

Canada's Green LNG Advantage

Extensive electrification offers critical
low-emissions advantage in the global
pursuit of clean growth



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INTRODUCTION

By leveraging abundant renewable energy, Canada stands to produce some of the cleanest liquefied natural gas (LNG) in the world. That could provide a competitive advantage that grows over time, as increasingly stringent emissions policies come into play in the years ahead.

With robust forecasts for growth in natural gas consumption in the decades ahead, leading in the stakes to be the “greenest” of the cleanest fossil fuel holds tremendous potential for Canada to future-proof the sector in an increasingly climate conscious world and allow it to be among the last producers standing. The key, say experts, is extensive electrification of every aspect of the natural gas value chain, from wellhead to waterline.

Reaching — and maintaining — that status is by no means guaranteed. While the technology exists for the most part, exporting the cleanest gas will require a large-scale build out of renewable energy production, tackling methane emissions, continued focus on new technology development and deployment, industry and government collaboration, and attention to the smallest detail every step of the way.

In this report we examine that unique Canadian opportunity, how to get there and why it matters. We look at:

- The need for Canadian producers to secure foreign

markets after the decline in demand from the U.S., its traditional market, due to the shale gas revolution;

- The opportunity for Canada’s leading low-emissions production to decrease overall emissions in LNG-receiving countries while reducing local air pollution;
- The current state of the Canadian LNG industry, how far along LNG projects are to meeting the cleanest production objective and how they compare internationally;
- The role that must be played by upstream emissions reductions in order to reach Canada’s low-emissions objectives;
- Navigating increasingly stringent regulations targeting both CO₂ emissions and fugitive methane releases; and,
- The benefits to Canada in pursuing world class environmental standards — and why it matters.

It is uncertain what kind of role Canada will play in the forecast expansion of the LNG trade in the decade ahead. What is sure is that Canada can hedge its bets and give its LNG sector the greatest chance to succeed by aiming high and reaching truly low levels of GHGs emissions from the get-go. Digging deep to minimize emissions today could provide the lessons learned to enable tomorrow’s projects to maintain the title of the world’s cleanest LNG supply in an increasingly competitive marketplace.

Brave new natural gas world

The world is hungry for natural gas, creating for Canada a once-in-a-generation opportunity to develop a liquefied natural gas industry to supply its gas to the world. The country's operators produce more gas than is needed for domestic markets. Our traditional foreign buyer, the U.S., has less demand for supplies from north of the border since the shale revolution flooded that market with cheap, reliable natural gas. As such, Canada is in need of new markets that can only be served by oceangoing tanker.

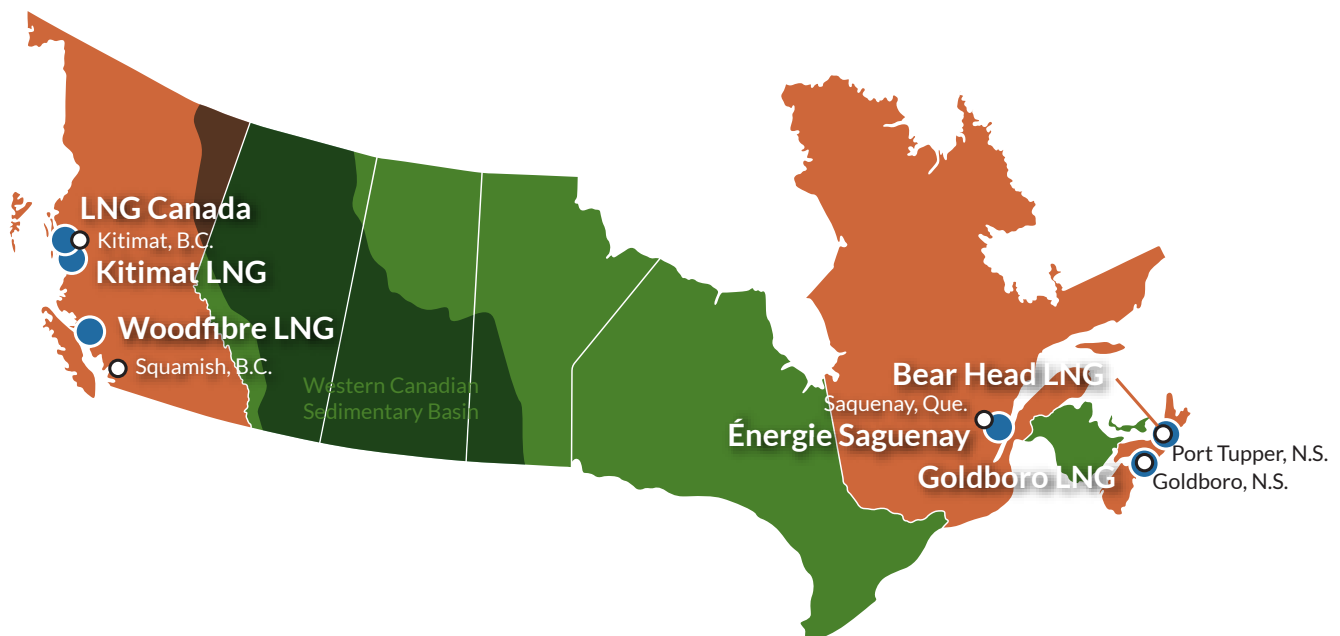
The country is a latecomer to the LNG marketplace, however, having missed the previous opportunity a decade ago when two dozen projects dotting the B.C. coastline were proposed, but none built. Instead,

countries like Australia, Qatar and the upstart U.S. filled the void. Round two, though, could be Canada's turn — if it plays its cards well.

A half-dozen projects on the Pacific and Atlantic coasts (see map) are methodically progressing forward, a few with positive final investment decisions (FIDs) and a few close to FID. Their construction and operation could provide a jolt to the struggling upstream natural gas sector in Alberta and northeast B.C., where the surplus North American natural gas market has left producers with fewer buyers.

In October 2018, LNG Canada announced a positive final investment decision (FID) for its proposed export project in Kitimat, B.C. Backed by LNG heavyweight

Canada's LNG Opportunity – Key Projects



Royal Dutch Shell, it is ranked among the largest private sector infrastructure projects ever to proceed in Canada should both phases go ahead. Just down the road from LNG Canada and two-thirds as large, Kitimat LNG appears to be next in line to receive an affirmative FID. Both are well placed to serve growing Asian markets and could be in operation within the next decade.

To the east, Nova Scotia's Goldboro LNG and Quebec's Énergie Saguenay are considered closest to FID, while Bear Head LNG may not be far behind. Importantly, Pieridae Energy (Canada) Ltd.'s Goldboro project, as well as LNG Canada and Pacific Oil & Gas' smaller Woodfibre LNG project in Squamish, B.C., have secured long-term buyers. Meanwhile, more projects are on the drawing board on both coasts.

Canada is the world's fifth largest natural gas producer and is estimated to have almost 1,225 trillion cubic feet of natural gas potential, located primarily in the Western Canadian Sedimentary Basin, according to the Canadian Association of Petroleum Producers (CAPP).

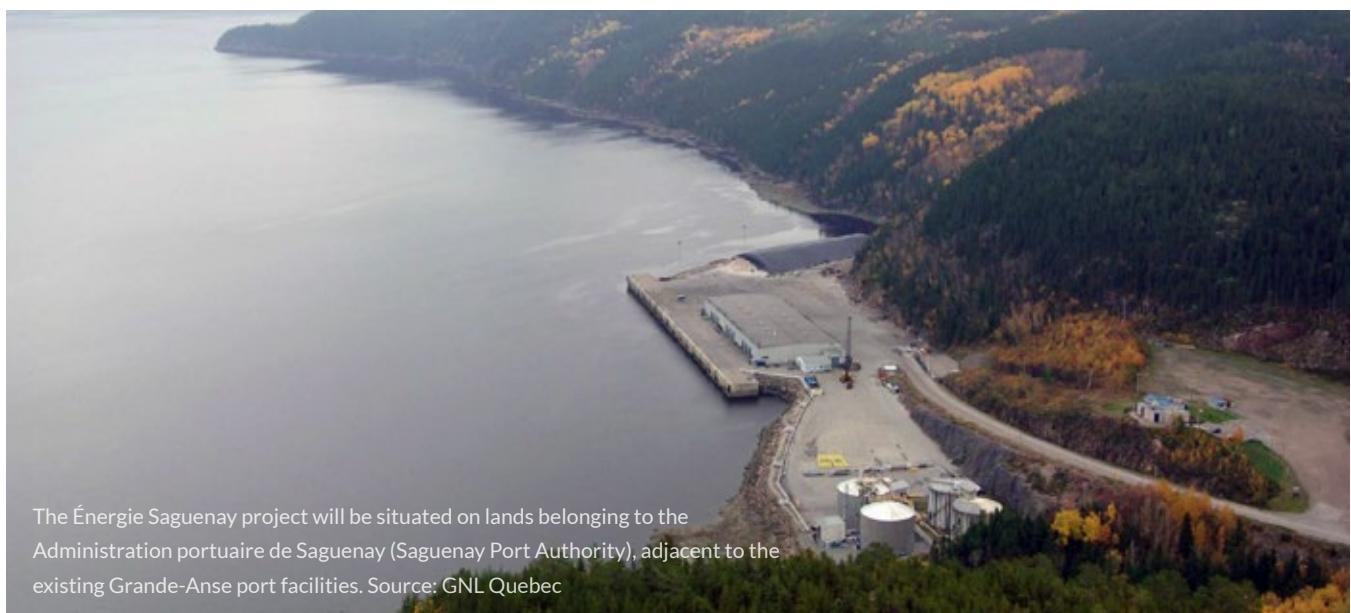
Dan Allan, president of the Canadian Society for Unconventional Resources, says LNG represents a key opportunity to launch Canada's natural gas sector back into high gear over the long-term. "A large majority

of our members are gas producers and they urgently require a robust LNG industry to allow for market diversification."

