Clean Technologies in Canada

Submission to the Standing Committee on Environment and Sustainable Development

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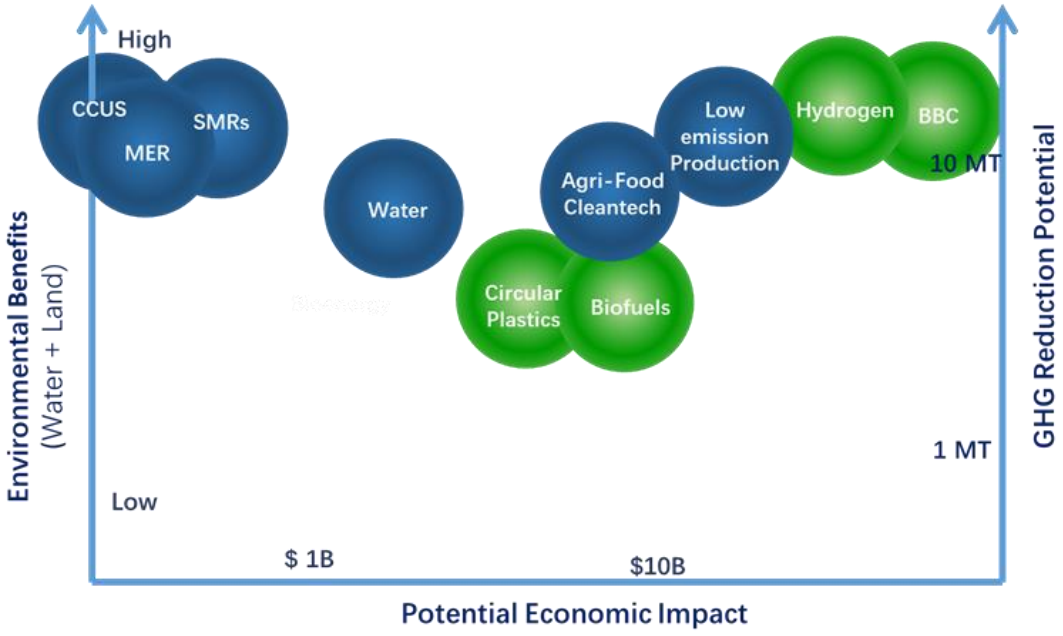
October 2022

Executive Summary

Our submission focuses on clean technologies being advanced through Alberta Innovates that will reduce greenhouse gas (GHG) emissions and other environmental impacts and enable the transition to a net-zero emission (NZE) economy in Canada.

We highlight the most promising and impactful technologies that Canada should pursue, based on the insights and experience we have gained from hundreds of clean technology projects over the last few decades. These technologies include carbon capture, utilization and storage (CCUS), methane emission reduction (MER), hydrogen, bitumen beyond combustion (BBC), low-emission hydrocarbon production technologies, water management, agri-food cleantech, biofuels, small modular nuclear reactors (SMRs), and circular plastics. They provide a suite of solutions for Canada to realize its NZE ambitions.

Recent investments by the federal government have shifted to commercial deployment or near-commercial demonstration of clean technologies to achieve short-term impacts such as 2030 emission reduction targets. However, to ensure prosperity in an NZE world, innovations across the full range of technology readiness levels (TRLs) must be supported. The federal government should also remove barriers and incentivize collaborations between federal and provincial innovation organizations and with industries.



The clean technologies highlighted in the graph above will help Canada meet its climate change targets and obligations. We can take it one step further by exporting our clean technology expertise and products to help other countries meet their NZE goals as well.

Introduction

Canada emitted 672 megatonnes of carbon dioxide equivalent (MT CO_2e) in 2020. Major sources were oil and gas (27 per cent), transportation (24 per cent), buildings (13 per cent), heavy industry (11 per cent), agriculture (10 per cent), electricity (8 per cent), and waste (4 per cent) (Environment and Climate Change Canada [ECCC], 2022a). Canada's GHG emission targets include a 40 to 45 per cent reduction by 2030 and net-zero emissions by 2050. The federal government has committed billions of dollars to deploy clean technologies to achieve these ambitious targets.

