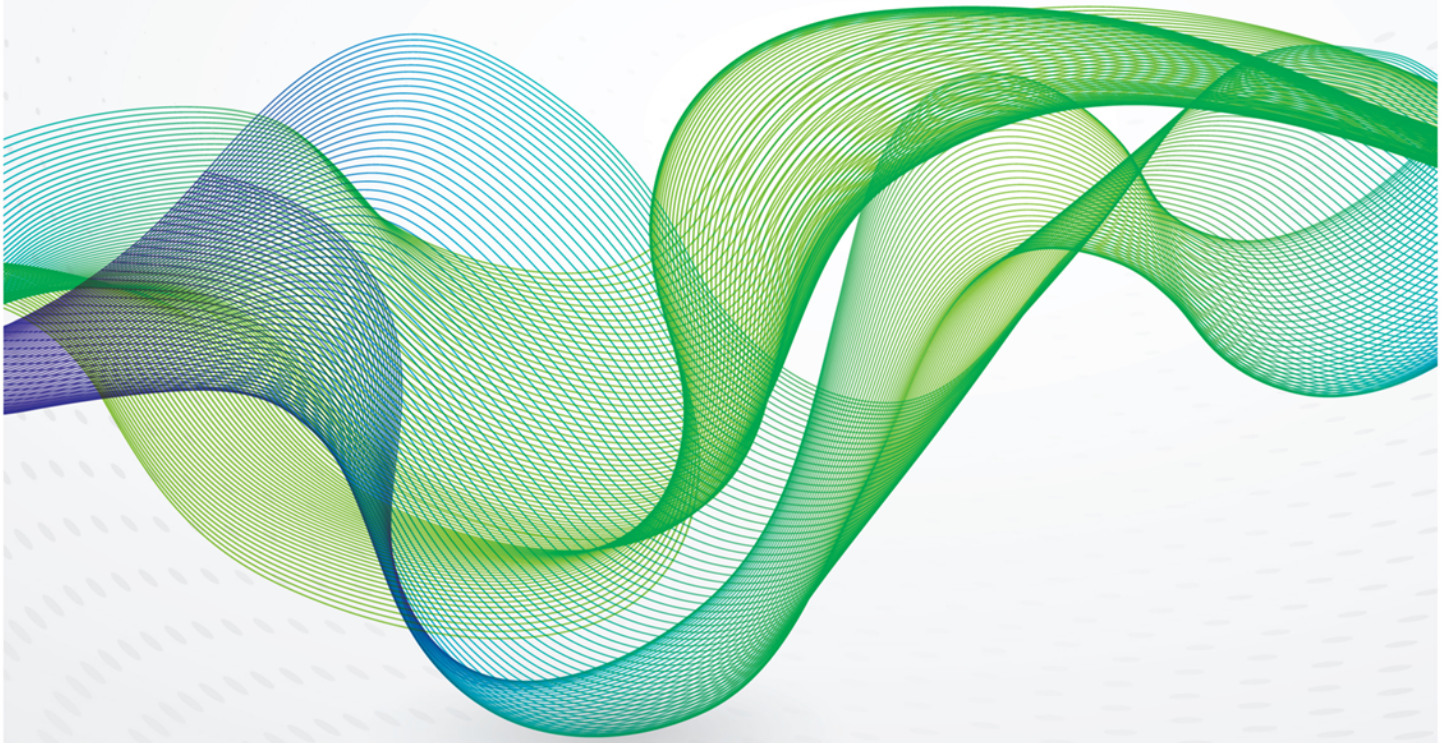
THE OXFORD INSTITUTE FOR ENERGY STUDIES

April 2023

Scaling CCUS in Canada:

An Assessment of Fiscal and Regulatory Frameworks



OIES Paper: CM02

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ISBN 978-1-78467-201-0

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1. Introduction

The global push for industrial decarbonization and transitioning away from fossil fuels has a few battlegrounds[1], and Canada is one of them. Although a staunch advocate of clean electrification, enabled by a power generation sector that is 83% emissions-free[2], Canada still finds itself cast as a villain when it comes to the energy transition. The reasons for this can be found in the vast oil sands deposits located in northern Alberta. While carbon emissions intensity has dropped by 20% since 2010, absolute emissions – driven by a 57% increase in oil production – have increased over the same period. From a well-to-wheels standpoint, oilsands crude is still up to 9% more carbon intensive than crudes refined in the United States[3]. Economically, crude oil is Canada's largest source of export revenue and is considered a significant part of the country's long-range economic plan.

It is no surprise, then, that the country enthusiastically welcomed the advent of carbon capture utilization and storage (CCUS). This technology has the potential to capture over 90% of the carbon emissions associated with flue gas production from various combustion processes[4]. Its appeal has been enhanced due to its role in enabling the production of cleaner hydrogen. Since 2014, a few projects have been piloted and commercialized in Canada spanning a variety of capture points from coal-fired power generation to bitumen upgrading, refining and ammonia processing. The most significant of these are the Quest project at the Shell Canada-operated Scotford upgrader in Central Alberta which captures approximately 1MtCO_2e/year, and the Alberta Carbon Trunk Line (ACTL) which captured 1.1MtCO_2e in its first year from the Northwest Redwater (NWR) refinery and the nearby Nutrien fertilizer plant[5].

These two projects have proven to be successful in meeting their operational targets, but the picture is more nuanced when it comes to their economic value. Quest permanently stores captured CO_2 in a saline aquifer and ACTL utilizes its CO_2 to stimulate depleted oil wells in Central Alberta for enhanced oil recovery (EOR). While the latter can be profitable through sales of the marginal crude oil produced, the former does not have the same ability to offset levelized CCUS costs which are, despite impressive cost reductions, estimated to be around \$74/tCO_2e[6,7]. In 2018, the Canadian government implemented the Greenhouse Gas Pollution Pricing Act (GHGPPA), comprising of a federal fuel charge for all fossil fuels paid by either the producer or distributor in a province; and an output-based pricing system (OBPS) for industrial facilities[8]. The federal OBPS is designed to ensure there is a price incentive for industrial emitters to reduce their greenhouse gas (GHG) emissions and spur innovation while maintaining competitiveness and protecting against "carbon leakage" (the risk of industrial facilities moving from one region to another to avoid paying a price on carbon pollution). Alberta has long had its own large emitter program and associated carbon price, beginning with the Specified Gas Emitter Regulation in 2007[9].

