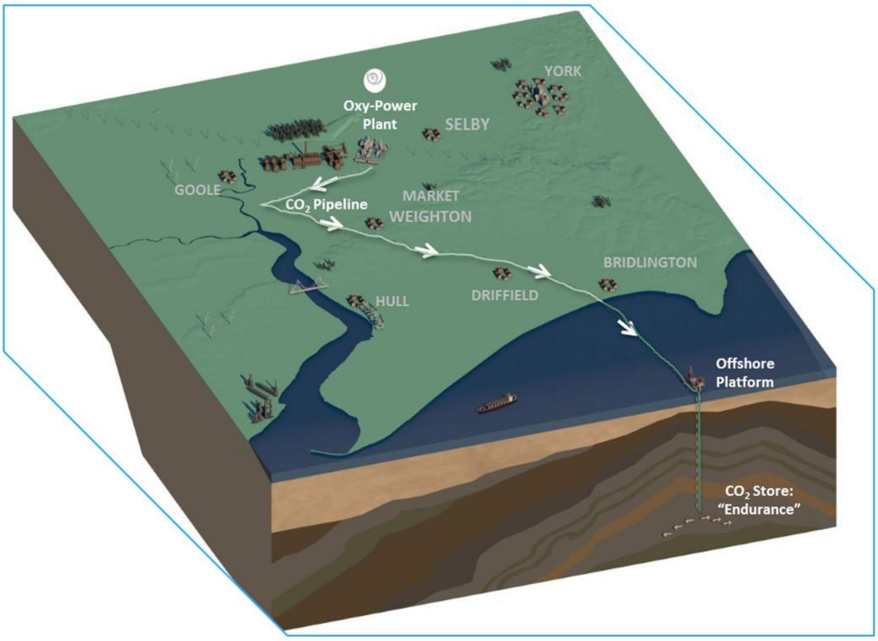
March 2016

K.04 Full-chain FEED lessons learnt

Commercial; Lessons Learnt



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Contents

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Key Words

Key Word	Description
ASUs	Air Separation Units
CAPEX	Capital expenditure
Capture	Collection of CO_2 from a power station combustion process or other industrial facility
Carbon	An element, but used as shorthand for its gaseous oxide, Carbon Dioxide
Carbon Capture and Storage	A technology which reduces carbon emissions from the combustion based power generation process and stores it in a suitable location
Carbon Dioxide	A greenhouse gas produced during the combustion process, the chemical symbol for which is CO_2
Export credit agency	A private or quasi-governmental institution that acts as an intermediary between national governments and exporters to issue export financing. Also known as an 'ECA' or 'investment insurance agency'.
Financial Close	The point at which the final investment decision is taken and the Notice to Proceed with the Construction Phase is issued
FOAK	'First of a Kind'
Multi-laterals	Financial institutions that have been established (or chartered) by more than one country, and hence are subjects of international law
OPEX	Operating expenditure
OPP Process	The flow of input and output streams through the Oxy Power Plant
Oxy Power Plant	An electrical power generation plant using oxyfuel technology including captured CO_2 processing for pipeline transport
Oxyfuel	The technology where combustion of fuel takes place with an oxygen/CO_2 mixture, replacing air as the oxidant for the process, with resultant flue gas being high in CO_2 concentration
Pipeline	The long pipe used for conveying CO_2 from the power plant to the storage facilities
Project finance	The long-term financing of infrastructure and industrial projects based upon the projected cash flows of the project rather than the balance sheets of its sponsors
RRP	Risk Reduction Phase
Storage	Containment of CO_2 in suitable pervious rock formations located under impervious cap rock formations
Transport	Transfer of processed CO_2 from the capture and process unit by pipeline, to the permanent storage site
White Rose	The White Rose Carbon Capture and Storage project

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Executive Summary

This K.04 Full-Chain FEED Lessons Learnt document 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 (Project). This document is one of a series of Key Knowledge Deliverables (KKD) from White Rose issued by DECC for public information. It provides a summary of the principal lessons learnt in the execution of the Risk Reduction Phase (RRP) for the development of White Rose.

White Rose comprises a new coal-fired ultra-supercritical oxy power plant (OPP) of up to 448 MWe (gross) and a carbon dioxide transport and storage system (T&S System) that will transfer captured carbon dioxide from the OPP by pipeline for permanent storage under the southern North Sea. The OPP captures around 90% of the carbon dioxide emissions and has the option to co-fire biomass. Delivery of the Project is through Capture Power Limited (CPL), a consortium of GE, BOC and Drax, together with National Grid Carbon Limited (NGC), a wholly owned subsidiary of National Grid (NG).

The RRP was a period of integrated commercial, technical and financial development activities undertaken between January 2014 and November 2015, financed by the White Rose sponsors and the UK Department of Energy and Climate Change (DECC). The RRP was intended to progress the development of the White Rose Project, including its commercial structure, sufficiently to enable a successful Final Investment Decision (FID) by the Project sponsors and DECC, followed by Financial Close of CPL's project financing. The RRP development process was executed as part of the UK CCS Commercialisation Competition (the Competition), managed by DECC. White Rose was one of two preferred bidders, the other being a gas-fired CCGT based proposal under development by Shell at Peterhead, Scotland. The Competition was conducted to evaluate bidders' suitability for the award of capital from a £1 billion ring-fenced budget, in addition to long-term operational funding from a Contract for Difference (CfD), the Strike Price for which was to be negotiated accordingly.

A primary objective of the Competition was to demonstrate that, with appropriate levels of government support, a 'first of a kind' (FOAK) CCS generation plant could be delivered in the UK and provide 'value for money' in the context of delivering a cost-effective regional decarbonisation platform to which follow-on generation plants and industrial facilities employing their own carbon capture technologies could benefit. The package of governmental support would be subject to the usual qualifying criteria for state aid approval by the European authorities.

The body of this document is structured according to 13 development challenges that White Rose faced in progressing the Project towards its FID objective. These development challenges are set out in the form of a brief description followed by the evidence demonstrating the nature of the challenges pertaining to the construction, operation and decommissioning phases of the OPP and T&S System as a "full-chain" CCS project. Subsequently the mitigation measures developed for each development challenge are presented and finally the lessons learnt. The interconnected nature of the underlying commercial, technical and financial risks inherent in the Project are clearly outlined, together with White Rose's efforts to mitigate them through the transfer of risk to the private sector to the greatest extent possible, with the remainder forming the basis of negotiating a package of governmental support from DECC.

The first development challenge addressed in the document (described in Section 4), pertains to that of cross chain default or "project on project" risk that was particularly demanding for the Project. The White

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Rose commercial structure (described in Section 2) was formulated with CPL building, owning and operating the generation and capture assets, together with NGC and its storage company Carbon Sentinel Limited (CSL) building, owning and operating the T&S System containing additional capacity for future users. CPL was conceived as a project financed Special Purpose Company (SPC), with NG providing corporate finance in relation to the T&S System. One important aspect to consider with this type of structure is the risk of potential default of one of the CCS chain links in the full-chain (particularly such as late construction completion, non-availability and insolvency) and the willingness of stakeholders in the remaining CCS chain links, specifically equity and debt providers, to absorb such cross-chain default risk.

The future development and commercial roll out of CCS is highly likely to evolve on the basis of clusters whereby developers of generation and capture assets or industrial capture projects will have contractually established access to common infrastructure, developed by CO_2 transport and storage providers. Except in circumstances where a single developer has the professional capability, financial strength and risk appetite to develop the entire CCS chain, cross chain default risk is likely to prove to be the most significant commercial challenge for future developers of CCS projects. This will remain the case at least until the CCS industry has reached a level of maturity to be considered “business as usual” with the availability of a more liquid, demonstrable and commercially financeable CO_2 transport and storage market.

During the RRP, significant engagement with the commercial insurance market was undertaken which was found to have its limitations as described in Section 12. Insurance alone could not offer a standalone solution to the cross-chain liability and default risk development challenge, but nevertheless played an important role in the hierarchy of mitigations that made the *likelihood* of cross-chain default leading to termination remote. The provision of cost-sharing financial support by Her Majesty’s Government (HMG) for Specific CCS risks (those mutually identified and agreed as CCS-related risks by HMG and White Rose) in the absence of available commercial insurance served as an important bridge in the White Rose insurance strategy until such insurances are available at reasonable prices.

The sharing of CCS specific risks by DECC as a feature of the Competition was also a key element of getting equity and particularly debt providers comfortable with the implementation of this FOAK technology. Good progress was made in this area during the RRP and it was found that all stakeholders could be made comfortable with a defined list of CCS specific risks. This was achieved by striking a balance between clear definitions of such risks so that they could be understood and recognised, but were not overly prescriptive in the contractual documentation, allowing a degree of interpretation and judgement should a CCS risk event actually occur. This is described further in Section 6.

For CCS to be successful in the UK and further afield, attracting private sector commercial investors will be key. The experiences of NGC in attracting storage partners to participate in the offshore CO_2 storage activities through CSL proved particularly challenging. Section 5 details these challenges but essentially the risk versus reward balance was not deemed attractive enough to encourage any meaningful participation by competent operators. Uncertainty about the growth prospects of the CCS industry in the North Sea provided further reason for caution. In short, CO_2 storage can be described as a highly specialised, high-risk waste disposal business, with low economic reward driven by the need to keep CCS competitive and affordable in a privatised electricity generation market. Without properly addressing the risk profile for the private sector, interest in the provision of CO_2 storage infrastructure may remain low.

Investment interest in the OPP was evident, particularly with strategic investors as outlined in Section 10. CPL demonstrated that certain types of equity providers are willing to accept some cross-chain default risk, mainly when such providers are sufficiently capitalised and have a strategic interest in developing CCS. It was however expected that equity providers without such strategic interest may find it difficult to accept such risks. Reducing the exposure of the OPP investors to the performance risk of the T&S System would mitigate such concerns, and simultaneously reduce the required reward for equity providers. In addition such risk reduction if extended to debt providers could also serve to attract longer term, lower priced debt to the Project. Both of these impacts would have the beneficial effect of reducing the required CfD Strike Price.

The debt raising activities of CPL have shown that there is wide variance in the degree of CCS literacy amongst commercial debt providers and an early engagement with these institutions is vital so as not to risk delays to the project financing programme. The approach of CPL included the selection of a relatively few ‘pathfinder’ banks to provide a confidential and interactive sounding board for iterating optimal and bankable commercial structuring solutions in parallel to the overall deal development. Including the pathfinder banks, CPL was in discussions with over 20 institutions who needed to be kept informed of progress and learnings related to the Project. During the RRP it was important to find the right balance between negotiating and developing the Project and apprising the wider debt provider community of the status without risking ‘deal fatigue’ through over-communicating during periods of minor development progress. This was achieved through a programme of periodic bilateral discussions as well as a town hall type meeting hosted by White Rose together with DECC which was particularly well received. As part of the overall risk mitigation, CPL looked at alternative uses of the generation assets for the unlikely scenario that, for whatever reason, the T&S System became terminally unavailable. Part of the potential mitigation involved the conversion of the power generation assets within the OPP site to use biomass or gas as an alternative fuel (described further in Section 13). No technical difficulties were identified to prohibit such a modification, however success would depend upon the prevailing electricity market conditions at the time of any planned conversion, including the availability for example of biomass subsidy support, or capacity market payments. For the providers of equity and debt into power stations fitted with CCS, this represents potential for some mitigation against losses in the event of permanent non-availability of the T&S System.

The commercial integration linking the elements of the full-chain flows through the CO_2 off-take agreement, the CO_2 Transport and Storage Services Agreement (TSSA), between CPL and NGC (see Section 9). The fact that two linked infrastructure projects were under development simultaneously by two independent entities meant that overall development coordination required significant iteration, not just between the developers, but also with DECC and the many counterparties to CPL and NGC. Bringing together a combination of the power industry, chemical industry and offshore hydrocarbon industry under a governmental procurement framework that ultimately satisfies state aid funding criteria is a challenging exercise and should not be underestimated. The use of suitably experienced development team members, supported by high-quality professional advisors, is critical to any CCS development.

Section 14 examines the sale of White Rose carbon transport and storage capacity, where consideration was given to commercial capacity reservation and pricing models that considered the use of the T&S System by third parties. Both ‘average cost pricing’ and ‘incremental cost pricing’ models for calculating capacity reservation and use-of-system tariffs were assessed jointly by CPL and NGC. The ‘incremental cost’ approach gave the lowest economic barriers to entry for secondary users and therefore had the greater chance of creating the long-term objectives of the Humber Cluster, the wider carbon transportation and storage system that would be essentially ‘anchored’ by the White Rose CCS Project. The bulk of the cost for the initial infrastructure would fall on the anchor user i.e. CPL through the TSSA. Even though such cost would pass though CPL ultimately to the electricity consumer via the CPL CfD, the wider commercial consequences need careful consideration in terms of any obligation to continue payment of the TSSA tariff should the anchor power station project be unavailable and not generating clean power and hence CfD-supported revenue.

Other lessons learnt in this document relate to consenting and permitting for the full chain (see Section 7), the negotiation of fixed-price procurement contracts (see Section 8), technical integration of the key components comprising the full-chain (see Section 11), designing the key interconnection infrastructure between the CPL OPP and its host site at Drax (see Section 15) and establishing a robust metering and measurement regime to support the proper commercial and technical operation (see Section 16). Together, all of the lessons learnt in this document comprise an overview of the major development challenges faced by the developers of the White Rose CCS Project.

On 25 November 2015, HMG set out its Spending Review outlining its capital budget and priorities. A market announcement on the same day stated that the £1 billion ring-fenced capital budget for the Carbon Capture and Storage Competition (Competition) was no longer available, and the Spending Review accordingly did not include such capital budget. This meant that the Competition could not proceed as originally envisaged. Following this decision, DECC issued a voluntary termination notice in respect of the White Rose FEED Contract on 23 December 2015. The FEED Contract terminated accordingly on 25 January 2016, prior to the expected completion date of FEED. HMG, CPL and NGC are committed to sharing the knowledge from UK CCS projects, and this Key Knowledge Deliverable document encapsulates the principal learning achieved up to the cancellation of the CCS Competition and termination of the FEED Contract. It does not therefore necessarily represent a complete and definitive description of the final completed Project.

The work performed during the RRP has highlighted the complexity and challenges associated with developing a CCS project, including its objective to serve as a precursor to the development of a wider CCS industry. Irrespective of the decision to discontinue with the Competition, the lessons learnt should provide future developers with valuable insight into the commercial, technical and financial challenges that need to be considered in developing any CCS project. The lessons learnt derive from significant effort expended on the part of White Rose’s expert development teams working closely with government, supported by highly skilled technical, legal, financial, insurance, tax and market advisors drawn from highly reputable consultants and practices. As such, this document makes an important contribution to the future development of the CCS industry in the UK and abroad.

It is not the purpose of this document to propose alternative approaches or solutions to the challenges faced in developing CCS projects, not least because all CCS projects are different, with their own characteristics, sponsors and development profiles. Nonetheless, the lessons learnt described herein provide a useful body of evidence that could assist the designers in the structuring of future programmes for the commercialisation of CCS. By considering the risk allocation between the public and the private sector, and as such by considering alternative ways of structuring future CCS projects particularly with respect to the cross chain risks, the potential exists to reduce costs of CCS and improve its affordability, albeit possibly with transfer of risk to the public sector.

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1 Introduction

The purpose of this document is to provide a summary of the principal commercial, technical and financial lessons learnt during the execution of the Risk Reduction Phase (RRP) of the White Rose Carbon Capture and Storage Project (White Rose or the Project). Sections 1 and 2 of this document provide an overview of the Project and the primary (Base Case) commercial structure developed during the RRP. Sections 3 - 16 summarise key full-chain risks identified in relation to this commercial structure during the RRP, as well as lessons learnt in relation thereto.

1.1 The UK CCS Commercialisation Programme and Competition

The majority of the lessons learnt during the RRP were gained in response to developing the Project under the terms and conditions of the UK CCS Commercialisation Programme as managed by the UK Department of Energy and Climate Change (DECC) through their Office of Carbon Capture and Storage (OCCS). The Commercialisation Programme contained, amongst other things, the provision of research and development funding by DECC for CCS-related activities and the UK CCS Commercialisation Competition (Competition). The Competition made £1 billion of capital funding available to successful bidding entities, together with additional operational funding through the UK Electricity Market Reform (EMR), to support the design, construction and operation of the UK's first commercial-scale CCS projects. The principal aims of the Competition were four-fold:

- generate learning that will help to drive down the costs of CCS;
- test and build familiarity with the CCS specific regulatory framework;
- encourage industry to develop suitable CCS business models; and
- support the development of early infrastructure for carbon dioxide transport and storage.

