

CANADA:

INNOVATION IS DRIVING GLOBAL INVESTMENTS

Canada's energy sector is transitioning to a low-carbon future

A look at innovative technologies and processes within progressive companies

Focus on British Columbia, Alberta, Saskatchewan and Newfoundland and Labrador

SPECIAL SUPPLEMENT TO

World Oil[®]

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CANADA:

CANADA. SWEEPING FORESTS, CASCADING MOUNTAINS, EXPANSIVE PRAIRIES, ROCKY COASTLINES—AND THE POWER TO TRANSFORM HIGH-CARBON ECONOMIES AROUND THE WORLD.

The energy sector is at the heart of Canada's environmental, economic and social agendas. Through hard work, ingenuity and collaboration, Canada is positioning itself as a leader in a world that is increasingly looking for the most sustainably sourced products.



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INNOVATING FOR A LOW CARBON FUTURE

The country's vast natural resources have helped to define Canada as a nation and shape us as a people, as a dynamic and innovative leader and as a global supplier of choice.

Now, as the urgency for climate action becomes the global challenge and necessity of our time, Canada is undergoing a generational transformation that is critical to its success in attracting investors in this century of clean growth.

GLOBAL STRENGTH IN OIL AND GAS

Canada is the world's fourth largest natural gas producer. It is home to the world's largest oil reserves open to private investment. And boasts one of the cleanest electricity grids. We also have a highly skilled workforce that is bringing innovation and change to Canada's oil and gas industries.

Canada is the only G7 country to have free trade agreements concluded with all other G7 nations, giving us access to vast markets in North America, Asia, and Europe, making us the envy of the world. Add to that a unique relationship with the United States, tied together in part by over 30 transmission lines and 70 pipelines.

According to the International Energy Agency's sustainable development scenario, demand for petroleum products will exist for decades to come as global emissions must decline. This opens a new world of opportunity for leadership in cleaner production.

The following pages tell a story about **Canada's innovation and environmental pledge**. They feature compelling reasons why investing in Canadian energy is the right choice, right now.

GREATER MODERNIZATION MEANS GREATER OPPORTUNITY

Canada's oil and gas industry adheres to some of the most stringent environmental and regulatory review processes on the planet. And through regulatory modernization we now have a space where industry and environmental leaders can work together to drive down GHG emissions.

Canada stands with Norway as the only two major oil-producing nations with carbon price systems in place. Canada is also working with its provincial partners to cap emissions from major development projects. And the Government of Canada's Oceans Protection Plan makes Canada a world leader in marine safety and ensuring responsible commercial shipping.

These relatively recent measures build on a foundation of progress. Over the past decade, Canada has cut oil sands emissions by 21% per barrel. New technologies could cut emissions further, by one-quarter in the next decade alone. Electrification of Canada's gas and LNG operations using hydroelectricity will produce the world's cleanest LNG.

CUTTING EMISSIONS, BOOSTING COMPETITIVENESS

Work is underway to put Canada on a trajectory to have the world's cleanest petroleum sector. Producers are spending billions on innovation, by themselves and through organizations like Canada's Oil Sands Innovation Alliance and the Clean Resource Innovation Network. These efforts will develop new clean technologies to mitigate environmental impacts on our air, land and water.



CANADIAN ENERGY AT A GLANCE



11%
of GDP



832k
Direct and indirect jobs



165
Countries
trade energy with Canada

INDUSTRY HIGHLIGHTS

Crude oil activities in Canada's energy sector include exploration, drilling production, field processing, storing and transporting oil.

Globally, Canada is ranked:

3RD largest oil reserves in the world

4TH largest producer of oil in the world

4TH largest producer of natural gas in the world

4TH in Cleantech Innovation

Source: Natural Resources Canada



REDUCING EMISSIONS FROM HEAVY OIL EXTRACTION

With heavy oil reserves shared by both provinces, Saskatchewan and Alberta have been leading research and development for decades into heavy oil extraction technologies.

Progressive cavity pumps, which allowed for sand along with heavy oil to be produced in heavy oil wells, and steam assisted gravity drainage (SAGD) are both technologies that were developed and deployed in Western Canada.

Meeting the technological challenges for oil sands production has resulted in some of the highest recovery rates in the world, with *in situ* methods ranging from 40-60% of oil-in-place, while open-pit mining typically exceeds 90%. For comparison, the average conventional well in Alberta yields 8%, while shale oil averages less than 10%.

LESS STEAM, LESS HEAT, FEWER GHG EMISSIONS

Innovation is characteristic of Canadian oil sands companies: less energy-intensive extraction technologies are constantly under development, with a recent emphasis on production that uses less steam. The heat required to create steam in a process like SAGD, for example, has historically been achieved through the burning of natural gas or other hydrocarbons and is the primary source of upstream GHG emissions.

One approach has been to explore the use of solvent injection technologies. Solvents such as propane, butane, methane and, significantly, CO₂ have been trialed in heavy oil operations. Such solvents lower the viscosity of oil, allowing for more recovery with fewer emissions, since they require less or even no heat.

TALKING JIVE: REDUCING EMISSIONS USING SOLVENT INJECTION

The Joint Implementation of Vapour Extraction (JIVE) program did field trials of solvent injection technologies in both Alberta and Saskatchewan between 2005 and 2011.

Husky, Nexen and CNRL each tested different solvents and injection configurations. Those trials, and a concurrent research and optimization program managed by the Petroleum Technology Research Centre (PTRC), demonstrated that solvent extraction is technically viable and improves oil recovery while significantly reducing CO₂ emissions. In cases where captured CO₂ is used as the solvent, emissions are also reduced from affiliated industrial processes.

