Peterhead CCS Project

Doc Title: FEED Decision Register

Doc No.	**PCCS-00-MM-AA-6605-0001**
Date of issue:	**04/02/2016**
Revision:	**K03**
DECC Ref No:	**11.020**
Knowledge Cat:	**KKD – Technical**

KEYWORDS

Goldeneye, CO_2, Carbon Capture and Storage. FEED Decision Register.

Produced by Shell U.K. Limited

ECCN: EAR 99 Deminimus

IMPORTANT NOTICE

Information provided further to UK CCS Commercialisation Programme (the **Competition**)

The information set out herein (the **Information**) has been prepared by Shell U.K. Limited and its sub-contractors (the **Consortium**) solely for the Department for Energy and Climate Change in connection with the Competition. The Information does not amount to advice on CCS technology or any CCS engineering, commercial, financial, regulatory, legal or other solutions on which any reliance should be placed. Accordingly, no member of the Consortium makes (and the UK Government does not make) any representation, warranty or undertaking, express or implied as to the accuracy, adequacy or completeness of any of the Information and no reliance may be placed on the Information. In so far as permitted by law, no member of the Consortium or any company in the same group as any member of the Consortium or their respective officers, employees or agents accepts (and the UK Government does not accept) any responsibility or liability of any kind, whether for negligence or any other reason, for any damage or loss arising from any use of or any reliance placed on the Information or any subsequent communication of the Information. Each person to whom the Information is made available must make their own independent assessment of the Information after making such investigation and taking professional technical, engineering, commercial, regulatory, financial, legal or other advice, as they deem necessary.

Table of Contents

Table of Figures

List of Tables

Executive Summary

The purpose of this document is to detail the Key Decisions made by the Peterhead CCS (PCCS) Project team during the Front End Engineering Design (FEED) phase of the Project, and to describe the Management of Change (MoC) process which was applied during FEED. A summary is provided of the overall authority thresholds that applied during FEED and a more detailed outline of the specific authority levels that applied to the change management process. The main attributes of the decisions in terms of cost and schedule are recorded in the register in the Appendix.

Areas where key decisions were made in FEED included:

- Contracting Strategy – i.e. Engineer, Procure, Construct (EPC) vs Build, Own, Operate (BOO);
- Full CCS chain technical considerations – including extension of the project design life from 10 to 15 years; and
- Individual technical considerations – including the number of offshore wells to be used for CO_2 injection and whether to apply a manufacturer's standard upgrade to the gas turbine at Peterhead Power Station which would be used to provide flue gas to the PCCS Project.

The decisions made during the FEED phase of the PCCS Project had been taken forward and were being considered in preparation for the Execute phase of the Project.

1. Introduction

The Peterhead Carbon Capture and Storage (CCS) Project aims to capture around one million tonnes of CO_2 per annum, over a period of up to 15 years, from an existing Combined Cycle Gas Turbine (CCGT) located at SSE's Peterhead Power Station in Aberdeenshire, Scotland. This would be the world's first commercial scale demonstration of post combustion CO_2 capture, transport and offshore geological storage from a gas-fired power station.

Post cessation of production, the Goldeneye gas-condensate production facility will be modified to allow the injection of dense phase CO_2 captured from the post-combustion gases of Peterhead Power Station into the depleted Goldeneye reservoir.

The CO_2 will be captured from the flue gas produced by one of the gas turbines at Peterhead Power Station (GT-13) using amine based technology provided by Cansolv (a wholly owned subsidiary of Shell). After capture the CO_2 will be routed to a compression facility, where it will be compressed, cooled and conditioned for water and oxygen removal to meet suitable transportation and storage specifications. The resulting dense phase CO_2 stream will be transported direct offshore to the wellhead platform via a new offshore pipeline which will tie-in subsea to the existing Goldeneye pipeline.