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[1] Nickel, R. & Williams, N. (2021, June 22). *Canada's climate plan charts hard road ahead for high-polluting oil sands*. Retrieved from Reuters: https://www.reuters.com/business/environment/canadas-climate-plan-charts-hard-road-ahead-high-polluting-oil-sands-2021-06-22/

[2] IEA (2022), Canada 2022, IEA, Paris https://www.iea.org/reports/canada-2022, License: CC BY 4.0

[3] Kaplan, L. & Milke, M. (2020, August 11). *Canada's emissions intensity has fallen 30% since 2000, ranking it lower than several energy-producing and consuming nations*. Retrieved from Canadian Energy Centre: https://www.canadianenergycentre.ca/evaluating-the-canadian-oil-and-gas-sectors-ghg-emissions-intensity-record/

[4] Serin, E. (2023, March). *What is carbon capture utilization and storage (CCUS) and what role can it play in tackling climate change?* Retrieved from LSE: https://www.lse.ac.uk/granthaminstitute/explainers/what-is-carbon-capture-and-storage-and-what-role-can-it-play-in-tackling-climate-change/

[5] Government of Alberta*Alberta Carbon Trunk Line project : knowledge sharing report, 2021*

[6] Venkatachalam, V., & Kaplan, L. (2022, July 5). *Assessing the future use of carbon capture, utilization and storage in Canada's oil and gas sector.* Retrieved from Canadian Energy Centre: https://www.canadianenergycentre.ca/assessing-the-future-use-of-carbon-capture-utilization-and-storage-in-canadas-oil-and-gas-sector/

[7] All amounts in Canadian dollars, unless otherwise specified

[8] Government of Canada. (2023, March 6). *Greenhouse Gas Pollution Pricing Act*. Retrieved from Justice Laws Website: https://laws-lois.justice.gc.ca/eng/acts/g-11.55/

[9] Emissions Reduction Alberta (2022). *We are a part of Alberta's climate and innovation history*. Retrieved from ERA: https://www.eralberta.ca/history/

Both parts of the GHGPPA are linked to a carbon pricing schedule that is $65/tCO_2e$ in 2023, with escalating annual increases of $15/tCO_2e$ until it reaches $170/tCO_2e$ in 2030. Provinces have been required to either implement an equivalent pricing system or be compelled to adopt the federal one as a backstop. Provincial systems must meet the minimum national stringency. In Alberta, facilities that are covered by the provincial Technology Innovation and Emissions Reduction (TIER) regulation enacted in 2020 are exempt from the federal OBPS. Under the initial rollout of TIER in 2019, facilities which emit over 100 $ktCO_2e$/year are required to comply with the regulations, while those emitting at least 10 $ktCO_2e$ annually can voluntarily participate. The allowable emissions limit for a facility is based on either a high performing benchmark or facility specific benchmark, subject to tightening rates. After a review of the TIER program in 2022, some changes were made to meet the updated federal benchmark criteria for 2023 to 2030. These are summarized in Table 1.

Table 1: Comparison of GHGPPA and TIER

Carbon Pricing Mechanisms	Federal OBPS	TIER (2019)	TIER (2022)
2023 Carbon Price ($/tCO$_2$e)	65	65	65
Facilities Covered (ktCO$_2$e/Year)	50	100	100
Facility Opt-In (ktCO$_2$e/Year)	10	10	2
Benchmark[1]	80% of Sector Best	90% of Facility Best	90% of Facility Best
Stringency Rate[2] (%)	Variable	1%	2%
Credits Expiry (Years)	5	Up to 9	5

[1]Historical performance, [2]Additional improvement over the historical performance required each year

Source: Compiled by authors from various sources

In addition to increasing the tightening rate, the changes also confirmed that the cost of a TIER fund credit would continue to match the federal carbon price, providing certainty to firms. Compliance options can be any combination of proven onsite emissions reductions, application of emissions performance credits (EPCs), use of Alberta-based emissions offsets or payment into the TIER fund[10]. The new regulations better align TIER with the amended federal requirements, and for Canadian oil and gas firms, they provide a measure of certainty to compliance costs.

This study examines the techno-economic reality of CCUS deployment in Canada today, with a focus on Alberta. It also assesses whether the current regulatory and fiscal frameworks are strong enough for CCUS to play a key role in Canada's goal of reducing emissions by over 40% by 2030, compared to 2005 levels[11].

2. CCUS in the Context of the Canadian Oilsands

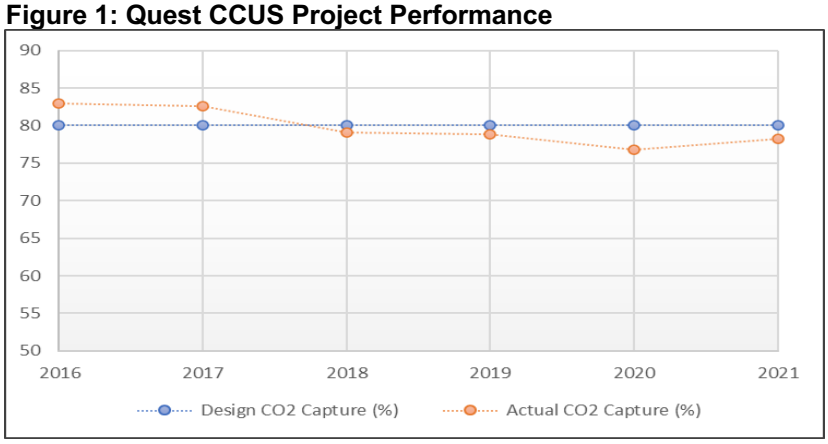
CCUS projects have existed in Canada for nearly a decade, but their operation – and potential limitations in application – may not be appreciated by the lay public. CCUS can be used to capture over 90% of the emissions associated with a particular process or unit. This is often translated in the general media as technology able to capture 90% of a facility's total Scope 1 emissions, but this is not practical. CCUS is generally installed at large point sources, where combustion for power or chemical processing occurs. At a typical industrial facility, this would largely be the steam and power generators, hydrogen production plants and in the chemical transformations required to produce fertilizer, synthetic fuels and cement. However, there are other units that consume heat, including buildings, mobile equipment, light-duty vehicles and other small point sources. Quest, for example, was designed to capture 80% of the

[10] Government of Alberta. (2023). *Technology Innovation and Emissions Reduction Regulation*. Retrieved from https://www.alberta.ca/technology-innovation-and-emissions-reduction-regulation.aspx

[11] Environment and Climate Change Canada (2022). 2030 Emissions Reduction Plan, Table 6.8.

CO_2 from the syngas streams at three hydrogen units within the Scotford upgrader. This corresponds to 50% of the total CO_2 emissions from those units[12].

