CCS in Canada Backgrounder

Why carbon capture and storage (CCS)?

Interest in capturing and storing carbon dioxide produced from large industrial processes is growing. Sequestering carbon that otherwise would be emitted to the atmosphere moves many jurisdictions closer to meeting environmental targets. At the same time, carbon sequestration creates economic opportunity through advanced technology development and, through use of that technology, extends conventional resource development within environmental parameters.

More than 30 carbon dioxide capture and storage programs now exist in the world, including six in the United States, seven in Europe, five in South America and two each in China and Australia. Together, these programs contribute to considerable world-wide CO_2 storage potential, including: up to 200 gigatonnes in unmineable coal formations; between 675 to 900 gigatonnes in depleted reservoirs; and between 1,000 to 10,000 gigatonnes in deep saline aquifers.

The movement to advance CCS is also timely: with concentration of atmospheric CO_2 expected to soon reach levels not seen in 10 million years, managing the carbon problem while continuing economic growth will be necessary for social stability and viability into the future.

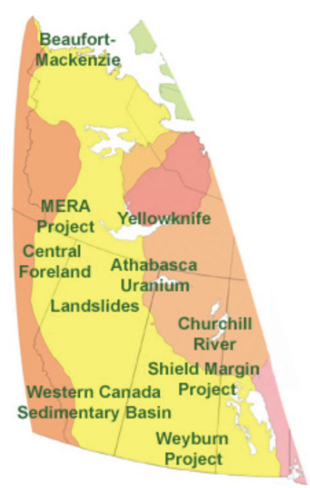
Separating carbon dioxide from the processes or exhaust streams of large industrial operations, then compressing and injecting it deep underground in secure geological formations is only one but an increasingly attractive solution to the carbon problem, particularly in jurisdictions where natural and/or industrial activity has created opportunity to advance the technology.

Carbon capture and storage in Canada

The tectonically stable Western Canada Sedimentary Basin is ideally suited for CCS. Reservoirs that contained Western Canada's vast oil and gas reserves may securely contain carbon dioxide. Further, many of the large CO_2 emitters, including coal-fired electricity generators and oilsands operators, are located in Western Canada where CO_2 capture and transportation technologies are already in place.

Further, the capacity for storing CO_2 in EOR, mature production fields and saline formations in the Western Canada Sedimentary Basin is impressive: EOR project potential alone is estimated at 450 megatonnes of carbon dioxide, while mature oil and gas reservoirs could hold almost ten times that amount at 4,000 megatonnes. Recent studies suggest that saline formations in the Western Canada Sedimentary Basin could hold at least one million megatonnes.

Western Canada Sedimentary Basin



Building the Canadian CCS framework

Industry, the government of Canada and the province of Alberta* have in recent years formed an effective triple helix of expertise in moving elements of CCS from concept to technical and economic viability at the pilot/testing stage. Key players in this research and implementation matrix include industry consortia (including the recently announced Alberta Saline Aquifer Project, a 19-member industry group, and ICO2N, a 15-member industry group) and key government research and funding agencies charged with moving CCS into the forefront of solutions to the carbon problem.

Together, these alliances over the years have advanced carbon capture technologies in three primary areas:

Solvent-based

A technique used in the Canadian natural gas industry, CO_2 is extracted from flu gases by bringing it into contact with amine-based solvents that are heated to release the CO_2 under low pressure.

Cryogenic separation and membrane filtration

Two distinct processes for capturing CO_2 that in each process is then dehydrated and compressed for pipeline transport and/or injected for enhanced oil recovery or sequestration.

** Because of its abundant resources and long-standing investment in their exploitation, Alberta continues to stand out as a key stakeholder but it should be noted Saskatchewan is quickly emerging as an open-for-business energy and research centre of significance in Canada.*

Key strategies going forward

Over the next ten years, two broad strategies present themselves as emerging areas of CCS development. Implemented at new and existing industrial plants, CCS could deploy steam methane reforming (SMR) upgrading facilities, whereby CO_2 is removed from the fuel itself, such as natural gas, rather than from exhausts resulting from burning the fuel in an industrial process. The ICO2N group anticipates SMR facilities could be deployed in the 2012-2015 time frame.

The same group also sees clean coal as promising technology that could be in operation after 2015. Here, coal is either pulverized for more efficient use of the energy required to burn it (similar to kindling being easier to light and convert into thermal energy than a whole log of wood), or the plant utilizes an integrated gasification combined cycle (IGCC) technology. IGCC similarly uses crushed coal but mixes it with oxygen and water in a high-pressure gasifier to make "syngas" – a combustible fuel that produces extremely low emissions and particulates. The IGCC method also uses less water, generates less solid waste and can concentrate carbon dioxide emissions, making CO_2 easier to capture and store.

Enhanced oil recovery projects

Canada's unique geography of abundant storage reservoirs provides the opportunity for North America to become a global leader in balancing energy supply with climate change requirements. It is estimated that hundreds of years' worth of emissions could be stored safely in the Western Canadian Sedimentary Basin alone, starting with proven enhanced oil recovery (EOR) processes.

Currently, there are four CCS projects in Canada involving carbon dioxide in enhanced oil recovery operations:

Weyburn-Midale

This project at Weyburn, Saskatchewan is the largest carbon dioxide EOR project in the world. It injects carbon dioxide produced and piped from a coal gasification plant in North Dakota into the Weyburn oil field. Production from the field has increased

How does it work?