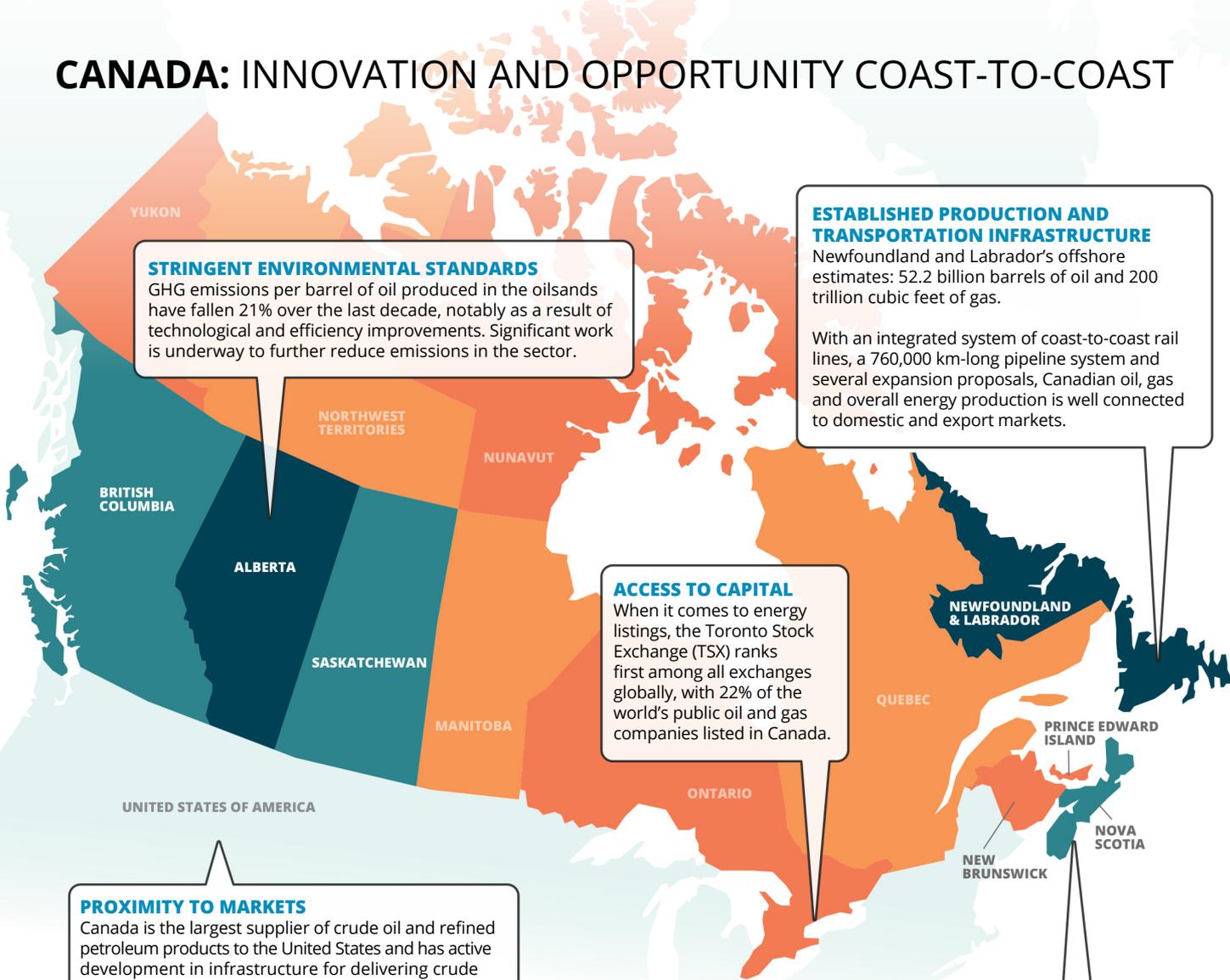
Husky Energy has moved on to commercial deployment of CO₂ solvent injection at its Edam, Mervin and Lashburn operations, with injected carbon dioxide captured from its nearby Lloydminster upgrader.



Photo: NEXEN Plover Pilot Plant for solvent injection.



CANADA: INNOVATION AND OPPORTUNITY COAST-TO-COAST



STRINGENT ENVIRONMENTAL STANDARDS

GHG emissions per barrel of oil produced in the oilsands have fallen 21% over the last decade, notably as a result of technological and efficiency improvements. Significant work is underway to further reduce emissions in the sector.

ESTABLISHED PRODUCTION AND TRANSPORTATION INFRASTRUCTURE

Newfoundland and Labrador's offshore estimates: 52.2 billion barrels of oil and 200 trillion cubic feet of gas.

With an integrated system of coast-to-coast rail lines, a 760,000 km-long pipeline system and several expansion proposals, Canadian oil, gas and overall energy production is well connected to domestic and export markets.

ACCESS TO CAPITAL

When it comes to energy listings, the Toronto Stock Exchange (TSX) ranks first among all exchanges globally, with 22% of the world's public oil and gas companies listed in Canada.

PROXIMITY TO MARKETS

Canada is the largest supplier of crude oil and refined petroleum products to the United States and has active development in infrastructure for delivering crude oil and natural gas supplies to Asian and European markets. Liquefied natural gas (LNG) transportation from western Canada to east Asia is 14 days faster than from the U.S. Gulf Coast.

OFFSHORE NOVA SCOTIA IS A PROVEN OIL AND GAS RICH REGION,

has been successfully producing natural gas for nearly 20 years. With a potential for 120 trillion cubic feet of natural gas and 8 billion barrels of oil in its offshore area, the region is attracting investment interest from global companies.

