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Heavy Oil

Controlled Document

Quest CCS Project

GHG & Energy Management Plan

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Summary

GHG Report for Quest CCS Project

Update to regulatory and power source and added Appendix A – NPV section.

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Quest, CCS, FID, EXECUTE, GHG, Greenhouse Gas, Energy

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1. INTRODUCTION

Shell Canada currently operates three Hydrogen Manufacturing Units (HMU) at the Scotford Upgrader. The production of hydrogen represents a significant source of CO_2 generated at the Upgrader, which is released from the reformer furnace stacks.

The Quest CCS scope consists firstly of an amine absorption and regeneration system used to recover 80% of the total CO_2 from the three HMU PSA feed gas streams. The absorption process used is the ADIP-X process, which is an accelerated MDEA-based process licensed by Shell Global Solutions International (SGSI). The CO_2 Rich Amine streams from each individual HMU are combined in a common Amine Regeneration section. The Regeneration section produces a CO_2 stream with >95% purity.

The recovered CO_2 is subsequently compressed in an 8 stage centrifugal Integral Geared (IG) compressor with an electric motor drive. In the first 5 stages, free water is knocked out through compression and cooling. The CO2 from the 6th stage of compression is routed through a TEG dehydration unit to reduce the water content to less than 4 lb per MMSCF. In the final two stages, the CO2 stream is compressed to a supercritical fluid state (dense phase) at 14,500 kPag. This dense phase CO2 is transported by pipeline from the Scotford Upgrader to the injection locations which are located ~64 kilometres from the Upgrader.

There will be 3 injector wells drilled to a depth of approximately 2200 m to inject the CO2 into the Basal Cambrian Sands (BCS) formation.

The CO_2 Strategy for Heavy Oil has 3 key areas of focus: energy efficiency, low carbon technologies and supply, and carbon capture and storage. The Quest project allows Heavy Oil to reach its midterm goals. For more details refer to the Environmental Performance Improvement 2013 Plan.

The Scotford Upgrader emitted 2.4 Million tonnes of CO_2 on average annually between 2010 and 2012. With no further action CO_2 emissions are forecasted at 2.9 Million tonnes on average annually until 2022. With Quest capturing 1 Million tonnes annually, the CO_2 emissions are forecasted to decrease.

Once Quest is turned over to Scotford, this document will be used in parallel with the CCS Offset Protocol. Technical and environmental groups at Scotford will provide data to the regulatory team in Calgary. The regulatory team will own the calculation methodology and spreadsheet but the site will provide assurance on the calculations.

In June 2011, agreements were signed with the Canadian and Alberta governments for a total of Shell share $865 million CAD that covers pre-FID, capital and 10 years of operation. A multi-credit agreement was also signed with Alberta that doubles the CO_2 credits that Quest will receive during the first 10 years of operations.

2. GHG REGULATORY AND POLITICAL ENVIRONMENT

All key regulatory approvals for the Quest project were forwarded to Shell by the regulators involved in 2012. These major project approvals were:

1. ERCB Directive 56 approval- for main pipeline
2. ERCB Directive 65 approval- for the CO2 storage scheme
3. Amendment of existing OSCA approvals- for capture infrastructure

Greenhouse Gas emissions in Alberta are governed by the Specified Gas Emitters Regulation (SGER). As part of this legislation, large final GHG emitters are required to report and reduce their GHG emission intensity; gradually until 12% reduction from base-line is achieved. Emitters which fail to meet the target are required to come into compliance by purchasing Emission Performance Credits, Offsets, or by paying into a technology fund, the cost of which is capped at C$15/tonne CO2. All GHG emissions related to the operation of the Quest project will be accounted for and reported on by the Scotford Upgrader.