Alberta is a global centre of energy production and a hub for cleantech expertise. With the ongoing global need for energy, the resource industry will contribute to the Alberta and Canadian economy for decades to come. At the same time, Alberta is well-positioned to build a multibillion-dollar clean technology sector.

Alberta Innovates is a publicly funded provincial corporation, dedicated to accelerating research and innovation to deliver social, environmental, and economic value for Albertans and Canadians. Clean technologies are a core focus for Alberta Innovates. Our investments of $300 million in cleantech over the last 12 years, which have leveraged billions more from our partners, have contributed to Alberta and Canada's leadership in CCUS, BBC, hydrogen, water management, biofuels and waste management.

Clean technologies being developed at Alberta Innovates can reduce emissions and other environmental harms from existing industries. They will also create a prosperous NZE economy in Canada. Some of the key technologies are summarized here.

Clean Technologies Toward a Net-Zero Emission Economy in Canada

Carbon Capture, Utilization, and Storage (CCUS)

CCUS is an important pathway for Canada to decarbonize heavy industries such as oil and gas, petrochemicals, and steel and cement manufacturing, to meet emission reduction targets and net-zero ambitions. CCUS can enable a low-emissions hydrogen industry using Alberta's massive natural gas reserves.

Industrial facilities are responsible for 41 per cent of Canada's GHG emissions, or 273 MT CO_2e (ECCC, 2022a). Theoretically, more than 90 per cent of these CO_2 emissions can be captured and permanently stored in deep aquifers or depleted oil and gas reservoirs. Aqueous amine technologies (a solvent for CO_2 separation) have been deployed at the commercial-scale Shell Quest and Boundary Dam projects in Alberta. Cost has been a major barrier for carbon capture, especially for low-concentration CO_2 streams (e.g., flue gases from natural gas combustion). Carbon utilization technologies are at the early stage of development.

Alberta Innovates (including its subsidiaries InnoTech Alberta and C-FER Technologies) and Emissions Reduction Alberta (ERA) have invested approximately $140 million in more than 100 CCUS projects in the last 25 years. These investments contributed to Alberta's international leadership and reputation in CCUS and measurement, monitoring and verification. The key learnings from these investments are summarized in a white paper published by Alberta Innovates, with recommendations for future investment priorities and focus areas to enable broad commercial-scale deployment of CCUS (Alberta Innovates, 2022).

Hydrogen

Hydrogen is poised to become a key energy source in transition to an NZE world. It can be produced from natural gas with low emissions when it is coupled with CCUS. The global demand for hydrogen is projected to increase tenfold over the next three decades, providing up to 24 per cent of global energy demand by 2050 (Bloomberg NEF, 2020).

The Government of Canada's Hydrogen Strategy (2020) aims to position the country to become a world-leading producer, user and exporter of hydrogen, as well as hydrogen technologies and services. Hydrogen has the potential to deliver up to 30 per cent of Canada's end-use energy by 2050, abating up to 190 MT CO_2e of GHG emissions from transportation, heating and industrial applications.

Alberta is already among the largest global manufacturers of hydrogen, and Canada's largest producer of hydrogen. The Government of Alberta's Hydrogen Roadmap (2021) will integrate hydrogen into Alberta's energy system for transportation, heating, power generation and storage, industry use and export by 2030. The goal of the roadmap is for Alberta to remain competitive in the global clean energy economy by leveraging existing strengths and expertise. Current federal investments in hydrogen (Clean Fuel Fund and Net Zero Accelerator) are largely focused on commercial-scale or high-technology readiness level (TRL) projects. To make the hydrogen economy a reality, hydrogen technologies (ex. pyrolysis and hydrogen carriers) need to be advanced through mid-TRL (3 to 7) levels across the value chain from production, transportation/distribution, carrier/storage to end use.

Alberta Innovates is leading a Hydrogen Centre of Excellence with an initial $50-million investment from the Government of Alberta. The centre will build a hydrogen ecosystem, support technology innovation, and build facilities/service capabilities required to support a hydrogen economy in Alberta and Canada.

Bitumen Beyond Combustion (BBC)

Most fossil fuel-related emissions (80 per cent on a life-cycle basis) are associated with end-use combustion. Emissions could be negated if Alberta's bitumen-rich oil sands were used as feedstock for advanced value products rather than fuels.

