Peterhead CCS Project

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Executive Summary

This document records the work done to select the optimum location(s) available for the Peterhead CCS Project regarding the Capture, Conditioning and Compression facilities.

The capture plant facilities will by definition be located at Peterhead Power Station. The site selection work considered the sites of St Fergus and Peterhead Power Station for the location of the compression and conditioning facilities.

This work confirmed the benefits of co-locating the Compression and the Conditioning facilities at Peterhead Power Station.

1. Introduction

The Peterhead CCS Project would be the world's first commercial scale demonstration of CO_2 capture, transport and offshore geological storage from a (post combustion) 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.

Approximately 1 million tonnes/year of CO_2 will be captured from the flue gas produced at the 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.

This report details the process followed for the selection of the optimal site for installation of the new capture and compression facilities and inherently covers the pipeline route selection.

2. Site Identification Work

Site identification work for the Peterhead Carbon Capture and Storage Project started as far back as late 2011, at which time the responsibility split between SSE (then Scottish & Southern Energy) and Shell meant that SSE were looking after the capture scope at Peterhead Power Station and Shell were primarily responsible for the compression facilities and onward transportation to the Goldeneye field for storage. The CO_2 capture plant must be located in close proximity to the combined cycle gas turbine at Peterhead in order to receive the flue gas optimally, so the principle site selection decision involved the optimum location for the onshore compression and conditioning facilities. Rather than building a brand new greenfield location it was decided early on that the compression plant should be close to the existing infrastructure and two suitable sites were identified; one immediately adjacent to the St Fergus Gas Terminal and one inside the Peterhead Power Station fence on the plot of an existing tank farm which had previously been identified for demolition. For Site Layout details see Figure 2-1.

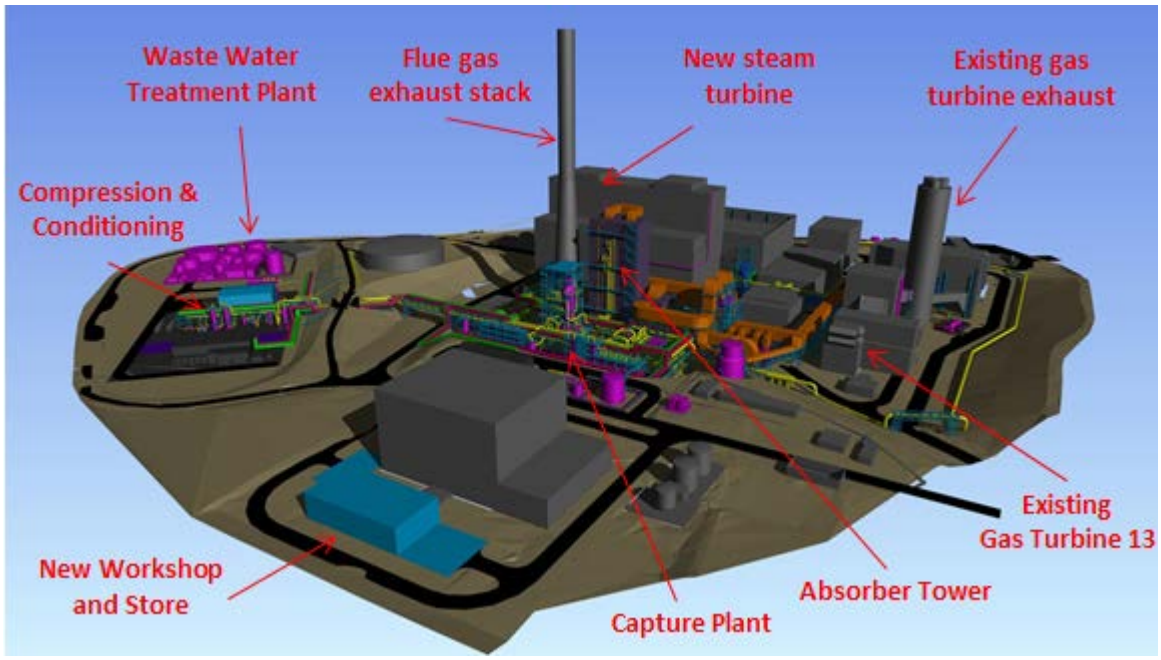

Figure 2-1: Site Layout at Peterhead Power Station

Note: Existing equipment in grey.
New equipment in colour.

3. Site Selection Work

3.1. St Fergus verses Peterhead Compression Facilities

Two sites were considered for the location of the Compression facilities:

- *Blackhill:* This is the site that was previously selected for the Longannet CCS project. The plot is adjacent to the Shell St Fergus terminal and the land is owned by National Grid, who were a consortium partner in the Longannet Project;
- *Peterhead:* this site is within the Peterhead Power Station fence line and is located at the former site of the heavy fuel oil tanks which were demolished and cleared in 2012. The land is owned by SSE (now SSE Generation Limited) and the soil is certified clear of contamination.

