Refuel

What Canadian LNG and oil exports could mean for global emissions

Public Policy Forum

BY MARK CAMERON AND ARASH GOLSHAN

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Report At-a-Glance

Canadian LNG has a
twofold climate advantage:
at the point of use, it's much cleaner than coal, and at the point of production, it's cleaner than many other sources of LNG. Achieving increased export volumes to unlock this potential is far from guaranteed and needs a new policy framework based on co-ordinated financing, efficient and effective regulatory approvals, enabling critical infrastructure, and increased Indigenous economic participation.

Historically, the emissions intensity of Canadian heavy oil has improved by about 30 percent since 2005.

Oil sands crude is typically in the heavy oil category, and it is only fair to compare it against other heavy crudes globally rather than against light sweet oils. Canadian heavy oil is already cleaner than key competitors; displacing dirtier imports with Canadian barrels lowers global emissions.

Equivalent to 6–10% of Canada's national emissions.

Canadian LNG is estimated to decrease global emissions by 40-70 Mt CO_2e, depending on the export market.

Canadian heavy oil has an 18–51 kg CO_2e/barrel advantage to Venezuelan heavy crude, which can potentially increase to a 35–68 kg advantage with the planned Pathways carbon-capture project.

By continuing to engage in international climate co-operation through emission trading agreements or championing production-based intensity standards, **Canada can expand its role as an energy exporter** while aligning with global climate objectives.

Executive Summary

Would expanding Canadian exports of liquefied natural gas (LNG), heavy and light oil raise or lower global greenhouse gas (GHG) emissions?

Alberta and Canada recently signed a memorandum of understanding, which committed to "increasing production of Alberta oil and gas to reach Canada's export and national security goals… while simultaneously reaching carbon neutrality."[1] Many have argued that these goals are incompatible. Drawing on analysis by Navius Research of likely Canadian oil and gas exports, as well as displacement scenarios by destination market by 2035, the central finding is nuanced but clear:

With maintaining the persistent downward trend in our fuels sector's carbon intensity via strong methane controls and other measures and with targeted market strategy, increased Canadian exports have the potential to reduce global emissions by displacing higher-intensity sources of supply. That's why we need to capitalize on our environmental advantages by leveraging our existing export capacity and unlocking the capital flow to new major projects in the sector by enhancing the economic competitiveness and viability of those projects.

+ LNG: Canadian LNG — especially from British Columbia — has a world-leading low life-cycle carbon intensity because:

1. Liquefaction is increasingly powered by clean hydropower;
2. Upstream methane leakage is significantly less than that of competitors due to relatively new resources and operations benefiting from high productivity and latest technologies, while also functioning under tight Measurement, Monitoring, Reporting and Verification (MMRV) protocols;
3. High-quality natural gas plays in British Columbia that benefit from low formation CO_2; and
4. Transportation benefits over competing U.S. supplies, thanks to shorter shipping distances to key Asian markets, which directly translates to lower shipping emissions.

LNG Canada's liquefaction facility is designed around ~0.15 tonnes of CO_2e (carbon dioxide equivalent) per tonne of LNG versus a global average of ~0.35 tonnes of CO_2e. Newer projects in B.C. are expected to emit even less. At the point of use, gas in efficient combined-cycle turbines emits roughly 50–60 percent less per megawatt hour (MWh) than coal, so the largest climate gains occur where LNG displaces coal generation.

A significant portion of global LNG exports is used for electricity generation in importing countries. Focusing the scope of our analysis to that portion, Canadian LNG offers a remarkable emission reduction potential over competing LNG as well: delivered to China, for example, B.C. LNG is estimated at ~74 kilotonnes (kt) of CO_2e per terawatt hour (TWh) of generated electricity versus ~124 kt/TWh for U.S. LNG — about 40 percent less — implying benefits even when Canadian volumes replace other LNG rather than coal.

Emissions reduction is also expected to be achievable in other LNG use cases, such as space heating and industrial processes, given the lower emissions intensity of Canadian LNG, which falls outside the scope of the analysis that informs this report.

