EQUITY RESEARCH

RBC Capital Markets

RBC Energy & Utilities Equity Team
Click here for contributing analysts' contact information

February 7, 2023

RBC ESG Stratify™: Pathways Alliance

Steering the Future

Our view: The oil sands were a game changer for Canada—and Pathways could be just as big. We know of no other jurisdiction in the world where a half-dozen leading energy producers have chosen to collaborate with a comprehensive goal of net zero Scope 1 & 2 GHG emissions by 2050. This ESG Stratify report explores the Pathways Alliance and builds on ESG Stratify reports "Carbon Capture & Storage: Dare to Dream Big" and "Carbon Markets: The Need for Speed".

RBC Dominion Securities Inc.
Research RBCCM Global Energy (Equity)
Greg Pardy (Head of Global Energy Research)
Robert Mann (Associate)
Justin Ho (Associate)
Luke Davis (Analyst)

RBC Europe Limited
Biraj Borkhataria (Associate Director of European Research)
Adnan Dhanani (AVP)

RBC Capital Markets, LLC
Scott Hanold (Analyst)

Highlights:

- **Credible Players.** Canadian Natural Resources, Suncor Energy, Cenovus Energy, Imperial Oil, MEG Energy, and ConocoPhillips Canada (which collectively operate about 95% or roughly 3.0 million bbl/d of oil sands production) joined forces in 2021 under what is today the Pathways Alliance.
- **Emissions in Context.** The oil sands account for about 12% of Canada's GHG emissions. Upstream GHG emissions of Canada's major oil sands producers are more than double those of the global major producers (Exhibit 1).
- **CCUS—A Big Component.** Pathways is anchored by Carbon Capture, Utilization & Storage (CCUS) and a 400 km (250 mile) 24-36 inch diameter trunk-line that will connect the oil sands to a carbon sequestration hub near Cold Lake, Alberta. CCUS accounts for up to 60% of Pathways' march to net zero.
- **Manifold Motivations.** The motivation to decarbonize the oil sands rests on maintaining a social license to operate and thrive, retaining long-term access to capital, and helping Canada meet its climate goals. Engineering net zero emissions over time could also engineer a lower cost of capital for Canada's majors—and a free cash flow yield approaching the US majors (Exhibit 2).
- **Phase 1—One-Third Reduction.** At a cost of $24.1 billion, Phase 1 is targeting a one-third (22 Mtpa) reduction in oil sands GHG emissions by 2030. CCUS projects within the Cold Lake storage hub area are slated to start up in late 2026 (pending regulatory approval), while those capture projects requiring the trunk-line are set to commence in early 2029.
- **Carbon Market Evolution Needed.** The sheer scale of decarbonization investment pending in Alberta means that there will be massive generation of carbon credits, but Canada's carbon market lacks fungibility in trading allowances and offsets nationally. Accordingly, Pathways is seeking expansion of the CCUS investment tax credit (ITC), a contract for differences, or some other federal mechanism to shore up the carbon credit value of CO_2 sequestered.
- **An Expanded Federal CCUS ITC?** Canada's CCUS ITC may be enhanced with release of the federal budget (expected this spring) to ensure competitiveness with the United States following passage of the Inflation Reduction Act of 2022, which supercharged 45Q incentives.
- **Alberta Incentives.** Alberta's incentives—potentially through modification of the Oil Sands Royalty Regime to include CCUS—will likely wait until after its provincial general election on May 29, 2023.

RBC ESG Stratify™
Responsible insights, sustainable ideas

Priced as of prior trading day's market close, EST (unless otherwise noted). All values in USD unless otherwise noted
Disseminated: Feb 7, 2023 16:08EST; Produced: Feb 7, 2023 16:08EST
For Required Non-U.S. Analyst and Conflicts Disclosures, see page 22

Table of Contents

Abbreviations			
bbl	Barrels	ESG	Environmental, Social and Governance
bbl/d	Barrels per day	GHG	Greenhouse gas
mmbbl/d	Million barrels per day	t	Tonne
mbbl	Thousand barrels	Mt	Megatonne
CO	Carbon monoxide	Mtpa	Megatonne per annum
CO_2	Carbon dioxide	Gt	Gigatonne
CO_2e	Carbon dioxide equivalent		

Pathways Alliance—FAQs

1.	**Who is behind the Pathways Alliance?**	Canadian Natural Resources, Suncor Energy, Cenovus Energy, Imperial Oil, ConocoPhillips Canada, and MEG Energy, which collectively operate about 95% (roughly 3 million bbl/d) of Canada's oil sands production.
2.	**Why is it called Pathways?**	Because no single solution will achieve net zero Scope 1 & 2 GHG emissions in the oil sands; multiple parallel pathways are needed.
3.	**How much of Canada's GHG emissions do the oil sands emit?**	At 81 Mtpa (2020), the oil sands accounted for 12% of Canada's GHG emissions, based on federal estimates.
4.	**Why are oil sands producers decarbonizing?**	To help meet Canada's climate goals, maintain a social license to operate and thrive, and retain long-term access to capital.
5.	**How long will it take to eliminate GHG emissions from the oil sands?**	Under a three-phase approach, Pathways is aimed at reducing Scope 1 & 2 oil sands GHG emissions by 22 Mtpa by 2030 and net zero by 2050.
6.	**How much will Pathways cost?**	At this juncture, the capital cost of Pathways is pegged at roughly $75 billion for the whole enchilada. This includes $24.1 billion of capital invested in Phase 1 between now and 2030.
7.	**Who is paying for Pathways?**	Pathways' member companies are planning to co-invest in partnership with the governments of Canada and Alberta.
8.	**What is this CCUS investment tax credit?**	Canada's federal government announced an ITC for capital invested in CCUS (excluding enhanced oil recovery) in 2022: 50% for equipment to capture CO_2 and 37.5% for investment in transportation, storage, and use.
9.	**Is the CCUS ITC functioning now?**	The ITC has not yet been legislated in Parliament, but we suspect that Canada's federal government may unveil an expanded ITC commensurate with its upcoming budget to ensure competitiveness with the US following passage of the Inflation Reduction Act of 2022 (which bolstered 45Q incentives).
10.	**Is Alberta expected to provide additional incentives for oil sands decarbonization?**	Yes, but such incentives—potentially through augmentation of the Alberta Petrochemicals Incentive Program (APIP) or modification to the Oil Sands Royalty Regime to include CCS and other expenditures—will probably have to wait until after Alberta's general provincial election on May 29, 2023.
11.	**Does Pathways have the green light to proceed?**	No, not yet. Pathways remains in the process of completing its various regulatory applications, which it plans to file in late 2023.
12.	**When will Pathways start-up?**	The lion's share of the CCS projects cannot start up until the trunk-line is in service, which requires a three- to four-year construction period following regulatory approval. The earliest start-up for those projects (assuming a one-year regulatory approval process) is early 2029.
13.	**Can the Pathways initiative be accelerated?**	No, not really. Think of Pathways as a mega project with lots of moving pieces, including securing regulatory approval for pore space, environmental field work, consultation with Indigenous communities, engineering work on multiple facilities, and regulatory approvals.
14.	**Can Pathways alone achieve the GHG reduction proposed in Options to Cap released last July?**	No, not realistically. Canada's Environment and Climate Change Ministry's Options to Cap proposal released last July framed a 31% absolute reduction in GHG emissions from the oil & gas sector (vs. 2005) to reach 110 Mtpa in 2030. Assuming that Pathways delivers 22 Mtpa by 2030, Canada's oil & gas emissions (vs. 2020) would still stand at about 147 Mtpa in 2030.
15.	**How much could oil sands GHG emissions per barrel drop by 2030?**	Simple math using federal GHG emissions suggests a 27% drop from 78 kg CO_2e/bbl in 2020 to 57 kg CO_2e/bbl in 2030 (ceteris paribus).

Summary—Steering the Future

The oil sands were a game changer for Canada—and Pathways could be just as big.

The Pathways Alliance finds its roots back in 2020—as both the pandemic and focus on the E in ESG were intensifying—when some of Canada's major oil sands producers began to discuss their decarbonization initiatives. The five-fold increase in oil sands output from 2000–21 to 3.1 million bbl/d established Canada as an important component of the non-OPEC supply chain and, along with a doubling of oil prices, helped fuel its net oil exports from about $6 billion to $88 billion over the same time frame. In spite of much-improved intensities over time, the GHG emissions per barrel of Canada's leading oil sands producers still sit more than double those of the global majors (Exhibit 1). The market took notice of this as environmental concerns took center stage. What seemed abundantly clear from discussions amongst oil sands producers was that collaboration on decarbonization would trump solo efforts.

Informal discussions gave way to more formal ones, and in 2021, Canadian Natural Resources, Suncor Energy, Cenovus Energy, Imperial Oil, MEG Energy, and ConocoPhillips Canada, which collectively operate about 95% or circa 3.0 million bbl/d of oil sands production, joined forces under what is today the Pathways Alliance.

The objective of Pathways is to work collaboratively with Canada's federal and provincial governments to reduce current oil sands Scope 1 & 2 GHG emissions of about 68 Mtpa in 2020 by approximately 22 Mtpa by 2030—and ultimately achieve net zero emissions by 2050. We know of no other jurisdiction in the world where a half-dozen leading energy producers have chosen to collaborate and co-invest with government.

Pathways is aimed at decarbonizing the oil sands in three phases at a cost of roughly $75 billion.

The motivation for oil sands decarbonization rests on maintaining a social license to operate and thrive, retaining long-term access to capital, and helping Canada to meet its climate goals. Engineering net zero Scope 1 & 2 emissions in the oil sands could also achieve a lower cost of capital for Canada's majors—and a free cash flow yield approaching US majors such as Chevron Corporation and ExxonMobil (Exhibit 2).

At an estimated price tag of roughly $75 billion for the whole enchilada, Pathways will be executed via a three-phase approach. It is anchored by CCUS and a 400 km, 24-36 inch diameter trunk-line that will connect the oil sands to a carbon sequestration hub near Cold Lake Alberta. Phase 1 has been estimated at $24.1 billion. Physically, CCUS accounts for up to 60% of Pathways' overall decarbonization game plan.