A total of three configurations were compared for the two sites to reflect the possible operating modes:

- Option 1: the capture plant and a low pressure compressor would be located at Peterhead Power Station and vapour phase[1] CO_2 would be transported to St Fergus via an onshore pipeline routed around the town of Peterhead. There is an existing redundant 18" [457mm] diameter gas pipeline that could be utilised if its integrity can be confirmed or alternatively a new pipeline would have

[1] 'Vapour Phase' denotes the condition at which the CO_2 is gaseous whilst at a pressure and temperature lower than its critical point. The vapour phase pipeline would operate at around 30 bara.

to be constructed along the existing route. These are presented as sub options to Option 1. The high pressure (HP) compressor would be located at St Fergus where the CO_2 would be compressed to its dense phase[2] condition before being fed into the existing St Fergus to Goldeneye gas pipeline;

- Option 2: the Capture plant and full HP compression plant would be located at Peterhead Power Station and the dense phase CO_2 would be transported directly offshore in a new circa 20km subsea pipeline spur which would tie into the existing Goldeneye to St Fergus gas pipeline at a convenient subsea location;
- Option 3: the Capture plant and full HP compression plant would be located at Peterhead Power Station and the CO_2 would be transported in dense phase via a new high pressure onshore pipeline routed around the town of Peterhead. This pipeline would connect directly into the existing Goldeneye to St Fergus gas pipeline.

These are shown in the figure below:

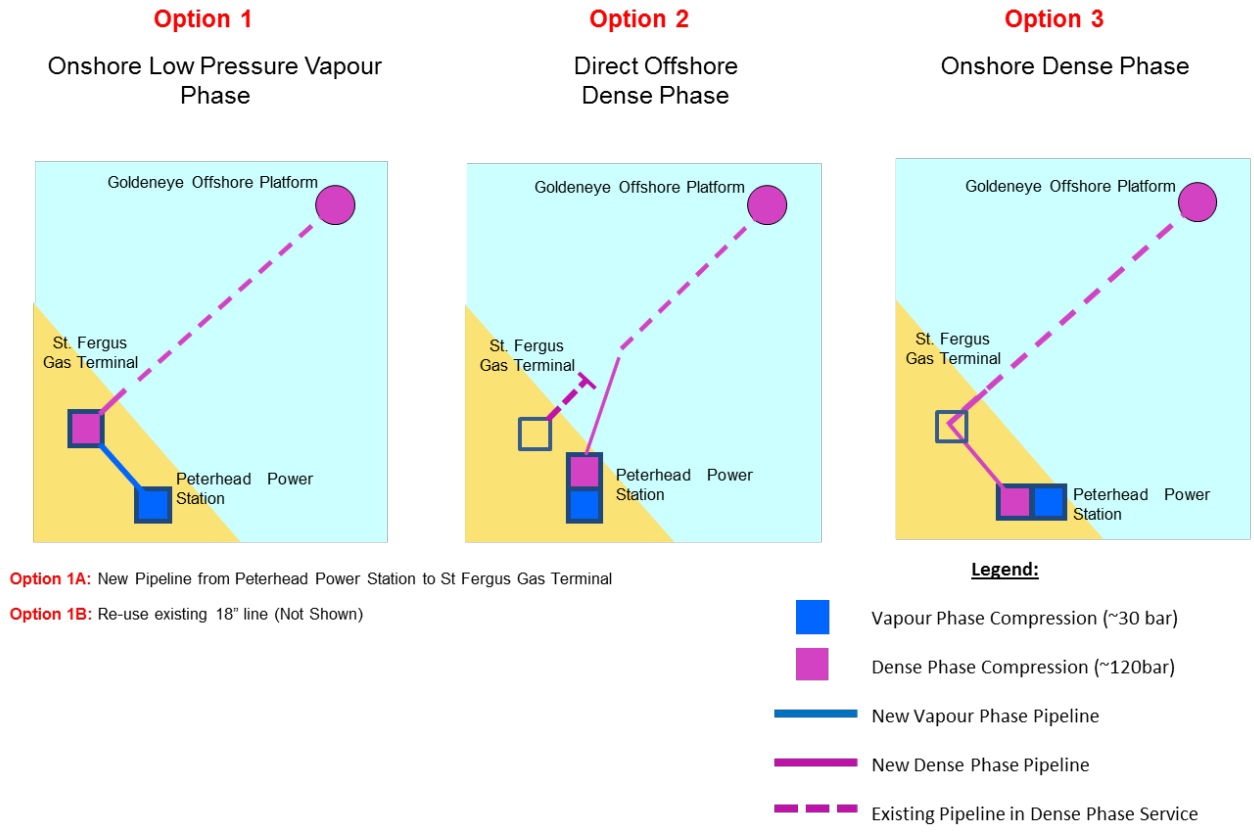

Figure 3-1: Potential Operating Modes.