The Competition opened in April 2012, and closed to bids in July 2012. A key requirement of the Competition was that bidders were to propose 'full-chain' projects or, in summary, projects that contained an electrical power generator, a carbon transportation pipeline and a long-term carbon storage facility all within a singular contractual entity. Another important requirement of the Competition was that projects were required to bid against a Baseline Risk Allocation Matrix (BRAM) established by DECC, which set out a proposed risk allocation between bidders and Government for both "business as usual" (BaU) and CCS specific risks.

On 20 March 2013 Her Majesty's Government (HMG) announced two preferred bidders: the White Rose project and the Peterhead project. In December 2013 and February 2014 respectively, White Rose and Peterhead projects were awarded multi-million pound contracts to undertake FEED studies and related commercial and financial development work to de-risk aspects of their proposals through an RRP, ahead of taking final investment decisions (FID) and in the case of White Rose, financial close with third party debt investors, proceeding subsequently to construction, commissioning, long-term commercial operation and subsequent decommissioning. During the RRP, the European Commission confirmed that White Rose had successfully qualified for the receipt of €300 million of funding support under the European Union's NER300 programme for clean generation projects. The detailed terms and conditions related to this funding was to form part of the negotiations with DECC for White Rose's access to the capital and operating funding available through the Competition.

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1.2 The White Rose CCS Consortium

The White Rose CCS Project was developed by a consortium comprising of Capture Power Limited (CPL) and National Grid Carbon Limited (NGC) (together the White Rose CCS Consortium or the Consortium). In order to deliver an integrated full-chain project, CPL was designated the nominated “Developer” entity under the terms and conditions of the Competition and therefore also became the contractual counter-party to DECC under the FEED Contract, with NGC as key sub-contractor. Beyond Financial Close, CPL was responsible for delivery of a commercial demonstration scale new-build coal-fired oxy-combustion power generation plant with carbon capture capabilities (the OPP), whereas NGC was responsible for the delivery of a carbon transportation and storage (T&S) system that would transfer the CO_2 from the OPP by pipeline for permanent storage under the southern North Sea. CPL would contract long-term carbon transportation and storage services from NGC via a services agreement.

An overview of each Consortium member is set out below.

1.2.1 Capture Power Limited

CPL was formed as a joint venture between Alstom[1] (subsequently acquired by GE), BOC and Drax, each of whom have an area of expertise and strategic interest relevant to the development of the OPP.

GE is a global leader in the world of power generation, power transmission and distribution. As a pioneer of large-scale and efficient CCS technologies, the company provides world leading CCS technology on coal power. In November 2015 GE acquired Alstom’s energy businesses through its largest industrial investment to date, a move that is critical to GE’s corporate transformation.

BOC is the UK’s largest industrial, medical and special gases provider with clean energy technologies at the forefront of investment as part of its innovation strategy. BOC has capabilities in all three currently viable CCS technologies (post-combustion capture, pre-combustion capture and oxy-fuel capture), it is also working with research partners to explore second generation carbon capture technologies.

Drax is the owner of Drax Power Station, the largest, cleanest and most efficient coal fired power station in the UK, possessing some 3,960 MW of output capacity in a single site. At current average output levels, Drax meets some 7-8% of the UK’s electricity needs. Currently following a decarbonisation strategy, with its ongoing conversion to burn sustainable biomass in place of coal being Europe’s largest decarbonisation project to date, Drax has the available land and connection infrastructure and coal-fired operating expertise to host the White Rose CCS Project.

1.2.2 National Grid Carbon Limited

NGC was created as an independent subsidiary of National Grid plc to lead the development of carbon dioxide transportation infrastructure in the UK. NGC works with industry, universities and government to determine how best to realise a carbon T&S network and to attract new entrants to invest in carbon dioxide storage.

[1] CPL was formed in December 2013 between Drax, BOC and Alstom UK Holdings Limited. In November 2015, General Electric acquired the energy businesses of Alstom including its interests in CPL.

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2 Principal Commercial Structure

This Section 2 provides an overview of the White Rose CCS Project's Base Case commercial structure developed for the Competition during the RRP. The context and intent of the Base Case design is required for subsequent understanding of the individual lessons learnt described in this document.

2.1 Commercial Structure

Figure 2.1 below summarises the proposed Base Case commercial structure of the White Rose CCS Project.

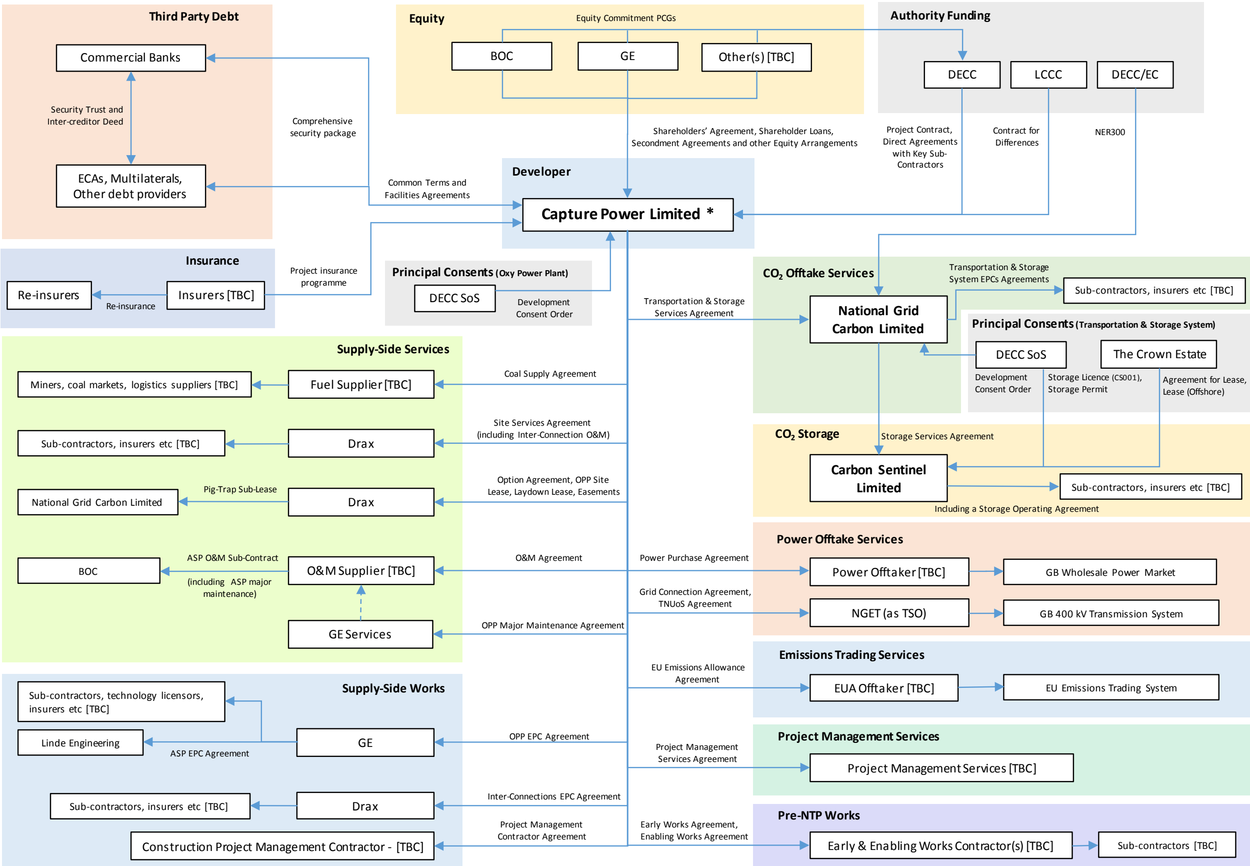

Figure 2.1: White Rose CCS Project Summary Base Case Commercial Structure Source: CPL

As shown above, CPL was the corporate delivery vehicle for the Project as the nominated Developer under the terms and conditions of the Competition and the intended single entity counter-party to the Project Contract with DECC. Through various contractual relationships with equity sponsors, third party debt investors and its supply chain (including NGC), CPL was to deliver and manage the full-chain CCS project in accordance with a programme for delivery agreed with DECC.

CPL was structured in accordance with standard project finance principles and designed to be capital funded through a mixture of sponsor equity, third party equity, non-recourse third party debt and HMG grant funding. This capital was to be repaid through operating revenues gained through the sale of generated electricity on the UK wholesale market, supported by a Contract for Difference (CfD) with the Low Carbon Contracts Company (LCCC). NGC on the other hand was to be funded entirely through corporate finance from its parent, National Grid, with such funding to be repaid through carbon transportation and storage services fees charged to users of its Humber Cluster network, with CPL's OPP as its initial 'anchor' customer.

Carbon Sentinel Limited (CSL) was incorporated as a wholly owned subsidiary of National Grid plc for the purposes of operating the chosen White Rose offshore carbon store 'Endurance'. NGC would sub-contract responsibility for the store to CSL through a storage services agreement and CSL would also be the recipient of the necessary (seabed) leases and operating consents, namely the Storage Permit. As the designated Storage Operator, CSL would be responsible for the sub-contracts necessary to undertake the construction and operation of the 'Endurance' carbon store.

2.2 Programme for Delivery

The White Rose delivery programme consisted of 7 key phases following a successful FID by the Project's sponsors and DECC and the achievement of Financial Close in respect of the OPP's project financing. The scope of each key phase is summarised below:

1. Pre-NTP Phase

Prior to CPL issuing a 'Notice to Proceed' (NTP) to its supply chain following Financial Close, certain preparatory works to the CPL OPP site at Drax were to be implemented, including the relocation of certain existing infrastructure and the execution of earthworks to de-risk and shorten the power plant construction phase. This phase was expected to be around 12 months in total duration.

2. Construction Phase

Following CPL issuing a NTP to its supply chain, both the OPP and T&S System are constructed and commissioned separately, before undergoing final commissioning tests and reliability runs as a full-chain. This phase was expected to be up to 5 years in total duration.

3. Commercial Proving Phase

Following final commissioning and a short reliability run it was planned to undertake a number of operating modes to demonstrate the flexibility of the OPP and its ability to respond to the dynamics of the wholesale electricity market. Certain risk support mechanisms from DECC remained available to CPL during these demonstrations. This phase was expected to be up to 3 years in total duration.

4. Operational Phase

Following completion of the preceding phase, the OPP was expected to run in baseload mode for the majority of its economic life, storing on average around 2 million tonnes of CO_2 per annum. This phase was expected to be up to 17 years in total duration.

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5. Decommissioning Phase

Once the OPP had ceased transferring CO_2 into the T&S System, the OPP was to be decommissioned; if NGC had no other users of the Humber Cluster network by this time, then the offshore T&S assets would be decommissioned in parallel, however the base case expectation was for growth of third party access business to mean that the T&S decommissioning would be much later (depending on the remaining life of third party contracts and the assets' useful technical life). This phase was expected to be around 2 years in total duration.

6. Monitoring Phase

Following the decommissioning of the carbon store, CSL was to undergo a monitoring phase to ensure the carbon remained locked in the geological formation, with routine maintenance activities undertaken in situ. This phase was expected to be up to 20 years in total duration, subject to agreement with the Oil and Gas Authority.

7. Handover Phase

Following the successful completion of the preceding phase, and assuming that the offshore carbon store had remained stable, ownership and responsibility for the store was to be handed back to OGA together with a cash fund sufficient for a further 30 years of monitoring.

For further details of the full-chain FEED programme of development activities, and the full-chain implementation programme, please refer to KKD documents K.10 and K.09 respectively.

2.3 Contracting Objectives

The key commercial objectives behind the contract structure set out in Figure 2.1 above are outlined below. These are intended to help provide an understanding of the Base Case commercial model and overall risk allocation of the Project, as well as context for the key full-chain risks and lessons learnt, as set out in Sections 3 – 16 below.

1. Authority Funding

This group of contracts provide, amongst other things, capital and operation funding support to the Project, together with financial support for consequences of any CCS specific risk event occurrences.

2. Principal Consents

These consents permit the lawful construction and operation of the OPP and T&S System, subject to certain restrictions and requirements. The permits are obtained following a fixed-duration democratic procedure involving the corresponding developer submitting proposals for planning consultation involving a number of governmental departments and the general public. In addition, the offshore carbon storage field is placed under long-term lease to CSL by the body responsible for awarding the rights for carbon storage in the UK's Gas Importation and Storage Zone.

3. Supply-Side Works

These contracts deliver the OPP, including infrastructure connections to fuel supply, electrical export systems and local utilities through substantially fixed price, fixed duration EPC construction contracts. A project management contractor (PMC) acts on behalf of CPL to manage delivery of these specific supply-side construction and commissioning works including the interfaces between the OPP constructor (GE), the site host and interconnections constructor (Drax). NGC would be responsible for the delivery of the transport system and CSL would be responsible for the Storage System. Both NGC and CSL would sub-contract their construction activities to various EPC contractors; this level of detail is not shown in Figure 2.1.

4. Supply-Side Services

These contracts provide long-term coal supply and associated delivery logistics to the OPP, along with the long-term site lease and associated easements for connections to utility infrastructure. Various utility supply services relevant to a coal-fired plant are provided under contract with Drax and the operations and maintenance of the oxy power plant is contracted to a suitably experienced operator, supported by a specialist equipment maintenance contract with GE.

5. Power Offtake Services

These contracts enable the long-term purchase of the electrical output of the OPP at a pre-determined price by a commercial counter-party trader, with the relevant export capacity reserved accordingly on the Great Britain 400 kV network operated by National Grid Electricity Transmission.

6. Carbon Offtake Services

This contract provides the commercial link between the OPP and the T&S System, providing also the operating standards for the full-chain Project. CPL reserves capacity on the NGC T&S System through this contract.

7. Carbon Storage Services

NGC's duties towards CPL for the long-term storage of its captured carbon is sub-contracted to a separate storage services company CSL that holds the legal responsibility for the safe operation and maintenance of the offshore carbon store.

8. Insurance

CPL transfers a number of power station construction and operation related risks to commercial insurers through a comprehensive framework of insurance policies. NGC and CSL have a similar framework of insurance policies related to pipeline and offshore platform construction and operation, although this is not shown in Figure 2.1.

9. Equity

This group of contracts provide the required level of injection of equity funding into CPL as a project financed special purpose company; this equity is expected to be provided as a shareholder loan to CPL. A shareholders' agreement governs the multi-shareholder ownership of CPL. The shareholder's equity commitments to CPL are supported by Parent Company Guarantees towards DECC.

10. Third Party (Commercial) Debt

These contracts provide the terms and conditions under which a collective of commercial banks, multi-laterals, export credit agencies and other organisations provide non-recourse debt finance to CPL, including the subsequent timescale and margins for repayment.

11. Project Management Services

This contract would engage an external professional services company in the provision of a wide range of commercial, technical and finance personnel, on a flexible basis as required, to act as an extension of the core CPL team in the implementation of its business, in particular across its entire supply chain during the Construction Phase. This service provision would be tapered off as CPL progressed beyond the Construction Phase, through the Commercial Proving Phase and in to the long-term Operating Phase when permanent CPL staff would be hired.

12. Pre-NTP Works

These contracts enable certain construction works to be undertaken that both shorten and de-risk the main Construction Phase for the OPP. Such works included the relocation of existing utility infrastructure and public rights of way over the oxy power plant site, together with site raising and levelling works to meet various permitting and construction requirements respectively.

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3 Summary of Principal Full-Chain Project Risks

Sections 4 to 16 summarise the 13 principal full-chain risks identified in relation to the Project during the RRP, as well as mitigation steps taken either jointly or individually by CPL and NGC in order to minimise such risks and lessons learnt in relation thereto.