Figure 1: Quest CCUS Project Performance

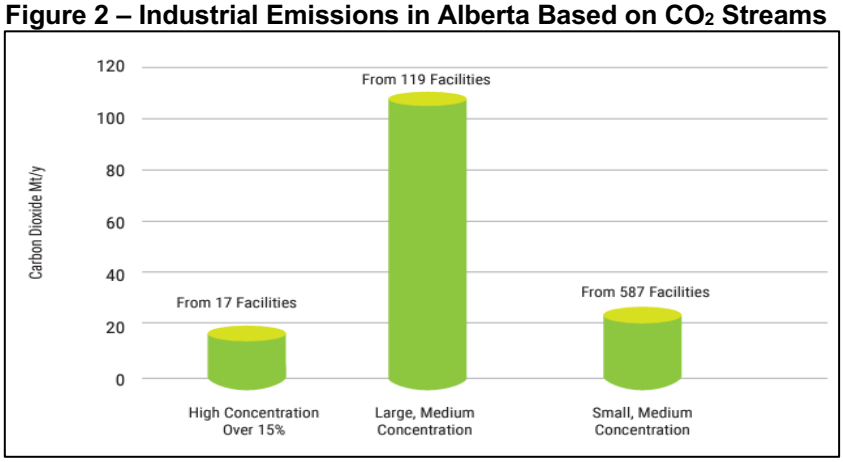


Source: Authors' illustration.

The actual performance of Quest relative to design is shown in Figure 1. Project utilization has averaged 99.6% in the first six years of operation and 0.8MtCO_2/year has been avoided when capture, transport and storage emissions are considered. Over the same time, the Scotford upgrader emitted an average of 1.2MtCO_2/year, resulting in a total facility emissions reduction of 40%. This full picture highlights both the world class application of CCUS technology in the Canadian oil industry and its limitations as a panacea for all Scope 1 and 2 emissions.

The Quest project has also demonstrated the safety and effectiveness of transporting CO_2 long distances in variable weather conditions for permanent storage, with no emissions losses. However, differences in point source size and CO_2 stream purity will be limiting factors in which technologies can be applied. Commercial technologies are available for facilities with high CO_2 concentrations, but these make up just over 11% of industrial emissions in Alberta[13]. As shown in Figure 2, most industrial emissions are from large facilities with medium concentrations of CO_2, particularly gas-fired boilers, once-through steam generators and high temperature furnaces.

Figure 2 – Industrial Emissions in Alberta Based on CO_2 Streams



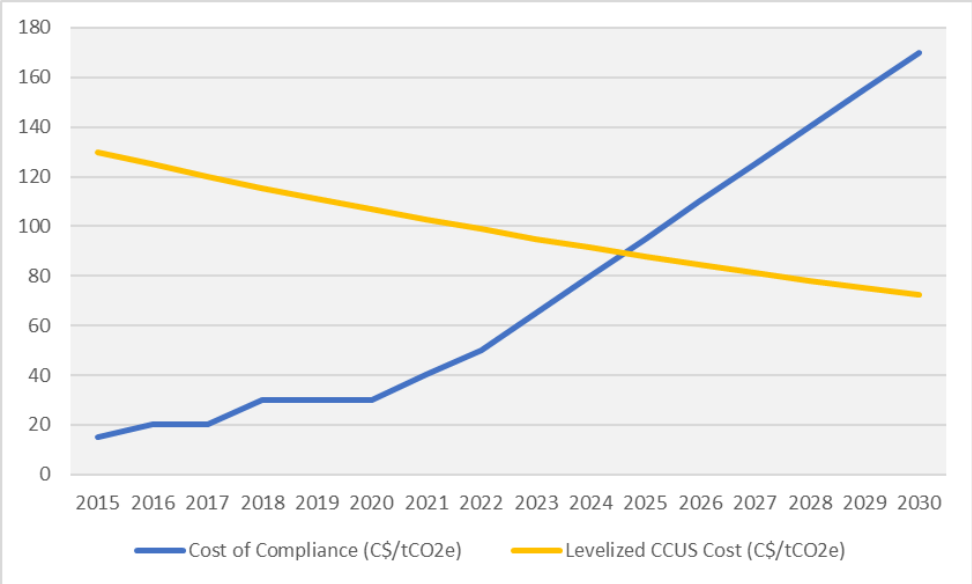
Source: Alberta Innovates

[12] Government of Alberta. (2011, December 1). *Environmental Assessment - Shell Canada Limited Quest Carbon Capture & Storage Project*. Retrieved from Alberta Open Government: https://open.alberta.ca/publications/4921835

[13] Alberta Innovates. (2022, April). *CCUS White Paper*. Retrieved from: https://albertainnovates.ca/app/uploads/2022/06/AI-CCUS-WHITE-PAPER_2022_WEB.pdf

The major roadblock to the widespread adoption of CCUS as a key tool in the reduction of site emissions is cost. In 2012, the Pembina Institute estimated the cost of carbon capture to be around US$80-US$100/tCO_2[14]. The revamped provincial and federal carbon price schemes, particularly the GHGPPA, have also created a *fait accompli* for CCUS adoption. Previous provincial programs for large emitters were not strong enough on their own – relative to CCUS cost – to make it economic. The pace of change since that time has accelerated, enabled by cost learnings associated with Quest and ACTL - it has been suggested that if Quest was built today, it would cost 30% less[15]. Leveraging 'learning by doing' to drive down cost and the rapidly escalating price for carbon have created a tipping point for CCUS adoption. Figure 3 shows CCUS costs compared to carbon pricing for heavy emitters in Alberta.

Figure 3: Tipping Point for CCUS Adoption? Carbon Pricing for Heavy Emitters in Alberta



Source: Government of Canada, Government of Alberta, Canadian Energy Centre[16], Pembina Institute

The experience that several Canadian producers have gained in exploiting oilsands resources in a harsh environment and proving out the operational effectiveness of CCUS drives a significant amount of confidence in how well CCUS can be executed in Canada. The cost has decreased to a level where multiple entrants are interested in deploying the technology and the potential to leverage the CO_2 networks to support other hard-to-decarbonize sectors is attractive and appears to be supported by governments. Firms – particularly those in oil and gas – are carrying most of the risk and their focus is on structuring their organizations and interactions to de-risk CCUS adoption as much as possible.

3. Enabling CCUS Deployment Through Collaboration

The Canadian government released a hydrogen strategy report in late 2020 which referenced CCUS as an enabler of blue hydrogen and is supporting that with the ongoing development of a carbon

[14] Kilpatrick, Ryan, Adam Goehner, Eli Angen, Matt McCulloch, and Duncan Kenyon. 2014. *CCS Potential in the Oilsands.* Report prepared for Alberta Government, Alberta Innovates, Energy and Environmental Solutions, and Climate Change Emissions Management Corporation, Pembina Institute.