Emission reductions that result from Quest will generate emission 'offset' credits. The detailed conditions under which projects are considered qualified to generate offsets and the quantification of these offsets is done through an "Offset Protocol" entitled "Quantification Protocol for CO2 Capture and Permanent Storage in Deep Saline Aquifers". This protocol is currently under development, and it is anticipated final version of the Protocol will be accepted into the Alberta Offset System by Alberta Environment and Sustainable Development (AESRD) in Q4 2014. Project emissions associated with capture, compression, transport and injection are subtracted from the baseline emissions to determine the net greenhouse gas reduction achieved by the project.

In June 2011, the Government of Alberta amended SGER to allow CCS proponents who meet a narrow set of project criteria to qualify for a second set of "additional credits". Every offset credit earned for the first ten years of operation will be matched with an "additional credit".

Outside of Canada, AOSP crudes could be subject to market standards based on life-cycle carbon intensities such as the California Low Carbon Fuel Standards (LCFS) or European Fuels Quality Directive (FQD). Depending on the details of those programs, Quest could reduce the GHG intensity of the AOSP crudes by approximately 8 kg/bbl.

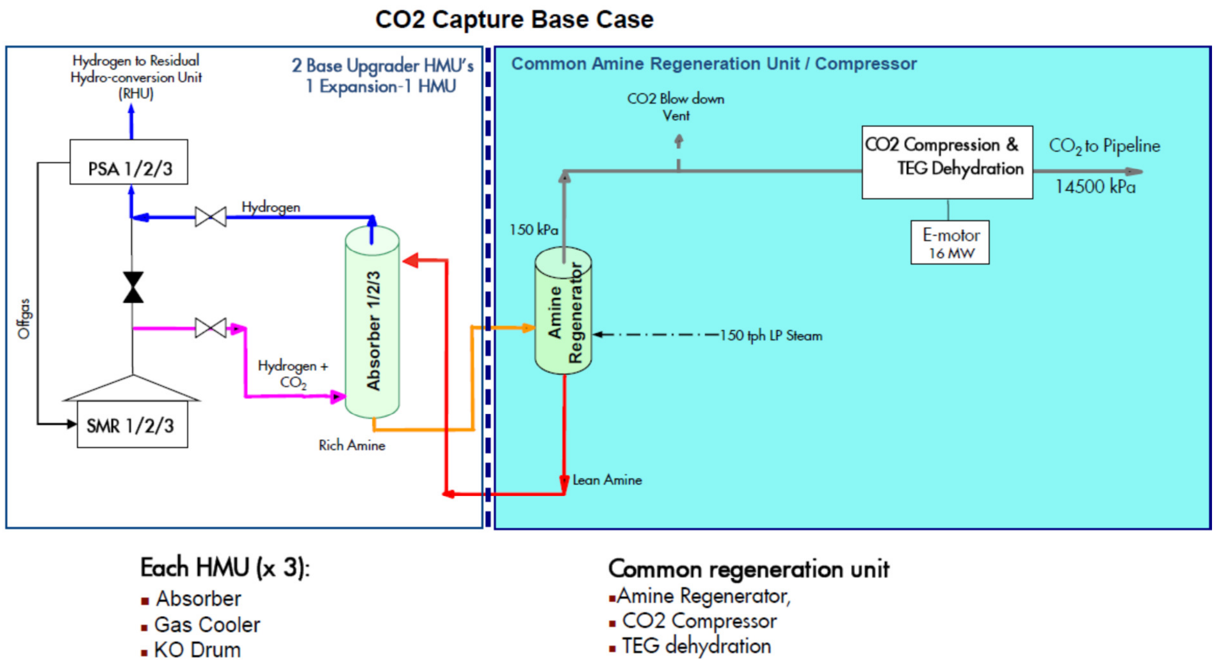
3. METHODOLOGY AND ASSUMPTIONS

Pricing assumptions for economic evaluations at the time of the Quest GIP (July 2012) are summarized in the table below:

Variable	2012	2015
Natural Gas	4.72 CAD/GJ	3.68 CAD/GJ
LP Steam	6.40 CAD/tonne	3.68 CAD/tonne
Electricity	119.00 CAD/MWh	109.00 CAD/MWh
CO2	40 USD/tonne	30 USD/tonne

4. DESIGN CONCEPT

A graphical overview of the Quest CCS process is shown below:



Steam and power comprise the majority of Quest emissions. 162 t/h of LP steam is needed for amine regeneration, while 18.3 MW of electricity is needed for various equipments (primarily the CO2 compressor). Neither steam nor electricity will be generated by Quest equipment, so from the perspective of the Offset Protocol, all emissions are considered indirect.