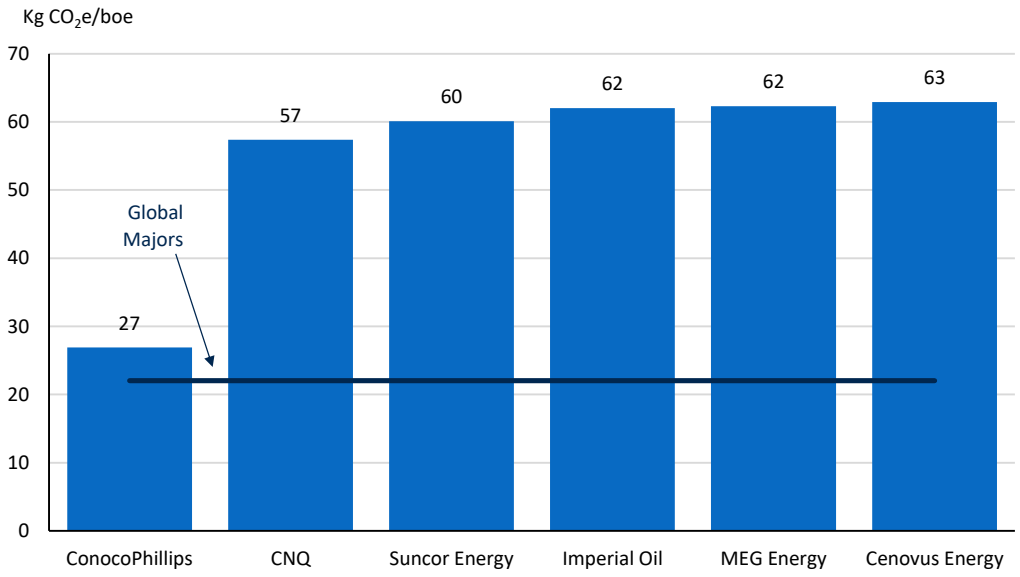
Canada's CCUS incentives could be enhanced this year at both the federal and provincial levels.

Canada's CCUS investment tax credit announced last year is a solid start and may be enhanced commensurate with release of the federal budget this spring, especially following passage of the US Inflation Reduction Act of 2022, which supercharged 45Q tax credits. The sheer scale of CCUS decarbonization investment pending in Alberta also means that there will be massive generation of carbon credits. As it stands, Canada's carbon markets are comprehensive yet regionally fragmented and do not permit the ability to trade allowances and offsets between federal and provincial programs. This is one of the main reasons that Pathways is seeking an expansion of the ITC to cover operating costs, a contract for differences, or some other federal mechanism to shore up the carbon credit value for CO_2 sequestered.

On the provincial front, Alberta remains in sharp focus; a recent United Conservative Party of Alberta leadership change and the forthcoming election on May 29, 2023 could temporarily delay the roll-out of CCUS incentives. That said, Canada's CCUS incentives could be enhanced this year at both the federal and provincial levels, pouring the foundation of capital investment that would benefit the country for decades to come.

Upstream GHG emissions intensities among Canada's oil sands producers are more than double the global major average.

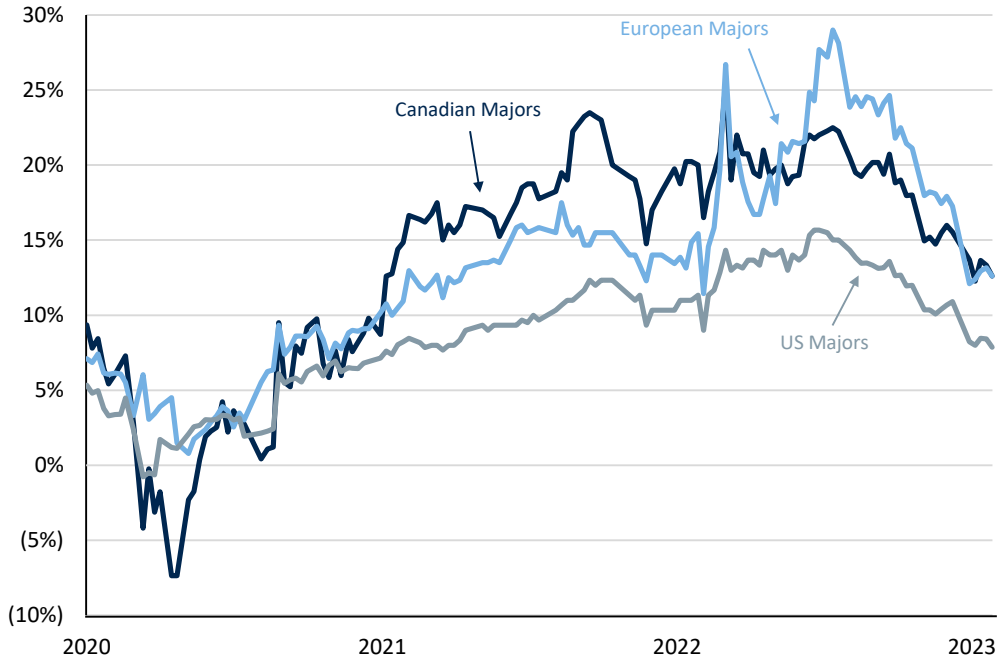
Exhibit 1 - Upstream Scope 1 & 2 GHG Intensity (2021)



Notes: (1) GHG emissions intensity calculated on a gross operated basis where disclosure is available, otherwise shown on a net equity basis where not disclosed by companies. GHG emissions intensity are RBC calculations where not disclosed by companies. (2) Global majors include Equinor, Galp Energia, TotalEnergies SE, Eni SpA, Shell PLC, ExxonMobil, Chevron, and Repsol SA and exclude BP given that its 2021 emissions intensity is not disclosed. (3) Upstream emissions for global majors exclude LNG where disclosure is available. (4) Integrateds, Cenovus Energy, Chevron, Eni SpA, Imperial Oil, Suncor Energy, and ExxonMobil figures include amounts attributable to the upstream segment only. (5) CNQ, Cenovus Energy, Imperial Oil, MEG Energy, and Suncor Energy have been adjusted for net production (after royalties). (6) Cenovus Energy, Imperial Oil and MEG Energy have reported emissions net of cogeneration. (7) CNQ and Suncor Energy have reported emissions including cogeneration emissions. (8) Syncrude has been excluded from Suncor's emissions calculations, as it did not maintain operatorship through the entirety of 2021.
Source: Company reports, RBC Capital Markets estimates

Engineering net zero emissions in the oil sands could also engineer a lower cost of capital—and better relative valuation—for Canada's majors.

Exhibit 2 - Global Majors Comparative Valuation Analysis: Free Cash Flow Yields (Futures)



Note: (1) Individual data excluded where unavailable. (2) FCF Yield = (Operating Cash Flow less Gross Capital Expenditures)/Equity Market Capitalization. (3) Analysis based on prevailing futures prices. (4) This chart is a regular feature in our Global Comparative Valuation Analysis.
Source: RBC Capital Markets estimates, Bloomberg

Meet the Pathways Alliance

In Canada, a half-dozen leading oil sands producers have joined forces to achieve net zero by 2050.

The Pathways Alliance[1] has roots that stretch back to 2020 as the pandemic was intensifying when the leaders of member companies began to discuss their decarbonization initiatives. What seemed abundantly clear was that collaboration amongst oil sands producers on decarbonization would trump solo efforts. In 2021, Canadian Natural Resources, Suncor Energy, Cenovus Energy, Imperial Oil, MEG Energy, and ConocoPhillips Canada, which collectively operate about 95% (circa 3.0 million bbl/d[i]) of oil sands production, formally announced the Oil Sands Pathways to Net Zero Alliance.

The objective of the Pathways Alliance is to work collaboratively with Canada's federal and provincial governments to reduce current oil sands Scope 1 & 2 greenhouse gas (GHG) emissions of about 68 Mtpa[2] in 2020 by approximately 22 Mtpa by 2030 and ultimately achieve net zero emissions by 2050. As the name suggests, Pathways recognizes that no single solution will achieve net zero and that multiple parallel pathways are needed. We know of no other jurisdiction in the world where a half-dozen leading energy producers have chosen to join forces with a comprehensive goal of achieving net zero by 2050.

Beyond collaboration, a big differentiator of Pathways is the degree of engagement among the senior leadership of its members, who meet weekly. These include: Murray Edwards, CNQ's Executive-Chairman; Alex Pourbaix, President and CEO of Cenovus; Brad Corson, Chairman, President and CEO of Imperial Oil; Kris Smith, interim-President and CEO of Suncor; Derek Evans, President and CEO of MEG Energy; and Bijan Agarwal, President of ConocoPhillips Canada. This dynamic has energized the group's forward momentum and served to overcome obstacles that arise. Kendall Dilling was appointed Pathways' President in 2022 after being seconded from Cenovus in 2021 by Al Reid, who was then Director of Pathways. The Alliance has extended an offer of Associate membership to the balance of companies representing 5% of production.

Pathways has approximately 200 personnel (inclusive of those seconded from its member companies) collaborating on its initiative; these include scientists, engineers, geologists, chemists, physicists, communicators and business development leaders. This figure jumps to 400–500 at peak when temporary contract employees are in place, typically during the summer months when field reconnaissance is under way. At any one time, there are currently 200–500 people advancing the Pathways decarbonization initiative.

Alliance Membership—Credible Players

Alliance's six member companies possess a track record of successfully executing mega projects.

The Alliance consists of member companies that possess considerable expertise and a track record of success in executing large-scale multibillion-dollar projects. Indeed, it has been no accident that Canada's oil sands production rose from about 611,000 bbl/d in 2000 to 3.1 million bbl/d in 2021[ii]. This growth has been anchored by multi-year mega investments in projects that include Horizon (100% CNQ), Kearl (71% Imperial Oil, 29% ExxonMobil), Christina Lake (100% Cenovus), Foster Creek (100% Cenovus), Christina Lake (100% MEG Energy), and Firebag (100% Suncor), among others. This growth has also been a powerful engine helping fuel Canada's net oil export receipts, which rose from about $6 billion in 2000 to $88 billion in 2021[iii].

---

[1] On June 15, 2022, the Oil Sands Pathways to Net Zero Alliance amalgamated with Canada's Oil Sands Innovation Alliance (COSIA), created in 2012, and the Oil Sands Community Alliance (OSCA), created in 2013, into a single organization called the Pathways Alliance.

[2] Canada's federal government pegs oil sands emissions at 81 Mtpa (2020) whereas the Pathways Alliance cites it at 68 Mtpa, the main differences being the treatment of co-generation power sold onto the Alberta grid and conventional heavy oil production in oil sands lease areas.

Three-Phase Approach

Pathways will be executed via a three-phase approach anchored by CCUS and a trunk-line that will connect the oil sands to a carbon sequestration hub near Cold Lake Alberta, but there is more to it than that. In terms of investment, Phase 1 has been estimated at $24.1 billion in the context of an overall capital cost estimate of $75 billion that will become more refined over time.

Phase 1 is aimed at a 22 Mtpa GHG reduction by 2030 at a $24.1 billion price tag.