If Canadian LNG capacity reaches 47.6 million tonnes per annum (MTPA) by 2035 — that is, if all LNG projects currently in the pipeline become operational and export to the largest Asian markets —

the net climate impact, according to Navius's "most likely scenario," would be 40–70 Mt CO_2e/yr in net reductions to global emissions. To put that into perspective, this equates to 6–10% of Canada's national emissions, and the higher end of the range is 10 Mt CO_2e/yr larger than British Columbia's annual emissions (60 Mt CO_2e/yr). This figure takes into consideration the announced climate policies and credible projections for the future composition of the electricity grids in destination markets of interest.

+ Canadian Heavy Oil:

Historically, the emissions intensity of Canadian heavy oil (heavy oil sands and conventional heavy) has improved by about 30 percent since 2005 to about 78 kilograms of CO_2e per barrel (kg CO_2e/bbl), comparable to (or cleaner than) several global heavy grades. The estimates for emissions intensity of the Venezuelan heavy (one of the key competitors with Canadian heavy oil) vary between around 96 kg CO_2e/bbl to 129 kg CO_2e/bbl, making it a prime displacement target.

If Canadian heavy displaces Venezuelan barrels, the analysis estimates an emissions advantage of ~18 – 51 kg CO_2e/bbl today, which could rise to ~35 – 68 kg CO_2e/bbl with the proposed Pathways Alliance CO_2 Trunkline (a planned storage hub in Alberta for sequestering carbon).

It's also worth noting that the growth in oil sands production comes from segments and sources with below-average intensity, which helps reduce the overall average intensity over time. Continued deployment of carbon capture and storage (CCS), solvent-assisted SAGD (steam-assisted gravity drainage) and electrification could push oil sands and other Canadian heavy oil production's upstream intensity into the 40s – 50s kg CO_2e/bbl by 2040–2050, further strengthening displacement benefits.

+ Canadian Conventional Light Oil:

Canadian non-oil sands light oil production (including frontier oil, pentanes plus and condensates production, onshore and Atlantic offshore) generally falls close to the global upstream average. The emissions intensity for this grade of products reduced from 57 kg CO_2e/bbl in 2005 to 49 kg CO_2e/bbl, before electrification. The global estimates for the average emissions intensity of comparable products range between 45 – 63 kg CO_2e/bbl. Given modest growth potential and strong methane and flaring controls, expanded exports here are highly unlikely to raise global emissions.

+ Policy Considerations:

As described above, Canada's natural gas, heavy and light oil exports offer a significant opportunity to displace dirtier alternatives and deliver global emissions gains. Clearly, this opportunity is strongest in the case of Canadian LNG.

Smart climate policy can help Canada to realize this advantage. For example, Canada should champion product-level carbon accounting and production-based intensity standards, which would reward low-carbon-intensity sources like Canada. Similarly, the federal government should pursue bilateral agreements, such as those recognized under Article 6.2 of the Paris Agreement climate change treaty to convert the global climate benefits into recognized credits.

However, a pragmatic approach is essential; Canada must not delay leveraging its oil and gas export potential by making such agreements a precondition or waiting for a fully-formed global framework, as this would voluntarily forfeit crucial economic, strategic, and environmental advantages that those products offer to Canada, its allies and the global fight against climate change.

To ensure that Canadian oil and gas continue to reduce production emissions and therefore have a more positive global climate impact, Canada needs to build on its successes in significantly cutting the emissions intensity of various segments of its oil and gas sector, maintain its emissions reduction policies and technologies and prioritize:

1. Assuming a leadership role in both harmonization of product-level carbon accounting that can lead to production-based intensity standards, as well as operationalizing Article 6 of the Paris Agreement to share verified reductions;
2. Targeting markets where LNG displaces coal or more emission-intensive gas, and heavy oil displaces other high-carbon sources;
3. Continuing to reduce upstream and midstream methane emissions and electrification of natural gas and oil production; and
4. Accelerating conventional and oil sands decarbonization (CCS, solvent-SAGD, electrification), without weakening the competitiveness of Canadian products over their competitors.

