

# White Rose Carbon Capture and Storage (CCS) Project

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**The White Rose CCS (Generating Station) Order**

**Drax Power Station, Selby, North Yorkshire**

**ES Volume 3 Section M - Green House Gas Assessment**

The Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009



**Applicant: Capture Power Limited**  
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**Revision History**

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## 1 GHG ASSESSMENT

### 1.1 INTRODUCTION

1.1.1 This Report presents a short review of the White Rose Carbon Capture and Storage (CCS) Project (the Project) and its potential operational CO<sub>2</sub> emissions. These emissions are considered in the light of the UK Government's Emissions Performance Standard (EPS), applicable to new fossil-fuel fired power generation capacity.

1.1.2 This report assesses the Project in the context of the provisions contained within the EPS, provides a brief review of the current estimate of carbon benefits anticipated to arise from the Project, and identifies the principal issues or options that might influence this indicative carbon benefit.

1.1.3 An overview of the Project is provided in *Section 1.2*. Relevant legislation, policy and guidance are described in *Section 1.3*. The Project emissions performance is studied in *Section 1.4*, including an analysis of the Project emissions with respect to the EPS. Emissions performance comparisons, based on different scenarios, are subsequently shown in *Section 1.5*.

### 1.2 THE WHITE ROSE CARBON CAPTURE SCHEME

1.2.1 The Project is one of the two schemes supported under the UK Government's £1 billion CCS development and commercialisation programme. A budget of around £100 million within this programme has been earmarked to support the planning and engineering of these CCS projects.

1.2.2 The proposed facility is an ultra-supercritical oxy-fuel coal fired power station located on land adjoining the existing Drax Power Station in North Yorkshire. In operation the Project will be capable of providing electricity to 630,000 households. The Project aims to demonstrate the viability of Oxy-fuel CCS technology in a modern coal-fired power plant that has a capacity for co-firing biomass. The plant therefore consists of a dual air (i.e. conventional)/oxygen fired pulverised coal boiler.

1.2.3 The capacity of the plant is up to 448 MWe (gross). Within design conditions, the plant will have a net output of approximately 300 MWe in the oxy mode, and about 390 MWe in the conventional air mode, i.e. without oxygen production and CO<sub>2</sub> capture.

- 1.2.4 Roughly two million tonnes of CO<sub>2</sub>, representing around 90% of CO<sub>2</sub> emissions from coal combustion, are projected to be captured and processed using components including:
- Air Separation Units (ASU) to provide an oxygen feed stream to the boiler to allow generation of a CO<sub>2</sub> rich flue gas via the Oxy-fuel process; and
  - a Gas Processing Unit (GPU) to process and compress the flue gas to achieve the required transport and storage CO<sub>2</sub> specifications and pressure.
- 1.2.5 The captured CO<sub>2</sub> will be transported and stored through a pipeline developed separately by National Grid Carbon Ltd (NGCL), for permanent storage in a deep saline formation in the North Sea.
- 1.2.6 The Project will become operational from 2021, with an expected lifetime of up to 30 years. Due to its size and nature, the Project qualifies as a Nationally Significant Infrastructure Project (NSIP), and is a key component of UK CCS deployment plans, as noted above.

### 1.3 *LEGISLATION, POLICY AND GUIDANCE*

#### GENERAL CONSIDERATIONS

- 1.3.1 This section summarises the national policy context relevant to an assessment of the CO<sub>2</sub> emissions performance of the Project. The subsequent assessment has been prepared in accordance with the EPS <sup>(1)</sup>, which presents a framework for assessing the emissions performance of the Project under the application of different scenarios.

#### CLIMATE CHANGE ACT 2008

- 1.3.2 In 2008, the UK Government passed legislation which introduced the world's first long term legally binding framework to tackle the dangers of climate change. One of the key provisions of the Climate Change Act was setting legally binding targets for greenhouse gas emission reductions through action

(1) Electricity Market Reform: Update on the Emissions Performance Standard, available from [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/48375/5350-emr-annex-d--update-on-the-emissions-performance-s.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48375/5350-emr-annex-d--update-on-the-emissions-performance-s.pdf); and  
Implementing the Emissions Performance Standard: Further Interpretation and Monitoring and Enforcement Arrangements in England and Wales - DECC Consultation Document 14D/340, available from [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/357217/implementing\\_emissions\\_performance\\_standard.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/357217/implementing_emissions_performance_standard.pdf)

in the UK and abroad of at least 80% by 2050 <sup>(1)</sup>, and reductions in CO<sub>2</sub> emissions of at least 26% by 2020 <sup>(2)</sup>, against a 1990 baseline.

