carbonNEXT

CCUS:

THE CASE FOR CANADA

November, 2022

FORESIGHT CANADA

Carbon Management Canada

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FORESIGHT CANADA

About Foresight

Foresight is enabling Canada to become the first G7 country to reach net zero. To accelerate the transition, we need to rapidly launch, commercialize, and scale climate solutions. With the support of our Helix 5 partners - innovators, industry, investors, government, and academia - Foresight is relentlessly driving cleantech innovation in Canada.

Carbon Management Canada

About CMC

Carbon Management Canada is the industrial solutions hub for greenhouse gas (GHG) reduction and carbon capture, utilization, and storage (CCUS). We provide experience, applied research, knowledge and infrastructure to accelerate results.

UNIVERSITY OF CALGARY
Global Research Initiative in Energy Research

About GRI

This research was supported in part through funding from the University of Calgary's Canada First Research Excellence Program: the Global Research Initiative in Sustainable Low-Carbon Unconventional Resources.

Foreword from carbonNEXT Title Sponsor, Scotiabank

Climate change is one of the most significant domestic and global challenges of the century. As a Leading Bank in the Americas, Scotiabank believes we have an important role to play in addressing climate change and supporting the transition to a low-carbon economy across our footprint and around the world.

Consistent with being a signatory to the Net-Zero Banking Alliance, we have committed to being a net-zero bank by 2050, including achieving net-zero emissions from our operations and net-zero financed emissions by 2050[1]. At Scotiabank, we recognize that efforts to address climate change will require action from both the public and private sectors. Technological innovation will be critical as we support our clients' decarbonization journeys, particularly those in carbon-intensive, hard-to-abate industries. For this reason, we have allocated $25 million over 10 years to support research and development that will help advance solutions for the transition to a net-zero economy.

As part of our commitment to being a net-zero bank by 2050, we are pleased to partner with carbonNEXT to help drive the development and scaling of Canadian CCUS ventures. Our partnership will support carbonNEXT as it works to accelerate commercialization and adoption of Canada's carbontech solutions, positioning Canada as a global leader in CCUS.

As this report outlines, and as highlighted in Scotiabank's Net-Zero Pathways report, carbon capture, utilization and storage (CCUS) must be a critical part of Canada's decarbonization pathway. CCUS is an important suite of technologies for reducing emissions from heavy industry (such as oil and gas) and for removing carbon already in the atmosphere. The International Energy Agency (IEA)'s energy sector modelling shows CCUS playing an important role in achieving net-zero by 2050.

The price on carbon – scheduled to reach $170/t-CO2 by 2030 – and the fiscal support through the Investment Tax Credit for Carbon Capture, Utilization, and Storage will help drive the business case for CCUS project development. Furthermore, world-leading regulatory clarity around CCUS development in Alberta and Saskatchewan and existing CCUS infrastructure, including the Alberta Carbon Trunk Line, the world's largest-capacity CO2 pipeline, are capturing investor attention and drawing increasing investment.

Canada's unique government policies and advanced infrastructure help make it a leading jurisdiction for CCUS project investments. Canada has an immediate opportunity to capture this growing global market opportunity, establishing itself as a leader in one of the most lucrative growth sectors of the energy transition. Yet, significant gaps remain in the innovation ecosystem preventing promising ideas from becoming commercially successful solutions. To fully leverage our innovation leadership for commercial and environmental success, we encourage greater strategic commercialization support from the private and public sector and increased collaboration as we work together to advance the transition.

Sincerely,

Kim Brand
Vice President & Global Head
Sustainability

Scotiabank®

[1] *Financed emissions is defined as "absolute emissions that banks and investors finance through their loans and investments." (PCAF Global GHG Accounting Standard for the Financial Industry, p.107)*

The Imperative for CCUS

There is growing consensus that carbon capture, utilization and storage (CCUS) must play a key role in the net-zero transition. According to the International Energy Agency (IEA), to achieve net zero by 2050, the CCUS sector will need to capture and sequester or convert more than 7.5 Gigatonnes of CO2 per year, representing an increase of 200 times today's level.[1] CCUS is recognized as a core solution by both the IEA and the Intergovernmental Panel on Climate Change (IPCC) and now is the time to grow the sector in Canada.[2,3]

