7.8 Insert 9.7 provides a comparison of the break-even carbon prices.

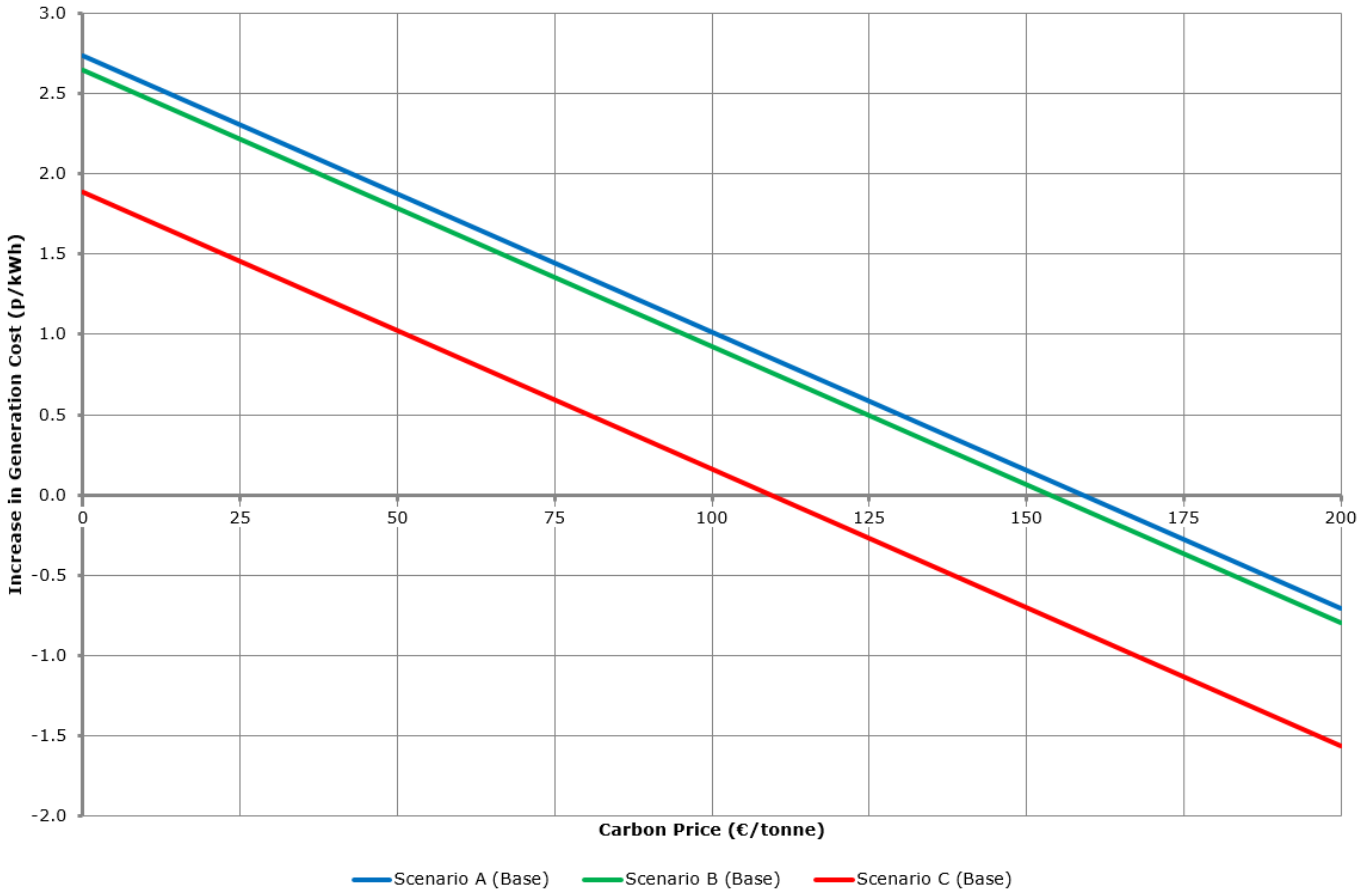
INSERT 9.2: DEVELOPMENT OPTION (i)
ECONOMIC MODEL FOR THE BASE CASE COMPARED WITH SCENARIO A AND SCENARIO B



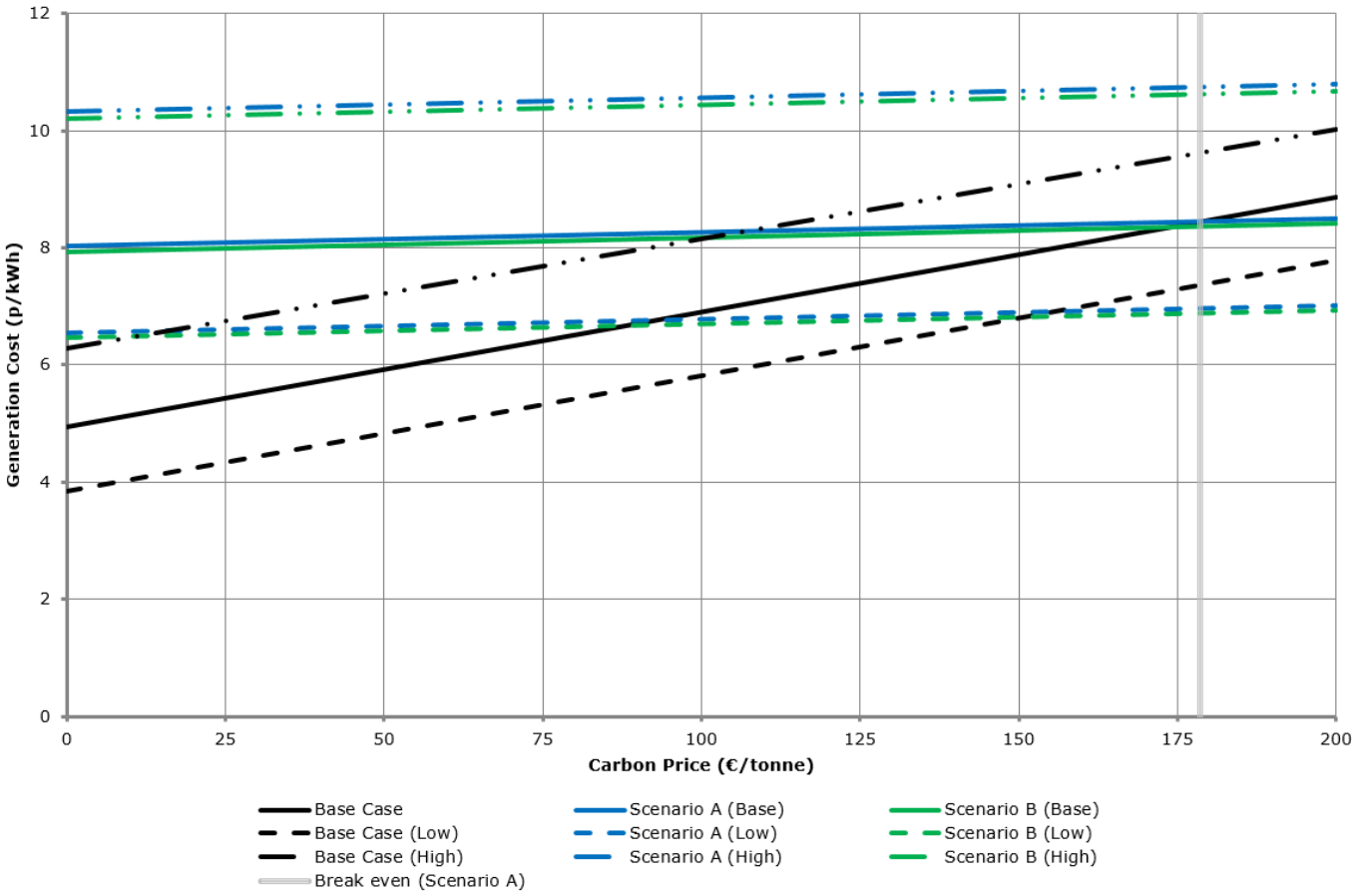
INSERT 9.3: DEVELOPMENT OPTION (i)
ECONOMIC MODEL FOR THE BASE CASE COMPARED WITH SCENARIO C



