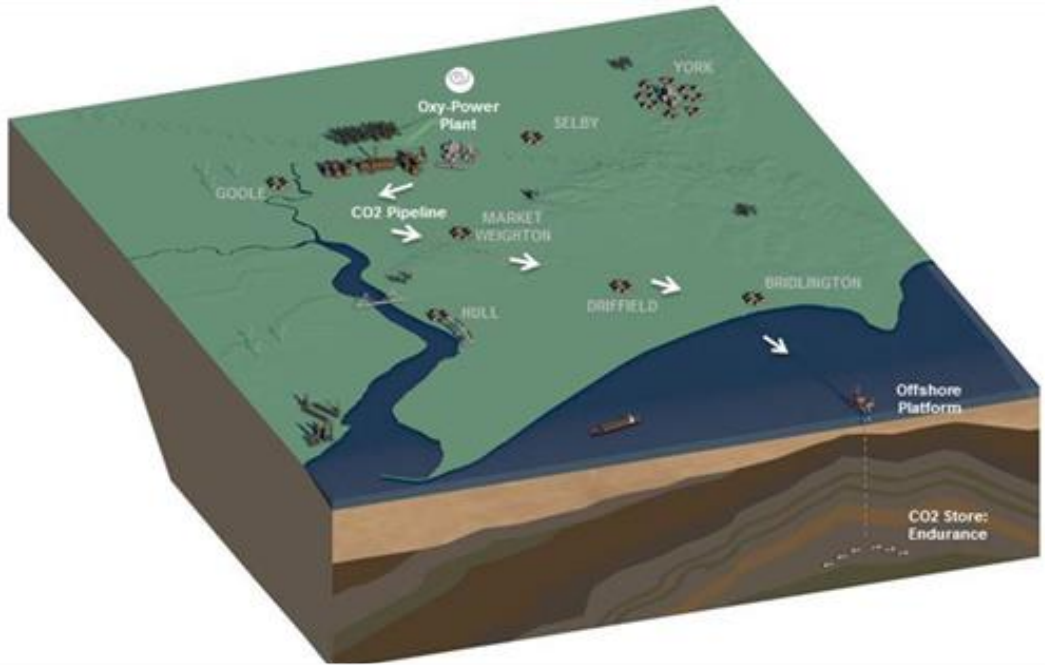
February 2016

WHITE ROSE

K14: Full Chain Interim Project Cost Estimate Report

Category: Full Chain



CAPTURE POWER

drax

BOC
A Member of The Linde Group

nationalgrid

Contents

Key Words

Key Words	Meaning or Explanation
Carbon Capture	Collection of carbon dioxide from power station combustion process or other facilities and its process ready for transportation
Capex	Capital expenditure
CCS	Carbon Capture and Storage
FEED	Front End Engineering Design
FEED Contract	CPL have entered into an agreement with the UK Government's DECC pursuant to which it will carry out, among other things, the engineering, cost estimation and risk assessment required to specify the budget required to develop and operate the White Rose assets
Full Chain	The complete process from the power generation and capture of the CO_2 at the emitter plant to its injection into the storage reservoir
Key Knowledge Deliverable	A series of reports (including this one) issued as public information to describe the flows and processes associated with the overall system. Also referred to as a KKD
Opex	Operational expenditure (also referred to as Operations and Maintenance)
Storage	Containment in suitable pervious rock formations located under impervious rock formations usually under the seabed
Transport	Removing processed CO_2 by pipeline from the capture and process unit to storage

Executive Summary

The Full Chain Interim Project Cost Estimate Report was generated as part of the Front End Engineering Design (FEED) contract with the Department of Energy and Climate Change (DECC) for White Rose, an integrated Full Chain Carbon Capture and Storage (CCS) Project. This document is one of a series of Key Knowledge Deliverables (KKD) from White Rose to be issued by DECC for public information.