Global LNG volumes are set to expand substantially — demand for natural gas grew 4.6% in 2018, its fastest annual pace since 2010. In BP's Evolving Transition scenario, LNG trade more than doubles to 2040, led by North America, followed by the Middle East, Africa and Russia.

Natural gas is also considered the best prospect for growth of all the fossil fuels due to its lower greenhouse gas (GHG) emissions profile, as signified by the move to gas among the supermajors in recent years. Efforts to decarbonize economies will only accelerate this trend. A Canadian energy industry with a higher weighting to gas, which can only be accomplished by finding new markets accessible by LNG, could service to better balance the hydrocarbon equation.

Whether the currently opening LNG window is a narrow one as some analysts predict or a wide one with decades of growth ahead, Canada — with export capabilities advantageously located on both coasts and abundant low cost gas situated in-between — is exceptionally well positioned to supply the growing global demand.



The Énergie Saguenay project will be situated on lands belonging to the Administration portuaire de Saguenay (Saguenay Port Authority), adjacent to the existing Grande-Anse port facilities. Source: GNL Quebec

LNG exports from Canada offer unique opportunity to clear the air, fight climate change across Asia

Four decades of intensive economic development lifted China to an industrial powerhouse. But the country's economic miracle was largely powered by coal combustion, which led to air quality concerns in major cities and industrial areas.

China's subsequent war against air pollution — coupled with aims to reduce greenhouse gas emissions — means replacing coal combustion with low emission alternatives. But renewables can't do it alone. Liquefied natural gas presents the greatest opportunity to rapidly clean up the air, while keeping the lights on.

Natural gas's relatively clean credentials have helped make it the fastest growing source of energy: worldwide consumption is rising rapidly, with gas accounting for almost half of the growth in total energy demand in 2018, according to the International Energy Agency (IEA).

China's growing appetite for LNG is echoed across much of Asia, from India — which is facing up to similarly devastating air quality issues — to traditional importers such as South Korea and Japan.

Indeed, the transition to cleaner power production across East and South Asia, increasingly supplied by natural gas, is expected to create demand for LNG for decades to come — opening the door for Canada to sate that demand with the trump card as supplier of the world's "cleanest" LNG.

"Canada can be a responsible energy provider to the world like we always have been," said Bryan Cox, president and chief executive officer of the B.C. LNG Alliance. "People die every year because of poor air quality in parts of the world and natural gas can help

with that right now. The International Energy Agency is showing a direct correlation between the deployment of natural gas in Asia and a reduction in the particulate matter in the air that literally saves lives right now."

Indeed, Canada's export opportunity "is absolutely unparalleled in what we are able to do to help the world," Cox said. For example, the LNG Canada project could displace between 60 million and 90 million tonnes of GHG per year in the best-case scenario, where it replaces coal.

The environmental benefit, of course, depends crucially on which sources of energy natural gas displaces, something that exporters have little influence over. While cautioning that natural gas displacement of coal on its own "does not provide a long-term answer to climate change," the IEA does say coal-to-gas switching avoided more than 500 million tonnes of CO₂ emissions since 2010. And it offers further opportunity for a "quick win" to provide another 1.2 gigatonnes of CO₂ abatement in the short term. "Doing so would bring down global power sector emissions by 10% and total energy-related CO₂ emissions by 4%."⁴

As the energy sector enters "a whole new phase of ESG [environmental, social and governance] conversations," Cox said that dialogue could offer further advantage to Canada's embryonic LNG sector. "It's a competitive advantage; [Asian companies] want the cleanest products they can get," he said. "Their shareholders are demanding it."

⁴ The Role of Gas in Today's Energy Transitions, International Energy Agency, 2019

LNG's carbon footprint

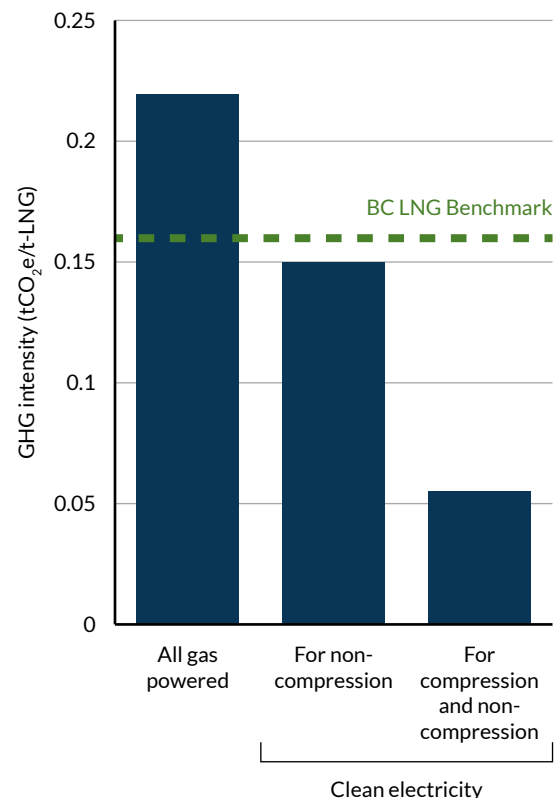
THE NUMBERS

Existing LNG facilities vary widely in terms of GHG emissions (in CO₂ equivalent) per tonne of LNG produced, depending on such factors as age and location, source of power for liquefaction and auxiliary power, and the various technologies employed. For example, a conventional off-the-shelf LNG facility using “direct drive” natural gas-powered configurations for the energy-hungry process of chilling the gas to the necessary minus 162 C needed to liquefy it, leads to higher emissions intensities. Modern electric drive, or e-drive, facilities powered by natural gas in a combined cycle power plant or better yet, driven by renewable sources, can drive numbers down significantly.

When upstream emissions — those involved in producing, processing and transporting natural gas — are taken into account, the numbers vary even more, depending on several factors unique to each project. These can range from type of production sourced — onshore or offshore, fracked or conventional — to existing concentrations of CO₂ in the formation and distance to tidewater.

A 2018 Delphi Group study found the GHG intensity performance of 19 LNG facilities globally ranged from roughly 0.15 (for the LNG Canada plant) to 0.44, with one outlier reaching about 0.70 tCO₂e (see graph, page 8). Intent on building the world's lowest emitting source of LNG, B.C. is aiming for all projects to come in under 0.15 (above which they fail to benefit fully from the carbon tax rebate) — though fully electrified projects, of which there are three planned or underway in the province, are projecting rates as low as 0.06⁵ — truly world-leading.