Once at the platform the CO_2 will be injected into the Goldeneye CO_2 Store (a depleted hydrocarbon gas reservoir), more than 2 km under the seabed of the North Sea. The project layout is depicted in Figure 1-1 below:

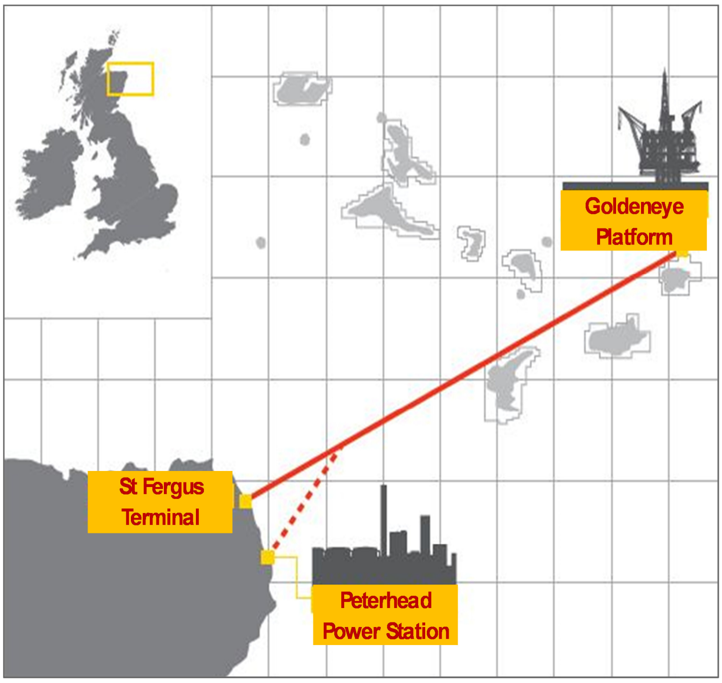

Figure 1-1: Project Location

2. Document Objective and Scope

This document presents the register of key decisions taken during the Front End Engineering Design (FEED) phase of the Peterhead CCS project as well as summary narrative provided in support of the presented decisions. The main attributes of the decisions are summarised in the register included in APPENDIX 1.

A summary of the standard Shell Management of Change (MoC) process which has been applied during the FEED phase of the Peterhead CCS Project is also included, to provide context for the decision-making process applied during FEED.

3. Key FEED Decisions

During FEED there were numerous decisions that had to be made in each of the different parts of the Project, from the Power Station Modifications through to the injection wells and the storage reservoir, as a result of the project evolving and developing. Many of the decisions, although not specifically First-Of-A-Kind (FOAK) CCS, required more consideration than would be the case for a project applying more mature technology. Some of these decisions in turn can be defined as Key Decisions because they affect the whole CCS chain, they impact on multiple stakeholders or they have a material impact upon the Project objectives / outcome. In terms of materiality, a cost impact above five million pounds (£5,000,000) or a schedule impact above three (3) months are taken as guidelines for a Key Decision. There were no decisions taken in the FEED phase that led to single sourcing of any key equipment which might also have been regarded as Key Decisions.

The following is the list of decisions taken during the FEED Phase which fall into this category:

1. Contracting Strategy / BOO
2. Project Design Life
3. Number of Injection Wells
4. Gas Turbine Upgrades to GT13
5. Absorber Location and Auxiliary Boiler Relocation
6. Waste Water Treatment Plant (WWTP) Design Premise
7. Horizontal Direction Drilling for Pipeline Landfall
8. Deferment of Existing Pipeline Inspection by Intelligent Pigging
9. Supply of Methanol from St Fergus
10. Walk to Work (W2W) Vessel for Offshore Execution Contract

Table 3-1: Key FEED Decision Summary

#	Decisions Identified	Summary Narrative
1	Contracting Strategy / BOO	The Contracting Strategy for the Execute phase is pivotal in determining how the Project scope is delivered and who is responsible. A Contract Strategy Workshop was held at the end of the Concept Select phase and various contracting models were considered for implementation. One such option was the so-called Build-Own-Operate (BOO) model, which was favoured by Shell Management because it had the potential to further the aim of widening participation in CCS and increasing the likelihood of subsequent replication projects. BOO is a form of project financing where the Contractor is responsible for the design, construction and operation of a facility and