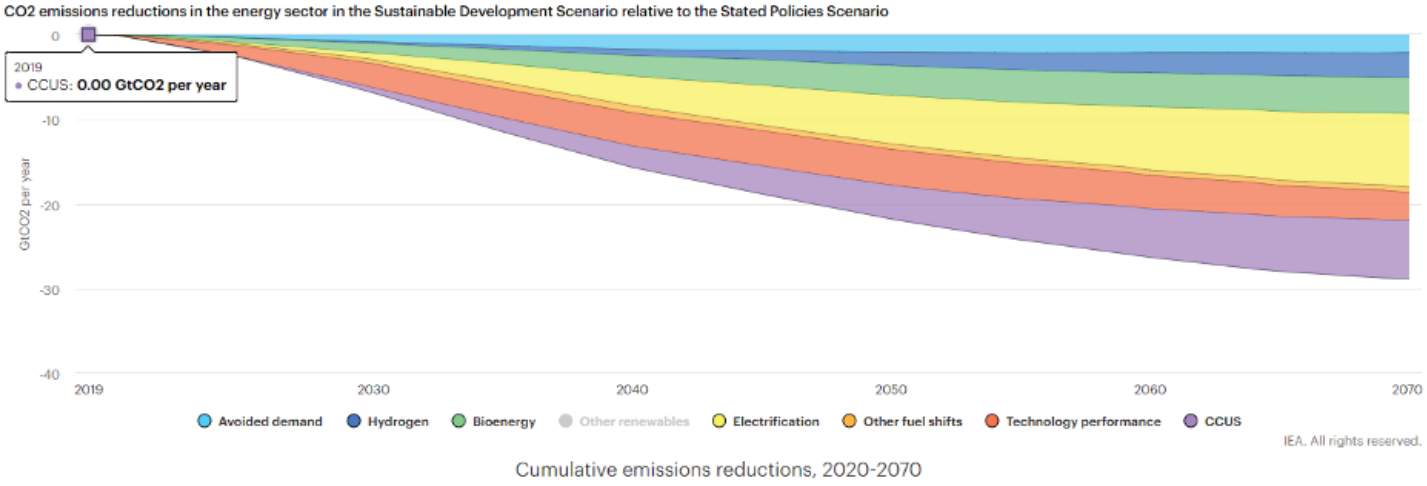

Figure 1: Cumulative Emissions Reductions by Abatement Solution[4]

While the evidence is clear that CCUS is a critical part of the net-zero future, significant technology gaps remain. Many emissions-intensive industries have little or no commercial experience with CCUS. Removing CO2 from the atmosphere is a critical tool for achieving net zero but remains too costly (see Box 1). According to the IEA, two thirds of the emissions reductions required through CCUS come from technologies that are not yet commercial.[4] Solving these technology innovation and commercialization challenges is essential.

While the scale of this endeavour may be daunting, it offers tremendous economic opportunity. Carbon180 estimates that the total market for CO2-based products and services could be worth well over $1 trillion USD per year.[5] It is a race among companies and countries to gain traction in this new sector.

Canada has many of the key ingredients to build a successful CCUS sector, including project expertise, strong climate policies and supportive fiscal frameworks, well developed regulatory frameworks and more. The country's CCUS technology leadership is evident, with the country outperforming on related patents and emerging start-ups. It is home to a dynamic ecosystem of innovators working to deliver the next generation of solutions. But obstacles remain. Canada has a poor track record of leveraging early innovation leadership into commercial success.

This report demonstrates Canada's unique opportunity in CCUS. To make the most of this opportunity, Canadians need to build on the momentum established from previous project investments with enabling policies and fiscal support. Industry and governments need to provide strategic innovation and commercialization support for emerging CCUS solutions. If done right, the country is poised to take an outsized share of the $1 trillion USD per year carbon sequestration market, help meet its own climate commitments, and provide the world with the storage and technology solutions needed for global net-zero success. This report explores the necessary conditions for Canadian leadership in CCUS, looking at how Canada can create the enabling environment for CCUS projects, and how to accelerate CCUS innovation.