With these in place, Canada can expand energy exports while supporting global decarbonization.

Introduction

For decades, Canadian oil and gas exports have been largely captive to the United States.

But in recent years, significant new export opportunities have emerged in the form of new liquefied natural gas (LNG) facilities like LNG Canada[2] and expanded oil export pipelines such as the Trans Mountain Expansion Project.[3]

As recent trade disputes with the United States have underlined, Canada can no longer rely on the U.S. as its primary export market for energy, or indeed other goods and services. To secure long-term prosperity and resilience, Canada must diversify its export markets, particularly toward fast-growing regions in Asia, where energy demand remains high and coal still dominates power generation, and to Europe, where Canadian oil and gas can replace Russian imports and contribute to global energy security. The Public Policy Forum's recent *Build Big Things* report underscores the importance of trade diversification and the policy changes that will be needed to expedite projects for LNG and oil export.[4]

Alberta and Canada recently signed a memorandum of understanding, which committed both governments to "increasing production of Alberta oil and gas to reach Canada's export and national security goals…while simultaneously reaching carbon neutrality." While both parties reiterate their commitment to achieving net-zero greenhouse gas emissions by 2050, the memorandum also calls for unlocking the growth potential of Western Canadian LNG and increasing and diversifying the export of Canadian oil through building a new bitumen pipeline to Asian markets.

As world markets open to Canada, and as Canada pursues policy changes to increase exports further, the potential to expand LNG and oil exports raises important questions about the net impact on global greenhouse gas (GHG) emissions. While higher domestic GHG emissions would seem to logically follow more exports, the landscape for the net impact on a global scale is far more complex.

Against the backdrop of a commitment to build nation-building projects in Canada and to ensure the important debates ahead are rooted in quantitative analysis, the Canadian Chamber Future of Business Centre and the Public Policy Forum commissioned a study from Navius Research, a non-partisan consultancy, that focuses on quantitative analysis.

We asked Navius to evaluate three export categories — LNG, heavy oil (conventional and oil sands) and conventional light oil — drawing on the latest projections by 2035, and examining likely displacement scenarios in different export markets and net GHG impacts by destination and by alternatives to Canadian products.

While the question is nuanced and subject to uncertainties, on balance the evidence shows that increased Canadian LNG and oil exports are unlikely to increase global emissions and could in fact help reduce them, especially when displacing high-carbon sources like coal and other grades or blends of heavy oil.

That's why we must make the most of our environmental strengths by using our current export capabilities and unlocking new project investment; along the way, we'll also have to address policy and regulatory-driven challenges to ensure we strengthen the underlying economics driving our biggest projects.

While higher domestic GHG emissions would seem to logically follow more exports, the landscape for the net impact on a global scale is far more complex.

LNG Exports and Global Emissions

LIFE-CYCLE EMISSIONS INTENSITY VS. GLOBAL ALTERNATIVES

Canada's largest new export opportunity, with potentially the greatest impact on emissions, is liquefied natural gas. Canadian LNG from British Columbia benefits from stringent methane controls and Measurement, Monitoring, Reporting and Verification (MMRV) upstream. Early-life and high-productivity gas fields and the use of cutting-edge technologies for extraction and processing also contribute to the lower methane leakage of the gas feeding Canadian LNG facilities. A natural geological advantage is also at play: British Columbia's largest gas play (Montney) is considered remarkably high quality with low formation CO_2.[5] These advantages, along with the use of clean hydroelectric power in the liquefaction process, result in producing exceptionally low GHG emissions when considering its entire life cycle.

LNG Canada's export project, for example, is designed for an emissions intensity around 0.15 tonnes CO_2e per tonne of LNG – less than half the global average (~0.35 tCO_2e/tonne) for liquefaction facilities, due to a colder climate, strict methane controls, and other measures.[6] The proposed Cedar LNG[7] Woodfibre LNG[8] and Ksi Lisims[9] projects will have even lower emissions intensities with plans to fully electrify the liquefaction process using B.C.'s clean hydro (0.08, 0.04, and 0.02 tCO_2e/tonne, respectively). By contrast, many LNG facilities world-wide, including on the U.S. Gulf Coast and in the Middle East, rely on gas-fired compressors and have life-cycle intensities roughly 0.3–0.6 tCO_2e/tonne of LNG produced. This means Canadian LNG production emits substantially less CO_2 per unit of fuel produced.