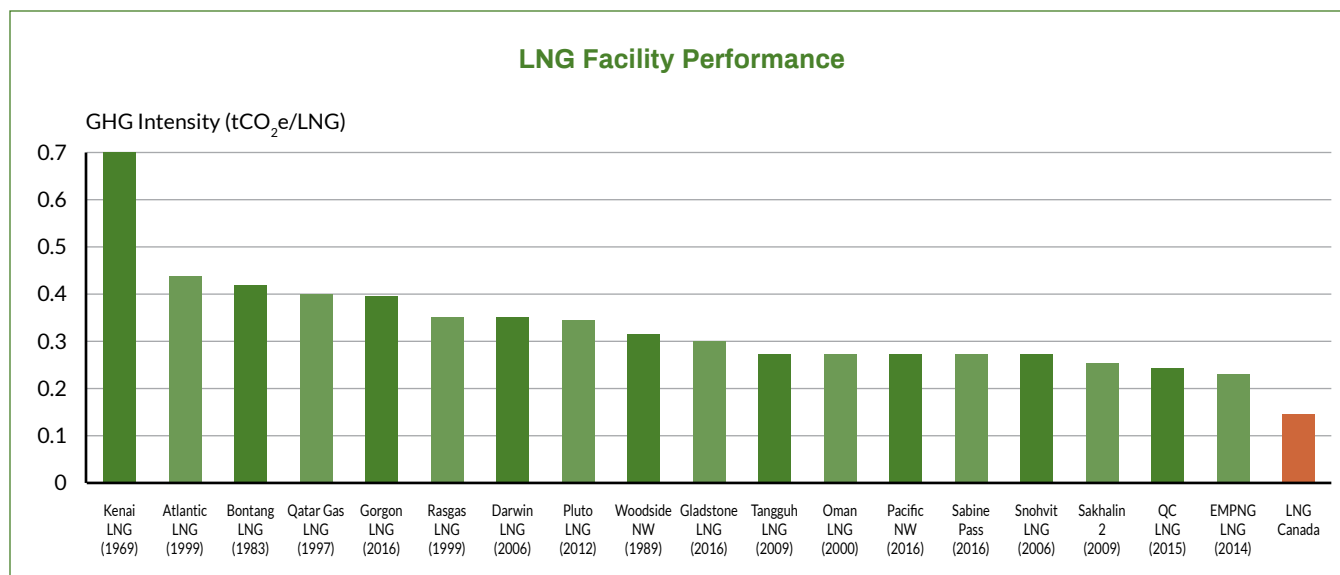
How different energy sources impact the GHG intensity of LNG terminals



Comparison of emissions intensities based on LNG projects all gas powered; using clean electricity for non-compression load, natural gas for compression load; and using clean electricity for non-compression and compression loads, as proposed by the scrapped Pacific NorthWest project, LNG Canada and Woodfibre LNG, respectively.

Source: Pembina Institute.

⁵LNG/Upstream Gas Electrification and GHG Reduction — Executive Summary, Richard Harper



Source: Delphi Global LNG Facility GHG Intensity Research Report, December 2018

WHERE CANADA'S PROPOSED PROJECTS RANK

The two largest projects most likely to be producing LNG in the next decade – the Kitimat, B.C.-based LNG Canada facility approved by Royal Dutch Shell and its four Asian partners last October and the Chevron

Corporation-backed Kitimat LNG project awaiting final investment decision – will both be world leaders in terms of GHG emissions.

Selected Key LNG Projects in Western Canada

Project	Owner(s)	Capacity	Capital Cost (billions)	Status
LNG Canada	Shell, PETRONAS, PetroChina, Mitsubishi Corporation, KOGAS	14-28 mtpa 1.8-3.6 bcf/d	\$40	Under construction; completion expected by 2025
Kitimat LNG	Chevron, Woodside Energy	10 mtpa 1.3 bcf/d	N/A	Chevron has applied to nearly double project capacity; completion expected by 2029
Woodfibre LNG	Pacific Oil & Gas	2.1 mtpa 0.3 bcf/d	\$1.8	Final investment decision expected in fall-2019; completion in 2023

* Only projects with export licenses and regulatory approvals in place are included. Source: Canadian Energy Research Institute, company announcements

Selected Key LNG Projects in Eastern Canada

Project	Owner(s)	Capacity	Capital Cost (billions)	Status
Goldboro LNG (Nova Scotia)	Pieridae Energy	5-10 mtpa 0.7-1.3 bcf/d	\$10	Final investment decision expected in 2020; completion in 2024-2025
Bear Head LNG (Nova Scotia)	LNG Limited	8-12 mtpa 1.1-1.6 bcf/d	\$6	
Énergie Saguenay (Quebec)	GNL Quebec	11 mtpa 1.5 bcf/d	\$9	Final investment decision expected in 2020; completion in 2025

* Only projects with export licences and regulatory approvals in place are included. Source: Canadian Energy Research Institute, company announcements

LNG Canada will have about half the intensity of the global LNG average, producing “the most competitive carbon footprint gas in the world,” Shell Canada president and country chair Michael Crothers declared last December. “It’s about 20% lower emission compared to the best current [facility] that we have been able to find, so that’s fantastic and it should be something that we can sustain into the future,” he said.

But it could be even lower. The first two LNG processing units — or trains — of what is likely to become a four-train facility will forgo lower emission e-drive in favour of gas turbines to compress the gas. The decision to power with natural gas dates back to the conception of the project several years ago, and substituting e-drive technology now could set the project back years, said Susannah Peirce, director, External Affairs, LNG Canada.

As it is, LNG Canada’s 14 million tonnes per annum (mtpa) first phase is designed to achieve levels of 0.15 tonnes of GHGs per tonne of LNG produced, just under B.C.’s low-emissions target. Thanks in part to \$220 million in funding from the federal government, it will incorporate low-emitting aeroderivative engines

to liquefy the gas. It will benefit from low-emission hydropower for its auxiliary power needs, the latest and most efficient equipment, and the lower ambient temperatures found on the B.C. coast compared to warmer climates.

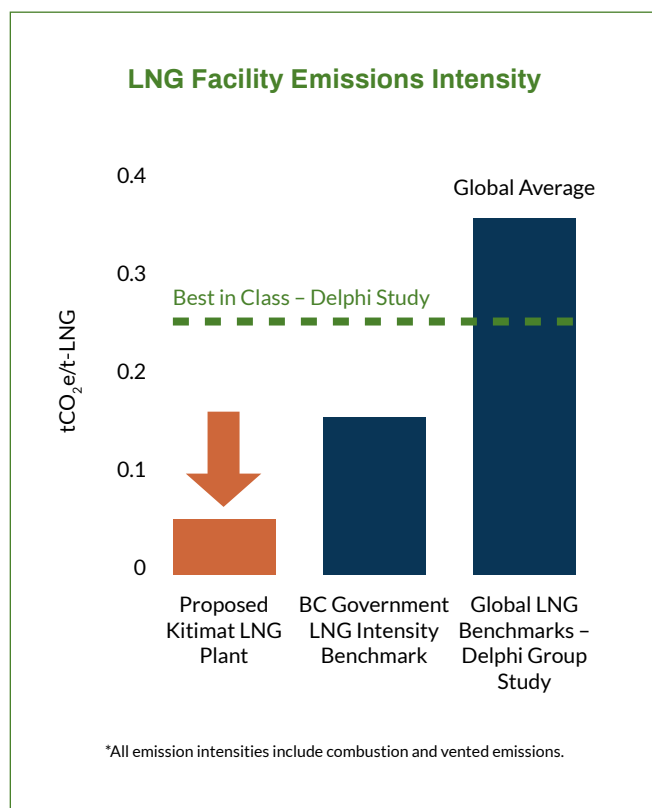
Considering the larger supply chain, it is also assisted by proximity to Asian markets compared to the U.S. Gulf Coast (it takes 10 days to move LNG from B.C.’s coast to primary markets in East Asia, compared to 25-30 days from the U.S. Gulf Coast via the Panama Canal, with commensurate fuel and emissions savings). Additionally, producers benefit from natural gas reserves with relatively low naturally occurring CO₂, assuming it consists mostly of hydraulically fractured gas production from the Montney formation straddling the Alberta-B.C. border that is relatively low in CO₂ content.

B.C. estimates the carbon impact of LNG Canada phase one from wellhead to waterline at 3.45 megatonnes (Mt) of GHG per year⁶ (1.24 Mt upstream, 0.11 Mt midstream and 2.10 Mt at LNG facility). LNG Canada has not committed to using e-drive in its next phase, but given B.C.’s climate targets it is considered unlikely by some

⁶ Implications of Positive LNG Canada FID, update and technical briefing, Government of British Columbia, Oct. 2, 2018

industry observers that gas drive would be approved by the province.

Kitimat LNG, on the other hand, will be all-electric from the outset, lowering its emissions profile to below 0.1 – which Chevron and its partner Woodside Petroleum Ltd. contend would be the lowest GHG-emissions per tonne of LNG of any large project in the world. Some studies⁷ indicate such a configuration could operate at a level as low as 0.05. According to Kitimat LNG's project application, the global average is more than 0.30 tonnes of CO₂ equivalent.



Kitimat LNG facility emissions. Source: Project Description Summary – Kitimat LNG Expansion Project, July 8, 2019

Kitimat LNG, which expects to source gas primarily from Alberta's Duvernay and B.C.'s Liard basins, recently applied to increase volumes to 18 mtpa from an earlier approved 10 mtpa. Full electrification would enable the project to expand capacity without

a corresponding increase in emissions of a traditional LNG facility, the proponents said. Renewable energy powered electric motor drives totalling 700 megawatts would run all liquefaction, utility compressors, pumps and fans, while diesel power generators serve as backup for emergencies.