Steam will be sourced from the Scotford Upgraders. Approximately 2/3 of this steam is a byproduct of hydrogen manufacturing, and has a GHG footprint of zero. Approximately 1/3 of this steam is generated in a Heat Recovery Steam Generator (HRSG), and has a non-zero GHG footprint. An additional 60,000 t of CO_2 can be avoided as compared to the base scenario of power coming from the grid if the power used by Quest comes from a CoGeneration facility. There are CoGeneration systems at the Upgrader, but the electricity used by Quest will be considered grid electricity by the provincial government because it only meets one of the two criteria required to be considered CoGeneration electricity. To be considered CoGeneration electricity, the electricity must be

1. directly connected to Quest
2. incremental generation

Any CoGeneration power other than those located at Scotford would not satisfy the criterion for direct connection. Of those CoGens located at Scotford, one of them does not have enough incremental capacity to meet the Quest demand. Contracting with the remaining CoGen will not be pursued because a premium to the value shown in Section 3 (for the price of electricity) would be applied to Quest when securing the CoGen's incremental capacity. The premium would be large enough to significantly impact the economics of the Quest opportunity in a negative way.

The summary table below presents the net CO_2 avoided.

Type of GHG Emissions	**"Grid Case" (tCO_2/year)**
(A) Gross Captured CO_2	1,080,000
(B) Direct Emissions	0
(C) Indirect Emissions	199,000
Net GHG Reductions	
Direct Emissions Assessment [(A) – (B)]	1,080,000
Streamlined Lifecycle Assessment [(A) – (B) – (C)]	881,000
Net CO2 Avoided as % of Total CO_2 in the HMU Raw H_2 Streams	**65%**

Using the data in this table, the estimated energy penalty of capture and sequestration is 2.02 MJ/kg CO2.

The term "parasitic losses", in reference to machinery, refers to energy use which does not contribute directly to (in the case of Quest) the capture and sequestration of CO2. The core piece of machinery for Quest is the 8-stage compressor, but dedicated parasitic loss calculations for this and other pieces of machinery were not performed during the design phase.

5. CONCEPT SELECTION & OPTIMISATION

During SELECT, a Class of Facilities workshop was carried out. One of the performance categories evaluated was Energy Efficiency and Carbon Management. Class 3 was selected for this category, which is defined as follows:

The project will include Best Available Techniques (BAT) for energy efficiency in the design. This Class is intended to ensure that the project incorporates BAT energy efficiency solutions in the design. The assumption in Class 3 is that taking BAT energy efficiency design criteria still leaves the overall project economically feasible, with the energy efficiency element bringing a Net Present Value (NPV) of greater than zero. This assumption should be checked against the specific design solutions.

The project team agreed to consider any BAT commercially available in 2010, in order to reduce the CO2 emissions of the new Quest facilities to ALARP. This was done as part of an optimization process where tradeoffs between CAPEX, OPEX, and CO2 emissions were analyzed with the intent of making the NPV for the project as close to zero as possible.

5.1. Heat Integration and Recovery Efficiency

Quest requires significant amounts of LP steam (~162 t/h) and cooling water (~5900 m^3/h). These utilities will be supplied from the existing spare capacity at the Upgrader. By drawing more from these underutilized utility systems, energy efficiency at the Scotford Complex will be improved.

In addition, Quest will use LP condensate from its amine regeneration process to heat demineralized water at Scotford, thereby reducing LP steam demand at Scotford by ~21 t/h, or 13% of the total LP steam used in Quest for amine regeneration. When we consider that ~52 t/h of LP steam is estimated to be needed from the HRSG for Quest operations, this results in a heat recovery efficiency of 40%.