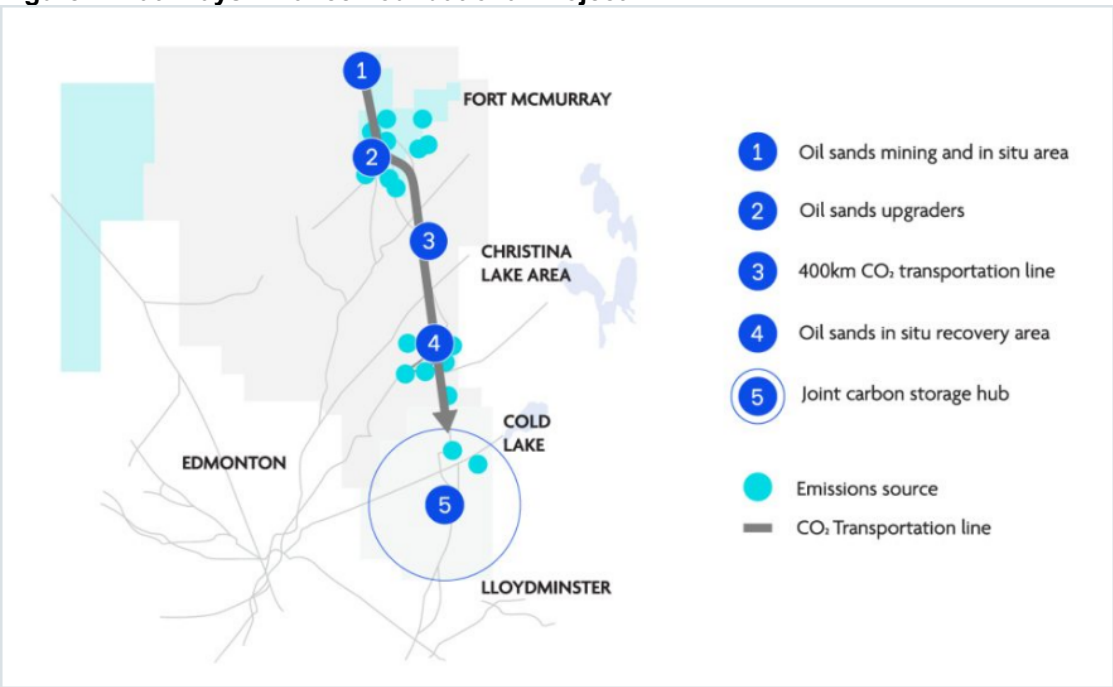
[15] Bakx, K. (2021, July 13). *Shell unveils new carbon capture project amid wave of new CCS proposals in Alberta*. Retrieved from CBC News: https://www.cbc.ca/news/business/shell-carbon-capture-alberta-government-1.6099797

[16] Venkatachalam, V., & Kaplan, L. (2022, July 5). *Assessing the future use of carbon capture, utilization and storage in Canada's oil and gas sector.* Retrieved from Canadian Energy Centre: https://www.canadianenergycentre.ca/assessing-the-future-use-of-carbon-capture-utilization-and-storage-in-canadas-oil-and-gas-sector/

management strategy[17]. The 2021 federal budget committed significant funding – $319 million directly for CCUS development and a further $5 billion for clean technologies including CCUS – over a seven-year period. The government also announced that it was opening a 90-day consulting period for interested stakeholders to provide feedback on a proposed investment tax credit for CCUS. Armed with this show of support from the federal government, even without clear details, a flurry of announcements was made over the next few months. Most of these focused on blue hydrogen projects, underpinned by the ability of the project owners to deploy carbon capture technology within the steam methane reforming (SMR) process used in producing hydrogen.

The most significant announcement was the collaboration of the largest oilsands-centric firms to form Oilsands Pathways to Net Zero. This entity later merged with two other existing industry groups, Canada's Oil Sands Innovation Alliance (COSIA) and Oil Sands Community Alliance (OSCA), into a single organization called the Pathways Alliance[18]. The alliance founders – Canadian Natural Resources Limited (CNRL), Cenovus Energy, Imperial Oil Limited (IOL), MEG Energy and Suncor Energy – would later be joined by ConocoPhillips Canada. Together, these firms make up 95% of oilsands production, about 3 million bpd. Colloquially called Pathways, this strategic alliance is structured – in part – to address some of the risks associated with oil sands decarbonization, notably CCUS deployment. Other focus areas include the previous scopes of COSIA and OSCA, including broader oilsands technology development and community engagement.

Figure 4: Pathways Alliance Foundational Project



Source: Pathways Alliance

As shown in Figure 4, the first phase of the Pathways project is the construction of a 400km CO_2 pipeline from Fort McMurray to a sequestration hub in Cold Lake. This route allows all the major oilsands and Steam-assisted Gravity Drainage (SAGD) producers to be able to tie carbon capture points to the main

[17] Natural Resources Canada. (2023). *Carbon Management Strategy (formerly known as the Carbon Capture, Utilization and Storage Strategy*. Retrieved from https://natural-resources.canada.ca/climate-change/canadas-green-future/carbon-capture-utilization-and-storage-strategy/23721

[18] Pathways Alliance. (2022, June 15). *Key oil sands groups join forces under Pathways Alliance banner*. Retrieved from https://pathwaysalliance.ca/key-oil-sands-groups-join-forces-under-pathways-alliance-banner/

trunk line with relative ease. With projects like Quest and ACTL demonstrating reliable carbon capture at point sources, the partners are convinced that they can replicate this within their operating boundaries. This approach allows the alliance to focus on addressing the most complicated aspects of the Pathways value chain – building a single pipeline and demonstrating the suitability and integrity of the chosen deep reservoir for storage. The alliance is also hoping to make the pipeline available to other industries, particularly cement and chemicals, looking to transport and store carbon. While these firms have previously shown a willingness to collaborate – COSIA was behind several technology development projects – this is the first time they have partnered to deliver on a suite of projects at this scale.

While there is some skepticism about the alliance's ability to deliver, given their disparate investor needs and inherent competitiveness, there is a more pragmatic logic to their approach, and to the government's backing. For the oilsands firms, it represents a way to prolong the viability of long-lived assets that could otherwise be stranded or be written down significantly. Decisions by banks and investment firms like Norge Bank and HSBC to stop investing in the oilsands are examples of the opportunity cost of doing nothing[19]. For the government, it is a clear pathway to maintaining revenues estimated at $3 trillion over the next 30 years, while meeting its commitment to reduce emissions by up to 40% in 2030[20]. It is also a way to prove out long distance transportation and permanent storage on a large scale in Canada, which can also act as an enabler of Direct Air Capture (DAC) by de-risking a key portion of the value chain.