Two smaller B.C. projects, both using e-drive, are also world leading in terms of carbon footprint. Woodfibre LNG near Squamish, with 2.1 mtpa capacity, and the Tilbury LNG project in Delta, are or will have carbon intensities of approximately 0.06-0.08, excluding emissions from electricity generation, according to Clean Energy BC.⁸

FortisBC announced in July that it had secured its first contract for the Tilbury LNG facility to export 53,000 tonnes of LNG a year, or about 60 standard-sized shipping containers a week, to China by the summer of 2021, made possible by the completion of the Tilbury LNG expansion project earlier in the year that added production capacity of 250,000 tonnes per annum. It represents the first agreement of its kind that will see Canadian LNG shipped regularly to China. The legacy LNG facility, which has been operating since 1971, had previously been supplying LNG to customers for export to China on a spot basis.

FortisBC said its carbon intensity of producing natural gas, liquefying and shipping it is approximately half that of an average facility on the U.S. Gulf Coast. The agreement would reduce between 90,000 and 180,000 tonnes of GHG emissions annually, according to a lifecycle GHG emissions tool developed specifically for Tilbury, FortisBC said, representing the GHG emissions equivalent of removing every passenger-sized diesel truck in B.C.

The proposed Énergie Saguenay LNG project in Quebec, also hydro-power driven, could reach as low as 0.04, according to Richard Harper of WSP

⁷ LNG/Upstream Gas Electrification and GHG Reduction—Executive Summary, Richard Harper, WSP Canada Group Limited

⁸ Electrification of British Columbia: Assessing the Economic and Environmental Benefits of Extensive Electrification in B.C., Clean Energy BC White Paper, Oct. 15, 2018

Canada Group Limited, who recently authored a study examining electrification of the sector, *LNG/Upstream Gas Electrification and GHG Reduction*. Mitigating acid gas removal emissions could bring numbers down in some projects to as low as 0.02.

LNG Canada's 14 million tonnes per annum (mtpa) first phase is designed to achieve levels of 0.15 tonnes of GHGs per tonne of LNG produced, just under B.C.'s low-emissions target.

Due to the use of hydropower, Énergie Saguenay proponents say GHG emissions from the project will be 84% lower than those of similar-size producers in the

U.S. and Asia. The project is also committing to strive to be carbon neutral in Quebec.

In the Environmental Assessment Report for the Goldboro LNG project in Nova Scotia, Pieridae Energy (Canada) Ltd. says a GHG management plan will be developed during FEED. The plan, amongst other measures, will evaluate alternative power supply options.

Pieridae says it is possible that there may be an option to obtain power off the NSPI grid and this would eliminate the need for power generation gas turbines. Use of the gas turbines would result an estimated 1.2 Mt (or 40% of the facility's total GHG release) of CO₂ to be released to the atmosphere. Currently, this is a conceptual option, pending a better understanding of the timeline and feasibility, which will be further examined during FEED.

U.S. competitors also going green

Freeport LNG in Texas could also reach new lows in the plant itself (excluding electricity generation). If grid emissions are included then the intensity is in the order of 0.24, according to the Harper study. However, large industrial users can request and pay for a package of 100% renewable power under the Texas Power Pool. In that scenario the intensity of Freeport LNG would be 0.08. It is also noted that the Texas grid itself is decarbonizing, as the state is a leading wind and solar power developer.

To be sure, competing natural gas jurisdictions like Texas are also moving to lower emissions with measures such as electrification, both upstream and at LNG facilities, putting more pressure on producers to minimize GHG emissions. "As the Texas grid decarbonizes the emissions of those facilities will go down," notes Harper. "They're seeing the value of electrification and they are moving in that direction, and I think B.C. and Alberta, if they want this industry to succeed, need to be cognizant of what their industry is doing and make sure they don't get left behind."

Defining the "cleanest" gas is, of course, a moving target. As technologies like e-drive increasingly take market share, as they are in Texas, new projects elsewhere could more effectively compete with Canada's clean projects. But B.C.'s hydroelectric dominated grid, sourcing some 98% renewable power, will continue to offer advantage over e-driven projects elsewhere, like Australia, where the majority of grid power remains tied to fossil fuels.

The scale of the challenge

Natural gas already claims the status as the cleanest fossil fuel — at some 50% and 30% less GHG emissions intensive when combusted than coal and crude oil, respectively. But in an increasingly carbon-conscious world, that fact alone no longer absolves natural gas of the obligation to aim even higher in the battle against climate change.

Canada's highly regulated environment already puts large onus on natural gas producers to keep emissions to a minimum. Alberta has long led in the effort to reduce venting and flaring, becoming a model for other jurisdictions. More recently, Canada, the U.S. and Mexico signed a deal to reduce methane emissions from the oil and gas industry 40%-45% by 2025, a commitment for which producing provinces can design their own equivalency regulations in order to meet that goal. And all provinces have their own GHG reduction commitments as part of the Canadian Paris target of a 30% reduction in emissions by 2030, which necessarily encompasses oil and gas emissions in producing provinces.

Industry has also independently taken on the emissions challenge. Several initiatives are underway to both tackle methane releases in the most cost effective ways and to reduce emissions more generally along the natural gas supply chain.

For example, industry association Petroleum Technology Alliance Canada (PTAC) is spearheading multiple efforts to develop new technologies to monitor and mitigate methane emissions. With industry partners, it has undertaken large-scale, multi-year field studies to test and improve new technologies and is involved in efforts to spread the use of existing

technologies throughout the industry.

Other industry associations are pursuing technology development through research and development, funding initiatives and grand challenges. For example, the Natural Gas Innovation Fund's (NGIF) most recent call for funding applications targets innovation in the natural gas production stream. NGIF is making up to \$3 million in reimbursable grant funding available to advance cleantech solutions in sustainable production and operations, and for improving environmental stewardship that can create value and mitigate environmental impacts in the production of natural gas in Canada. NGIF is offering up to \$1 million per project, representing as much as 25% of a project's eligible expenses.

The Clean Resource Innovation Network (CRIN) — which interconnects energy producers and service providers with innovators, government entities, non-profits and academic institutions — is also actively promoting development and deployment of new technologies that both reduce environmental impacts and improve cost performance.

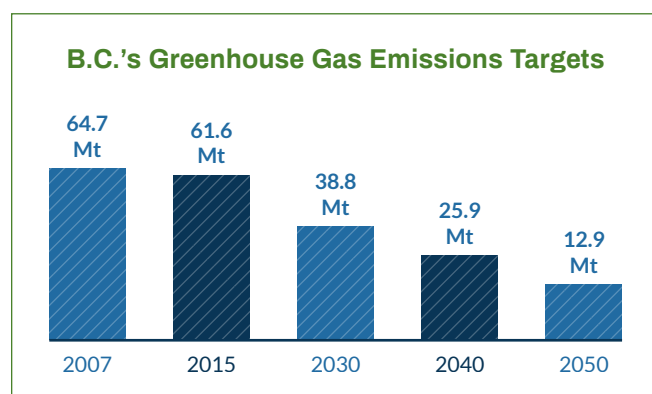
In October, Emissions Reduction Alberta (ERA) launched a \$50-million Natural Gas Challenge to unlock innovation across Alberta's natural gas value chain, from production to market and all points in between. The government agency, which receives funding from the province's large final emitters' carbon levies, said the challenge would support clean technology projects that reduce GHG emissions and improve the competitiveness of the natural gas industry. ERA, whose previous initiatives have already reduced Alberta's GHG emissions an estimated 42 million tonnes to 2030, will

fund up to \$10 million per project and up to 50% of total project costs, creating potentially over \$100 million in project value.

Concerns about human-caused global warming and the increasingly urgent calls to address it is the main driver behind the need to green any new energy projects and gain social licence to build them.

In response to the crisis, B.C. — the likely home to the largest concentration of Canadian LNG projects — has undertaken several measures aimed at complying with the Paris Accord, which seeks to keep global warming below 2 C. Not least of these measures is to ensure any future LNG production in the province is the world's "cleanest."

As part of its climate plan, CleanBC, the province has mandated ambitious GHG emissions reductions in the decades to 2050, significantly limiting the scope of any new emissions that may arise out of an emergent LNG sector. The current government has legislated reduction targets of 40% by 2030, 60% by 2040 and 80% by 2050. While the province is not yet on a path to meeting those targets, it maintains that its new plan manages to allow LNG Canada to go ahead and still meet them.



Source: BC Government

Along with the emissions restrictions come incentives to the industry, including a reduction in the carbon tax

where facilities can meet low-emissions benchmarks. LNG project proponents will be rebated on a sliding scale, depending on emissions per tonne of LNG produced, for the amount of any carbon tax over \$30 per tonne GHG emissions.

To grasp the scale of the challenge, a handful of conventional LNG projects, with typical 40-year life spans, would scuttle any chance of B.C. meeting the 2050 goal (of about 13 Mt CO₂e). Existing emissions from B.C.'s oil and gas industry — which is expected to ramp up production further to fill the LNG tankers for export — are already about 11 Mt. LNG Canada estimates CO₂e emissions from the first phase of what is expected to be a two phase project will be two Mt a year. But by some estimates, which take both upstream and downstream emissions of both phases into account, emissions could be as high as 12 Mt CO₂e per year, amounting to about a third of B.C.'s 2030 target and almost its entire 2050 objective.