White Rose comprises a new coal-fired ultra-supercritical Oxy Power Plant (OPP) of up to 448 MW_e (gross) and a Transport and Storage (T&S) network that will transfer the carbon dioxide (CO_2) from the OPP by pipeline for permanent storage under the southern North Sea. The OPP captures around 90% of the CO_2 emissions and has the option to co-fire biomass.

Delivery of the project is through Capture Power Limited (CPL), an industrial consortium formed by General Electric (GE), BOC and Drax, and National Grid Carbon Limited (NGC), a wholly owned subsidiary of National Grid.

This report provides a description of the cost inputs (capex and opex) required by the Financial Model (KKD 18).

Her Majesty's Government (HMG) Spending Review was set out on 25 November 2015 outlining its capital budget and priorities. A market announcement on the same day indicated that the £1 billion ring-fenced capital budget for the Carbon Capture and Storage Competition was no longer available, the Spending Review accordingly did not include such budget. This meant that the Competition could not proceed as originally envisaged. Following this decision, a notice of termination was issued on 23 December 2015 under the White Rose FEED Contract, which terminated accordingly on 25 January 2016, prior to the expected completion date of FEED. The Government and CPL are committed to sharing the knowledge from UK CCS projects, and this Key Knowledge Deliverable represents the learning achieved up to the cancellation of the CCS Competition and termination of the FEED Contract and therefore does not necessarily represent the final and completed constructible project.

The report should be read in conjunction with the following documents:

- K.18 Financial Model.

1 Introduction

1.1 Background

The White Rose Carbon Capture and Storage (CCS) Project (White Rose) is an integrated Full Chain CCS project comprising a new coal-fired Oxy Power Plant (OPP) and a Transport and Storage (T&S) network that will take the carbon dioxide (CO_2) from the OPP and transport it by pipeline for permanent storage under the southern North Sea.

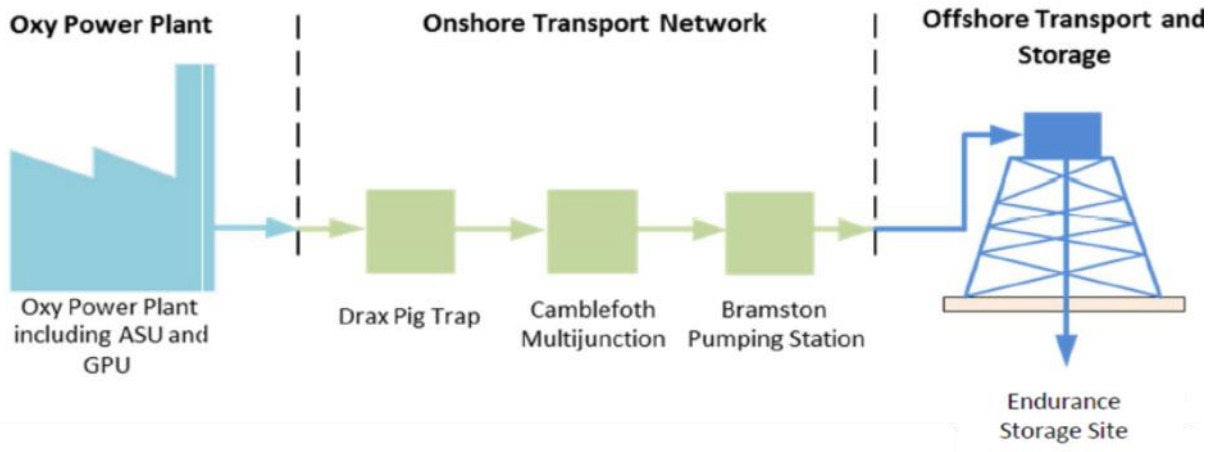
The OPP is a new ultra-supercritical power plant with oxyfuel technology of up to 448 MWe gross output that will capture around 90% of CO_2 emissions and also have the option to co-fire biomass.