#	Decisions Identified	Summary Narrative
		in many cases also takes an equity stake in that facility – enabling the Contractor to recover its investment and operating and maintenance expenses directly from the project. Considerably more risk is apportioned to the BOO contractor compared to the main contractor in a normal Engineering/Procurement/Construction (EPC) contracting model. In a BOO arrangement, overall contractual ownership remains with the developing Company which gets the benefit of any residual value in the project. A BOO scheme involves large amounts of finance and a long payback period. Shell approached the market at the start of the FEED phase to determine if there might be interest in a BOO development approach from large, experienced construction / development companies with a previous track record of this type of contract. However, none of the tender responses received was sufficiently competitive for this contracting strategy to be selected in preference to the more common Engineering, Procurement and Construction (EPC) approach. The simplest EPC strategy for Shell would be to tender the full chain workscope for the Capture, Compression and Conditioning Plant, Subsea Pipeline and Goldeneye Topsides modifications as a single package to one contractor. This would eliminate several interfaces and would enable savings to be made in temporary works and contract administration. Engagement sessions were held with potential EPC contractors and the response was that very few, if any, contractors would be interested in bidding for all three different workscopes as a package. Adopting this approach would therefore carry the risk of having no competition in the tendering process or having large amounts of risk premium money factored into the bids to cover the parts of the scope that were less attractive to each contractor. Based on the feedback from the supply chain, the preferred contracting strategy selected for Execute was therefore to develop the Shell construction and commissioning scopes under three separate work packages, with the major construction scopes managed under EPC contracts with overall project management provided by Shell.
2	Design Life	A ten-year operating period was originally proposed for the PCCS Project as a result of the stated remaining service life of the existing GT13 after completion of a major overhaul prior to commencing PCCS operations. However a ten-year life span is relatively short for major utilities projects which recoup the initial investment over a longer period of time, so the project evaluated the possibility of extending the operating life of the Project and thereby having a positive impact on the strike price. The evaluation showed that most of the new facilities provided under the PCCS Project would have an inherent design life in excess of fifteen years so there was no obvious cost-saving opportunity in limiting the design life to ten years. Therefore, an extension of the

#	Decisions Identified	Summary Narrative
		project design life was considered in FEED. In order to evaluate the impact on the strike price, the main elements of the Power Station 'brownfield' scope had to be evaluated, which involved carrying out physical condition surveys, reviews of maintenance and inspection records and obtaining recommendations for life extensions from equipment manufacturers for all critical items of equipment and infrastructure. The conclusions of the asset condition assessments made recommendations for certain refurbishments over the fifteen-year term. These take the form of up-front life extension works and ongoing fixed maintenance throughout the term. The costs for the up-front life extension scope differed by some £4 mln between the ten- and fifteen-year options and the fixed maintenance costs would be somewhat higher for the fifteen-year term due to additional outage requirements. Parallel studies were performed to determine the impact on the other main pieces of existing infrastructure such as the Goldeneye Pipeline and the Goldeneye Platform. The evaluation showed that an extension from ten to fifteen years would not entail significant additional costs. In conclusion, the evaluation of the design life extension from ten to fifteen years showed that the increased design life would result in a material decrease in the strike price due to the longer payback period for similar capital expenditure and there were no major hurdles identified, so the decision was taken to implement this change.
3	No. of Wells	The philosophy pre-FEED was to recomplete all five of the existing Goldeneye production wells and retain them for future use for CO_2 injection under PCCS operations. The wells are valuable assets and it would be prohibitively expensive to bring a drilling rig back in the future to workover an additional well, even if that were still technically feasible, so the planning assumption was to retain maximum flexibility / redundancy even though the Project objectives could be achieved with fewer wells (as long as they are all available when required). To reduce the overall CAPEX cost and hence the Strike Price, it was proposed at the outset of FEED to recomplete only four out of the five wells since a maximum of three operating wells was identified as being required for the PCCS CO_2 injection duty and adding a fourth well gave sufficient redundancy to mitigate the risk of premature well failure. The fifth well would therefore be plugged and abandoned during the planned drilling rig workover campaign. In case any unexpected problems were to materialise during the well workover campaign, the problematic well could become the one destined for abandonment and the last (fifth) well on the sequence could be re-allocated for operational service, thus retaining an additional degree of contingency.
4	Modification	The gas turbine chosen for clean energy generation, GT13, is a Siemens SGT5-4000F and was installed at Peterhead Power Station in 2000 so is

