

Significant Canadian CCS activities to date

Canada has taken action to foster the deployment of CCS by completing full-scale commercial CCS projects, by implementing policy and regulatory changes to support CCS, and by creating a strong research and technology development ecosystem. The leadership and action that has been done on CCS in Canada now needs to find space in the discussion needed to implement comprehensive climate policies in Canada and our provinces and to drive economy-wide reductions in greenhouse gas emissions.

Significant Canadian CCS Projects	
Shell Quest	In November 2015, Shell and their partners in the Athabasca Oil Sands Project (Chevron Canada and Marathon Oil Canada) will officially launch the Quest Carbon Capture and Storage project near Edmonton, Alberta. The project will capture 1.1 Mt of CO ₂ from the Scotford Upgrader, a facility that converts bitumen into synthetic crude oil. The concentrated CO ₂ stream comes from the upgrader's steam methane reformer unit. It is transported in liquid form 80 km by underground pipeline and injected into a saline porous rock formation approximately 2 km below the surface. The Alberta government has committed \$745 million ¹ to the project and the Government of Canada has invested \$120 million. The project will also receive two-for-one credits for 10 years from the Alberta government under the Specified Gas Emitters Regulation (credits are currently valued at \$15/tonne, increasing to \$30/tonne by 2017).
SaskPower Boundary Dam	In October 2014, SaskPower started operating the CCS unit on unit #3 of its Boundary Dam Generating Station. The project retrofitted an existing coal-fired generation unit with a post-combustion carbon capture system. ² It captures approximately 1 Mt annually using the Cansolv system that utilizes rechargeable amines to capture CO ₂ and SO ₂ . The project's final cost was \$1.5 billion, with the Government of Canada contributing \$240 million. ³ Captured CO ₂ will be almost completely used for enhanced oil recovery (EOR) in the Weyburn project, with some of the CO ₂ stored in the Aquistore storage project. ⁴
Weyburn-Midale	Operated by Cenovus Energy, the Weyburn operation has been injecting CO ₂ since 2000. Cenovus estimates that to date, it has stored more than 24 Mt CO ₂ in the formation. Cenovus currently purchases CO ₂ from Dakota Gasification's Great Plain Synfuels Plant in Beulah, North Dakota, as well as from the SaskPower Boundary Dam project.

¹ All amounts are in Canadian dollars unless otherwise noted.

² SaskPower, "Capturing Carbon and the World's Attention," *Innovating Today to Power Tomorrow* (2015). <http://www.saskpower.com/our-power-future/innovating-today-to-power-tomorrow/capturing-carbon-and-the-worlds-attention/> (September 21, 2015)

³ The final \$150-200 million budget overrun was a result of challenges with the installation of the new generating unit. Brian Banks and Mark Bigland-Pritchard, *SaskPower's Carbon Capture Project: What Risk? What Reward?* (Canadian Centre for Policy Alternatives, 2015), 4. https://www.policyalternatives.ca/sites/default/files/uploads/publications/Saskatchewan%20Office/2015/02/Saskpowers_Carbon_Capture_Project.pdf

⁴ Aquistore. <http://aquistore.ca/> (September 21, 2015)