At a cost of $75 billion over three phases, this suite of projects being executed by committee appears to be a sound approach. From an investment standpoint, the alliance is anchored by mature and established players in the country's oil and gas industry, who have previously demonstrated technological and operational capability to unlock oilsands resources in a harsh climate. The value of the emissions reduction – a targeted 22 $MtCO_2$/year in phase 1 compared to the industry's emissions of 68 $MtCO_2$/year, or 32% – is also one that is likely to allow the firms to maintain their social license to operate in a carbon-constrained world and have access to cheaper capital for future development[21]. Future phases of Pathways are planning to branch out further technologically to deepen the scale of emissions reduction. Phase 2 is designed to involve sustaining existing carbon capture by adding more points while pioneering the use of alternative power sources such as small modular reactors to address smaller emission sources. This is estimated to further reduce emissions by 25 $MtCO_2$/year. Finally, phase 3 is an ode to the fact that carbon capture cannot be deployed everywhere. To completely offset any remaining upstream emissions, Pathways is examining the possibility of implementing DAC plants along the CO_2 pipeline route. Given the capacity of the line and storage reservoir, this is likely the most cost-effective way of implementing DAC in Canada and if executed, could offset upstream emissions by a further 21 $MtCO_2$/year. On paper, these plans articulate a clear path forward and in practice the technologies required to support each phase of the CCUS value chain are proven. While Canada's rapidly increasing carbon price and the promise of investment support has stimulated the CCUS landscape in Canada, there appears to be hesitation on the part of the Pathways partners from sanctioning any plans until stronger – and more significant – support has been received[22].

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[19] Saldanha, Ruth. 2020. "Canadian energy hits an ESG roadblock." *Morningstar.* May 19. Accessed July 22, 2021. https://www.morningstar.ca/ca/news/202403/canadian-energy-hits-an-esg-roadblock.aspx.

[20] Imperial Oil Canada. 2021. *Canada's largest oil sands producers announce unprecedented alliance to achieve net zero greenhouse gas emissions.* June 9. Accessed July 2, 2021. https://news.imperialoil.ca/news-releases/news-releases/2021/Canadas-largest-oil-sands-producers-announce-unprecedented-alliance-to-achieve-net-zero-greenhouse-gas-emissions/default.aspx.

[21] RBC Energy & Utilities Equity Team. (2023). *RBC ESG Stratify: Pathways Alliance Steering the Future.* Toronto: RBC Capital Markets.

[22] Platt, B., & Tuttle, R. (2023, January 19). *Oil Firms Eye $11 Billion Canada Fund to Match Biden's Subsidies.* Retrieved from Bloomberg News: https://www.bloomberg.com/news/articles/2023-01-19/oil-sands-firms-eye-11-billion-canada-fund-to-match-joe-biden-s-subsidies#xj4y7vzkg

4. The Canadian CCUS Tax Credit – Is It Enough?

Canada is often referenced as one of the most regulated countries in the world[23]. For Canadian producers, this is exacerbated by higher costs of production compared to other jurisdictions and reduced foreign investment driven by the 2015 oil price crash and global pressures to reduce oil and gas production. Those looking to expand or grow production have taken to buying up smaller players and absorbing them into their larger operations. Others with untapped potential within their ranks have spent sustaining capital to debottleneck operations and unlock top-line value with minimal cost impact. The challenge with CCUS is that it, in the short term, adds to operational cost without increasing production or marginal profit. CCUS likely impacts the long-term ability of the firm to be operational and profitable, but by default this implies risk avoidance rather than a guaranteed return on capital for investors who would prefer to have their funds invested in increasing reserves or unlocking production. In Canada – given the escalating cost of carbon emissions – investors seek to de-risk exposure to emission costs even further by lobbying for grants and other cost recovery schemes that can minimize the burden of the CCUS investment.

This picture is different in the United States, where only a handful of states have a carbon price in the form of cap-and-trade systems, and where there is no federal carbon price[24]. Options are a bit simpler for major US emitters, who can position CCUS to investors entirely as a present-dated cost for future-dated returns via longer production windows. Irrespective of that, potential implementers of CCUS in both countries have advocated for significant subsidies to be put in place to minimize the short-term financial risks to their operations. This section will highlight the approaches Canada and the United States have taken – or are proposing to take – with respect to CCUS support, and how these could impact the dynamics of capital movement on the continent, relative to broader trends that have been observed over the past half-decade.

As part of its 2022 budget statement, the Canadian government introduced an investment tax credit (ITC) for CCUS[25]. The credit, retroactive to January 2022 and in place until 2040, would apply to the cost of purchasing and installing eligible equipment for use in an eligible CCUS project, and with the further proviso that the captured CO_2 was used for an eligible use. The project would also be required to submit to validation and verification processes to ensure both the eligibility of use and the accuracy of emissions capture reported through climate financial disclosures. Table 2 summarizes the credit rates that would apply for various projects and time durations.

Table 2: Canadian CCUS Investment Tax Credit Features

Feature	Time Period	DAC	Other Capture	Transport/Storage/Use
Credit Rates	2021 - 2030	60%	50%	37.5%
	2031 - 2040	30%	25%	18.75%
Capital Cost Allowance	2021 - 2040	8%	8%	Transport/Storage - 8%
				Use - 20%
Eligible Project	2021 - 2040	CO_2 from Ambient Air		Can be located outside Canada
		CO_2 must be captured in Canada		
Eligible Uses	2021 - 2040	Minimum 10% geological or concrete storage. EOR excluded		
Storage Requirements	2021 - 2040	Alberta, BC and Saskatchewan only. Concrete storage subject to approva		
Credit Recovery Assessment	2021 - 2040	Every 5 years		

Source: Government of Canada

[23] Government of Canada. (2023, January 11). *How Canada's regulatory system works.* Retrieved from https://www.canada.ca/en/government/system/laws/developing-improving-federal-regulations/how-canadas-regulatory-system-works.html

[24] The states are California, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Washington State, Vermont and Virginia

[25] Government of Canada. (2022, April 7). *Investment Credit for Carbon Capture Utilization and Storage.* Retrieved from https://www.budget.canada.ca/2022/report-rapport/tm-mf-en.html#a3_2

Eligible equipment would include those solely dedicated to the capture, transportation, storage, and usage of CO_2. Any equipment serving dual purposes, for example the production of hydrogen or processing of natural gas, would not be covered. Eligible projects were determined to be those that captured CO_2 that would otherwise be released into the atmosphere, and for direct-air-capture (DAC), CO_2 had to be captured directly from ambient air. In addition, while the CO_2 could be stored or used outside Canada, it had to be captured in Canada. Finally, eligible uses are required to be at least 10% of the overall usage and have been limited to storage in concrete or geological storage – EOR was specifically called out as an ineligible use of captured CO_2.