While it may seem hard to imagine many additional projects going ahead, as hoped for by the industry, under those circumstances, it is entirely conceivable that a growing sector could still fall under the tightening limits. Aside from buying carbon credits operators could, for example, accomplish so-far unprecedented near- to net-zero emissions levels for their projects. That is something some experts say is doable with additional measures including extensive electrification and carbon capture and sequestration.

Going forward, all the technology development efforts ongoing nationwide could prove vital in allowing the LNG sector to grow within the confines of various jurisdictions' emissions reductions requirements. Both environmental advocates and project proponents can agree that in a future carbon-constrained world, the cleanest supply will offer market advantages and the best prospects of outlasting the competition.

Reducing emissions — from wellhead to waterline

MINIMIZING UPSTREAM EMISSIONS VITAL TO CAPTURING CLEANEST LNG CROWN

A Delphi Group analysis in 2013 that benchmarked a selection of LNG plants around the world provides insight on differing GHG intensities and the reasons behind them. It found that while a clean grid-powered B.C. LNG facility could indeed lead the world (with an intensity then calculated at 0.17 tCO₂e), it was unlikely to do so if upstream emissions are included.

Snøhvit LNG in northern Norway, which incorporates a refrigeration process powered by gas turbine electrical generators (as opposed to the typically used direct drive natural gas powered compressors) and grid electricity back-up as well as carbon capture and storage, was ranked lowest at just under 0.3. The then-planned facilities at Sabine Pass in Louisiana and Australia's Gorgon, also incorporating carbon capture and storage (CCS), were set to come in even lower, in the 0.26-0.27 range. Qatargas 1 and 2, considered to have typical emission intensities for the industry as a whole, emitted about 0.49 and 0.41, respectively.

All plants were adjusted to an inlet concentration of 1.5% CO₂ for comparison purposes. In most cases removed CO₂ — in the process of acid gas removal, which could occur both upstream and at the plant — is vented to atmosphere, accounting for a major source of plant emissions that rise when gas is sourced from high concentration CO₂ formations.

The majority of emissions, however, typically arise from combustion of natural gas in the gas turbines driving the refrigeration process, which typically ranges from about 50% to upwards of 90% of emissions. The main mitigation strategies for the plant itself include incorporating energy efficient technologies and processes, electrification of the plant using low emissions electricity and CCS, according to the Delphi study⁹. The purchase of offset credits is also an option.

A second Delphi report¹⁰ looked at a hypothetical B.C. LNG value chain, including all upstream gas production, processing and transmission emissions, and compared e-drive to the industry standard natural gas combustion direct drive refrigeration compressors. When upstream emissions were taken into account, B.C. was found to lose its lowest-emissions status, even with industry leading LNG facility ranking.

This is in part due to the use of GHG intensive shale gas, the study found, with the formation the natural gas originates from having a significant impact on emissions. The Montney contains roughly 1% or less CO₂, whereas the less developed Horn River play to the north contains about 10-12% CO₂. Carbon dioxide content must be reduced to about 2% to be pipelined (and further reduced to near zero at the LNG facility) and stripped out CO₂ is typically vented to atmosphere, pointing to the possible need for upstream CCS.

⁹ LNG Emissions Benchmarking, Prepared for: BC Climate Action Secretariat, Delphi Group, March 2013

¹⁰ LNG Production in British Columbia: Greenhouse Gas Emissions Assessment and Benchmarking, Client: BC Climate Action Secretariat, Delphi Group, May 2013

The best-in-class value chains benefited from both low-emission LNG facilities and use of offshore gas with sub-sea gathering systems that result in very low upstream GHG emissions. The two lowest emitting schemes, Snøhvit and Gorgon, also included CCS to reduce emissions from the venting of CO₂ contained in the facility feed gas, resulting in emissions intensities of about 0.35 tCO₂e.

“CCS is a possibility [to further cut emissions], but it’s also very expensive. We are seeing costs of about \$110, \$120 a tonne. Right now it would be more cost effective to buy offsets on the market than it would be to do carbon capture and storage,” says Harper.

Delphi found at the time that the average GHG intensities of the hypothetical B.C. value chains all fell

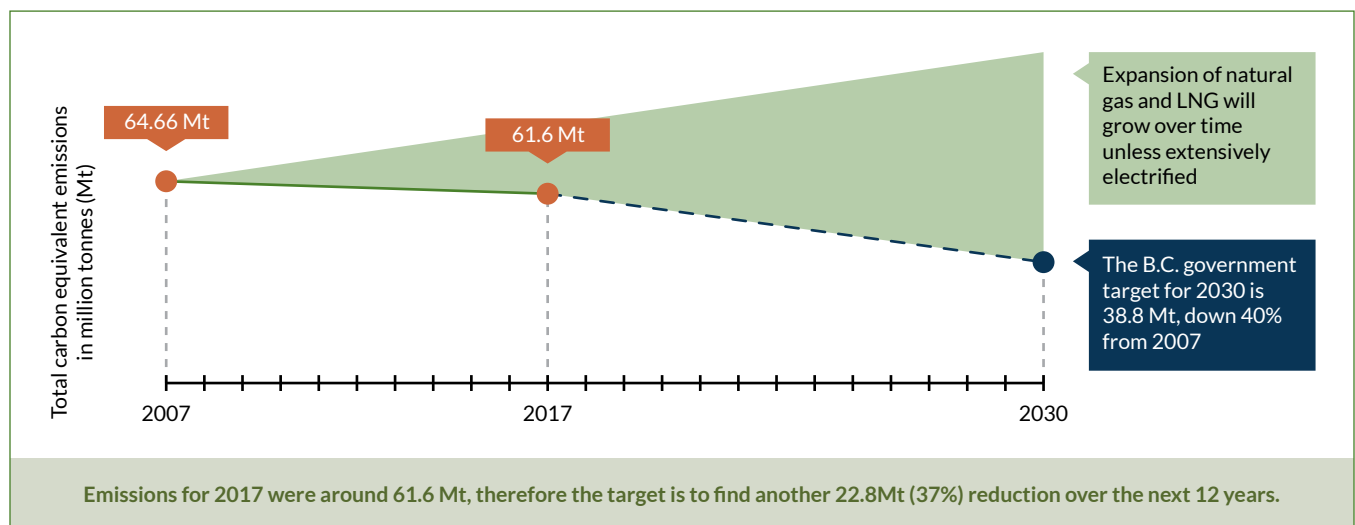
above the global average intensity of 0.58 tCO₂e due to B.C.’s higher upstream emissions intensity. The range of calculated B.C. value chain emissions intensities indicated that hypothetical value chains with grid-connected LNG facilities could have GHG intensities lower than the global average if upstream emissions are mitigated. The lowest emissions scenario could have emissions intensity closer to, but still approximately 20% greater than, the lowest global GHG intensity value chains.

“This indicates that global ‘low intensity value chains,’ which have access to natural gas from low emissions intensive formation types, would likely have lower emissions intensities than any hypothetical B.C. value chain considered in this report,” Delphi concluded.

ELECTRIFICATION IS KEY

Subsequent assessments — with an increased emphasis on mitigation of upstream emissions — have had a more positive outlook on the potential for Canada to be a world leader from wellhead to waterline. The Clean Energy Association of British Columbia (also known as Clean Energy BC), which represents renewable and clean energy operating and development companies, suppliers, contractors and service providers, believes

that extensive electrification is a key solution to B.C.’s emissions dilemma, not just for the LNG sector but across the economy. It would require a massive build-up in renewable power, however. To electrify the entire industry could require five or six times more power than the under-construction Site C hydroelectric dam will deliver.



Source: Clean Energy BC

The association concedes reaching B.C.'s targets "will be exceptionally challenging," assuming the province's projected LNG industry could contribute, on a business-as-usual basis, as few as seven and as many as 45 Mt of GHG emissions to the atmosphere per year,¹¹ against the target to lower emissions by 22.8 Mt per year by 2030. Still, Clean Energy BC is confident it can be done.

"If they seriously ramped up [the LNG sector] to what the gas guys want to do, then everybody else has to reduce their GHG emissions to close to zero. And I know that a lot of people will balk at that. But if you realize there's a whole bunch of countries around the world that are committing to reduce that gap to net zero in the same timeframe, you see it's not impossible — it's just going to be more of a challenge," Martin Mullany, Clean Energy BC interim executive director, said in an interview.

Indeed, Germany, Japan and the U.K. are among the nations that have set targets of reaching net-zero emissions of GHGs by 2050 in line with the Paris Accord. In the U.S., several Democratic contenders for president have similarly proposed setting a net-zero goal by 2050 or earlier. Even Shell CEO Ben van Beurden said he supports efforts to reach Paris targets, maintaining that the net-zero transition is now non-negotiable. The public will simply "not stand for" current emissions trajectories, he told the company's annual

Energy Summit in July. "The whole world has to get to that point," he said. "Now some people say the whole world needs to get there by 2070, and some people say 'No, you have to get there by 2050.' But whatever timeframe you pick, getting to net zero will require an absolutely unprecedented level of co-ordinated action.