Its attractive shipping distances to world markets, deep tide water ports and pre-zoned industrial lands means Nova Scotia is also well positioned to become a contender for LNG export to international markets.

(Source: Nova Scotia Department of Energy and Mines)



FOCUS ON: **BRITISH COLUMBIA**

LEVERAGING CLEAN POWER TO PRODUCE THE LOWEST EMISSION LNG IN THE WORLD

Traditionally known for its breathtaking natural beauty and abundant natural resources, British Columbia's proximity to Liquefied Natural Gas (LNG) customers, plentiful natural gas and cool climate make it ideal for LNG investment.

Located on the Pacific Ocean with more than 16,000 miles of coastline, British Columbia is within ten days' shipping distance to Japan and China, compared to 24 days from the U.S. Gulf Coast. Without Panama Canal shipping costs, moving LNG to customers from British Columbia offers a distinct financial advantage.

HYDROELECTRIC POWER CONTRIBUTES TO THE WORLD'S LOWEST EMISSION LNG

The province also has abundant, clean hydroelectric power, thanks to many rivers, lakes, streams and considerable rainfall. This enables British Columbia to produce LNG with fewer emissions, including at the existing electric powered FortisBC Tilbury LNG facility and proposed all-electric LNG facilities such as Kitimat LNG and Woodfibre LNG. Other facilities, such as LNG Canada will rely on hydro power for their auxiliary power. LNG Canada is also using highly efficient turbines that will reduce the overall emissions of its LNG by at least half the global average.

British Columbia will produce the lowest emission LNG in the world—at least half the global average—and in the case of all-electric LNG facilities, even lower.

The town of Kitimat, where the LNG Canada and Kitimat LNG projects are located, has an average temperature ranging between 23- and 73-degrees Fahrenheit, well

below most LNG-producing countries. This reduces the amount of energy required to cool the natural gas to minus 260 degrees Fahrenheit, providing another significant cost advantage.

BRITISH COLUMBIA HAS SEEN MANY DECADES OF SUCCESSFUL LNG INVESTMENT

Experienced LNG producers such as Shell, Chevron and FortisBC have been operating in Canada for decades. FortisBC's Tilbury facility has been producing LNG in Delta, British Columbia since 1971. Shell and Chevron have successfully operated both oil and natural gas development and have headed the under-construction LNG Canada and proposed Kitimat LNG facilities, bringing their decades of global LNG experience to these projects.

LNG projects in British Columbia have also focused on developing strong working relationships with Indigenous peoples. Both LNG Canada and Kitimat LNG have agreements with the Haisla Nation, whose traditional territory includes the proposed project sites. Additionally, the Woodfibre LNG project, located on British Columbia's Howe Sound near Squamish, has forged a leading Environmental Assessment process, which was overseen by the Squamish Nation.

Location, abundant natural gas resources, responsible development, experienced LNG producers, shipping and climate cost advantages and the greenest LNG in the world make British Columbia an attractive opportunity for LNG supply and investment.



DIVING INTO GLOBAL LNG MARKETS

Spotlight on LNG Canada

Located in Kitimat, British Columbia, in the traditional territory of the Haisla Nation, LNG Canada represents the largest private sector investment in Canadian history. Currently in its second year of construction, at full build out the project will deliver 28 million tonnes per annum of LNG each year.

Exporting cleaner-burning Canadian natural gas will help coal-dependant nations have access to lower emission sources of power and improve their energy security. BC's advantage is that 93% of electrical power is hydro based, positioning the province as a world leader in managing greenhouse gas (GHG) emissions from the natural gas and LNG sectors. Compared to an average facility, LNG Canada will emit a 50% decrease in emissions and a 33% decrease compared to best performing ones, according to independent benchmarking studies.

INCREASING GLOBAL DEMAND FOR CLEANER ENERGY

International energy trade is a vital part of the Canadian economy. By developing and exporting low carbon produced LNG, Canada is poised to realize an opportunity that will bring economic and environmental benefits on a global scale.

Exporting surplus natural gas to countries like China, India and other parts of Asia can help them move away from coal.

China alone accounts for 30% of global GHG emissions and under its Paris Agree-

ment commitment, it can grow emissions to 2030. LNG is an alternative that allows China to simultaneously grow its economy and reduce emissions, which could help them meet their targets sooner.

CONSULTATION IS KEY

In reaching its final investment decision, LNG Canada worked closely with a broad range of stakeholders and Indigenous partners to address economic growth, environmental governance and partnerships with First Nations.

The company discovered how to produce LNG more sustainably, putting environmental and social priorities on equal footing with technical and commercial interests.

"We acknowledged that our business success depended on finding ways to share value with local communities, with the province and the country," says Susannah Pierce, Director Corporate Affairs, LNG Canada. *"Well before the BC Government adopted the Declaration on the Rights of Indigenous Peoples Act, we proactively acknowledged the traditional rights and titles of Indigenous Peoples."*

The company focused on building relationships prior to project construction and continues to nurture those relationships throughout the process. *"We understood that 'trust takes years to build, seconds to break and forever to repair,'"* adds Pierce, *"and trust is earned when actions meet words."*

ACT LOCALLY, THINK GLOBALLY

In the case of greenhouse gases, LNG Canada understands the need to think and act locally and globally. The province of BC and Canada must do their part to meet their own commitments and recognize that more must be done.

The Intergovernmental Panel on Climate Change Special Report on Global Warming emphasizes the need for transformative global actions and global cooperation to decarbonize the energy system.