#	Decisions Identified	Summary Narrative
	to GT13	already 15 years old. The Original Equipment Manufacturer (OEM) offers several standard upgrade options to increase the performance in terms of power output and efficiency of such machines. During the discussions with the OEM at the end of 2014, as part of the Long Term Service Agreement (LTSA) negotiations, the OEM provided updated performance expectations for potential upgrades to the SGT5-4000F unit. The proposed upgrades were Compressor Mass Flow Increase (CMF+) and Service Pack 7 (SP7). The Project evaluated the option to implement either CMF+ alone or CMF+ and SP7 together. The evaluation showed that the strike price reduction was largest when both CMF+ and SP7 were implemented so the decision was taken at the end of FEED to implement both CMF+ and SP7. It should be noted that as this decision was reached at the end of the FEED phase and the implementation was to be picked up in the Execute phase, the PCCS technical documentation and in particular the Key Knowledge Deliverable 11.003 – Basic Design Engineering Package [1] does not include for provision of the afore-mentioned gas turbine upgrades.
5	Absorber Location and Aux Boiler Relocation	It was identified early in FEED that the CCP absorber tower location proposed during the pre-FEED phase of the Project would involve very challenging and costly civil works, including stabilising a near vertical 18m high embankment located close to live high pressure fuel gas facilities. This represented considerable risk to the execution schedule and budget so the Onshore FEED contractor was tasked with identifying suitable alternative plant layouts to reduce the civils workscope / complexity. Another constraint was the requirement dictated by SSE that there should be a minimum separation between the Power Station buildings and the Shell-operated Capture Plant, including retention of road access all around the existing boiler house and turbine hall. Taking the various constraints into account, the optimal location for the absorber tower and Direct Contact Cooler (DCC) was found to be the current location of the auxiliary boiler house. This placed the absorber / cooler building more in line between the GT13 heat recovery steam generator and the 170 m exhaust stack, thereby optimising the equipment lay-out and minimising the length of flue gas ducting, which is a major cost driver. One consequence of the revised layout was the necessity to relocate the existing auxiliary boilers and a new site was agreed by SSE and Shell adjacent to the Unit 1 boiler house. The relocation of the absorber tower reduces the cost of civil works to create the required footprint and also reduces the cost of flue gas ducting since the lengths can be shorter. These cost savings are to be weighed against the cost of relocating the auxiliary boiler house and the decision to relocate the absorber tower ends up more or less cost

#	Decisions Identified	Summary Narrative
		neutral.
6	Waste Water Treatment Plant Design Premise	A Waste Water Treatment Plant (WWTP) was always included in the scope for the Onshore Capture Plant but at the beginning of FEED it was not known whether the acid wash effluent could be treated on site, so the Basis for Design assumed that this stream would be trucked off-site for remote disposal. However, since it is preferable on environmental grounds to treat such streams at source, the FEED scope included an investigation into on-site treatment for this stream. Note that the Thermal Reclaimer Bottoms effluent stream was always intended to be transported to a licensed disposal site for incineration. Initial laboratory-scale testing indicated that the acid wash effluent containing amine compounds could be broken down in a dedicated bio-treater although the WWTP operators would have to perform complex tuning of operating parameters to get the residence time down to acceptable durations. The design completed by the Onshore FEED contractor therefore assumed inclusion of this stream and the WWTP facilities ended up far more complex and expensive than had originally been anticipated. A review was carried out by Shell's own water treatment specialists who concluded that the design as proposed would be very challenging to operate, would require additional dedicated operators and would inevitably result in increased downtime. A follow-up study was therefore commissioned to de-risk the WWTP design and this recommended a return to off-site disposal of the acid wash effluent and a simplified, well-tried bio-treatment process for the remaining ammonia-containing effluent streams. Suitable disposal sites in the UK were identified for the incineration of the acid wash effluent and costs were also obtained for transportation and handling. As a result of this review the decision was taken to adopt the simplified Waste Water Treatment Plant design specification in conjunction with offsite disposal of the acid wash effluent. It should be noted that as this decision was reached at the end of the FEED phase and the implementation was to be picked up in the Execute phase, the PCCS technical documentation and in particular the Key Knowledge Deliverable 11.003 – Basic Design Engineering Package [1] does not include the simplification of the Waste Water Treatment Plant and the offsite disposal of the acid wash effluent stream.
7	HDD	At the start of FEED, Horizontal Directional Drilling (HDD) was the preferred landfall method for the offshore pipeline to minimise environmental impacts and HSE risk during construction. However, an open-cut trench alternative was also evaluated in parallel since the preferred HDD solution was not without risk, largely in terms of the suitability of the substrata / rock for drilling operations. A dedicated geotechnical survey was commissioned early in FEED in

