Quest Carbon Capture and Storage

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Introduction

- Tim Wiwchar, AOSP Portfolio Manager
How did Quest come to be?

In 2000, Shell Canada established an external Climate Change Advisory Panel.

In mid-2000, CCS took on new importance for Royal Dutch Shell.

Quest was already positioned to lead amongst Shell’s various opportunities.
Government Support

- Total Cost of Quest - $1.35 billion, FEED, Capital + 10 years OPEX

- The governments of Alberta and Canada contributed CAN $745M and CAN $120M respectively to Quest, for a total of $865M

- As a result of the funding, Quest is required to have:
  - extensive knowledge sharing
  - stringent reporting and MMV plan
  - net revenue neutral requirement
**Quest Overview**

- **Quest CCS** - fully integrated CCS (capture, transport & storage)
- One million tonnes CO\(_2\) per year capacity for 25 years
- Equiv to emissions from ~250,000 cars
- JV with Shell (60%); Chevron (20%); and Marathon (20%)*
- 35% reduction of Scotford Upgrader CO\(_2\) emissions
- Permanent storage 2 km underground in the Basal Cambrian Sands
Hardware

- 65-km pipeline from the upgrader to 3 injection wells
- CO₂ transported by 12 inch pipeline to storage, with 6 inch laterals
- Route selected to meet stakeholder requirements:
  - 28 km follows existing ROW
  - Drilled under North Saskatchewan River
First Year’s Performance

- Observed a daily average injection rate around 1.2 Mtpa
- Captured first 1 million tonnes in August 2016
- 99% reliability
- Excellent porosity in the storage reservoir
A BETTER LIFE WITH A HEALTHY PLANET. PATHWAYS TO NET-ZERO EMISSIONS

Shell's latest thought piece builds on its 2013 New Lens Scenarios to illustrate choices, challenges and ideas for society to decarbonise the global economy in a way that might address both the challenge of climate change and the desire for broader economic growth.

The Shell Scenarios, Mountains and Oceans, provide a detailed analysis of current trends and their likely trajectory into the future. They dive into the implications for the pace of global economic development, the types of energy we use to power our lives and the growth in greenhouse gas emissions. The two scenarios also highlight areas of public policy likely to have the greatest influence on the development of cleaner fuels, improvements in energy efficiency and on moderating greenhouse gas emissions.

To learn more, visit: www.shell.com/scenarios

MOUNTAINS This is the world with status quo power locked in and held tightly by the currently influential.

OCEANS Influence stretches far and wide in the world of Oceans. Power is devolved, competing interests are accommodated and compromise is king.

The scenarios are based on plausible scenarios and assumptions, and they are designed to avoid over- or under-estimation of their risks and impact. Nevertheless, we are confident in our ability to fine-tune the result. We thank you for your consideration and wish you success in your work in relation to Shell's journey to a sustainable future.
Why CCS?

World demand for energy is growing:

- Population growth and economic development could double energy needs by 2050

- The mix of energy sources will change gradually – fossil fuels will still be a big part of the energy mix
Shell and the CO$_2$ Challenge

- Shell’s role is to meet our customers’ growing need for reliable, affordable energy
- Our response to the CO$_2$ challenge focuses on cost effective solutions available now

- Our priorities are:
  - Natural Gas
  - Biofuels
  - Carbon Capture and Storage
  - Energy Efficiency
Equipment
## Basal Cambrian Sand Storage Complex

<table>
<thead>
<tr>
<th>Layer</th>
<th>Depth</th>
<th>Description</th>
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<tbody>
<tr>
<td>Ultimate Seal</td>
<td>85m</td>
<td>Prairie Evaporite</td>
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<tr>
<td>Winnipegosis Complex</td>
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<td>Winnipegosis</td>
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<tr>
<td>Ultimate Seal</td>
<td>84m</td>
<td>Upper Lotsberg</td>
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<tr>
<td>Secondary Seal</td>
<td>34m</td>
<td>Lower Lotsberg</td>
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<tr>
<td>Primary Seal</td>
<td>44m</td>
<td>MCS – Middle Cambrian Shale</td>
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<tr>
<td></td>
<td></td>
<td>LMS – Lower Marine Sand</td>
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<tr>
<td>Injection Target</td>
<td>41m</td>
<td>BCS – Basal Cambrian Sand</td>
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<tr>
<td></td>
<td></td>
<td>PreCambrian Basement</td>
</tr>
</tbody>
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![Diagram of Basal Cambrian Sand Storage Complex](image)
Storage Lease Area