In addition to the benefits from jobs and economic activity that exporting LNG brings, Canada will continue to show its global leadership in sustainable energy development.



93%
of BC's electrical power
is hydro-based





FOCUS ON: ALBERTA

DEPLOYING CONTINUAL INNOVATION IN THE OIL SANDS

Innovation is a driving force for economic growth in Alberta. The provincial government supported early *in situ* oil sands R&D, which led to a multibillion-dollar industry that reflects over 85% of all crude oil production in the province today.

MAKING OILSANDS MORE COMPETITIVE

Oilsands development is based on continuous innovation, leading to the development of Steam Assisted Gravity Drainage (SAGD), Paraffinic Froth Treatment, Non-Condensable Gas Injection, Flow Control Devices and other technologies.

Greenhouse gas (GHG) emissions intensity has decreased by 21% in the last decade, with potential for further significant reduction.

Industry, government and academia have also made strides toward the next generation of *in situ* oil sands, using solvents to enhance recovery.

Imperial Oil's \$2.6 billion Aspen project is based on Solvent-Assisted SAGD, while other industry members are piloting other solvent technologies on a commercial scale.

These technologies have the potential to significantly reduce costs (-50% CAPEX and OPEX), GHG emissions (-50%) and water consumption (-90%) compared with SAGD.

HYDROCARBON PRODUCT DIVERSIFICATION AND VALUE-ADD

Bitumen Partial Upgrading (BPU) technologies demonstrate the potential to significantly reduce diluent requirements to transport bitumen, leading to reduced costs to industry, increased realizations on product shipped, up to 40% increase in pipeline capacity and reductions in life cycle GHGs. Three BPU pilots are in operation and a commercial plant is at the planning stage.

BITUMEN BEYOND COMBUSTION

With 80% of GHGs associated with petroleum at the combustion stage, Alberta Innovates initiated the Bitumen Beyond Combustion (BBC) program in 2016 to convert bitumen into high-value non-fuel products.

Synergistic with BPU, BBC is currently developing a range of products to supply the growing global demand for materials, including carbon fiber, asphalt, and vanadium.

The Carbon Fibre Grand Challenge is a \$15-million international competition to accelerate the production of carbon fibre from bitumen-derived asphaltene.

METHANE EMISSIONS REDUCTION

With federal regulations mandating a 45% reduction in methane emissions by 2025, stakeholders across industry and government formed the Canadian Emissions Reduction Innovation Network (CERIN) to dramatically accelerate the development and deployment of technologies.

DIGITAL INNOVATION IN CLEAN ENERGY

With drones, digital twins, augmented reality, cloud computing, and blockchain employed in Alberta's oil sands mining operations, Alberta Innovates grant programs accelerate the use of digital technologies.

ENVIRONMENTAL INNOVATION: PROTECTING ALBERTA'S WATER AND LAND RESOURCES

Numerous initiatives include water supply and watershed management, healthy aquatic ecosystems, water use conservation, oil sands tailings mitigation, climate adaptation and abandoned well reclamation.

A culture of collaboration permeates this space; Canada's Oil Sands Innovation Alliance (COSIA), an industry group representing more than 90% of oil sands production, has shared 981 environmental technologies representing investment of \$1.4 billion to date.

INVESTING IN CLEAN ENERGY INNOVATION FOR ALBERTA'S PROSPERITY AND ENVIRONMENTAL SUSTAINABILITY

Alberta Innovates includes a clean resources division that helps technology developers and industry clients accelerate technology development and deployment, grow their business and enhance resource sector competitiveness, providing scientific and technical insights to the Government of Alberta on resource development, energy diversification, emissions reduction, and water and land policies.

INDUSTRY PARTNERSHIPS IN CLEAN ENERGY INNOVATION

Alberta Innovates supports clean energy innovation through industry partners including COSIA, Clean Resource Innovation Network, Petroleum Technology Alliance Canada, Canadian Heavy Oil Association, and Alberta Irrigation Projects Association and government-industry initiatives such as the National Partial Upgrading Committee and the Alberta Smart Grid Consortium.



FROM STORAGE TO UTILIZATION: THE ALBERTA CARBON CONVERSION TECHNOLOGY CENTRE

InnoTech Alberta, the province of Alberta's applied research agency, has been a central fixture in western Canada's innovation ecosystem since 1921—nearly a century of success.

Its multi-disciplinary research teams and unique facilities accelerate technology development and scale-up for the private and public sectors. From generating new ideas to testing, de-risking and scale-up, their work focusses on productive commercial applications and end uses that build business in Alberta.

Leveraging years of research, InnoTech is now focused on carbon capture utilization and storage. It operates the Alberta Carbon Conversion Technology Centre (ACCTC), a unique facility built to demonstrate novel CO₂ capture and conversion technologies. In 2020, the ACCTC will host five NRG COSIA Carbon XPrize challenge finalists, offering outdoor testing capability at semi-commercial rates under industrial conditions.

The ACCTC will accelerate technology development related to industrial greenhouse gas emission sources. It will also facilitate adoption by de-risking commercially viable technologies that produce valuable products from CO₂ feedstock. The facility will be a testbed for entrepreneurs working to create value from waste.

The site has five 25,000 square-foot test bays. Each is individually metered and serviced with CO₂, natural gas, electrical, and utilities such as water, wastewater and other waste services. Flue gas (industrial CO₂ supply) comes from an adjacent natural-gas-fired power plant. A newly added carbon capture unit also allows for solutions that require highly concentrated CO₂ streams.

When the NRG COSIA Carbon XPrize competition is complete, this facility will be open to the world as a solution space for technology development.



