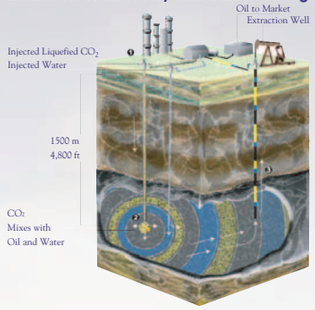
The World's Largest CO_2 Storage Research Project with EOR

Introduction: IEA GHG Weyburn-Midale CO_2 Monitoring & Storage Project

- An 8-year, $80 million project on carbon storage funded by partners around the world
- Investigates potential for storage of man-made CO_2 in the enhanced oil recovery (EOR) process, from technical and regulatory perspectives
- The world's largest, full-scale, in-field Measurement Monitoring and Verification study with EOR
- First phase led by the Petroleum Technology Research Centre (PTRC), which currently leads the technical component of the final phase
- Industry and government sponsors provide input and guidance through the leading sponsors executive committee (LSEC) and technical steering committee (TSC)

Enhanced Oil Recovery with Carbon Storage



1) CO_2 is injected, along with water, deep underground (1,500 metres at the Weyburn field) into a partially depleted oil field. The CO_2 used at Weyburn and Midale comes from the Dakota Gasification Plant in Beulah, North Dakota. There, the gas is captured after coal gasification (rather than vented to the atmosphere), liquefied by compression and pipelined 320 km north to the oil fields. It is the first man-made source of CO_2 being used for enhanced oil recovery.

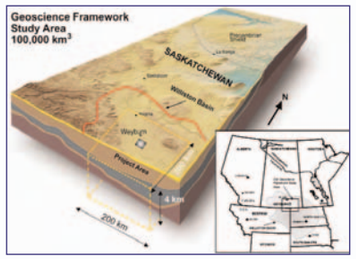
2) In an operating strategy that alternates gas and water injection, CO_2 injection increases reservoir pressure and oil fluidity, enabling oil to escape from rock pores and flow more readily toward production wells.

3) Much of the injected CO_2 is pumped to the surface together with oil and water, then separated and re-injected. At the end of the enhanced oil recovery period, virtually all injected and recycled CO_2 is permanently stored.

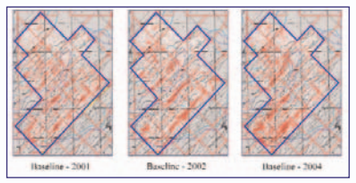
What's the significance of the IEA GHG Weyburn-Midale CO_2 Storage Project?

When it was launched, the project set international benchmarks for three reasons:

1. It took advantage of existing carbon capture technology and studied the feasibility of using man-made CO_2 for EOR, reducing the natural resources required for oil recovery
2. It was the first and largest in-field research project to assess whether man-made CO_2 - diverted from entering our atmosphere - could be geologically contained underground, long term, in depleted oil fields.
3. It was the first major international collaborative project on CO_2 geological storage in association with enhanced oil recovery. The project integrated government, industry and researchers, nationally and internationally, to collectively fund research and share results.



Extensive historical field and well datasets make EnCana's Weyburn field and Apache's Midale field, located in southeast Saskatchewan, Canada, ideal natural laboratories for CO_2 geological storage research.



Seismic surveys were one of the many techniques used to track CO_2 movement. In this field, there is a natural flow trend for the CO_2, or natural permeability, that runs Northeast and Southwest. The red areas on the graph demonstrate qualitatively where CO_2 is in the reservoir.

About the IEA GHG Weyburn-Midale CO_2 Monitoring & Storage Project

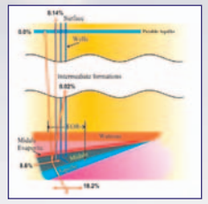
IEA GHG Weyburn-Midale CO_2 Monitoring & Storage Project: First Phase

The first phase began in 2000 and ended in 2004. The purpose of the first phase was to predict and verify the ability of an oil reservoir to securely and economically store and contain CO_2.

The storage feasibility was investigated through a comprehensive analysis of the many process factors that are involved in storage. The fields were monitored, and results were modeled and extrapolated into the future in order to measure, monitor and track the CO_2 in the EOR environment and predict trends for the future.

Summary of Key Findings from First Phase

- Based on preliminary results, the natural geological setting appears to be highly suitable for long-term CO_2 geological storage. Specifically the primary carbonate caprock and the secondary shale strata serve as effective seals to prevent upward migration of CO_2.
- There is hydraulic separation between aquifers lying above and below the oil reservoir, strongly suggesting CO_2 won't migrate to adjacent aquifers.
- Further technical research is required, particularly in risk assessment, well-bore integrity, and geochemical modeling, to improve the CO_2 monitoring and verification technologies developed in the project.