The key full-chain risks relate to:

1. Cross-chain liabilities and default risk between CPL and NGC;
2. Operation of the offshore carbon store;
3. Definition of CCS risks and their sharing amongst stakeholders;
4. Obtaining the required implementation and operating consents, permits and licences;
5. The negotiation of fixed-price procurement contracts;
6. Commercial integration of the various stakeholders across the full-chain;
7. Attracting commercial debt and third party equity finance to the OPP;
8. Technical integration of the key components comprising the full-chain;
9. Limitations of obtaining commercial insurance;
10. Limitations of alternate uses for the generation assets in the event of a terminal failure of CCS technology;
11. Selling capacity in the T&S System to third parties in the Humber area;
12. Designing the key interconnection infrastructure between the CPL OPP and its host site at Drax; and
13. Establishing a robust metering and measurement regime to support the proper commercial and technical operation.

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4 Cross-chain Liabilities and Default Risk

The future development and commercial roll out of CCS is highly likely to evolve on a ‘cluster’ basis where developers of generation and capture assets or industrial capture projects have contracted access to common infrastructure, developed by CO_2 transport and storage providers. The White Rose commercial structure was devised in accordance with this expected development pathway (as shown earlier in Figure 2.1) with CPL delivering the generation and capture assets, NGC and CSL delivering the transport and storage assets respectively, together with additional capacity for future users. One important aspect to consider with this type of structure is the risk of potential default of one of the CCS chain links in the full-chain (particularly such as late construction completion, non-availability and insolvency) and the willingness of stakeholders in the remaining CCS chain links, specifically equity and debt providers, to absorb such cross-chain default risk.

The cross chain default risk, pertaining to the liabilities faced by either CPL or NGC through the potential default of the other, was the dominant commercial risk facing the project. Except in circumstances where a single developer has the professional capability and risk appetite to develop the full CCS chain, cross chain default risk is likely to prove to be the most significant commercial challenge for future developers of CCS projects at least until the CCS industry has reached a level of maturity to be considered business as usual.

4.1 Evidence

CPL, a project financed entity owned by several private shareholders, relies upon the availability and performance of the T&S System to accept all captured carbon emissions from the OPP so that it may generate low-carbon electricity and earn revenues in accordance with its contractual mandate and operating legislative permits. As with all project financed special purpose vehicles, CPL is designed to repay its implementation capital, including third party debt, from operating revenues. Similarly, the T&S System implemented by NGC through corporate finance capital loaned from its parent National Grid relies predominantly on a revenue stream gained as capacity fees charged to CPL for the long-term transportation and storage of its captured carbon (see Section 14 for further details on T&S capacity charging). For equivalence with CPL’s project finance structure so that certain commercial concepts were mirrored appropriately, a portion of National Grid’s corporate finance loans to NGC were deemed to be ‘equity-like’.

This inherent commercial structure, devised by the White Rose CCS Consortium in response to the requirements of the Competition to bid ‘full-chain’ solutions, means that a default by NGC in relation to the T&S System may impact CPL’s revenue stream and expose it to liabilities vis-a-vis its debt providers, sub-contractors and/or DECC. This ‘project-on-project’ or ‘cross-chain default’ risk exists equally for NGC upon a CPL default and could ultimately lead to the insolvency of the “innocent” party due to the two integrated parts of the full-chain Project failing to function together as intended. Such failure could be manifest by either party through either construction delay, or the continued non-performance of the OPP or T&S System.

As set out in Section 1 above, a requirement of the Competition was that the White Rose Project was expected to bid against DECC’s BRAM, which importantly included the expectation that the private sector would be responsible for all ‘business as usual’ (BaU) risks relating to a CCS commercialisation project. For White Rose, with its consortium structure, this meant that CPL and NGC were expected to price into its

Base Case commercial structure all project-on-project risk, since the BRAM regarded it as a wholly BaU risk.

Market testing carried out by CPL with its funder group during the RRP has demonstrated that providers of debt are unwilling and/or unable to carry the full extent of cross chain default and corresponding liabilities on the basis of the commercial structure adopted for White Rose as a precursor to the future CCS industry. For CPL's debt providers this was a particular concern given that the banks had no security over the T&S assets which were being financed separately by NGC.

Certain types of equity providers are willing to accept some of the cross chain default risk where they are sufficiently capitalised and have a strategic interest in developing CCS. Equity providers without such strategic interest may find it difficult to accept such risks. Both CPL through its sponsors and NGC were indeed prepared to accept some cross chain default risk, however only to the limit of their own equity committed and/or placed at risk (including provisions for liquidated damages through the Transport and Services Agreement).

4.2 Mitigation Steps

This fundamental risk was recognised early in the development of the Project. Throughout the RRP, the Consortium sought to develop various mitigation measures to help make the risk of cross chain default as remote as possible. A summary of these arrangements is outlined below.

The primary tool used to mitigate the risk of cross-chain default between CPL and NGC was the inclusion of damages in the TSSA. These damages were calculated based on the expected financial losses of the "innocent" party and were payable in circumstances where there were delays to construction of the OPP or T&S System, or unscheduled interruptions during the commercial Operational Phase. In accordance with standard project finance principles, these cross-chain damage payments from NGC to CPL would be backed by a parent company guarantee, but not vice versa as it was structured and financed as a special purpose company.

Once a framework of damage payments was established under the TSSA, the subsequent challenge was to push these potential liabilities away from the respective parties to this contract and into the respective supply chains. Since there is significant cross-chain liability inherent in the parallel construction of the OPP and the T&S System, the bulk of these liabilities were passed down to the construction contractors. This was achieved primarily by placing as much construction scope as possible under fixed-price and delivery date certain EPC contracts, with delay damages due to the employers under the various EPC contracts mirroring (to the extent possible) those for which their respective employer would then become liable for payment under the TSSA. These potential delay damages would then in turn be priced into the EPC construction contracts by the EPC contractors. However, not all construction scope was able to be contained under EPC contracts, as described in Section 8.

An integrated framework of insurance policies supporting the Construction Phase through to the Operational Phase was developed. This provided CPL and NGC with finite sums of financial support for the impact of any insurable events occurring. However, insurance risk appetites are subject to fluctuation as described further in Section 12 of this document, and all policy pay-outs are subject to waiting periods and exclusions.

The financial impact of potential cross chain default risk events that were not passed down to the supply chain or covered by insurance products were then left with CPL and NGC accordingly. A finite sum of contingent equity was to be made available by the sponsors of both CPL and NGC at Financial Close and once in commercial operation, both CPL and NGC accrued operational reserves, built from revenue streams, with CPL reserves being sufficient to satisfy third party debt providers under typical project finance requirements.

Finally, to lessen the financial impact of an unavoidable early termination of the TSSA, both CPL and NGC pursued mitigating strategies outside the scope of the Project. For NGC this meant the sale of capacity in the T&S System to third party carbon capture users such as other power generators and industrial facilities in the Humber Cluster. CPL investigated the possibility of converting the OPP to run entirely on biomass (or together with coal) or on natural gas, thus enabling it to operate within its environmental permits without the need for NGC's T&S System. These alternate use investigations are described in further detail in Section 13 of this document.

4.3 Lessons Learnt

Although the mitigation measures described above helped make the risk of cross chain default remote, evidence gathered by the Consortium showed that third party debt providers nonetheless remained uncomfortable taking the balance of such risks on a FOAK CCS project, bearing the potential impact of such events in mind as well as the likelihood of full recovery in a default scenario. In the absence of a single developer for the full-chain, it is the view of CPL and its financial and legal advisors as well as the appointed lenders legal advisors that given the experience with the White Rose project, part chain industrial developers are unlikely to bear cross-chain default risk and the potential financial consequences of such.

In considering lessons learnt from the Project, there remains a wider question as to whether there may be alternative ways of structuring future CCS projects, which would further minimise or remove project-on-project risk and potentially reduce costs (albeit possibly with transfer of risk to the public sector).

5 Storage Operation

A key requirement of the Project during the RRP to make it a financeable proposition was to obtain a Storage Permit consent for the chosen offshore carbon store from the relevant UK regulator, the Oil and Gas Authority (OGA), an executive agency sponsored by DECC. To secure this Storage Permit, it was necessary to provide sufficient evidence that the 'Endurance' geological carbon storage site in the North Sea would contain White Rose's captured carbon quantities safely and permanently, and that the Project had the necessary competencies to operate the offshore storage asset safely. As such, the attainment of the Storage Permit encompassed a number of commercial, technical and consenting activities, including fulfilling NGC's strategic intent for entering the offshore carbon storage business, the lessons learnt from which are outlined in this Section 5.

National Grid established its own storage company, Carbon Sentinel Limited (CSL), to undertake its storage development activities and to be the registered assignee of the Storage Permit, amongst other granted legislative rights. CSL had to consider the key technical and commercial risks associated with offshore geological carbon storage and develop solutions accordingly, including the establishment of agreed levels of financial securities it had to put in place as a requirement of the European Commission CCS Directive, as transposed into UK legislation.

During the RRP, NGC decided that it was prudent to seek third party investors to take the lead role in delivering the offshore carbon store and subsequently promote the creation of a storage industry that could progress to deliver further storage sites as necessary to grow CCS at scale. This strategy was also aimed at a number of objectives including:

(i) procuring the best skills and experience to manage the CO_2 storage element of the CCS chain and associated risks;
(ii) allowing NGC to focus more of its investment of time and money on delivering the CO_2 transportation business;
(iii) developing a business model able to attract new entrant investors to the carbon storage sector, thereby expanding the CCS industry; and
(iv) accessing operating synergies with nearby gas field operations where possible.

Additionally, NGC sought both a Pipeline Works Authorisation (PWA) and a Storage Permit from the OGA.

5.1 Evidence

In developing the storage operation proposal in conjunction with running a process to attract a third party equity investor in CSL, NGC created important evidence and learning for application to future CCS projects. The technical, commercial and corporate structuring evidence that shaped NGC's development processes is outlined below.

The majority of the carbon store's technical development programme is identical to that employed for developing hydrocarbon resource fields. Characterisation of the store was performed by NGC under an earlier development programme funded by the European Commission's 'European Energy Programme for Recovery' (EEPR). This evaluation work that included drilling an appraisal well demonstrated to the storage owner, regulator and other CCS developers that they should have confidence that Endurance's geological formation could be used to store carbon safely and permanently. A comprehensive, independent quantitative risk assessment of the integrity of Endurance was conducted by an external organisation which concluded that “the risk assessment provides a high level of confidence that long-term containment of the CO_2 planned to be stored will be achieved, and the system will evolve to long-term stability. Risks to human health or environmental receptors associated with loss of containment (in the unlikely event it occurs), displacement of brine and deformation are either low or very low”.

A key commercial requirement of the T&S System is its high level of availability, particularly as it is designed for multiple carbon capture users. Despite the assurances previously described, there remains, as with a hydrocarbon development, a degree of subsurface performance risk after a FID and until reservoir (or well) performance history is established. With high availability, the commercial storage proposition is significantly more attractive if the scheduling of its shutdowns for planned maintenance can be synchronised to that of its users. In addition, minimising the impact of unscheduled interruptions to its availability is also required as a design objective to aid the commercial proposition.

Storage operators are required to post financial securities with their Storage Permit applications, as required by the European Commission CCS Directive. Such securities cover the cost of the following:

(i) monitoring obligations through the injection phase and post-closure monitoring phase;
(ii) decommissioning of the storage site infrastructure/ wells;
(iii) a financial contribution to the OGA for monitoring costs following site hand-back, plus a provisional payment to HMG for any storage operator default;
(iv) remediation of any leakage; and
(v) surrender of EU ETS credits for any carbon escaping to atmosphere from the store.

Whilst some of these financial exposures such as decommissioning costs could be estimated accurately, many could not. This posed a challenge to the development of a satisfactory commercial framework for offshore carbon storage.

A Pipeline Works Authorisation (PWA) issued by the OGA provides an infrastructure developer with consent to construct an offshore pipeline within a defined location. PWAs are typically obtained post Financial Close by developers of conventional hydrocarbon projects. Since a wealth of industry experience has demonstrated that the need to re-route offshore pipelines after engaging the OGA is seldom required, obtainment of a PWA is often viewed as relatively low risk post FID activity. Nevertheless, NGC sought prudently to obtain its PWA during the White Rose RRP.

Following receipt of NGC’s PWA application, there ensued a discussion with the OGA over the timing of the PWA application processing and subsequent award. Due to the nature of the White Rose PWA application in the context of a FOAK CCS project, a greater quantity of supporting information was required by the OGA in comparison to a similar sized hydrocarbon development project. At the time of HMG’s announcement on 25 November 2015 regarding the cancellation of the CCS Competition, the issue was still under discussion between NGC and the OGA and so there remains some uncertainty as to the degree to which this aspect of risk reduction can be achieved prior to FID.

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5.2 Mitigation Steps

Whilst the technological solutions were well understood from the various evaluation activities, the commercial and financial development of the store required a number of risk mitigations.

A full-chain RAM study indicated that, over the life of the project, high levels of availability and reliability could be achieved with the implementation of three injection wells into the store to provide an appropriate level of redundancy. However, to meet the required availability target, the robust co-ordination of maintenance activities across the full CCS chain is essential. Appropriate downtime planning mechanisms, including protocols for communicating the need for unscheduled downtime, were put into the TSSA.

To balance the need for posting financial securities with overall capital affordability for private investors, a Storage Sinking Fund (SSF) was developed to cover storage liabilities. The SSF was built up by NGC by extracting a proportion of capacity fees paid by users of the carbon transportation and storage system and was designed to reach a given cumulative sum by a predetermined date. Any storage liabilities that arose would be covered by the SSF. Negotiations were held with DECC and other parties such as insurers with regards to them covering any shortfall in the SSF, should it arise.

National Grid conducted two extensive market tests during the RRP to identify and attract the entry of candidate equity investors in CSL either immediately or at Financial Close of the Project. The market tests explored the interests of more than 65 companies across a wide range of existing relevant industries: hydrocarbon exploration and production, natural gas utilities, hydrocarbon service providers, gas storage operators, nuclear waste management operators, waste-water utilities and financial investors.

To mitigate the issue with the Pipeline Works Authorisation (PWA) timing and likely award post FID, NGC undertook a stakeholder consultation with all offshore licence block owners along the proposed pipeline route to ensure that any risks to re-routeing post FID were identified during the RRP. In addition, NGC prepared a draft PWA application for review and comment by the OGA during the RRP with the aim of ensuring all known issues could be identified and resolved during the RRP and ahead of a formal application post FID.

To mitigate the issue with the Storage Permit, NGC undertook extensive engagement with the OGA during the RRP including a number of technical meetings and a core workshop in Aberdeen to show members of the OGA team the core samples taken from the appraisal well. In addition, NGC staggered the submission of draft permit application documents to enable the OGA to review and comment on individual sections rather than the entire extensive draft application.

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5.3 Lessons Learnt

Whilst the technical and commercial development of the carbon transportation and storage asset was able to progress during the RRP, with risk mitigations as described above, it was not possible to secure the entry of an equity investor in CSL. The principal reasons given for this lack of entry were:

- Lack of fit with corporate strategic intent;
- Lack of confidence in government CCS policy commitment; and
- Time and cost involved in completing a government procurement process.

Additional themes also emerged:

- Return on investment for the storage business of CSL deemed insufficient to justify taking reservoir / well performance risks that might be accepted by hydrocarbon project investors;
- Natural gas utilities are only interested in storage so as to further their gas transportation business;
- Financial investors are unable to bring the necessary offshore operator skills; and
- Hydrocarbon services companies are not interested in taking equity positions in the CO_2 storage sector.

There was found to be some interest in R&D co-operation, but that this learning could be satisfied elsewhere without the need for equity investment in a storage company.

The lessons learnt should inform those changes required to attract new investors to carbon storage and thereby help deliver the CCS industry. Principally, potential new entrants require a business model suited to the specifics of carbon storage as a low return, high risk activity, confidence in the government's long-term decarbonisation policy, and a less onerous programme to Financial Close.

Whilst the offshore activities of carbon storage are comparable to those of hydrocarbon exploration and production, the commercial model of the former, ostensibly a waste disposal business, is viewed as providing insufficient reward for the potential risk impact involved. The physical risks related to carbon storage are of low probability, whereas their potential financial impacts remain high, including cross chain liabilities for service interruption and the purchase of emissions certificates at an unpredictable price in case of leakage to atmosphere. Furthermore, whilst the probability of a carbon storage risk incident occurring is low in comparison to the risks facing producers of hydrocarbons offshore, oil and gas businesses are able to balance such risks against the relatively high value of their product, compared with the storage of captured carbon, particularly since there is a track record of sufficient reward for taking such risks. There is no such track record of reward for investment in carbon storage; this will therefore only occur with the relevant assistance from government in delivering the commercialisation of the CCS industry.

