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Heavy Oil

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Quest CCS Project

Quest GHG and Energy Report

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Summary

GHG Emissions and Energy Consumption Report for the 2015 submission of the Quest annual report to the Alberta Department of Energy

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1. ENERGY AND GHG EMISSIONS OVERVIEW

This document provides a summary of the energy consumption and greenhouse gas (GHG) emissions data for the Quest project in 2015. Note that the Energy and GHG emissions data provided are aligned with the specific requirements for reporting under the CCS Protocol and the Quest CCS Project Plan, which has been posted on the Alberta Emissions Offset Registry. Energy and GHG emissions are provided for the period from August 23, 2015 to December 31, 2015, because CO_2 Injection commenced on Aug. 23, 2015. This document fulfills the data requirements of sections 1.4, 2.4, 2.5, 4.5 and 4.6 of the annual Detailed Report to the Alberta Department of Energy for the Quest CCS project.

1.1. Energy Consumption and Energy Penalty of Capture – Performance (Section 1.4)

Table 1 on the following page provides an annual summary of the energy consumption/energy penalties associated with the Quest CCS project in 2015. Energy consumption values or energy penalties for Capture, Transportation, and Storage (Section 1.4 of the Detailed Report) are provided for various categories including steam consumption, compression requirements, total electricity usage, and cooling requirements. Since several of the metrics are measured as combined energy penalties for the integrated project (Capture, Transport, Storage), parameters in Table 1 indicate whether the data supplied is a summation for the entire project, or related to a specific project component.

As the energy for Quest is provided from two difference sources, grid electricity and thermal (e.g. steam, etc.), the total energy penalty has been provided separately for electricity usage and thermal and has been denoted as MJ_e and MJ_{th}, respectively, in Table 1. It is important to note that the electricity usage has been divided by the average Canadian electricity generation efficiency of 77.59% as per internal Shell reporting standards. However, the factor used to calculate CO2 emissions is the Alberta grid electricity factor of 0.64 tonnes CO2e / MWh, and does not include the 77.59% efficiency factor as per the reporting protocol (see Tables 2 & 3).

Quest draws its cooling water from existing Upgrader infrastructure. As a result, the power consumed by cooling water circulation pumps and cooling tower fans have been proportioned to Quest based on the Quest cooling water circulation rate relative to the Upgrader. This procedure results in the energy penalty to Quest for cooling as indicated in Table 1. In addition, Shell implemented a project to capture excess heat from Quest and preheat Upgrader Demineralized Water, the Demineralized Water Preheat Project. This project has reduced the heating requirements (less steam required in the de-aerator) for the Upgrader. As a result, the Demineralized Water Preheat Project results in a negative energy penalty for Quest.

None

Table 1 - Energy Consumption / Energy Penalty of Capture

Parameter	**Value**
Total Energy Penalty for the integrated project (Capture + Transport + Storage)	(0.71 MJ_e + 0.77 MJ_{th})/kg
Steam - Energy Penalty (Capture + Transport)	1.10 MJ_{th}/kg
Cooling Requirement - Energy Penalty (Capture + Transport)	0.04 MJ_e/kg
Water Consumption - Energy Penalty	Negligible
Electricity Usage (including Compression of CO2 for transport) - Energy Penalty (Capture + Transport + Storage)	0.67 MJ_e/kg
Electrical Recovery - Energy Penalty	Not applicable
Compression Requirements (Included in Electricity Usage) - Energy Penalty (Transport Only)	0.52 MJ_e/kg
Air Separation Energy - Energy Penalty	Not applicable
Demineralized Water Preheat Project (heat recovery) - Energy Penalty (Capture Only)	(0.33) MJ_{th}/kg

1.2. Transportation Emissions and Energy Consumption (Sections 2.4, 2.5)

Transportation of CO_2 from the Capture site to the Injection site requires energy and results in greenhouse gas (GHG) emissions. Based on the specific requirements as described in the Detailed Report, GHG Emissions from Transportation only includes fugitive and fuel emissions (Section 2.4 of the Detailed Report). Note that no fugitive emissions are reported under GHG Emissions from Transportation, because fugitive emissions reported as per the CCS Protocol only include fugitives that are downstream of the wellhead flow meter. Fuel emissions for Transportation only include diesel and gasoline usage for maintenance and inspections and aviation fuel for pipeline inspections (Table 2).

Most of the GHG emissions for Transportation of CO_2 would include the indirect emissions from grid electricity consumption for compression and the indirect emissions from High Pressure steam for the Glycol Dehydrator. As a result, total direct and indirect GHG Emissions from Transportation are also included in Table 2 as this is more comparable to the Energy Consumption for Transportation (Section 2.5 of the Detailed Report). The Energy Consumption for Transportation includes grid electricity consumption

None

for compression, High Pressure Steam for the Glycol Dehydrator, diesel, gasoline, and aviation fuel.

Table 2 - Emissions and Energy Consumption from Transportation (Sections 2.4/2.5)

Parameter / Units	**Value**
Fuel Emissions (tonnes CO2e/month)	8
Direct + Indirect Emissions (tonnes CO2e/month)	6,168
Daily Average Transport Energy Consumption (MWh/day)	(409 MWh_e + 14 MWh_{th})/day

Note that the fugitive emissions in 2015 from Pipe Fittings for valves and flanges downstream of the wellhead meters were approximately 2 tonnes CO2e. Fugitive emissions for Quest upstream of the wellhead meter are not required to be reported under the CCS Protocol as mentioned above. However, there would be minor amounts of fugitive CO2e emissions from Quest Transportation for the pipeline, including the Line Break Valves (LBVs), and the compressor and dehydrator at the Quest Main Plot at Scotford.

For the pipeline, the imbalance from the pipeline inlet meter and the well injection meters is less than 0.2%. Given that the error in the measurement can be the sum of the 3 meter errors (0.1+0.1+0.05 = 0.25%), the imbalance would be mostly due to the uncertainty range of the meters. As a result, there would only be a very minor amount of fugitive emissions from the pipeline.

1.3. CO_2 Emissions and Emissions Avoided (Sections 4.5, 4.6)

Total CO_2 emissions from the Quest CCS Project are included in Table 3. As noted previously, these emissions are for the period of injection, which was from August 23, 2015 to December 31, 2015. Gross CO2 Injected and Total CO_2 Emissions Avoided, or Net CO2 Injected, for this same time period are also provided in Table 3. In addition, annualized data has also been supplied for clarity because the 2015 operating period was only 131 days.

None

Table 3 – CO_2 Emissions and Emissions Avoided (Sections 4.5/4.6)

Parameter / Units	**Value**
Total CO2 Emissions for Aug. 23-Dec. 31 (tonnes CO2e)	57,393
Capture CO2 Emissions Aug. 23-Dec. 31 (tonnes CO2e)	30,420
Transport CO2 Emissions Aug. 23-Dec. 31 (tonnes CO2e)	26,935
Storage CO2 Emissions Aug. 23-Dec. 31 (tonnes CO2e)	39
Total CO2 Emissions - Annualized (tonnes CO2e/yr)	159,913
Gross CO2 Injected from Aug. 23 - Dec. 31 (tonnes CO2e)	370,987
Gross CO2 Injected - Annualized (tonnes CO2e/yr)	1,033,667
Net CO2 Injected from Aug. 23 - Dec. 31 (tonnes CO2e)	313,594
Net CO2 Injected Annualized (tonnes CO2e/yr)	873,754