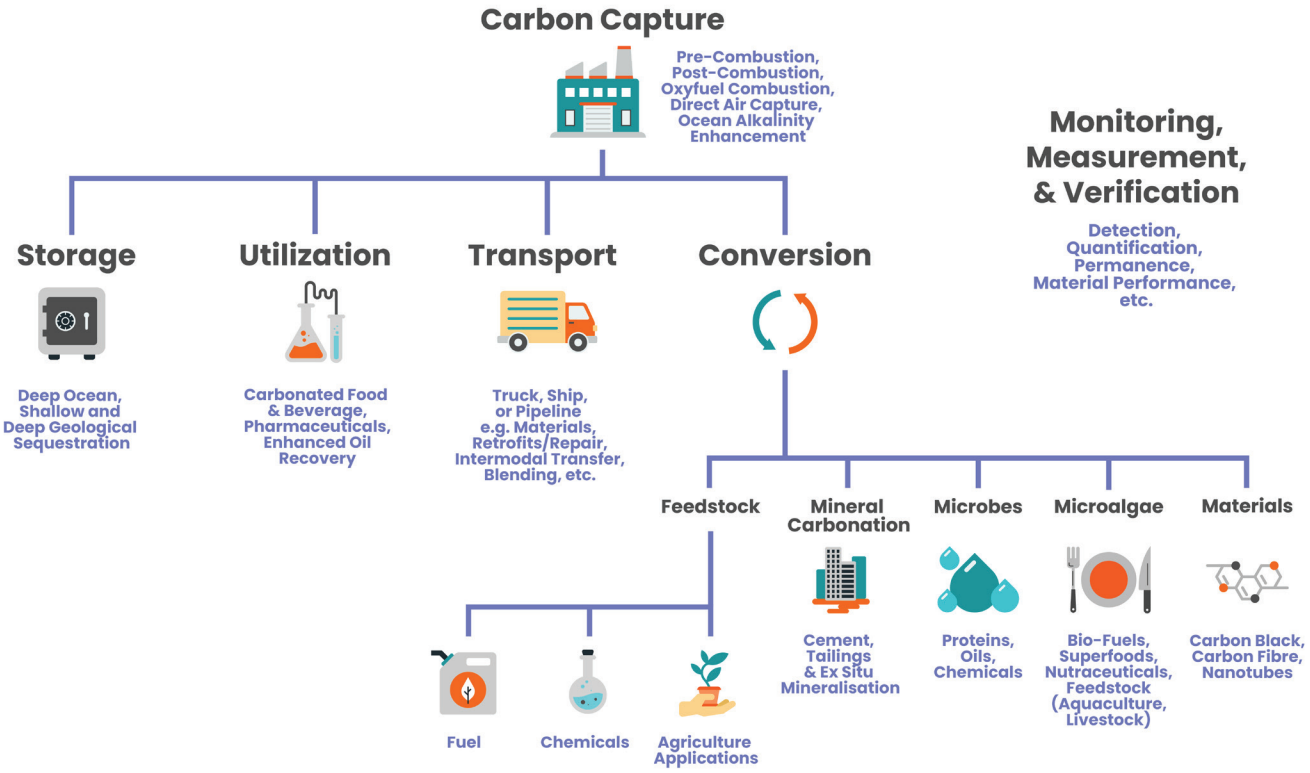

Figure 2: CCUS and carbontech value chain

What is CCUS?

It is the capture, utilization, storage and monitoring of carbon dioxide, the primary greenhouse gas pollutant that drives climate change. It has been identified as imperative to reduce emissions to reach net zero by the IEA, IPCC and Energy Transition Commission. CO2 can be captured from industrial flue gases (smoke stacks) or removed directly from ambient air. It must then be transported and stored or converted into valuable products that retain the CO2.

Storage can be in geologically stable capped formations underground, similar to those which oil and gas are found in, where it ultimately can become rock. These formations have retained hydrocarbons for thousands of years without releasing them to the surface. CO2 can also be sequestered in minerals on the surface that react naturally to retain the CO2.

Once separated, CO2 can be an ingredient in numerous chemicals, fuels, nutrients, and other products that have a high value, displacing existing pathways for those products. Monitoring and measurement technologies are critical for demonstrating that the CO2 is captured and remains in storage or in products, a vital element in carbon credit transactions and in social license for these efforts. CCS, or industrial CO2 capture and geological storage, has over 40 years of operational history behind it.

Canada's experience started in 2000 in Weyburn, Saskatchewan. There, roughly 40 million tonnes of CO2 have been captured at a power plant in North Dakota, piped across the border and sequestered to improve recovery from oil reservoirs through enhanced oil recovery. Global estimates of potential geological sequestration total 13,000 Gigatonnes (Gt) of Carbon Dioxide, with over 400 Gt in Canada alone.