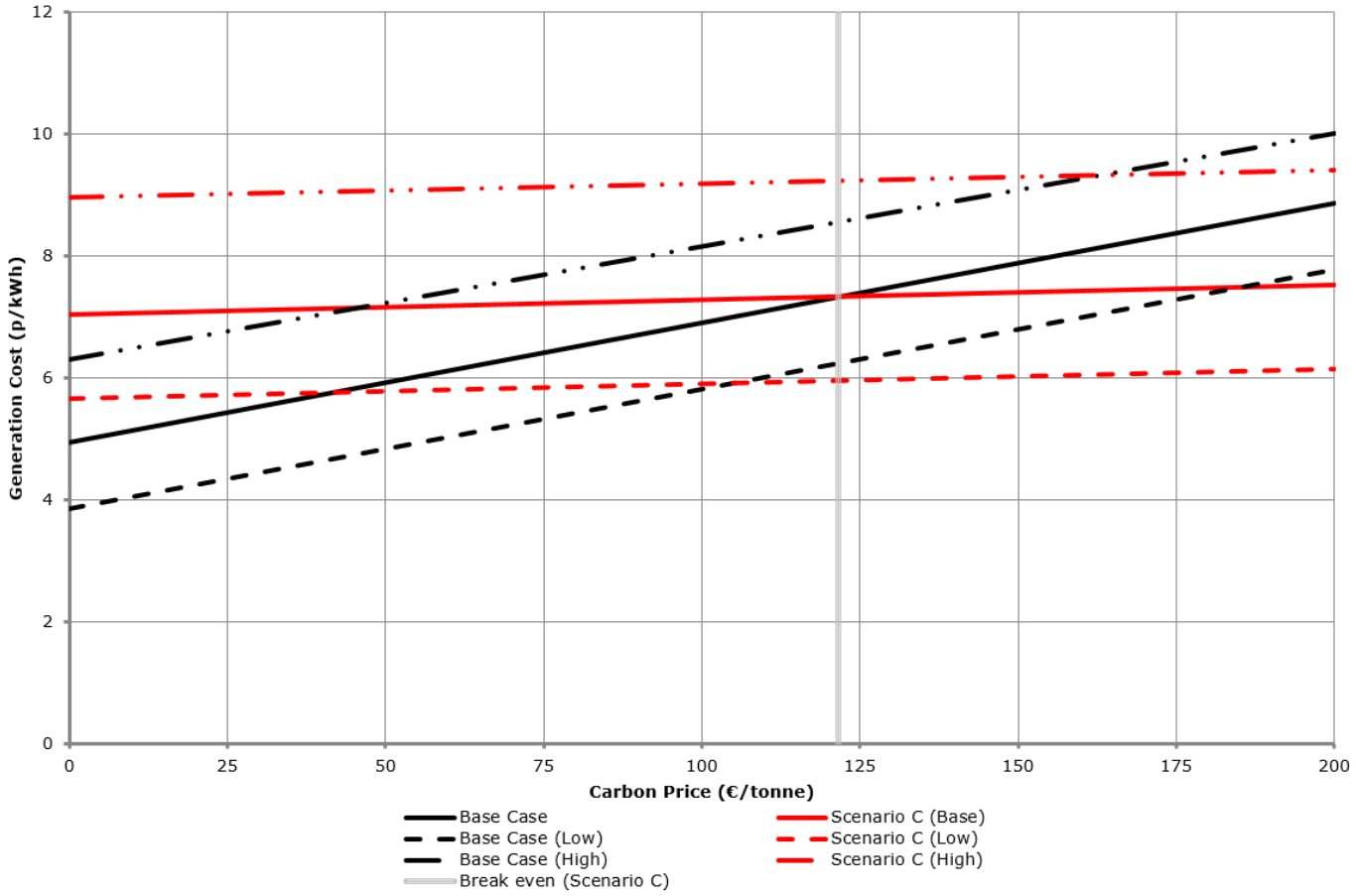
INSERT 9.4: DEVELOPMENT OPTION (i)
COMPARISON OF BREAK-EVEN CARBON PRICES



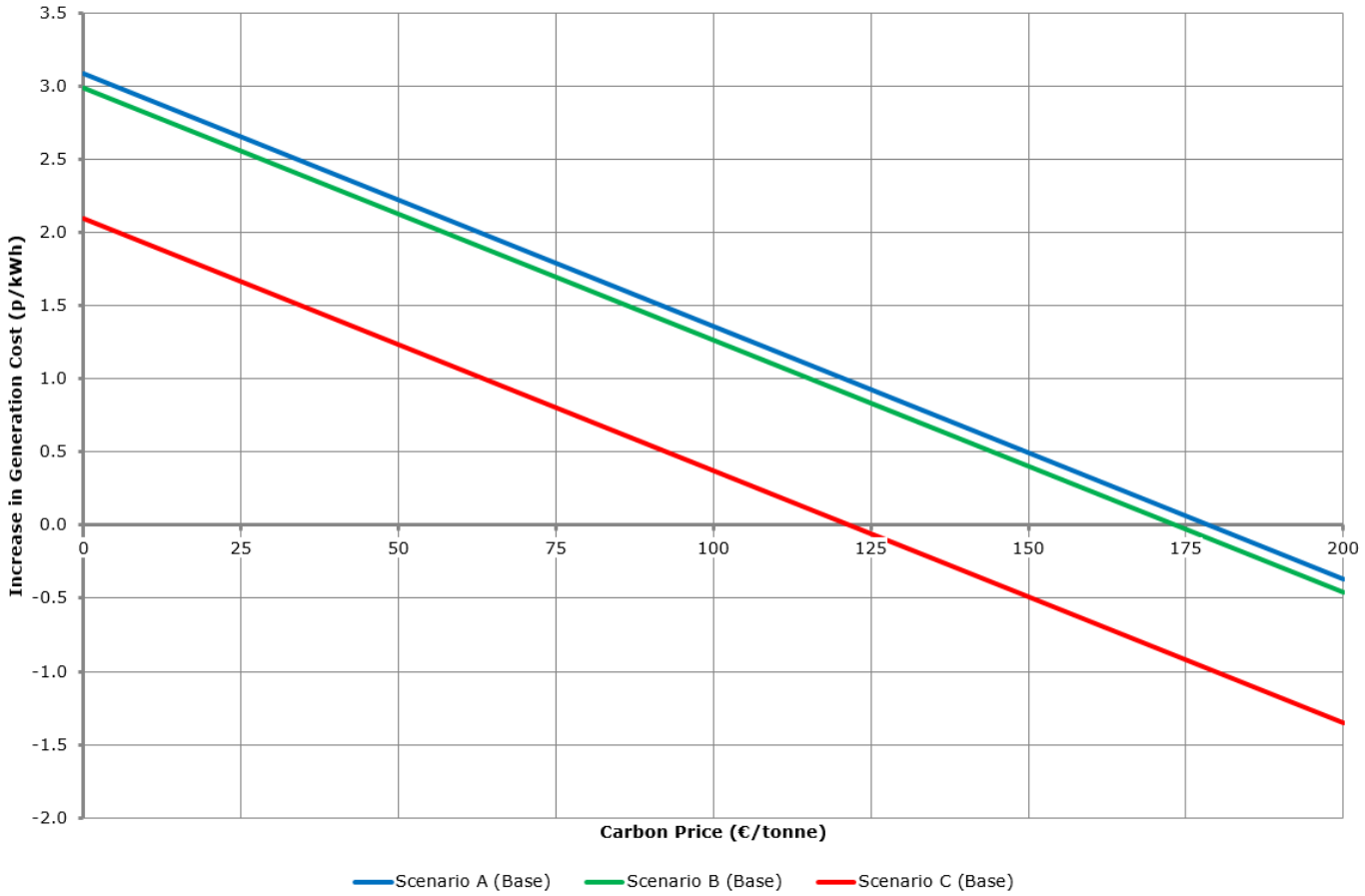
INSERT 9.5: DEVELOPMENT OPTION (ii)
ECONOMIC MODEL FOR THE BASE CASE COMPARED WITH SCENARIO A AND SCENARIO B



INSERT 9.6: DEVELOPMENT OPTION (ii)
ECONOMIC MODEL FOR THE BASE CASE COMPARED WITH SCNEARIO C



INSERT 9.7: DEVELOPMENT OPTION (ii)
COMPARISON OF BREAK-EVEN CARBON PRICES



9.8 Impact of Capacity Factor

9.8.1 The assumed capacity factor of 75% for the CCGT unit(s) has an impact on the cost of electricity.

Development Option (i)

9.8.2 If the capacity factor is adjusted to 100%:

- For the Base Case (i.e. within CO_2 capture, transport and storage), the lifetime cost of electricity ranges between 4.61 p/kWh (at €0/t CO_2) and 8.53 p/kWh (at €200/t CO_2);
- For Scenario A, the break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario A) would drop to approximately €133/t CO_2; and,
- For Scenario C, the break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario A) would drop to approximately €95/t CO_2.

Development Option (ii)

9.8.3 If the capacity factor is adjusted to 100%:

- For the Base Case (i.e. within CO_2 capture, transport and storage), the lifetime cost of electricity ranges between 4.62 p/kWh (at €0/t CO_2) and 8.55 p/kWh (at €200/t CO_2);
- For Scenario A, the break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario A) would drop to approximately €148/t CO_2; and,
- For Scenario C, the break-even carbon price (where the cost of electricity for the Base Case equals the cost of electricity for Scenario A) would drop to approximately €105/t CO_2.

9.9 Conclusions

9.9.1 In interpreting the following, it is important to note that whilst the EU-ETS carbon price has recovered from its mid-2014 low of around €5/t CO_2, its current price is still only around €27/t CO_2.

Development Option (i)

9.9.2 The results of the economic assessment indicate that the retrofitting of CO_2 capture, transport and storage becomes economic:

- Under Scenario A (First of a Kind Plant, with dedicated Transport and Storage) on the basis of carbon prices of approximately €159/t CO_2; and,
- Under Scenario C (Nth of a Kind Plant, with shared Transport and Storage) on the basis of carbon prices of approximately €109/t CO_2.

9.9.3 Increasing the assumed capacity factor from 75% to 100%, the results of the economic assessment indicate that the retrofitting of CO_2 capture, transport and storage becomes economic:

- Under Scenario A (First of a Kind Plant, with dedicated Transport and Storage) on the basis of carbon prices of approximately €133/t CO_2; and,
- Under Scenario C (Nth of a Kind Plant, with shared Transport and Storage) on the basis of carbon prices of approximately €95/t CO_2.

Development Option (ii)

9.9.4 The results of the economic assessment indicate that the retrofitting of CO_2 capture, transport and storage becomes economic:

- Under Scenario A (First of a Kind Plant, with dedicated Transport and Storage) on the basis of carbon prices of approximately €179/t CO_2; and,

- Under Scenario C (Nth of a Kind Plant, with shared Transport and Storage) on the basis of carbon prices of approximately €122/t CO_2.