- 1.3.3 The Climate Change Act states that decisions on NSIPs must be taken in accordance with the relevant National Policy Statement (NPS), which detail required infrastructure and project assessment criteria. The Overarching National Policy Statement for Energy (NPS EN-1), Fossil Fuel Electricity Generating Infrastructure (EN-2) and Electricity Networks Infrastructure (EN-5) were enacted in 2011, and are relevant to the Project.

#### ELECTRICITY MARKET REFORM

- 1.3.4 In 2011, the Electricity Market Reform (EMR) White Paper was published to signal the UK Government's commitment to drive energy security, decarbonisation and affordability of electricity forward. The EMR introduced two new market mechanisms: Feed-in Tariffs with Contracts for Difference (CfDs) and capacity agreements, to be supported by the Carbon Price Floor and the EPS <sup>(3)</sup>.

#### EMISSIONS PERFORMANCE STANDARD

- 1.3.5 The EPS provides a regulatory back-stop on CO<sub>2</sub> emissions from new power stations by setting an annual limit on CO<sub>2</sub> emissions from new fossil fuel plants, with generating capacity of at least 50 MWe, equivalent to 450g/kWh at baseload.
- 1.3.6 The EPS thus requires that new coal-fired power stations are equipped with CCS to enable them to operate under this emissions threshold. Power stations consented under the EPS would be subject to the 450 g/kWh level until the end of 2044 <sup>(4)</sup>.
- 1.3.7 The annual EPS limit of 450g/kWh is to be interpreted as a total CO<sub>2</sub> tonnage allowance within which the generating plant would have to remain each year. The annual limit is applied based on a load factor of 85% and the plant's installed electrical capacity.

(1) The Climate Change Act and UK regulations, available from <http://www.theccc.org.uk/tackling-climate-change/the-legal-landscape/global-action-on-climate-change>

(2) The Climate Change Act 2008 (2020 Target, Credit Limit and Definitions) Order 2009, available from [http://www.legislation.gov.uk/ukdsi/2009/9780111478523/pdfs/ukdsi\\_9780111478523\\_en.pdf](http://www.legislation.gov.uk/ukdsi/2009/9780111478523/pdfs/ukdsi_9780111478523_en.pdf)

(3) Electricity market reform: policy overview, available from [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/48371/5349-electricity-market-reform-policy-overview.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48371/5349-electricity-market-reform-policy-overview.pdf)

(4) Electricity Market Reform: Update on the Emissions Performance Standard, available from [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/48375/5350-emr-annex-d--update-on-the-emissions-performance-s.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48375/5350-emr-annex-d--update-on-the-emissions-performance-s.pdf)

## 1.4 THE PROJECT EMISSIONS PERFORMANCE

- 1.4.1 The Project as proposed consists solely of generation and CO<sub>2</sub> capture stages. For the purposes of this assessment consideration has been given to the complete chain of generation, capture, transport and storage to understand the range of performance that could occur due to circumstances outwith the control of the Project.
- 1.4.2 Project documentation indicates that the plant is projected to generate 2.21 million tonnes (Mt) CO<sub>2</sub> annually. It is expected that 90% of these emissions, i.e. 1.99 Mt CO<sub>2</sub>, will be captured every year and transported via the NGCL pipeline system for storage in the North Sea. Over the Project lifetime of up to 30 years, the total CO<sub>2</sub> emitted and captured would be equivalent to up to 66.3 Mt CO<sub>2</sub> and 59.7 Mt CO<sub>2</sub> respectively.
- 1.4.3 By abating CO<sub>2</sub> through CCS, the plant would effectively only be emitting 0.22 Mt CO<sub>2</sub> each year. The net projected emissions over the lifetime of the plant would be up to around 6.6 Mt CO<sub>2</sub>.