And I believe governments will need to do a lot and will need a lot of help as well."¹²

In its report published last fall, Clean Energy BC found embracing extensive electrification using B.C.'s already low emissions grid would "position the province for competitiveness and prosperity in the global low-carbon economy."

"British Columbia is particularly well-suited for clean electrification. In fact, electrification offers the province a critical competitive advantage in the global pursuit of clean growth. The province boasts one of the lowest-carbon electricity grids in North America. Its power generation sector can responsibly and cost-effectively provide the additional

renewable electricity that extensive electrification will require," it states.

The benefits of electrification when paired with enhanced energy efficiency are enormous, it states, showing that extensive electrification could reduce LNG industry emissions up to 72% below business-as-

"We think B.C. will need to double its electricity production over the next 10 or 20 years to meet all of our goals, but we have more than enough geographical space for all the wind farms and solar plants and [run of] river [hydro] projects we need. So there won't be any trouble getting enough renewable power."

— Martin Mullany, Interim Executive Director, Clean Energy BC

¹¹ Electrification of British Columbia: Assessing the Economic and Environmental Benefits of Extensive Electrification in B.C., Clean Energy Association of British Columbia, pg. 10

¹² Shell boss: Net zero is 'the only way to go', <https://www.businessgreen.com/bg/news/3078443/shell-boss-net-zero-is-the-only-way-to-go>

usual levels, natural gas production emissions up to 60%, trucks and trucking up to 84%, and residential and commercial building heating by up to 98%. “Extensive electrification would enable B.C. to meet our climate targets and would require increasing B.C.’s production of renewable energy by as much as 50% to meet the 2030 GHG targets, and by as much as 100% to meet the 2050 targets.”

In the upstream, the industry could realize the largest GHG reductions by switching compressor and generator power from natural gas and diesel to clean grid electricity, according to Clean Energy BC. “Replacing gas activated pumps and compressors with electrical equipment will eliminate or reduce methane venting and fugitive emissions, assisting the industry in meeting the methane emission regulations [requiring a 40-45% reduction from 2012 levels by 2025] recently introduced by the government of Canada.”

Mullany doesn’t think there will be any shortage of renewable power in B.C. It is more a matter of building and transporting it in time for industrial users to take advantage of it. In fact, it will create more economic

growth. “We think B.C. will need to double its electricity production over the next 10 or 20 years to meet all of our goals, but we have more than enough geographical space for all the wind farms and solar plants and [run of] river [hydro] projects we need. So there won't be any trouble getting enough renewable power.”

In August 2019, the B.C. and federal governments recommitted to electrifying the natural gas value chain with a memorandum of understanding affirming their commitment to power the province’s natural gas production and LNG sectors with clean electricity.

Ottawa and Victoria are examining \$680 million in near-term electrification projects for joint funding. In April 2019, the federal government provided \$84 million of investment to help electrify industrial operations in B.C.’s Peace region, with provincial Crown utility BC Hydro providing \$205 million.

Electrifying natural gas projects in the Peace region will cut carbon pollution by 2.6 million tonnes and is a key commitment in Phase 1 of the CleanBC plan to meet its climate change commitments, according to the province.

TRIMMING UPSTREAM EMISSIONS

By some estimates, the upstream emissions associated with producing, processing and transporting natural gas — as well as methane leaks — are higher than the GHG emissions from liquefaction on the coast. As with the LNG facility, the upstream can be tackled by extensive electrification. In fact, Shell Canada and other producers have already made significant strides in electrification on the B.C. grid.

Over the last three years, Shell’s Groundbirch asset in northeast B.C. — including some 500 wells and four gas plants — has reduced GHG emissions by about 25% by taking conscious steps to reduce its footprint, said Jana Masters, interim manager, Media Relations.

Some of the biggest gains have been realized by

“They are the greenest gas plants in the world. If you connect that with LNG on the West Coast, which also will be powered with hydroelectricity, which then moves gas in the shortest route available to Asia you are reducing emissions by over 60%,”

— Doug Suttles, President & CEO, Encana



Encana's Tower sweet gas plant, located near Dawson Creek, B.C. Source: Encana Corporation

electrifying gas plants sourcing low-emissions hydroelectric power. In 2016, Shell electrified its main gas plants at Groundbirch, reducing emissions by about 150 kilotonnes each year (equal to taking about 37,500 cars off the road annually). Direct emissions have decreased by approximately 90%, or an estimated 150,000 tonnes of CO₂e per year, in the Saturn gas plant alone since full electrification, sourcing BC Hydro power from the Dawson Creek-Chetwynd Area Transmission (DCAT) project, according to Masters. (Some 13 of 110 gas plants in B.C. are now electrified, according to the BC Oil and Gas Commission.)

Other Canadian producers are moving in the same direction. For example, Encana Corporation with partners Mitsubishi Corporation and Veresen Inc. brought online three large gas plants powered by hydroelectricity, reducing GHG emissions by 860,000 tonnes per year. "They are the greenest gas plants in the world. If you connect that with LNG on the West Coast, which also will be powered with hydroelectricity, which then moves gas in the shortest route available to Asia you are reducing emissions by over 60%," Doug Suttles, Encana president and CEO, commented last

year. (Encana intends in early 2020 to rebrand under the name Ovintiv Inc.)

Canadian Natural Resources Limited and ARC Resources have also designed natural gas plants to run on hydroelectricity, as well as applying other low-emission technologies. At its Septimus plant Canadian Natural has avoided emitting 355,226 tonnes of carbon dioxide equivalent (CO₂e) since 2011 and its Noel plant has avoided emitting 59,949 tonnes of CO₂e since 2014¹³. The company also uses solar power at many of its remote well sites. ARC's use of electric-driven compressors and instrument-air systems instead of instrument-gas to eliminate the need for venting have resulted in reduced emissions of 539,743 tonnes of CO₂e since 2010.

Meanwhile, an IHS Markit study found that in the last decade, Alberta has reduced the GHG intensity of oil and gas by 25%. While overall emissions continue to rise due to increased production, it is anticipated that emissions intensity will continue to decline by upwards of 20% by 2030 with additional technology development.

¹³ 5 reasons B.C. is a leader in clean natural gas, Canadian Association of Petroleum Producers, https://context.capp.ca/articles/2018/feature_bc-producers-provide-clean-natural-gas

REDUCTIONS AT THE WELLHEAD

Similar electricity-related emissions reductions are taking place at the wellsite. Shell introduced a new well pad design last year to increase production capacity while decreasing costs and methane emissions. Its Generation Four multi-well pad design uses electric actuators in place of fuel gas to activate valves to eliminate venting. They require less electricity than a blow dryer to operate the entire multi-well pad, resulting in GHG emissions reductions of 91% per pad, said Masters. Building on the success of the new well pad design, any future well pads will employ this

technology, she said, while the switch to natural gas-powered drilling rigs instead of diesel also reduces emissions.

It is anticipated the LNG Canada partners will need to drill about 200 new wells per year for the life of the LNG plant. New well pads run on electricity through a combination of solar panels and thermoelectric generators. Shell is looking at further measures such as the use of zero-emissions methanol fuel cells, which have no carbon emissions.



Shell's Groundbirch operations. Source: Shell

MOVING MOLECULES

Extensive electrification will require not only a substantial expansion in the renewable power sector, but the construction of transmission lines to get the electrons to end users in remote regions of the province. In addition to BC Hydro's DCAT project, which allowed Shell's Saturn plant to tap into the grid, the \$298-million Peace Region Electricity Supply (PRES) project currently under construction will come online in 2021.

The twin 230-kilovolt transmission line will run from the Site C dam to the Groundbirch region near Chetwynd, providing access to another 600 megawatts of power for the region. Ottawa announced in April 2019 it would contribute \$83.6 million to the project. The province said electrification would result in a 2.6 Mt annual reduction in GHGs. It is anticipated more lines will be necessary for full electrification of facilities in the region.