9.9.5 Increasing the assumed capacity factor from 75% to 100%, the results of the economic assessment indicate that the retrofitting of CO_2 capture, transport and storage becomes economic:

- Under Scenario A (First of a Kind Plant, with dedicated Transport and Storage) on the basis of carbon prices of approximately €148/t CO_2; and,
- Under Scenario C (Nth of a Kind Plant, with shared Transport and Storage) on the basis of carbon prices of approximately €105/t CO_2.

10. HAZARDOUS SUBSTANCES CONSENT

10.1 Requirements of the CCR Guidance

10.1.1 The CCR Guidance states that if the proposals for the CO_2 capture technology and / or CO_2 transport involve the storage or use on site of substances classified under Schedule 1 of the Planning (Hazard Substances) Regulations 1992[25], it may be necessary to make an application for HSC at the same time as applying for initial generating station consent.

10.1.2 Therefore, the requirement for this assessment is to determine the need, or otherwise, for an application for HSC.

10.2 Assessment

10.2.1 For Development Option (i), the assessment (based on a post-combustion CO_2 capture process using an amino acid salt) in Section 10 of the 2014 Updated CCR Feasibility Study remains valid and appropriate. This assessment concluded that, on the basis of current knowledge, an application for HSC was not required.

10.2.2 For Development Option (ii), the assessment (based on a post-combustion CO_2 capture process using MEA) in Section 10 of the 2010 CCR Feasibility Study remains valid and appropriate. This assessment concluded that, on the basis of current knowledge, an application for HSC was not required.

10.3 Future Considerations

10.3.1 As part of the Status Reports, this assessment will be reviewed.

[25] Now the Planning (Hazardous Substances) Regulations 2015, available at: http://www.legislation.gov.uk/uksi/2015/627/contents/made

11. CONCLUSIONS

11.1.1 This 2019 Updated CCR Feasibility Study, in combination with the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study (as independently verified by Imperial College in the 2014 Assessment of the CCR Compliance of the Proposed Gateway Energy Centre Report), demonstrates that it remains feasible to retrofit a CO_2 capture chain to GEC within its 35 year operating lifetime, and that GEC remains compliant with the requirements of the CCR Guidance.

11.1.2 Based on the requirements of the CCR Guidance, Table 11.1 provides the required content of a CCR Feasibility Study and a link to the relevant section(s) of these documents where the required content can be found.

TABLE 11.1: REQUIRED CONTENT OF A CCR FEASIBILITY STUDY

Requirement	***Description***	***Reference***
Technical Assessment – Space Requirement		
CCR Guidance (Paragraphs 18 to 19)	The requirement for this technical assessment is to provide an illustrative site layout ("*outline plot level plan*") which is sufficiently detailed to show: • The footprint of the Proposed Development; • The location of the CO_2 capture plant technology; • The location of any CO_2 compression technology; • The location of any chemical storage facilities; and • The exit point of the CO_2 pipeline.	Information provided in Section 5 (Technical Assessment – Space Requirement). In particular: • For Development Option (i), Figure 1620002349-018-00006 (P02) provides the associated illustrative site layout, which covers an area of approximately 4.5 ha. The CO_2 terminal point has been placed to match the most likely CO_2 transport option (i.e. via on shore pipeline). • For Development Option (ii), Figure 1620002349-018-00007 (P02) provides the associated illustrative site layout, which covers an area of approximately 2.4 ha. The CO_2 terminal point has been placed to match the most likely CO_2 transport option (i.e. via on shore pipeline).
	Basic calculations, using the estimated CO_2 requirements, could usefully be included.	Information provided in Section 4 (Proposed CO_2 Capture Process and Estimated CO_2 Capture / Storage Requirements). In particular: • For Development Option (i), Table 4.1 provides a summary of the estimated CO_2 capture and storage requirements. • For Development Option (ii), Table 4.3 provides a summary of the estimated CO_2 capture and storage requirements.
Technical Assessment – Retrofitting and Integration		
CCR Guidance (Paragraphs 30 to 31)	The 'CCR Feasibility Study' should make clear which CO_2 capture plant technology is considered most appropriate for retrofitting and integration.	Information provided in Section 4 (Proposed CO_2 Capture Process and Estimated CO_2 Capture / Storage Requirements).
	The 'CCR Feasibility Study' should provide sufficient detail to demonstrate that there are currently no known technical barriers to subsequent retrofitting and integration of this CO_2 capture plant technology.	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration).
	The 'CCR Feasibility Study' should take into account the IEA Reference Document (IEAGHG 2007/4 'CO_2 Capture Ready Plants') Advisory Checklists.	In terms of this 2019 Updated CCR Feasibility Study, the technical assessment is made against the information provided in Annex C ('Environment Agency Verification of CCS Readiness New Natural Gas Combined Cycle Power Station using Post Combustion Solvent Scrubbing') of the CCR Guidance.

Requirement	***Description***	***Reference***
Annex C: 'Environment Agency Verification of CCS Readiness New Natural Gas Combined Cycle Power Station using Post Combustion Solvent Scrubbing'		
C1: Design, Planning Permissions and Approvals	The CCR Guidance requires that: "*a pre-feasibility level conceptual capture retrofit study should be supplied for assessment showing how the proposed CCR features would make adding post-combustion capture technology technically feasible, together with an outline plot level plan for the plant retrofitted with capture*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.2 to 6.2.3. Also see information provided in Section 5 (Technical Assessment – Space Requirement) and Section 6 (Technical Assessment – Retrofitting and Integration). In particular: • For Development Option (i), Figure 1620002349-018-00006 (P02) provides the associated illustrative site layout, which covers an area of approximately 4.5 ha. • For Development Option (ii), Figure 1620002349-018-00007 (P02) provides the associated illustrative site layout, which covers an area of approximately 2.4 ha.
C2: Power Plant Location	The CCR Guidance requires that: "*the work undertaken on CO_2 transport and storage should be referenced; the exit point of gases from the curtilage of the plant and how this affects the configuration of the capture equipment is the important aspect for the Environment Agency*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.4 to 6.2.5. Information provided in Section 5 (Technical Assessment – Space Requirement), Section 7 (Technical Assessment – CO_2 Storage Sites) and Section 8 (Technical Assessment – CO_2 Transport). In particular for both Development Option (i) (on Figure 1620002349-018-00006 (P02)) and Development Option (ii) (on Figure 1620002349-018-00007 (P02)), CO_2 terminal point has been placed to match the most likely CO_2 transport option (i.e. via on shore pipeline).

Requirement	***Description***	***Reference***
C3: Space Requirements	The CCR Guidance states: *"space will be required for the following:* *(a) CO_2 capture equipment, including any flue gas pre-treatment and CO_2 drying and compression;* *(b) Space for routing flue gas duct to the CO_2 capture equipment;* *(c) Steam turbine island additions and modifications (e.g. space in steam turbine building for routing large low pressure steam pipe to amine scrubber unit);* *(d) Extension and addition of balance of plant systems to cater for the additional requirements of the capture equipment;* *(e) Additional vehicle movements (amine transport, etc.); and,* (f) *Space allocation for storage and handling of amines and handling of CO_2 including space for infrastructure to transport CO_2 to the plant boundary."* The CCR Guidance requires that: "*it is expected that all of the provision in a-f above will be implemented, including the provision of space and access to carry out the necessary works at the time of retrofitting without excessive interruptions to normal plant operations. A statement describing how the space allocations were determined and how they be met is required. Further details are required in the following sections as appropriate. The space for capture equipment might be significantly reduced if flue gas recycling through the gas turbine is used to concentrate the CO_2, but to validate this option suitable demonstrations of its feasibility by the gas turbine supplier would be required*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.6 to 6.2.8.
C4: Gas Turbine Operation with Increased Exhaust Pressure	The CCR Guidance states: *"the gas turbine (and upstream ducting and heat recovery steam generator (HRSG)) must be able to operate with the increased back pressure imposed by the capture equipment, or alternatively space must be provided for a booster fan*". The CCR Guidance requires that: "*a statement is required giving the expected pressure drop required for current commercial capture equipment together with a manufacturer's confirmation that the gas turbine can accommodate this and any effects on the performance, or alternatively describing booster fan specification together with space and other installation requirements*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.9 to 6.2.12.

Requirement	***Description***	***Reference***
C5: Flue Gas System	The CCR Guidance states: *"space should be available for installing new duct work to enable interconnection of the existing flue gas system with the amine scrubbing plant and provisions in the duct work for tie-ins and addition of items, such as bypass dampers and isolation dampers, will be required as a minimum. If selective catalytic reduction (SCR) or other flue gas treatment is likely to be added at the time of retrofit then space for this should also be provided"*. The CCR Guidance requires that: "*a statement is required describing the space and required flue gas system configuration for retrofit requirements and how they will be implemented*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.13 to 6.2.15.
C6: Steam Cycle	The CCR Guidance requires that: "*a statement is required giving steam pressure at the steam turbine IP/LP crossover (or other steam extraction point), together with a description of any post-retrofit equipment modifications / additions. It should be demonstrated that the steam cycle could be operated with capture using solvent systems with a range of steam requirements. The energy penalty involved in such steam extraction should be estimated and compared to theoretical minimum values (i.e. for extraction from a similar steam cycle that has been purpose-built for such steam extraction)*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.16 to 6.2.22.
C7: Cooling Water System	The CCR Guidance states: *"the amine scrubber, flue gas cooler and CO_2 compression plant introduced for CO_2 capture increase the overall power plant cooling duty*". The CCR Guidance requires that: "*a statement is required of estimated cooling water demands (flows and temperatures) with capture and how these will be met. It is expected that necessary space and tie-ins for cooling water supplies to post-combustion capture equipment will be provided and a description of these should be included*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.23 to 6.2.27.
C8: Compressed Air System	The CCR Guidance states: *"the capture equipment addition will call for additional compressed air (both service and instrument air) requirements"*. The CCR Guidance requires that: "*a statement is required of estimated additional compressed air requirements together with a description of how these will be accommodated*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.28 to 6.2.30.