#	Decisions Identified	Summary Narrative
		order to assess the geological suitability along the planned trajectory of the hole, but the initial results were not encouraging as the granite rock within the Power Station boundaries was found to be severely weathered and prone to crumbling / hole collapse. The quality of rock improved in the offshore direction so the decision was taken to move the HDD initiation point from the Compression area to a location as close to the perimeter fence as possible. A thorough review was carried out by a recognised independent tunnelling and trenchless technology consultancy but, although the revised proposal was endorsed, significant geological risk remained. In order to confirm the HDD decision in FEED, a 12-inch pilot hole was drilled in Q1 2015 to prove the viability of the HDD solution. The pilot hole was successfully drilled for some 500 metres along the intended trajectory and, on the basis of this positive result, a decision was taken to select Horizontal Directional Drilling as the preferred landfall method for the Execute phase. The pilot hole was filled with soft grout and was left in a suitable state to be re-used in the future, which would involve drilling out the grout and then reaming the hole out to the required diameter. An option for open cut was nevertheless retained in the Landfall, Pipeline and Subsea EPCI to cater for unforeseen difficulties in executing the full HDD scope and the impacts for open cut were also included in both the onshore and offshore environmental statements.
8	Deferment of Existing Pipeline Inspection by Intelligent Pigging	Verification of the condition of the existing Goldeneye to St Fergus gas pipeline has always been a pre-requisite for the successful implementation of the Peterhead Carbon Capture and Storage Project. Positive data was collected during the hydrocarbon-freeing and pipeline cleaning activities carried out in May 2013, when almost no corrosion products were found in the pipe, but the only way to be sure of the integrity is to carry out a full length survey using a so-called intelligent pig. This is a device that travels along the inside of the pipeline and records wall thickness and any evidence of deterioration such as internal or external corrosion or pitting. In order to mitigate risk and achieve maximum cost and schedule certainty, it was planned to execute the inspection early in the FEED Phase. The intelligent pigging of the pipeline was estimated to cost some £4mln. Whilst early knowledge of pipeline condition is advantageous, there are a number of benefits from deferring the pigging operation to the Execute Phase. Later execution would allow the inspection of the new 20km spur line from Peterhead at the same time as the existing pipeline. It would mean the survey data reflects the pipeline condition close to start-up and would pick up any further deterioration during the construction phase. The pipeline also currently contains biocide and a later implementation would allow this to decrease in toxicity, reducing the environmental impact of the inspection activity.

#	Decisions Identified	Summary Narrative
		These benefits and the intrinsic value of deferring expenditure until after FID were weighed against the primary drivers of early risk mitigation and cost and schedule certainty in the project planning, and the decision was taken to defer the intelligent pigging until the next phase of the project. The risk of remedial works being required on the pipeline was assessed as very low and the advantages of deferring expenditure, obtaining a baseline integrity dataset for the whole CCS pipeline and minimizing the environmental impact of project activities outweighed the disadvantages. There was no impact on the overall project budget since the costs are simply shifted in time.
9	Methanol from St Fergus	The pre-FEED design premise was that the CCS Project would be wholly supported and operated from Peterhead - requiring a 20 km 4" [101.6 mm] methanol line to be laid in parallel with the new CO_2 pipeline spur from the Power Station to the existing Goldeneye to St Fergus gas pipeline. A knock-on effect was that the 4" 'piggy-back' line would make the pipeline bundle too large to go through the HDD landfall tunnel so a second separate HDD tunnel would have to be drilled to accommodate the methanol line. It was recognised at the start of FEED that there was a significant cost saving potential if the existing 4" glycol pipeline from St Fergus to Goldeneye could have a change in service and be re-used to supply methanol to the platform. The downside of this would be a continued involvement from, and reliance on, the Shell St Fergus Gas Plant operators but the material cost saving potential would make this worthwhile. There were a number of other benefits that supported the re-use of the existing 4" pipeline. The inventory of flammable methanol would be stored at St Fergus, which already has a large inventory of flammable / explosive substances so there would only be a minor increase in risk at the location compared with a more significant change at Peterhead. Also, the tie-in of the CO_2 pipeline from Peterhead to the Goldeneye pipeline would necessarily involve diving intervention but the addition of the new 4" methanol line would significantly increase the diving hours required, which would in turn increase the safety exposure. An alternative of storing methanol at the Goldeneye platform and pumping directly downhole was also considered but was rejected on cost grounds. Offshore bunkering and storage of methanol would introduce a hazardous inventory to the platform, would increase the offshore manning requirements and would introduce more equipment that would need to be maintained and which would add to the potential sources of downtime. On the basis of the reduced capital cost and the improved Safety exposure the decision was taken to convert the existing glycol line and storage facilities at St Fergus for methanol service and to delete the new methanol facilities and pipeline spur at Peterhead.