In future, private investors in CCS commercialisation projects need to see clear, consistent and enduring government policy in order to provide the necessary commercial confidence to invest in storage operations. This in turn would lead to shorter negotiation timeframes for investment deals to be made.

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If a store fails during operation for geological reasons, the store may need to be abandoned and a search for a replacement can be prolonged. Geological risk is site specific and may only manifest itself during operation whereas understanding of capture and transportation risks can be transferred from analogues or pilot schemes. Government support to establishing a commercial scale carbon store is essential so that these risks can be better understood and mitigated. The duration required for storage identification, access and characterisation can be several years requiring considerable financial commitment and involving geological (exploration) risk. Store characterisation is critical before other participants in the full-chain are willing to consider joining any development activities. In the case of the White Rose carbon store, Endurance, work would not have progressed without EEPR support ahead of the present Competition.

The consenting regimes for CO_2 transportation and storage – based upon hydrocarbon regulation – do not enable all principal offshore consents to be obtained pre-FID. Particularly with regards to the Pipeline Works Authorisation, some risks will remain on the offshore pipeline route post FID unless further work is undertaken between developers and the authorities to accelerate the offshore consenting process for CCS projects to bring its potential award to within the equivalent of the RRP.

The application for CO_2 Storage Permits is a new practice reflecting the novelty of CCS in general. Until more experience has been acquired it should be expected that the application for a Storage Permit is going to be a lengthy process. For the purposes of applying for a Storage Permit developers should not underestimate the time and resource required to engage with the Oil and Gas Authority.

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6 CCS Risk Definition and Sharing

The role of HMG in the implementation of the White Rose CCS Project would involve not only financial support for its construction and operation but also a share in the financial impact of those incidents deemed a manifestation of a defined CCS risk. Essentially, the CCS market is widely considered to be 'broken' in that despite CCS technology being widely recognised as a potentially cost-effective approach to reducing carbon emissions from the power generation sector and from industry, CCS project construction and operation involves certain risks that private companies are unwilling to take alone, thereby creating a need for government-level intervention to mitigate such risks to a level at which Projects become financeable.

Establishing the point of market failure along a number of negotiating fronts between CPL and DECC, and in turn between CPL and its supply chain, insurers and debt providers, was in principle a core outcome of the RRP, against which the Baseline Risk Allocation Matrix (BRAM) defined DECC's preferred outturn position. Without reaching a successful conclusion on CCS risk allocation, amongst other development challenges, the Project would not be able to achieve Financial Close, and if the development of contractual mechanisms for CCS risk allocation was not sufficiently thorough, it would leave both equity and debt investors at risk during the construction and operation of the Project.

6.1 Evidence

The offer for government to share in CCS risks in the Project was reflected early in the draft documentation regarding Authority Funding of the commercial model – see Figure 2.1 for details. This offer would be subject to negotiation of the associated Authority Funding contracts, which in turn would be rolled down to its various counter-parties in the commercial structure through subsequent negotiation, with the potential for multiple iterations as CPL searched for the limit of risk allocation appetite in the private sector involvement in its commercial framework.

An important aspect of the risk allocation framework with government related to compensation on termination should the project be unsuccessful due to "CCS Specific Risks" (as opposed to risks arising from normal business activities); including the extent of compensation to debt providers.

6.2 Mitigation Steps

The CCS risk allocation negotiations between White Rose and DECC specifically involved principally the determination of two fundamental outcomes:

- Those risks which could be argued successfully to be CCS related, and how they would be defined subsequently in the applicable contracts; and
- The sharing ratio between CPL and DECC for the financial impact of each qualifying CCS risk which would be applied.

In turn, a procedure of CCS risk determination, definition and allocation was devised by CPL to support its CCS risk allocation negotiations with its commercial structure counter-parties. This procedure began with a compilation of a robust Project risk register, completed with the involvement of various professional advisors and key personnel in the supply-chain counter-parties. A two-step review and filter process was then applied to scrutinise those individual risks to determine if they were arguably CCS related and thereby required allocation ultimately to government under the Authority Funding contracts.

The first step consisted of assessing if a commercially proven solution was already available for mitigating an individual risk in the risk register, based upon one or a more of the following:

- good industry practice;
- public domain knowledge;
- industry supply-chain know-how; and
- third party technology (from the relevant industry or from other industries) for which a licence could be obtained on commercially acceptable terms.

If the first assessment returned negative to all the above criteria, the risk was classified as a CCS specific risk in the risk register and the evaluation process was complete. If the response to any of the above criteria was affirmative, or if it was agreed that the risk was generic, a second assessment was performed based upon probability or extent to which the risk could be allocated to one or a combination of:

- supply-chain organisations;
- debt providers;
- insurers;
- equity investors; and
- others.

This second evaluation step involved a degree of subjective judgement based on experience of other project developments. In the case where a risk was insufficiently allocable, and therefore CPL remained with high residual uncertainty which was not capable of being reasonably priced, the risk was classified as a “CCS risk” requiring HMG support.

To complete the definition process and negotiation, percentages of sharing the financial impact of a CCS risk event were presented by CPL to DECC. From this agreed allocation, the financial impact of a CCS risk event, should it have occurred during the Construction, Commercial Proving or Operational Phases, could be shared accordingly under various contractual mechanisms in the Authority Funding agreements.

The approach also allowed for the retirement of CCS risks in time by assessing whether the two step process above would yield a different result with the passage of time for example if a previously defined CCS risk became insurable, or could otherwise be placed in the private sector on terms that represented better value for money.

It is also worth noting that by exposing their equity to CCS risks (or ‘equity-like’ funding on the part of NGC), including any contingent equity injection up to the full amount, both CPL and NGC were putting significant quantities of investment funding at risk, irrespective of where across the full-chain CCS risks might crystallise. This formed an important part of the integration dynamic of the White Rose project and ensuring collaborative behaviours between the parties in the management and mitigation of CCS risks.

6.3 Lessons Learnt

The CCS risk list was determined after several iterations between CPL and its commercial counter-parties, including the government. It was found that all stakeholders could be made comfortable with a list of CCS specific risks. This was achieved by striking a balance between clear definitions of such risks so that they could be understood and recognised, but were not overly prescriptive in the contractual documentation, allowing a degree of interpretation and judgement should a CCS risk event actually occur.

7 Consenting

A full-chain consenting regime for the White Rose CCS Project did not exist prior to the start of the RRP. Instead, CPL and NGC pursued separately the necessary consents for the OPP and for the T&S System respectively. Since the key consenting challenge for the T&S System was the attainment of its Storage Permit, the lessons learnt from which are contained as part of Section 7, this section deals with the challenges relating to consenting the full-chain from the perspective of the CPL OPP.

Whilst there was no special consenting regime for the OPP, it still required existing consenting regimes to be fitted to the specifics of White Rose as a FOAK power plant project. This inevitably raised new issues with the regulators which needed timely resolution.

CCS is a new industry and as such provides extra challenges to regulating authorities as they attempt to understand the planning and development impacts of individual projects. The time required to obtain permits for such FOAK projects may therefore be less predictable (potentially longer) than for standard technologies; as such, the Project risked delays to its programme to Financial Close.

7.1 Evidence

Development Consent Order and Environmental Permit

The OPP required two key consents: a Development Consent Order (DCO) and an Environmental Permit (EP). Obtainment of both is linked heavily to the technical design and operation of the Project and accordingly, designing the Project to meet consent requirements can have a material impact on its economics and implementation programme. Health and safety considerations are also a key part of the consent application evaluation process.

For the DCO, managed by the Planning Inspectorate (PINS), there is a clearly defined, open process with definitive timescales to completion from the point of application submission by the developer. However, the primary planning legislation applicable to the obtainment process is relatively new.

In applying for its EP, CPL found that, whilst there is published guidance for developers, the progress of the application appeared to be largely at the discretion of the Environment Agency (EA), the competent authority for this permit. Considerable time was spent by the Project at an early stage pre-application engaging the EA in understanding the particular features of oxy-fuel technology and CCS. Despite this initiative, there was considerable delay whilst a large number of highly technical questions raised by the EA were answered to their satisfaction before evaluation of the EP application could begin. In addition, the EA provided a draft Best Available Techniques (BAT) document on oxy-fuel technology for CPL to comment on as part of the EP application process.

The calculation of air emissions from the OPP was required for both possible operating modes, “oxy mode” (the normal carbon capture operating mode for the OPP) and “air mode” (similar to conventional fossil-fuel power plant operating without carbon capture and primarily used during OPP commissioning and start-up), as part of the DCO process (and also to inform discussions with the EA regarding the Environmental Permit). These calculated emissions were assessed, along with their likely impact on receptors.

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Health & Safety Considerations

A CCS plant naturally introduces the additional hazard of large quantities of concentrated carbon dioxide and in the case of an OPP, large quantities of oxygen and nitrogen. These are potential hazards not present on conventional power plants. It was found that whilst oxygen and nitrogen hazards are well known and sufficient guidance to industry is readily available, there is less industry guidance available for carbon dioxide hazards. Carbon dioxide is not classified as a hazardous substance, but it is however both an asphyxiant and toxic above certain concentrations.

The UK Health and Safety Executive, the competent authority for assessing such risks, indicated that they had no current plans to reclassify carbon dioxide as hazardous material, or otherwise bring in specific legislation. Its stated position was that industry should develop best practice for handling carbon dioxide in the context of existing legislation.

Emissions Performance Standards

The Emissions Performance Standards (EPS) limits the carbon dioxide emissions from a fossil fuel power plant to a maximum annual value based on its electrical generation capacity. For a new-build unabated coal plant current EPS this would limit its operation to between 50% - 60% of its full output per year.

With regards to the application of EPS to the Project, it was found that the UK Energy Act 2013 contains a provision to exempt that part of a newly-constructed power station that is equipped with CCS from the EPS for a maximum period of three years from the point of commencement of commissioning. The commencement of commissioning for the purposes of EPS exemption is coterminous with the availability of the transport and storage system ready-for-commissioning. As a result, commissioning of the power plant prior to this does not benefit from the exemption including commissioning of capture facilities depending upon the sequencing.

7.2 Mitigation Steps

The technical queries regarding the OPP were progressed with the relevant authorities as part of the consent application and evaluation process. Whilst, as indicated above, there was considerable effort expended in this regard in both the DCO and EP application processes, mitigation of the risks to progress of the application is largely a function of engaging highly competent developers, supported by reputable professional advisors.

However, there were a number of mitigation steps that were taken in advance of submitting the consent applications for the OPP. Since the CCS industry is new to the UK, consultees involved in the consenting process are unlikely to be familiar with the technology and its operation. As such, CPL gave careful consideration to the pre-application consultation phase of the Project to minimise the risk of delays to consent award through misunderstanding or challenges to the application. This pre-application consultation with consultees was subsequently beneficial to their understanding and engaging in the Project's continued development and evolution. The risk mitigations for the pre-application consenting phase involved:

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- Early briefings and engagement to help ensure stakeholders and communities not only had an involvement in the development of the Project, but also gained in-depth understanding so in turn they could give informed feedback. In addition, it provided time to fully explore and resolve any concerns prior to submission of the DCO application;
- Setting the right tone and content of consultation materials using straightforward language and 'hands-on' visuals to ensure that those stakeholders with very limited technical knowledge could engage fully;
- Holding public exhibitions at local venues at convenient times to help enable as many individuals as possible to fully participate, even if they are time-poor or without access to suitable transportation. The chosen venues had sufficient car parking, provided disabled access and could accommodate the consultation materials comfortably;
- Learning from previous DCO applications to provide for example consenting duration estimates for project scheduling purposes;
- Establishing a website to provide accurate and timely information to help drive understanding and participation in the consultation, particularly for those unable to attend the public exhibitions. An online feedback form helped capture as many stakeholder views as possible;
- Providing a freephone, email address and freepost address in particular helped to ensure lines of communications with residents and stakeholders remained open and questions could be answered in the often lengthy gaps between the consultation stages. These also help support participation in the consultation as consultees and residents can ask questions about forthcoming events or the feedback process. Similarly, newsletter and leaflets allow information to be communicated to a wide audience and in an easy to read way;
- Early engagement with PINS ensured that the projects were fulfilling the requirements to the DCO application and all stakeholders and interested parties were consulted in the correct way; and
- Using commercially-available computer software to track, understand, structure and implement the stakeholder engagement processes.

7.3 Lessons Learnt

In addition to the de-risking of the pre-consultation process as described above, the experience of progressing the consents application process provided important lessons for future CCS projects in the UK.

The level of input to the DCO from the engineering contractors in the supply chain was high and involved the development of information not associated with FEED studies, but which would set the basis of the DCO requirements and possibly constrain their execution strategy for the project. Engineering contractors need to be prepared to apply realistic experience based predictions concerning construction activities.

CPL discovered that the current approach adopted by the EA has the potential on a FOAK project to cause delay if not properly factored into the planning of the consenting process and overall schedule to RRP completion. A developer should allow for significant levels of questioning ahead of the EA beginning its formal evaluation of an EP application, rather than simply dealing with them during the normal examination process. In addition, the question of how BAT should be established and applied to a FOAK project needs to be tackled by all parties, well in advance of permit application, so that the application documents can fully address the matter. This approach needs upfront agreement with the EA and requires additional time

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to be allowed in the consenting programme. Furthermore, establishing BAT should be based on industry experience rather than on literature searches, particularly in the case of projects such as White Rose that introduce FOAK technology.

CPL learnt that whilst both its DCO and EP applications entered their respective examination and evaluation phases concurrently, the present consenting regimes do not permit their consideration in a manner which allows common issues to be dealt with unitarily, and thus enable the EA to engage fully in the DCO examination. Engaging the EA earlier in the White Rose consenting process on specific issues and items through the Consents Services Unit of PINS would, in retrospect, have provided beneficial support to the EA and CPL throughout the EP application process.

The following key learning points should be considered by a FOAK project developer, particularly with respect to allowing sufficient programme time to ensure that the challenges of agreeing an EP with the EA do not cause a delay to development completion:

- In instances such as the employment of new technology, the developer should work in parallel with a dedicated EA team that includes a case officer so as to identify potential issues and likely questions at an early stage;
- Whilst the EA has autonomy over the EP consenting process, the developer and the EA should aim to agree an engagement protocol from the beginning. Such a protocol should address, inter alia:
  - how the EA and PINS will interact in the DCO process, both during the preparation of the Preliminary Environmental Information Report (PEIR) and its subsequent examination; and
  - The agreement of, and issue by, the EA of appropriate BAT guidance (if it is to be applied) sufficiently early in the process to inform the applicant accordingly.

For specific health, safety and environment lessons, when the OPP is in commissioning and then operation, all operators need to wear three-way personnel gas detection equipment measuring for carbon dioxide, oxygen enrichment and oxygen depletion. CPL approached the design of the OPP to minimise the potential hazards through a combination of designing to minimise leakage, eliminating as far as possible areas where carbon dioxide could concentrate, and monitoring accordingly for leaks. Consideration also needs to be given to venting of concentrated carbon dioxide during periods when the T&S System is unavailable, in particular to ensure that ground level concentrations do not cause a hazard to life, or that the levels at the air intake to the air separation units do not exceed the safe limits for their operation. For White Rose, these were modelled and found to be satisfactory. Note that the T&S System design was conducted using the precautionary approach of assuming carbon dioxide is a hazardous substance. This has the advantage of future-proofing its design against changes in legislation.

For environmental impacts, CPL showed that in addition to reducing carbon dioxide emissions across the range of pollutants from conventional coal-fired power plant such as SOx, NOx, CO and heavy metals, the emissions mass flow rate is significantly lower in oxy mode, with impacts at ground level receptors significantly reduced.