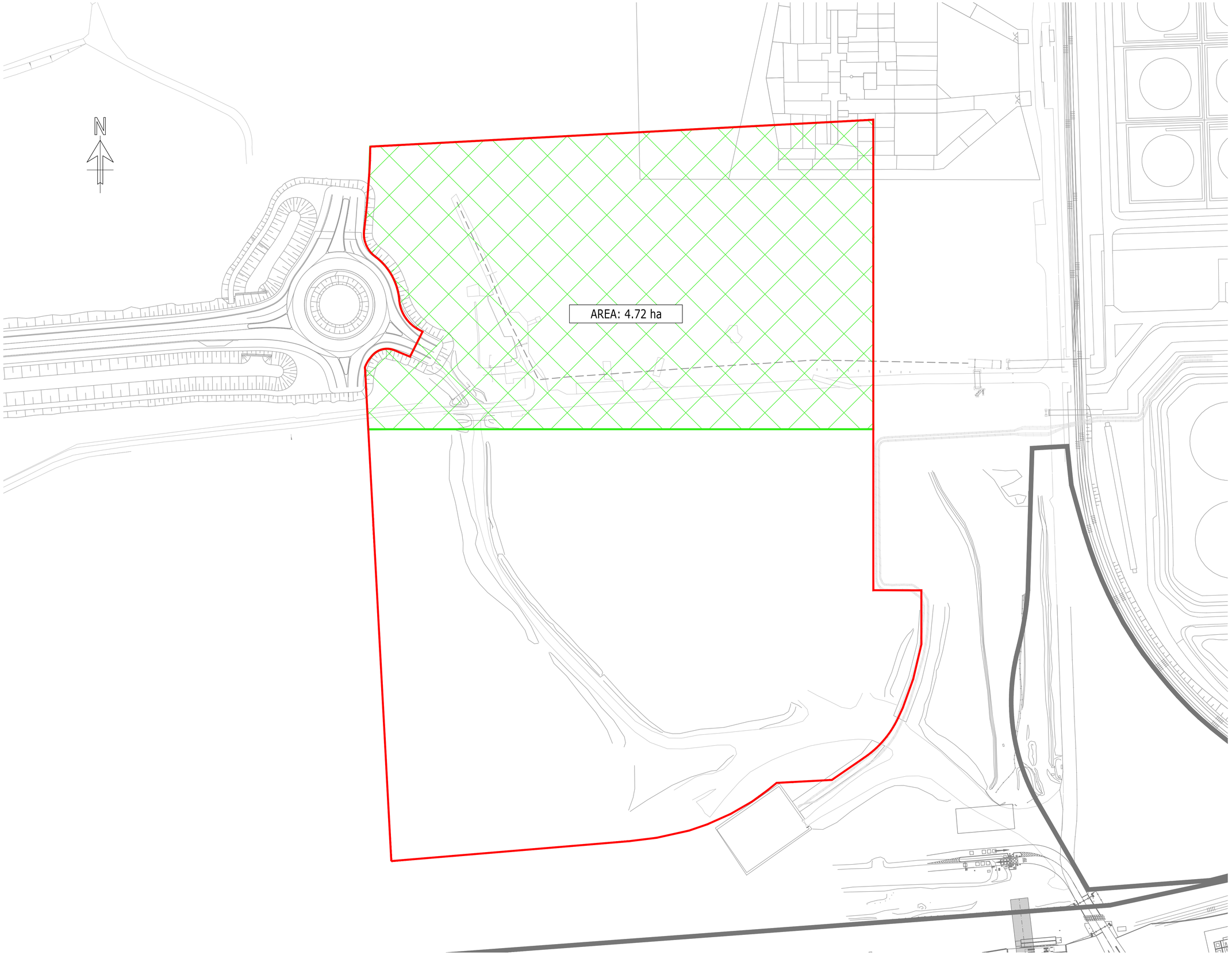
Requirement	***Description***	***Reference***
C9: Raw Water Pre-Treatment Plant	The CCR Guidance states: *"space shall be considered in the raw water pre-treatment plant area to add additional raw water pre-treatment streams as required".* The CCR Guidance requires that: "*a statement is required of estimated treated raw water requirements together with a description of how these will be accommodated"*.	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.31 to 6.2.33.
C10: Demineralisation / Desalination Plant	The CCR Guidance states: *"a supply of reasonably pure water may be required to make up evaporative losses from the flue gas cooler and / or scrubber. Estimates of this water requirement should be made and space allocated for the necessary treatment plant (and an additional water source be identified if necessary"*. The CCR Guidance requires that: "*a statement is required saying which one of the above are needed and in what quantity and also describing how the necessary provisions will be implemented"*.	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.34 to 6.2.36.
C11: Waste Water Treatment Plant	The CCR Guidance states: *"amine scrubbing plant along with flue gas coolers (if appropriate) provided for post-combustion CO_2 capture will result in generation of additional effluents"*. The CCR Guidance requires that: "*a statement is required giving estimated additional waste water treatment needs and describing how the necessary space and any other provisions will be provided to meet expected demands"*.	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.37 to 6.2.40.
C12: Electrical	The CCR Guidance states: *"the introduction of amine scrubber plant along with flue gas coolers, booster fans (if required), and CO_2 compression plant will lead to a number of additional electrical loads (e.g. pumps, compressors)"*. The CCR Guidance requires that: "*a statement is required listing the estimated additional electrical requirements and describing space allocation in suitable locations for items such as additional transformers, switching gear and cabling*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.41 to 6.2.45.
C13: Plant Pipe Racks	The CCR Guidance states: *"installation of additional pipework after retrofit with carbon capture will be required due to the use of a large quantity of LP steam in the amine scrubbing plant reboiler, return of condensate into the water-steam-condensate cycle, additional cooling water piping and possibly other plant modifications."* The CCR Guidance requires that: "*it is expected that provision will be made for space for routing new pipework at the appropriate locations. A statement identifying anticipated significant additional pipeline and describing space allocations to accommodate these is required*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.46 to 6.2.47.

Requirement	***Description***	***Reference***
C14: Control and Instrumentation	The CCR Guidance requires that: "*it is expected that space and provisions for additional control equipment and cabling will be implemented. A statement identifying anticipated additional control equipment and describing space and other provisions to accommodate these is required*".	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.48 to 6.2.50.
C15: Plant Infrastructure	The CCR Guidance states: *"space to widen roads and add new roads (to handle increased movement of transport vehicles), space to extend office buildings (to accommodate additional plant personnel after capture retrofit) and space to extend stores buildings are foreseeable. Consideration should also be given as to how, during a retrofit, vehicles and cranes will access the areas where new equipment will need to be erected".* The CCR Guidance requires that: "*it is expected that the provisions above will be implemented. A statement identifying anticipated requirements and describing how they will be met is required".*	Information provided in Section 6 (Technical Assessment – Retrofitting and Integration). In particular, see paragraphs 6.2.51 to 6.2.53.
Technical Assessment – CO_2 Storage Sites		
CCR Guidance (Paragraph 42)	The requirement for this technical assessment is to: • Provide the estimated CO_2 storage requirement; • Identify a possible CO_2 storage site, including delineating the geological extent of that site, and identify within that site at least two oil or gas/gas condensate fields (or saline aquifers) listed in the range of geological formations identified as "viable" or "realistic" in 'Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK'[26] (October 2006); and, • Provide an estimate of the potential total CO_2 which could be stored in the CO_2 storage site.	Information provided in Section 7 (Technical Assessment – CO_2 Storage Sites). In particular, for both Development Option (i) and Development Option (ii): • Table 7.1 provides a summary of the estimated CO_2 storage requirements over a 35 year period. • In line with both the 2010 CCR Feasibility Study and the 2014 Updated CCR Feasibility Study, the Hewett (L Bunter) gas field and the Leman gas field, within the South North Sea (SNS) region, were identified as possible CO_2 storage sites. Both gas fields are identified as "viable" or "realistic" in 'Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK' (October 2006), with CO_2 storage capacities of 237 Mt of CO_2 and 1,203 Mt of CO_2 respectively. • Table 7.2 provides the estimated percentage CO_2 storage requirements over a 35 year period for the identified gas fields.