Alberta Innovates' Bitumen Beyond Combustion (BBC) strategy (Alberta Innovates, 2021) offers a pathway for the oil sands industry to add value in a net-zero economy. Instead of releasing carbon into the atmosphere through combustion, it would remain trapped in products such as

carbon fibre, asphalt binder and activated carbon. BBC products have lower GHG intensity than currently used products – carbon fibre and asphalt binder made from Alberta bitumen are about 50 per cent lower in GHG intensities than those made from commercial processes (Kumar et al., 2021; Hesp and Ding, 2022).

BBC could create a multibillion-dollar industry in Canada, including thousands of jobs. The climate benefit of BBC is even more important. For every million barrels of bitumen a day used for BBC, there is potential to avoid combustion-related (or Scope 3) GHG emissions by 65 million tonnes a year. The benefits would extend further. BBC products make transportation more energy efficient, infrastructure last longer and renewable generation and energy storage more economical. Examples include lighter, stronger composite materials for automobile and wind blade construction; activated carbon for use in batteries and other energy storage devices; and asphalt that lasts longer, is more durable and can be recycled multiple times.

However, BBC development is still at an early stage. In partnership with Clean Resource Innovation Network (CRIN), Alberta Innovates is supporting university researchers and SMEs to develop carbon fibres using bitumen. This Carbon Fibre Grand Challenge will soon move into the pre-commercialization demonstration phase. Alberta Innovates and Sustainable Development Technology Canada are supporting the first commercial plant to manufacture activated carbon using bitumen feedstock. Alberta Innovates is also working with three SMEs making asphalt binders from bitumen.

Low-Emission Bitumen Production and Processing

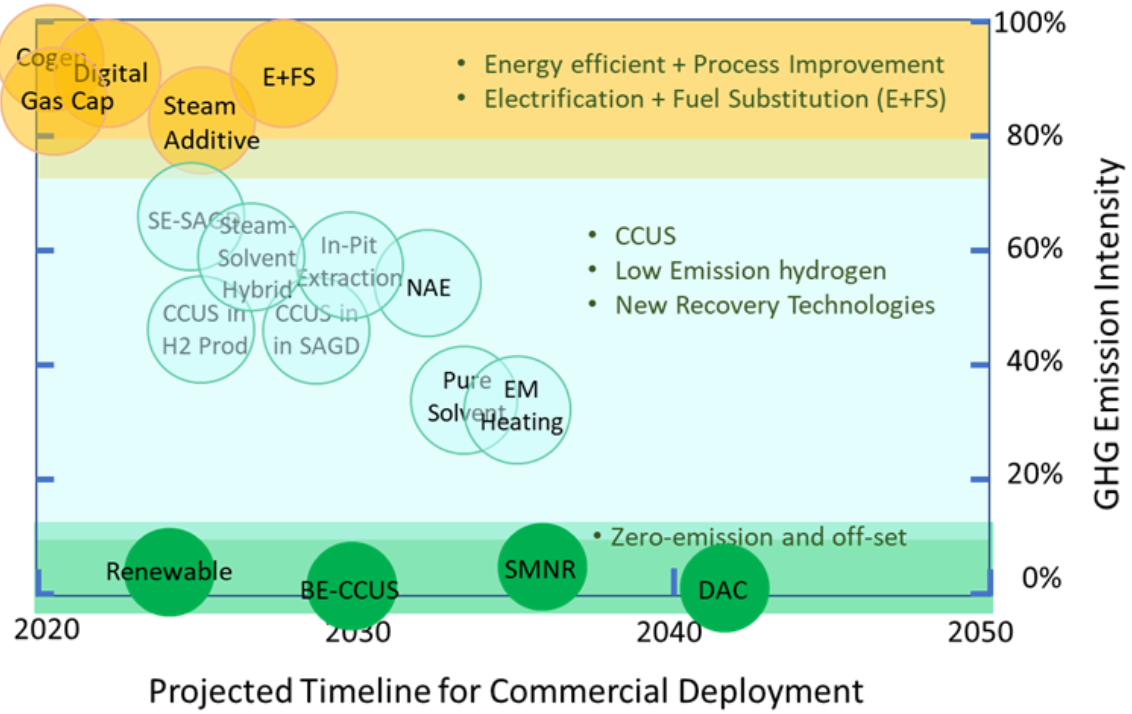
Canada's oil sands industry currently produces 3.5 million barrels per day. The combined environmental, social and governance (ESG) performance of the oil sands industry has improved over recent decades to become one of the best in the world (Dziuba et al., 2021). GHG emission intensity in oil sands production decreased by 20 per cent between 2009 and 2018 (IHS Markit, 2018) and the emissions intensity from some large oil sands assets is