#	Decisions Identified	Summary Narrative
10	Walk-to-Work Vessel (W2W)	The Goldeneye Platform is a Normally Unmanned Installation (NUI) and the accommodation module only caters for 12 people, which imposes a severe restriction on any offshore construction schedule. The option was considered to make use of additional 'free' accommodation capacity when the drilling rig is mobilised but the platform is so small that it was deemed impractical and too hazardous to consider coincident drilling and engineering works. Therefore the use of a dedicated accommodation vessel was considered, either floating or fixed (jacked up on the seabed). The water depth at Goldeneye is relatively deep for jack-up vessels so this form of accommodation would be expensive and there might not be very much competition in the market. The use of floating accommodation vessels on the other hand is already widespread in the North Sea and there has been good experience recently with so-called W2W vessels. This is a dynamically positioned boat with a computer-controlled dynamic gangway which can be deployed at any time that people need to get on or off the platform, weather permitting. A W2W vessel would be cheaper than a more traditional accommodation barge permanently moored alongside the platform but it would restrict the number of people on the platform to 24. This is because the Persons on Board (POB) are limited by platform lifeboat capacity since the workforce must always be independent in case the W2W vessel is temporarily unable to re-attach to the platform. In practice the constraint of 24 is not a serious limitation since the platform is too small to create enough workfronts for significantly more people to be deployed simultaneously. The use of a W2W vessel also enables a night shift to be deployed and helps optimise and reduce the likely overall duration of the offshore construction campaign. On this basis the decision was taken to use a W2W vessel to augment the Goldeneye accommodation capacity during the offshore construction work.

4. Shell's Management of Change Process

The Opportunity Realisation Process (ORP) is the approach Royal Dutch Shell (Shell) uses for managing opportunities such as capital projects, acquisition/divestment opportunities, infrastructure investments or "integrated" opportunities.

Within the ORP process, Shell applies a standard Management of Change (MoC) process to projects which is applied appropriately throughout the difference stages of a project:

- Pre-FEED: Change is considered healthy but needs to be managed;
- FEED and Execute: Change should be kept to a minimum with a "No Change" mindset encouraged across the project delivery team.

In general, no change should be considered after commencing FEED unless it is as a result of the following conditions:

- The project is unsafe;
- The project will not deliver on its objectives, including operability; or
- Change is necessary to meet statutory requirements.

Key relevant features of Shell's MoC Process, as applied to the PCCS Project FEED study, are summarised below.

4.1. Purpose

The MoC process is used to ensure that the proposed and anticipated project scope changes are managed and controlled effectively and that these changes are documented and tracked to provide the necessary audit trail. The process is necessary to ensure possible consequences of any prospective change are fully understood before making a change decision.

4.2. Scope of Application and Exclusions

Proposed changes to the Project that impact upon the MoC Control Documents will require application of the MoC process. The MoC Control Documents comprise a set of key baseline documents that are defined at the start of the FEED phase, including the:

- FEED contractual agreement between Shell and DECC;
- Peterhead Concept Select Report;
- Pre-FEED Basis for Design; and
- Scheduling and budgeting data.

Certain changes fall outside of the scope of MoC including:-

1. Commercial changes to Project implementation – which are governed via other Shell internal processes;
2. Changes to executed contracts – controlled via the variation requirements specified in each contract document;
3. Design Development that has no impact to the MoC Control Documents, or HSSE and SP risks.

4.3. Levels of Approval and Change Threshold Criteria

The MoC operates with appropriate authority levels as defined within Shell's standard management processes, ranging from Level 1 to Level 4, with Level 1 being the highest. The following table shows the relationship between the anticipated change in Project metric and the authority level required to approve the project change. The key metrics were identified and the change thresholds were established prior to commencing the FEED project phase.