On the consumption side, the end-use combustion of natural gas still produces CO_2, but natural gas power generation emits about 50 percent less CO_2 than coal-fired generation per unit of electricity.[10] In efficient combined-cycle gas turbines, the emissions advantage can be on the order of 50–60 percent lower GHG per MWh compared to a typical coal plant. In other words, using LNG in modern gas power plants can roughly halve the emissions relative to coal-fired power for the same electricity output.

If Canadian LNG exports displace coal for electricity generation in countries like China or India, there is a significant net GHG reduction per unit of electricity generated. Life-cycle analyses consistently show the climate benefit of LNG is maximized when it replaces coal. For example, one recent industry analysis found that U.S. LNG delivered to coal-dependent China has about 50 percent lower total life-cycle emissions than the electricity from older Chinese coal plants.[11] Canadian LNG, as we illustrate below, with its cleaner production process (due to hydro-powered liquefaction, low formation CO_2, and low methane leakage), would offer a greater advantage.

It is instructive to consider the scenario where Canadian LNG doesn't create new gas demand but rather displaces LNG from other producers. In that case, the benefit depends on differences in life-cycle carbon intensity between Canadian LNG and the alternative LNG. Here, Canada still holds an edge: B.C. LNG has a significantly lower life cycle inventory (LCI) than LNG from the U.S. and many other suppliers on a full "well-to-wire" basis (from production through combustion per unit electricity), due to advantages in upstream electrification, gas quality and transport distance.

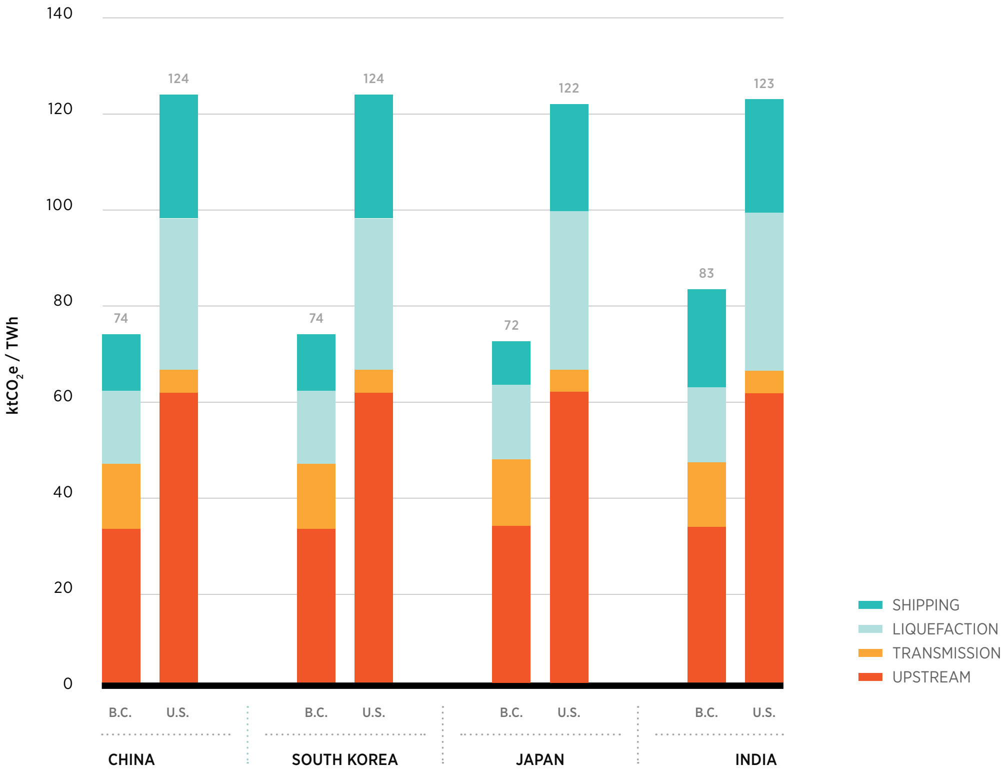
The Navius research compared life-cycle GHG intensities of power generation using Canadian LNG versus U.S. LNG across different potential export markets. In each case, LNG from B.C. had a lower LCI than U.S. LNG, with well-to-wire emissions roughly 25–50 percent lower than the equivalent U.S. LNG supply. This analysis focuses on potential fuel displacement in the electricity generation sector only (fuel displacement could also occur in other sectors, for example, using LNG for space heating and industrial processes, which is outside the scope of this study).