- Phase 1 (2020–30)—Foundational: 22 Mtpa, $24.1 Billion

  Phase 1 is targeting a 22 Mtpa CO_2e reduction. It is anchored by a core infrastructure corridor linking a network of oil sands facilities in the Fort McMurray, Christina Lake, and Cold Lake regions of Alberta via a 24-36 inch diameter, 400 km long (about 250 miles) pipeline (paralleling existing rights-of-way to the maximum extent possible) to a carbon sequestration hub in a saline aquifer deep underground near Cold Lake. The trunk-line would have phased expansion capability to capture CO_2e from more than 20 oil sands facilities, with Phase I volumes of approximately 10–12 Mtpa of CO_2e from 14 facilities. Phase 1 carries an estimated capital cost of $16.5 billion by 2030 on the CCUS project (the largest component of which is the capture facilities) and is targeted to commence capturing and sequestering CO_2 (pending regulatory approvals) as early as late 2026 for capture projects that do not require the trunk-line. The lion's share of capture projects require the trunk-line (which requires a three- to four-year construction period following regulatory approval) and would start operating in early 2029.

  Pathways' investment is expected to climb into the billions in the 2025–26 time frame.

  Phase 1 will seek to remove the balance of 10–12 Mtpa CO_2e by 2030 through an estimated $7.6 billion of non-CCUS emissions reduction projects. These include deployment of innovative in-situ recovery techniques involving solvents such as propane to replace steam. This first phase also includes Suncor's $1.4 billion coke-fired boiler replacement project at its Oil Sands Base Plant. This project is an example of fuel switching under which petroleum coke combustion will be replaced with cleaner-burning natural gas cogeneration[3]. Suncor's project is slated to come on line in late 2024, provide steam to its Base oil sands operations, generate around 800 megawatts of electrical power, and reduce its Scope 1 & 2 GHG emissions (including sulphur dioxide and nitrogen oxides) by approximately 1 Mtpa. Significant Pathways R&D expenditures in the 2020–30 time frame will be aimed at lowering the cost of GHG-reduction technologies.

- Phase 2 (2030–40)—Expansion: 25 Mtpa

  Phase 2 is targeting a 25 Mtpa CO_2e reduction through expanded carbon capture within the corridor and the application of low-GHG-intensity in-situ recovery techniques. Phases 2/3 would see a targeted CCUS expansion of up to 40 Mtpa from 20+ facilities. Advanced R&D will also be carried out on the potential use of hydrogen or small modular nuclear reactors for oil sands power generation.

- Phase 3 (2040–50)—Finishing: 21 Mtpa

  Phase 3 is targeting the final 21 Mtpa CO_2e via carbon capture on remaining accessible streams, ongoing process improvements, energy efficiency, fuel switching, and electrification. Evaluating, piloting, and accelerating the application of potential emerging emissions-reducing technologies (including direct air capture) will also be undertaken.

[3] Suncor's cogeneration units generate power at an emissions intensity of about 0.25–0.28 tCO_2 per MW-hour versus about 1 tCO_2 per MW-hour for a coal facility.

The Here and Now

Pathways will invest approximately $100 million in 2023 across a variety of initiatives including engineering and design, stakeholder consultation, and R&D to advance its decarbonization objective. Capital will climb into the billions of dollars once the organization begins to invest earnestly in CCUS in the 2025–26 time frame. Early engagement with 20+ First Nations in Alberta has been under way for some time and will move to formal consultation this year. Preparation of Pathway's multiple applications to the government of Alberta (Alberta Energy Regulator) will be ongoing in 2023.

The major risk we see to Pathways' 2030 target is delays in regulatory permits.

Accelerating the velocity of capital investment aimed at CCS is not realistically feasible given a multitude of constraints. The sheer scale of long-term decarbonization capital required in the oil sands is not unlike executing a series of oil sands projects simultaneously. To illustrate, CCS capture components will need to be retrofitted onto large operating oil sands facilities (including hydrogen plants and central processing units). Then there is the large CO_2 trunk-line and further subsurface pore space analysis.

These projects involve detailed front-end engineering and design, cost estimates, regulatory approvals at various levels of government, and formal consultation with First Nation and Métis communities. Indeed, Pathways is still working to build regulatory submissions (with plans to submit in late 2023) to proceed with Phase 1. This all points toward a level of process complexity that may not be fully appreciated—and a multi-year process for the deployment of capital that will harness decarbonization benefits for decades to come. The major risk we see to the Phase 1 2030 timing revolves around delays in regulatory permits.

The extensive Basal Cambrian Sandstone is Pathways' sequestration zone of choice.

Underground Sequestration—Securing Pore Space

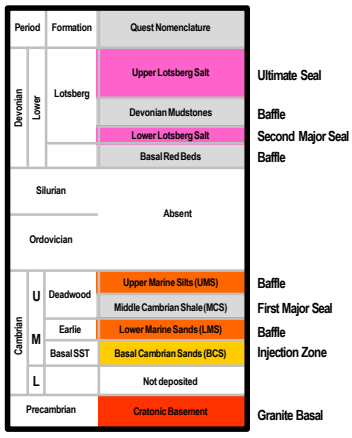
In October 2022, Pathways' proposed carbon capture and storage site near Cold Lake was selected by the Alberta government to advance to the next stage of evaluation. This process will involve detailed geological engineering studies and include drilling a series of stratigraphic wells to fully understand subsurface conditions.

The Lotsberg Salt formation is the ultimate seal for the Basal Cambrian.

There are five key points:

1. Pathways is targeting the Basal Cambrian Sandstone formation at a depth of 1,100–1,800 metres (3,600–5,900 feet) as its sequestration zone of choice[iv]. As a thick sheet-like sand deposit with a huge areal extent of 600,000–800,000 square km (375,000–500,000 square miles), the Basal Cambrian formation is suitable for large-scale CO_2 sequestration because it affords high levels of injection (due to its permeability), sits underneath a number of thick seals, and is isolated from overlying reservoirs[v].
2. Based on Pathways' analysis of extensive 2-D and 3-D seismic data, the Basal Cambrian is non-hydrocarbon-bearing with 100% salt water saturation. It has an average thickness of 75 metres (246 feet) (net/gross of 96.4%) and average porosity of 21% (using a 6% porosity cut-off); 29 of 77 penetrated wells have core and permeability of 1,000 millidarcies[vi]. The Basal Cambrian has no major faults and is not naturally fractured.
3. The proposed sequestration site near Cold Lake is seismically quiet with no observed earthquake activity within 150 km[vii]. CO_2 will be injected far from any active resource extraction.
4. The primary and ultimate seal of the Basal Cambrian is the Lotsberg Salt formation. The Lotsberg is an ideal caprock because it behaves as a ductile material (with the capability to heal structural deformations over time amid salt creep)[viii]. Quest is an operating analog that demonstrates the Lotsberg Salts to be world class.
5. The Basal Cambrian sits on top of a Precambrian granite basement (igneous/ metamorphic), with no porosity observed.

Quest Stratigraphic Nomenclature:

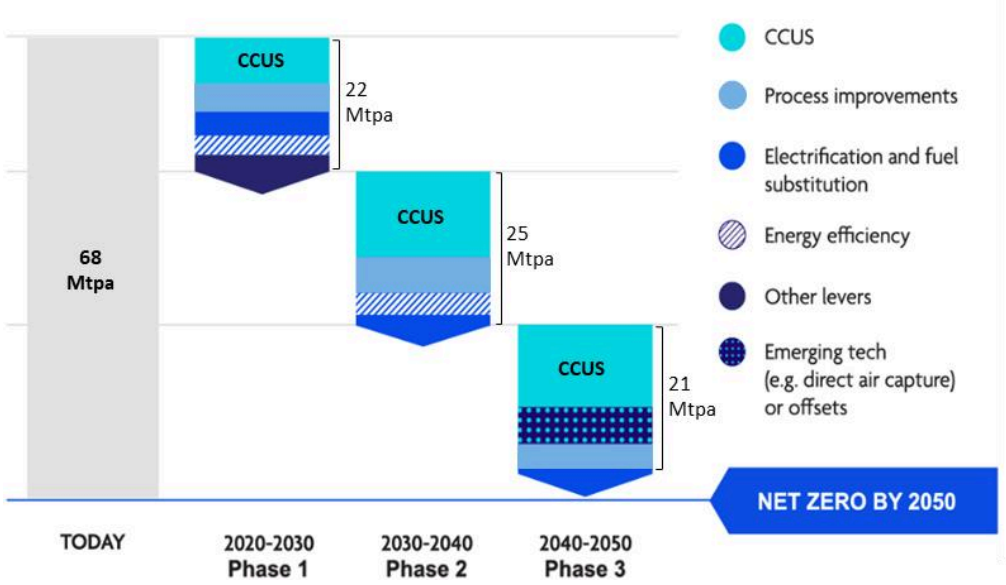


Source: IEAGHG

Pathways' decarbonization process will unfold in three-phases: dropping CO_2e by 22 Mtpa by 2030 and 25 Mtpa by 2040, and finishing the job by 2050.

CCUS accounts for up to 60% of Pathways' march to net zero.

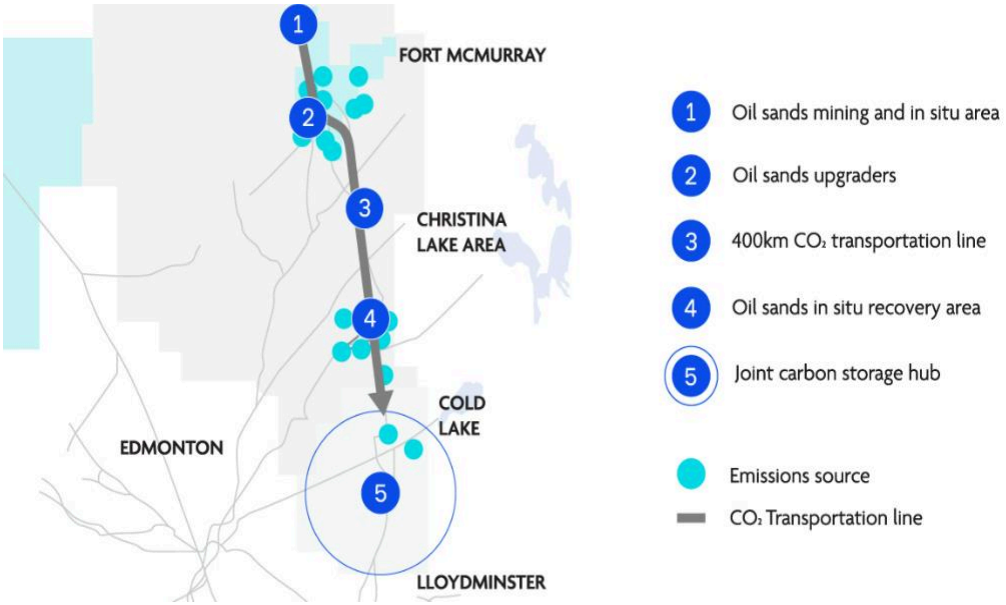
Exhibit 3 - Pathways Alliance's Three-Phase Approach to Net Zero



Note: Canada's federal government pegs oil sands emissions at 81 Mtpa (2020) whereas the Pathways Alliance cites it at 68 Mtpa, the main differences being the treatment of co-generation power sold onto the Alberta grid and conventional heavy oil production in oil sands lease areas.
Source: Pathways Alliance

A 400 km, 24-36"diameter CO_2 pipeline running from the oil sands to a carbon storage hub near Cold Lake is a big pillar in Phase 1.

