CO$_2$ Recovery and Sequestration at Dakota Gasification Company

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30% Total Reduction in CO$_2$ Emissions Since 1999!

HOW?
A Look at the Past

- Plant origin: ‘70s energy shortages
- $2.1 billion cost
- First SNG produced in July 1984
- DGC began operating facility in 1988 as a subsidiary of Basin Electric Power Cooperative
Synfuels Plant Today

- **Work Force**: more than 700 people
- **Daily Production Capacity**: 170 mmscfd SNG, along with many by-products
- **Annual Plant Loading Factor**: 90-92%
Ammonia
1150 tpd

Ammonium Sulfate
575 tpd

Phenol
33 million lb/yr

Cresylic Acid
33 million lb/yr
Carbon Dioxide - 95 mmscfd

Used in enhanced oil recovery
**14 Lurgi Mark IV Gasifiers**

**Typical Lignite Analysis**
- 37% Moisture
- 6% Ash
- 27% Volatile Matter
- 30% Fixed Carbon
- 7000 BTU/lb

**Typical Raw Gas Analysis**
- 39% Hydrogen
- 32% CO₂
- 15% CO
- 12% Methane
- 0.8% C₂+
- 0.7% H₂S
- 315 BTU/scf (HHV)
Great Plains Synfuels Plant
Process Flow

COAL
- LOCK GAS TO BOILER
- COAL DUMPERS
- LOCK

GASIFIER
- OXYGEN PLANT
- BOILER STEAM
- OXYGEN
- LIQUID NITROGEN
- KRYPTON/XENON

LOCK GAS TO BOILER
- COAL LOCK

RAW GAS
- CARBONIZED ZONE
- CARBONIZATION ZONE
- COMBUSTION ZONE

OXYGEN PLANT
- NITROGEN

COAL DUMPERS
- LOCK

LOCK

GASIFIER
- DRYING ZONE
- CARBONIZED ZONE
- CARBONATION ZONE
- COMBUSTION ZONE

OXYGEN
- BOILER STEAM
- LIQUID NITROGEN
- KRYPTON/XENON

WASTE GAS
- HEAT EXCHANGER
- GAS COOLING
- SHIFT CONVERSION
- RECTISOL UNIT
- WASTE GAS

CONDENSATION
- PROCESS WATER
- FEED WATER

CO2 COMPRESSION
- TO
- AMMONIA PLANT
- METHANATION
- HIGH PRESSURE
- STEAM TO PLANT
- STEAM SYSTEM
- PRODUCT GAS
- COMRESSOR TO PIPELINE
- CO2 PRODUCT TO PIPELINE

RAW GAS LIQUOR
- TAR OIL
- BOILER LIQUOR

RAW GASES
- NAPHTHA
- FGD SCRUBBER
- CONDENSED PROCESS
- WASTE GAS
- WATER TREATMENT

AMMONIA
- AMMONIUM SULFATE
- PHENOL
- CRESYLIC ACID

STORAGE
- WATER TO COOLING TOWER

CO2 WASTE GAS
- BYPRODUCT PURIFICATION
- WATER TO COOLING TOWER

KRYPTON/XENON LIQUID
Ammonia Plant (foreground)
Ammonium Sulfate Plant (background)
The Story of the CO$_2$ Project

- The sale of CO$_2$ from the Synfuels Plant for tertiary or enhanced oil recovery (EOR) had always been technically possible.
Why does DGC’s CO₂ have an advantage over other sources for EOR?

- Natural sources are often far from the oil fields that could use it.
- Flue gas contains water vapor and nitrogen.
- DGC Product CO₂:
  - -100º F Dew Point
  - 96.8% Carbon Dioxide
  - 1.1% Hydrogen Sulfide
  - 1.0% Ethane
  - 0.3% Methane
  - 0.8% Other
The Story of the CO₂ Project

• The sale of CO₂ from the Synfuels Plant for tertiary or enhanced oil recovery (EOR) had always been technically possible.

• Financial & contractual stumbling blocks.