5.2. Renewable Energy

At the line break valve stations along the CO2 pipeline, Quest will use solar panels to power the SCADA system. The Scotford Upgrader will also install solar panels along its main entrance road with a total capacity of 150 kW which can be considered as powering Quest.

The Government of Alberta embedded into the CCS Offset Protocol this stipulation: that to have any electricity source with carbon intensity better than grid average recognized as an input to CCS projects, that electricity generation has to be: 1) incremental; and, 2) directly connected. Shell considered wind generation but none of the wind projects satisfied the directly connected criterion as there are no wind generators connected to the Scotford ISD.

5.3. Load Lists

All load lists (e.g. for rotating equipment, and for electrical equipment) were identified and reviewed for inefficiency during the detailed engineering phase. Load lists can be found in the BDEP.

6. METERING AND SURVEILLANCE STRATEGY

Proper metering is essential for regulatory reporting purposes. Those meters identified for these purposes will be labeled "Regulatory" to ensure regular maintenance and calibrations are completed as required. Under Alberta's Specified Gas Emitters Regulation (SGER), maintenance records for "Regulatory" meters must be presented during third party audits.

7. TECOP ASSESSMENT

As part of the risk management process for the Quest CCS Project, risks have been identified and evaluated across the 5 TECOP categories. Regarding CO2 in particular, the major risks leading up to FID were these:

1. The risk that an immature regulatory framework (with respect to CCS) may lead to delays in regulatory approvals, impacting the project schedule.
2. The risk that a significant international campaign against oil sands and against CCS may lead to delays in regulatory approvals, impacting the project schedule.
3. The risk that unfavourable GHG legislation may lead to CO2 credits being untradeable or to CO2 being priced below the project premise, impacting project economics.

4. The risk that ineffective stakeholder engagement may lead to stakeholder objections, impacting the project schedule and the project cost (if money is spent to appease stakeholders).

Now that regulatory approvals have been secured without notable stakeholder objection, double credits have been successfully negotiated with the provincial government, and FID has been passed, these risks have been either taken or closed. Going forward, stakeholder engagement will continue (see next section), and the effects of possible future regulation will need to be monitored (see section 2 above). The current risk status for these and all other project risks can be found in the project risk register.

8. CO2 STAKEHOLDER ENGAGEMENT

Stakeholders have identified several issues of concern that are particular to CO2 and/or CCS:

- Perception that CCS is not a proven technology, or otherwise impractical
- Loss of CO2 containment (particularly from the reservoir, the wells, or the pipeline)
- Groundwater contamination
- Burying "waste" underground
- Government support for CCS projects that are not economically viable without support
- CCS as an "enabler" for additional oil sands development
- Perception that climate change is not something to be concerned about

To understand how these and all other stakeholder issues are being managed, please consult the Stakeholder Engagement Plan.

9. ACRONYMS

AENV – Alberta Environment
ALARP – As Low as Reasonably Practicable
BAT – Best Available Technology
BDEP – Basic Design Engineering Package
CAD – Canadian Dollars
CAPEX – Capital Expenditure
CCS – Carbon Capture and Storage
CO_2 – Carbon Dioxide
E&S – Economics & Scheduling
EHT – Electrical Heat Tracing
ERCB – Energy Resources Conservation Board
FID – Final Investment Decision
GHG – Greenhouse Gas
GJ – Gigajoule
HMU – Hydrogen Manufacturing Unit
kPag – kilopascal (gauge)
LP – Low Pressure (steam)
MDEA – Methyl Diethanolamine
MMSCF – Million Standard Cubic Feet
MWh – Megawatt-hour
NPV – Net Present Value
OPEX – Operating Expenditure
OSE – Operations Support Engineer
PSA – Pressure Swing Adsorber
SCADA – Supervisory Control and Data Acquisition

TECOP – Technical, Economic, Commercial, Organizational, Political
TEG – Triethylene Glycol
USD – U.S. Dollar