The government also announced that two new capital cost allowance classes, one for usage equipment at 20% and another for capture, transportation, and storage equipment at 8%, would be introduced. These would allow these projects to be depreciated at the specified rates, significantly reducing their income tax burden over time. The CCUS Tax Credit is intended to be paid upfront based on the designed eligible use factor (ratio of ineligible use to eligible use) over the first 20 years of operation. Tax recovery assessments are to be performed at five-year intervals with firms required to refund a portion of the credit if their commitments are not met.

The launch of the US tax credit 45Q in 2008, which covered investments in carbon capture, has long been described as the benchmark – rather than one-off grants and subsidies seen with Quest and the ACTL – that needed to be met to stimulate ongoing CCUS investment in Canada. 45Q provides a credit amount for every ton of CO_2 sequestered geologically, with a reduced credit where the CO_2 was used for EOR. This has stimulated investment in US-based CCUS that the IEA estimates will increase from 23 $MtCO_2$/year in 2022 to 113 $MtCO_2$/year by 2030[26].

Table 3: 45Q Tax Credit Design Features (2008-2022)[27]

Feature	Qualifier	2008	2018	2022	
				Point Source	DAC
Value ($/t)[17]	EOR/Utilization	10	35	60	130
	Storage	20	50	85	180
Commence Construction Date[18]	-	January 2024	January 2026	January 2033	
Term[19]	-	N/A (75 Mt cap)	12 years	12 years	
Transferability	-	Limited – the capturing party only	Broad with Limits – the capture party and owner	Broad – transferrable to an unrelated taxpayer for cash	
Qualified Size	Power Generation[20]	500,000 t/y	500,000 t/y	18,750 t/y	
	Industrial		100,000 t/y	12,500 t/y	
	Industrial Pilot	-	25,000 t/y	1,000 t/y	
	DAC	-	100,000 t/y	1,000 t/y	
Credit Eligibility	-	EOR, Storage	EOR, storage, utilization, DAC,	EOR, storage, utilization, DAC,	
Direct Pay	-	No	No	Yes[21]	
Size Cap	-	75 Mt total	N/A	N/A	

Source: Goddard (2023).

[26] IEA (2022), Carbon Capture, Utilisation and Storage, IEA, Paris https://www.iea.org/reports/carbon-capture-utilisation-and-storage-2, License: CC BY 4.0

[27] Goddard, A. (2023). Prospects for financing carbon management in the US after the Inflation Reduction Act: An Appraisal of 45Q. Oxford Institute for Energy Studies. Working Paper.

As part of the Inflation Reduction Act submitted to the US Congress by the Biden administration in 2022, several tax credit schemes including the 45Q were enhanced, as part of a plan to drive emissions to a 31-44% reduction by 2030, compared to 2005 levels[28]. The enhancement sharply increases the credit for CO_2 captured from DAC, with substantial increases for CO_2 stored geologically and CO_2 used for EOR. In addition, the minimum plant capacity thresholds to qualify for the credits have been decreased significantly, opening the investment space to smaller firms and others developing small-scale plants to pilot new CCUS technologies. The old and new provisions of the 45Q tax credit are shown in Table 3. As with the original credit, the claim period is limited to the first 12 years of the project's operation. The latest project start date was also extended, from 2026 to 2033. By adding a direct pay option for the first 5 years, the government struck a compromise with CCUS lobbyists who wanted that provision for the entire 12-year duration. Direct pay would, in theory, allow project developers to keep project costs on their books since they can obtain annual tax refunds, rather than raising additional capital to finance the projects.

A closer look at the different CCUS credit provisions in Canada and the US reveals some unique differences. Fundamentally, although both are called investment tax credits, only the Canadian version is an actual investment credit – the equipment costs associated with the projects are the baseline for the credits received, regardless of the amount of CO_2 captured and stored. The American tax credit is more of a production tax credit, with annual remittances for reported captured, stored and/or utilized carbon. Combined with the lack of a federal carbon price, the 45Q credit appears to be structured as a way of providing a financial return on investment and stimulating growth in the sectors CCUS can be applied to. Comparatively, the Canadian CCUS tax credit has been set up to reduce the cost of regulatory compliance, with the intent of supporting the current production level and useful life of the country's assets. To illustrate differences between the Canadian ITC – in conjunction with output pricing - and the US 45Q, a hypothetical CCUS plant built in the Fort McMurray region of Alberta has been modeled (Tables 4a & 4b).

Table 4a: CCUS Investment Credit Model

Design & Financial Parameters	
Location	SCO Upgrader in Northern Alberta
Features	Post-combustion capture installed in existing H_2 Plant
CO2 Capture Rate	90%
Project Delivery Period	3 years
Capture Capacity	600,000 tCO_2/year
Capacity Factor	90%
Operational Emissions	40,000 tCO_2/year
Net Capture	500,000 tCO_2/year
Start of Operations	2029 (align with start of 4% tightening rate under TIER)
Operational Period	20 years
Total Capital Cost (TCC)	$600M
Carbon Capture Cost	0.75 TCC
Transport & Storage Cost	0.25 TCC
Eligible Equipment Share of TCC	50%
Operating Cost (Per Year)	$20M
Capital Cost Allowance	8%
Effective Tax Rate	25%
Discount Rate	5%

[28] Global CCS Institute. (2022, August 27). *The U.S. Inflation Reduction Act of 2022.* Retrieved from https://www.globalccsinstitute.com/news-media/latest-news/ira2022/

Table 4b: Comparison of Canadian and US-style CCUS Investment Tax Credits

	Canadian ITC	45Q-Style ITC (no EOR)
Credit-Eligible Investment Cost	$300M	N/A
Tax Credits Received	$141M	$510M
PV of TCC & Operating Costs	$691M	$691M
PV of Tax Credits	**$126M**	**$377M**

Source: Author Calculations

It should be noted that this is an idealized model that relies on some key assumptions[29], but it is instructive. In terms of direct fiscal support, the 45Q credit is much stronger, with three times the present value of the Canadian ITC. However, as outlined earlier, Canada has two regulatory levers: the Canadian ITC and carbon pricing. Taking the latter into account – as an avoided cost since it is a *fait accompli* for operators in heavy emitting industries – alters the picture. For CCUS project investors, the 45Q will be more attractive, since it promises a better return on investment. Adding EOR as an end use further enhances the attractiveness of US-based CCUS projects from an investment standpoint. However, for Canadian operators, incorporating the avoided cost of emissions will significantly narrow and perhaps eclipse the gap. Using the same hypothetical model shown in Tables 4a & 4b, incorporating the avoided cost of carbon into project economics adds an additional $574 million in value to the operator. It has been suggested that Canada could introduce the 45Q-style credit while keeping carbon pricing to further strengthen the business case for CCUS. This would significantly improve project economics but is just as likely to result in excess sequestration credits that are worth much less than the carbon price. More broadly for projects under the Canadian ITC, the largest driver of value is avoiding the cost of future emissions. This may make them riskier plays for potential investors considering the gap on that front to US-based projects. To counter this, the value of avoided CO_2 emissions will need to be predictable and at least in line with the differential between US tax credits and those in Canada. This is examined next.