Canada's CCUS Project Development Strengths

Canada has been identified as a global leader in CCUS by the IEA,[6] by Wood Mackenzie,[7] and by other independent experts. With global interest growing in CCUS, Canada is well-positioned to take an outsized share of this emerging industry. Companies and investors are starting to take notice.

Canada has a $25B CCUS Megaproject Pipeline

Today, there are at least 10 CCUS megaprojects proposed, with capital budgets of $1 billion or more (see Table 1), spanning industrial applications. The total capital budget of this CCUS project pipeline is estimated at over $25 billion by 2030.[8] The associated sequestration capacity is similar in scale to all the CCUS projects currently operating in the world, or about 40 Mtpa. What makes these numbers even more impressive is that the projects have all been announced between 2021-2. This momentum is a result of several factors, including:

- **Renewed global interest** in CCUS and hydrogen;
- **Strengthened climate policies** and generous funding support in Canada;
- **Increased commitments** to net-zero by Canada's industrial companies;
- **Increasing access to capital** for large-scale clean energy projects.

Project	Status	Application	CO2 capacity - Mtpa
Shell Polaris	Advanced Development Mid 2020s	Chemical and refining	0.75
Shell & Mitsubishi Hydrogen project	Early Development, Mid 2020s	Hydrogen production	~1.5*
Pieridae Caroline Carbon Capture Power Complex	Early Development Mid 2020s	Power generation	1 - 3
Nauticol / Enhance Energy Blue Methanol	Early Development Late 2020s	Methanol production	1
Air Products net-zero hydrogen complex	Advanced Development Mid 2020s	Hydrogen production	up to 3
Suncor & ATCO Heartland Hydrogen Project	Early Development Mid 2020s	Hydrogen production	2.4
Oil Sands Net-Zero Pathway Alliance	Early development Late 2020s	Steam and power generation for oil sands production	8 by 2030, 30 by 2050
Capital Power Genesee CCS	Early development Late 2020s	Power generation	up to 3
Pembina Pipelines & TC Energy Alberta Carbon Grid	Early development Late 2020s	CCS network	up to 20
Dow net-zero ethylene plant	Early development Late 2020s	Ethylene and chemicals	tbd

Table 1: Major CCUS project proposals in Canada (capital budget > $1 billion)[9]

The successful construction of many these projects is vital for Canada to meet its net-zero commitments and to provide market opportunities for CCUS innovators. But building large and complex capital projects is challenging and development conditions must be right before investors can allocate the billions of dollars needed.

Canada's core competitive advantages in CCUS project development are outlined below.

Canada has been an early leader in CCUS projects:

Canada was one of the earliest adopters of industrial scale CCUS. The country is home to five of the world's 27 operating industrial scale CCUS projects, which together have sequestered about 50 Mt CO2, or about 1/7th of the world's total.[10] This includes the largest cross-national CCUS project (Weyburn-Midale Carbon Capture Project)[11] and the only successful post-combustion CCUS power plant (Sask Power Boundary Dam project).[12]

As urgency to address climate change increases, momentum is building for another wave of CCUS project development in Canada.

> **Canada is already a global leader in CCUS with (five of the world's 27) commercial projects in operation as well as extensive expertise in research and development.**
>
> **– International Energy Agency** [24,25]

Canada is implementing ambitious GHG reduction policies and specific CCUS policy, enabling regulation and financial incentives to drive industrial carbon abatement:

Canada is targeting 15 Mtpa reductions from CCUS as part of its goal to reduce emissions by 40-45% by 2030. To achieve this, the country has implemented a strong climate policy framework, including one of the world's highest carbon prices scheduled to reach $170/t-CO2e by 2030[13], as well as complementary policies including a Clean Fuel Standard with an effective price of over $200/t and an explicit CCUS compliance pathway.[14] Recently, the federal government has firstly taken measures to guarantee the future price of carbon for major industrial abatement projects, and secondly to reduce the capital barrier through a CCUS specific capital investment tax credit, with $8.6 billion of funding available through 2030.[15] A national CCUS strategy is currently in development and is expected soon.

> **In the field of carbon capture and storage (CCS), Alberta is internationally recognized as a leader, with a well-developed business environment including a legal framework and carbon pricing system.**
>
> **- Japanese Oil, Gas and Metals National Corporation (JOGMEC)** [26]

The recent passage in the US of the Inflation Reduction Act substantially increases CCUS support there, transforming fiscal support for CCUS projects to advance.[16] While this may be seen as a challenge to attracting project investments into Canada, it should be seen as further building momentum for the CCUS sector at large, while firmly establishing North America as the top location for CCUS and carbontech in the world.