FOUR MILLION TONNES AND COUNTING: SHELL QUEST CARBON CAPTURE AND STORAGE

Shell Quest, operated by Shell Canada on behalf of the Athabasca Oil Sands Project (AOSP), is the largest carbon capture and storage (CCS) project in the world with dedicated onshore CO₂ geological storage. Quest has captured and safely stored over four million tonnes of CO₂ since beginning operation in 2015.

The \$1.3 billion facility—which was supported by federal and provincial governments—captures CO₂ from three hydrogen manufacturing units at AOSP's Scotford Upgrader, near Thorhild, Alberta.

Hydrogen is produced for use in upgrading oil sands bitumen into a lighter, synthetic crude. The capture process employs an amine solution that yields 98% pure CO₂, which is then compressed and sent 65 km by pipeline for permanent storage in the Basal Cambrian Sands formation more than two kilometres underground. This location was chosen for its ideal geological properties— including the low density of legacy wells, which lowers the risk of unexpected leakage pathways.

Quest has exceeded performance expectations, sequestering its first million tonnes of CO₂ in just 10 months, highlighting the success that can be achieved when industry and governments collaborate toward innovation. Direct emissions from the Scotford Upgrader are now being reduced by as much as 35%.

In addition to CO₂ reductions, the intellectual property and data generated by the Quest project are publicly available for new carbon capture, utilization and storage projects to access and improve upon.

As a proof-of-concept, Quest's process can be applied to a host of other industries besides petrochemicals, such as oil and gas, fertilizer production and cement production. The project's success has attracted interest from governments and research institutions around the world.



COLLABORATING TO REDUCE METHANE EMISSIONS

Since inception as a not-for-profit organization, Petroleum Technology Alliance Canada (PTAC) has completed over 600 R&D projects that have significantly improved the environmental, safety and financial performance of the oil and gas industry. In 2019 alone, PTAC had more than 100 ongoing R&D projects, which were guided and supported by over 250 industry experts from its diverse stakeholders.

THE 45% SOLUTION

In Canada, the federal government is working with provinces and territories to reduce methane emissions by 45% below 2012 levels by 2025.

Numerous technologies developed through PTAC's consortia are already significantly reducing methane emissions.

These technologies have the collective capacity to reduce the sector's methane emissions by upwards of 30%. PTAC aims to increase the capacity through several initiatives to 45% by the end of 2020.

A VISION TO HIT TARGETS, CUT COSTS AND CREATE JOBS

PTAC's vision is to reduce methane emissions to a cost of \$5 per tonne of CO₂ equivalent, significantly below current CO₂ reduction costs. It is estimated that accomplishing this vision will enable producers to meet the methane emissions reduction target by 2025, while reducing the industry's costs by \$550 million per year and creating 2,300 jobs.

PTAC has undertaken several initiatives that enable companies to detect and cut emissions, including a hub for collaboration and information, a consortium of testing facilities, numerous applied research projects, and several technology development, demonstration and deployment projects.

COLLABORATION FOR A CAUSE: MERN

Leveraging more than 220 member organizations and collaborating with the over 1,000 members of the Clean Resource

Innovation Network (CRIN), PTAC created a unique innovation ecosystem called the Methane Emission Reduction Network (MERN).

A BILLION DOLLARS SUPPORTING NEW TECHNOLOGY TRIALS

PTAC recently established a methane testing facility consortium that tests near-commercial tech solutions. Its membership includes 15 producers/transporters, eight Canadian and two US academic institutions, six public-sector laboratories, along with five industry facilitators and associations. Together, these members hold field assets and testing facilities worth over one billion dollars to conduct trials on new technologies at a complete range of upstream oil and gas assets.

A FIRST-OF-ITS-KIND METHANE DETECTION AND QUANTIFICATION PROJECT

The Fugitive Emissions Management Program Effectiveness Assessment (FEMP EA) is the world's largest methane detection and quantification project.

Immense in scope, FEMP EA covers 2,500 square kilometers in the Red Deer region and includes participation from 30 producing companies and nearly 200 oil and gas facilities.

FEMP EA will not only establish the basis for the industry to considerably reduce GHG emissions within Alberta, but will produce vast learnings applicable to other oil and gas jurisdictions both domestically and internationally.

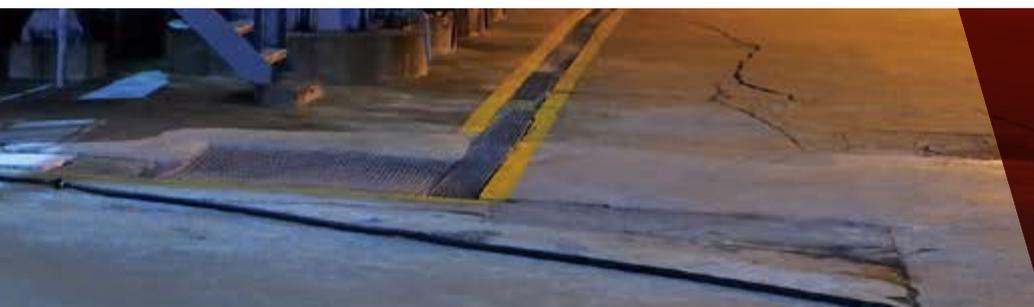


PUMPING OUT THE FUTURE OF METHANE



EXISTING PNEUMATIC INSTRUMENTS AND PUMPS ARE A LARGE SOURCE OF METHANE EMISSIONS, CONTRIBUTING TO ALMOST 40% OF OVERALL RELEASES.