<p>Alberta Carbon Trunk Line</p>	<p>Enhance Energy continues to work on the Alberta Carbon Trunk Line Project, a 240-km pipeline that will transport CO₂ from industrial emitters in and around Central Alberta to EOR operations. Currently, Agrium (fertilizer facility)⁵ and Northwest Upgrading Project (oil sands bitumen refinery) have both agreed to supply CO₂ to the pipeline when it is completed. The project will receive just over \$0.5 billion in public funding from the Government of Alberta and Government of Canada.</p>
<p>Government Programs</p>	
<p>Natural Resources Canada</p>	<p>This federal government department seeks to enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resources products. The organization develops policies and programs that enhance the contribution of the natural resources sector to the economy, with a particular focus in energy, forests, and minerals and metals. NRCan represents Canada at the international level to meet the country's global commitments related to the sustainable development of natural resources. As a result, NRCan is one main funder for CCS projects in Canada.⁶</p> <p>1. Funding for CCS projects</p> <p>ecoENERGY Technology Initiative (2007-2012). The ecoENERGY Technology Initiative was introduced in 2007 to contribute to the Government of Canada's Clean Air Agenda through the development and dissemination of new knowledge and technologies. The program provided funds for research, development, and demonstrations to support the development of next generation energy technologies needed to achieve emissions-free fossil fuel production and use.⁷ A total of \$112 million was used to fund industry-led CCS initiatives.⁸</p> <p>Clean Energy Fund (2009-2014). The Clean Energy Fund was announced in 2009 to support clean energy research, development, and demonstration projects, including CCS. Initially announced as a \$1 billion investment, that was reduced by \$205 million in Budget 2010 to provide additional funds to the ecoENERGY Retrofit-Homes initiative. The major part of the funding was allocated for large-scale CCS projects, including the Shell Canada Energy Quest and the Alberta Carbon Trunk Line Carbon Capture and Storage projects (see sections above).⁹</p> <p>ecoENERGY Innovation Initiative (2011-2016). The ecoENERGY Innovation Initiative received funding in Budget 2011 for a comprehensive suite of research and development and demonstration projects. The program will provide \$268 million to support energy technology innovation to produce and use energy in a cleaner and more efficient way in five strategic priority areas: energy efficiency, clean electricity and renewables, bioenergy, electrification of transportation, and unconventional oil and gas. The</p>

⁵ Agrium, "Enhance Energy and Agrium Sign CO₂ Agreement," news release, May 27, 2008. <http://www.agrium.com/en/investors/news-releases/2008/enhance-energy-and-agrium-sign-co2-agreement> (September 22, 2015)

⁶ Natural Resources Canada, About us, <http://www.nrcan.gc.ca/department> (October 9, 2015)

⁷ Natural Resources Canada, Audit of the ecoENERGY Technology initiative AU2011, <http://www.nrcan.gc.ca/audit/reports/2011/986> (October 9, 2015)

⁸ Natural Resources Canada, "Carbon Capture and Storage (CCS) in Canada," presentation to CCS Technical Experts Meeting (UNFCCC), Bonn, Germany, October 21, 2014. http://unfccc.int/files/bodies/awg/application/pdf/02_canada_martin_aube.pdf

⁹ Natural Resources Canada, Clean Energy Fund Program, <http://www.nrcan.gc.ca/energy/funding/current-funding-programs/cef/4949> (October 9, 2015)

	<p>initiative will help in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use.¹⁰ A total of \$26 million was awarded to research and development projects to develop the second and third generation CCS technologies.</p> <p>2. CanmetENERGY</p> <p>With over 450 scientists, engineers, and technicians, Natural Resources Canada's CanmetENERGY is one of the top Canadian leaders in clean energy research and technology development. CanmetENERGY supports NRCan's priorities to promote the sustainable and economic development of Canada's natural resources.¹¹</p> <p>3. International engagement on CCS</p> <p>Collaboration with other governments — NRCan is engaged in several international initiatives, such as the Carbon Sequestration Leadership Forum and the IEA Greenhouse Gas R&D Programme. NRCan also represents Canada in bilateral initiatives with the U.S. (Clean Energy Dialogue, Enhanced Energy Collaboration), the United Kingdom (Joint Statement on CCS); as well, it maintains CCS-related arrangements with government entities in Japan, China, South Korea, and Mexico.</p> <p>Collaborations with industry abroad — NRCan has 20 years of collaboration with the power generation sector in China, including on CCS-related issues. NRCan also collaborates with Foster Wheeler toward an oxy-fuel demonstrator in Spain.¹²</p> <p>U.S.-Canada Clean Energy Dialogue — Both countries are working together on the development of clean energy science and technologies to reduce greenhouse gases and combat climate change.¹³ The Carbon Capture and Storage working group is working to facilitate dialogue and collaborative efforts for improving framework conditions to enable the development and deployment of CCS in Canada and the United States.¹⁴</p>
<p>Government of Alberta</p>	<p>When the Government of Alberta unveiled its climate change strategy in 2008, CCS was one of the three pillars proposed to reduce by 50% the province's GHG emissions by 2050 compared to business as usual. The strategy outlined a set of actions and measures to allow CCS to take off at a significant scale by 2020.¹⁵</p> <p>Regulatory framework assessment</p> <p>Following its decision to deploy CCS, the Government of Alberta initiated a process called the Regulatory Framework Assessment (RFA) in March 2011. This multi-stakeholder process meant to make sure that the right regulations are in place before full-scale CCS projects start operating in Alberta. The RFA looked at the regulations that apply to CCS in Alberta as well as regulations and best practices in other parts of the world. It examined in detail the technical, environmental, safety, monitoring, and closure requirements that apply to a CCS project. Many Canadian and international experts from industry, universities, research organizations, environmental groups, and provincial and national governments participated in the RFA, which was guided by a</p>