One of the first large scale demonstration plants of its type in the world, White Rose aims to prove CCS technology at commercial scale as a competitive form of low-carbon power generation and as an important technology in tackling climate change. The OPP will generate enough low carbon electricity to supply the equivalent needs of over 630,000 homes.

White Rose is being developed by Capture Power Ltd (CPL), a consortium of General Electric (GE), BOC and Drax. The project will also establish a CO_2 T&S network in the region through the Yorkshire and Humber CCS pipeline being developed by National Grid Carbon Ltd (NGC).

The Full Chain and its component parts are shown in Figure 1.1.

Figure 1.1: Key Elements of the Full Chain



Source: CPL

The standalone OPP will be located to the northeast of the existing Drax Power Station site near Selby, North Yorkshire (see **Figure 1.2**) within the Drax Power Limited landholding and benefits from fuel import and power transmission infrastructure currently in place.

Figure 1.2: White Rose CCS Project Artist Impression

Source: CPL

Figure 1.3 below gives a geographical overview of the proposed CO_2 transportation system.

Figure 1.3: Geographical Overview of the Transportation System

Source: NGC

White Rose will benefit the UK and continued development of CCS technology by:

- Demonstrating oxy-fuel CCS technology as a cost effective and viable low-carbon technology;
- Reducing CO_2 emissions in order to meet future environmental legislation and combat climate change;
- Improving the UK's security of electricity supply by providing a new, flexible and reliable coal-based low-carbon electricity generation option;
- Generating enough low-carbon electricity to supply the energy needs of the equivalent of over 630,000 households; and
- Acting as an anchor project for the development of a CO_2 T&S network in the UK's most energy intensive region thereby facilitating decarbonisation and attracting new investment.

1.2 Purpose of the Document

This document provides a summary of the cost inputs (capex and opex) required by the Financial Model. It covers the Full Chain and for all Phases through to decommissioning and provisions for long term storage obligations.

The document includes the costs of the project split into three phases, including a single point estimate (p50) cost for each element and an uncertainty spread for each:

- Implementation phase;
- Operations phase; and
- Decommissioning.

The report should be read in conjunction with the following documents:

- K.18 Financial Model.

2 Implementation Phase (Capex)

2.1 Estimation Basis

Estimation of the Full Chain project costs has been undertaken by the Key Sub-Contractors: GE, BOC, Drax and NGC for their respective areas of responsibility. The Key Sub-Contractors have estimated the vast majority of the costs meaning that a market enquiry has been undertaken for over 90% of the project costs. Therefore costs are assessed to be at an equivalent stage to an Association for the Advancement of Cost Engineering (AACE) cost estimate Level 2 for the majority of capital expenditure items (typical accuracy of +12.5% to +35% and -7.5% to -21%). Costs provided to CPL were based on a Notice To Proceed (NTP) date of April 2016 and on exchange rates of the day. Costs presented in the table below have been adjusted to the assumed NTP date and exchange rates as at 30 November 2015.

Each Key Sub-Contractor has identified their costs within a specific Cost Breakdown Structure (CBS) on a much more detailed basis than presented within this report. Each cost has been estimated as a specific cost distribution which has been used to generate an uncertainty band for each cost item. Calculation of uncertainty bands has been through Monte Carlo analysis, whereby a large number of simulations for each cost element are undertaken giving an overall probability distribution. This analysis generated a: p50 cost which is equivalent to the cost that is likely to be sufficient with 50% certainty, a p10 value which is the cost that will be sufficient with a 10% probability; and a p90 value which is the cost that will be sufficient with a 90% probability. The cost presented in Table 2.1 has been built up from the results of the detailed Key Sub-Contractor Monte Carlo analyses through importing the cost distribution for twenty-eight line items and subsequently re-running for the six cost elements shown. The basis of FEED was to reduce risk and associated uncertainty this led the Key Sub-Contractors to include the cost of risks within their base estimates. This has had the effect of increasing the p50 estimate and narrowing the uncertainty band on certain of the chain elements.