Canada offers regulatory clarity for sub-surface sequestration:

In addition to strong climate and CCUS financing support federally, key provinces have also created regulatory clarity for sub-surface sequestration. Early project experience in Alberta and Saskatchewan addressed many of the legal and regulatory uncertainties that could impede project development, such as ownership of pore space, management of long-term liability, barriers to social acceptability,

> **Canada has the geological capacity to support the world in their goals of reducing CO2. That in itself will become an industry. Selling offset credits or running CCUS projects to industries around the world.**
>
> **- Greg Maidment, CMC, Director of Operations and Applied Research**

and monitoring to address long-term safety. The concept of carbon tenure (occasionally called pore space tenure) is widely accepted in Alberta. Carbon tenure allows any organization that holds it to conduct well tests and inject CO2 into the subsurface for economic reasons (i.e., injection for the purpose of earning carbon credits).

While Alberta and Saskatchewan have been identified as leaders and models to follow, important regional differences exist. Provinces can create and implement their own frameworks. CCUS policy frameworks are more mature in Alberta and Saskatchewan than in other provinces, grounded in a history of CCUS projects and oil and gas-related experience.

> **Dow selected the Fort Saskatchewan site for a multi-billion dollar investment as the region offers a highly competitive energy and feedstocks position and access to available third-party CO2 infrastructure.**
>
> **- Jim Fitterling, Dow Chairman and CEO** [27]

Canada has the storage to accommodate the world:

The Global CCS Institute reports that Canada has on the order of 400 Gigatonnes of potential onshore geological CO2 sequestration capacity.[17] This exceeds the total global storage needs to meet net-zero emissions for over 50 years. [18] Most of this storage is located in the Western Canada Sedimentary Basin, which has roughly 390 Gt of mapped storage capacity. Importantly, this storage resource overlaps with much of Canada's emissions-intensive industry. Additional offshore opportunities are being investigated in BC and the Maritimes. Canada is home to world-leading research on enhanced weathering and ex-situ (above ground) mineralization. BC alone may be home to over 56 Gt in theoretical potential for ex-situ (above ground) mineralization leveraging existing mine tailings. [19] Storage may also be possible in Ontario due to an abundance of salt formations and depleted oil and gas reservoirs, but additional investigation is needed.

Canada already has key CCUS hubs and support infrastructure in place, and is building out more in the future:

While CCUS hubs remain a theory in most places, in Canada they are reality today. The 14 Mtpa Alberta Carbon Trunk Line (ACTL) – the world's largest capacity CO2 pipeline – connects the Edmonton Industrial Heartland to Enhanced Oil Recovery injection sites near the town of Lacombe, some 240 km away. The ACTL currently gathers 2 Mtpa from capture facilities at the NWR Sturgeon Refinery and the Nutrien Redwater Fertilizer Facility. Several additional megaprojects have been announced with plans to link into the ACTL, including a Dow net-zero ethylene and chemicals facility and the Air Products net-zero hydrogen complex. Both have highlighted the ACTL as key reason to invest in Canada.[20]

To drive cost-efficient growth of operating CO2 sequestration sites, the Alberta Government has undertaken a call for large-scale injection hubs. Six CCUS hub proposals are currently being evaluated by the Alberta Government for the Edmonton region alone,[21] and 19 additional hubs are in planning stages across Alberta.

Social license is strong in Canada's key CCUS regions:

Past Canadian CCUS projects have often not faced the public opposition that projects in other countries have experienced. Enabling factors include:

- **A growing domestic history of successful project** development and operation experience,
- **Effective benefit sharing arrangements** with host communities,
- **Positive perceptions** about projects among host communities and wider publics, and
- **Trust in mechanisms** to mitigate project-related risks that include geological storage, extensive monitoring, and CO2 transport safety.

These positive indicators are underpinned by trust in the processes for securing operating permits and permission from the host community.

Projects are arguably more likely to come to fruition in Canada than in other jurisdictions. Of eight large-scale demonstration projects provided Canadian Federal funding support between 2008-2015, five are in commercial operation today.[22] By contrast, a recent study by the US Government Accountability Office found that of the 11 CCUS projects of similar scale supported by the US DOE over the same time period, only two are operating today.[23] Most notably, given the challenges faced by pipelines, the world's largest CO2 pipeline was built without notable public protest or opposition.