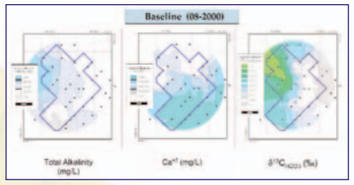


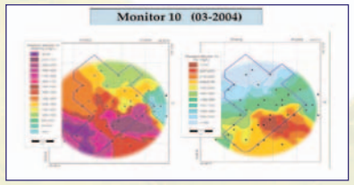
A simplistic deterministic risk assessment (RA) of the study region was conducted in the Phase 1 to predict the performance of long-term storage 5000 years beyond the end of EOR operations. The results of the RA work showed that a tiny portion of the CO_2 made its way to the surface (0.1%). Over 99% of the CO_2 migration was confined within the 10 km X 10 km study region at or below the reservoir level, with 26.8% migrating beyond the EOR operating area.

Phase 1 of the project has produced arguably the most complete, comprehensive, peer-reviewed data set in the world for CO_2 geological storage in association with EOR.

In the field, the 320 km pipeline was constructed with "tap points" for future delivery of CO_2 to other oil fields. EnCana and Apache are fully utilizing the current available supply.

- CO_2 purity 95% (less than 2% H2S) ; trace mercaptans
- Apache began injection at Midale in September 2005, injecting 5-10 mmscfd; by Q3 2006 injection was 25 mmscfd or 1350 tonnes/day to recover an additional 45-60 million barrels over project life.



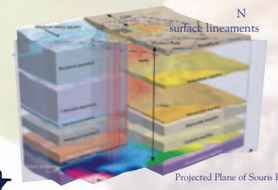


Fluid Monitoring Surveys were used to track CO_2 fluid chemistry.

Competing Reactions:

$CO_2 + H_2O \leftrightarrow H^{++} HCO_3^-$
$CO_2 + Ca_2^{++} H_2O \leftrightarrow 2H^{++} CaCO_3$
$CO_2 + H_2O + CaCO_3 \leftrightarrow Ca_2^{++} 2HCO_3^-$

Changing fluid chemistry was monitored to track CO_2 movement in the reservoir and evaluate mechanisms for permanently trapping CO_2.



A 3D geological model has been constructed from ~1000 wells for an area extending 10 km beyond the limits of the Weyburn field CO_2 injection area.

I E A G H G
Weyburn-Midale CO_2 Monitoring and Storage Project

"The continued success of this Project will have incredible implications for reducing CO_2 emissions throughout the world."

John Gale, Chairman
International Energy Agency

"The Weyburn-Midale Project will provide policymakers, the energy industry, and the general public with reliable information about industrial carbon sequestration and enhanced oil recovery."

Samuel Bodman, Secretary of Energy
United States of America

About the PTRC

The mission of the PTRC is to improve the efficiency and effectiveness of oil recovery in Canada by developing better processes and technologies for production. More efficient technologies mean reduced CO_2 emissions, and reduced strain on the environment during oil production.

The PTRC is a not-for-profit corporation that initiates, provides funding for and manages research projects concerning oil production technology. We are an independent connection to a breadth of information; industry and government's arm's length, one-stop-shop for a variety of leading research results on efficient oil production technologies. The research projects we manage are conducted by a number of research organizations from Canada and around the world.

We were founded in 1998 by: Saskatchewan Industry & Resources, Natural Resources Canada, The University of Regina, and Saskatchewan Research Council. We are funded by Canadian and international governments and industry. Associated research organizations also provide in-kind support.

IEA GHG Weyburn-Midale CO_2 Monitoring & Storage Project: Final Phase

Building on the positive results received from the first phase, the objective of the Final Phase is to encourage the widespread use of technologies required to design, implement, monitor and verify a significant number of CO_2 geological storage projects throughout the world. Through both a technical component, led by the PTRC, and a public policy and community outreach component, managed by the Leading Sponsors, including Natural Resources Canada and the US Department of Energy-NETL, the second phase will further carbon storage in Canada by:

- Building a Best Practices Manual (BPM) as a practical, technical guide for design and implementation for CO_2 storage associated with EOR
- Influencing the development of clear, workable regulations for CO_2 storage, building upon an existing, effective regulatory framework
- Influencing the development of an effective public consultation process
- Influencing the development of an effective business environment

Final Phase: Technical Research Component

Managed by the PTRC

Geological Integrity (Site Selection)
Steve Whittaker (CCEC), Ben Rostron (U of A)
- develop firm protocols for site selection
- minimum data set required for successful site selection and full RA
- integrate hydrogeological, geophysical, geological data sets vis à vis seal integrity
- impact of CO_2 on geochemical and geomechanical processes and regional seals/geology

Wellbore Integrity
Chris Hawkes (U of S), Craig Gardiner (Chevron)
- essential parameters to define well-bore integrity
- potential remediation strategies
- impact of current well abandonment practices on long-term CO_2 storage and proposed future abandonment requirements
- conduct cased-hole dynamic testing (pressures and mobile fluids that signal CO_2 migration out of zone)
- document safe practices and impact on wellbore integrity and geomechanics

Storage Monitoring Methods (Geophysics, Geochemistry)
Don White (GSC), Jim Johnson (LLNL)
- quantitative prediction of CO_2 location and volume
- are multi-year 4D seismic programs an appropriate monitoring and verification requirement?
- in-situ, time-lapse well logging to verify and quantify results from seismic and other monitoring approaches
- continue to explore passive seismic monitoring
- verify predictions using spinner surveys, selective drilling, coring and logging of vertical slim holes: to determine CO_2 distribution

