

# PROGRAM facts

## Carbon Sequestration

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U.S. DEPARTMENT OF ENERGY  
OFFICE OF FOSSIL ENERGY  
NATIONAL ENERGY TECHNOLOGY LABORATORY



## COMMERCIAL-SCALE TESTS DEMONSTRATE SECURE CO<sub>2</sub> STORAGE IN UNDERGROUND FORMATIONS

Two industry-led commercial-scale projects, the Sleipner Project off the coast of Norway and the Weyburn Project in Ontario, Canada, have enhanced the option of sequestering carbon dioxide (CO<sub>2</sub>) in underground geologic formations. The United States Department of Energy (DOE) collaborated in both projects, primarily by providing rigorous monitoring of the injected CO<sub>2</sub> and studying CO<sub>2</sub> behavior to a greater extent than the project operators would have pursued on their own – creating a mutually beneficial public/private partnership.

The most significant outcome from both field projects is that CO<sub>2</sub> leakage has not been observed, nor is there any indication that CO<sub>2</sub> will leak in the future.

### Sleipner

Statoil's Sleipner field in the Norwegian North Sea is a large producer of natural gas. The natural gas reservoir is deep – 3,500 meters below the sea floor – and the natural gas produced contains 9 percent CO<sub>2</sub>. The CO<sub>2</sub> must be reduced to 2.5 percent in order to meet criteria for sale into a natural gas pipeline. Statoil operates a natural gas processing platform that scrubs CO<sub>2</sub> with amine absorbents.

At about 1,000 feet below the seabed and above the Sleipner natural gas reservoir is a large, porous sandstone formation with a shale cap rock, called the Utsira formation. This formation is an ideal setting and Statoil decided to go forward with plans to capture CO<sub>2</sub> from the natural gas processing platform and inject it into the Utsira formation. Prior to the project, the scrubbed CO<sub>2</sub> was vented to the atmosphere, but a CO<sub>2</sub> emissions tax levied by the Norwegian government motivated

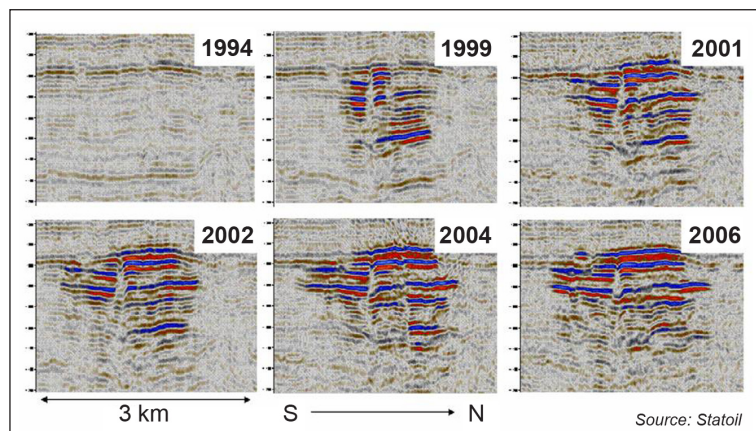
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Time-lapse seismic datasets of CO<sub>2</sub> stored in the Utsira formation.



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Statoil to consider capturing the vented CO<sub>2</sub>, compressing it, and injecting it underground. Over 9 million tons of CO<sub>2</sub> have been injected to date, and scientists estimate the Utsira formation has the capacity to store 600 billion tons of CO<sub>2</sub>.

The CO<sub>2</sub> flow in the Utsira formation has been monitored using time-lapse seismic technology, in which scientists take a seismic snapshot of a formation before and after injection and study the differences. CO<sub>2</sub> is more compressible than brine, and sound waves travel through it at a different velocity; thus, CO<sub>2</sub> in a saline formation leaves a bright signature. The time lapse seismic results shown in the figure indicate that there is no migration of CO<sub>2</sub> out of the Utsira formation<sup>1</sup>.

A primary project goal at Sleipner is to quantify the change in the local gravitational field in order to assess the ability of microgravity techniques to monitor geologically-sequestered CO<sub>2</sub>. In 2002 and 2005, DOE supported the University of California in successfully conducting microgravity sea floor surveys with better-than-expected repeatability.

## Weyburn

The Weyburn Oilfield in Saskatchewan, Canada, was discovered in 1954 and reached a peak crude oil production of 50,000 barrels per day in 1967. In 1997, the Canadian company, EnCana, announced that it would develop an enhanced-oil-recovery project with the goal of extending the oilfield's life by more than 25 years and extracting an additional 122 million barrels of crude oil.

EnCana solicited proposals for CO<sub>2</sub> supply from anthropogenic sources, which was won by the Dakota Gasification Company, operator of the Great Plains Synfuels plant, in Beulah, North Dakota. Dakota Gasification offered to build a 325-km pipeline between Beulah and Weyburn with a capacity to supply at least 2.7 million metric cubic tons per day (m<sup>3</sup>/day) of CO<sub>2</sub>. As of May 2003, the cumulative CO<sub>2</sub> injected totaled 3.5 million metric tons; another 20 million tons of CO<sub>2</sub> will be injected over the life of the project.

The Petroleum Technology Research Center (PTRC), a not-for-profit research and development organization with offices and laboratories in Regina, Saskatchewan, Canada, initiated a research project to operate in parallel with the commercial oil recovery project<sup>2</sup>. The goals of the research project are to develop a rigorous baseline of the formation, use the CO<sub>2</sub> flood as an opportunity to gain understanding of the behavior of injected CO<sub>2</sub>, field test a range of CO<sub>2</sub> monitoring technologies, and develop the ability to model and predict the flow of CO<sub>2</sub> in an underground formation over long periods of time. DOE co-funded this research project that is managed by its National Energy Technology Laboratory (NETL).

A wide range of CO<sub>2</sub> measurement and monitoring approaches were tested at the Weyburn site, including observation wells; three-dimensional (3-D) seismic, cross-well seismic, and soil monitors; and gas tracers. Researchers predict that they can use 3-D seismic to detect volumes of CO<sub>2</sub> as small as 2,500 metric tons. Soil sampling conducted at the site indicates there is no leakage of CO<sub>2</sub> from the reservoir. DOE is currently working on the next phase of the Weyburn project, which will look to continue CO<sub>2</sub> injection in the region and study the permanence of CO<sub>2</sub> in these geologic formations.

## References

<sup>1</sup> Arts, et al., 2004 "Recent Time-Lapse Seismic Data Show No Indication of Leakage at the Sleipner CO<sub>2</sub> Injection Site" presented at the 7<sup>th</sup> International Conference of Greenhouse Gas Control Technologies (GHGT-7).

<sup>2</sup> Monea, M., and M. Wilson, 2004, "IEA GHG Weyburn CO<sub>2</sub> Monitoring & Storage Project Summary Report 2000-2004," from the proceedings of GHGT-7.