CCS involves three stages, all of which are in current use, although an industrial-scale integration of the components has yet to be developed.

Capture and Compression

Depending on the process used, carbon dioxide can be captured post-combustion or pre-combustion, and can be captured from industrial processes, including fertilizer, hydrogen and cement production. Of CCS's three stages, carbon capture is the most complicated and expensive.

Transport

Captured and compressed carbon dioxide can be transported by pipeline to storage facilities. An example is an existing pipeline that transports carbon dioxide from a coal gasification plant in North Dakota to EnCana's Weyburn-Midale enhanced oil recovery project in Saskatchewan. In all, there are more than 4,000 kilometres of similar pipelines in the U.S., while other pipelines in Canada transport acid gas to disposal facilities. Transport is the least expensive of the three components.

Injection and Storage

Carbon dioxide is then pumped or injected into producing oil and gas fields, depleted oil or gas reservoirs, coal seams, or deep saline aquifers underlying sedimentary basins throughout North America. When injected into producing fields, the carbon dioxide can improve the productivity of the field in a process known as enhanced oil recovery (EOR).

65 per cent since the start of the injection program in 2000, and the reservoir may be capable of storing up to 40 megatonnes of carbon dioxide.

Pembina Cardium

This EOR project uses carbon dioxide as a miscible flooding injectant to improve production from what is Canada's largest conventional oilfield with an estimated 7.5 billion barrels of original oil in place. EOR is expected to enhance recovery by 15 to 20 per cent over those portions that can be flooded with CO_2.

Carbon Sequestration and Enhanced Methane Project (CSEMP)

This project in Alberta is aimed at testing the ability of carbon dioxide injected into unmineable coal seams to enhance coalbed methane production while storing carbon dioxide. A successful pilot program was completed in 2006. Further testing at a larger scale is ongoing.

Fenn-Big Valley

An Alberta-based project similar to CSEMP is now in its third (ongoing) phase; it aims to reduce greenhouse gas emissions by sub-surface injection of CO_2 into deep coal beds and to enhance methane recovery factors and production rates as a result of CO_2 injection.

Enhanced oil recovery continues to be an important kick-starter to CCS development in Canada but support from governments in the form of grants and university-based research resources and talent will continue to be required on short- and medium-term bases.

Economic challenges of CCS

The economics of CCS development is tempered by costs, EOR revenues and other supply and demand factors. Currently, about 80 per cent of CCS costs lies in CO_2 capture, resulting in an economic and risk gap whereby investments spanning four to five years must accommodate high capture costs and declining EOR sales as projects mature.

This could be exacerbated by the threat of CO_2 oversupply that must also be taken into account, wherein EOR storage facilities actually become saturated and revenue falls even further. In the worst case, a capture company's only option might be to pay for direct (at the source) storage, conceivably driving down its price close to zero.

In turn, erosion of the EOR market price could discourage capture companies from investing, thereby delaying or limiting growth in CCS.

While laudable and desirable in essence and effect, a North American approach to CCS development must take into account all facets of current technological and market dynamics, if orderly and aligned development is to proceed. A major challenge will be the full integration and application of the key components of CCS – viz. capture, transport and storage – in commercial industrial facilities on a massive scale.

Risks of CCS

Alignment of Canadian and U.S. interests in CCS development will also need to take into consideration a number of key risk factors, including issues of liability in CO_2 transportation and storage. Most scientists agree a comprehensive monitoring program, an appropriate regulatory system and emergency response plans should be in place before carbon injection and storage projects are initiated.

The good news is the technological and environmental issues around CCS are similar to other procedures in the hydrocarbon industry: for example, acid gas injection into deep saline formation is considered a large-scale analogue for CO_2 injection. As for monitoring, a precedent has been set by the Weyburn project, where approximately two million tonnes of CO_2 per year have been stored at the site since 2001: in this case, volumes are continuously and carefully measured while seismic surveys track CO_2 movement through the formation.

Transportation

Moving carbon dioxide by pipeline presents issues similar to transporting crude oil, natural gas or refined products. However, because CO_2 is corrosive, the risk of leaks may be more prevalent than with other substances transported by pipeline. As well, CO_2 is heavier than air and may not dissipate in low-lying areas, presenting public health concerns. And unlike sour gas, it does not have an odour and so may not be immediately detected in the case of a pipeline leak.

Storage

Containment of CO_2 in depleted gas, oil or bitumen reservoirs may present risks similar to those of natural gas storage. Because CO_2 is injected at high pressures, it may open fissures in the rock surrounding the reservoir; there is also potential for the gas to leak in the case of well casing failures. In such cases, dissipating gas could potentially contaminate existing energy, mineral and/or groundwater resources, or move up the formation to the surface.

However, the Intergovernmental Panel on Climate Change has stated that the "fraction of CO_2 retained in appropriately selected and managed geological reservoirs is very likely to exceed 99 per cent over 100 years and is likely to exceed 99 per cent over 1,000 years," where "likely" is a probability between 66 per cent and 90 per cent, and "very likely" is a probability between 90- and 99 per cent. A key issue in mitigating CCS risk here would appear to be the appropriate selection and management of storage sites.

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