Using LNG in modern gas power plants can roughly halve the emissions relative to coal-fired power for the same electricity output.

FIGURE 1

Life-cycle GHG emissions; B.C. LNG versus the average U.S. LNG used in selecting destination markets for electricity generation.

Source: Navius Analysis commissioned for this report, 2025



For instance, delivering B.C. LNG to China for power generation yields an estimated 74 kt CO_2e/TWh, versus 124 kt CO_2e/TWh for U.S. LNG — about 40 percent less. Exports to other Asian destinations, including South Korea, Japan and India, follow the same pattern.

This indicates that even if Canadian LNG simply replaces other LNG (with no increase in global gas use), global GHG emissions would still fall because each unit of Canadian LNG carries fewer upstream, liquefaction and shipping emissions than the marginal competitor it displaces.

Canadian LNG has a twofold climate advantage: at the point of use, it's much cleaner than coal, and at the point of production, it's cleaner than many other sources of LNG. Realizing a net global emissions reduction, however, requires that these advantages are applied against higher-emitting sources such as coal or higher carbon intensity LNG, rather than against clean energy.

GEOGRAPHIC MARKETS AND LIKELY DISPLACEMENTS

A rigorous analysis of the potential GHG impacts from Canadian LNG exports hinges also on a key assumption about its influence on global LNG supply—specifically, the extent to which incremental Canadian production displaces other suppliers rather than augmenting total global volumes as a new supply. We have already covered one end of the spectrum, in which Canadian LNG replaces U.S. LNG and showcased its significant environmental benefits for select key Asian export markets, due to lower life-cycle emissions and shipping advantages. But to get to a more realistic scenario, S&P Global estimates that new LNG supply will increase global natural gas supply by 50%. This means half of Canadian incremental LNG production will displace existing supply, and the other half will be additive and replace other electricity generation fuels such as coal, natural gas, nuclear or renewables in the export market.[12] Navius used this estimate to narrow down the estimated global emissions impact of Canadian LNG.