### PERFORMANCE AGAINST EPS ALLOWANCE

The total allowance for the Project can be calculated as <sup>(1)</sup>:

<p>Emission Limit (tonnes CO<sub>2</sub>) = Statutory Rate of Emissions (in g/kWh) x Installed Generating Capacity (in MW) x 7.446 (representing baseload operation)</p> <p>= 450 g/kWh x 448MW<sub>e</sub> x 7.446</p> <p>= 1,501,114t CO<sub>2</sub></p> <p>= 1.50 Mt CO<sub>2</sub>/year</p>
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- 1.4.4 The main assumption underlying this calculation is that the plant would be operational continuously, i.e. 24 hours a day, 365 days a year. The calculation above shows that under design assumptions the Project would be performing well within the total annual allowed CO<sub>2</sub> emissions, and would therefore be compliant with the EPS.

(1) Methodology shown within 'Implementing the Emissions Performance Standard: Further Interpretation and Monitoring and Enforcement Arrangements in England and Wales - DECC Consultation Document 14D/340', available from [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/357217/implementing\\_emissions\\_performance\\_standard.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/357217/implementing_emissions_performance_standard.pdf)

## 1.5 EMISSIONS PERFORMANCE VARIABLES AND SCENARIOS

### GENERAL CONSIDERATIONS

1.4.5 This net annual emissions figure for the Project, of 0.22 Mt CO<sub>2</sub>, presupposes abatement through a fully functional, available and reliable CCS system that relies on the following factors:

- reliance on the NGCL Transport and Storage (T&S) network, from commencement of operations, with the reliability of this system noted in the Project documentation as being 99%;
- use of the conventional (air-fired) mode only for the commissioning and performance guarantee test, start-up and shut-down modes, and as a short term back-up in case of unavailability of the T&S network;
- an operational intention to run the plant continuously, but with an additional assumption related to reliability and availability of operation, resulting in the plant being in offline mode during 15% of the year;
- a CO<sub>2</sub> capture rate of 90%, and availability targets of 86% and 85% for the oxy fuel plant and full chain CCS respectively;
- use of a wide range of coals, such as Kellingley, Maltby, Ravenstruther, Colombian and Central Appalachian coals as fuel;
- the co-firing of biomass; and
- operation at baseload as the primary operating mode.

1.4.6 Given the assumptions being applied to reach the annual emissions intensity, it is important to review the Project's performance relative to the EPS, if some of the factors were different from the design conditions.

1.4.7 A number of scenarios have been devised to see how the capture performance would change in the light of revised assumptions or different operational modes.

#### NGC T&S NETWORK

##### *Commencement of T&S Network Operation*

- 1.4.8 The final investment decision for the NGCL transport system is thought to happen around the end of 2015. The first CCS transport and storage operations should commence in 2021 <sup>(1)</sup>.
- 1.4.9 An important assumption is that the T&S network will be fully constructed as soon as the Project begins its operations. Should the construction of the pipeline be delayed beyond the start of 2021, CO<sub>2</sub> abatement through CCS would not occur in the first few years of plant operation.
- 1.4.10 Delays to the T&S system might arise also from delays in securing all necessary permits for injection at the storage site, which in turn, must have obtained the requisite licence to operate.
- 1.4.11 For every year that the CCS component of the Project is not operational, the net emissions for that year would be the total emissions without abatement, i.e. 2.21 Mt CO<sub>2</sub>, which would exceed the EPS allowance. Government guidance relating to application of the EPS <sup>(2)</sup> proposes that CCS projects will be exempt from the EPS for a period of three years from the point at which a complete CCS chain with which a fossil fuel generation plant is equipped is ready to use. This exemption is time limited and will come to an end in 2027.
- 1.4.12 Should it be necessary to apply this exemption, the maximum additional CO<sub>2</sub> that the Project could emit during the three year exemption period would be 3 \* (2.21 - 0.22) = 5.97 Mt CO<sub>2</sub>.

##### *T&S Network Availability*

Another important assumption is that the T&S network will be 99% available.

