The Alberta Carbon Trunk Line – CCUS Project
CO$_2$ EOR Growth in Alberta

Tim Benko, P. Eng.
Project Manager, ACTL
Enhance Energy

Presented at the
20$^{th}$ Annual CO$_2$ Flooding Conference

December 11-12, 2014
Midland, Texas
Certain information set forth in this document contains forward-looking statements including management's assessment of future plans and operations, expected activity levels, timing of completion of facilities construction and the effects thereof, capital expenditure plans and the impact thereof. By their nature, forward looking statements are subject to numerous risks and uncertainties, some of which are beyond the company’s control, including the impact of general economic conditions, industry conditions, volatility of commodity prices, changes to regulatory requirements, risks associated with oil and gas exploration, development, exploitation, production, marketing and transportation, loss of markets, delays resulting from or the inability to obtain required regulatory approvals, environmental risks, competition from other industry participants, the lack of availability of qualified personnel or management and ability to access sufficient capital from internal and external sources. The foregoing list is not exhaustive. Additional information on these and other risks that could affect operations and financial results are available on request.

Readers are cautioned that the assumptions used in the preparation of such information, although considered reasonable at the time of preparation, may prove to be imprecise and, as such, undue reliance should not be placed on forward-looking statements. The actual results, performance or achievements of the company could differ materially from those expressed in, or implied by, these forward-looking statements and, accordingly, no assurance can be given that any of the events anticipated by the forward looking statements will transpire or occur, or if any of them do so, what benefits the company will receive. The company disclaims any intention or obligation to update or revise any forward-looking statements, whether as a result of new information, future events or otherwise.
Agenda

• Existing state of CO$_2$ EOR in Alberta
• What is Enhance Energy Inc?
• ACTL Project update
• Challenges to developing CO$_2$ EOR business in Alberta
• Benefits of CO$_2$ EOR (CCUS) in Alberta and Canada
• Future opportunities to encourage more CCUS in Alberta
Existing State of CO₂ EOR in Alberta

No natural CO₂ supplies exist in Alberta

- Presently one commercial flood under operation (~ 15mmcf/d)
- Several CO₂ pilots have been conducted over past 20+ years

Constraint to CO₂ EOR has been affordable CO₂ supply

- Majority of CO₂ emissions are contain large amounts of impurities
  - Costly to capture and clean or,
  - Located significant distances from top tier EOR pools or,
  - Volumes not large enough for economic EOR development
What is Enhance Energy?

- **CO₂ Supply**
  - 20 yr+ contracts
  - Two separate suppliers
  - One existing, one under construction

- **EOR Reservoirs**
  - >30 MM BBL Upside at Clive
  - 5 B BBL OOIP within ACTL reach

- **Government Funding**
  - $275MM in capital support
  - $150/MM in operating support
  - $0.76/mcf CO₂ sequestration credit

- **Alberta Carbon Trunk Line**
  - Capture and Compression
  - 240 KM, 16” Line
  - 800 mmcf/d CO₂ capacity
  - Initial deliveries 120 mmcf/d
The Alberta Carbon Trunk Line (ACTL) CCUS project supported by the Alberta and Canadian governments

- Ultimate pipeline capacity 800 mmscf/d a year of CO₂
- Able to unlock >1 Billion barrels of light oil
- Storage of 2-3 Billion tonnes CO₂
The Alberta Carbon Trunk Line (ACTL)

**Fully Integrated CCUS Project**

- CO₂ capture from two sources
  - Agrium Redwater Fertilizer Plant
  - NWR Bitumen Refinery
- CO₂ Transport
  - via ACTL Pipeline
- CO₂ EOR and Sequestration
  - Anchor field at Clive unit (central Alberta)
  - Leduc and Nisku geological formations
North Dakota to Weyburn: 300km
Initial injection rate: ~ 100 mmscfd
Source: Gasification facility

Weyburn is currently the largest Carbon Capture Utilization and Storage (CCUS) project in the world

Redwater to Clive: 240km
Initial injection: ~ 100 mmscfd
Source: Gasification Facility and Chemical Facility