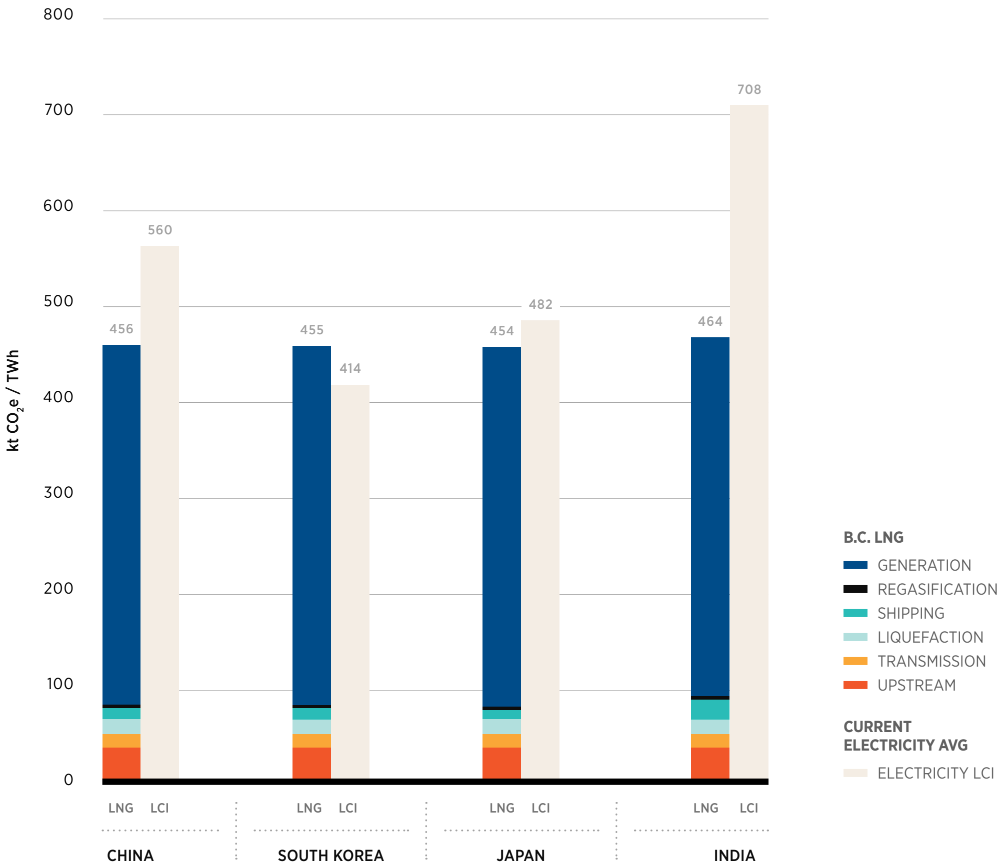
The other key factor in this analysis is the export destination. Because different global regions have very different power mixes and alternatives, the destination to which Canadian LNG is exported will affect the emissions outcome. FIGURE 2 illustrates the life-cycle emissions for B.C. LNG compared with the average life cycle inventory (LCI) of emissions for electricity generation in select importing countries.

Many Asian countries' climate pledges involve reducing coal reliance, meaning Canadian LNG could serve as a bridge to cleaner energy by accelerating coal plant retirements.

FIGURE 2

Life-cycle GHG emissions; B.C. LNG versus the average life cycle inventory (LCI) of emissions for electricity generation in various regions.

Source: Navius Analysis commissioned for this report, 2025



This data confirms that if Canadian LNG is predominantly sent to countries where it substitutes for coal-fired power, the GHG reductions per unit energy are very large — on the order of 40–60 percent fewer emissions per MWh because each unit of electricity generated from Canadian gas emits far less than the coal it displaces. In the timeframe of 2030–2050, many Asian countries' climate pledges involve reducing coal reliance, meaning Canadian LNG could serve as a bridge to cleaner energy by accelerating coal plant retirements. In South Korea, which also uses considerable LNG and some nuclear, B.C. LNG emissions are roughly on par with the current grid average, indicating a potentially smaller benefit.

In practice, global LNG supply and demand and projecting what new and existing LNG molecules will replace are extremely complex. To estimate these effects, Navius used a study by *Stanford University's Energy Modeling Forum (EMF)*, which models fuel displacement under new natural gas supply across 14 different models (i.e., what fuel Canadian LNG is most likely to displace in the export market).[13] Combining those displacement estimates with the assumption about the portion of Canadian LNG that is considered a new supply and the energy mix of the future for various potential export markets, Navius proposes a "most likely scenario," in which **Canadian LNG is estimated to *decrease* global emissions by 40-70 Mt CO_2e, depending on the export market**. This equates to 6–10% of Canada's national emissions.