Commercial arrangements both between CPL and Key Sub-Contractors and between CPL and DECC have not been completed leading to uncertainty over ownership of risk and likely final cost. Commercial risk for the full chain has therefore not been fully included within the interim project cost estimate.

2.2 Implementation Phase Capex

Table 2.1 presents the expected implementation phase capex for the project. This shows CPL's expected value for each cost (p50) and the percentage decrease or increase in cost to p10 and p90 respectively.

Table 2.1: Expected Implementation Phase Capex (Nominal Costs, NTP September 2017)

Cost Element	Notes	p50 value (£m)	p10	p90	Drivers of Uncertainty
1. Externally supplied utilities	Interconnections for coal, limestone, water and power	49	-3%	+3%	Commodity prices and labour prices
2. Oxyfuel boiler, Air Separation Unit (ASU) and Gas Processing Unit (GPU)		455	-2%	+3%	Commodity prices, labour prices, new technology risks
3. OPP Generation Equipment and Balance of Plant (BoP)	Excludes costs for site raising, laydown areas and commissioning/ testing. Includes turbine, generators, environmental control equipment, transformers, switchgear, water systems (including raw, treatment, heating, cooling and waste), coal, limestone and ash handling systems, auxiliary systems, erection costs, project management costs and plant civil costs.	471	-3%	+4%	Commodity prices and labour prices
4. Onshore CO_2 pipeline and associated costs	includes multi- junction, CO_2 pumping station, the land, meters and monitors, and NGC business costs	358	-6%	+6%	Commodity prices and labour prices
5. Offshore pipeline and associated costs	includes pipeline, landfall metering and monitoring and, NGC business costs	225	-11%	+11%	Commodity prices, labour prices and offshore risk
6. Storage facilities	includes the platform, the wells and any monitoring/ metering and NGC business costs	344	-17%	+21%	Commodity prices, labour prices, offshore risk, storage risk
TOTAL		1,902	-6%	+7%	

Capex for White Rose for FEED purposes has been estimated on a complete basis for the specific equipment configuration, participants and location. This included costs that would not necessarily be incurred or incurred to the same extent if a similar oxy-fired CCS project was to be implemented at a different site, in a different country or by a different type of client. To try to ensure consistency of presentation with reports on oxy-technology internationally, capex in this report has been presented on the basis of:

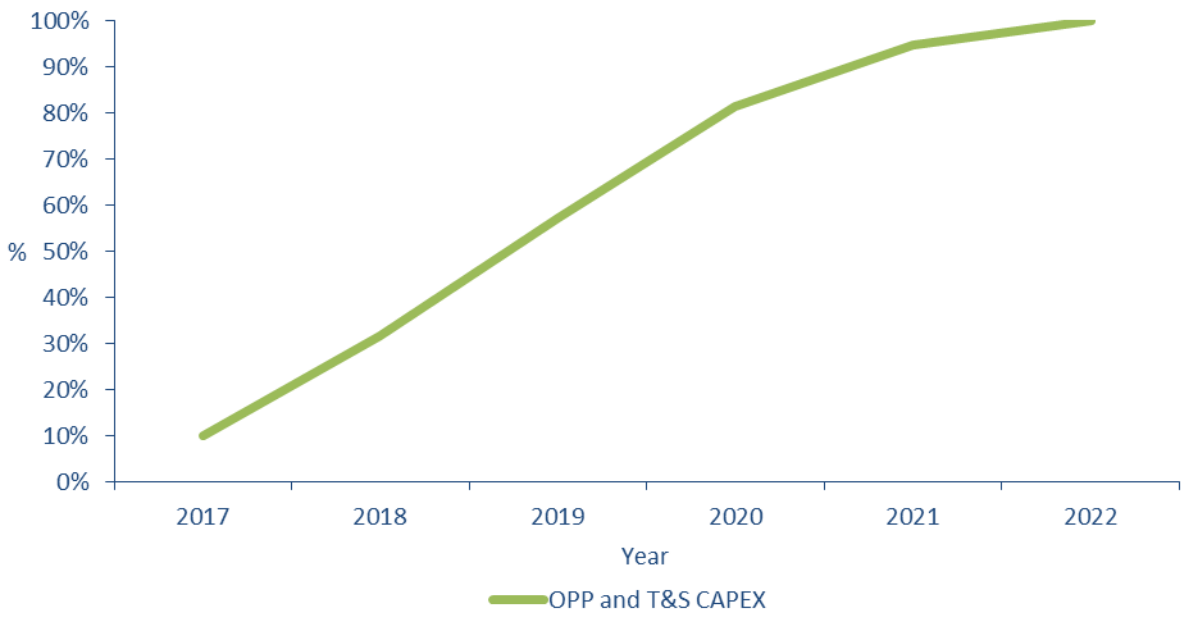
- Costs for elements 2 and 3 have been amended to a US Gulf Coast basis to be consistent with the majority of international reports on CCS costs. Localisation to the UK would require uplift of 29% and 34% respectively;
- The site identified in the UK required significant preparation, in particular for flood protection. These site preparation costs have been excluded;