Risk Assessment; Storage and Trapping Mechanisms, Remediation Measures, Environment, Health and Safety
Rick Chalaturnyk (U of A)
- full-field risk assessment from Phase 1 completed
- risk levels for various operating scenarios
- ultimate fate of CO_2, relative volumes in each trapping mechanism, time lapse to trapping, and factors affecting these
- study natural analogues with respect to leakage and storage integrity
- determine methods for stimulating/accelerating CO_2 mineral fixation at reservoir conditions

Final Phase: Policy Research Component

Public Communications and Outreach: Achieving Acceptance and Permission
- Work with stakeholders to assure better public awareness of CO_2 geological storage, especially on the issue of safety
- Communicate technical findings of the project to non-technical audiences and illustrate carbon capture and storage as a GHG mitigation option, with comparisons to other options
- Based on feedback, give guidance to technical and policy research components for further work and update Best Practices Manual

Regulatory Issues: Clear, Workable and Science-based Regulations for CO_2 Geological Storage

Provide advice to regulators and policymakers to assure that appropriate regulations for CO_2 storage exist, including:

1. conduct regulatory gap assessments using existing provincial regulations for oil and gas production and international protocols for gas-credit accounting
2. review drilling and well completion standards with CO_2 injection and storage in mind
3. develop metrics to benchmark performance
4. evaluate existing emergency planning and protection protocols

Based on identified gaps and feedback, give guidance to technical and policy research components for further work and update Best Practices Manual.

Fiscal Policy Requirements: Drivers and Incentives for Building a CO_2 Geological Storage Industry

- Work with stakeholders to build a coherent description of the key fiscal issues facing EOR-based CO_2 storage
- Determine CO_2 pricing/credits required to make sources, sinks and infrastructure economic
- Build an acceptable business economic model to be used to frame discussion on drivers and incentives for a CO_2 storage industry
- Provide advice to policymakers and regulators to monetize gas credits

The Facts about the IEA GHG Weyburn-Midale CO_2 Monitoring & Storage Project

The Project is Recognized and Endorsed By:

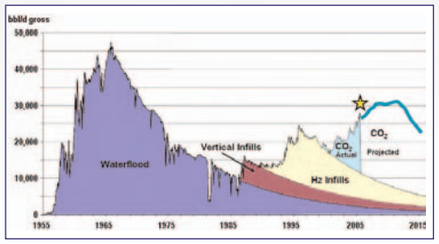
- The International Energy Agency Greenhouse Gas R&D Programme (ensuring technical excellence)
- The Carbon Sequestration Leadership Forum (ensuring sound policy and regulation development)

The Source of CO_2

CO_2 is captured from the Dakota Gasification Plant in Beulah, North Dakota and transported at approximately 2200 psi to Weyburn-Midale through a 320 km pipeline.

World's Largest Natural Laboratory for Environmental and Economic Success

The Weyburn-Midale CO_2 Project is operated in conjunction with two billion-dollar commercial CO_2 floods in Saskatchewan, Canada, where huge volumes of the gas are injected to revive oil production. These operations make PTRC's technical research project the world's largest, full-scale, in-field Measurement Monitoring and Verification study with EOR.



Weyburn Field Statistics

- Field size: 70 square miles
- Original oil in place: 1.4 billion barrels
- Oil recovery (pre-CO_2-EOR): 370 million barrels
- Projected CO_2 Incremental Oil Recovery: 155 million barrels
- 18,000 incremental barrels of oil per day (bopd)
- 30,000 bopd total unit production
- **More than 7 million tonnes of CO_2 have been injected and stored to-date**
- **Projected CO_2 stored: 30+ million tonnes (gross)*, or 26+ million tonnes (net)****
  ***That's equivalent to removing more than 6 million cars off the road for a year**
  ***net tonnes of CO_2 stored takes into account the emissions from oil production operations*

Midale Field Statistics

- Field size: 40 square miles
- Original oil in place: 515 million barrels
- Oil recovery (pre-CO_2-EOR): 130 million barrels
- Projected CO_2 Incremental Oil Recovery: up to 60 million barrels
- **Projected CO_2 stored: 10+ million tonnes (gross)*, or 8.5+ million tonnes (net)****
  ***Equivalent to removing more than 2 million cars off the road for a year**
  ***net tonnes of CO_2 stored takes into account the emissions from oil production operations*

Potential for Canadian oil fields

- 3.8 billion incremental barrels of oil potential in western Canada using CO_2 injection technology
- The worldwide potential: huge

Profit Boosting Technology

The Weyburn-Midale CO_2 Project is applying a rigorous scientific approach to the injection and storage of CO_2 from industrial sources - a technique that's proving to be good for both the environment and the bottom line.

With huge environmental benefits and economic incentives for corporate implementation, this project has the potential to provide a real and imminent tactic to reduce greenhouse gas emissions around the world.