comparable to the average U.S. barrel of oil (Sleep et al., 2020). However, production has been outpacing the rate of decrease in GHG emissions intensity, so absolute GHG emissions from oil sands production has been increasing. Total GHG emissions from oil sands extraction were 83 million tonnes in 2019, representing 11 per cent of Canada's overall GHG emissions (ECCC, 2021).

Alberta Innovates supports the industry in developing low-emission bitumen production and processing technologies. These include:

- energy efficiency and process improvements;
- electrification and fuel substitution in drilling, mining equipment and vehicles;
- low-emission hydrogen;
- CCUS; and
- new recovery technologies.

However, these technologies will not achieve complete NZE in bitumen production without additional zero-emission and offset technologies such as renewables, SMRs, bioenergy-CCUS (BE-CCUS) and direct air capture (DAC).

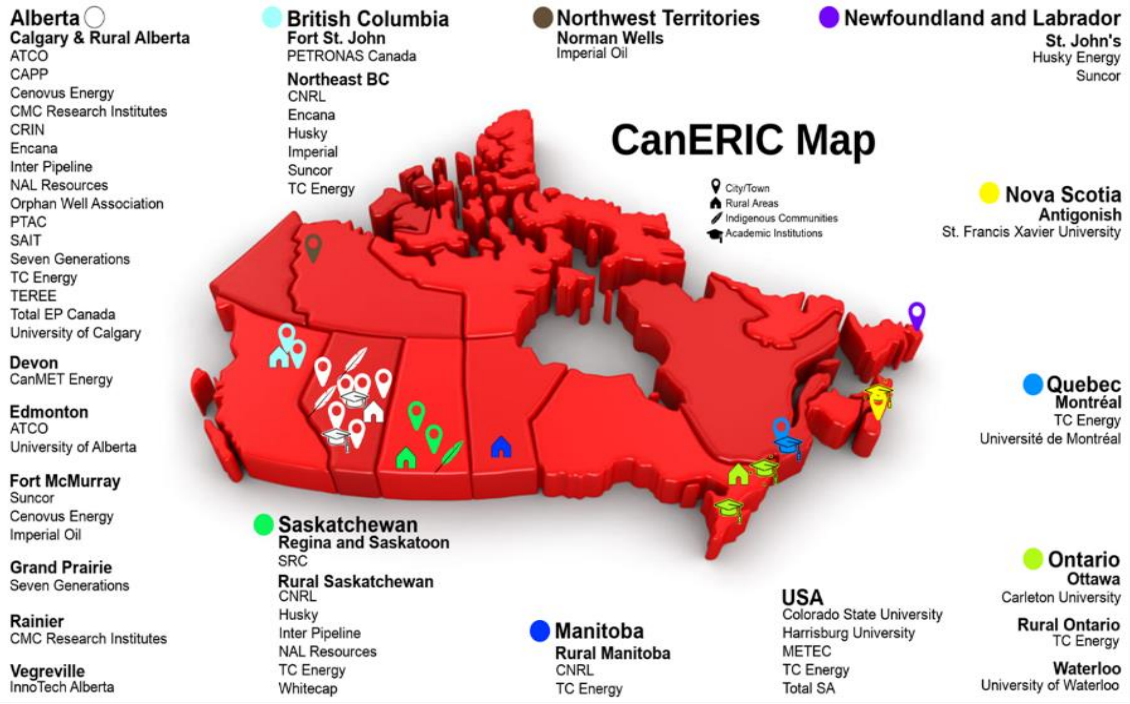


Projected timelines for commercial deployment of various emission reduction technologies are illustrated above. Most energy-efficient and process-improvement technologies (in the top area of the diagram) are commercial and would need to be widely deployed to impact emissions. Technologies (middle area) can contribute to emissions reduction in the oil sands industry as they are commercialized, but not all technologies will be successful or be deployed on the projected timeline. Considering the magnitude of reduction required, CCUS, bioenergy-CCUS and SMRs (bottom zone of diagram) are particularly important high-impact pathways for the oil sands industry to reach NZE.