Exhibit 4 - Proposed CCUS Project and CO_2 Transportation Line



Source: Pathways Alliance

Framing Canada's Carbon Policy

Canada is pursuing a 40–45% economy-wide reduction in GHG emissions (vs. 2005) to roughly 408–445 Mtpa by 2030.

Canada's 2030 Emissions Reduction Plan (ERP) refined the country's approach to achieving its Nationally Determined Contribution under the Paris Agreement. The new ERP equates to a 40–45% economy-wide reduction in GHG emissions (below 2005 levels) by 2030, or 408–445 Mtpa, and net zero emissions by 2050. Canada's stated net zero by 2050 objective revolves around the economy achieving either no GHG emissions or that all emissions are completely compensated for by removing carbon from the atmosphere (negative emissions) via other actions (including CCUS and tree planting). This game plan also includes a target to reduce methane emissions by 75% below 2012 levels by 2030 from the oil & gas sector. In 2020, Canada's CO_2e emissions totaled some 672 Mt, of which 81 Mt (12%) arose from the oil sands[ix]. Under the federal framework, Canada's provinces and territories are able to develop their own carbon pricing schemes and apply for equivalency to the federal system. The plan is underpinned by one of the most progressive carbon taxes in the world, which sits at $65/t in 2023 and will more than double to $170/t in 2030 (Exhibit 6).

CCUS Investment Tax Credit—Unveiled in 2022

Canada's 2023 budget may bolster its CCUS ITC, especially following passage of the US IRA in 2022, which supercharged 45Q.

Under its 2022 budget, Canada's federal government announced an investment tax credit (ITC) for capital invested in CCUS provided they permanently store captured CO_2 through an eligible use. This includes dedicated geological storage and storage in concrete but excludes enhanced oil recovery (EOR). For 2022–30, the ITC is set at:

- 60% for investment in equipment to capture CO_2 in direct air capture projects;
- 50% for investment in equipment to capture CO_2 in all other CCUS projects; and
- 37.5% for investment in equipment for transportation, storage, and use.

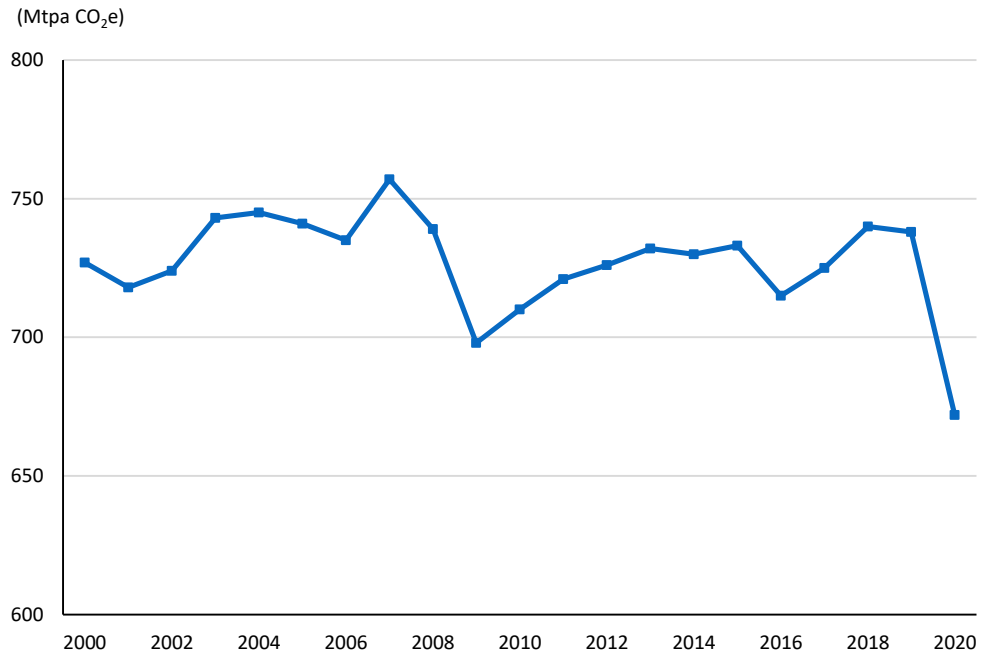
To encourage rapid adoption, these rates will be reduced by 50% from 2031 through 2040. The federal government will, however, undertake a review of ITC rates before 2030 to ensure alignment with its environmental objectives. The ITC has yet to be legislated in Parliament (though we understand that it is technically in effect) and may be expanded when the 2023 budget is unveiled, especially following passage of the Inflation Reduction Act (IRA), which bolstered 45Q incentives.

The proposed refundable tax credit is expected to cost $2.6 billion over five years starting in 2022–23, with an annual cost of about $1.5 billion in 2026–27. The federal government will engage with provinces in the expectation that they will further strengthen financial incentives to accelerate the adoption of CCUS. However, the federal ITC is not dependent on provincial incentives. Although termed a tax credit, eligible capital investment will be recovered in the year incurred. A federal ITC of 50% on the capture component (typically 75–80% of total capital costs) of CCUS projects is logical, while the 37.5% ITC applicable to transportation, storage, and use represents about 20–25% of total costs.

Although a federal ITC is in place related to capital expenditures, the Pathways group is working with the governments of Alberta and Canada as it relates to CCUS operating costs. Capturing CO_2 from flue gas streams and other sources, and then compressing the gas into a liquid form for pipeline transport to the sequestration site, is an energy-intensive process (involving heat and electrical power) impacting CCS operating costs. Our discussions with Pathways members suggest that operating costs can be as much as two-thirds of the total cost associated with CCS, and the generation of power to capture/compress the CO_2 can result in an incremental 0.3 tonnes of CO_2 for every tonne of CO_2 captured.

Canada's GHG emissions have largely remained within a 700–750 Mtpa range over the last 20 years, dipping in 2020 amid the pandemic.

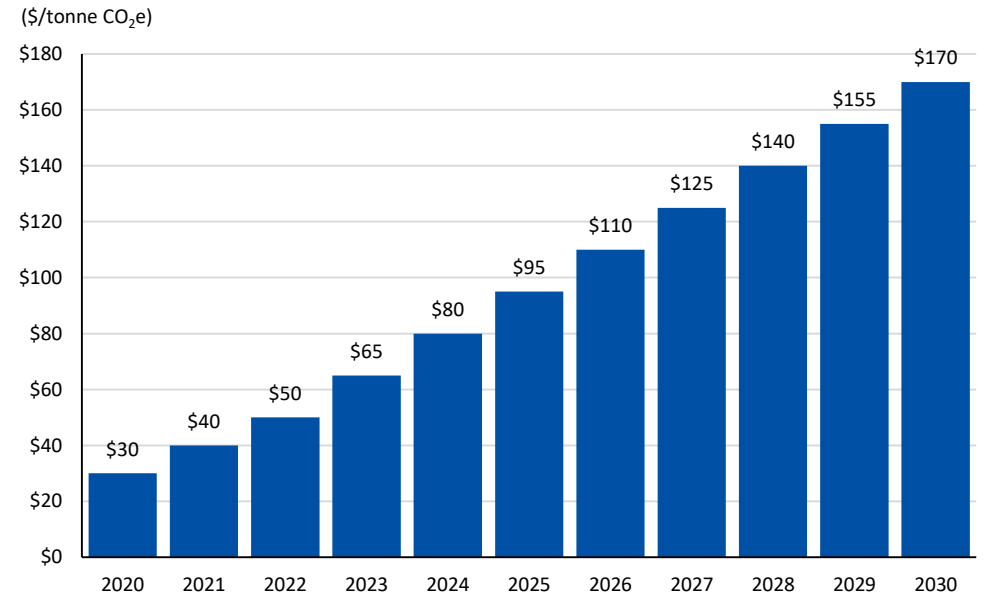
Exhibit 5 - Canada: GHG Emissions, 2000–20



Source: Greenhouse Gas Emissions Report (Environment and Climate Change Canada)

Canada's carbon tax is one of the most progressive in the world—moving to $170/t in 2030.

Exhibit 6 - Canada's Federal Carbon Tax, 2020–30



Source: Update to the Pan-Canadian Approach to Carbon Pollution Pricing 2023–30 (Government of Canada)

Inflation Reduction Act (IRA)—Supercharging 45Q

The IRA supercharged the 45Q tax credit—positioning the US to add blue water on its global competition, including Canada.

The Carbon Sequestration Tax Credit, commonly referred to as 45Q, came into force in 2008 and is aimed primarily at incentivizing geologic carbon sequestration. The 45Q tax credit has evolved over the years and underwent considerable enhancement in connection with passage of the US Inflation Reduction Act of 2022. The IRA served to substantially bolster the attractiveness of CCUS investment in the US while preserving its indexation to inflation and duration of 12 years. In so doing, the United States has positioned itself to add blue water on its global competition when it comes to the development of CCUS. There are five key points:

1. 45Q tax credits for CCUS boosted 70% from US$50/t of stored CO_2 to US$85/t.
2. 45Q credits for Enhanced Oil Recovery CCUS projects increased 86% from US$35/t to US$65/t.
3. New Direct Air Capture (DAC) projects were added to the policy and will receive US$180/t for sequestration and US$130/t for EOR DAC.
4. The IRA extended the 45Q credit such that it is now available for CCUS projects commencing construction before 2033. Thus, a CCUS developer has 10 years to start a project and still receive full credits/benefits over a period of 12 years.
5. The IRA broadened the definition of what CCUS facilities may qualify for the 45Q credit by reducing annual thresholds of carbon sequestration. CCUS developers may also elect to receive a direct payment equal in amount to the 45Q tax credit over the first five years.

Canada's CCUS Incentives—More to Come? We Think So

America's supercharging of CCUS incentives via the 45Q tax credit may spur Canada's federal government to expand its ITC in order to remain competitive. Indeed, the added attractiveness of CCUS projects in the Lower 48 will likely draw intensified capital investment.

Canada's 2023 federal budget may expand its CCUS ITC.

Accordingly, while Canada's CCUS ITC has not yet been enacted, this may be by design. It would not surprise us to see Canada's federal government expand the ITC substantially in order to spur investment in CCUS, especially in hard-to-abate sectors. This announcement may occur as a part of Canada's federal budget (typically in the spring).

Canada does not permit the trading of carbon credits between federal and provincial programs—we think this needs to change.