The EPS places an annual limit on CO_2 emissions from a fossil fuel power station. The EA have published guidance on its application to CCS plants, in particular an exemption period of three years to cover the

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period during which commissioning of the full CCS system will take place. Liaison is required with the EA to ensure there is a clear understanding of the required commissioning sequence for the full CCS chain and that the exemption period can be most effectively applied to support its timely realisation. Early discussion on the detailed application of the 3-year exemption from EPS for CCS projects is therefore advised.

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8 Fixed-Price Procurement

To facilitate a successful Financial Close at the conclusion of the RRP, the Project was required to demonstrate in advance that it met the minimum requirements of those stakeholders holding a financial interest. This demonstration would be achieved largely through the use of a detailed financial model that reflected accurately the expected economic performance of the Project, in conjunction with due diligence performed by HMG, in parallel with potential debt and equity investors, on the various finalised agreements that made up the commercial framework.

To minimise the risk of material change to a project's economic performance subsequent to a successful financial close, it is commonplace for the developer to seek, wherever possible, fixed-price contractual arrangements with its supply-chain, along with other determinations such as defined delivery dates and minimum technical performance standards of the delivered product. This in turn transfers risk from the employer to the contractor and normally results in the contractor adding a risk premium to the offered contract price.

Without a fixed price procurement approach, equity and debt investors are exposed to a material risk to the outturn economic performance of a project, either at completion of construction, where equipment and labour cost variations may impact, or later through imbalanced economic movements in the operational supply chain. The greater the duration between a project's Financial Close and the execution of the elements of a particular contract that are not fixed-price, the greater the economic risk to the project and its investors.

8.1 Evidence

A fixed-price contracting approach is common in the power generation industry, where project finance or similar structured finance methodologies based on limited or non-recourse debt leverage are implemented. Power plant projects developed to project finance standards are typically constructed under fixed-price contracts and wherever possible, the operational supply chain agreements (for example for fuel procurement and power sales) are based on long-term fixed unit prices with appropriately balancing indexation arrangements. In this way, the power generator is insulated from market risk as much as possible. However, in the case of approaching the commercial development of the White Rose CCS Project with a fixed-price contracting objective, several challenges became apparent in the negotiations with candidate construction and operational supply chain contractors.

In the procurement of the T&S System (a significant capital cost element in the Project), contractors are less inclined to enter into fixed-price contracts, in particular in the offshore industry sector from which a significant portion of the T&S delivery was to be procured. Engagement costs for offshore construction labour, equipment and materials can be subject to material changes with the varying economic sentiments of the hydrocarbon sector (a major driver of offshore activity in the North Sea) and costs to completion can be influenced heavily by environmental factors such as adverse weather conditions. In addition, with the OPP Construction Phase expected to be up to five years in duration, obtaining even indicative prices for specialist offshore installation and full-chain commissioning work several years after financial close was challenging, more so when such procurement engagement commenced some time ahead of forecast Financial Close date.

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In the development of the OPP, two key challenges became apparent when the procurement negotiations were begun, stemming in particular from the Project's coal-fired design. These issues related to both its construction and operation.

Firstly, there is no indigenous experience amongst the construction supply-chain of modern ultra-super-critical coal-fired power plant boiler fabrication. The last large-scale coal-fired power station to be constructed in the UK was the extension to Drax Power Station in the early 1980s, delivered under the UK state-owned Central Electricity Generating Board ahead of its privatisation in the 1990s. Related to this issue was also the concern amongst global contracting organisations with the UK's relatively poor economic measure of national productivity (the economic value of its output against the time required for delivery) compared with other developed nations. This measure is an important factor in the contractor's estimation process in determining a fixed-price offering.

Secondly, with the rising global sentiment against the use of coal as fuel for power generation and industry, some candidate coal suppliers were unable to offer long-term prices for the supply of a given quality of coal for the expected duration of the Project's operating life, irrespective of the usual application of market indices to allow for periodic unit price movements in the commodity. In addition, the benchmark price of wholesale electricity in the UK is becoming increasingly less driven by coal prices as it disappears rapidly from the UK generation mix. Therefore, CPL could have exposure to gross margin risk for period variations between fuel cost and power sale prices.

8.2 Mitigation Steps

The Project made use of two key mitigation methods to solve the risks linked to the fixed-price procurement challenges described above. The application of these mitigation measures enabled the Project to develop an overall commercial structure suited to non-recourse debt project finance.

The first mitigation approach made use of the offer from DECC to share in the costs of construction scopes of work that could not be satisfactorily fixed under contract ahead of Financial Close. This sharing was achieved through the terms of the Project Contract with DECC (still under discussion in November 2015). In this approach, a 'pain-gain share' mechanism was employed where for those portions of outturn variable construction costs that differed from their estimates at Financial Close, the cost or saving margin would be shared with DECC according to a given percentage. Through the sharing mechanism, the Project remained incentivised to deliver outturn variable costs at or below their Financial Close estimates. The approach to both fixed and variable costs was supported by the use of prudent contingencies priced into the commercial structure accordingly.

The second adopted mitigation approach enabled CPL to continue engaging in negotiations with those coal suppliers unable to offer long-term indexed supplies through the division of supply volumes into tranches from different supply organisations, thereby avoiding reliance on any one supplier. In addition, CPL made use of the offer from DECC to allow fuel cost to feature as part of the indexation basket for the CfD. Fuel price indexation is not included at present in the standard CfD model for UK renewables supported by HMG since the bulk of renewable projects have no fuel cost, save for those using biomass.

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8.3 Lessons Learnt

Despite the inherent challenges to delivering fixed-price procurement arrangements that faced the Project over its full-chain, suitable commercial mechanisms were available to provide adequate mitigation so that in this regard, the Project could be considered a financeable proposition. This was only made possible in the context of delivering a commercial-scale coal-fired CCS project through the use of the risk-sharing mechanisms available within the Authority Funding agreements.

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9 Full-Chain Commercial Integration

The full-chain White Rose CCS Project consists of a number of organisations across its full-chain commercial model, as shown earlier in Figure 2.1. In order for the Project to operate as a full-chain system that is both financeable and maintains the long-term objectives of its various stakeholders, careful consideration is required as to the overall integration of the elements of its commercial model.

The key building blocks of the White Rose full-chain technical proposal are procured from different industries that each have their own commercial norms and typical approaches for contracting and risk allocation. The power generation block was procured from the power industry, the ASU from the chemical process equipment industry and the T&S System largely from the suppliers to the hydrocarbon industry, in particular for the offshore elements. In addition, and as outlined in earlier sections of this document, HMG was involved in providing capital and operating support to the Project, together with sharing in the various construction and operating risks in order to make the Project financeable.

As such, the development of an integrated full-chain commercial proposition that delivered long-term economic and strategic value to its equity investors, debt payment surety to its debt providers, and value for money to UK taxpayers and electricity consumers was challenging. The risks inherent in the Base Case commercial model therefore had to be considered carefully across the economic life of the Project so that they could be mitigated appropriately. This was achieved namely through the transfer of risk as far as possible from CPL (as the central contracting body) to those parties that were more suited to managing the risk. The allocation of such risks would be reflected accordingly in the Project's commercial pricing structure.

Where financial support for the Project was provided by HMG, principally in the provision of a capital grant, sharing of CCS risk impacts and revenue support to CPL via the CfD, HMG sought to limit the aggregate quantum provided. This limitation was expressed as the Maximum Funding Amount (MFA).

9.1 Evidence

The commercial development of the Project in essence operated across two negotiating fronts, with CPL as the lead. In order for the package of HMG support to the Project to satisfy the criteria for acceptable state aid, CPL had to demonstrate beforehand to DECC the boundary line of 'market failure' across the full-chain i.e. pass over to HMG only a justifiable and evidenced quantum of risks that otherwise prevented the Project from being acceptable ultimately to its equity investors and debt providers.

Prior to the RRP, the Project had received various documentation from DECC that outlined HMG's position in respect of its risk appetite and the various terms and conditions related to the provision of capital and operational funding support to the Project. This formed a basis for negotiations between the Project and DECC, and an indication of those contractual terms and conditions that CPL would likely have to roll down through its supply chain contracts and other counterparties. Similarly, CPL began developing its supply chain commercial structure with the contractual terms and conditions typical for the industry in which it was interfacing, on the expectation that in due course, these contracts would be modified to include those obligations that CPL was expected to agree with DECC but would ultimately be delivered through its supply chain. The development of the integrated full-chain commercial model would therefore involve iterative negotiations between CPL, DECC, and CPL's supply chain until a financeable commercial proposition was delivered that could then achieve Financial Close. Central to these negotiations was the

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premise that CPL would be a project financed entity and NGC a corporately financed entity, with both approaches having certain commercial expectations and norms.

The procurement of the power generation block was made under an EPC form of contract typically used in the construction of independent power projects. The risk allocation approach, namely for a fixed-price and date-certain completion with liquidated damages payable to the employer for non-performance, is a contracting standard familiar also to project financiers. The procurement of the ASU was intended initially by the vendor to be supplied under an EPC form of contract typically used in the chemical industry. Whilst it offered a fixed-price and date-certain completion, performance guarantees and limitations of liability were lower than those typical in the power industry; make-good guarantees were available however for product quantity and quality below critical thresholds. In order to reduce the number of Construction Phase interfaces for CPL, and provide greater comfort to debt providers, the approach taken by CPL was for GE as the power generation block EPC contractor to “wrap” the ASU within its EPC scope. This arrangement in the Project’s commercial model is shown in Figure 2.1

Interfacing the OPP to the T&S System through the TSSA critically integrated commercially the power generation market with the hydrocarbon industry. This created challenges for determining fixed price construction agreements as covered in Section 8 in greater detail. The repayment of construction funds for the T&S System is made through NGC charging a capacity fee to CPL, meaning that CPL faced a significant financial exposure in the event that it could not generate electricity sales revenue for reasons not related to CCS risk events; as outlined further in Section 6, CCS risks could be shared with HMG. However, since the CCS risks in the full-chain Project are found largely in the offshore section, and NGC had no direct contractual relationship with HMG in the Project’s commercial structure, CPL functioned as the conduit for passing the financial impact on NGC of any CCS risks to HMG.

The Authority Funding agreements, namely the Project Contract, was based largely upon PPP/PFI approaches typically used in government procurement of standard infrastructure such as hospitals and educational facilities. Clearly the need to control the deployment of government capital funding, including the grant funding envisaged under the CCS commercialisation programme, is an essential part of the government procurement process. The PPP/PFI approach would seem to be a logical place to start where the required contractual structures have been tried and tested.

There are however other aspects of the PPP/PFI approach that are more challenging for a FOAK CCS project like White Rose. For standard infrastructure developments, the government is the prime user of the delivered product for the provision of public services, whereas in the case of White Rose, whilst DECC was an important stakeholder, it was not the legal owner or operator of the OPP or T&S System. As a result, there remained some difficulty in reconciling the needs of:

(i) the developers as builders, owners and operators of the assets;
(ii) the requirements of the debt providers; and
(iii) the mechanisms of PPP/PFI in relation to controlling the deployment of funding to a defined maximum quantum.

In relation to defining a maximum quantum of financial support to White Rose, HMG introduced the MFA device as a critical part of its commercial position, and expressed broadly in concept through its proposed

Project Contract agreement. Negotiation of the MFA sought ultimately to define an absolute maximum financial sum, the reaching of which would result in the termination of the Project Contract between DECC and CPL.

Given that the lender group that CPL was engaging with came typically from an energy sector non-recourse financing background, this resulted in some differences in approach to risk allocation and project implementation which presented challenges. As an example, the debt providers to CPL would require certainty that grant amounts will flow to the project as scheduled along-side equity as a condition for the release of progress related debt tranches. This can be at odds with the provisions of the PPP/PFI mechanisms for release of grant amounts related to milestones independently determined by DECC.

9.2 Mitigation Steps

Taking the above key commercial challenges into account, the Project development team underwent a process of iterative negotiation between the contractual counterparties in order to produce a financeable integrated full-chain commercial model. Critical to the support of these negotiations was a robust financial model, constructed and operated by CPL, so that the economic performance of the full-chain Project could be easily understood as the commercial arrangements were developed in increasing detail. NGC operated its own financial model concurrently for the calculation of T&S capacity fees, to which CPL had transparent access.

In respect of the negotiations between the Project and DECC, those elements of DECC's commercial position that were challenging with respect to producing a financeable result overall were overcome through the presentation of evidence by CPL and NGC as gathered from its professional advisors or as a result of supply chain negotiations so as to justify its case accordingly. In the case of the MFA, CPL devised a methodology for calculating the maximum funding that would be required by the Project over its economic lifetime. This calculation considered the following:

- (i) Operating income: the total expected payments to CPL under its CfD with LCCC;
- (ii) Grant support: the total expected capital grant payment to CPL from HMG under the Project Contract, plus any further capital support to the Project from the European Commission under the NER300 scheme;
- (iii) CCS risk support: the total financial support required from HMG to compensate for its share in the impact of any CCS risk events in the Project i.e. those risks not absorbed by the supply chain, equity investors, debt providers or the insurance markets;
- (iv) Emerging cost sharing: the HMG share in capital costs that were not fixed, and which in turn were eligible for sharing between White Rose and HMG (see Section 8 for further details); and
- (v) Other Project Contract support: any other support to the Project provided by HMG under the Project Contract, such as support for qualifying changes in law and acting as 'insurer of last resort' (see Section 12 for further details).

It was CPL's position (still under detailed discussion with DECC) that the MFA would also be made subject to economic indexation so that the absolute financial limit of the contractual device was altered over the Project's lifetime in accordance with publically-quoted indices.

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9.3 Lessons Learnt

Bringing together a combination of the power industry, chemical industry and offshore hydrocarbon industry under a governmental procurement framework that ultimately should satisfy allowable state aid funding criteria was challenging. The use of suitably experienced development team members supported by high-quality professional advisors is critical to making timely RRP progress.

As the project development progressed, it became apparent that although progress was being made, reaching a comprehensive agreement on risk allocation between DECC and the developers of the White Rose project was challenging. The associated iterative process involved in cascading the risk allocation to all counterparties to CPL including the supply and services chain (including NGC) and the debt providers presented challenges in terms of HMG's desired Competition process timescales.

For future programmes aimed at the commercialisation of CCS it may be worth considering alternative ways of approaching the allocation of risk and project implementation that provide HMG with the controls it needs for the deployment of government capital funding, as envisaged in the PPP/PFI approach, whilst being compatible with non-recourse debt financing structures potentially through a hybrid control process and common sign off. This is discussed further in Section 10.

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10 Attraction of OPP Financing

The financing of CPL's OPP was composed of both debt funding from commercial institutions together with equity financing from its sponsors under the typical approach of non or limited-recourse financing principles commonly referred to as "project finance". Project finance is commonly adopted for the funding of independent power projects (IPPs) for which there is considerable market precedence, both in the UK since privatisation of the electricity industry in 1990, and many other countries such as the Middle East where the state backs or underpins certain risks. As a result, the major finance institutions, including commercial banks, export credit agencies and multilaterals, are highly familiar with the concepts and application of project finance, together with its accepted principles of risk allocation between the project company, its equity sponsors and debt providers.

Typically for IPP projects, candidate commercial debt providers and their appointed professional legal, technical and insurance advisors, are engaged latterly in the development programme once the commercial structure is largely complete and draft agreements are well developed. Furthermore, these IPPs are normally based on technology that has a consistent track record of deliverability and reliability.

In order to maximise both the pool of commercial debt providers familiar with the White Rose CCS Project and, ultimately, the level of competition between them when CPL would later procure debt finance, the CPL development team together with its financial advisor engaged over 20 such institutions early during the RRP. Several were even engaged prior to CPL being awarded its FEED Contract as it was recognised at an early stage that consensus needed to be developed with this community and that gaining their confidence and trust would take time given the lack of precedent for commercially funding a project of this type. With the relative complexity of the White Rose commercial, technical and financing structure when compared with the majority of recent project finance deals such as offshore wind farms, CPL deployed as an integral part of the RRP an ongoing campaign of both educating the commercial debt providers with respect to full-chain CCS and updating them as its negotiations with various counter-parties progressed towards its Financial Close objective.

Furthermore, bringing new equity investors to a project during its development phase can help bolster its appeal to debt providers and other stakeholders by demonstrating early the strategic and economic appeal of the project ahead of Financial Close. It can also mitigate sponsor risk and enable the continuation of the project when earlier financing assumptions change.