The zero-emission fail-safe electric dump valve actuator, being developed in collaboration with Natural Resources Canada, has the potential to replace all pneumatic devices. The technology has already saved the equivalent emissions of taking 130,000 per year cars off the road and resulted in \$15 million per year in value creation. Full industry uptake would result in \$160 million per year in value creation and emissions reductions equivalent to taking 1.6 million per year cars off the road.



FUNDING THE EMISSIONS REDUCTION TECHNOLOGIES THE WORLD NEEDS

Emissions Reduction Alberta (ERA) is a unique organization with one core purpose: accelerating development of the innovative greenhouse gas-reducing technologies the world needs.

These technologies include:

- capturing carbon dioxide (CO₂) and turning it into valuable products;
- using big data and artificial intelligence (AI) to increase well production while reducing operating costs; and
- digital imaging technology that identifies methane leaks and integrity problems downhole.

FROM CARBON COMES CAPITAL

ERA's capital comes from the carbon price paid by Alberta's large emitters of greenhouse gases. These investments help innovators from around the world develop and demonstrate technologies that help industry reduce emissions and improve competitiveness.

Approximately 60% of ERA's investments go toward oil and gas-related technologies. The remaining spans food, fibre and bioindustries; low carbon processes and products; and a low emitting electricity system.

"ERA was established 10 years ago to help deliver on Alberta's climate change and economic goals," says Steve MacDonald, ERA CEO. "Since 2009, we have funded 166 projects, investing \$564 million into innovative technologies worth over \$4.3 billion. These projects are designed to deliver both the economic and environmental outcomes Alberta and the world need."

A REDUCTION OF OVER 40 MILLION TONNES IN CO₂ EQUIVALENTS

ERA's funded projects are estimated to directly deliver reductions of 41.2 million tonnes of CO₂ equivalent in Alberta by 2030.

"We seek out game-changing solutions to some of the world's greatest challenges and help to de-risk them by co-investing with industry in late-stage technology demonstration," adds MacDonald.

A \$35 MILLION CHALLENGE TO ACCELERATE INNOVATIVE CARBON USE

In October 2019, ERA announced the winners of its global \$35 million Grand Challenge: Innovative Carbon Uses. This five-year funding competition focused on accelerating unique, promising and impactful solutions in the emerging field of CO₂ utilization.

ERA not only invests in and de-risks game-changing technology, it also provides access to other financing partners, informs the policy and regulatory environment in Alberta and champions business innovation.

"Innovation in any sector, and specifically the oil and gas industry, is challenging. You need all the right pieces in place to be successful. You need to have the right regulatory framework, predictability in terms of policy direction and innovative business models," says McDonald. "We try to be a convener and bring the whole village together to turn ideas into the products and processes industry needs to be more carbon- and cost-competitive."



GRAND CHALLENGE: INNOVATIVE CARBON USES WINNERS

Ambyint

ERA's \$2 million investment into **Ambyint's** innovative digital platform is another example of helping to advance bold innovation. The Calgary, Alberta- and Houston, Texas-based company uses AI to monitor, control, and analyze the performance of oil and gas wells, allowing producers to remotely control performance and safety.

DARKVISION

DarkVision is helping to address the significant challenges around methane emissions. DarkVision's technology, which received \$3.2 million in funding from ERA, provides clear and detailed images of downhole problems causing Surface Casing Vent Flows (SCVFs). This allows oil and gas operators to use established intervention techniques to stop leaks in wells, addressing a widespread problem for the industry.

MANGROVE WATER TECHNOLOGIES

Mangrove Water Technologies uses CO₂ to turn waste products from oil and gas operations into valuable chemicals, reducing GHG emissions. The company estimates an annual market of \$350 million (USD) across the oil sands industry, with GHG reduction potential of 1.4 million tonnes of CO₂ equivalent per year by 2030. ERA awarded \$5 million to move Mangrove's technology toward commercialization.

FOCUS ON: SASKATCHEWAN

RICH IN RESOURCES. RICH IN OPPORTUNITIES

Saskatchewan is one of the only jurisdictions in the world that produces crude oil, natural gas, coal, uranium, biofuels, geothermal, wind and hydro power.

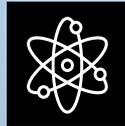
As Canada's second-largest oil producing province, Saskatchewan is the sixth-largest onshore producer in Canada and the U.S. With approximately 37,700 active oil wells, the province produced 178.4 million barrels in 2018.

Not only are the province's oil plays cost-competitive, companies view Saskatchewan as a great place to pilot, commercialize and scale new energy-related technologies.

The province is a leader in petroleum research, especially in the areas of enhanced oil recovery and horizontal well drilling. These completion techniques have greatly improved production from formations such as the Bakken—one of North America's largest oil plays.

Saskatchewan is also Canada's third-largest producer of natural gas—184 billion cubic feet in 2018. The combined estimated value of oil and gas production was over \$9.8 billion.

The province exports nearly 90% of its uranium, with the remaining 10% fueling Canada's nuclear reactors. Saskatchewan's uranium is responsible for powering approximately one in 20 homes in the U.S.



**SASKATCHEWAN'S URANIUM
POWERS ABOUT 1 IN 20
U.S. HOMES**



AQUISTORE PROJECT: A WORLD FIRST IN INTEGRATED SUBSURFACE STORAGE

Advances in solvent injection continue, with the PTRC conducting a program to help optimize cyclic solvent injection (CSI) in heavy oil fields. CSI involves solvent injection followed by an additional soaking period before oil extraction begins. The ongoing research program will examine various solvent combinations in relation to different field conditions.