- 1.4.13 In the most severe instance of catastrophic failure, the network would presumably not operate at all, and this would give rise to a situation where abatement via CCS would cease completely until the network was restored, which could be a potentially lengthy process.
- 1.4.14 In less severe cases, for example due to operational issues such as pump failure, this might lead to short-term network unavailability. It is assumed

(1) National Grid: White Rose, available from <http://www2.nationalgrid.com/About-us/European-business-development/Carbon-capture-and-storage/White-Rose/>

(2) Implementing the Emissions Performance Standard: Further Interpretation and Monitoring and Enforcement Arrangements in England and Wales - DECC Consultation Document 14D/340, available from [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/357217/implementing\\_emissions\\_performance\\_standard.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/357217/implementing_emissions_performance_standard.pdf)

that such a scenario can be represented by system shutdown over a few weeks for maintenance.

1.4.15 In this ‘short-term shutdown’ scenario, a system shutdown of seven weeks is modelled. The overall availability of the T&S network would be reduced to 86%, and the resulting annual emissions capture would be 1.71 Mt CO<sub>2</sub> instead of the anticipated 1.99 Mt CO<sub>2</sub>, resulting in net emissions of 0.50 Mt CO<sub>2</sub> for that year. The emissions performance of the Project would still be well within the EPS allowance were a comparable situation to occur in any given year.

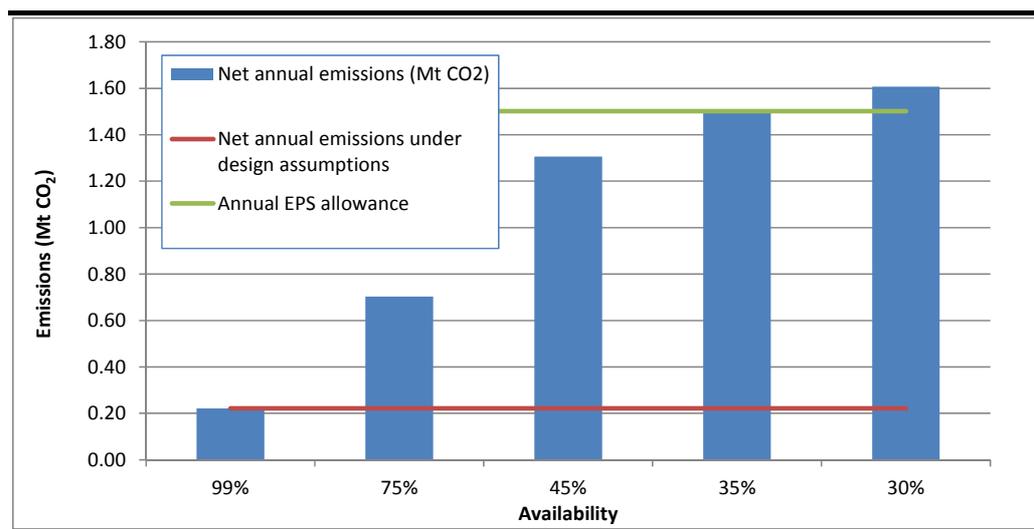
Table 1.1 below shows the Project emissions performance with respect to varying availability of the NGCL T&S network.

**Table 1.1** *Project emissions performance based on T&S network availability (or limit of operation)*

Availability	99%	75%	45%	35%	30%
Total annual emissions (Mt CO <sub>2</sub> )	2.21	2.21	2.21	2.21	2.21
Emissions captured annually (Mt CO <sub>2</sub> )	1.99	1.51	0.90	0.70	0.60
Net annual emissions (Mt CO <sub>2</sub> )	0.22	0.70	1.31	1.51	1.61

At 35% limit of operation, the Project would no longer be under the annual EPS allowance of 1.50 Mt CO<sub>2</sub>, as depicted in Figure 1.1 below.