Table 4-1: PCCS MoC Approval Authority Table

Key MOC Items	Metric	Level 4	Level 3	Level 2	Level 1
DECC FEED	£ GBP	Δ < £50k	£50k ≤ Δ < £250k	£250k ≤ Δ < £1m	Δ ≥ £1m

Key MOC Items	Metric	Level 4	Level 3	Level 2	Level 1
Budget					
Shell Project Budget	£ GBP	Δ < £0.5m	£0.5m ≤ Δ < £5m	£5m ≤ Δ < £10m	Δ ≥ £10m
DECC FEED Schedule	Time (Wk/Mth)	Δ < 1 wk	1 wk ≤ Δ < 2 wk	2 wk ≤ Δ < 1 mth	Δ ≥ 1 mth
Overall Schedule	Time (Wk/Mth)	Δ < 2 wk	2 wk ≤ Δ < 1 mth	1 mth ≤ Δ < 3 mth	Δ ≥ 3 mth
CO_2 Injection Rate	MT p.a.	Δ < 0.02	0.02 ≤ Δ < 0.05	0.05 ≤ Δ < 0.1	Δ ≥ 0.1
PCCS Chain Availability	%	Δ < 1	1 ≤ Δ < 5	5 ≤ Δ < 9	Δ ≥ 9
Clean Energy Efficiency	MW	Δ < 1	1 ≤ Δ < 5	5 ≤ Δ < 15	Δ ≥ 15

The defined Levels of Authority applied during the PCCS FEED study are summarised in Table 4-2. Although written, to summarise the governance proposals for the Execute phase of the PCCS Project, more detail on the Shell project organisation structure and arrangements can be found in Key Knowledge Deliverable 11.062 – Project Organisation [2]. The Project governance arrangements proposed for the Execute phase generally replicate Shell's project governance arrangements which were applied during FEED.

Table 4-2: PCCS FEED Levels of Authority

Approval Level	Approval Authority	Comment
Level 4	Shell Engineering Manager Shell Integration Manager Shell Construction Manager SSE Project Manager / Development Manager	No impact changes to a discrete area No impact changes across areas / interfaces SSE Design and Technical Authority to approve prior to SSE sign-off
Level 3	Shell Project Manager SSE Project Director	After Management of Change Panel endorsement
Level 2	Shell Business Opportunity Manager (BOM) SSE Managing Board	After Management of Change Panel endorsement
Level 1	Shell Decision Executive SSE's Managing Board	After Management of Change Panel endorsement

4.4. Process Steps

The MoC process applied during FEED is defined by the following steps:-

1. IDENTIFY/INITIATE – Initial proposal is made to the MoC Panel.
2. SCREENING – The proposal is screened by the MoC Panel to identify if it should be further pursued and with what resources.
3. DEVELOP, REVIEW, QUANTIFY – Formal development of proposal, with estimates required for implementation.
4. APPROVE – Subject to Levels of approval
5. IMPLEMENT – Within the terms authorised.
6. CLOSE OUT, LOOK BACK, LESSONS LEARNED

4.5. Administration

MoC panel meetings were scheduled every 2 weeks throughout FEED. The MoC process was further monitored through monthly reporting and maintenance of the Decision Register following proposals received and decisions made at the MoC Panel meetings.

The MoC process that would be applied to the subsequent Execute phase of the PCCS project is described further in the Key Knowledge Deliverable 11.062 – Project Organisation [2].

The end of FEED Basis of Design information is presented in the Key Knowledge Deliverable 11.001 – Basis of Design [3].

5. Conclusion

This document provides an overview of the key decisions made during the Front End Engineering and Design (FEED) phase of the Peterhead CCS Project, along with a summary of the Management of Change (MoC) process used to manage these changes / decisions.

6. References

1) Basic Design Engineering Package (Key Knowledge Deliverable 11.003)
2) Project Organisation including roles, responsibilities, resourcing and onboarding plan (Key Knowledge Deliverable 11.062)
3) Basis of Design (Key Knowledge Deliverable 11.001)