5. Leveraging Carbon Markets to Close the CCUS Investment Gap

With the announcement of the Canadian ITC, Canada has now introduced two significant mechanisms – the other being the federal carbon price – in its bid to reduce emissions to 60% of the 2005 level by 2030. While there is a relative degree of satisfaction that the barriers to the widespread deployment have eased, several commentators believe that this is not enough. Firms in heavy industry are required to comply with large emitter programs, while their ability to raise capital is likely to be impeded by the growth limitations necessitated by CCUS investment in Canada. The ability for firms to justify these investments will be linked to the outputs of the various processes and mechanisms CCUS deployment will require. These include CO_2 by-products, hydrogen production and a viable market for credits obtained through CCUS and other decarbonization efforts.

Although geological and concrete storage were the only specified eligible uses of CO_2, that clause was inserted primarily to prevent the use of CO_2 for EOR. By focusing efforts on permanent storage, this also creates geological space – and cost learning – for other carbon capture pathways. Other uses would be considered if they did not result in additional oil production. In addition to concrete, other potential uses of CO_2 that would not result in leakage or future emissions include in chemical processes like soap, potash, and solvent manufacturing. Other posited uses include insulation, home furnishings

[29] Since this is a hypothetical comparison of a single Canadian project implemented under different tax credit schemes, the assumption was made that even if a US-style 45Q credit was introduced in Canada, EOR would still be a prohibited use. Another assumption made was that carbon pricing would not exist under the 45Q-style credit. The model changes dramatically if either of these variables change.

and polymer-based pellets that can be melted and used for packaging[30]. These potential CO_2 storage applications share one thing in common: they are largely untested and even if piloted, are a long way from commercial scale. The development of blue and turquoise hydrogen is also underway, occurring in parallel with CCUS deployment in Canada[31]. This work is underpinned by Alberta's hydrogen roadmap, which aims to support this potential increase in hydrogen supply by increasing demand sources, particularly through deployment of the fuel carrier in key sectors like heavy industry and the long-distance transportation sector[32].

A more viable route towards an improved fiscal incentive for CCUS deployment in Alberta – given the outsized role it is slated to play relative to the rest of Canada – may lie in how emissions performance credits (EPCs) and emissions offsets are handled provincially. EPCs are generated by facilities which emit below their approved limit, and can either be applied to future years, or traded to other facilities. Emissions offsets are projects built by a company – common examples in Alberta are wind and solar PV installations – where the exported emissions can be applied by that company to its other facilities within the province which may be above their limits or traded. To maintain the market price signal for carbon, there needs to be a higher net compliance obligation than volume of credits or offsets available. To ensure the attractiveness of generating offsets, it is important that CCUS projects do not oversupply credits to the market. Alberta government has revised the TIER program to improve the competitiveness of CCUS, with a focus on three levers – the expiry period for credits/offsets, emissions reduction targets (tightening rate) and increasing the number of participants. Additional backstops, such as carbon contracts for difference, could help strengthen the market further.

5.1 Credits/Offsets Expiry Period

Starting in 2017, emissions offsets credits and emissions performance credits were given a nine-year expiry, commencing from when the offset or reduction was made. While this was implemented to incentivize facilities to adopt emissions reduction efforts, the long-term nature of the expiry meant that firms were more likely to hold onto their credits for longer, rather than releasing them to the market. The changes to TIER include a reduction in the expiry period to 5 years[33]. This will reduce the volume of available credits, increasing the value of carbon offsets and potentially making CCUS projects more valuable for the largest emitters.

5.2 Tightening Rates

When TIER was launched in 2020, facilities where the facility-specific benchmark applied were required to reduce emissions by 10% relative to the benchmark, with a subsequent 1% reduction annually. Given the cost of non-compliance relative to the cost of large decarbonization projects, there was very little movement in the deployment of CCUS. The benchmarks will be tightened by 2% per year starting in 2023, with oilsands facilities subject to a further increase in 2029 and 2030, as shown in Table 5. Increasing the tightening rate to 2% could result in an additional compliance requirement of 11 $MtCO_2e$/year while increasing it to 3% has the potential to add 31 $MtCO_2e$ of compliance obligations relative to projections for 2030[34]. This increase in compliance obligations can help to ensure that the supply of offsets does not far outstrip demand as CCUS and other large decarbonization projects are brought onstream.

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[30] Cho, R. (2019, May 29). *Capturing Carbon's Potential: These Companies Are Turning CO2 into Profits.* Retrieved from Columbia Climate School: https://news.climate.columbia.edu/2019/05/29/co2-utilization-profits/

[31] Blue hydrogen is produced when carbon capture units are installed on the steam methane reformers used to produce hydrogen. Turquoise hydrogen is produced through methane reforming. This process is considered to have low emissions if the thermal energy is provided by renewable energy and the CO_2 is permanently stored or used.