Advancing CCUS projects outside the Canadian Oil and Gas sector:

While Canada's CCUS project pipeline shows a diversity of projects across sectors, geographically these are concentrated in Alberta, whereas Canada's manufacturing sector is concentrated in Ontario and Quebec. To remain competitive while positioning for net zero by 2050 is a disproportionate challenge for many of Canada's emission-intensive industrial manufacturers. Industries including steel and aluminum smelting, commodity chemicals, fertilizer, and pulp and paper generally have long-lived, non-uniform facilities producing low margin goods while facing trade-exposure and emissions-leakage risks. Their limited ability to pass costs on to customers coupled with low free cash flow decreases their ability to invest in capital-intensive plant upgrades. Unlike Canadian oil and gas, which has been at the global forefront of CCUS investment globally since the early 2000s, these industries have been less of a focus for activists, regulators and climate-focused investors until recently. There is a political tendency to shelter these facilities from regulation due to fears around employment loss. As a consequence, many of these manufacturers have not faced carbon pricing to date, and are only now staffing up with expertise in energy transition. CCUS is especially important for these industries, as many of their core processes are inherently CO2 emitting (e.g., pulp and paper, steel making, cement). Even if all energy needs are met with clean sources, CCUS will still be needed to achieve deep carbon reductions. In addition to limited project experience, most face significant challenges around CO2 sequestration due to lack of proven technology, unfavorable geology and absence of physical and regulatory CCUS infrastructure in the parts of the country in which they operate.

Carbon-intensive low-margin commodity industries outside of oil and gas jurisdictions will need additional support to achieve a critical mass of project deployments. Federal funding support through the CCUS investment tax credit is limited to $8.6 billion, will be allocated on a 'first come, first serve basis', and must be invested by 2030. This favours those facilities with associated infrastructure and policy in place already, and those who are already organized to receive it, resulting the geographic concentration within the project pipeline above.

Federal and provincial governments should work with these sectors to build capacity, develop tailored policy support, and advance infrastructure solutions to enable successful CCUS uptake across a range of heavy industries.

Canada's CCUS Innovation Ecosystem Strengths

While there is increasing acknowledgment that CCUS is a critical solution to reach net-zero, there is also acknowledgment that serious technology gaps still exist (see Box #3[28,29]). Canada is well placed to address many of these gaps.

> **Two-thirds of the cumulative emissions reductions from CCUS … come from technologies that are currently at the prototype or demonstration stage. Given the time lags involved, innovation needs to be stepped-up now to ensure key applications are commercially available in the coming decades**
>
> **- International Energy Agency[30]**

Key CCUS Technology Gaps:

Through research, practical experience and consultation with industry, innovators and other stakeholders, the following technology gaps were identified in the CCUS landscape:

Capture:

- Design high performing solvents with lower costs and lower energy requirements
- Develop solutions for post combustion capture from flue gases with low CO2 concentrations
- Novel direct air capture technologies that are energy efficient and have costs comparable to current and future carbon pricing systems

Sequestration:

- Improve technologies to more simply and more accurately assess pore-space availability to identify locations and help with regulatory approvals
- Understanding dynamic pressure limits for gigatonne-scale CO2 injection
- Commercialize and scale mineralization solutions to realize this gigatonne carbon removal opportunity

Utilization:

- Develop novel processes to use CO2, carbon black and related substances as feedstock for useful products and e-fuels

Measurement, Monitoring and Verification:

- Better measurement, monitoring and verification (MMV) technologies to reduce costs and build trust in sequestration performance

Canada has established a high-performing CCUS innovation ecosystem for generating CCUS technologies, and building CCUS companies:

Canada has a large network of world-class research centres focused on CCUS-related Research and Development– the first step in the technology innovation process.

Grounded in this diversity of academic work and motivated by public interest, the country has become a world leader in CCUS start-up generation and technology patenting. According to recent research, Canada holds eight per cent of the global carbon to value patent pool, and 14% of CCUS patents overall.[31]

The country is home to four XPRIZE winners, and three of the most successful CCUS start-ups with Carbon Engineering, Svante, and CarbonCure – each of which have raised over US$100 million and are likely on track for unicorn status (>US$1billion valuation).