ACTL capacity – up to 800 mmscfd
ACTL Overview

Capture

- Agrium Fertilizer ~ 32 mmscfd CO₂
- North West Redwater ~ 70 mmscfd CO₂

Transportation

- 12” and 16”, 240 km pipeline system
- Designed for 800 mmscfd CO₂

Storage

- Mature oil fields at Clive

Initial Injection is set for Q4 2016
ACTL Overview

Overall ACTL Project Schematic

Capture / Compression
AGRIUM CO₂ RECOVERY FACILITY ("AGRIUM CRF")
- Wet CO₂
- inlet condenser
- inlet separator
- six stage compressor package
- dehydration package
- refrigeration package
- CO₂ pump

Capture Ready
AGRIUM FERTILIZER PLANT

Transportation
TRANSPORTATION (Enhance Energy)

Storage
STORAGE (Enhance Energy)

NWR CO₂ RECOVERY FACILITY ("NWR CRF")
- Dry CO₂
- booster compression*
- main compression

Clive CO₂ Injection
CLIVE CO₂ INJECTION (storage site)

* Located on NWR Rectisol Site

(pipeline)

NOT TO SCALE
CAPTURE
Agrium & North West Redwater Partnership
CO₂ Recovery Facilities (CRF)
Capture Facility Locations – Alberta Industrial Heartland

[Image of a map with a red dotted line indicating the capture facility area. The image includes labels such as Agrium and Gasifier CO₂ source.]
Capture Facility Locations – Alberta Industrial Heartland
Agrium is a major retail supplier of agricultural products and a leading global producer and marketer of agricultural nutrients and industrial products

- $15 Billion Agricultural products company
- The largest global agricultural retailer, with approximately 1,250 facilities
- The Agrium Redwater Facility is the largest fertilizer complex in North America
  - CO₂ production is in excess to the facility’s operational needs
Agrium CO$_2$

Agrium CO$_2$ Recovery Facility (CRF)

- 32 mmscfd of wet, low pressure, high purity CO$_2$
- CRF located on perimeter of Agrium site
- Modular package design to minimize onsite construction
- Detailed engineering complete
- All of the major mechanical equipment has been procured
- On-site tie-in to Agrium plant completed
- Tie into second plant stream scheduled for March 2015
Agrium CO$_2$ Recovery Facility
Agrium CRF - Compressor
Agrium CRF - Equipment
North West Redwater Partnership Sturgeon Refinery

World’s first refinery with an integrated carbon management solution

- Processing 50,000 barrels per day of bitumen in first of three phases
- Producing refined products such as ultra low sulphur diesel with lowest carbon footprint in the world
- Using Lurgi gasifier technology to produce hydrogen and pure (99%+) dry CO₂ from bitumen bottoms (with no coke by-product)
- NWR Sturgeon Refinery has regulatory approval for three phases
NWR Sturgeon Refinery CO₂

- Dry, low pressure, low temperature
- High purity, no contaminants
- Process more straightforward than Agrium design
- Only requires compression and cooling, no dehydration, refrigeration or pumping required
- CO₂ compression system designed for 70-86 mmscfd
- 3 stage booster compressor in manufacturing

3 stage booster at NWR Rectisol unit
17,000 HP (190 psi, 100°F)

24 inch line to NW corner of NWR plant
~ 1200 m

36 inch line to Enhance CRF
~ 4000 m

5 stage compressor at Enhance CRF
13,000 HP (2600 psi)
NWR CO$_2$ Booster Compression Facility
Transportation
ACTL Pipeline
ACTL Pipeline

- Right of Way purchased (~400 landowners)
- Phase One of the Right of Way Clearing completed in the first calendar quarter of 2013
- Received approval to construct from AER (Alberta Energy Regulator)
- Received approval for Conservation and Reclamation Plan from Alberta Environment
- Received construction proposals - clarification and review process underway
- Pipeline valves procured and in storage
- Pipe for major HDD across North Saskatchewan River procured
ACTL Pipeline Specifications

- CO₂ transported in dense phase at 2,600 psig (17,900 kPag) maximum operating pressure
- 150 miles (240 km) of 16” pipe
- Buried to minimum depth of 4’ (1.2 m)
- Valve stations every 15 km – ability to receive or deliver CO₂ at valve stations
- 17 directional drills
- Destructive testing of line pipe specification using CO₂ completed in 2012 at Stress Engineering, Houston.
  - Pipe designed to withstand longitudinal ductile fracture – no crack arrestors required
ACTL Pipe  (transition pieces between valving and mainline)
EOR & Storage