¹⁰ Natural Resources Canada, The ecoENERGY Innovation Initiative, <http://www.nrcan.gc.ca/energy/funding/current-funding-programs/eii/4985> (October 9, 2015)

¹¹ Natural Resources Canada, CanmetENERGY, <http://www.nrcan.gc.ca/energy/offices-labs/canmet/5715> (October 9, 2015)

¹² Natural Resources Canada, "Carbon Capture and Storage (CCS) in Canada."

¹³ Government of Canada, Action on Climate Change, <http://www.climatechange.gc.ca/dialogue/default.asp?lang=Enn=E47AAD1C-1>

¹⁴ Ibid.

¹⁵ Government of Alberta, *Alberta's 2008 Climate Change Strategy* (2008). <http://environment.gov.ab.ca/info/library/7894.pdf>

	<p>steering committee and included an international expert panel. The RFA concluded in December 2012 and resulted in 71 individual recommendations and 9 conclusions, which were combined into 25 actionable items for the Government of Alberta to consider.¹⁶</p> <p>Funding for CCS projects (Carbon Capture and Storage Funding Act)</p> <p>The Government of Alberta announced in 2008 a \$2-billion CCS fund with the objective of making Alberta a global leader for CCS. The program aimed at building a first wave of three to five CCS demonstration projects, through joint government and industry collaboration. Two out of the four selected large-scale CCS projects were cancelled in 2013. The two remaining projects — the Alberta Carbon Trunk Line project and the Quest Project (see above) — are moving forward with a total commitment of \$1.3 billion from the Government. These will reduce Alberta's GHG emissions by 2.76 Mt annually beginning in 2015.¹⁷</p> <p>Other</p> <p>Quantification protocol for CO₂ capture and permanent storage in deep saline aquifers. The Specified Gas Emitters Regulation that came into effect in 2007 requires facilities that emit 100,000 tonnes or more of GHG a year to reduce their emissions intensity. Non-compliant facilities can either pay \$15 into the Climate Change and Emissions Management Fund for every tonne they exceed the allocated limit, or purchase Alberta-based carbon offset or performance credits. In June 2015, a protocol for CCS in deep saline aquifers was added to the Alberta offset credit system.¹⁸</p>
<p>Alberta Geological Survey</p>	<p>As part of the Alberta Energy Regulator, Alberta Geological Survey (AGS) provides geological information and expertise to government, industry, and the public about Alberta's resources and geological processes. Its role is to record the rock record in Alberta, collect and quantify the chemical and physical characteristics of rocks and minerals, analyze and interpret air photos and satellite images, and deliver this information to the public. AGS participates in Alberta government strategic initiatives and collaborates with other government departments and agencies, geological surveys, academia, industry groups, and non-profit organizations.¹⁹</p> <p>Characterization of storage potential in Alberta</p> <p>AGS released in 2000 a basin-scale assessment of the suitability of the Western Canada Sedimentary Basin for geological sequestration of CO₂.²⁰ The National Geological Survey has estimated that the Western Canada Sedimentary Basin can store more than 100 billion tonnes of CO₂.²¹</p>