Sequestration Lease area = 3670 km$^2$
### Quest MMV Plan

**Atmosphere**
- LightSource Laser CO2 Monitoring
- Eddy Covariance Flux Monitoring

**Biosphere**
- CO2 Natural Tracer Monitoring
- CO2 Flux and Soil Gas
- Remote Sensing (Brine & NDVI)

**Hydrosphere**
- Shell Groundwater Wells: Continuous EC, pH
- Discrete Chemical and Isotopic Analysis on water and gas
- Private Landowner Groundwater Wells (discrete chemistry and Isotopes on water and gas)

**Geosphere**
- Time-Lapse Walkaway VSP Surveys
- Time-Lapse 3D Surface Seismic
- InSAR
- Downhole Pressure & Temperature (DHPT) above Storage Complex (CKLK Fm)
- Downhole Microseismic Monitoring

**Deep Monitoring Wells**
- Injection Rate Metering, RST Logging, Temperature logging

**Injection Wells**
- DHPT, Well Head PT, Distributed Temperature and Acoustic Sensing, Annulus Pressure Monitoring, Wellhead CO2 Sensor, Mechanical Well Integrity Testing, Operational Integrity Assurance

**Time (years)**

- **Baseline**
  - 2010
- **Injection**
  - 2015
  - 2020
  - 2025
  - 2030
  - 2035
  - 2040
  - 2045
  - 2050
- **Closure**
  - CBL, USIT
**Quest Stakeholder Engagement**

- Engaged Pembina Institute to help develop stakeholder engagement plan

- Stakeholder engagement program initiated Jan 2010
  - 20 open houses from 2010 through 2015
  - 2 Quest Café’s in 2011
  - 3 Community coffee sessions in 2014
  - Bi-annual municipal council updates
  - Community Advisory Panel (CAP) started in 2012
**Quest Costs**

**Project Capital Costs – Reported in 2015 Annual Report**
- Capture – $623 mln CAD
- Transportation – $127 mln CAD
- Storage – $40 mln CAD
Total Capital Cost: $790 mln CAD

**Expected Operating Costs - 2015 Annual Report**
- Average $42 mln CAD / year (incl. TA, Sustaining Capital)
- 2016 costs trending significantly lower

**Potential savings for future projects**
- Reduced venture costs
- Reduced capture costs
- Reduced pipeline/subsurface costs

**Forecasted Cost/Tonne (incl Feasex)**
- A. Capture - CAPEX
- B. Transportation - CAPEX
- C. Storage - CAPEX

**Potential savings for future projects**

20-30% reduction possible
Cost and Revenues

Project Costs
- Capital - $791M million (excl. Feasex)
- Operating - $23 million in first year (No sustaining capital or TA)

Funding Status
- $6.7 million - Alberta Innovates
- $120 million - NRCan Clean Energy Fund
- $447 million - GoA Agreement (Milestones #1 – 7 and Commercial Operation)
- Total funding to date – $573.7 million

Remaining Funding
- $298 million – GoA Agreement based on net tonnes of CO2 sequestered / year over 10 years

Revenues
CCS Installations Currently Operating

There are currently 15 large-scale CCS project operating globally with another 6 under construction.

Source: Global CCS Institute
Climate Change Challenge

Case Study: Desert Sunlight Solar Farm
- Opened in 2015
- Displaces 300,000 tonnes CO₂ per year
- Size: Covers equivalent of 32 WEM (16 km²)
- Cost: $2 billion USD, aided by $1.46 billion government loan

Case Study: Quest CCS
- Opened in 2015
- Displaces 1,00,000 tonnes CO₂ per year
- Size: Covers equivalent of Wal-Mart parking lot
- Cost: $1.35 billion (incl. 10 years operation) aided with governments grants of $865M