- Costs for testing and commissioning of the project, including labour, consumables and utilities have been excluded as these will depend on the local cost of labour, fuels and utilities; and
- Owner's costs for developing the project including project management, administration, development, insurance and hedging have been excluded as these will depend on the nature of any existing client/developer organisation.

Capex for Transport and Storage has been estimated on the basis of sizing the infrastructure to enable further projects to be accommodated. This is due to the limited additional capex that would be required to future proof the investment in comparison to the expenditure that would be required to increase capacity at a later date. The decrease in cost for sizing the infrastructure only for White Rose would be £110m. Commercial charging arrangements between NGC and White Rose would have ensured that this additional capex would not have been borne by the White Rose project.

Figure 2.1 presents a simplified total expenditure S-curve for capex spend. The S-curve applies for all three levels of certainty.

Figure 2.1: Simplified S-Curve



Source: CPL

2.3 Operation (Annual Opex)

The annual cost of operation for the Full Chain is shown in nominal terms for the first full year of operation for the project in Table 2.2. Uncertainty bands have been provided for the opex costs based on the variability for both time and cost and the lower maturity of opex cost estimation compared to capex.

Table 2.2: Annual Opex

Cost Element	Notes	Expected Cost (£m per annum)	Uncertainty Band	Drivers of uncertainty
1. Projected fuel costs	Coal cost (including transport)	60	+/-25%	International coal market price
2. Projected externally supplied utility costs	Includes: water, power import, costs for start-ups, chemical costs and landfill costs	11	+/-25%	Costs will be agreed under long term contracts that will reflect market forces at the time they are let
3. Projected operation and maintenance costs for OPP	Operation and maintenance costs for OPP, including ASU, GPU and BoP	67	+/-20%	Costs will be driven mainly by labour market and commodity prices
4. Projected operation and maintenance costs for T&S	Includes full costs of onshore and offshore transport and storage.	47	+/-27%	Costs will be driven mainly by labour market, commodity

Cost Element	Notes	Expected Cost (£m per annum)	Uncertainty Band	Drivers of uncertainty
				prices and insurance requirements

2.4 Decommissioning Costs

Decommissioning costs for the off-shore facilities are estimated to be £64.5m in real (2014) terms. This cost includes removal of jacket and topsides and abandonment of wells.

3 Glossary

Abbreviations	Meaning or Explanation
ASU	Air Separation Unit
BoP	Balance of Plant
CCS	Carbon Capture and Storage
CO_2	Carbon Dioxide
CPL	Capture Power Limited
DECC	UK Government's Department of Energy and Climate Change
EPC	Engineering Procurement and Construction
FEED	Front End Engineering Design
GE	General Electric
GPU	Gas Processing Unit
KKD	Key Knowledge Deliverable
NGC	National Grid Carbon Limited
OPP	Oxy-Power Plant
T&S	Transport and Storage