[26] Available at:
https://webarchive.nationalarchives.gov.uk/+/http:/www.berr.gov.uk/files/file35684.pdf

Requirement	***Description***	***Reference***
Technical Assessment – CO_2 Transport		
CCR Guidance (Paragraph 61)	The requirement for this technical assessment is to: • Demonstrate that a feasible on-shore and off-shore route exists from the Proposed Development site to the CO_2 storage site; • Identify, for the first 10 km surrounding the Proposed Development site, 1 km wide corridor for the route; • Identify, after the first 10 km from the Proposed Development site, a 10 km wide corridor for the route (including both the on-shore and off-shore route).	Information provided in Section 8 (Technical Assessment – CO_2 Transport). In particular, for both Development Option (i) and Development Option (ii), the CO_2 transport technical assessment in Section 8 of the 2010 CCR Feasibility Study and Section 8 of the 2014 CCR Feasibility Study remains valid and appropriate.
Economic Assessment		
CCR Guidance (Paragraph 61)	The requirements for the economic assessment are to demonstrate the full range of costs and benefits associated with the deployment of the CO_2 capture plant technology, CO_2 transport and CO_2 storage, and discuss: "*the likelihood that it will be economically feasible within the power station's lifetime to link it to the full CCS chain, covering retrofitting of carbon capture equipment, transport and storage*".	Information provided in Section 9 (Economic Assessment).
Hazardous Substances Consent		
	Determine the need, or otherwise, for an application for a Hazardous Substances Consent (HSC).	Information provided in Section 10 (Hazardous Substances Consent). In particular, for both Development Option (i) and Development Option (ii), the assessment concluded that, on the basis of current knowledge, an application for a HSC was not required.

FIGURES



Notes

Rev	Description	Date	By	Chk	App
P02	COMMENTS INCORPORATED.	21/05 2019	RISMI		EAGU

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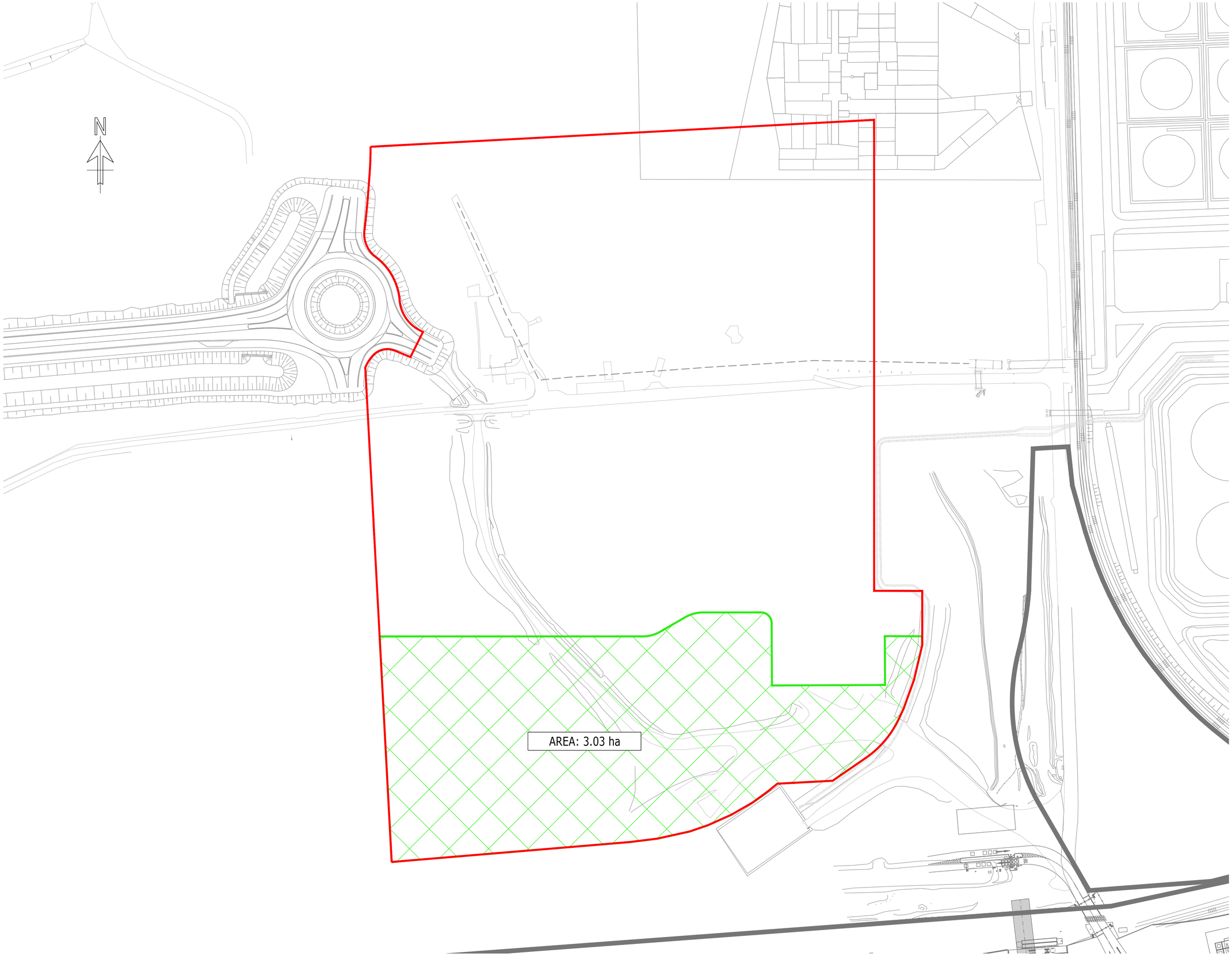
CARBON CAPTURE READINESS 'CCS Site for Development Option (i)'

Scale:	Date:	Drawn:	Checked:
1:1000 @A1	14/05/2019	RISMI	EAGU

Drawing No.: 1620002349-018-00004

Rev: P02



Notes

Rev	Description	Date	By	Chk	App
P02	COMMENTS INCORPORATED.	21/05 2019	RISMI		EAGU

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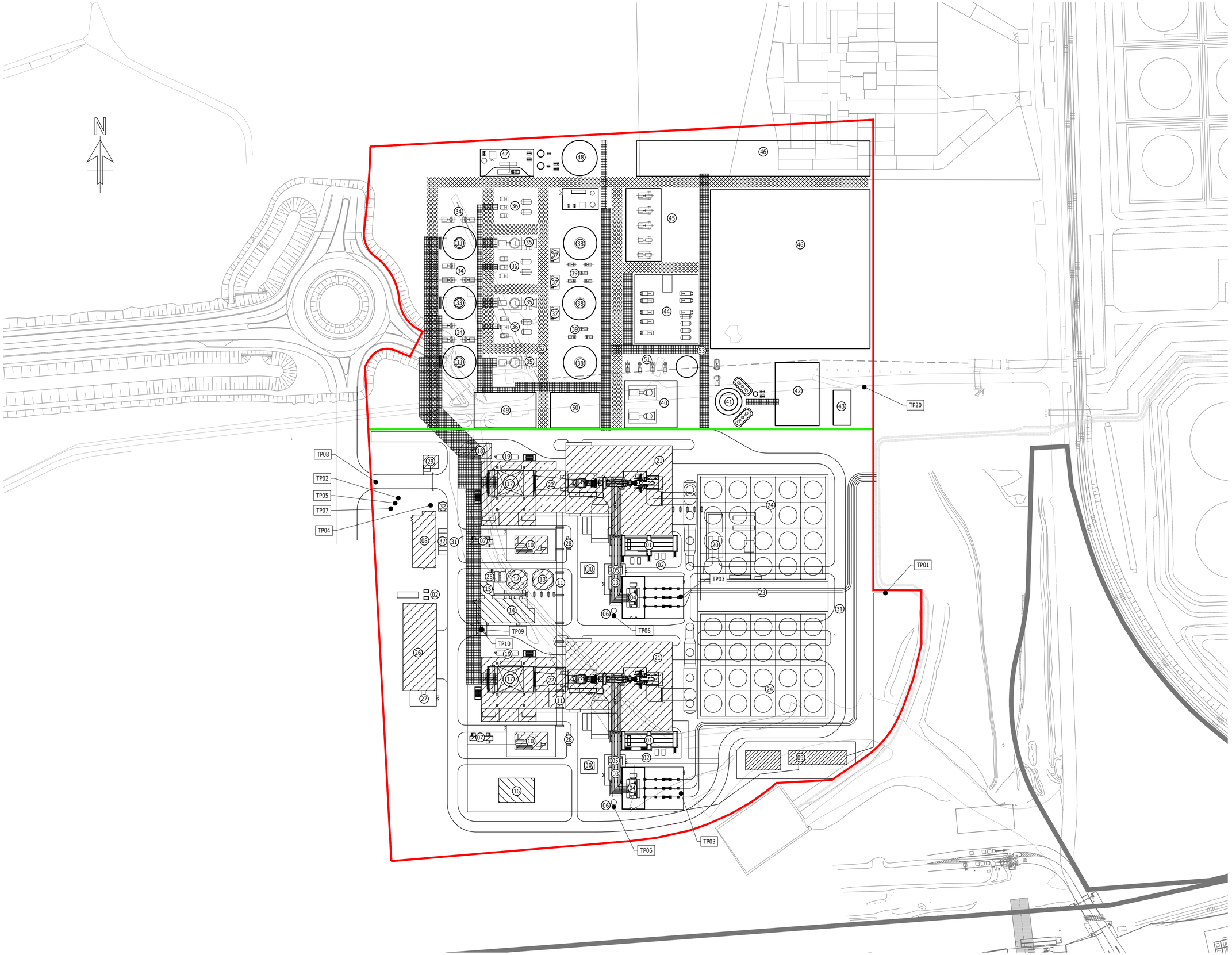
CARBON CAPTURE READINESS
'CCS Site for
Development Option (ii)'