Clive Field
Reservoir Characteristics

- Nisku and Leduc Devonian reef formations
- Depth ~1,900m (6,200’)
- Current reservoir pressure ~13,000 kPag (1,885 psig)
- Temperature ~69°C (156°F)
Reservoir Characteristics

**Enhance Anchor Project**

Clive Reservoir CO\textsubscript{2} EOR

- Anchor project provides substantial incremental reserves of >30 million barrels and peak production of 8,000 bopd

Technical work completed to mitigate risk:

- Full geological model, black oil simulation, coreflood testing, miscibility testing
- Analogue reservoirs support forecast response and recovery
- Third party opinions support reservoir response
  - GLJ
  - Avasthi and Associates
  - Epic (Baker Hughes)
Secure Storage

MMV Plan under development

- Alberta Innovates-Technology Futures (AITF) working with EEI to develop.
- Following activities completed:
  - geological, hydrogeological and geomechanical characterization
  - rock mineralogy and fluid composition of the sedimentary succession and saline aquifers
  - site characterization strategy and risk assessment
  - baseline data acquisition program being finalized
ACTL Project Summary

Project on track for commercial operation Q4 2016

Plans for 2015:

• Completer detailed engineering at Clive EOR site and NWR off site compression
• Continued procurement and contracting for construction
• Public consultation for the EOR at Clive to be initiated as an extension to the consultation from the ACTL Project
• Initiate construction of ACTL components – pipeline, Agrium CRF, NWR CRF
• Drill initial injection wells
Challenges to CO$_2$ EOR growth in Alberta

- CO$_2$ supply
  - EOR purity sources very limited
  - Alberta Industrial Heartland targeted due to highest availability of pure CO$_2$
  - Post combustion clean up processes still not commercial
  - Additional source timelines have been pushed out beyond 2020

- Enhance has 20+ year contracts for 100 MMSCFD supply
  - NWR timing key to ACTL development

- Infrastructure to move CO$_2$
  - ACTL will provide a step change in enabling EOR in Central and Southern Alberta
    - Backbone for future EOR development
  - Infrastructure is required for Northern Alberta ~ 2.5 times the distance to sources in Fort McMurray area
ACTL – Enabler Towards Large Scale CCUS

Potential Industrial CO₂ Sources

Potential CCUS Sites

ACTL Phase
One

Potential ACTL Growth
Producing Lower Carbon Footprint Oil

Incremental production

1++ Billion barrels of oil
Benefits of the ACTL

- Government support for initial CCUS projects help kick start the industry in Alberta
- Government investment will help us build infrastructure for future projects
- EOR royalties will return more than 10X the CCS investment
- Additional benefits of long term jobs, taxes and technology improvements

Royalties $19 Billion

Increased Jobs
Alberta Specified Gas Emitter Regulation

• Alberta currently has a carbon reduction and credit system
  • Regulates all facilities emitting over 50,000 tonnes/year of CO₂, and specifies reduction targets for all those emitting over 100,000 tonnes/day
  • A $15/tonne carbon payment is imposed if reduction targets are not met. This payment goes to the Climate Change and Emissions Management Corporation (CCEMC)
    • Supports clean technology and CO₂ reduction projects
  • Protocols exist that offer credits to facilities who actively reduce greenhouse gas emissions

• The government of Alberta is working to encourage more EOR CCUS in the province. This is being done by enhancing the regulatory system, supporting climate change policies and enhancing royalty programs
What do we need to do next?

Capture More CO$_2$
Continued Improvement

- Incentives or regulations for new facilities to produce and store pure CO$_2$
  - Incorporate Best Available Technology Economically Achievable (BATEA) into review of all new facility applications

- Make “Capture Ready” real not just space

- Incentives for coal-fired and natural gas power CCUS in Alberta
  - Capture cost is still a challenge for coal CCUS
The Alberta Carbon Trunk Line

Enhance Energy Inc.
www.enhanceenergy.com