Since early 2015, the Aquistore Project near Estevan in southeastern Saskatchewan has been taking captured CO₂ from unit three at SaskPower's Boundary Dam coal-fired power station and injecting it into a deep saline geological formation almost 3.2 km underground.

The Boundary Dam carbon capture facility—built between 2011 and 2014 at a cost of \$900 million—was the first in the world to

use post-combustion capture on a coal-fired plant. To date, the Aquistore site has successfully stored over 267,000 tonnes of captured carbon dioxide.

"The research at Aquistore is designed to determine what measurement, monitoring and verification technologies are best suited for assuring injected CO₂ stays safely underground," notes Erik Nickel, Director of Operations for the Petroleum Technology Research Centre, which manages the project.

In addition to downhole fibre optic lines and acoustic sensors, a permanent seismic array of 650 geophones helps create a 4-dimensional image of the CO₂ in the sandstone and brine formation. The project's ground water, soil gas and passive seismic monitoring demonstrate that CO₂ remains contained in the target formation and no earth movements are occurring.

"The data and testing of different monitoring technologies at Aquistore has drawn sponsorship from around the globe," says Nickel. *"The implications of our findings in the next few years could help improve efficiencies and monitoring capabilities across many different industries and solidify CCS as a viable option to mitigate emissions."*

SASKPOWER'S BOUNDARY DAM CCS FACILITY (BD3)

Located near Estevan Saskatchewan, **Boundary Dam** is the world's first fully integrated and full-chain carbon capture and storage facility on a coal-fired power plant.



Photo: SaskPower

CLEANER OIL AND GAS

The Petroleum Technology Research Centre in Regina, Saskatchewan is a not-for-profit research and development company.

SEQUESTERING CO₂ EMISSIONS

In the late 1990s, the Petroleum Technology Research Centre approached an oil company named Pan-Canadian about establishing a research program to run in tandem with a CO₂ injection project about to begin in south-eastern Saskatchewan.

The CO₂, which was being captured at a coal gasification facility in Beulah, North Dakota, would be transported across the U.S.-Canada border and injected into the Weyburn oilfield to help enhance oil production. The field, which had dropped from a peak of 47,000 barrels of production per day in the 1960s to under 15,000 by 1997, was seeking innovative enhanced oil recovery methods to help improve extraction.

CO₂ as a solvent in oil production is not new, of course. Operators in the Permian Basin in Texas have been re-injecting carbon dioxide from naturally occurring underground sources for more than 40 years and operators continue to do so using new anthropogenic (human-caused) CO₂ sources such as the Petonova coal-fired power station.



SETTING STANDARDS FOR RE-INJECTING CARBON DIOXIDE

What made the Weyburn oil field in the late 1990s of particular interest to research scientists, government regulators and oilfield operators was the opportunities the project held for helping set standards for measuring, monitoring and verifying injected CO₂.

At the turn of the century, the Weyburn-Midale oilfields were the first in the world injecting CO₂ from a man-made resource and the research program that took place over the next 15 years helped set international standards for storage and monitoring deep in the sub-surface.

With carbon capture and storage emerging as an important climate change mitigation technology, the Weyburn-Midale Carbon Dioxide Project captured the attention and funding of governments and research organizations across Canada, the U.S., Japan, the Middle East and several members states in the European Union.

Since 2000, the operators of the Weyburn and Midale fields have injected and sequestered almost 40 million tonnes of CO₂—the equivalent of removing over 8 million cars from the road. While both the Weyburn and Midale fields have changed company hands several times—currently Weyburn is operated by Whitecap Resources and Midale by Cardinal Energy—the joint goals of permanent sequestration and improved oil recovery remain the same.



MITIGATING GHG EMISSIONS: NEW TECH COULD HELP ADDRESS CLIMATE CHANGE

NEW TECHNOLOGIES TO MITIGATE GHG EMISSIONS

There are a lot of new developments happening in the world of emissions reduction technologies.

The Saskatchewan Research Council (SRC) created the Centre for the Demonstration of Emissions Reductions (CeDER) to facilitate testing in real-world situations for industry and technology developers. This means technologies can be adopted by industry sooner because they've been demonstrated to work, moving industry quickly towards mitigating emissions.

CeDER is a platform that provides real-world testing, demonstration and validation of emissions measurement, reduction, capture and conversion technologies related to greenhouse gas (GHG) emissions.

CeDER—MOBILE TESTING WITH APPLICATIONS BEYOND OIL AND GAS

Through CeDER, SRC provides industry with GHG emission reduction strategies in Canada. *"We offer assessments to help industries identify technologies,"* explains Erin Powell, who manages SRC's Process Development business unit, *"that will lower their greenhouse gas emissions to meet regulatory requirements."*

Through regular monitoring of the oil and gas sector, Powell's team has also developed a comprehensive database of nearly 400 current commercial and emerging GHG emissions reduction technologies, such as those related to carbon capture and utilization, to help identify what technologies are most applicable to a clients' specific operation. They then evaluate the technologies' performance against client requirements.

CeDER is also mobile, enabling independent third-party technology demonstration and performance validation, as well as air quality monitoring and emissions testing. For example, SRC has tested the capabilities of drones for use in gas leak detection.

Industry, with the help of researchers, engineers and scientists, has already implemented many innovative technologies and processes to reduce environmental impacts.

This next phase in the regulatory framework will require out-of-the-box thinking across the production process. Collaboration, nationally and globally, will be key to finding solutions for this challenge and the next one to come.



CeDER
GHG EMISSION
REDUCTION STRATEGY



CeDER is a platform that provides real-world testing, demonstration and validation of emissions measurement, reduction, capture and conversion technologies related to GHG emissions.