Scale:	Date:	Drawn:	Checked:
1:1000 @A1	14/05/2019	RISMI	EAGU

Drawing No.: 1620002349-018-00005

Rev: P02



Notes

1. DRAWING LAYOUT BASED ON SIEMENS DRAWING GEC SCENARIO 1 AND SIEMENS POSTCAP - CO2 CAPTURE PLANT AREA INVESTIGATION.

KEY

01	CCGT	POWER CONTROL CENTRE
02	CCGT	LV AUXILIARY POWER TRANSFORMERS
03	CCGT	MV AUXILIARY POWER TRANSFORMERS
04	CCGT	GENERATOR TRANSFORMER
05	CCGT	START-UP TRANSFORMERS
06	CCGT	OIL INTERCEPTOR TANK
07	CCGT	EMERGENCY POWER GENERATING SET
08	CCGT	CONTROL ROOM BUILDING
09	CCGT	GAS PRESSURE REDUCING STATION
10	CCGT	GAS FINAL FILTER AND PREHEATING
11	CCGT	PIPE BRIDGE
12	CCGT	RAW WATER STORAGE TANK
13	CCGT	DEMINERALISED WATER STORAGE TANK
14	CCGT	WATER TREATMENT PLANT
15	CCGT	NEUTRALIZATION SYSTEM
16	CCGT	RAIN WATER RETENTION
17	CCGT	HEAT RECOVERY STEAM GENERATOR
18	CCGT	AUXILIARY STEAM GENERATOR
19	CCGT	SAMPLING CONTAINER
20	CCGT	CONDENSATE POLISHING PLANT
21	CCGT	GAS AND STEAM TURBINE BUILDING
22	CCGT	DIFFUSER
23	CCGT	FIN FAN COOLERS
24	CCGT	AIR COOLER CONDENSER
25	CCGT	FIRE FIGHTING PUMP CONTAINER
26	CCGT	WORKSHOP BUILDING
27	CCGT	GAS BOTTLE STORAGE
28	CCGT	AMMONIA DOSING CONTAINER
29	CCGT	GATEHOUSE
30	CCGT	CO2 SUPPLY SYSTEM
31	CCGT	ROADS
32	CCGT	PARKING AREA
33	CCS	FLUE GAS COOLER
34	CCS	QUENCH WATER PUMPS
35	CCS	FLUE GAS BLOWER
36	CCS	QUENCH WATER HEAT EXCHANGER W/ FILTER STATION
37	CCS	DOSING UNIT
38	CCS	ABSORBER
39	CCS	RICH SOLVENT PUMPS
40	CCS	LEAN SOLVENT FLASH UNIT
41	CCS	DESORBER UNIT
42	CCS	CO2 COMPRESSOR
43	CCS	DEHYDRATION UNIT / DE-OXYGENATION UNIT
44	CCS	LEAN SOLVENT COOLER; RICH/LEAN HEAT EXCHANGERS; STAND-BY HEATER
45	CCS	PUMPS OF SECONDARY COOLING SYSTEM
46	CCS	AIR COOLER
47	CCS	TRUCK UN-/LOADING STATION
48	CCS	SOLVENT STORAGE
49	CCS	ELECTRICAL POWER EC&I
50	CCS	STEAM AND CONDENSATE
51	CCS	LEAN SOLVENT PUMPS
52	CCS	ROAD
53	CCS	PIPE RACK

TERMINAL POINTS

TP01	CCGT	FUEL GAS
TP02	CCGT	RAW WATER / FIRE EXTINGUISHING WATER
TP03	CCGT	ELECTRICAL ENERGY HV
TP04	CCGT	TELEPHONE SYSTEM
TP05	CCGT	SANITARY WASTE
TP06	CCGT	DEPOSITS FROM OILY WATER
TP07	CCGT	STORM WATER
TP08	CCGT	ROADS
TP09	CCGT	CHEMICALS
TP10	CCGT	AMMONIA WASTE
TP20	CCS	C02 TERMINAL POINT

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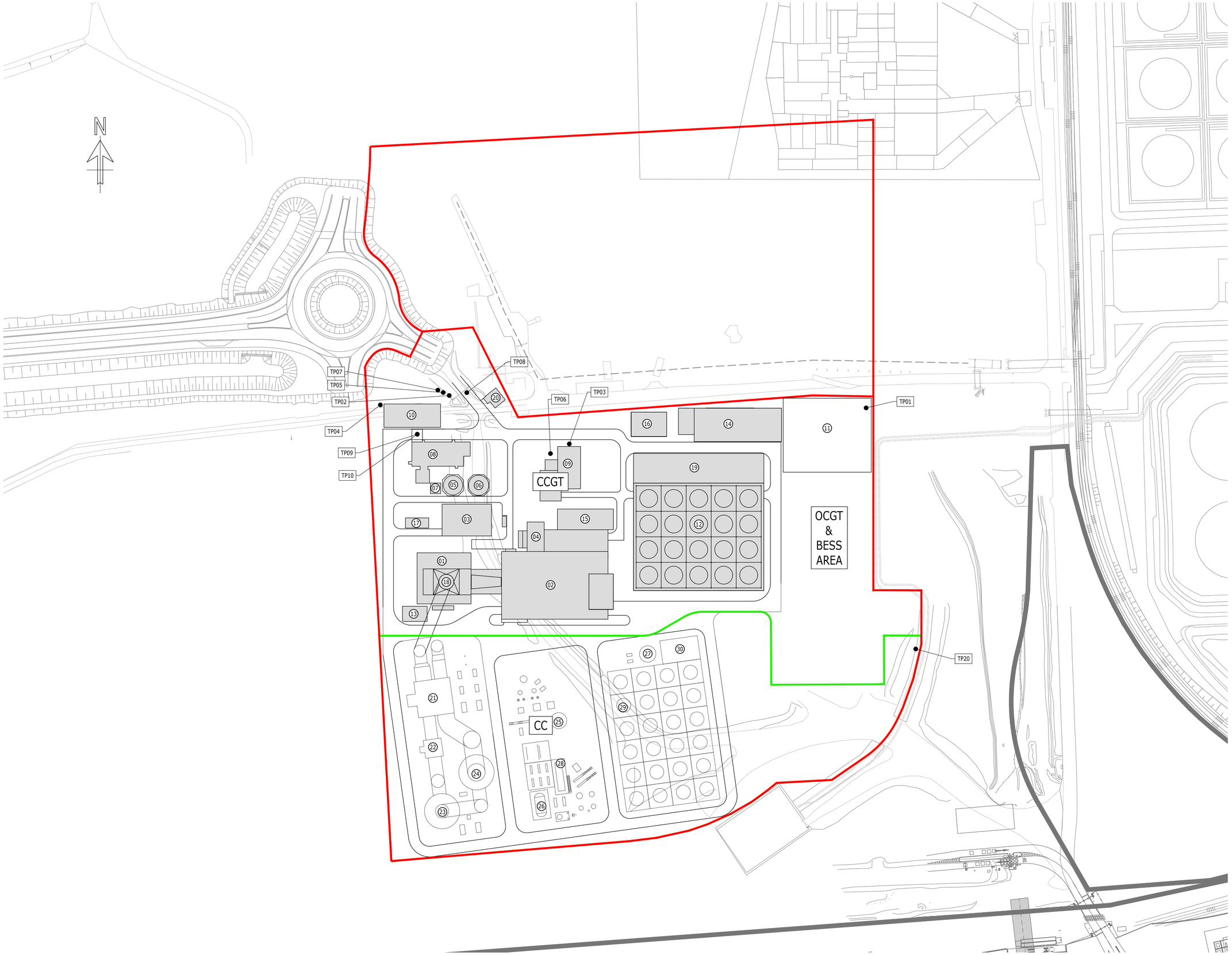
'Development Option (i)'
Illustrative Site Layout

Scale:	Date:	Drawn:	Checked:
1:1000 @A1	14/05/2019	RISMI	EAGU

Drawing No.: 1620002349-018-00006

Rev: P02



Notes

1. DRAWING LAYOUT BASED ON SIEMENS DRAWING GEC SCENARIO 2 AND FIGURE 1 - PROPOSED LAYOUT OF CCGT, OCGT AND CCS, REFERENCE 482301-1-01.

KEY

01	CCGT	HEAT RECOVERY STEAM GENERATOR
02	CCGT	TURBINE HALL
03	CCGT	GAS FINAL FILTER AND PREHEATING
04	CCGT	GT INLET FILTER
05	CCGT	DEMINERALISED WATER STORAGE TANK
06	CCGT	RAW WATER STORAGE TANK
07	CCGT	FIRE FIGHTING PUMPS
08	CCGT	WATER TREATMENT PLANT
09	CCGT	GENERATOR TRANSFORMER
10	CCGT	CONTROL / ADMIN BUILDING
11	CCGT	GAS PRESSURE REDUCTION STATION
12	CCGT	AIR COOLER CONDENSER
13	CCGT	AUXILIARY BOILER
14	CCGT	WORKSHOP / WAREHOUSE
15	CCGT	POWER CONTROL CENTRES
16	CCGT	RAIN WATER RETENTION
17	CCGT	EMERGENCY GENERATOR
18	CCGT	CCGT STACK
19	CCGT	FIN FAN COOLERS
20	CCGT	GATEHOUSE
21	CCS	GAS-GAS HEAT EXCHANGER
22	CCS	BLOWER
23	CCS	DIRECT CONTACT COOLER
24	CCS	ABSORBER
25	CCS	STRIPPER
26	CCS	RECLAIMER
27	CCS	SOLVENT STORAGE TANK
28	CCS	CO2 COMPRESSOR
29	CCS	FIN FAN COOLERS
30	CCS	CW PUMP HOUSE