10.1 Evidence

CPL found early in the RRP that there was a broad spectrum of CCS familiarity across the cohort of candidate commercial debt providers which put the onus on CPL to establish a common foundation of understanding via education and active engagement on specific topics and issues. In addition, CPL's negotiations with HMG relied heavily on being able to determine a clear dividing line of 'bankability' across a number of frontiers in the White Rose deal that would define ultimately the role that debt would play in the financing of the Project. There was little precedence, if any, of project finance involvement in CCS prior to White Rose. Engaging the commercial debt providers later in the RRP programme, as with the development of a more conventional IPP, presented considerable risk to the planned date for Financial Close. However, CPL had to balance the level of effort required to keep over 20 institutions informed of progress and learning related to the Project with the time required to negotiate and develop the Project itself and in addition, prevent the occurrence of 'deal fatigue' through over-communicating during periods of minor development progress.

As the capital funding requirements of the OPP evolved through the RRP, it became clear that CPL's gearing would increase. Following related discussions between CPL and its financial advisor, the decision was taken to increase gearing to 65:35 from approximately 50:50 assumed prior to the RRP. Whilst CPL and its financial advisor were comfortable that the overall economics of White Rose would subsequently remain robust, it was decided that third party equity would be raised for CPL to reinforce its capital structuring, given the existing commitments of its incumbent sponsors. DECC and its financial advisor appeared comfortable with this evolution on gearing levels as greater visibility was being provided on cost certainty due to CPL's concurrent discussions with its sub-contractors.

Whilst the required amount of additional equity was to be assessed on the basis of the revised debt funding requirement and ultimately the Project's risk allocation, CPL took steps to identify potential third party equity investors. A discrete financial advisor was then mandated to approach potential third party equity providers in a disciplined and efficient manner. Given the early stage of the development of the Project's Base Case commercial model at this point in the RRP, it was decided to first undertake an initial market sounding exercise to gauge the potential interest in providing third party equity to CPL only. NGC opted at this stage to continue with its intention to fund the T&S System corporately.

10.2 Mitigation Steps

Early in the RRP, CPL selected 4 leading commercial debt providers (including a multi-lateral) to be the so-called 'pathfinder banks' for the Project. These funders were chosen to be representative of a cross-section of the funding community at large both in terms of geography but also likely risk appetite. Additionally, CPL appointed professional legal, technical and insurance advisors to act on behalf of the entire cohort of candidate commercial debt providers far in advance of their actual engagement to negotiate lending terms. With these 4 pathfinder banks, together with their professional advisors, CPL could in confidence discuss and test key aspects of the Project's commercial structure and risk allocation for overall 'bankability' from the outset. In this way, CPL could mitigate the risk of prejudicing the wider syndicate against the viability of the Project deal as solutions to the various development challenges were devised. Once material progress was made in the Project's development, then updates were provided to the wider lending community.

In parallel with the detailed development of the Project, both the pathfinder banks and the complement of commercial debt providers were kept updated through regular bilateral meetings on critical foundation topics such as developments in White Rose's chosen CCS technology, changes in UK energy policy and the intended role for CCS, and important consenting milestones. On one occasion, White Rose hosted a town-hall style joint presentation with senior representatives from DECC to the entire funding community to demonstrate the commitment of each to the success of both the Project and to the development of the Humber Cluster.

The CPL third party equity search process was launched in July 2015, with a teaser being sent to a pre-marketing short-list of 10 entities ranging from utility and commodity companies to financial investors. The

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purpose of the pre-marketing phase was to gauge initial interest only, ahead of a full marketing campaign in 2016 should the Project be received positively beforehand.

Two companies expressed positive feedback upon receiving the teaser: a UK-based green-field development fund and a global commodity company. Upon further discussion, the green-field development fund expressed interest in understanding the Project further with a view to providing a Letter of Support for the purpose of representing its indicative interests to DECC.

In October 2015 Chinese President, Xi Jinping, visited London as part of a HMG-led initiative to encourage foreign investment in key UK infrastructure such as the new nuclear power plant Hinkley Point C. CPL decided concurrently to re-engage with certain Chinese investors. Later in October 2015, CPL identified and met with a premier Chinese utility company. Upon learning more about White Rose, this utility company expressed an interest in participating in the Project's development as well as taking an equity investment in CPL of up to 49%. A Letter of Intent (LOI) was negotiated between CPL and the utility to confirm the serious interests of both in progressing this equity-backed entrance of the utility to the Project. The LOI also expressed the willingness to attract additional Chinese investment into the Project.

A formal LOI signing ceremony was scheduled to take place in Beijing on 30 November 2015. This was abandoned however at very short notice following the public announcement on 25 November 2015 by HMG of its cancellation of the £1 billion of capital funding for the UK CCS Commercialisation Programme as part of its Spending Review.

Earlier in 2015, CPL engaged with the European Investment Bank (EIB) in the context of the EIB's managed execution of the European Fund for Strategic Investment (EFSI), or the "Juncker Plan" as it is more commonly named. The EFSI seeks to use €21 billion of EU funding, either as investment or for the provision of guarantees, to leverage up to €315 billion of total funding from combined public and private sources. The fund is designated for strategic European infrastructure projects that the market cannot finance alone and runs over a three-year period from January 2015. In essence, the EFSI seeks to de-risk transactions to encourage follow-on investment and can provide funding for example in the form of term debt, mezzanine, equity, loan guarantees and first-loss type support.

CPL discussions with the EU Directorate General for Economic and Financial Affairs and the EIB suggested that CCS is an area of strategic importance. On this basis CPL could qualify for EFSI support. EIB pre-qualified (listed) the Project for evaluation starting on 04 May 2015 and work was commenced with the EIB to satisfy their front-end due diligence requirements; this would then lead to a discussion on whether direct EIB lending or EFSI products would be made available. A dedicated electronic due diligence portal was created for this purpose. Under the Juncker Plan project list, White Rose was listed specifically as potentially eligible for a range of EFSI products that included senior debt, subordinated debt, equity and other products within the EIB's expanded mandate.

10.3 Lessons Learnt

A number of critical lessons were learnt in relation to engaging the commercial debt providers for the Project. Principally, there is wide variance in the degree of CCS literacy amongst these institutions and so early engagement to communicate the specifics of the Project is vital so as not to risk delays to the project financing negotiation programme. Furthermore, selection of a relatively few 'pathfinder' banks is advisable to provide the CCS project developers and DECC with a confidential and interactive sounding board for iterating optimal and bankable commercial structuring solutions.

Building on the early engagement with commercial debt providers, it nevertheless is prudent to develop a power generation-based CCS project to match as best as possible the commercial structure and risk allocation to that of a typical IPP. Overlaying this template onto the specific CCS project enables the developer to address any material differences with the lending community. Enabling the commercial debt providers to become comfortable with the chosen CCS technology, quality of Project sponsors, quality of supply chain organisation and their respective balance sheet strengths, together with risk insulation to the degree developed in White Rose goes towards getting banks interested in the first place. This in turn enables the developer to negotiate reasonable terms for example for debt-to-equity ratios, debt margins, required DSCR etc. The pathfinder banks and their professional advisors played a critical part in CPL's efforts to evidence and then develop solutions to mitigate cross-chain liabilities and default risk described in detail in Section 4. The banks were comforted that the operation of key elements of the T&S System were familiar to them from their oil and gas activities and that a hierarchy of risk allocation and contractual protections could be provided in this FOAK project ahead of CCS transitioning to a more liquid, demonstrable and commercially financeable CO_2 transport and storage market.

HMG's support for CCS specific risks was in general well received by the commercial debt providers in addition to its commitment to creating a wider CCS market as witnessed recently in regards to the creation of the offshore wind sector. Furthermore, the commercial debt providers viewed as positive certain other commercial features of the Project such as the tenor of the CfD, the inclusion of an indexation basket for the CfD Strike Price and the option to rebase the CfD Strike Price at two specific milestones in CPL's economic lifecycle: at completion of the Construction Phase and at completion of the Commercial Proving Phase.

Material evidence of strong interest from high-quality potential third party equity investors in CPL was obtained during the RRP. This included Chinese investors attracted to White Rose due to their positive perception of the support package offered by HMG through capital grant funding, CfD and sharing in CCS risks. The opportunity to form a strong partnership with the world-renowned incumbent sponsors through third party equity participation was also viewed as attractive.

In addition, CPL discovered evidence of interest both from UK development funds and the EFSI, a significant European infrastructure development fund, the latter as a 'de-risking' tool giving further recognition to the fact that the CCS market is 'broken' and therefore requires national and/or multi-national government funding to initiate its delivery. The learning obtained from White Rose's third party equity search process should prove useful to future CCS projects if similar governmental support packages and regulatory frameworks materialise together in the future.

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11 Full-Chain Technical Design and Integration

As a FOAK project, the White Rose development team faced a number of design issues and some unprecedented project management challenges. Since the proper design and delivery of the Project as a technical endeavour is closely linked to achieving Financial Close and ultimately satisfying its target economic performance, such issues and challenges represent a key risk. The mitigation of these design and delivery risks provide important lessons for future CCS projects.

11.1 Evidence

In developing a CCS power generation project, the natural approach of the developer is to approach the technical design and integration with the carbon transportation and storage system from the normal mind-set and general engineering principles gained from experience in the power generation industry. However, the additional capital cost, reduced net efficiency, operating constraints, payment mechanism and cashflow considerations are different in a full-chain CCS project, and as such this will impact the design of the plant when striving for the optimum techno-economic solution. The challenges encountered, from a full-chain perspective, are outlined in this Section 11.

Value Engineering

Value engineering factors for cost of capital, efficiency and reliability should be estimated using higher values than those normal for conventional power plant. This is due to higher capital costs and reduced power output adding a ‘premium’ for the value of clean power production. This is likely to result in different conclusions for optimum power plant efficiency (with a much higher value for reliability) than compared with unabated fossil-fuel generation projects. Furthermore, the likely operating pattern of the OPP will impact its design, particularly the requirements of the ASU and their ancillary systems. A baseload power plant will have different requirements to one designed and incentivised to match the less predictable and varying demand pattern of a mid-merit plant. Similarly, a T&S System designed for a single-source flexible carbon supply will differ from that designed for either a baseload supply, or for a portfolio of suppliers that offers the potential for T&S ‘load balancing’.

The White Rose CCS Project was designed to allow low-carbon flexible (or so-called “mid-merit”) operation. This characteristic is widely seen as crucial to maintaining asset profitability in the long-term as UK wholesale power markets become increasingly volatile, driven largely by low marginal cost nuclear generation and intermittent renewables such as wind generation; there is an increasing need for flexible mid-merit plant as a number of flexible convention plants are retired. White Rose decided therefore that it was important for the Project to demonstrate that CCS plants can be operated flexibly, despite CPL having a CfD that would maintain economic solvency for the Project if operating in a steady-state ‘baseload’ manner.

Liquid Oxygen Back-up

The Liquid oxygen (LOX) backup decision process is a particularly informative example of value engineering on the Project. The initial FEED design included LOX storage associated with two ASUs to achieve two functional requirements: firstly, allow flexible OPP day/night operation and secondly, provide a back-up oxygen supply, via vaporisation, to the boiler for a maximum of 8 hours on the trip of one of the ASUs. The latter approach requires around 1000 tonnes of LOX to be stored. LOX back-up is standard feature of ASU design across all industries, providing continuity of supply in cases of short term ASU trips e.g. from instrumentation failures. BOC, as ASU supplier to White Rose, forecast from experience that each of the ASUs would likely suffer a small number of short-term trips every year. These could lead to outages of a few minutes through to a full 8 hours. The resulting total LOX storage volume (combined with other hazardous substances on site) would then result in the site being classed as upper tier for the purposes of the Control of Major Accident Hazards (COMAH) 2015 Regulations.

Start-Up Times and T&S System Flexibility

The duration to reach oxy mode i.e. clean electricity production, was found to be significantly longer than for air mode due to the need to establish first O_2 purity in the ASU and then CO_2 purity on the Gas Processing Unit (GPU) before generation with concurrent CO_2 capture is established. This is further extended after a prolonged shutdown where both the ASU and GPU need additional time to cool down to their cryogenic operating temperatures. This focuses attention on minimising the number of start-ups both through eliminating trips/ improving reliability and having the design matched to the operating pattern including the ability to do virtual “two shifting” while maintaining the plant operation on CO_2 supply to the T&S System.

It is important to integrate the dynamic operation of the T&S System with that of the OPP, particularly in the design of the CO_2 pumping system and well injection system. Whilst the thermal cycling of wells is not thought to be an issue, there exists the potential for wellbore damage from halite precipitation if wells are shut in for prolonged periods. The formation water in Endurance is near to being salt saturated. Injection of CO_2 will theoretically precipitate halite in the formation and, depending how this occurs, could lead to formation permeability reduction and hence performance degradation for the CO_2 injection wells.

Carbon Transportation and Storage Entry Specification

The entry specification for CO_2 to the T&S System and requirements for verification that it is met must be appropriately selected, particularly for a multi-user system, in a way that gives the lowest net cost for all parties, facilitates new entrants from a range of industries, and gives clarity and mutual protection on commercial issues.

The CO_2 entry specification to the T&S System defines the CO_2 temperature, pressure and composition ranges accordingly. It was found that reducing the original maximum entry temperature of 40oC to 20oC gave savings in the cost of the transportation pipeline, primarily by allowing the use of reduced pipe wall thicknesses. A secondary benefit was reduced risk of thermally-induced crop damage along the route of the pipeline through agricultural land. The savings overall were greater than the additional operating cost to the OPP of adding a refrigeration unit and exchanger to ensure the specification could be met. While reducing the temperature to 20oC gave maximum benefit to the T&S System, if the specified temperature was 30oC then the trade-off between the elements of the chain was less clear cut. However, this analysis only considered the benefits with the White Rose OPP providing CO_2 to the chain. Once other T&S System users join, there is no additional benefit to the T&S System but instead a growing disadvantage to the other users who would potentially be compelled to add refrigeration units to meet the specification.

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The CO_2 entry specification to the T&S System also defines the acceptable level of non-CO_2 components entering the pipeline. While some of these are non-negotiable (e.g. H_2O, NOx, SOx, H_2S) for corrosion reasons, the O_2 content is set by the end use of the CO_2 and the conditions and materials to be used in the well. For White Rose, an O_2 level of 10 ppm was specified in order to allow the use of less expensive materials for the well tubing where it is in contact with the highly saline water in the storage formation. This specification also made the CO_2 suitable for future re-use for Enhanced Oil Recovery (EOR). For the OPP, this required a design of GPU with a higher capital and operating cost than the one originally envisaged to produce CO_2 at a specification suitable for storage in a saline formation. Again the cost for future users should be considered, though for many CO_2 recovery processes, O_2 specification will not be an issue.

Cross-Industry Project

As a full-chain CCS project, White Rose was a cross-industry endeavour, with components proposed, designed and built by organisations from the power, industrial gases, chemicals and hydrocarbons industries. Their normal approach to project development and the level of engineering detail required is different and reflects the differences in typical project execution strategies and approaches to risk. As a result the level of detail of the FEED work across different elements of the Project varied, reflecting the norms for each industry partner involved. In example of the ASU, the industry norm is for a relatively light amount of engineering pre-contract as the technology and manufacturing are largely in-house and the key externally sourced equipment items (e.g. large compressors) are procured through existing frame agreements, with key suppliers giving good certainty on pricing. Similarly for the power generation plant, GE was to source most of the technology in-house, delivered to CPL under an EPC wrap as discussed in Section 8. For the T&S System, a very different and industry-typical approach was adopted, in large part due to the bespoke character of each store and the associated development concept, requiring more detailed FEED work to allow the work to be offered for tender to the EPC market. These differences in approach need to be understood and accepted between the Consortium partners to ensure that the interfaces are detailed sufficiently for the requirements of all parties.

Similarly, in some instances additional work was undertaken or extensive background information provided, beyond the norm of the respective industry, to satisfy the requirements of other Consortium partners and to satisfy the due diligence requirements of the sponsors, investors, HMG and regulators.

Full-Chain Control

System modelling of full-chain CCS systems has often sought to develop control strategies for the Full-Chain with a master controller over-seeing its operation. For White Rose, through the FEED work, a different approach was developed, choosing to interface rather than integrate the control system for each element of the chain.