[2] 'Dense Phase' denotes the condition at which the CO_2 exists as a fluid above its critical point. The dense phase pipeline would operate at around 120 bara.

Given that selection of the dense phase compressor location, pipeline routing and service conditions were key decisions to be made, an evaluation scorecard was developed based on the top value drivers. Evaluation was carried out using six selection criteria:

Rating \ Criteria		Capex	Time to FID (Note 1)	Health & Safety (Note 2)	Public Acceptance	Commercial Do-ability	Expandability
Unacceptable		Significant increase (~£50mln higher than base case)	> Dec 2015	Does not meet Project minimum Standards	Clearly untenable	Commercial deals not possible within required FID timeframe	
Acceptable	Low	Similar to base case	2015	Least favourable	High potential for delay due to public acceptance issues	Requires significant levels of negotiations, parties not currently aligned	Minimum scope for networking and expansion
	Mid	Significant savings (~£50 mln lower than base case)	FID 2nd half 2014	Less favourable	Some potential for delay due to public acceptance issues	Some commercial issues and alignment required	Some scope for expansion
	High	Substantial savings (~£100 mln lower than base case)	FID 1st Half 2014	Most favourable	Minimal potential for delay due to public acceptance issues.	No major commercial issues, parties aligned	Easily expandable

Figure 3-2: Operating Modes Scorecard.

Note 1: Excludes overrun risk covered by other selection criteria i.e. essentially deterministic.

Note 2: Input to ALARP demonstration (cost should not be grossly disproportionate to risk reduction achieved)

The Option Selection process was carried out at a fairly high level but the following specific details were used to come up with the relative ranking for the non-technical risk areas:

Health & Safety: The route directly offshore removes any hazard to the public due to proximity to CO_2 inventory. The vapour phase onshore pipeline does introduce a potential hazard but the risk remains very low with limited escalation potential. For a dense phase onshore pipeline, although the risk would still be very low and is deemed manageable, the potential consequences of an incident would increase significantly, hence the Amber rating, although this is based partly on perception. The direct route offshore was also favoured by the UK Health and Safety Executive rather than the dense phase onshore option.

Environment: The differences in environmental impact were not considered to be primary differentiating factors between the three options. The onshore pipeline options would involve laying a new pipeline in the existing corridor between the power station and St Fergus, so the risk to cultural heritage would be deemed to be minor. There are no designated environmental sites along the route but with a length of 18km through established countryside there would be a number of locally sensitive areas requiring habitat surveys and associated mitigation measures.

The offshore pipeline route does necessarily traverse a designated Special Protection Area but engagement with environmental stakeholders (Marine Scotland, SNH, JNCC) did not identify any serious concerns as long as the construction is well managed according to established practices.

Flood risks were not specifically considered during Option Selection. The onshore pipeline option would follow the existing pipeline corridor between the power station and St Fergus and the flood risk during the construction phase would be managed locally by using horizontal directional drilling under streams etc. Given that the pipeline corridor exists already, this risk was not identified as significant enough to be a differentiator between options.

Public Engagement: The direct pipeline offshore has the least impact on the public but is recognised to have some environmental impact in a designated area. The onshore vapour phase

pipeline would bring some disruption and visual impact during construction but there is nothing out of the ordinary regarding the approval process. The onshore dense phase pipeline on the other hand would be a first with no precedent for the approval process. Perceptions around the risks associated with the onshore dense phase pipeline were considered to be potentially challenging.

Expandability: Options routing the CO_2 via St Fergus were deemed to be optimal for creating the potential to take in other sources of CO_2. The direct offshore option from Peterhead means that any CO_2 from an alternative source would have to be transported to the power station in order to enter the system.