**Figure 1.1** *Impact of reduced T&S network availability on annual emissions*



CAPTURE MODE

1.4.16 The anticipated operational profile makes provision for the oxy-fuel system, when fully commissioned, to be operational for 85% of the year. Table 1.2

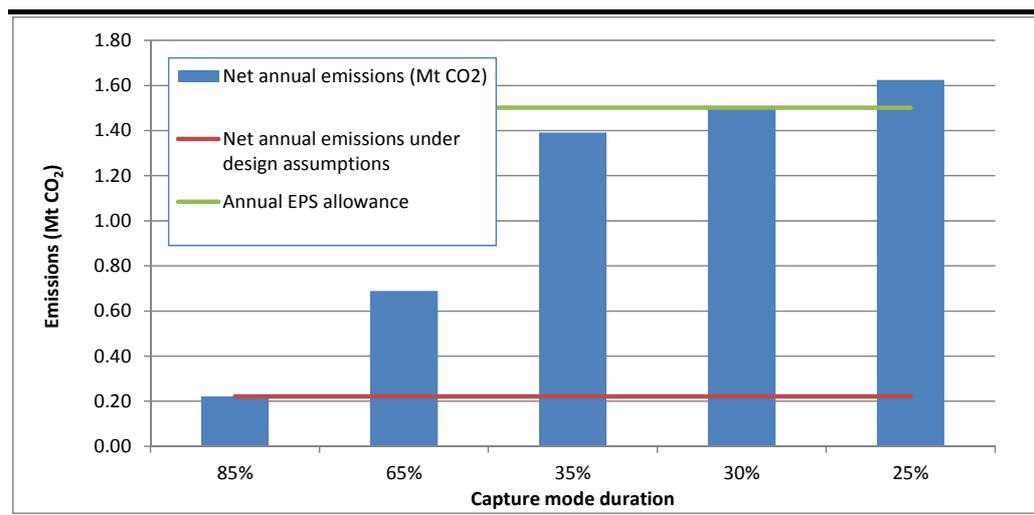
details the emissions performance with a decreased duration of the capture mode at 65%, 35%, 30% and 25% in any given year.

**Table 1.2** *Project Emissions Performance with decreasing Capture Mode Duration*

Capture mode duration	85%	65%	35%	30%	25%
Total annual emissions (Mt CO <sub>2</sub> )	2.21	2.21	2.21	2.21	2.21
Emissions captured annually (Mt CO <sub>2</sub> )	1.99	1.52	0.82	0.70	0.59
Net annual emissions (Mt CO <sub>2</sub> )	0.22	0.69	1.39	1.51	1.63

The Project would no longer comply with the EPS if it is operating in capture mode for less than 30% of the year. *Figure 1.2* provides a graphical representation of the annual Project emissions for various percentages of capture mode operation.

**Figure 1.2** *Impact of Capture Mode Percentage on Annual Emissions*



#### CAPTURE PERFORMANCE

1.4.17 The Project's CO<sub>2</sub> capture rate is anticipated to be 90%, with availability targets for the Oxy-fuel power plant and full chain CCS being 86% and 85% respectively. Design documentation states that this availability may not be achieved immediately.

1.4.18 This scenario assumes that factors such as the new Oxy-fuel technology being employed and/or possible operational issues in the early stages might affect the capture performance of the scheme at the very beginning of operations.

1.4.19 A lower capture rate of 45%, i.e. half of the anticipated capture rate of 90%, at operation commencement is considered here. Even at this capture rate, the

net annual emissions would be around 1.22 Mt CO<sub>2</sub>, and below the EPS allowance.

Table 1.3 shows what the Project emissions performance would look like with a range of lower capture rates over any given year of the Project, in the event that the system's capture performance is lower than anticipated.

**Table 1.3** *Project Emissions Performance Corresponding to Lower Capture Rates*

Capture rate every year	90%	75%	45%	31.5%	25%
Total annual emissions (Mt CO <sub>2</sub> )	2.21	2.21	2.21	2.21	2.21
Emissions captured annually (Mt CO <sub>2</sub> )	1.99	1.66	0.99	0.70	0.55
Net annual emissions (Mt CO <sub>2</sub> )	0.22	0.55	1.22	1.51	1.66

It is only when the capture rate is reduced to 31.5% that net annual emissions exceed the total annual EPS allowance.

#### BIOMASS CONTENT

1.4.20 Co-firing has been assumed at 0% for the design case <sup>(1)</sup>. If a design decision were taken to include co-firing of biomass, however, the Project emissions performance under the EPS would be different <sup>(2)</sup>, as shown in Table 1.4 below. In addition, a scenario is considered under which shortage of biomass supply might reduce biomass content, represented by reduced biomass contents of between 0% and 15%. The assumption is maintained that emissions would still be captured at a rate of 90% during capture mode.