The proposed scheme reflects the control solutions deployed for similar applications, such as National Grid's existing natural gas pipeline networks. Integration of the chain control systems into one unified system was not considered suitable as the approach would not support the system ownership and local operational requirements.

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Each element of the full CCS chain will be supervised and operated in an independent fashion from its own permanently-manned control rooms according to local operating procedures. This solution was chosen as the preferred control option due to the diverse operating environments and specialist skills required for each element of the chain. However, to minimise possible disruption to full-chain operation, a system of co-ordinating the respective maintenance outage periods for the CCS chain link elements is desirable.

11.2 Mitigation Steps

To mitigate the various technical design and delivery challenges in the Project, White Rose employed good engineering practice, together with a pragmatic integrated approach to its FEED sub-contractors, led accordingly by the core CPL and NGC technical teams considering always the full-chain aspect of technical design decisions.

Furthermore, the core CPL and NGC technical teams worked in close collaboration with the commercial teams. Interaction with the Project financial models in particular provided both valuable input and feedback to technical decision making processes. This was particularly the case with the value engineering processes and the valuation of extra capital components to increase operational flexibility and minimise off-spec risk, thus reducing the risk of this creating cross-chain liabilities.

From this approach, outlined below are the specific lessons learnt against the sub-topics discussed above as relevant to the technical integration of full chain CCS systems designed for multi-user operation.

11.3 Lessons Learnt

Full-Chain Economic Proposition

Undertaking a multi-disciplinary effort to iterate the commercial design of the Project with its technical design, since the two are heavily linked, is a critical factor to progressing the RRP. The use of a comprehensive, detailed financial model containing an accurate coding of the Project's technical characteristics, together with scenario analysis flexibility, enabled both the commercial teams and the technical teams to collaborate over a common tool in making various decisions jointly and transparently. Until successful Financial Close and subsequent delivery into full-chain completion is achieved, the financial model is all that is available in terms of a tangible full-chain representation of the Project. Outturn parameters can be used to replace values in the financial model that were decided upon at Financial Close to update the model as the project progresses through the delivery phases towards full commercial operation.

In the case of White Rose, the use of the CPL financial model was particularly important for value engineering analysis, discussing start-up times with candidate power purchasers, and deciding the LOX backup strategy.

Entry Specifications

The developer of a CO_2 T&S System should consider how the CO_2 entry specification will impact on the ability of and attractiveness to emitters from a range of industries to provide CO_2 into the system. When

CO_2 is supplied to the T&S System, a clear protocol needs to be established on how the measurements are made and verified so that there is clear traceability on the source of any contamination and robust controls to minimise the same. For the CPL OPP, this led to the move from a single to duplicate analysis stations with a procedure on how to address any divergence in their readings. This approach allowed greater assurance on limiting any liability for damage to pipeline from off spec CO_2.

The T&S System needs to be as close as possible to "plug and play" for new entrants from a diverse range of industries, with clearly defined entry requirements that can be met easily. T&S System users should be able to concentrate on their core business and not be expected to become expert in other areas. Having to work outside their core competencies will make such connection projects much longer to develop and more expensive.

Cross-Industry Project

As a cross-industry endeavour, the design requirements of a full-chain CCS project manifest largely at the back end of FEED. This should be recognised when specifying the required outputs at the start of FEED so that the expectations and requirements of all stakeholders needed to make a final investment decision can be satisfied.

Particularly, as with White Rose, where elements of the chain are single-sourced, sufficient detail must be available so that the Employer's Requirements can be fully defined in the respective EPC contracts and that the resultant pricing can demonstrate value to the employer and third party stakeholders.

Bringing together different industries in a full-chain project can also lead to confusion through the use of industry-specific terminology or short-hands. For instance:

i) The use of the relative positional terms "upstream" and "downstream" on the full-chain CCS project that is placing fluid into the store rather than extracting it from the store as would be typical when using hydrocarbon production terminology;
ii) Active commissioning of a plant with the process fluid would be known as "hot commissioning" on a power plant and "cold commissioning" on a cryogenic plant such as the ASU or GPU; and
iii) Definitions of reliability and availability may differ across different industries.

Full-Chain Control and T&S System Flexibility

Dynamic modelling of the OPP and the T&S System confirmed the approach with their control systems giving safe, reliable and stable operation as they respond to operational changes within other elements of the chain. The approach also facilitates new CO_2 emitters entering the chain, and recognises that for them the capture and storage of CO_2 is a necessity rather than their core business and should not be the primary driver controlling the operation of their assets.

Analysis also showed that the compressibility of the CO_2 in the dense phase is significantly less than for natural gas traversing traditional gas pipelines. However, it is possible that 'line-packing', the ability to

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compress the fluid, in the pipeline by a small additional margin, could be used to a very limited extent to manage abnormal conditions and small transients due to time lags between balancing supply and demand.

In order to allow the chain to realise the overall CCS function, a degree of system interfacing and operations coordination is required. This means that while each elements' control system will be entirely independent of each other, they will include the signal exchange required to provide reliable coordination of the overall process and appropriate responses to emergency or out of limits measurements. These signals will be transmitted directly between the control systems for each element of the CCS chain. Key operational monitoring and records data will also be transmitted from each control system to the Management Information Systems (MIS) databases. Key data from the MIS will be available to operators across the chain. The Full-Chain elements are interconnected such that a start, controlled stop or trip of any component within the chain can provide information and alarms to both the upstream and downstream process systems. Interfacing signals between the chain elements are therefore required to ensure the process is managed safely and efficiently.

A regime for the co-ordination of maintenance outage periods between the OPP and the elements of the T&S System was devised and drafted in to the TSSA. Whilst this co-ordination may not be possible with third party users of the T&S System, it was deemed as critical to CPL for the maximisation of green electricity generation and the subsequent payment of the T&S System tariff.

The project facilities design includes water facilities that allow the injection of a quantity of brine (seawater), envisaged to be approximately 1,000 m^3 in volume, to re-dissolve any precipitated halite and displace it out into the saline formation away from the near well bore area, reducing any skin factor that has been created. The benefits of pre-injecting seawater prior to first CO_2 injection would be considered later during the detailed design phase post Financial Close. The injection facilities will allow for the worst case scenario that formation water flows back to the injection well perforations whenever injection is interrupted and allows re-precipitation of halite in the near wellbore area when CO_2 injection recommences.

Liquid Oxygen Backup

A review of the impacts of installing and using LOX storage to allow for back-up in the case of an ASU trip showed that overall it is not economically beneficial. With a fixed CfD Strike Price, the cost of the lost power production during the period when the LOX storage is being replenished outweighs the benefit of continuing full boiler load running during such an outage.

During the replenishing phase a double hit to output occurs. Gaseous O_2 that would have allowed the oxy-fuel boiler to operate at full gross load is diverted to liquid production causing an increase in parasitic load, thus further reducing the net output of the OPP. The CfD regime, incentivising the operator to maximise output all the time, is different from typical O_2 supply schemes where LOX can be replenished during periods of low O_2 demand and/or low power prices. This allows volume of LOX back-up storage to be greatly reduced, although not eliminated as there has to be sufficient volume to allow the boiler, for example under an ASU trip, to be run down smoothly from 100% to 50% load.

The reduction of LOX storage reduces the quantity of hazardous substance stored on site. This allows the site to achieve a lower tier COMAH status, bringing additional operational benefits.

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12 Limitations of Insurability

The design and development of an integrated insurance programme played a key part in the development efforts to bring White Rose towards DECC's opening risk allocation position on full-chain commercial integration as expressed in the BRAM, as described earlier in Section 4. However, the insurance market, and in turn the insurability of the Project, was found to have its limitations as described in this Section 12. Insurance alone therefore could not offer a standalone solution to the cross-chain liability and default risk development challenge, but nevertheless played an important role in the hierarchy of mitigations that made the likelihood of cross-chain default leading to termination remote.

12.1 Evidence

As a risk transfer scheme, the White Rose insurance programme is designed to perform an important role in the overall commercial framework of the Project that seeks to transfer those risks that can be economically insured in the market away from the special project vehicles CPL, NGC, CSL, their respective shareholders and HMG. The insurance programme was developed through close working between CPL and NGC together with their respective insurance brokers to design the appropriate complementary insurance solution. The insurance programme, designed to be as seamless as possible in the respective policy covers across the full-chain, contained at least the following key features:

- A separate Owner Controlled Insurance Programme (OCIP) procured by CPL for the Construction Phase of the OPP (including commissioning), incorporating the capture plant technology and other assets located at the CPL site in Drax. The OCIP would include Construction All Risks (CAR), Delay in Start-Up (DSU), Marine Cargo and Public Liability (PL) policies;
- A separate operational insurance programme procured by CPL for the Commercial Proving and Operational Phases of the Project for the OPP incorporating the capture plant technology and other assets located at the CPL site in Drax. The programme would include Property Damage (PD) and Business Interruption (BI) policies;
- A separate construction insurance programme similar to CPL's, procured by both NGC and CSL for the T&S System covering the Construction Phase incorporating on-shore pipeline and offshore assets;
- A separate operational insurance programme similar to CPL's, procured by both NGC and CSL for the T&S System covering the Commercial Proving and Operational Phases of the Project, incorporating both onshore pipeline and offshore assets;
- A stand-alone cover for offshore Delay in Start-up (DSU) procured by both NGC and CSL for the Construction Phase; and
- A stand-alone cover procured by both NGC and CSL for offshore Business interruption (BI) for the Commissioning, Commercial Proving and Operational Phases of the Project providing cover for CPL, NGC and CSL for their respective risks.

As part of this development effort, CPL and NGC approached prospective insurers that were familiar with CCS, both commercially and technically, to test market appetite and to further the adaption of conventional energy policies to CCS projects. It became evident early in such discussions with insurers that there were both clear CCS risks that the commercial market would not accept i.e. were uninsurable, and more conventional risks that were better understood for which cover could be purchased economically. Section 6 discusses CCS risk sharing in further detail.

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The continued availability of insurance throughout the Operational Phase however cannot be guaranteed. Operational insurances are purchased annually and market appetite for insurance risk can vary significantly depending on overall global economic conditions and the available data relating to specific risk event occurrences. This variability constituted a significant issue for CPL and NGC.

12.2 Mitigation Steps

White Rose dealt with the limitations and variability of the commercial insurance market capacity, as explained below.

Firstly, it ensured that the definition of what constituted a CCS risk was clearly defined in the Authority Funding agreements between CPL and HMG that provided financial support for the impact of CCS risk events. This would ensure that, there were no gaps in the risk transfer from the Project to either HMG for the majority of CCS risk impacts and to commercial insurers for complementary risk events.

Additionally, as discussed generally in Section 4 relating to cross-chain liabilities and default risks, both CPL and NGC maintained contingent finance for deployment when other risk transfer mechanisms were insufficient. Such contingent finance was provided initially at Financial Close by the sponsors in the form of contingent equity. Once in commercial operation, both CPL and NGC built contingent reserves from operating revenues.

The Project Contract foresees HMG sharing in any CCS risks to the extent that insurance cover was not available from the commercial market. Nevertheless, discussions were also ongoing with respect to HMG providing insurance services as an “Insurer of Last Resort” for example in circumstances where there are limitations on the available cover for certain insurable risks, or where gaps appeared due to cover that could be purchased economically from commercial insurers in one year becoming unavailable in a subsequent operating year. The need for this however had not been firmly established or agreed at the point of Competition cancellation.

12.3 Lessons Learnt

During the development of the Project insurance programme, the variability and limitations of the commercial insurance markets became understood more clearly. Whilst it may play an important role in large technical endeavours such as White Rose, and indeed the purchase of adequate insurance is a requirement of project financing, insurance is not a panacea for all risks, especially those relating to FOAK commercial-scale CCS projects.

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13 Limitations of Alternate Uses

To cater for the possibility that the T&S system would fail to perform, or that the CfD be terminated under scenarios in which debt & equity were not fully recompensed, the White Rose development team sought alternative uses for its physical components, predominantly the OPP as a potentially valuable power generation asset. During the course of the RRP, no alternate uses of the T&S System were considered.

13.1 Evidence

During the initial bankability assessment for the OPP, it became clear that the CPL group of candidate debt providers potentially required assurances that the OPP could be somehow repurposed to operate on an alternate fuel that would allow compliant operation without CCS technology to mitigate the impact of the power plant becoming stranded from the transportation and storage assets. Therefore, the scope of a short desktop technical study was defined.

The driver for the alternate uses study was that in the event that the CCS Project could not be made to operate satisfactorily to the relevant technical and/or economic criteria, there was a risk that such an event may give rise to termination scenarios under which commercial debt providers and equity investors would not be recompensed fully.

At a similar time to these considerations, around the commencement of the RRP, CPL met with the US Department of Energy (US DoE) and it was apparent there was a joint interest in both oxy-combustion in general and potential application of the OPP technology with carbon capture in combination with co-firing of biomass with coal. This approach is commonly referred to as ‘bio-energy CCS’ (BECCS). The US DoE’s interest was in the application of BECCS to support the US coal industry, including finding ways to continue its fuelling of large thermal plant under increasingly stringent environmental limits. During a related discussion in Washington in late 2014, the US DoE planned to conduct a study on alternative fuel conversion and suggested using White Rose data as part of this project. This work was strictly outside the scope of the FEED Contract. The CPL development team agreed to provide technical data and support to this study where possible. CPL anticipated using the results of the DoE study in support of its own project finance structuring activities later in the RRP.

13.2 Mitigation Steps

To investigate means to mitigate the financial impact of a failure of CCS technology in the Project, the alternative fuels study was launched. To disaggregate the aims and objectives of the study, and thereby de-risk the study itself, three distinct phases/scopes were clearly defined:

- Phase 1 - investigation of the technical feasibility of future conversion using alternative fuels;
- Phase 2 - deeper investigation into the preferred alternative fuel option; and
- Phase 3 - a study on the application of BECCS.

Phase 3 was of particular interest given the Project’s proximity to Drax Power Limited, Europe’s largest biomass conversion scheme. Following a competitive tender process, the engineering consultant AECOM was mandated by the US DoE to undertake the work.

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The Phase 1 objectives gravitated around the investigation of the technical feasibility of future conversion of the proposed White Rose OPP to operate in conventional “air mode” using alternative fuels in order to meet the relevant environmental emissions criteria without the use of CCS technology. Specifically, a preliminary screening analysis of the conversion options available was undertaken.

The alternative fuels (and combinations thereof) considered from a heat input perspective were:

a) 100% biomass - low moisture pelletized wood only considered;
b) 100% natural gas; and
c) 60%/40% biomass/coal.

In line with progress made during the extent of the RRP, only Phase 1 of the alternative fuels study was completed.

13.3 Lessons Learnt

The initial findings of Phase 1 of the study were that there are no overriding technical barriers that could prevent the conversion of the OPP to fire biomass pellets. Additional or upgraded facilities to accommodate import of biomass to the OPP site are likely to include:

- Increased off-load and storage capacity at Hull / Immingham ports;
- Additional rolling stock to increase rail transport capacity from the ports to Drax;
- Additional biomass storage capacity at the OPP site; and
- Replacement of the proposed conveying and mill delivery systems (with potential re-use of the coal conveyor route and transfer towers).

Similarly, the Phase 1 study found no overriding technical barriers preventing the OPP being converted to fire natural gas, assuming that the OPP has a natural gas fuel demand of 2,000 m^3/h. Additional or upgraded facilities to accommodate the conversion to fuelling the CPL OPP on natural gas are likely to include:

- A new 12 inch fuel gas supply pipeline to the OPP site, comprising of a:
  - New NTS system exit point from National Grid feeder pipeline;
  - New pipeline route from NTS exit point to the OPP site;
  - New gas receiving / pressure reduction station on the OPP site; and
- NTS feeder pipes in the Drax area.

The biomass/coal combination was only explored to the extent of understanding effects on boiler performance, and limited consideration was given to balance-of-plant equipment or supporting infrastructure.

Given the significant difference in capital expenditure between the biomass and natural gas conversion options, and the fact that the current subsidy regime for biomass generation in the UK ceases as from

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2027, should Phase 2 of the study have progressed, it would have delved deeper into the natural gas option so that CPL could have had more visibility to include in its risk mitigation activities.