METHANE EMISSION REDUCTIONS PIVOTAL

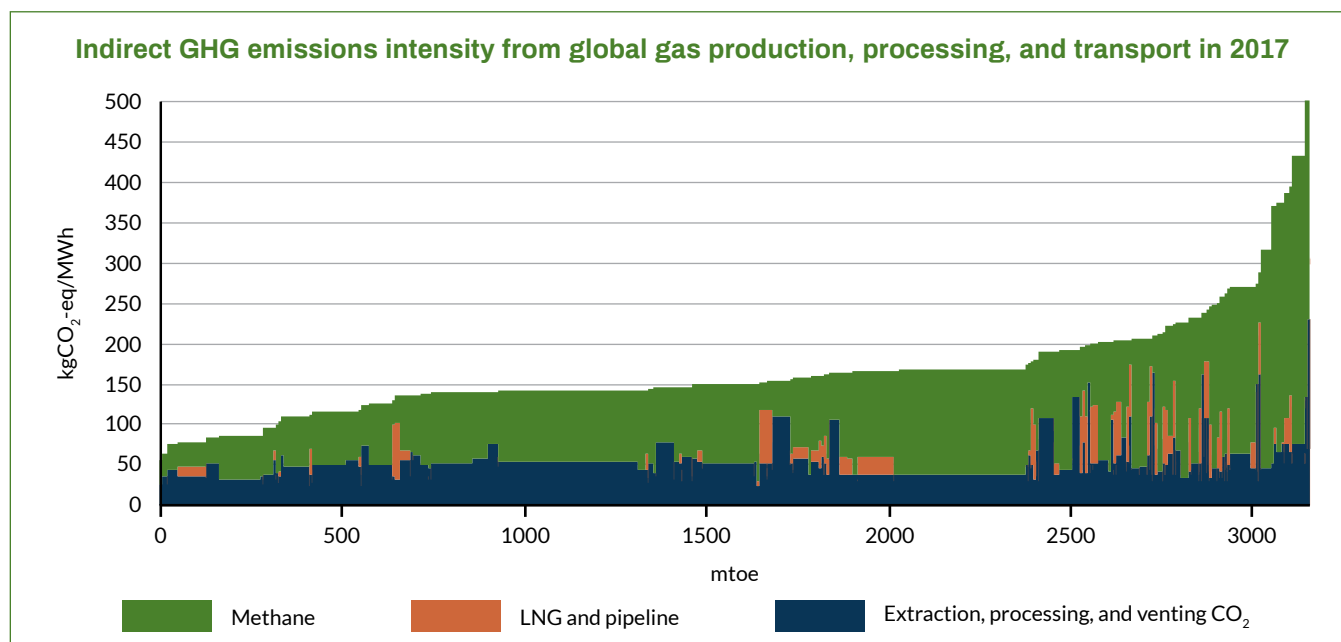
Any failure to tackle methane emissions, which occur throughout the supply chain, could become the Achilles heel of the industry. Not only would it put at risk B.C.'s targets, but it could seriously erode natural gas's green credentials. Combined unintentional (leaks) and intentional (for example, pneumatic pumps and devices) methane emissions range from 1-9% of total life cycle emissions — anything over about 3% is thought to negate natural gas's GHG emissions advantage over coal in the production of electricity.¹⁴ (A potent GHG that persists in the atmosphere for a much shorter time than CO₂, methane is calculated to have a planetary warming potential between 28 and 36 times greater than CO₂ over a 100-year time frame, or 84 to 87 times greater over a 20-year window.¹⁵)

The federal government's mandated reductions, for which some provinces are introducing equivalence regulations for industry compliance, are expected to reduce 20 Mt of methane emissions in 2030 — or about a 10% overall GHG emissions reduction, equivalent to

taking about five million passenger vehicles off the road each year.

Still, some environmentalists say methane emissions are significantly underestimated by governments and industry, and hope to turn the tide against natural gas's perceived status as a low-emissions alternative to coal. As one recent New York Times headline put it: "As Coal Fades in the US, Natural Gas Becomes the Climate Battleground." At risk are not only public perceptions, but investment in the sector going forward. As a global group of more than 140 investors that represent more than US\$5.5 trillion in assets put it in a reaction to U.S. efforts to weaken methane regulations: "The rollback of federal regulation will lead to excessive methane emissions, threatening the role of natural gas in the low carbon future and challenging oil and gas companies' social license to operate."¹⁶

Some of the largest oil companies also oppose the rollbacks — and in fact are working together to target



Source: IEA

¹⁴ Alvarez, R.A., S.W. Pacala, J.J. Winebrake, W.L. Chameides, and S.P. Hamburg. 2012. [Greater focus needed on methane leakage from natural gas infrastructure](#). Proceedings of the National Academy of Sciences 109:6435–6440.

methane emissions through organizations such as the Oil and Gas Climate Initiative, an industry organization whose members have pledged to collectively cut average methane emissions to less than 0.25% of gas sold by 2025.

Globally, Shell has set a target to maintain methane emissions intensity below 0.2% by 2025. Shell says

its Groundbirch asset has already achieved a 0.1% methane emissions intensity rate and will continue to improve operations to further reduce emissions. “As an example, Shell is trialing the use of a catalyst that could reduce the amount of unburned methane released from natural gas-fuelled engines used in our asset, but more importantly, in gas engines around the world,” Masters stated.

Measuring methane emissions

The carbon intensity for sourced natural gas, like other commodities, is coming under increased scrutiny as climate change drives policy, investor decisions and consumer demands. Now, new technologies are making it easier to distinguish natural gas produced to the highest levels of sustainability, opening the door for producers of “cleaner” gas to enhance the longevity of their projects in a carbon-constrained world – and perhaps charge a premium for their product.

One set of technologies – largely satellite-based – will zero in on actual emissions throughout the value chain with unprecedented precision, while another – based on digital technologies such as artificial intelligence (AI) and blockchain – will track lifecycle emissions so as to allow producers to independently verify their low-emissions performance.

Falling costs to launch increasingly small satellites – no larger than a microwave oven – combined with improved sensor technologies and data analytics are leading to a step-change in highly accurate, low-cost space-based monitoring.

Montreal-based GHGSat was among the pioneers developing satellite-based GHG monitoring capabilities, working in part with Alberta oilsands producers to commercialize the technology. Its soon-to-be-launched MethaneSAT’s objective is to measure methane emissions from shale plays with a wide angle lens, then to zoom in on individual facilities with a higher resolution complementary satellite. Additional satellite launches are planned. The company is also developing artificial intelligence to predict facility level risks of methane emissions.

In August 2019, GHGSat announced \$3.3 million in funding from Sustainable Development Technology Canada for a \$9.8-million, 33-month project to provide emissions measurements of oil and gas facilities in the Montney region of B.C. The project seeks to demonstrate that a tiered monitoring system using GHGSat’s newest satellite platform and aircraft instruments under development can detect more leaks quicker and at a lower cost than the regulatory standard, based on optical gas imaging cameras.

¹⁵ IEA: The environmental case for natural gas, October 2017.

¹⁶ Major Endowments Prod Oil Firms to Ignore Trump’s Methane Rollback, Bloomberg News, <https://www.bnnbloomberg.ca/major-endowments-prod-oil-firms-to-ignore-trump-s-methane-rollback-1.1308899>

ANALYSIS: WHY IT MATTERS

There are signs of a sea-change afoot in public perceptions of climate change and the increasingly urgent need to do something about it. The issue has risen toward the top of the agenda of many lawmakers, business leaders and investors, who perceive the risks involved in maintaining what has become the status quo of taking only marginal action to mitigate global warming and deal with its effects.

Yet the world's energy systems cannot turn on a dime and magically decarbonize overnight. The energy transition will stretch into several decades, during which time energy producers will need to meet the power demands of growing populations around the world.

"While it's difficult to predict exactly how quickly the transition will play out, it behoves energy producers to find an insurance policy that protects them from a rapid transition that could leave them stranded — the energy equivalent of Blockbuster Video or the Kodak moment," says Maurice Smith, technology editor for the *Daily Oil Bulletin*.

Relatively low-emissions LNG, likely the last fossil fuel to be targeted for reductions, could represent that insurance, he says. And differentiating oneself as the cleanest supplier of LNG takes that insurance one step further — it could represent the organic or fair trade equivalent of the food industry for energy.

"While necessity requires that we still rely on fossil fuels early in the transition, we can choose to consume the cleanest available petroleum products as it progresses," says Smith. "Some LNG producers recognize the distinction."

LNG Canada sees low emissions production as a competitive advantage in a world increasingly having

to differentiate between the products they buy, says spokesperson Pierce. "I think that we're in a transition period now where people are beginning to realize that it's not just about what we emit [ourselves], but it's also the things that we are buying — where those products come from, and the emissions creating those products.

"LNG in terms of the overall carbon footprint, measured by the carbon intensity of the LNG that is produced, is

absolutely, I think, an advantage that increasingly will be a differentiator, if you can make those arguments and demonstrate that. If you have a choice between purchasing LNG from a place where emissions are much higher per tonne of LNG versus purchasing it from a place that's clearly showing leadership, I think the argument will follow that you want to go to the place of clearly showing leadership and is price competitive."

This is where British Columbia comes in, she says. "We already have among the most progressive

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— Maurice Smith, Technology Editor, *Daily Oil Bulletin*



greenhouse gas policies in the world, and are the first to design a carbon-intensity benchmark into LNG facility regulations.”