FOCUS ON: NEWFOUNDLAND AND LABRADOR

OFFSHORE OPPORTUNITIES

Newfoundland and Labrador has four producing oil fields, more than 650 leads and prospects, as well as an ongoing, world-class seismic program with more than 20 basins mapped.

In the past three years, there have been eight new entrants and \$4 billion in recent exploration work commitments.

Advance 2030—The Way Forward on Oil and Gas is the government of Newfoundland and Labrador's commitment to drive exploration in the oil and gas industry, developed to position the province as a globally preferred location for oil and gas development that values safety and environmental responsibility.

To date, over 95% of immediate priority actions identified in Advance 2030 are in progress or complete. Work continues to enhance the development, competitiveness and sustainability of the province's oil and gas industry.

AMONG THE WORLD'S LOWEST CARBON INTENSITY EMITTING OILFIELDS

While the demand for oil will continue to exist, the global outlook for energy is changing and a reduction in emissions is urgently required. Offshore Newfoundland and Labrador projects are already among some of the lowest carbon intensity emitting oilfields in the world and global energy companies focused on environmental sustainability are increasingly interested in this low greenhouse gas production.

For example, Hibernia has been validated at 12kg of carbon per barrel, with more reductions expected as new technologies are introduced. This compares favourably to international estimates ranging from 18kg to over 50kg of carbon per barrel.

Work to improve emissions in Newfoundland and Labrador's offshore is continuing. Some actions include:

- modernizing offshore regulations to reduce oil and gas sector methane emissions by 40 to 45 percent from 2012 levels;
- implementing a carbon pricing system in the offshore;
- improving efficiency of the environmental assessment process, while ensuring the highest standards of environmental protection;
- slowing supply vessels to optimal speeds to reduce energy consumption;
- using higher efficiency turbines;
- maintaining steady-state operations to avoid use of diesel backup;
- cooperating on transportation to improve efficiency; and
- requiring exploration license owners to support environmental studies on petroleum exploration, development and production activities through the Environmental Studies Research Fund.

A PROGRESSIVE NEW PLAYER IN OIL AND GAS



The Oil and Gas Corporation of Newfoundland and Labrador began operations on January 1, 2020. Focused on developing resources and attracting exploration investment to the province, it will work with government and industry stakeholders to implement Advance 2030. The corporation is also focusing on local supply and service industry opportunities to create jobs and business opportunities for the people of the province.



EMISSIONS FROM OFFSHORE OIL EXTRACTION

Global energy demand will continue for decades, even accounting for continued improvements in energy efficiency.

Increased use of renewable energy sources will help meet some of the burden of growing global energy demand; however, various forms of energy will be needed for the foreseeable future.

At the same time, countries need to find a way to balance natural resource driven economies with the real challenges of climate change.

CANADA IS HOME TO SOME OF THE WORLD'S MOST RESPONSIBLY PRODUCED ENERGY

With its demonstrated commitment to ongoing innovation and new technology developments, Canada has an important role to play in supplying responsibly produced energy to the world.

In fact, among oil and natural gas-producing nations, Canada is a leader in environmental, social and governance measures. And the offshore industry is no exception.

In recent years Canada's offshore oil and natural gas operators have significantly reduced flaring, one of the primary sources of offshore emissions. Operators have reduced their own energy consumption by improving efficiency of power generation

units and other key equipment, using fuel management and monitoring systems on supply vessels and sharing transportation services to improve efficiency and reduce environmental impact.

\$500 MILLION INVESTED IN R&D IN NEWFOUNDLAND AND LABRADOR ALONE

Offshore operators have also invested in research and development to identify new ways to reduce environmental impact—over \$500 million in R&D, education and training in Newfoundland and Labrador alone.

Offshore oil and natural gas companies are involved in international projects to determine how the industry can play a key role in driving change with low-carbon technologies. This includes considering everything from identifying alternate power sources for offshore facilities and supply vessels to offshore carbon capture and storage projects.

Canada's energy sector has the opportunity to lead in a low-carbon future by reducing greenhouse gas emissions through the development of cost-effective, clean technology and the implementation of Canada's robust climate policies.

THANKS TO THE FOLLOWING ORGANIZATIONS FOR THEIR CONTRIBUTIONS:



WHY INVEST IN CANADA?

1. A WEALTH OF TALENT

- 2-week processing of work permits for employers to hire highly skilled foreign talent
- 119% increase in international students
- 42 business incubators affiliated with 96 Canadian universities

2. AN INNOVATION HUB

- First to develop an AI strategy
- Five tech superclusters across Canada supporting leading companies choosing to innovate in Canada
- Cluster funding matched dollar for dollar by the private sector

3. ACCESS TO GLOBAL MARKETS

- 14 trade agreements, 51 countries
- 1.5 billion consumers
- \$49.3 trillion USD in combined GDP

4. STRONG BUSINESS FOUNDATION

- Best business costs in the G7
- Soundest banking system in the G7
- Lowest Marginal Effective Tax Rate on new investments in the G7

5. GREAT PLACE TO LIVE

- Best in the world for quality of life
- Best in G7 for overall living conditions
- Most peaceful country in the world

LOOKING FOR YOUR BEST INVESTMENT DESTINATION?

Canada helps global companies make money and minimize risk. Invest in Canada makes it easy. We bring industry, community and government partners together to offer seamless services that make it easy for you to grow your operations in Canada.

“ For BP, Canada is one of the better places to invest in the world. It is a stable economy; it has a stable political system. It has pragmatic regulations that allow us to be both safe and efficient. It has great people... just great talent locally. ”

Murray Auchincloss
Upstream CFO, BP



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