**Table 1.4** *Project Emissions Performance assuming higher Biomass Content*

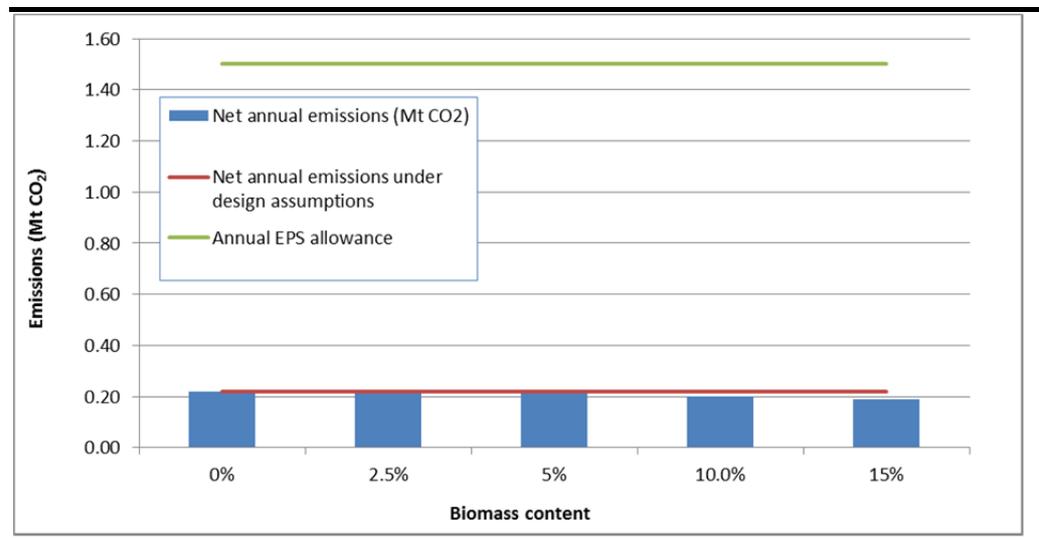
Biomass content	0%	2.5%	5%	10%	15%
Total annual emissions (Mt CO <sub>2</sub> )	2.21	2.15	2.10	1.99	1.88
Emissions captured annually (Mt CO <sub>2</sub> )	1.99	1.94	1.89	1.79	1.69
Net annual emissions (Mt CO <sub>2</sub> )	0.22	0.22	0.21	0.20	0.19

Increased biomass content would reduce net annual emissions further below the EPS allowance, as depicted in Figure 1.3 below. This means that the Project would continue to comply with the EPS regardless of the level of biomass consumption during firing in the oxy mode.

(1) Capture Power Ltd, White Rose Project – Basis of Design, July 2014

(2) CO<sub>2</sub> emissions arising from non-fossil sources are not attributable emissions under the EPS.

Figure 1.3 Net Annual Emissions with Higher Biomass Content



#### SCENARIOS INVOLVING A COMBINATION OF FACTORS

##### General Considerations

1.4.21 The independent effects of different factors on the Project's emissions performance have been considered above. It is also conceivable that one or more of these factors may occur in combination. This possibility is reflected in a series of illustrative scenarios as defined below.