TERMINAL POINTS

TP01	CCGT	FUEL GAS
TP02	CCGT	RAW WATER / FIRE EXTINGUISHING WATER
TP03	CCGT	ELECTRICAL ENERGY HV
TP04	CCGT	TELEPHONE SYSTEM
TP05	CCGT	SANITARY WASTE
TP06	CCGT	DEPOSITS FROM OILY WATER
TP07	CCGT	STORM WATER
TP08	CCGT	ROADS
TP09	CCGT	CHEMICALS
TP10	CCGT	AMMONIA WASTE
TP20	CCS	CO2 TERMINAL POINT

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'Development Option (ii)' Illustrative Site Layout

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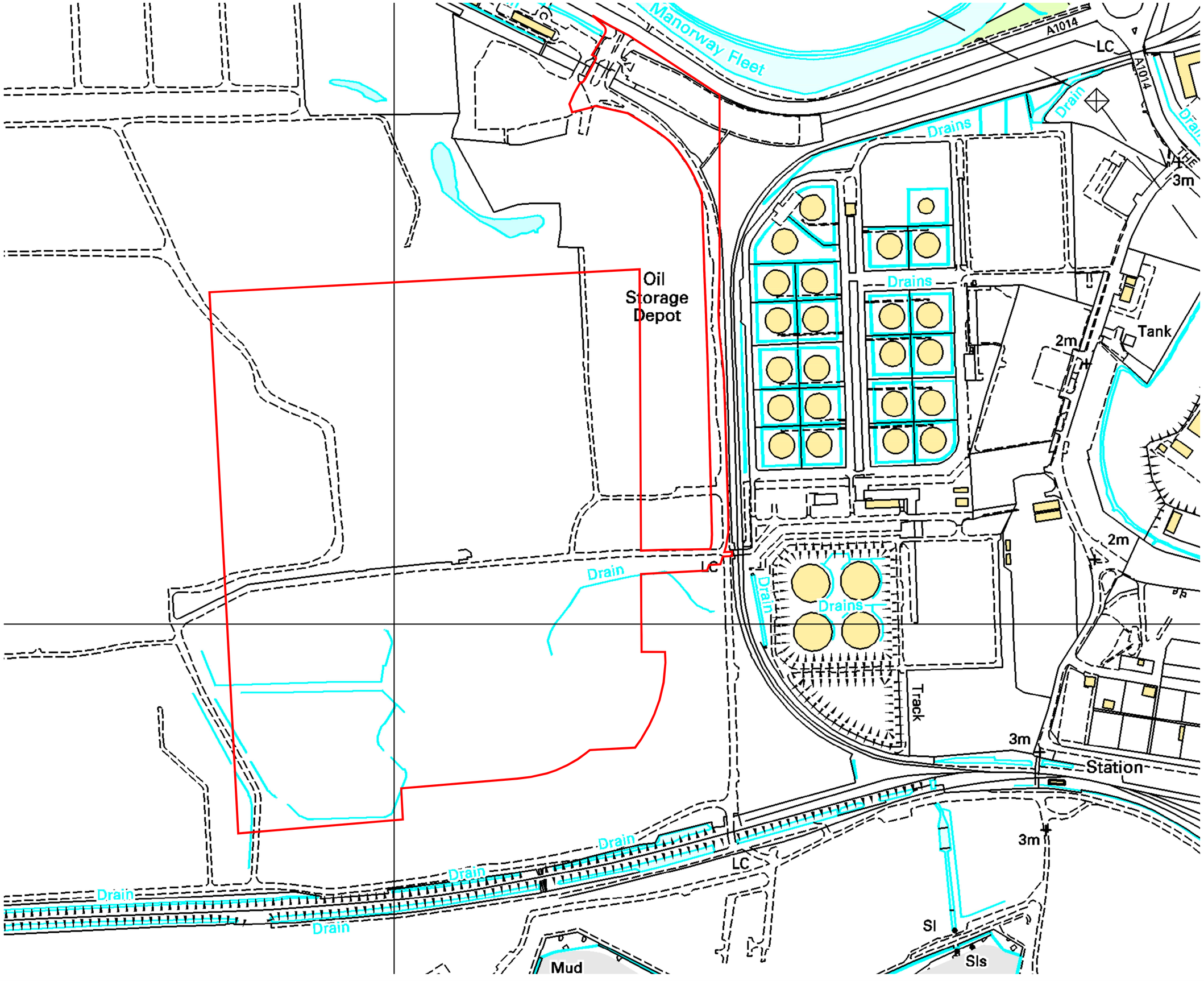
Drawing No.: 1620002349-018-00007

Rev: P02

APPENDIX A

This Appendix provides:

- The Overall Red-Line Boundary: FIGURE 63114-PBP-0025 associated with the existing consent;
- The Current Designated Site: The Land Hatched Yellow on FIGURE 3-B 'Illustrative Site Plan with Carbon Capture Areas' from the 2010 CCR Feasibility Study, dated 16/02/2010 associated with the existing consent;
- The Extent of the CO_2 Storage Sites / 10 km Wide Corridor for the CO_2 Transport Pipeline Route: FIGURE 4 'Indicative Location of Storage Areas and Off-Shore Pipeline Route' from the 2010 CCR Feasibility Study, dated 23/09/09; and,
- 1 km Wide Corridor for the CO_2 Transport Pipeline Route: FIGURE 5 'Indicative On-Shore / Near Shore Pipeline Route' from the 2010 CCR Feasibility Study, dated 22/09/09.



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REV	DATE		BY	CHKD	APPD

NOTES

- CLIENT: INTERGEN
- PROJECT: GATEWAY ENERGY CENTRE
- TITLE: RED LINE BOUNDARY

- DATE: 18/02/10
- SCALE: 1/2000 @A1
- CAD REF:

DRAWN BY	DD
PRODUCED BY	DD
CHECKED	JS
APPROVED	JS

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Amber Court, William Armstrong Drive, Newcastle upon Tyne, NE4 7YQ
Tel: 44-(0191) 2261234 Fax: 44-(0191) 2262345

- DRAWING NUMBER: 63114-PBP-0025 | –

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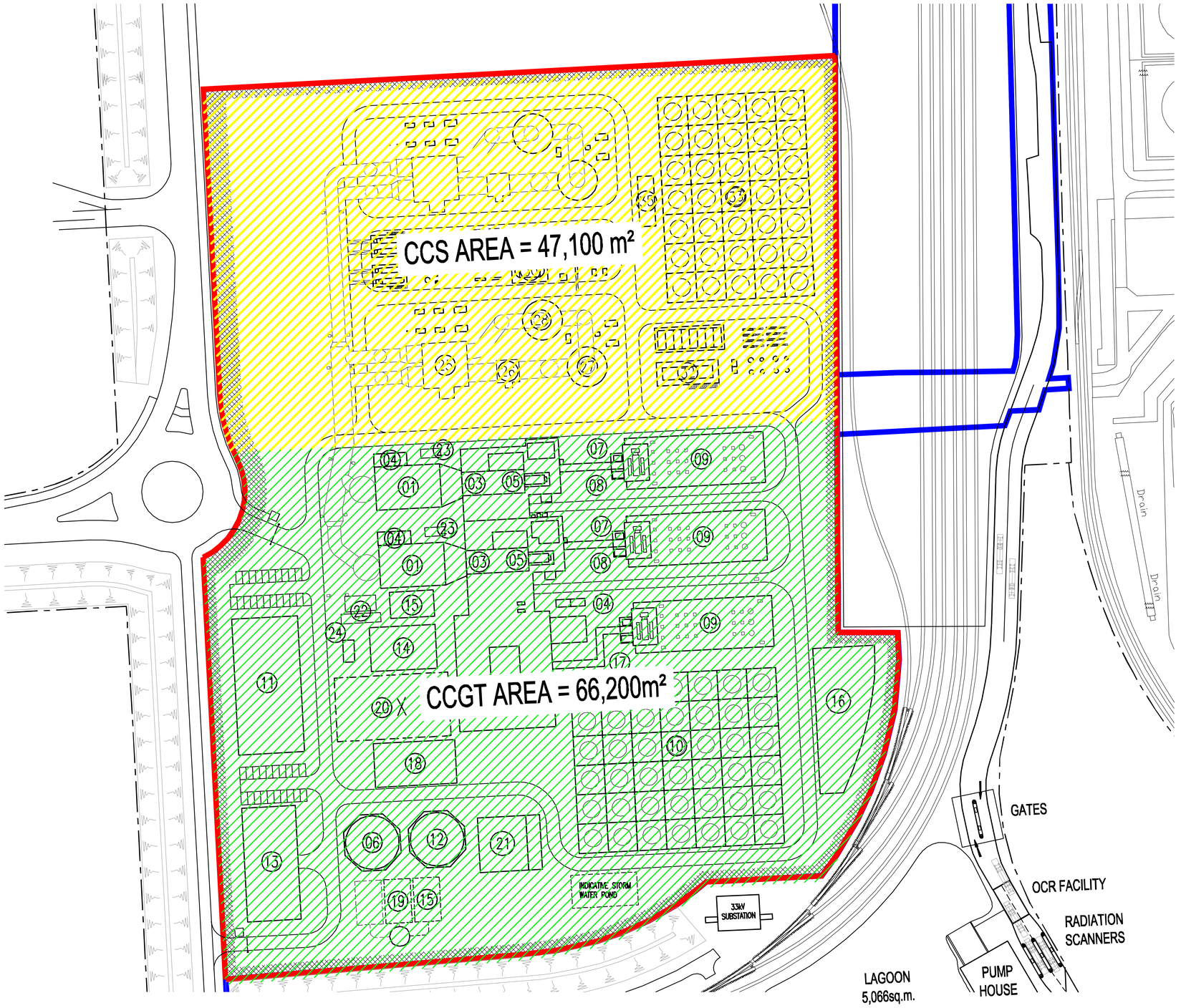