¹⁶ Government of Alberta, *Carbon Capture & Storage: Summary Report of the Regulatory Framework Assessment* (2013). <http://www.energy.alberta.ca/CCS/pdfs/CCSrfaNAppD.pdf>

¹⁷ Government of Alberta, Carbon Capture and Storage, <http://www.energy.alberta.ca/OurBusiness/3815.asp> (October 9, 2015)

¹⁸ Government of Alberta, *Carbon Capture and Storage: Quantification Protocol for CO₂ Capture and Permanent Storage in Deep Saline Aquifers* (2015). <http://aep.alberta.ca/climate-change/guidelines-legislation/specified-gas-emitters-regulation/documents/QuantificationProtocolCO2-Jun23-2015.pdf>

¹⁹ Alberta Geological Survey, About Alberta Geological Survey, http://www.ags.gov.ab.ca/about_ags.html (October 9, 2015)

²⁰ Alberta Geological Survey, CO₂ Sources and Basin Suitability, http://www.ags.gov.ab.ca/co2_h2s/co2_sources.html (October 9, 2015)

²¹ ICO₂N, Carbon Capture and Storage: Understanding the Basics, 2010, http://www.ico2n.com/wp-content/uploads/2010/09/CCS_ICO2N_Brochure.pdf (October 9, 2015)

<p>Climate Change and Emissions Management Corporation (CCEMC)</p>	<p>The CCEMC is an independent organization that was established in 2009 as a key part of Alberta’s Climate Change Strategy and movement toward a lower-carbon economy. Its mission is to accelerate the achievement of actual and sustainable reductions in GHG emissions and support climate change adaptation through partnerships and collaboration in the discovery, development, and deployment of technology for application in Alberta. The CCEMC is funded through the Climate Change and Emissions Management Fund, which collects the carbon tax that non-compliant large industrial GHG emitters are required to pay under Alberta’s Specified Gas Emitters Regulation. It has three priority areas for funding, aligned with Alberta’s 2008 Climate Change Strategy: conserving and using energy efficiently; implementing CCS; and greening energy production.</p> <p>CCS project funding</p> <p>One of CCEMC's areas of funding focuses on projects that capture and store CO₂ and assess its potential uses and value. The CCEMC has funded eight projects in this area for a total of \$11,442,331. Three of these projects are complete and five of them are currently in development.</p> <p>Grand Challenge</p> <p>The CCEMC Grand Challenge is a competition launched in 2013 offering \$35 million to support innovative technology that will convert CO₂ emissions into new carbon-based products and markets. While the technology can be developed anywhere in the world, it must be applicable to Alberta and be capable of being commercialized in the province. The challenge is a three-stage competition with opportunities for funding at each stage. Through the structure of this challenge, the global community has the opportunity to network and collaborate together on novel solutions. The process also enables the CCEMC to support the development of multiple ideas that can progress simultaneously. During the first round, from 2013 to 2014, the CCEMC awarded \$12 million via 24 grants of \$500,000 each. Starting in September 2015, the second round will see up to \$15 million awarded through a maximum of five grants of \$3 million. The third round from 2017 to 2019 will evaluate round two winners and award a final \$10 million grant.</p>
<p>Research Programs/Organizations</p>	
<p>IEA GHG Weyburn-Midale CO₂ Monitoring and Storage Project</p>	<p>Started in 2000, the IEA GHG Weyburn-Midale CO₂ Monitoring and Storage Project is an international collaborative scientific study to assess the technical feasibility of CO₂ storage in geological formations in the context of enhanced oil recovery. The project, managed by the Petroleum Technology Research Centre (PTRC), has examined the storage of nearly 25 Mt of CO₂ in two depleted oil reservoirs (Weyburn and Midale, respectively operated by EnCana (now Cenovus Energy) and Apache Canada) in southeastern Saskatchewan. Approximately 8,500 tonnes per day of CO₂ are captured from a coal gasification facility owned by the Dakota Gasification Company in Buelah, North Dakota. The CO₂ is compressed to a liquid phase and transported via a 320-km pipeline to Saskatchewan, where it is injected along with water in the Weyburn and Midale oil fields. Some of the CO₂ is pumped back to the surface together with oil and water, then separated and re-injected. The objective of the research project is to ensure that the CO₂ used for EOR will remain safely stored underground.²² The IEA GHG project ended in 2011 and resulted in the publication of a manual in 2012.²³ The project was a major international cooperative effort with a budget of \$40 million and</p>