• July 1997 - DGC & PanCanadian (now EnCana Corporation) signed a contract for 95 MMSCFD of CO₂.
Permissions Were a Challenge

- Landowners
  - 246 in ND
  - 65 in Canada
- International Boundary Commission
- ND Public Service Commission
- ND Water Commission
- ND Historical Society
- US Army Corps of Engineers
- US Dept. Of Interior BLM
- US Dept of Agriculture Forest Service
- Canadian NEB and other country/municipality agencies
Pipeline Safety

- Regulated by US DOT & Canadian NEB as a hazardous liquid
- Leak detection system (LDS) software
- Worst-case scenario modeling
- Reverse 911
- Public meetings for landowners, residence, and local emergency response personnel
- Pigging requirements
CO$_2$ Pipeline Crossing at Lake Sakakawea
The CO$_2$ Pipeline:

- 205 miles
- 14” and 12” carbon steel pipe
- MAOP 2700 psig & 2964 psig
- Strategically routed through Williston Basin oil fields
$CO_2$ Compressors

- Manufactured by GHH BORSIG (now MAN Turbomaschinen AG).
- 8-Stage Centrifugal.
- Serial Numbers 1 & 2.
CO$_2$ Compressors

- Two 19,500 hp compressors
- 55 million scf per day each
- 2700 psig discharge pressure
Integral Bull Gear

- Single bull gear drives 4 pinions.
- Each pinion drives 2 compression stages.
- 4th pinion operates at 26,400 rpm.
EnCana Corporation
Weyburn Unit

- (Can)$1.3 billion investment in CO₂ project
- Distribution & injection equipment
- Separation & recovery facilities
- Recycle compressors
C02 injection oil recovery

TO SEPARATOR

CO2/WATER INJECTION

ADDITIONAL OIL RECOVERY

OIL BANK

MISCIBLE ZONE

CO2

WATER

CO2

DRIVE WATER
Weyburn CO₂ Project-Forecast

Weyburn Unit Oil Production

- Original Verticals
- Infill Verticals
- Hz Infill
- CO₂

Date

BOPD (Gross)

- Actual
- Forecast
Weyburn Oil Production
CO₂ Flooded Fields

- Actual Oil
- WF Decline

CO₂ Injection Begins
Oct. 2000

7000 bopd Incremental oil
Financial Impact

• EnCana
  ➢ $1.3 billion (Canadian) project investment
  ➢ 130 to 140 million bbl additional oil

• DGC/Synfuels Plant
  ➢ $100 million initial investment
  ➢ $15-18 million annual net revenue
Sequestration: “The act of setting apart for safekeeping”

• “Terrestrial” carbon sequestration is the natural storage of carbon in plants and soil.

• “Geological” carbon sequestration is the storage of CO$_2$ in underground geological formations.
  – Sleipner Project off the coast of Norway (CO$_2$ injection into a deep saline reservoir under the North Sea).
  – Tertiary oil recovery using CO$_2$ (such as the EnCana/DGC project).
CO$_2$ Sequestration Credits

- DOE Form EIA-1605: Voluntary Reporting of Greenhouse Gases.
- 3$^{rd}$ party verification of calculations by consultant.
-Filed annually.
- No monetary benefit at this time.
Sequestration Credits

Data Management System

- Credit - CO$_2$ sales.
- Debit - Electrical Power for Compressors at DGC and EnCana.
- Debit - Replacement fuel CO$_2$ content.
- Debit - EnCana flaring.
- Net sequestration credit = 1,133,000 metric tons for 2003 (73% of CO$_2$ sales volume)
$CO_2$ Emissions Reduction at the Synfuels Plant

30% reduction in $CO_2$ emissions

2000 2003

= 100,000 cars per day
**CO$_2$ Future Expansion**

- **Current sales = 95 mmscfd**
- **Potential sales = 200 mmscfd**
  - Would require up to 2 additional compressors at DGC and a booster pump at pipeline midpoint.
  - Taps installed at strategic locations along the pipeline.
Summary

• The DGC/EnCana project uses an industrial source of CO$_2$ that would otherwise be emitted to the atmosphere.

• Naturally occurring CO$_2$ for EOR results in no net reduction in CO$_2$ emissions.

• 2,725,500 metric tons of CO$_2$ sequestered through the end of 2003.