A next generation of CCUS-focused start-ups is rapidly gaining traction, backed by leading cleantech investors such as Bill Gates and Lowercarbon Capital, and by climate-minded celebrities such as Leonardo DiCaprio.

> **The Canadian government is good at supporting early-stage innovation, while Canada's industries are often slow to adopt new technologies.**
>
> **– David Sanguinetti, Foresight Canada**

While Canada has shown strong innovation leadership in cleantech generally, it has been less successful in bringing solutions to market and scaling them broadly. The challenges for scaling and commercializing cleantech solutions in Canada have been extensively studied and include[32]:

- **A lack of capital at specific points in venture development:** Solution providers find it challenging to access private capital to build their start-up and to scale up their innovation. While public grants are abundant, they are generally focused on enabling early-stage innovation, with a gap in funding for scaling and for large capital-intensive project deployment.

- **Lack of alignment with regulatory standards, combined with slow updating of these standards:** Regulatory standards and codes do not adapt to novel technology offerings, providing a critical barrier for adoption.

- **Lack of market understanding by solution providers:** Innovators need to strengthen their understanding of their customers and target markets, as well as the associated regulatory, safety, logistical and other constraints faced 'on site'.

- **Solution fatigue:** Industry leads are overwhelmed by the number of solutions presented to them and by how to best evaluate emerging technologies for their operations.

- **Excessive focus on domestic markets rather than global opportunities:** Canadian cleantech companies often focus on Canadian markets, and are unaware of the global opportunities for their technology solutions.

- **Lack of ecosystem coordination:** A complex ecosystem that is challenging to navigate for early-stage companies

- **Lack of startup experience:** Limited entrepreneurial experience, business training and soft skills within the cleantech entrepreneur community

The capital-intensive nature of CCUS projects builds on these challenges by decreasing risk appetite by industrial customers or project developers to back capital-intensive and unproven concepts. Solution providers, industry, and governments must work together to overcome these challenges to capitalize on Canada's CCUS innovation leadership

Addressing Ecosystem Gaps

Given Canada's CCUS innovation strength, it is critical to address these innovation ecosystem gaps. Below we explore two key initiatives that aim to do just that.

National CCUS Solutions Accelerator

In 2021 Foresight and CMC established carbonNEXT, Canada's carbontech commercialization hub, with the goal to streamline the journey for innovators and for industry partners. We leverage the country's largest pipeline of emerging cleantech solutions providers through Foresight Canada. CMC provides valuable knowledge, connections, access to test bed facilities, and experience supporting industrial emissions reduction solution validation and commercial deployment.

carbonNEXT works with partners across the innovation ecosystem to grow the number, quality, and scale of carbontech ventures through CCUS-specific training, mentoring, validation & capital access support. It seeks to establish a demand-led innovation ecosystem that collaborates to accelerate carbontech solutions to real market needs. To do so, it leverages existing infrastructure across the country including CMC and public sector technology validation facilities, technical expertise, and funding partners. It drives domestic and international adoption by heavy emitters leveraging our relationships and innovation challenge model.

Using Challenges to Accelerate CCUS Solution Commercialization:

Context:

There is insufficient effort focused on innovation in CCUS to drive down cost, broaden commercial applications across hard-to-abate industries, and improve scalability. In spite of the ~20% of global emissions that are forecast as needing to be addressed by CCUS to achieve net zero, annual CCUS investment accounts for less than 0.5% of the total R&D investment in clean energy and abatement technologies according to the IEA.

Solution:

An innovation challenge grant or prize pulls forward technology to commercialization more quickly, or focuses innovators and research on needs that would not otherwise be addressed by the market, while derisking the solution for prospective buyers. Core to their success is a combination of marketing and market: to mobilize the largest number of solution developers, and to provide innovators with customers who will buy the resulting technology at a scale needed to make viable a business. XPRIZE Foundation reports that it is critical in these efforts to focus a challenge on a need that would not be solved by the market on its own, either because the available solutions are immature or because the current portfolio of potential solutions is too narrow.

CRIN LEVAP:

In 2021, the oil and gas focused Clean Resource Innovation Network (CRIN) ran a $30M Low Emissions Fuels and Products competitive challenge. Out of 46 submissions, four winning partnerships between small and medium-sized enterprise innovators and oil and gas producers received funding for projects with a total capital cost of $106M, deploying emerging solutions for hydrogen production through methane pyrolysis, fuel cell-enabled industrial flue gas carbon capture, and transformation of captured CO2 to graphene. CRIN estimates these projects will result in 55 Mt in greenhouse gas emissions reductions by 2033. As part of the carbonNEXT initiative, annual industry-led innovation challenges will be used to drive solutions to the gaps impeding CCUS deployment.