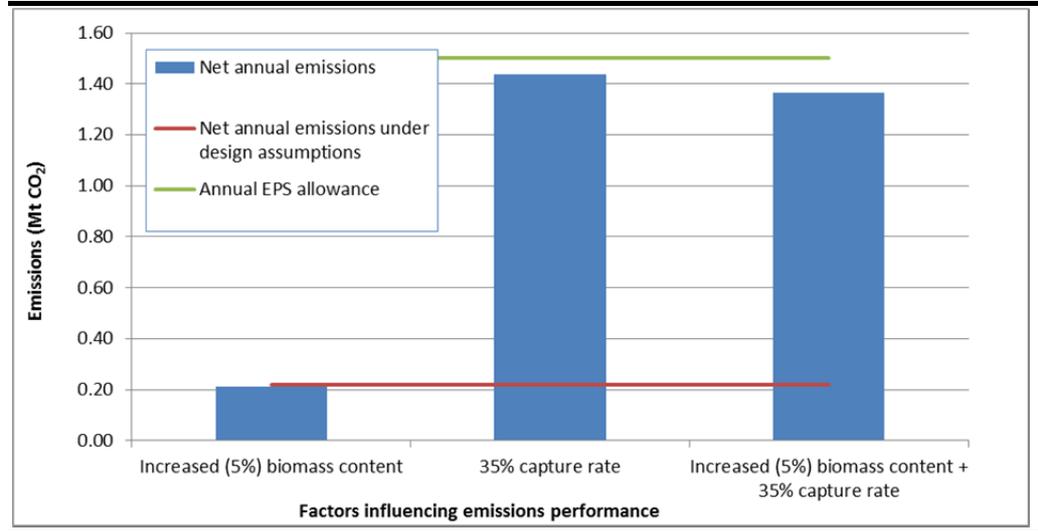
1.4.22 Since at this stage it is not possible to define the likelihood associated with each factor, scenarios have been defined to illustrate potential 'in-combination' outcomes as an indicator of CO<sub>2</sub> capture consequences rather than as an exhaustive test of possible outcomes.

##### Scenario 1 - Lower Capture Rate and Reduced Biomass Content

1.4.23 Within this scenario it is assumed that the Project capture rate starts out at 35% in early years of operation, and that the biomass content of the fuel is maintained at 5% during this period.

1.4.24 Where both of these instances occur at the same time over a period of a year, net emissions for that year would be approximately 1.36 Mt CO<sub>2</sub>. Under these circumstances, the Project emissions performance would remain below the EPS allowance, as shown in Figure 1.4 below.

**Figure 1.4** *Impact of Reduced Capture Rate and Higher Biomass Content on Project Emissions Performance*

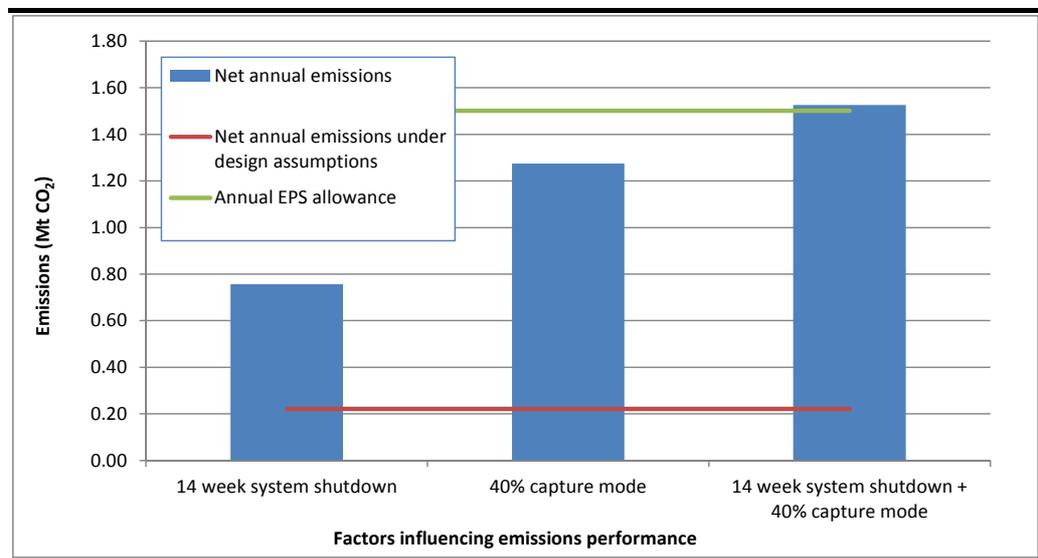


*Scenario 2 - System Shutdown and Shorter Capture Mode duration*

1.4.25 This scenario assumes a combination of operational issues arising, such that the T&S system faces a system shutdown over a fourteen week period, and also that the Project operates in capture mode over a shorter period, for 40% of the year. It is further assumed that the system shutdown and capture mode periods coincide.

1.4.26 This combination of factors would lead to net emissions increasing, as depicted in *Figure 1.5*, and crossing the annual EPS threshold.