Comprehensive, yet regionally fragmented, Canada's carbon markets desperately need to establish fungibility in trading carbon allowances (and offsets) nationally if ambitious federal GHG-emission targets are to be met[4]. The sheer scale of CCUS decarbonization investment pending in Alberta means that there will be massive generation of carbon credits. As it stands, Canada does not permit the trading of credits (or offsets) between federal and provincial programs. This is one of the main reasons that Pathways is seeking an expansion of the ITC to cover operating costs, a production tax credit, contract for differences, or some other federal mechanism to shore up the carbon credit value for CO_2 sequestered. In our view, Canada lost the global LNG race to the US, but it could emerge as a global CCUS leader amid Pathways' work to refine and ultimately export carbon capture technology.

Alberta's CCUS incentive roll-out is likely to come after its May 29 election.

On the provincial side of things, Alberta remains in sharp focus; a recent United Conservative Party of Alberta leadership change and the forthcoming election could temporarily delay the roll-out of CCUS incentives. That said, we suspect that further provincial incentives for oil sands decarbonization could eventually come in the form of amendments to Alberta's Oil Sands Royalty Regime that would permit CCS expenditures as a qualifying cost in the Revenue-Cost calculation used to determine royalties payable. Augmentation of the Alberta Petrochemicals Incentive Program (APIP) to include CCS is another possible policy avenue for Alberta's government. That said, such incentives may not be formalized until after Alberta's upcoming provincial general election on May 29, 2023.

[4] Please see RBC ESG Stratify reports "Carbon Markets—The Need For Speed" and "Can Europe regain its CCS momentum?", as well as "EU Green Deal Industrial Plan announced", for a rundown on global carbon markets and CCS developments.

Quest—A Leading CCS Project

The Quest project in Alberta was one of the world's earliest commercial-scale CCS ventures integrated within an industrial complex[x]. Having surpassed 6.8 Mt of injected CO_2 in 2021 since project start-up, Quest has permanently stored more CO_2 underground than any other onshore CCS facility with dedicated geological storage[xi].

Quest is one of Alberta's leading CCS projects and has been in operation since 2015.

In our view, Quest constitutes a private-public framework for future CCS projects because its success depended on the partnership and collaboration of energy producers and governments alike. Indeed, Quest pioneered new ground-breaking regulations aimed at CO_2 storage along with monitoring and verification procedures.

There are seven key points:

1. Quest is operated by Shell Canada Energy on behalf of the Athabasca Oil Sands Project (AOSP) joint venture partners—Canadian Natural Resources (70% wi), Chevron Canada (20%), and Shell Canada (10%)[xii].
2. Quest captures about 1.2 Mtpa of CO_2, or more than 35% of the CO_2 produced at the Scotford Upgrader[xiii]. Design, construction, and start-up of Quest occurred between 2009 and 2015, with commercial operations commencing in October 2015[xiv]. Quest's capital cost of $790 million benefited from its technical integration within the Scotford complex. The project included funding from Shell and the governments of Alberta and Canada.

Quest is technically integrated with a concentrated CO_2 stream at Scotford.

3. Quest was developed to capture CO_2, a by-product from the three hydrogen manufacturing units within the Scotford Upgrader[xv]. The project uses Shell's amine (ADIP-X) technology, which captures about 80% of the CO_2 produced in the reformer unit[xvi]. This CO_2 is subsequently compressed and dehydrated into a dense-phase (fluid) state for pipeline transport. ADIP-X has been used for decades to capture CO_2 in gas processing and liquefaction plants. Quest uses electricity (capture and dehydration) drawn off the Alberta power grid and gas turbines in the Scotford Upgrader Cogeneration Plant.
4. Quest's reservoir modeling continues to indicate that there is more than sufficient storage capacity to accommodate the full project's CO_2 volume of 27 Mt[xvii].
5. A 12-inch diameter pipeline with a capacity of 3.0 Mtpa transports CO_2 from the Scotford Upgrader some 65 km (40 miles) to Thorhild, Alberta[xviii]. There, three horizontal wells inject the CO_2 (99%+ pure) deep underground into the Basal Cambrian sands[xix]. At a depth of about 2 km (1.25 miles), the Basal Cambrian formation is ideal for permanent sequestration because it accommodates high levels of injection and sits beneath a number of thick seals (Upper and Lower Lotsberg Salts)[xx]. The three horizontal wells are designed for a maximum combined CO_2 injection rate of about 3,750 t/day[xxi].

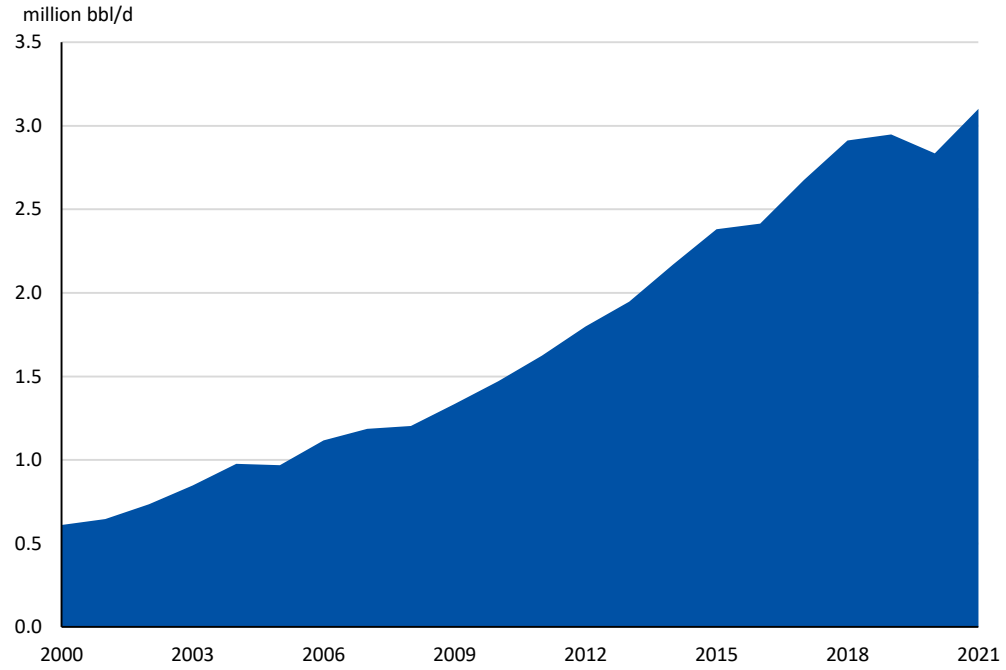
Quest's project operating costs were about $54/t in 2021.

6. Under a multi-credit arrangement, revenue streams for Quest include the generation of offset credits for the net CO_2 sequestered and an additional credit for CO_2 captured under Alberta's Technology Innovation and Emissions Reduction (TIER) Regulation.
7. Project operating costs (including sustaining capital) for Quest were approximately $56.6 million in 2021 or $53.65/t, up from $31.8 million in 2020 or $33.80/t[xxii]. The increase in costs from 2020 through 2021 largely reflects higher direct personnel, labor, corporate, and other costs[xxiii]. Quest is supported directly by about 25 full-time employees.

Alliance partners have been a driving force behind Canada's oil sands growth.

Canada's oil sands production has grown almost five-fold since 2000 to 3.1 million bbl/d in 2021.

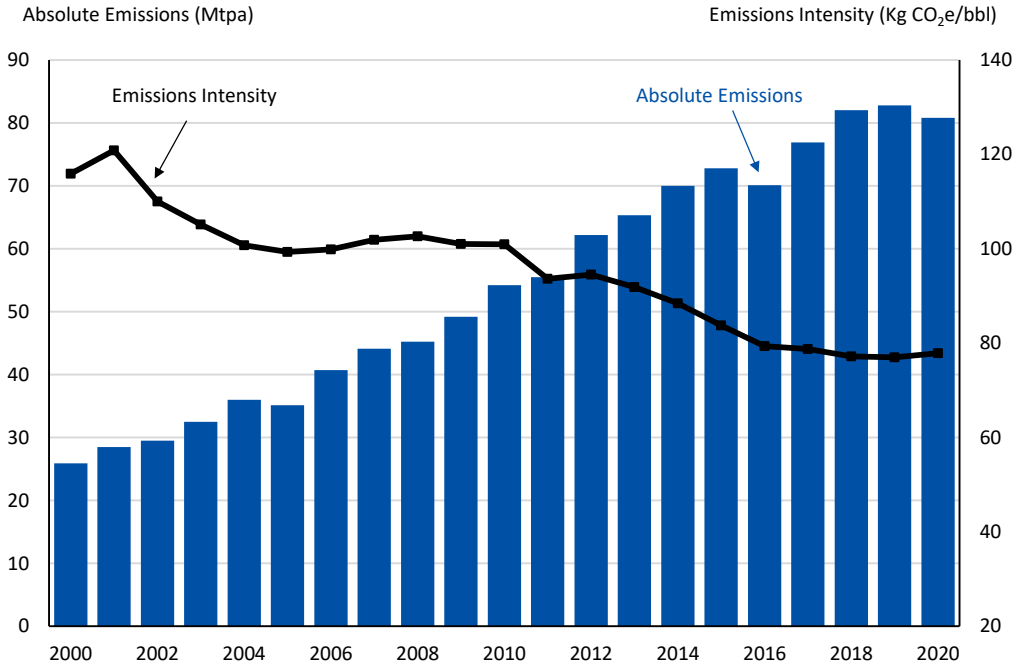
Exhibit 7 - Oil Sands Production, 2000–21



Source: CER

Absolute oil sands GHG emissions reflect big production growth over the last two decades, but emissions have declined on an intensity basis.

Exhibit 8 - Oil Sands Emissions, 2000–20



Note: Oil sands emissions intensity calculated as annual absolute emissions/total annual oil sands production.
Source: Greenhouse Gas Emissions Report (Environment and Climate Change Canada), CER

Exhibit 9 - Current Decarbonization Work Under Way

Company	Initiatives
Canadian Natural	• Piloting solvent EOR technology on its thermal in-situ assets with an objective to increase bitumen production, reduce the SOR, reduce GHG intensity, and realize high solvent recovery. This technology has the potential for application throughout CNQ's extensive thermal in-situ asset base. • CNQ is progressing with engineering and design of a commercial-scale solvent SAGD pad development at Kirby North, which is targeted to commence solvent injection in early 2024. • CNQ's solvent pilot in the Primrose steam flood area began solvent injection in November 2021 with plans to continue for approximately two years to achieve targeted SOR and GHG intensity reductions of 40–45%, with solvent recovery greater than 70%. The company is seeing positive operating results to date, including SOR reductions of approximately 50%.
Suncor Energy	• Fuel-switching that will replace coke-fired boilers with significantly lower emission cogeneration units ($1.4 billion project). • Allocating approximately 10% of its annual capital budget from 2022–25 to investments that advance its low-carbon energy offerings.
Cenovus Energy	• Completed feasibility study for carbon capture at Christina Lake. • Evaluated feasibility of carbon capture at the Elmworth gas plant as well as the Minnedosa Ethanol Plant, including the drilling and testing of a CO_2 sequestration appraisal well. • Initiated a technology screening study to determine the optimal CO_2 capture technology at the Lloydminster Upgrader. • Completed pre-FEED studies for commercial-scale carbon capture applications at two Cenovus assets, working with Svante. • Committed to a power purchase agreement (PPA) to buy renewable electricity and associated emissions offsets.
Imperial	• Progressing Grand Rapids development at Cold Lake, using steam-reducing technology (solvent-assisted, steam-assisted gravity drainage [SA-SAGD]) as well as other solvent technologies. • Expanding implementation of boiler flue gas technology at Kearl. • Pursuing CCS emissions reduction opportunity that captures efficiencies with Cold Lake operations.
MEG Energy	• Carbon capture and sequestration conceptual studies and initial Pre-FEED activities. • Shallow sequestration scoping studies.
ConocoPhillips Canada	• Various engineering studies are under way to explore operational efficiencies (facilities optimization, capture), while several field pilots are under way (steam drive + gas, steam additives, Warm Applied Solvent Process [WASP]). • Through COSIA participation, Natural Gas Decarbonization, Small Modular Nuclear Reactors (SMRs), and transformational capture technologies are being explored.