REV	DATE	DESCRIPTION	BY	CHKD	APPD

00/00/00

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• CLIENT/PROJECT

GATEWAY ENERGY CENTRE

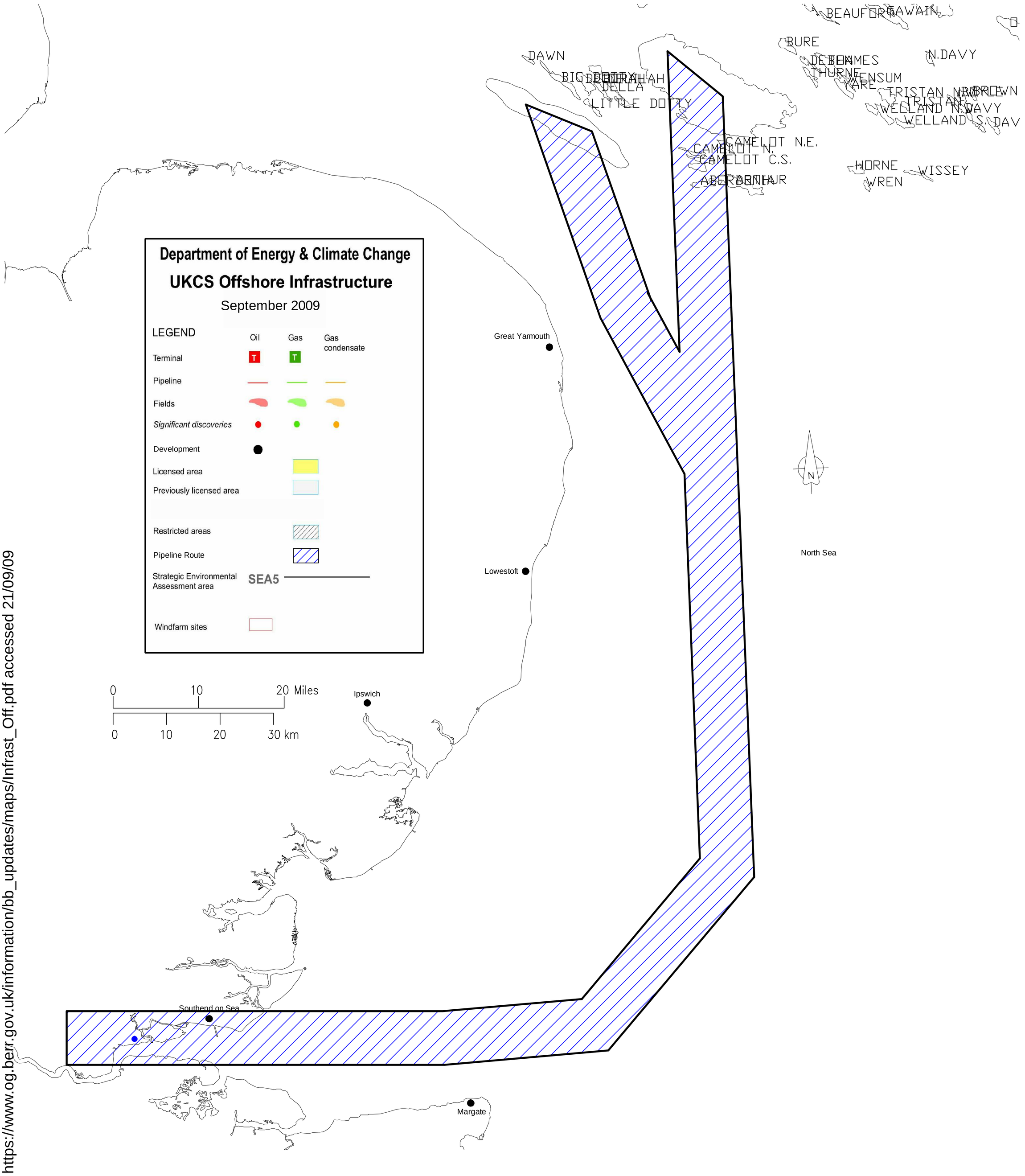
• TITLE

ILLUSTRATIVE SITE PLAN WITH CARBON CAPTURE AREAS

• DATE	16/02/10
• SCALE	1:2000 @ A3
• CAD REF	
DRAWN BY	DD
PRODUCED BY	DD
CHECKED	EA
APPROVED	

• DRAWING NUMBER

FIGURE 3–B | –



https://www.og.berr.gov.uk/information/bb_updates/maps/Infrast_Off.pdf accessed 21/09/09

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- TITLE
INDICATIVE LOCATION OF STORAGE AREAS OFFSHORE PIPELINE ROUTE

- DATE 23/09/09
- SCALE N/A
- CAD REF

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PRODUCED BY DD
CHECKED AP
APPROVED EA

- DRAWING NUMBER
FIGURE 4 | –

23/09/09

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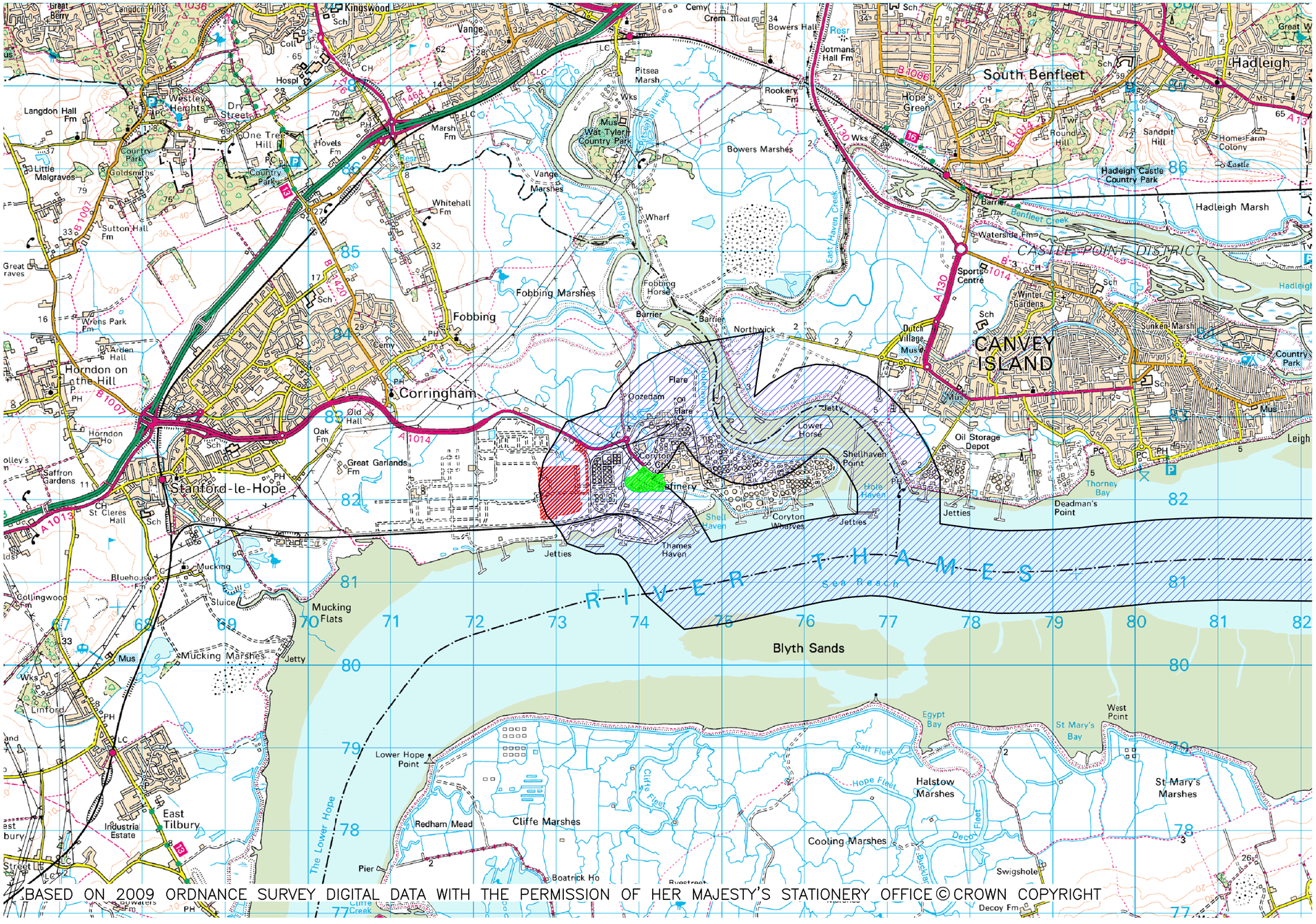

LEGEND

GEC APPLICATION SITE LOCATION

CECL POWER STATION LOCATION

PIPE LINE ROUTES

0 1000m 2000m 3000m

BAR SCALE 1:50,000

REV	DATE	DESCRIPTION	BY	CHKD	APPD

00/00/00

• NOTES

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• TITLE
INDICATIVE ON-SHORE/NEAR SHORE PIPELINE ROUTES

• DATE 22/09/09
• SCALE N/A
• CAD REF

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PRODUCED BY	DD
CHECKED	AP
APPROVED	EA

• DRAWING NUMBER
FIGURE 5 | –

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