Methane Emissions Reduction

Developing and deploying methane reduction technologies is essential to realizing real emissions reductions. In 2020, total Canadian methane emissions were 92 MT CO_2e. Of that, the oil and gas sector accounted for 35 MT CO_2e (ECCC, 2022a). The 2022 Emissions Reduction Plan (ECCC, 2022b) calls for a 75 per cent methane emission reduction from 2012 levels by 2030.

The Canadian Emissions Reduction Innovation Network (CERIN), jointly funded by Alberta Innovates and Natural Resources Canada (NRCan), is a pan-Canadian network of researchers and end-users to develop, validate and deploy technologies to reduce methane emissions. Open data-sharing across the network accelerates technology development and deployment. The network currently comprises two consortia led by the Petroleum Technology Alliance Canada (PTAC) and Natural Gas Innovation Fund (NGIF).



PTAC's Canadian Emissions Reduction Innovation Consortium (CanERIC)

The Canadian oil and gas sector is a global leader in methane emission reduction (PTAC, 2021; ECCC, 2022c). Methane emissions have dropped by 42 per cent between 2012 and 2020 in the oil and gas industry despite an increase in production (ECCC, 2022a). The methane mitigation technologies being tested by CERIN partners have the potential to reduce the oil and gas sector's methane emissions by at least 48 per cent and may be able to reach 90 per cent by 2030 (PTAC, 2021). CERIN's programs can inform protocols and standards for the detection and mitigation of methane emissions that will become the benchmark for Canada and the world.

The Government of Canada has committed to establishing a global Centre for Excellence on methane detection and elimination (GoC, 2022). Alberta Innovates would like to contribute to this centre.

Biofuels

Liquid biofuels are critical to decarbonizing and reducing GHGs in the transportation sector. In an NZE scenario, use of biofuel will need to increase by 20 times by 2050 (IEA, 2021). IEA's NZE scenario has liquid biofuels providing 14 per cent for transportation fuel and 45 per cent of global aviation fuel in 2050. Advanced Biofuels Canada has estimated the economic impact from domestic biofuel production could exceed $14 billion annually by adding 10 billion litres of new capacity by 2030, creating more than 28,000 jobs and eliminating 25Mt GHG (Advanced Biofuels Canada, 2022).

Roughly 93 per cent of transportation biofuels come from crops such as sugarcane, corn and soybeans. These crops compete directly for land that can be used for food production, which limits the ability to expand output. As a result, growth in biofuels production must come from feedstocks such as biomass waste, residues and woody crops. Alberta Innovates is collaborating with municipal governments, academia and major energy partners such as Suncor to develop and deploy advanced biofuels and biojet production.

Small Modular (Nuclear) Reactors (SMRs)

SMRs can provide baseload electricity (5MWe to 300MWe) and help to decarbonize Canada's electricity sector. SMRs also have potential to provide thermal energy for heavy industries, replacing gas-fired boilers to generate steam for bitumen recovery and generate electricity. SMRs can add capacity to smaller power grids, off-grid locations and communities, and allow for greater load following. SMR technologies are at various stages of technical and regulatory progress around the world and still require demonstration and cost reduction. The global market for SMRs is estimated to reach $150 billion (CAD) per year by 2040 (Hatch, 2021).

Ontario, Saskatchewan, New Brunswick and Alberta have signed a Memorandum of Understanding to advance the development and deployment of SMRs in Canada. Ontario Power Generation is working with GE Hitachi Nuclear Energy to deploy a 300 MWe SMR at their Darlington site (OPG, 2021), and SaskPower is working with GE Hitachi to evaluate SMR deployment (SaskPower, 2022). Working with industry partners, Alberta Innovates is conducting a feasibility study of SMR application in resource industry.