²² Petroleum Technology Research Centre, Weyburn-Midale. <http://ptrc.ca/projects/veyburn-midale>

²³ Petroleum Technology Research Centre, *Best Practices for Validating CO₂ Geological Storage: Observations and Guidance from the IEA GHG Weyburn-Midale CO₂ Monitoring and Storage Project* (2012).

	involvement of 15 industry and government sponsors and 25 research and consulting organizations from several countries. ²⁴ CO ₂ continues to be injected today as part of the EOR process.
Petroleum Technology Research Centre	PTRC is a not-for-profit corporation founded in 1998 to foster research and development into enhanced oil recovery and CO ₂ storage in Canada. Based in Regina, Saskatchewan, it was founded by four partners: Natural Resources Canada, the Government of Saskatchewan, University of Regina, and the Saskatchewan Research Council. The PTRC develops technologies that increase the recovery from existing conventional and heavy oil reserves and improve access to resources like tight oil in Saskatchewan's Bakken formation, while reducing the environmental footprint of the oil and gas industry. PTRC also conducts research to better characterize different kinds of oils, to understand the ways they react with solvents, additives, and other compounds. Its board of directors is composed of representatives from its four founding members as well as from the oil and gas industry. One of its most famous project is the IEA GHG Weyburn-Midale CO ₂ Monitoring and Storage project, which involved researchers from around the globe and resulted in a best-practices publication (see previous section). ²⁵
Integrated CO₂ Network	ICO ₂ N is a group of Canadian companies representing multiple industries with a strong interest in and a commitment to develop CCS in Canada. Founded in Edmonton, Alberta, in 2005, ICO ₂ N currently has 11 member companies that include oilsands producers, large-scale electricity producers and other companies that are connected to the energy industry. ICO ₂ N works with multiple levels of governments, industry partners, academia and environmental organizations to accelerate CCS deployment as a means of reducing CO ₂ emissions, and fundamentally transforming the way Canada can develop and use its fossil fuel energy resources. ICO ₂ N has completed extensive technical, economic, and policy analysis on CCS, and developed its own unique economic model of large-scale CCS in Canada. ²⁶
Carbon Management Canada Research Institutes	CMC Research Institutes (CMC) is an independent, not-for-profit business with the mission of accelerating innovation to eliminate industrial GHG emissions. Incorporated in 2009 under the name of Carbon Management Canada, Inc., CMC was the result of a successful proposal under the federal Networks of Centres of Excellence program that resulted in an award of \$25 million with an additional \$25 million grant received from Alberta Environment. CMC has awarded \$22 million to a portfolio of 44 research projects and supports 155 researchers and over 200 graduate students and postdoctoral fellows. The organization has built an extensive national and international collaborative network with strong ties with Universities and research centres in Canada, the United States, the United Kingdom, Germany, Korea, and Australia. Rebranded as the CMC Research Institutes in 2014, the company shifted its business model and restructured with three business units to serve clients from the oil and gas, electricity generation, and cement and chemical manufacturing industries. CMC provides the integration, adaptation, application development, field-testing, and scale-up services required to rapidly move concepts from lab bench to field. ²⁷ One of its business units, the Carbon Capture and Conversion Institute (CMC.CCCI), was developed in partnership with the University of British Columbia and BC Research Inc. to accelerate the development, piloting, scale-up, and validation of new technologies to capture and convert carbon from industrial processes. ²⁸