Source: Pathways Alliance

Exhibit 10 - Technologies Prioritized for Pathways Alliance

Technology	Project Initiatives/Collaborators
Carbon Capture & Storage	• Piloting next-generation technologies, such as those developed by Svante (Cenovus, Suncor, ConocoPhillips Canada). • Piloting the use of Molten Carbonate Fuel Cells (CNQ, Cenovus, Suncor). • Continuous improvement of capture plants to improve energy and cost efficiency (Cenovus, MEG Energy). • Identifying and developing plans to reduce costs of next-generation capture technologies (Cenovus, Suncor, Imperial, ConocoPhillips Canada, CNQ). • Evaluating the feasibility of CO_2 sequestration in depleted gas fields (Cenovus).
Natural Gas Decarbonization and Hydrogen Use	• Undertaking feasibility studies for deploying hydrogen as a substitute fuel to displace natural gas use (Cenovus, Suncor, Imperial, ConocoPhillips Canada, CNQ). • Evaluating technology options for converting carbon in natural gas and flue gas into economically useful products (Cenovus, Suncor, Imperial, ConocoPhillips Canada, CNQ).
Steam Reduction Technologies	• Pilot of next-generation high-concentration solvent technology developed in Imperial's oil and gas research center (CNQ, Cenovus, Suncor, Imperial, ConocoPhillips Canada, MEG Energy). • Solvent-assisted SAGD optimization (CNQ, Cenovus, Suncor, Imperial, ConocoPhillips Canada, MEG Energy).
Other Key Technologies	• Switching fuel and electrification of mine haul trucks (Cenovus, Suncor, Imperial, ConocoPhillips Canada, CNQ). • Use of geothermal energy to produce hot water and steam to reduce emissions (Cenovus, Suncor, Imperial, ConocoPhillips Canada, CNQ). • Advancing approaches to better manage fugitive emission (Cenovus, Suncor, Imperial, ConocoPhillips Canada, CNQ). • In pit extraction processes to minimize mine hauler fleet and associated emissions (CNQ). • Advancing direct air capture technology to remove CO_2 from the ambient air for underground storage and/or conversion to liquid fuels. • Assessing the future viability of small modular reactors—safe, versatile, and scalable technology that could supply zero-emissions energy for various oil sands applications.

Source: Pathways Alliance

Exhibit 11 - Select CCS/CCUS Projects

Project	Operators	Location	Estimated Capacity (Mtpa)	Project Status	Project Summary
Quest Carbon Capture & Storage	Shell	Alberta	1.2	Operating (2015 start-up)	• Constructed over the 2009-15 time frame, the Quest Carbon Capture and Storage project, located northeast of Edmonton, Alberta, with commercial operations commencing in October 2015. The project was designed to capture up to circa 1.2 million tonnes per annum of CO_2 from the 320,000 bbl/d Scotford Upgrader (a part of the Athabasca Oil Sands Mining and Upgrading Project) and represented the world's first commercial-scale CCS facility applied to oil sands operations. • To date, Quest has captured and stored more than 6.8 million tonnes of CO_2. • Quest captures CO_2 from hydrogen plants at the Scotford Upgrader. The CO_2 gas is compressed to liquid form and transported via pipeline before being injected more than 2km underground.
Horizon Oil Sands Carbon Capture Project	Canadian Natural Resources Canadian Natural	Alberta	0.4	Operating	• Integrated within its oil sands mining and upgrading operations, the Horizon project also captures CO_2 via its Hydrogen Plant. • On an annual basis, Horizon's CO_2recovery plant carries a capture capacity of 400,000 tonnes of CO_2. • A unique aspect of the capture process at Horizon is the level of integration within the existing facility. To that end, CNQ uses captured CO_2 from the Hydrogen plant and adds into its tailings stream before eventually entering the tailings pond, where it creates a chemical reaction that changes the tailings water pH to be the same as river water. This reaction allows solids to settle more quickly and is increasing water recycling and improving tailings consolidation over time.
Boundary Dam Carbon Capture and Storage	SaskPower SaskPower	Saskatchewan	1.0	Operating (2014 start-up)	• The Boundary Dam Power Station near Estevan, Saskatchewan retrofitted its Unit #3 to become the world's first commercial-scale CCS process on the coal-fired power plant. Unit #3 produces 115 MW of power—enough to power about 100,000 homes. It's also capable of reducing CO_2 emissions from coal processes by up to 90%. • The Unit #3 retrofit cost circa $1.5 billion dollars and has captured 4.6 million tonnes of CO_2 since operational start-up in 2014 (as of July 2022).
North West Sturgeon Refinery (Alberta Carbon Trunk Line)	North West Redwater Ownership (split between Canadian Natural Resources and the Alberta government) NWR	Alberta	1.2	Operating (2020 start-up)	• The North West Redwater Partnership's Sturgeon refinery developed a bitumen-processing solution to produce ultra-low sulphur fuels. The refinery uses gasification to convert the heavy bottoms (waste product of bitumen) into hydrogen required within refinery operations and a CO_2 steam that is captured instead of being vented into the atmosphere. Captured CO_2 is then sold to third parties for enhanced oil recovery and permanent storage. • With the government recently purchasing a 50% equity stake from the NWR in 2021, it now shares a 50-50 ownership between the Alberta Petroleum Marketing Commission and Canadian Natural Resources Ltd. • Located 45km northeast of Edmonton, the refinery can process 79,000 bbl/d of diluted bitumen into low-carbon ultra-low sulphur diesel, vacuum gas oil, diluent, and natural gas liquids.
Nutrien Fertilizer Facility (Alberta Carbon Trunk Line)	Nutrien Nutrien	Alberta	0.3	Operating (2020 start-up)	• Nutrien's Redwater fertilizer plant is the other source for CO_2 on the ACTL, where nitrogen fertilizer requires ammonia production first, with CO_2 as the byproduct. The plant sent around 139,000 tonnes of CO_2 to the ACTL in 2021. • Nutrien has also used carbon capture since 2013 at its Geismer facility in Louisiana, eliminating 248,000 tonnes of CO_2 in 2021. • Captured CO_2 is transported through Wolf Midstream's pipeline and injected into depleted oil reservoirs to aide in EOR efforts, and then reinjected into the well for sequestration.
Weyburn EOR	Whitecap Resources WHITECAP RESOURCES INC	Saskatchewan	2.0	Operating (2000 start-up)	• The Weyburn EOR project has been in operation for decades, with CO_2 injection beginning in 2000. The project is recognized as one of the largest geologic CO_2 storage projects in the world, sequestering carbon approximately 1,500 metres underground. • The project's current injection capacity is approximately 2.0 million tonnes per annum of CO_2 sources from the Dakota Gasification facility and SaskPower's Boundary Dam. • To date, Weyburn has sequestered more than 36 million tonnes of CO_2, averaging 1.7 Mtpa of CO_2 since inception.
Rolling Hills Carbon Sequestration Hub	Whitecap Resources and AltaGas WHITECAP RESOURCES INC AltaGas	Alberta	TBD	Proposed: 2026	• Rolling Hills Carbon Sequestration Hub is a prospective open-access project that would be located near AltaGas's Harmattan Gas Plant. • The project is designed to include CO_2 injection wells, carbon storage in underground reservoirs, and various intra-hub pipelines. • As of Q3/22, the project has been selected by the Government of Alberta to enter into an agreement for continued evaluation work.