Water Management

Water issues transcend all industries and affect all communities and economic opportunities. Climate change makes flooding and drought events more frequent and severe. For example, in Alberta, the impact of the 2013 flood has been assessed at approximately $5 billion and severe drought in 2021 cost more than $1 billion in crop insurance payouts (Globe and Mail, 2021).

Alberta Innovates' Water Innovation Program has established an international reputation and generated significant impacts for both industry and government. The program supported efforts by the agriculture and oil sands sectors in Alberta, and resulted in water conservation, efficiency and productivity improvements of approximately 30 per cent (AWC, 2017). The knowledge and technologies generated through the WIP can be applied across Canada.

Agriculture Cleantech

The agriculture and agri-food sector is the fifth-largest GHG emitter in Canada (ECCC, 2022a). GHG emissions include methane from cattle digestion and manure; nitrous oxide from nitrogen fertilizer use; energy used to produce fertilizer and other chemicals; and farm fuel and power use.

Clean technologies can help address challenges in this sector while enhancing sustainability and reducing GHG emissions. Smart technologies are leading to greater efficiencies, improved yields and reduced inputs, sustainable processes and land use, and new sector capacity. These technologies are also optimizing fertilizer use and better quantifying soil nitrogen availability. Enhanced breeding develops traits such as feed-efficient, low-methane-emitting cattle and crops that can use nitrogen more efficiently.

The federal government should promote sustainability in agriculture and the agri-food sector, including improved livestock practices, nature-based solutions that improve carbon sequestration, greening on-farm energy use, increased fuel efficiency and zero-emission farm equipment, optimizing resource use at production and processing, and reducing food waste throughout the value chain. Alberta Innovates is proposing a Farming the Future initiative to reduce emissions from nitrogen fertilizer and livestock operations.

Circular Plastics

Alberta Innovates is working with the federal and Alberta governments and industry partners such as BASF and NOVA Chemicals to develop a low-carbon circular plastics economy. There is the potential to create 10,000 to 27,000 direct jobs with 1.8 Mt per year of GHG emissions avoided if 90 per cent of plastic waste can be diverted away from Canada's landfills (ECCC, 2019). We are advancing innovation across the value chain from plastics resin production and manufacturing to end-of-life management to drive more sustainable production and use.

In 2018, the Canadian Council of Ministers of the Environment agreed to work toward the goal of zero plastic waste and to keep all plastics in the economy and out of the environment. The Government of Canada published its Single-use Plastics Prohibition Regulations in June 2022 (Canada Gazette, 2022). Alberta plans to establish itself as a western North America centre of excellence for plastics diversion and recycling by 2030 (GoA, 2020) and is implementing extended producer responsibility to incentivize recycling.

Other Clean Technologies

In addition to clean technologies described above, Alberta Innovates has also been working on:

- Land management for land reclamation and restoration, and climate adaptation;
- Alberta Smart Grid Consortium to increase renewable energy for electricity production and improve energy efficiency in power distribution;
- Digital Technology for Clean Energy (DICE) to improve energy efficiency in all aspects of industrial resource operations, and

- Bioindustrial Materials to improve sustainability and energy efficiency in the built environment.

Concluding Remarks

Leadership and significant support are needed from governments and the private sector to drive innovation, especially around hydrogen, CCUS, bitumen beyond combustion, and sustainable agriculture. Beyond funding support, governments have a role in promoting collaboration between jurisdictions and agencies to promote development and reduce barriers.

Existing programs, infrastructure and expertise mentioned in this paper should be leveraged to accelerate the development and deployment of clean technologies across Canada. Clean technology innovation can be accelerated if federal funding could leverage programs already in place at organizations such as Alberta Innovates. Artificial barriers to funding flow should be removed.

Just as several technologies contribute to the existing energy mix, a suite of solutions will be needed to decarbonize our economy and address the climate change crisis. It is appropriate for the federal government to focus on cleantech deployment that can help Canada achieve its 2030 targets. However, a fraction of the funding should also be made available to support cleantech development that will ensure Canada is on a good course for achieving its longer-term net-zero goals.

The clean technologies highlighted here will help Canada meet emissions targets and obligations, and we can take it one step further by exporting our technology and expertise to help other countries meet their NZE goals as well.

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