In that respect, B.C.’s climate plan actually benefits the industry, she adds. “B.C. is uniquely advantaged that way, because of the clean hydro it has and other aspects. It’s an incredible and emerging advantage, because B.C. continues to be very focused on how it drives emissions performance, but then also recognizing that in order to be a place that can demonstrate emissions performance, they also have to have sustainable investment. It’s a combination of ensuring that you have sustainable investment and also emissions performance. That I think is the key.”

B.C. is also committed to work collaboratively with industry to find ways of driving even better emissions performance, Pierce states. “It is already a leader. We can see it across the value chain. And there [are] opportunities for more of that, particularly in electrification of the upstream.”

WSP’s Harper echoes that assessment. The competitive advantage to Canada’s LNG industry is the clean grid, he says. “Because in my opinion, the LNG with the greatest longevity will have the lowest carbon intensity. Extensive electrification will future-proof the B.C. upstream gas and LNG industry for the transition to a low carbon economy.”

CONCLUSION

Canada is fortunate to have both a world-class natural gas resource and a world-leading clean energy grid from which to power the exploitation of that resource. The combination makes it uniquely positioned to produce some of the lowest emissions LNG available, at an affordable price. And the timing is right to capitalize on the competitive advantage that offers, one that stands to gain in significance as the world's energy systems transition to lower carbon-intensity alternatives.

While the sector, and the province, stands to benefit from those advantages, they will have to keep their eye on the “green” ball to ensure the advantage is a lasting one. Other jurisdictions are likely to follow suit to the extent that they are able, while fossil fuel opponents will attempt to poke holes into any claims of environmental leadership with any lack of the strictest adherence to low emissions efforts as well as use of industry-leading best practices and technologies.

But the clock is ticking on Canada's opportunity to leverage its natural advantages. Even the lowest

emissions source of the lowest emissions fossil fuel is still a GHG producer — a detriment that could erode the sector's competitiveness if the most stringent of climate change scenarios plays out in the coming decades. Once considered the bridge fuel to transition to a low carbon economy, filling the gap left by the intermittent nature of renewables like wind and solar, even that opportunity is at risk as renewables combined with energy storage that have cratered in cost eat into market share. In other words, the window to benefit from those advantages in what the IEA in recent years has called “a Golden Age for gas” could close faster than expected.

The industry is on the right track to position itself advantageously as a world-leading producer. Future proofing lies in driving down GHG emissions to the lowest possible levels throughout the value chain — something the sector is on track to accomplish. It is in the industry's self interest to stay on that path if it truly wants to be the last producer standing in the decades to come.

REFERENCE MATERIAL – KEY CANADIAN LNG PROJECTS¹⁷

1. LNG Canada

- Location: Kitimat, B.C.
- Proponents: A joint venture comprised of Royal Dutch Shell plc, through its affiliate Shell Canada Energy (40%); PETRONAS, through its wholly-owned entity, North Montney LNG Limited Partnership (25%); PetroChina Company Limited, through its subsidiary PetroChina Canada Ltd. (15%); Mitsubishi Corporation, through its subsidiary Diamond LNG Canada Partnership (15%); and Korea Gas Corporation, through its wholly-owned subsidiary Kogas Canada LNG Ltd (5%).
- Capacity: The project will initially export 14 mtpa, the equivalent of about 1.8 bcf/d, from two processing units. At full build out, LNG Canada will have four trains or processing units, each with the capacity to process approximately 7 mtpa of LNG for export to countries in Asia and elsewhere.
- FID: A final investment decision was made for the first two trains on Oct. 1, 2018
- Anticipated onstream date: 2025
- Associated infrastructure: TC Energy will build, own and operate the 670-kilometre Coastal GasLink (CGL) pipeline that will connect natural gas from northeast B.C. to the export plant.
- Regional economic benefits: 4,500 people employed at peak construction on the Kitimat site.
- Recent announcements:
 - In September 2019, LNG Canada prime contractor JGC Fluor awarded Clough PPM the EPC for the project's loadout line trestle.
 - In June 2019, the federal government said it will spend \$220 million to help fund energy-efficient gas turbines and another \$55 million to replace a bridge for the project.
 - In April 2019, the LNG Canada project owners officially handed over construction management to their prime contractor, JGC Fluor.
 - In January 2019, LNG Canada approved \$937 million in contracts and subcontracts to First Nations and Canadian businesses.
- More details: <https://www.lngcanada.ca/>

¹⁷ Updated as of Sept. 30, 2019

2. Kitimat LNG

- Location: Bish Cove, near Kitimat, B.C.
- Proponents: The proposed project is a 50/50 joint venture between Chevron Canada Limited and Woodside Energy International (Canada) Limited.
- Capacity: The Kitimat LNG plant includes up to three LNG trains totalling 18 mtpa (6.0 mtpa/train). The initial foundation project consists of two trains (12 mtpa).
- Anticipated FID: 2022 to 2023
- Construction of Phase 1: 2022/23 to 2028/29; commissioning of first LNG train begins after construction is complete; commissioning of second LNG train begins three weeks after the commissioning of the first train; construction and commissioning of the third LNG train as market conditions allow.
- Associated infrastructure: The 471-kilometre Pacific Trail Pipeline (PTP).
- Regional economic benefits: At peak construction of the LNG facility, it is estimated that more than 3,000 people would be working on the Kitimat LNG plant site with another 1,500 workers building PTP. In addition, Kitimat LNG has a benefits agreement with the Haisla Nation for the plant, which is located on Haisla Nation Reserve land, and an agreement with all 16 First Nations along the proposed PTP route through the First Nations Limited Partnership (FNLP)
- Recent announcements:
 - In September 2019, Woodside said it was seeking to reduce its stake in the Kitimat LNG product to cut its capital exposure.
 - In July 2019, in an NEB filing, the proponents said supply will come from the equity gas resources of Chevron and Woodside held together in the Liard Basin, Chevron's equity gas resource in the Kaybob Duvernay resource and, if needed, from other contingent and prospective resources, and open market purchase or swaps made in WCSB market hubs.
 - In July 2019, the project proposed to become an all-electric plant that will be powered by hydroelectricity from BC Hydro. In July, the proponents also proposed a third train for the project.
- More details: <https://canada.chevron.com/our-businesses/kitimat-lng-project>

3. Woodfibre LNG

- Location: Squamish, B.C.
- Proponents: Woodfibre LNG Limited is a subsidiary of Pacific Oil & Gas Limited (PO&G), part of the Singaporean conglomerate RGE.
- Capacity: The project is licensed to export about 2.1 mtpa for 40 years.
- Anticipated FID: Fall 2019
- Anticipated onstream date: 2023
- Associated infrastructure: The project will receive natural gas from the Eagle Mountain – Woodfibre Gas Pipeline (EGP) Project.
- Regional economic benefits: 650+ jobs at peak construction; 100+ jobs at Woodfibre site; 1,410+ additional indirect or induced jobs during construction or at the site thereafter.
- Recent announcements:
 - In July 2019, the BC Oil and Gas Commission

(OGC) approved Woodfibre LNG's permit for its export facility.

- In June 2019, Woodfibre said that BP Gas Marketing Limited had agreed to buy 0.75 mtpa of LNG for 15 years starting in 2023.

- In May 2019, PO&G said it is acquiring all of the issued and outstanding shares of privately-held Canbriam Energy Inc. and its Montney assets.

- More details: <https://www.woodfibrelng.ca/>

4. Goldboro LNG

- Location: Goldboro, N.S.
- Proponents: Pieridae Energy (Canada) Ltd.
- Capacity: up to 10 mtpa
- Anticipated FID: 2020
- Anticipated onstream date: Commercial deliveries of gas to Uniper are expected to start between Nov. 30, 2024, and May 31, 2025.
- Associated infrastructure: The facility is located adjacent to the Maritimes & Northeast Pipeline, a 1,400-kilometre transmission pipeline system built to transport natural gas between developments in Nova Scotia, Atlantic Canada and the northeastern United States.
- Regional economic benefits: Construction phase – up to 3,500 jobs at the Goldboro site; ongoing operation and maintenance – up to 200 positions.
- Recent announcements:
 - In July 2019, Pieridae said it has negotiated extensions of the key deadlines under its 20-year agreement with German utility Uniper.
 - In June 2019, Pieridae signed a purchase and sale agreement with Shell Canada Energy to acquire all of Shell's midstream and upstream assets in the southern Alberta Foothills for \$190 million. Shell Canada will take an equity stake in Pieridae.
- More details: <http://goldborolng.com/>

Glossary & Conversions

mmcf/d = million cubic feet per day

bcf/d = billion cubic feet per day

tcf = trillion cubic feet

bcm = billion cubic metres

mtpa = million tonnes per annum

1 bcf/d = 7.55 mtpa

1 mmcf/d = 0.267 mtpa

1 cubic metre = 0.0007 tonnes

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Canada's Green LNG Advantage

Extensive electrification offers critical
low-emissions advantage in the global
pursuit of clean growth