The resulting assessment against the selection criteria is given in the figure below:

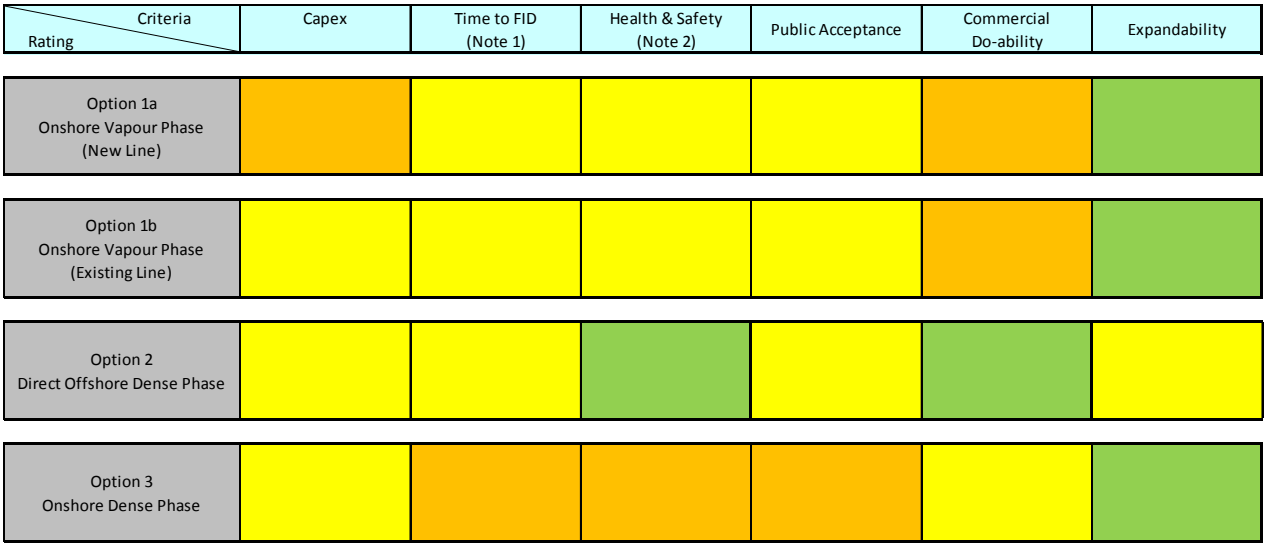

Figure 3-3: Operating Modes Selection Assessment

Note: See Note 1 and Note 2 from Figure 3-2 above.

The site selection decision was reduced to a choice between dense phase compression at St Fergus (Options 1a & 1b) versus dense phase compression at Peterhead (Options 2 & 3). On the basis of the option selection scoring it was concluded that Option 2, with all the compression at Peterhead and direct transportation of dense phase CO_2 offshore via a new subsea pipeline section, represented the best combination with significant potential for simplification, reduction of capital and operating costs due to centralisation of the compression, and reduced impact to the community. Peterhead was therefore chosen as the preferred location for the compression facilities.

3.2. Conditioning Plant Location Options

The conditioning facilities will remove residual oxygen and water vapour from the CO_2 stream in order to eliminate the risk of corrosion before it enters the carbon steel pipeline. The catalytic oxygen reduction process and the dehydration process using molecular sieves both operate optimally at a pressure of around 40 bar so the conditioning plant will take the medium pressure CO_2 from one of the interstages of the compressor and will feed it back again after treatment. Once the decision was taken to locate the all the compression facilities at Peterhead Power Station, it became obvious that the conditioning facilities would also need to be situated there. SSE expressed a preference, as owners of the Peterhead Power Station site, to locate the compression and conditioning facilities on the

former tank farm site. This location was assessed and deemed suitable. This area was cleared of all redundant tanks and associated equipment and the soil certified as clear of contamination. The site retains its tiered topographical nature but is ready for future redevelopment.

4. Conclusions

Sites have been selected for the following main components of the Peterhead CCS Project:

- By necessity the capture plant will be located immediately adjacent to the power station gas turbine;
- Dense phase compression will be located at Peterhead with the CO_2 transported directly offshore via a new subsea pipeline section;
- The compression and conditioning plants will be located adjacent to each other and close to the capture plant within the fenced boundary of the Peterhead Power Station. The former heavy fuel oil tank farm area has been cleared and made available for these facilities.

5. Glossary of Terms

Term	Definition
ALARP	As Low As Reasonably Practicable
CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage
CO_2	Carbon Dioxide
FID	Final Investment Decision
GE	Goldeneye (Platform)
GT-13	Denotes tag number for related Gas Turbine chosen for the Carbon Capture Project
HP	High Pressure
PPS	Peterhead Power Station
SF	St Fergus
SSE	SSE Generation Ltd (formerly Scottish and Southern Energy Ltd)

6. Glossary of Unit Conversions

For the provision of the SI metric conversion factor as applicable to all imperial units in the Key Knowledge Deliverable.

Table 6-1: Unit Conversion Table

Function	Unit - Imperial to Metric conversion Factor
Length	1 Foot = 0.3048 metres 1 Inch = 25.4 millimetres
Pressure	1 Bara = 14.5psia
Temperature	°F=(1.8)(°C)+32 °R=(1.8)(K) (absolute scale)
Weight	1 Pound = 0.454 Kilogram