Source: Company reports

Exhibit 12 - Select CCS/CCUS Projects

Project	Operators	Location	Estimated Capacity (Mtpa)	Project Status	Project Summary
Alberta Carbon Trunk Line	Enhance Energy, Wolf Midstream, Northwest Redwater Parnership, Nutrien	Alberta	14.6	Operating (2020 start-up)	• The Alberta Carbon Trunk Line (ACTL) system is a large-scale integrated CCUS system located in Central Alberta. The ACTL system captures CO_2 at the North West Redwater Partnership (NWR) Sturgeon Refinery and the Nutrien Redwater fertilizer plant. • Carbon is transported via a 240 km pipeline to Enhance Energy's Clive enhanced oil recovery (EOR) project for injection into underground reservoirs. • The project was supported at the federal level via the ecoEnergy Technology Initiative and the Clean Energy Fund ($63 million in total). The Alberta government also provided funding through the Carbon Capture and Storage fund ($495 million committed through 2025). • Total ACTL capacity supports 14.6 million tonnes of CO_2 annually. The consortium estimates this accounts for approximately 20% of current oil sands emissions (as of June 2020).
Advantage Glacier Gas Plant Phase 1 & 2	Entropy Inc	Alberta	0.2	Phase 1 start-up in 2022, Phase 2 in Q2/2023	• Phase 1 capital expenditures of $31 million (47,000 tonnes of CO_2/year). Phase 2 capital expenditures of $49 million (136,000 tonnes of CO_2/year). • First commercial project of Entropy Inc., features proprietary modular CCS technology (>90% capture efficiency from exhaust gas). • Waste-heat integration for improved process efficiency; expected operating costs of roughly $15/$TCO_2$ e. • Phases 1 and 2 to capture flue gas from 12 gas-driven reciprocating compressors and four generators (200,000 Tpa total). • Sequestration in existing deep saline aquifer at expected rates of 10 mmcf/d (>99% CO_2). • Entropy's pipeline of projects includes five projects in the MOU stage (>3 Mtpa) and four projects in the FEED stage (>1 Mtpa).
Alberta Carbon Grid	Pembina and TC Energy 50/50 JV	Alberta	Phase 1: 10.0 Fully Developed: 20.0	Proposed (potential final investment decision in 2024–25; possible completion by around 2030)	• On October 18, 2022, ACG announced that it had entered into a carbon sequestration agreement with the Government of Alberta to further evaluate one of the Areas of Interest (AOI) for safely storing carbon. This agreement will allow ACG to continue evaluating the suitability of its AOI and move forward with the next phase of the province's CCUS process. • ACG proposes to utilize existing right of ways and/or pipelines to connect the Alberta Industrial Heartland to the sequestration location. • ACG will be developed in phases; the first phase will have the potential capability of transporting and storing up to 10 Mtpa of CO_2. Beyond that, ACG will look to grow and expand through multiple storage hubs to sequester up to 20 Mtpa of CO_2 throughout Alberta.
Genesee Carbon Capture and Sequestration (Genesee CCS)	Capital Power	Alberta	3.0	Proposed (start-up as early as 2027)	• Capital Power approved a Limited Notice to Proceed (LNTP) for the Genesee CCS project in Q4/22, positioning it to make a Final Investment Decision (FID) in Q3/23. • The project could be operational as early as 2027 and capture 3 Mtpa of CO_2 from the repowered Genesee 1 and 2 units. • Carbon would be transported and stored through Enbridge's Open Access Wabamun Carbon Hub. • Project costs are estimated to be $2.3 billion, with the company anticipating that federal investment tax credits (ITC) will represent 42% of the total costs, with the remaining 58% being funded roughly on a 50/50 basis between other government sources (such as the Strategic Innovation Fund and/or the Canada Infrastructure Bank) and Capital Power.
Genesee Carbon Conversion Centre (GC3)	Capital Power	Alberta	< 0.1	TBD	• Capital Power aims to build the world's largest commercial scale production facility of carbon nanotubes (CNT) at its Genesee generation station. • GC3 will have an initial production capacity of 2,500 tonnes of CNTs; once completed, it will be capable of producing up to 7,500 tonnes annually. • As it takes four tonnes of CO_2 to produce one tonne of CNT, the project is expected to consume 30,000 CO_2 per year for use in CNT production. • According to Emissions Reduction Alberta, the estimated project cost is $85 million.
Enbridge Open Access Wabamun Carbon Hub	Enbridge	Alberta	TBD	Proposed (initial phase start-up as early as 2026)	• In September 2022, Enbridge signed a carbon sequestration evaluation agreement with the Government of Alberta, and it expects to drill two wells in 2023 to evaluate the suitability of the underlying geology. • Phased in-service dates could start as early as 2026 with notable commitments of nearly 4 million tonnes supported by carbon capture projects being advanced by Capital Power and Lehigh Cement (approximately 3 million annually from Capital Power and approximately 0.8 million annually from Lehigh Cement). • Once built, the Hub will remain open access and can be scaled to meet the needs of other nearby industrial emitters.

Source: Company reports, Lehigh Cement Press Release (January 26, 2022), Alberta Carbon Grid Press Release (October 18, 2022)

Exhibit 13 - Select CCS/CCUS Projects

Project	Operators	Location	Estimated Capacity (Mtpa)	Project Status	Project Summary
Polaris	Shell	Alberta	0.75 (Initial)	Planned (2023 FID)	• The proposed Polaris CCS project would capture carbon dioxide from the Shell-owned Scotford refinery and chemicals plant. The initial phase is expected to start operations around the middle of the decade, subject to a final investment decision by Shell expected in 2023. Polaris would have storage capacity of about 300 million tonnes of CO_2 over the life of the project. • The intial phase of the project would capture and store approximately 0.75 Mtpa of CO_2 from the Scotford refinery and chemicals plant. The second phase involves the creation of a CO_2 storage hub in Alberta, further decarbonizing Shell's facilities, and storing emissions on behalf of third-party industry sources. Fully built, and contingent on acquiring pore space leases from the Province of Alberta, Polaris could serve as a CO_2 storage hub for more than 10 Mtpa. • In the initial phase, CO_2 captured from the refinery's hydrogen plants would produce blue hydrogen for use in the refining process, with the potential for large-scale blue hydrogen production in future phases.
Caroline Carbon Capture Power Complex	Pieridae	Alberta	3.0	TBD	• Pieridae announced the creation of the Caroline Carbon Capture Power Complex with the ability to sequester up to 3 Mtpa of CO_2 annually into one of the Caroline Facility's depleted gas reservoirs. Phase 1 of the Complex will sequester 1 Mtpa of CO_2 and produce approximately 200MW of blue power annually. • The Complex will have a maximum power production capacity of 7.9 billion KWh and will capture carbon from CO_2 generated at the gas processing facility, CO_2 generation from power production, and CO_2 produced by third parties. • Pieridae will reuse and repurpose existing infrastructure at the Facility to lower overall capital costs and environmental impacts.

Source: Company reports, Lehigh Cement Press Release (January 26, 2022), Alberta Carbon Grid Press Release (October 18, 2022)

End Notes

[i] Canada Energy Regulator (2022): Estimated Production of Canadian Crude Oil and Equivalent, https://www.cer-rec.gc.ca/en/data-analysis/energy-commodities/crude-oil-petroleum-products/statistics/estimated-production-canadian-crude-oil-equivalent.html

[ii] Ibid

[iii] Statistics Canada. Table 12-10-0121-01 International merchandise trade by commodity, monthly (x 1,000,000) (Customs basis, unadjusted), https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1210012101

[iv] Pathways Alliance (2023), Technical Summary directly from Pathways Alliance team

[v] Ibid

[vi] Ibid

[vii] Ibid

[viii] Ibid

[ix] Environment and Climate Change Canada (2022) National Inventory Report 1990–2020: Greenhouse Gas Sources and Sinks in Canada, https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

[x] Shell, https://www.shell.ca/en_ca/media/news-and-media-releases/news-releases-2020/quest-ccs-facility-captures-and-stores-five-million-tonnes.html

[xi] Ibid

[xii] Ibid

[xiii] Quest annual summary, p. i, https://open.alberta.ca/dataset/f74375f3-3c73-4b9c-af2b-ef44e59b7890/resource/ff260985-e616-4d2e-92e0-9b91f5590136/download/energy-quest-annual-summary-alberta-department-of-energy-2019.pdf

[xiv] Quest Carbon Capture and Storage project : annual report, 2021, https://open.alberta.ca/dataset/f74375f3-3c73-4b9c-af2b-ef44e59b7890/resource/ff260985-e616-4d2e-92e0-9b91f5590136/download/energy-quest-annual-summary-alberta-department-of-energy-2019.pdf

[xv] Ibid

[xvi] Ibid

[xvii] Ibid

[xviii] Global CCS Institute, https://www.globalccsinstitute.com/archive/hub/publications/196788/quest-less-co2-learning-ccs-implementation-canada.pdf

[xix] Quest annual summary, p. i, https://open.alberta.ca/dataset/f74375f3-3c73-4b9c-af2b-ef44e59b7890/resource/ff260985-e616-4d2e-92e0-9b91f5590136/download/energy-quest-annual-summary-alberta-department-of-energy-2019.pdf

[xx] Global CCS Institute, https://www.globalccsinstitute.com/archive/hub/publications/196788/quest-less-co2-learning-ccs-implementation-canada.pdf

[xxi] Quest Carbon Capture and Storage project : annual report, 2019, https://open.alberta.ca/dataset/f74375f3-3c73-4b9c-af2b-ef44e59b7890/resource/ff260985-e616-4d2e-92e0-9b91f5590136/download/energy-quest-annual-summary-alberta-department-of-energy-2019.pdf

[xxii] Quest Carbon Capture and Storage project : annual report, 2021, p. 10-4, https://open.alberta.ca/dataset/113f470b-7230-408b-a4f6-8e1917f4e608/resource/e957e772-4fe2-4504-8fea-439120134427/download/quest-annual-summary-report-alberta-department-of-energy-2021.pdf

[xxiii] Ibid

Contributing Authors

RBC Dominion Securities Inc.

Research RBCCM Global Energy (Equity)	(416) 842-7575	rbccmglobalenergy@rbccm.com
Greg Pardy (Head of Global Energy Research)	(416) 842-7848	greg.pardy@rbccm.com
Robert Mann (Associate)	(416) 842-7915	robert.mann@rbccm.com
Justin Ho (Associate)	(416) 842-8375	justin.ho@rbccm.com
Luke Davis (Analyst)	(403) 299-5042	luke.davis@rbccm.com

RBC Europe Limited

Biraj Borkhataria (Associate Director of European Research)	+44 20 7029 7556	biraj.borkhataria@rbccm.com
Adnan Dhanani (AVP)	+44 20 7029 7810	adnan.dhanani@rbccm.com

RBC Capital Markets, LLC

Scott Hanold (Analyst)	(512) 708-6354	scott.hanold@rbccm.com

Companies mentioned

Canadian Natural Resources Limited (TSX: CNQ CN; C$77.70; Outperform)
Cenovus Energy Inc. (TSX: CVE CN; C$25.03; Outperform)
Chevron Corporation (NYSE: CVX US; $169.64; Sector Perform)
ConocoPhillips (NYSE: COP US; $107.49; Outperform)
Imperial Oil Limited (TSX: IMO CN; C$67.13; Outperform)
MEG Energy Corp. (TSX: MEG CN; C$21.37; Outperform)
Suncor Energy Inc. (TSX: SU CN; C$43.88; Outperform)

Required disclosures

Non-U.S. analyst disclosure

One or more research analysts involved in the preparation of this report (i) may not be registered/qualified as research analysts with the NYSE and/or FINRA and (ii) may not be associated persons of the RBC Capital Markets, LLC and therefore may not be subject to FINRA Rule 2241 restrictions on communications with a subject company, public appearances and trading securities held by a research analyst account.

Conflicts disclosures

This product constitutes a compendium report (covers six or more subject companies). As such, RBC Capital Markets chooses to provide specific disclosures for the subject companies by reference. To access conflict of interest and other disclosures for the subject companies, clients should refer to https://www.rbccm.com/GLDisclosure/PublicWeb/DisclosureLookup.aspx?entityId=1. These disclosures are also available by sending a written request to RBC Capital Markets Research Publishing, P.O. Box 50, 200 Bay Street, Royal Bank Plaza, 29th Floor, South Tower, Toronto, Ontario M5J 2W7 or an email to rbcinsight@rbccm.com.

The analyst(s) responsible for preparing this research report received compensation that is based upon various factors, including total revenues of the member companies of RBC Capital Markets and its affiliates, a portion of which are or have been generated by investment banking activities of the member companies of RBC Capital Markets and its affiliates.

With regard to the MAR investment recommendation requirements in relation to relevant securities, a member company of Royal Bank of Canada, together with its affiliates, may have a net long or short financial interest in excess of 0.5% of the total issued share capital of the entities mentioned in the investment recommendation. Information relating to this is available upon request from your RBC investment advisor or institutional salesperson.

