IEAGHG Summary Report of the Shell Quest Carbon Capture and Storage Project

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Abstract

An IEAGHG report 2018-XX funded by the US Department of Energy (DOE) concerning the aforementioned project will be issued in Fall 2018. The report will outline the successes and challenges of the Shell Quest CCS Project to provide valuable insights to similar upgrading and refining facilities that wish to reduce greenhouse gas emissions through CCUS. The subject report will also draw comparisons with other projects recently studied by IEAGHG, namely the SaskPower Boundary Dam Power Station’s CCS installation that began operation in September 2014 (IEAGHG Report 2015-06) and the Air Products’ Port Arthur Steam Methane Reformer Integrated Carbon Capture and Storage Project (IEAGHG Report 2018-XX) that began operation in January 2013.

In August 2015, Royal Dutch Shell (RDS) began capturing CO₂ at industrial scale from the Scotford Upgrader at an annual rate of 1.2 million tonnes of CO₂e for geological storage in a nearby deep saline aquifer. The upgrader captures 35% of its carbon footprint during the conversion of bitumen into 42,100 cubic metres (265,000 barrels) per day of synthetic crude oil. Bitumen is produced at two oil sands mines located in the Athabasca region near Fort McMurray, Alberta, while the Scotford Upgrader is located just northeast of Edmonton, Alberta. Diluted bitumen produced at the mines is transported via a dedicated 510 km pipeline to the Scotford Upgrader.

The C$1.35 billion Shell Quest CCS Project (see Figure 1) consists of:

- ADIP-X amine absorption carbon capture facility at three upgrader steam methane reformers
- 65 km CO₂ pipeline
- CO₂ injection into the Basal Cambrian Sandstone (BCS) saline aquifer formation (see Figures 2 and 3) near Thorhild which has the following attributes:
  - reservoir thickness: 35-46 metres
  - reservoir depth: 1.8-2.1 kilometres
  - reservoir pressure: 20 MPa
  - three new injection wells with CO₂ injected at 21 MPa (only two currently in operation)
  - monitoring wells deployed with micro-seismic, temperature and pressure monitoring
- Comprehensive MMV activities associated with CO₂ geological storage

Shell Canada’s early thinking about deploying CCUS at its oil sands operations began in 2006, enabling it to quickly respond to a 2008 Government of Alberta announcement for its C$1.24 billion
Carbon Capture and Storage Fund. Quest was one of two projects that successfully secured funds that totaled C$745 million over 15 years. Shell Canada also secured C$120 million from the Government of Canada’s C$795 million Clean Energy Fund for a combined total of C$865 million in government funding. At the time of the project application in 2008, the regulated carbon price in Alberta was C$15 per tonne. That price rose to C$20 in 2017, C$30 in 2018 and is expected to rise to C$50/tonne by 2022. Consequently, by 2025 Shell should have recouped the C$1.35 billion project cost.

In July 2012, the Alberta regulator approved the application for the CO2 transportation and geological storage components of the Shell Quest Project, including exclusive mineral rights at the 3,600 km² Radway Field carbon sequestration leases. The final investment decision was taken by RDS in August 2012. Construction began in Q2 2012 and was completed by the end of Q1 2015.

A risk-based framework for MMV was developed for the 25-year project lifetime. MMV activities to monitor conformance and containment include: downhole micro-seismic, temperature and pressure monitoring; time-lapse seismic surveys; InSAR; remote Multi-Spectral Image Analysis; line-of-sight CO2 flux monitoring (LightSource) above ground level; and soil gas and groundwater surveys.

The first year of operation demonstrated that:

- CO2 capture and storage was 20% more efficient than designed
- operating costs were 30% lower than anticipated
- construction costs were 20-30% lower than originally estimated
- parasitic energy losses associated with the CCUS project amount to 12-15% of CO2e
- sustained average capture ratio of over 80% was achieved
- operational uptime was over 99%
- sustained injection rate of up to 150 tonnes per hour utilizing two of the three purpose-built injection wells, and
- pressure build-up in the reservoir was less than 2 MPa

Although RDS sold most of its Canadian oil sands assets in March 2017, Shell Canada remains the operator of the Scotford Upgrader and the Quest CCS Project with shared ownership by Canadian Natural Resources Limited and Chevron Canada.

The Shell Quest Project is the first example of CCUS deployed in Canada’s oil sands and the global heavy oil industry. Unlike many recent industrial CCUS projects, Quest involves storage of captured industrial emissions in a deep saline aquifer rather than utilization for CO2-enhanced oil recovery (EOR). In 2018, the new Sturgeon bitumen refinery near Edmonton will begin capturing 1.2 million tonnes per year of CO2 for transportation via the Alberta Carbon Trunk Line (ACTL) to regional CO2-EOR operations in the Alberta Basin.

The Shell Quest Project has significant replicability potential at oil sands or heavy oil upgraders and refineries globally that have in recent years come under considerable environmental scrutiny. In Canada alone, more than 265,000 cubic metres (1.67 million barrels) per day of synthetic crude oil is produced from bitumen and heavy oil (BHO). That was only 14.5% of 2010 global conversion capacity. The Quest Project entails 35% carbon capture for approximately 16% of Canada’s total bitumen and heavy oil conversion capacity, making the total Canadian and global BHO upgrading and refining CCUS potential up to 21 and 145 million tonnes CO2e per year, respectively.

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1 The original C$2 billion Alberta Carbon Capture and Storage Fund was decreased due to two projects (Pioneer and Swan Hills) not advancing to the construction stage. Hence funding was cancelled.
RDS has led the way globally by demonstrating the viability of CCS to significantly reduce the carbon footprint of heavy oil conversion. As world demand for oil increases, while conventional reserves become heavier, the technology proven by RDS will be increasingly critical to managing our global climate impact, while continuing to utilize hydrocarbons for transportation and petrochemicals.

Figure 1 - Components of Shell Quest CCS Project

Figure 2 - Stratigraphy of Shell Quest BCS Storage Complex
Figure 3 - Map Indicating Aerial Locations of Injector Wells, Legacy Wells, Screening MMV Surveys, Scotford Upgrader, and CO₂ Pipeline