The Canadian Carbon Capture, Utilization and Storage Research and Technology Network

Canada has many testing facilities and expertise-based organizations for CCUS technology development and commercialization. However, finding the right organization to advance a technology quickly and efficiently can be a challenge for industry and technology developers. While Canada's CCUS-related infrastructure network is world class, the path for commercialization for both domestic and global technology developers is often slowed by a lack of connections and inefficiencies in the system. The Canadian CCUS Research and Technology Network connects innovators, industry and funders with the facilities and expertise needed to validate their solutions, advance prototypes and pilot pre-commercial technologies. Members share expertise, capacity, testing and demonstration services, technologies, research and development, and funding opportunities with each other to accelerate the commercialization of solutions. Carbon Management Canada acts as the concierge to communicate the members' capabilities to global and domestic solution developers. In advancing the Network, the five world-class Canadian organizations have connected to provide their expertise with facilities and equipment to help demonstrate, scale and validate CCUS technologies.

Through these activities, carbonNEXT and the Canadian CCUS Research and Technology Network aim to bring together partners to help overcome key barriers to scaling the country's carbontech solutions. Their ultimate goal is to drive a commercial inflection point that will fast-track adoption of Canadian technology to support the world in its quest to reach net-zero.

Photo Credit: Carbon Upcycling Technologies

Photo Credit: Alberta Carbon Conversion Technology Centre. Photo provided by InnoTech Alberta

Alberta Carbon Conversion Technology Centre:

InnoTech Alberta operates the Alberta Carbon Conversion Technology Centre (ACCTC). InnoTech is a member of the Canadian CCUS Research and Technology Network. The ACCTC is a custom facility established to de-risk and demonstrate CO2 capture, utilization, conversion, and hydrogen technologies in real-life conditions within a semi-commercial scale environment.

A recent example of supporting the innovation community is its work with the award-winning startup Carbon Upcycling Technologies. The startup tested its technology by using ACCTC's amine capture unit capturing CO2 from the nearby natural gas powerplant. Over repeated visits to this controlled testing environment, Carbon Upcycling was able to build their 20 tonne/day reactor, scale up and build their 50 tonne/day modular reactor, and validate their technologies with over 30 different feedstocks. ACCTC provided critical R&D space to test and validate the technology, allowing the Carbon Upcycling Team to validate their designs and focus their technology to customer needs.

Summary and Call to Action

There is increasing understanding that CCUS has a critical role to play in achieving the world's net-zero goals. CCUS is not just an environmental imperative, but also offers substantial economic opportunity. Canada has been identified as a top location for CCUS project deployment and technology development by leading institutions including the IEA and Wood Mackenzie. The country has all the key ingredients for success, including ample project experience, strong policy support, suitable geology, existing large-scale CCUS infrastructure, a rich innovation ecosystem, and more. This is a chance for Canada to attract $billions in investments, enhance the long-term competitiveness of our domestic manufacturing industries, make meaningful progress towards our climate targets, and help develop the climate solutions needed for the global net-zero transition.

It also represents a chance to turn the page on the country's past challenges to leverage innovation leadership into commercial success. Strategic innovation support is needed to address gaps in the current innovation ecosystem such as carbonNEXT and the Canadian CCUS Research and Technology Network.

CCUS represents a trillion dollar market opportunity. If played right, Canada has a chance to take an outsized share in this to advance its economic and environmental objectives. To advance projects and the innovation ecosystem, the following priorities should be pursued:

- **Position Canada as a leader:** As laid out in this report, Canada has many strengths and differentiators, including project experience and social license, which should be communicated to project developers, investors, and innovators;

- **Collaboration across stakeholders:** Governments, industry, innovators, and thought-leaders must lean in to make CCUS a commercial and environmental success;

- **Level the playing field:** Align incentives for project development with US and provide additional support for early deployments across the country;

- **Close the technology gaps:** Accelerate the innovation ecosystem in Canada through support for technology validation, commercialization and first deployments, addressing the mismatch in decision cycles between startups and large corporates, collaborating to bring the most promising and needed solutions to markets, and delivering clearly-articulated parameters regarding market needs.

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