Explanation of RBC Capital Markets Equity rating system

An analyst's 'sector' is the universe of companies for which the analyst provides research coverage. Accordingly, the rating assigned to a particular stock represents solely the analyst's view of how that stock will perform over the next 12 months relative to the analyst's sector average.

Ratings

Outperform (O): Expected to materially outperform sector average over 12 months.
Sector Perform (SP): Returns expected to be in line with sector average over 12 months.
Underperform (U): Returns expected to be materially below sector average over 12 months.
Restricted (R): RBC policy precludes certain types of communications, including an investment recommendation, when RBC is acting as an advisor in certain merger or other strategic transactions and in certain other circumstances.
Not Rated (NR): The rating, price targets and estimates have been removed due to applicable legal, regulatory or policy constraints which may include when RBC Capital Markets is acting in an advisory capacity involving the company.
As of March 31, 2020, RBC Capital Markets discontinued its Top Pick rating. Top Pick rated securities represented an analysts best idea in the sector; expected to provide significant absolute returns over 12 months with a favorable risk-reward ratio. Top Pick rated securities have been reassigned to our Outperform rated securities category, which are securities expected to materially outperform sector average over 12 months.

Risk Rating

The **Speculative** risk rating reflects a security's lower level of financial or operating predictability, illiquid share trading volumes, high balance sheet leverage, or limited operating history that result in a higher expectation of financial and/or stock price volatility.

Distribution of ratings

For the purpose of ratings distributions, regulatory rules require member firms to assign ratings to one of three rating categories - Buy, Hold/Neutral, or Sell - regardless of a firm's own rating categories. Although RBC Capital Markets' ratings of Outperform (O), Sector Perform (SP), and Underperform (U) most closely correspond to Buy, Hold/Neutral and Sell, respectively, the meanings are not the same because our ratings are determined on a relative basis.

Distribution of ratings

RBC Capital Markets, Equity Research

As of 31-Dec-2022

			Investment Banking Serv./Past 12 Mos.	
Rating	**Count**	**Percent**	**Count**	**Percent**
BUY [Outperform]	**839**	**56.05**	**225**	**26.82**
HOLD [Sector Perform]	**603**	**40.28**	**151**	**25.04**
SELL [Underperform]	**55**	**3.67**	**3**	**5.45**

Conflicts policy

RBC Capital Markets Policy for Managing Conflicts of Interest in Relation to Investment Research is available from us on request. To access our current policy, clients should refer to
https://www.rbccm.com/global/file-414164.pdf
or send a request to RBC Capital Markets Research Publishing, P.O. Box 50, 200 Bay Street, Royal Bank Plaza, 29th Floor, South Tower, Toronto, Ontario M5J 2W7. We reserve the right to amend or supplement this policy at any time.

Dissemination of research

RBC Capital Markets endeavors to make all reasonable efforts to provide research content simultaneously to all eligible clients, having regard to local time zones in overseas jurisdictions. RBC Capital Markets provides eligible clients with access to Research Reports on the Firm's proprietary INSIGHT website, via email and via third-party vendors. Please contact your investment advisor or institutional salesperson for more information regarding RBC Capital Markets' research.
For a list of all recommendations on the company that were disseminated during the prior 12-month period, please click on the following link: https://rbcnew.bluematrix.com/sellside/MAR.action
The 12 month history of SPARCs can be viewed at RBC Insight.

Analyst certification

All of the views expressed in this report accurately reflect the personal views of the responsible analyst(s) about any and all of the subject securities or issuers. No part of the compensation of the responsible analyst(s) named herein is, or will be, directly or indirectly, related to the specific recommendations or views expressed by the responsible analyst(s) in this report.

Third-party disclaimers

The Global Industry Classification Standard ("GICS") was developed by and is the exclusive property and a service mark of MSCI Inc. (“MSCI”) and Standard & Poor's Financial Services LLC (“S&P”) and is licensed for use by RBC. Neither MSCI, S&P, nor any other party involved in making or compiling the GICS or any GICS classifications makes any express or implied warranties or representations with respect to such standard or classification (or the results to be obtained by the use thereof), and all such parties hereby expressly disclaim all warranties of originality, accuracy, completeness, merchantability and fitness for a particular purpose with respect to any of such standard or classification. Without limiting any of the foregoing, in no event shall MSCI, S&P, any of their affiliates or any third party involved in making or compiling the GICS or any GICS classifications have any liability for any direct, indirect, special, punitive, consequential or any other damages (including lost profits) even if notified of the possibility of such damages.

RBC Capital Markets disclaims all warranties of originality, accuracy, completeness, merchantability or fitness for a particular purpose with respect to any statements made to the media or via social media that are in turn quoted in this report, or otherwise reproduced graphically for informational purposes.

Disclaimer

RBC Capital Markets is the business name used by certain branches and subsidiaries of the Royal Bank of Canada, including RBC Dominion Securities Inc., RBC Capital Markets, LLC, RBC Europe Limited, RBC Capital Markets (Europe) GmbH, Royal Bank of Canada, Hong Kong Branch, Royal Bank of Canada, Singapore Branch and Royal Bank of Canada, Sydney Branch. The information contained in this report has been compiled by RBC Capital Markets from sources believed to be reliable, but no representation or warranty, express or implied, is made by Royal Bank of Canada, RBC Capital Markets, its affiliates or any other person as to its accuracy, completeness or correctness. All opinions and estimates contained in this report constitute RBC Capital Markets'' judgement as of the date of this report, are subject to change without notice and are provided in good faith but without legal responsibility. Nothing in this report constitutes legal, accounting or tax advice or individually tailored investment advice. This material is prepared for general circulation to clients and has been prepared without regard to the individual financial

circumstances and objectives of persons who receive it. The investments or services contained in this report may not be suitable for you and it is recommended that you consult an independent investment advisor if you are in doubt about the suitability of such investments or services. This report is not an offer to sell or a solicitation of an offer to buy any securities. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. RBC Capital Markets research analyst compensation is based in part on the overall profitability of RBC Capital Markets, which includes profits attributable to investment banking revenues. Every province in Canada, state in the U.S., and most countries throughout the world have their own laws regulating the types of securities and other investment products which may be offered to their residents, as well as the process for doing so. As a result, the securities discussed in this report may not be eligible for sale in some jurisdictions. RBC Capital Markets may be restricted from publishing research reports, from time to time, due to regulatory restrictions and/ or internal compliance policies. If this is the case, the latest published research reports available to clients may not reflect recent material changes in the applicable industry and/or applicable subject companies. RBC Capital Markets research reports are current only as of the date set forth on the research reports. This report is not, and under no circumstances should be construed as, a solicitation to act as securities broker or dealer in any jurisdiction by any person or company that is not legally permitted to carry on the business of a securities broker or dealer in that jurisdiction. To the full extent permitted by law neither RBC Capital Markets nor any of its affiliates, nor any other person, accepts any liability whatsoever for any direct, indirect or consequential loss arising from, or in connection with, any use of this report or the information contained herein. No matter contained in this document may be reproduced or copied by any means without the prior written consent of RBC Capital Markets in each instance.

Additional information is available on request.

To U.S. Residents:
This publication has been approved by RBC Capital Markets, LLC (member FINRA, NYSE, SIPC), which is a U.S. registered broker-dealer and which accepts responsibility for this report and its dissemination in the United States. Any U.S. recipient of this report that is not a registered broker-dealer or a bank acting in a broker or dealer capacity and that wishes further information regarding, or to effect any transaction in, any of the securities discussed in this report, should contact and place orders with RBC Capital Markets, LLC.

To Canadian Residents:
This publication has been approved by RBC Dominion Securities Inc.(member IIROC). Any Canadian recipient of this report that is not a Designated Institution in Ontario, an Accredited Investor in British Columbia or Alberta or a Sophisticated Purchaser in Quebec (or similar permitted purchaser in any other province) and that wishes further information regarding, or to effect any transaction in, any of the securities discussed in this report should contact and place orders with RBC Dominion Securities Inc., which, without in any way limiting the foregoing, accepts responsibility for this report and its dissemination in Canada.

To U.K. Residents:
This publication has been approved by RBC Europe Limited ('RBCEL') which is authorized by the Prudential Regulation Authority and regulated by the Financial Conduct Authority ('FCA') and the Prudential Regulation Authority, in connection with its distribution in the United Kingdom. This material is not for general distribution in the United Kingdom to retail clients, as defined under the rules of the FCA. RBCEL accepts responsibility for this report and its dissemination in the United Kingdom.

To EEA Residents:
This material is distributed in the EU by either RBCEL on an authorised cross-border basis, or by RBC Capital Markets (Europe) GmbH (RBC EG) which is authorised and regulated in Germany by the Bundesanstalt für Finanzdienstleistungsaufsicht (German Federal Financial Supervisory Authority) (BaFin).

To Persons Receiving This Advice in Australia:
This material has been distributed in Australia by Royal Bank of Canada, Sydney Branch (ABN 86 076 940 880, AFSL No. 246521). This material has been prepared for general circulation and does not take into account the objectives, financial situation or needs of any recipient. Accordingly, any recipient should, before acting on this material, consider the appropriateness of this material having regard to their objectives, financial situation and needs. If this material relates to the acquisition or possible acquisition of a particular financial product, a recipient in Australia should obtain any relevant disclosure document prepared in respect of that product and consider that document before making any decision about whether to acquire the product. This research report is not for retail investors as defined in section 761G of the Corporations Act.

To Hong Kong Residents:
This publication is distributed in Hong Kong by Royal Bank of Canada, Hong Kong Branch, which is regulated by the Hong Kong Monetary Authority and the Securities and Futures Commission (SFC) in Hong Kong, RBC Investment Services (Asia) Limited and RBC Global Asset Management (Asia) Limited, both entities are regulated by the SFC. This material is not for general distribution in Hong Kong to persons who are not professional investors (as defined in the Securities and Futures Ordinance of Hong Kong (Cap. 571) and any rules made thereunder.

To Singapore Residents:
This publication is distributed in Singapore by the Royal Bank of Canada, Singapore Branch, a registered entity licensed by the Monetary Authority of Singapore. This material has been prepared for general circulation and does not take into account the objectives, financial situation, or needs of any recipient. You are advised to seek independent advice from a financial adviser before purchasing any product. If you do not obtain independent advice, you should consider whether the product is suitable for you. Past performance is not indicative of future performance. If you have any questions related to this publication, please contact the Royal Bank of Canada, Singapore Branch. Royal Bank of Canada, Singapore Branch accepts responsibility for this report and its dissemination in Singapore.

To Japanese Residents:
Unless otherwise exempted by Japanese law, this publication is distributed in Japan by or through RBC Capital Markets (Japan) Ltd. which is a Financial Instruments Firm registered with the Kanto Local Financial Bureau (Registered number 203) and a member of the Japan Securities Dealers Association (JSDA) and the Financial Futures Association of Japan (FFAJ).