[32] Government of Alberta. (2021, November). *Alberta Hydrogen Roadmap.* Retrieved from https://www.alberta.ca/hydrogen-roadmap.aspx

[33] Government of Alberta. (2023). *Technology Innovation and Emissions Reduction Regulation*. Retrieved from https://www.alberta.ca/technology-innovation-and-emissions-reduction-regulation.aspx

[34] Bishop, G., & Bernstein, M. (2022, October). *Alberta carbon pricing system needs an important fix.* Retrieved from Clean Prosperity: https://cleanprosperity.ca/alberta-carbon-pricing-system-needs-an-important-fix/

Table 5: TIER Tightening Rate Changes

Reduction Target	2023	2024	2025	2026	2027	2028	2029	2030
FSB - General	**0.14**	**0.16**	**0.18**	**0.20**	**0.22**	**0.24**	**0.26**	**0.28**
FSB – Bitumen - Oil Sands In Situ	0.14	0.16	0.18	0.20	0.22	0.24	0.28	0.32
FSB – Bitumen - Oil Sands Mining; Upgrading	0.20	0.22	0.24	0.26	0.28	0.30	0.34	0.38
HPB - General	**0.02**	**0.04**	**0.06**	**0.08**	**0.10**	**0.12**	**0.14**	**0.16**
HPB – Bitumen - Oil Sands In Situ	0.02	0.04	0.06	0.08	0.10	0.12	0.16	0.20
HPB – Bitumen - Oil Sands Mining; Upgrading	0.08	0.10	0.12	0.14	0.16	0.18	0.22	0.26
FSB – Aggregate Stationary Fuel Combustion	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26
FSB – Aggregate Flaring	0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24

Source: Government of Alberta[35]

5.3 Market Players

The original TIER regulations excluded electricity generation from tightening requirements as their collective performance – based on high-performance benchmark – was considered "as good as it gets"[36]. Under the new regulations, these sectors are required to meet the 2% tightening rate on an annual basis until 2030. As facilities in this sector are less likely – based on announced projects and cost – to implement CCUS, this provides an avenue for offsets generated through CCUS projects to be competitively traded. In addition to this change, smaller facilities (emitting less than 2 ktCO_2/year) can opt into the TIER regulation. Whether these changes materially improve the demand for offsets and credits is uncertain, given the relative volumes involved.

5.4 Carbon Contracts for Difference

Although the Supreme Court of Canada has struck out opposition to the GHGPPA by some Canadian provinces, the risk remains that a future government could repeal the Act. While unlikely – given the social and environmental implications – firms still acknowledge this potential risk. Having either or both governments offer carbon contracts for difference (CCfD) is an option that has been proposed to cover off the risk[37]. This would guarantee that facilities which invest in decarbonization and other low-carbon technologies like CCUS receive a guaranteed strike price from the government. Assuming supply of credits overwhelms demand or where compliance costs come down, such projects would still receive a price that maintains current project competitiveness. Conversely, if the strike price is too low relative to future reference prices, facilities would be required to pay the differential.

[35] Government of Alberta. (2023). *Technology Innovation and Emissions Reduction Regulation*. Retrieved from https://www.alberta.ca/technology-innovation-and-emissions-reduction-regulation.aspx
[36] Ibid
[37] Lithgow, M. (2023, February 21). *Carbon contracts for difference can help Canada compete with US renewable incentives.* Retrieved from Carbon Pulse: https://carbon-pulse.com/192877/

6. Discussion and Conclusion

Canada's position as a global leader in oil and gas production, as well as a proponent of emissions reduction, has led to significant support for the commercialization of CCUS. Viewed as the best way to reduce emissions from heavy industry, CCUS can also enable the value chain for technologies like DAC which are seen as the future of carbon capture. Technologically, Canada is home to two leading CCUS projects. The Shell Canada-operated Quest facility is considered one of the best examples of CCUS project development, deployment and operation. In addition to capturing emissions at or above nameplate performance throughout its operation, it has also been able to demonstrate the possibility of CO_2 transport and deep underground storage with no carbon leakage. A short distance away, the ACTL pipeline collects captured CO_2 from two different types of facilities – a refinery and a fertilizer plant – and transports them 240km to depleted oil fields in central Alberta for EOR. Demonstrating viability in different applications, with a variety of logistical options, CCUS makes a strong case as an important lever in the decarbonization of Canadian industries reliant on fossil-fuel power.

However, very few CCUS projects have been sanctioned, as the country's largest emitters ponder how to minimize their cost of carbon compliance and decarbonize their facilities. Despite some structural differences, there has been strong alignment on carbon pricing and CCUS incentives at the provincial and federal levels. In the province of Alberta, the likely hub of CCUS activity in Canada, the TIER regulation for industrial emitters has been deemed sufficient to avoid the federal large emitter program being applied as a backstop. The possibility of too many players implementing CCUS – and therefore excess credits that can potentially be sold for less than the value of the price of carbon – was a major driver behind the changes to the TIER program announced in late 2022. With the changes, particularly the increased tightening rate for oilsands facilities in 2029 and 2030 and introduction of sequestration credits, there is now a very clear price signal for CCUS. The formation of the Pathways Alliance reflects the oilsands sector's trend towards collaboration as a way of supporting the sector's economic future. If successful, the alliance will see sharing of common costs like transportation and storage, further reducing the risk for individual facilities and driving down the levelized cost of CCUS.

The CCUS ITC announced as part of the federal government's 2022 budget will go some way to assuaging concerns by industry and should result in several projects sanctioned before 2025. However, compared to the 45Q regulation for CCUS projects in the United States, the ITC is not as lucrative for investors. In addition, because the 45Q incentivizes actual carbon stored, rather than the capital invested in the project, it is likely to lend itself to more cost learning and efficiency opportunities. Over time, these could drive down US-based project costs faster, making them even more attractive to investors. Beyond these advantages, the 45Q also allows the use of captured carbon for EOR, which the ITC specifically excludes. Finally, several states in the US where CCUS projects are likely to be installed, particularly Texas, Louisiana and Oklahoma; do not have carbon pricing. In these locations, if the combination of 45Q credits and EOR revenues exceeds the levelized cost of CCUS, carbon capture could be a profitable endeavor. In Canada, as presently structured, it can only be a compliance mechanism with the potential promise of preventing high-value assets from becoming stranded.

For Alberta-based firms, price certainty from TIER combined with the Canadian ITC could provide enough of an incentive for Canadian firms to initiate the development of CCUS projects. There is also the potential advantage of leveraging the Pathways Alliance to unlock efficiencies. To sustain momentum and ensure that these projects are commissioned into operation, additional economic and compliance levers may need to be pulled. The Canadian government is under some pressure from industry to respond to the revised 45Q, either by improving the ITC or working with provincial governments to offer an additional tax credit. Tying this additional support to actual CO_2 capture would close the investment gap to the 45Q further, even if EOR continues to be an ineligible use. In addition to sufficient tax credits, the carbon offsets market will need to be balanced to ensure that the price signal remains close to the federal price and in line with project premises. Although likely to be minimal, a relatively robust market for CO_2 by-products can help reduce reliance on offsets markets by providing an additional monetary stream. For captured carbon stored underground, it will be important to ensure that the supply of offsets and credits does not exceed demand for them, as that will further erode the

already tenuous economics of CCUS. In this regard, further changes to the tightening rate or expiry of emissions credits are likely. If some of these changes are made, CCUS will be in a much stronger position to attract the internal and external investment required to ensure its success.