7. Glossary of Terms

Term	Definition
CMF+	Compressor Mass Flow Increase
CO_2	Carbon Dioxide
BOM	Business Opportunity Manager
BOO	Build-Own-Operate
CAPEX	Capital Expenditure
CCGT	Combined Cycle Gas Turbine
CCP	Carbon Capture Plant
CCS	Carbon Capture and Storage
DCC	Direct Contact Cooler
DECC	Department of Energy & Climate Change
EPC	Engineer-Procure-Construct
EPCI	Engineering, Procurement, Construction and Installation
FEED	Front End Engineering Design
FID	Final Investment Decision
FOAK	First-Of-A-Kind
GBP	Great British Pounds
GT	Gas Turbine
HDD	Horizontal Direct Drilling
HSSE	Health, Safety, Security and Environment
KKD	Key Knowledge Deliverable
LTSA	Long Term Service Agreement
MoC	Management of Change
NUI	Normally Unmanned Installation
OEM	Original Equipment Manufacturer
ORP	Opportunity Realisation Process
PCCS	Peterhead Carbon Capture and Storage
PCF	Project Change Form
POB	Persons on Board
SP	Social Performance
SP7	Service Pack 7
SSE	SSE Energy Generation Limited
UK	United Kingdom
W2W	Walk-to-Work
WWTP	Waste Water Treatment Plant

8. Glossary of Unit Conversions

Table 8-1: Unit Conversion Table

Function	Unit - Imperial to Metric conversion Factor
Length	1 Inch = 25.4 millimetres

APPENDIX 1. PCCS Key Decision Register

Table A-1: PCCS Key Decision Register

Index	PCF No.	Issue	Decision	Stage	Project Capex Impact	Project Opex Impact	Project Schedule Impact	Comments
1	PCF n/a	Contracting Strategy / Build-Own-Operate (BOO)	NOT APPROVED (BOO) Jun-2014	CLOSED	None	None	None	Build-Own-Operate proposals from the market not commercially competitive
2	PCF D018	Extending Peterhead CCS design and operating life from 10 to 15 years	APPROVED 21-Aug-2014	IMPLEMENTATION	GBP < 5 mln	Extended by 5 years at GBP 270 - 290 mln/a	None	Extension to full 15 years dependant on timing and costs of second major gas turbine GT13 overhaul.
3	PCF C004	Reduce from five injection wells to four	APPROVED 06-Feb-2014	IMPLEMENTATION	GBP 7 to 10 mln	None	None	Fifth well can be reinstated in the plan any time up to the well workover campaign.
4	PCF D026	Gas Turbine Modifications to improve efficiency and output (CMF+ & SP7)	APPROVED 08-Oct-2015	IMPLEMENTATION	GBP < 5 mln	GBP 590k /a LTSA costs + GBP 5.8 – 7.5 mln Fuel Gas (indexed)	None	Some debottlenecking of existing equipment required (275kV export cable). Other costs spread across Long Term Service Agreement.
5	PCF D011	Absorber Location and Auxiliary Boiler Relocation	APPROVED 08-Oct-2015	IMPLEMENTATION	Cost neutral	GBP 200 – 300 k/a reduction in booster fan power consumption	+ 6 Months	Relocation of auxiliary boilers necessary to accommodate absorber tower. Cost of boiler relocation offset by civils and ducting savings. EPC critical path extended.

Index	PCF No.	Issue	Decision	Stage	Project Capex Impact	Project Opex Impact	Project Schedule Impact	Comments
6	PCF D032	Waste Water Treatment Plant De-risking	APPROVED 08-Oct-2015	IMPLEMENTATION	GBP ca. 7 mln reduction	GBP 70k/a Opex reduction	None	Significant improvement in reliability / uptime expected.
7	PCF D021	Drill HDD Pilot hole	APPROVED 19-Dec-2014	COMPLETE	GBP 1 mln	None	Neutral	Pilot hole will be grouted and retained for re-entry later. Pilot hole was technically successful.
8	PCF C001	Deferment of Existing Pipeline Inspection by Intelligent Pigging	APPROVED 23-Jan-2014	COMPLETE	Cost neutral	None	None	Possible schedule impact if pipeline integrity issues are identified late in Execution.
9	PCF C002	Supply of Methanol from St Fergus instead of Peterhead	APPROVED 06-Feb-2014	IMPLEMENTATION	GBP -15 to -20 mln	GBP 300k/a increase	None	Savings in HDD, pipelay and subsea tie-ins.
10	PCF n/a	Walk to Work (W2W) Accommodation Vessel to support Goldeneye offshore construction activities	APPROVED Feb 2014	IMPLEMENTATION	GBP 15 to 20 mln	None	None	Not subject to MoC as this was not a change. W2W chosen from several options of which it was the cheapest. Cost quoted is absolute value.