**Figure 1.5** *Emissions Performance with a 14 week T&S System Shutdown and Capture Mode for 40% of the Year*

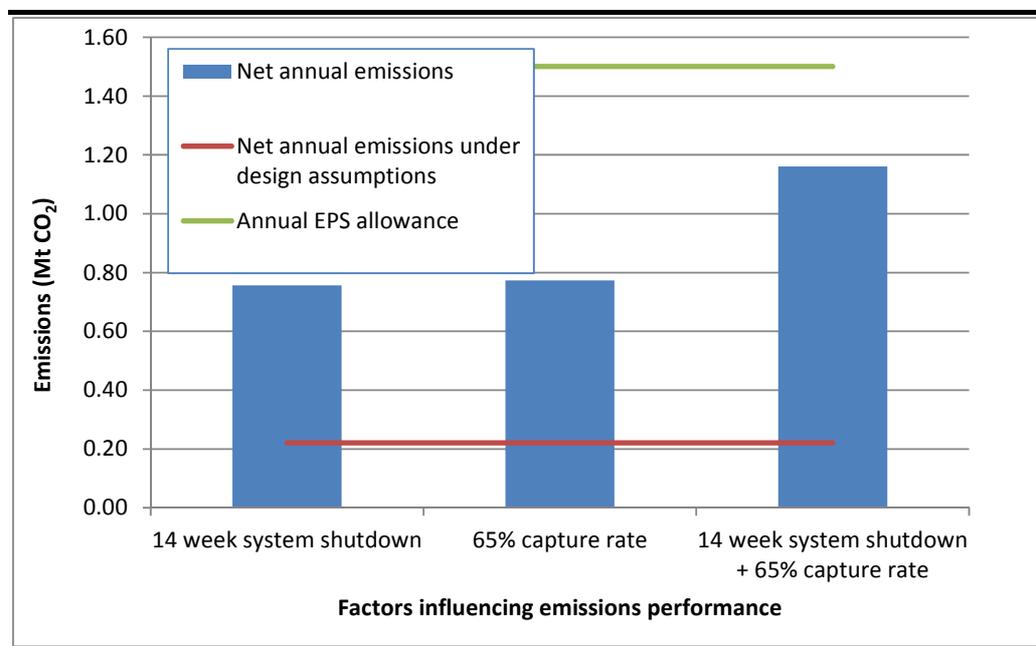


*Scenario 3 – T&S System Shutdown and Lower Capture Rate*

This scenario assumes a fourteen week shutdown in T&S operations coupled with a capture rate limited to 65%.

The net annual emissions for that year would still be within the EPS allowance, as shown in *Figure 1.6*.

**Figure 1.6** *Emissions Performance with a 14 week T&S shutdown and reduced Capture Rate of 65%*



**1.6 SUMMARY**

1.4.27 The Project as defined, coupled with a fully-functional T&S system for transport and storage, is anticipated to perform significantly better than the requirements of the EPS.

1.4.28 Several individual factors can influence the Project emissions performance to various degrees. Such factors include the following.

- **T&S pipeline construction or permitting delays could prevent abatement of Project emissions through CCS.** However, under the proposed conditions accompanying the operation of the EPS, the Project will be exempt from the EPS for a period of three years from the point at

which the complete CCS chain is ready to use. This exemption is time limited and will come to an end in 2027.

- **T&S system shutdown over a limited time due to operational issues can have an effect on the Project emissions performance.** At a reduced limit of operation of 35%, as opposed to the expected T&S network availability of 99%, the Project would no longer comply with the EPS.
- **Operation of the Project in capture mode below the anticipated 85% per year can effect net Project emissions.** When the project is functioning in capture mode for less than 30% of the year, the Project will not comply with the EPS.
- **Project system capture performance could influence compliance with the EPS.** If system capture performance falls below 31.5%, the net emissions will exceed the EPS allowance.
- **Biomass co-firing content.** The Project would continue to comply with the EPS if biomass content increases from the base assumption of 0%.

#### 1.4.29

Combinations of factors occurring simultaneously increase the chances that Project operational emissions would exceed the EPS threshold. The overall effect of individual or 'in-combination' factors leading to non-compliance with the EPS would depend upon how the EPS is applied in respect of the Project but could involve reduced hours of operation.