²⁴ IEA Greenhouse Gas R&D Programme, *IEA GHG Weyburn CO₂ Monitoring & Storage Project*. http://www.ieaghg.org/docs/general_publications/weyburn.pdf

²⁵ Petroleum Technology Research Centre, *Leading the World*, http://ptrc.ca/+pub/document/Fact%20sheet%20PTRC_5March2013.pdf (October 9, 2015)

²⁶ ICO₂N, *About ICO₂N – An overview*, <http://www.ico2n.com/about> (October 9, 2015)

²⁷ CMC Research institutes, *About us*, <http://cmcghg.com/about-u> (October 9, 2015)

²⁸ CMC Research Institutes, *Carbon Capture and Conversion Institute*, <http://cmcghg.com/business-units/ccci> (October 9, 2015)

	<p>Another CMC business unit, the Containment and Monitoring Institute, has started a field research station. This project, developed in partnership with Cenovus and the University of Calgary, will have a test facility located near Brooks, Alberta. The carbon dioxide injection and monitoring project will have the capability to monitor and secure containment of fluids in the subsurface and the testing of new seismic technologies and methods.²⁹</p>
<p>Canada's Oil Sands Innovation Alliance (COSIA)</p>	<p>COSIA is an alliance of oilsands producers launched in March 2012 to focus on accelerating the pace of improvement in environmental performance in Canada's oilsands through collaborative action and innovation. COSIA's four environmental priority areas are tailings, water, land, and greenhouse gases.³⁰</p> <p>NRG COSIA Carbon XPRIZE</p> <p>The NRG COSIA Carbon XPRIZE is a global competition launched in September 2015 offering \$20 million to innovators best able to convert CO₂ emissions into a usable and valuable product. The competition is structured as a two-track prize, with one track focused on testing technologies at a natural gas facility, and the other focused on testing technologies at a coal power plant. A prize of \$10 million is available to the winners of each track. The NRG COSIA Carbon XPRIZE will have three rounds: first round will consist of assessment of submissions for technical and business viability; second round will involve a pilot-scale competition; third round will consist of a demonstration-scale competition. With the funding from eight oilsands companies, COSIA is the Canadian sponsor of this competition, along with NRG Energy, one of the largest power companies in the U.S.³¹</p> <p>Greenhouse Gas Environmental Priority Area</p> <p>COSIA's GHG environmental priority area investigates ways to reduce energy use and associated GHG emissions through the development of innovative technologies for oilsands in situ and mining operations. CCS is one of the explored options to store CO₂ from steam generators and other large oilsands facilities.³² As a member of COSIA, Shell has shared their Quest CCS technology with COSIA's GHG environmental priority area.³³</p>

²⁹ CMC Research Institutes, Containment and Monitoring Institute <http://www.cmc-nce.ca/business-units/cami/> (October 9, 2015)

³⁰ Canada's Oil Sands Innovation Alliance, About COSIA, <http://www.cosia.ca/about-cosia> (October 9, 2015)

³¹ Canada's Oil Sands Innovation Alliance, NRG COSIA Carbon XPRIZE, http://www.cosia.ca/initiatives/greenhouse_gases/nrg-cosia-carbon-xprize (October 9, 2015)

³² Canada's Oil Sands Innovation Alliance, Greenhouse Gases, http://www.cosia.ca/initiatives/greenhouse_gases (October 9, 2015)

³³ Canada's Oil Sands Innovation Alliance, Carbon Capture and Storage, http://www.cosia.ca/initiatives/greenhouse_gases/carbon-capture-and-storage (October 9, 2015)