The Phase 3 (BECCS) report was agreed as a follow-on report, given the potentially significant benefits that would accrue in North America if this technology was adopted. Following the cessation of the Competition, discussions are ongoing between the US DoE and GE regarding completion of both the Phase 2 and Phase 3 reports.

14 Sale of Carbon Transportation and Storage Capacity

The White Rose CCS Project was the anchor project underpinning delivery of the multi-user Humber Cluster. The Humber Cluster itself was conceived as the foundation of the UK CCS industry and represented a principal objective for the Project. Central to the White Rose scope of works was therefore the delivery of a T&S System with sufficient long-term capacity to satisfy multiple carbon capture sites in the Humber area, with CPL's OPP being the first connected user.

The Humber Cluster T&S System was designed to accept a peak flow of up to 17 million tonnes per annum of carbon dioxide captured from a number of network points. The offshore carbon store 'Endurance' to which the Humber Cluster T&S System was to be connected, is situated in a subsea geological Bunter sandstone formation in the North Sea. Endurance was selected for the White Rose CCS Project due to confidence in its ability to hold potentially 300 million tonnes of carbon dioxide injected at a rate of around 10 million tonnes per annum for a period of 30 years. This total capacity and injection rate was therefore more than sufficient for the carbon transportation and storage needs of the CPL OPP, capturing on average 2 million tonnes per annum over 20 years.

The long-term objective for NGC as the developer and operator of the Humber Cluster was to expand the Humber Cluster pipeline network to attract further users beyond those reachable from its initial layout under the scope of the White Rose CCS Project. It would also connect to other offshore carbon stores subsequently as the UK CCS industry's storage needs expanded beyond that offered by Endurance. Additionally, the offshore portion of the T&S System could be expanded to facilitate the sale of captured carbon to oil producers using EOR techniques (injection of carbon dioxide into oil wells) to improve their production yields.

Considering the commercial objectives of the above, White Rse had to establish a fair and economically attractive methodology for the sale of T&S System services to not only CPL as the anchor customer, but also to follow-on users. The risk in not achieving such a capacity sales methodology meant that the Humber Cluster may not expand beyond having CPL as its only user, therefore reducing the 'value for money' legacy of the White Rose CCS Project.

14.1 Evidence

The design of commercially attractive network capacity charging methodologies is a complex area of economics. However, the principles as applied to White Rose and the longer-term objectives of the Humber Cluster were relatively straightforward, particularly since the T&S System was to be constructed concurrently with the CPL OPP. Whilst this gives rise to default and termination risks between CPL and NGC as the two initial parties in the White Rose full-chain as outlined further in Section 4, there were two fundamental capacity charging methodologies to consider:

i) An 'average cost' scheme where individual users pay a tariff based on the total cost of constructing and operating the T&S System, weighted to their average capacity reservation; and

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ii) An ‘incremental cost’ scheme where the anchor customer pays a fixed tariff based on the total capital cost of constructing the entire T&S System, plus a variable tariff based on operating costs. Subsequent users pay a tariff based on the incremental costs of connecting to the (existing) T&S System, plus a variable tariff for their incremental operating costs.

The selection of either methodology outlined above presented both advantages and disadvantages respectively for CPL, NGC and the full-chain White Rose CCS Project as a whole.

For CPL, the most attractive was the ‘average cost’ methodology. Under this approach, CPL’s capacity fees would be a fraction of those calculated under the incremental cost methodology since it would only use around 15% of the total transportation per annum capacity, and around 25% of the total storage capacity per annum[2] .

For NGC, the most attractive was the ‘incremental cost’ methodology. Under this approach, the repayment of the total capital cost of the carbon transportation and storage system was covered by the contractual relationship with the CPL oxy power plant. This had the added advantage that the connection costs for subsequent users were more attractive than under the average cost methodology, and thereby the incremental cost approach served better the overall White Rose objective of growing the CCS industry.

14.2 Mitigation Steps

For the benefit of the overall White Rose objective, CPL and NGC agreed to implement the incremental cost charging methodology for the calculation of carbon transportation and storage fees. The existing HMG guidance on Third Party Access also follows the incremental cost charging methodology. The resultant capacity reservation fees, estimated during the RRP ahead of NGC securing finalised construction and operating contracts with their supply chain as outlined in further detail in Section 5 and Section 8, were then drafted into the TSSA between CPL and NGC.

The capacity fees charged by NGC under the TSSA were treated as an operating expense by CPL, since these charges were set on an annual basis by indexing an initial value to be set at Financial Close and charged to CPL accordingly once the full-chain Project was complete and fully commissioned for commercial operation. These capacity fees became a significant element in the CPL CfD Strike Price.

14.3 Lessons Learnt

The consideration of both the anchor project and the long-term objective for a new multi-user CCS network is critical to its overall ‘value for money’ objective, both to the initial investors and governmental sponsor, but also to those individual follow-on users taking their own commercial decisions to install CCS equipment. Comparing the two methodologies, the incremental cost capacity fee approach gave the lowest economic barriers to entry for follow-on users and therefore had the greater chance of creating the long-term objectives of the Humber Cluster.

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However, under the incremental cost methodology as described above, there were two distinct disadvantages to CPL as the anchor project. Firstly, the resultant CfD Strike Price was greater than under the average cost methodology, since as the anchor user, CPL is responsible for repaying the total capital cost for the initial scope of the T&S System. This impact created a challenge for CPL when the economic attractiveness of the White Rose proposal as a whole was being considered purely on the magnitude of the CPL CfD Strike Price alone. Secondly, the greater capacity fee charges created an increase in the cross-chain liability considerations between CPL and NGC as covered in more detail in Section 4. There were proposed revenue and upside sharing arrangements in the agreements between CPL and the Authority, which allowed the option for the CfD Strike Price to be abated in order to share the benefit of increased use of the shared infrastructure across all users. The detailed arrangements of such an approach, in particular the consequences of costs relating to a third party being dependent upon the performance of an independent counterparty, had not been settled before the closure of the competition.

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15 Interconnections Design

The CPL OPP is designed to be constructed and operated entirely on land owned by the site host, Drax Power Limited. To reduce the capital spend required for the new-build OPP, the CPL development team, in conjunction with Drax, designed the OPP to make use of existing infrastructure at the Drax site. Such existing infrastructure included the raw water extraction, processing and discharge system, the fuel stockpiling area and rail delivery facilities, the 400 kV sub-station and the fly ash storage mound. CPL would require the construction of a new coal conveyor, ash removal conveyor, an underground cable to the sub-station and various connection infrastructure, mainly various water media, to the existing Drax systems so that the OPP could function as necessary.

Use of such existing Drax infrastructure, and any consumables therein, would be charged to CPL under a long-term Site Services Agreement. In addition, long-term land rights would be granted to CPL by Drax for placement of new interconnection infrastructure. Figure 2.1 shows the contractual arrangements in further detail. Since Drax is a live operating plant of significant electrical generating capacity, it was decided that Drax alone would be responsible, and therefore take the risk, for constructing the new interconnection infrastructure under an EPC contract with CPL.

The reliance of CPL on Drax for interconnection construction and operation was deemed a risk to CPL. This risk was required to be properly mitigated, predominantly through careful technical design, insurance provisions and robust land rights in order for CPL to be a financeable entity. Similarly, the construction and operation of the CPL oxy power plant represented a risk to Drax's own existing operations.

15.1 Evidence

CPL and Drax Power Limited are separate corporate entities operating independently of each other. There was therefore the possibility of a Drax default or insolvency impacting either the interconnections construction programme, or the operations and maintenance of the completed interconnections.

Furthermore, Drax was designed and built as an unabated coal-fired plant and is currently transforming into being fuelled entirely by biomass. Towards the end of the RRP, Drax had converted three out of its six boilers to run entirely on biomass, with public statements that it intended to convert a fourth. This left two boilers still operating on coal and therefore providing justification for Drax's continued operation of its coal-related systems, such as the rail delivery infrastructure, its handling and stockpiling equipment, its limestone bulk storage and its gypsum removal systems, all upon which CPL relied.

The economic operation of unabated coal-fired generation is now becoming increasingly less profitable and therefore it was highly likely that Drax would cease coal operations in the near future. The exact date is difficult to forecast due to various external influencing factors, but the cessation would certainly occur within CPL's Operating Phase. This phase out, together with the risk of a Drax default or insolvency impacting on CPL operations had to be mitigated appropriately.

From Drax's perspective, the construction and operation of the CPL OPP was a material risk to the integrity of its existing operations. Therefore, adequate financial protection measures were required to be put in place to recompense Drax in the event of a CPL incident leading to Drax suffering damage.

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15.2 Mitigation Steps

The approaches to mitigation of risk to CPL's interconnections were several: the careful planning of the physical layout of the CPL interconnections to the Drax site, the insertion of adequate land rights in the site lease agreements, open discussions about the ramifications of Drax ceasing its coal-fired operations and consideration of the existing Drax assets and operations in the CPL insurance programme for third party damage and business interruption.

The physical layout of the interconnections between CPL and Drax were made such that in the event of the worst case scenario, a Drax insolvency leading to a decommissioning and removal of the generation assets at the centre of its existing site, would not impact upon CPL's interconnection infrastructure. These connections were routed through peripheral land parcels (still under Drax ownership) that allowed CPL to maintain access to the rail head, coal stockpile and water abstraction and discharge points even in the event of a complete repurposing of the main existing Drax generation site.

In the agreements between CPL and Drax for the construction, operation and maintenance of the CPL interconnection infrastructure, appropriate step-in rights were included such that if Drax defaulted on its contractual obligations, CPL could take over the works. These rights were supported through the land lease agreements for the interconnections infrastructure and were made robust with easement rights.

Discussions between CPL and Drax established financial values for required levels of cover in the various policies making up the CPL insurance programme. Technical assessments undertaken by CPL's insurance advisor ascertained the financial impact to Drax from a broad severity spectrum of incidents at the CPL OPP site. This data was then reflected accordingly in the assessment of CPL's ability to obtain both third party damage and business interruption insurance.

15.3 Lessons Learnt

The risk of default or insolvency of the host site organisation is a significant risk in any independent tenant development project, particularly where the tenant makes use of existing infrastructure owned, operated and relied upon by the host. However, through pragmatic technical, contractual and commercial discussions between host and tenant, these risks can be suitably mitigated. In this regard, the success of the interconnection discussions between CPL and Drax mean that White Rose remained a financeable project.

16 Metering and Measurement Regime

Critical to the effective and reliable operation of any multi-entity commercial model in the energy sector is a robust and reliable measurement and metering regime. In the case of the White Rose CCS Project, with its full-chain commercial model consisting of several inter-linked organisations (see Figure 2.1 for details), the development of the measurement and metering regime was a key part of the technical design process.

An important operating parameter for White Rose as a coal-fired low carbon commercial demonstration project is the effectiveness by which it captures carbon from the combustion of its coal fuel, transports it offshore and delivers it securely to its geological formation store. The measurement and metering of carbon volumes passing along the full-chain is therefore a critical element of the Project's commercial model, particularly since CPL earns CfD revenue only from its 'clean electricity' output, and pays both capacity reservation fees and variable charges to NGC for the transportation and storage of captured carbon.

In addition, CPL monitors its carbon capture rate as a key performance indicator for the OPP, and upon which the success of its construction is determined at completion and subsequent commissioning. Damages may be levied to the construction contractor if this carbon capture rate is below a given target (90%) since CPL would in this event suffer financial loss over its operating lifetime. See Section 8 for further details on this commercial contracting arrangement with the supply chain.

Both CPL and NGC are required to purchase the necessary EU ETS carbon emissions certificates for any ejection of carbon to atmosphere, either through the normal operation of the OPP or as the result of emergency venting or leakage. The risk of an inadequate metering and measurement system therefore is that the economics and lawful operation of the CCS full-chain becomes difficult to ascertain.

16.1 Evidence

At the outset of FEED an approach to metering and determination of the CO_2 capture rate was defined. This approach originated from the current industry practice which reflects the requirements of EU ETS reporting, the carbon input to the plant calculated on a quarterly or annual basis with no need for real time results and the long timeframes smoothing out anomalies and allowing good prediction of CO_2 emissions prior to EU ETS submission. Accurate direct measurement of CO_2 emissions from traditional unabated coal plants is impractical as there is no capture equipment. Therefore, emissions need to be calculated indirectly from a number of discontinuous inputs to the required accuracy, as shown below:

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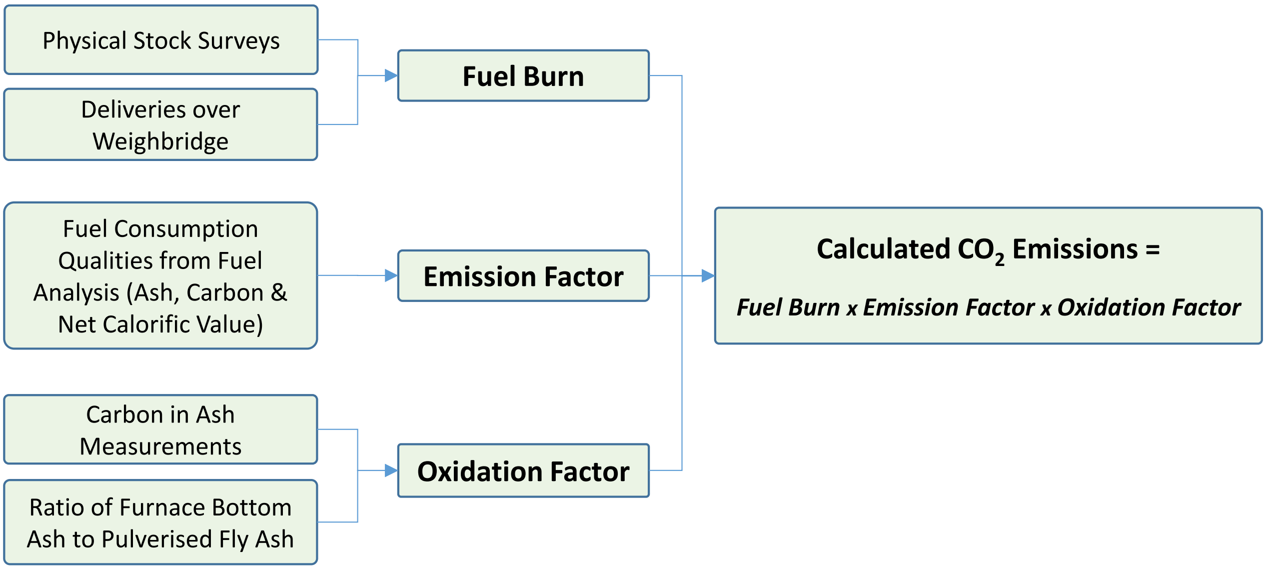
Figure 16.1: Flowchart for Indirect Calculation of Carbon Emissions



Source: CPL

16.2 Mitigation Steps

For the OPP it was initially assumed that this approach of retrospective calculation of the carbon input be combined with direct real time measurement of the CO_2 captured and sent to storage. However, the CfD reporting requirements are very different to that of the EU ETS. The CfD operates under 30-minute settlement periods and so emissions measurements must be clearly attributable to each period. This means real time results are required for both the carbon input and CO_2 sent to storage in order to determine the CO_2 capture rate for that period. Furthermore, the CO_2 capture rate has a high impact on profitability and so measurement uncertainty should be minimised, with simple and transparent methods employed that are not open to interpretation.

Due to the much lower flowrates (around 5%) and higher CO_2 concentration (around 35%) when compared with a similar-sized conventional coal plant, CO_2 stack emissions from the OPP can be measured accurately, reliably and continuously using commercially available instrumentation.

16.3 Lessons Learnt

The White Rose approach moves the calculation from relying on a combination of 14 batch, continuous and implied values of varying accuracy and immediacy to be calculated from four accurate continuous real time measurements. This approach also reduces the uncertainty in capture rate calculation by an order of magnitude. Therefore for White Rose, the approach was changed and rather than using a retrospective calculation of carbon into the plant, continuous measurements of CO_2 to the atmosphere via the stack and CO_2 into the T&S System will be used for determining the capture rate each half hour. This approach

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automatically excludes any unburned carbon from the calculation, so no retrospective adjustment for carbon in ash is required. The EU ETS related measurements and associated periodic calculations can provide subsequently an “audit” for the revised approach.

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