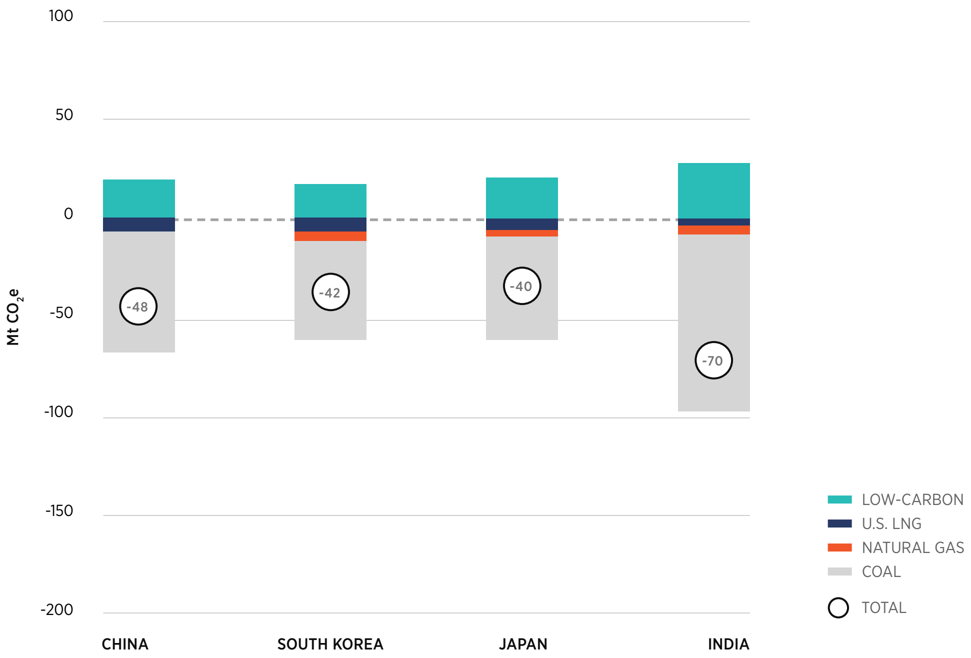
In this study, we assume Canadian LNG capacity reaches 47.6 million tonnes per annum (MTPA) or 6.26 billion cubic feet per day (Bcf/d) by 2035 — that is, if all LNG projects currently in the pipeline, including LNG Canada Phase 1 and 2, Woodfibre LNG, Cedar LNG, Ksi Lisims LNG, and Tilbury LNG Phase 2 become fully operational by 2035. Of course, given the challenges that Canada has had in executing major projects over the past decade or more, achieving these increased export volumes is far from guaranteed. As PPF's *Build Big Things* report points out, Canada needs a new policy framework based on co-ordinated financing, efficient and effective regulatory approvals, enabling critical infrastructure (like ports and electrical transmission), and increased Indigenous economic participation in order to advance these kinds of ambitious projects.[14] But if Canada is able to overcome these challenges, then significantly increased export volumes of Canadian LNG could follow.

Article 6 opens the door to potentially claim some of those overseas reductions towards this country's own climate goals.

FIGURE 3

Emissions impact of BC LNG displacing other generation fuels in various regions.

Source: Navius Analysis commissioned for this report, 2025



* Displaced fuel GHG impact is calculated as: % share of LNG assumed to replace each fuel type based on EMF and S&P Global studies (BC LNG LCI – fuel LCI). For export market LCIs, the same approach was used as for the GHG impact range calculations. Where the EMF/S&P % share of LNG replacing a specific fuel type was greater than the generation by said fuel type in an export market, greater displacement of the other fuel types was assumed.

This finding suggests it is most plausible that new Canadian projects could partially displace coal and dirtier LNG elsewhere — for example, facilities in jurisdictions without emissions regulations or that rely on coal/gas power for liquefaction. Capturing a modest portion of the market from such sources yields a global emissions decline per unit of energy. Overall, the most likely scenario is that Canadian LNG backs out coal in Asia, some high-carbon LNG from other exporters, and, in limited cases, low-carbon sources, leading to a net decline in global emissions.

As PPF's 2024 paper on LNG, How to Have It All, pointed out: "Realistically, Canada has very few chances to take a material bite out of global emissions. Switching coal (or even gas from less favourable suppliers) for Canadian LNG presents one of those opportunities. That said, proving replacement on a molecule-by-molecule basis would be challenging. However, if Canadian LNG can keep demonstrating its life cycle emission advantage...then Canadian LNG can convincingly establish itself to importing nations as a superior alternative to either coal or a higher-emission LNG."[15]

NEW OPPORTUNITY: INTERNATIONAL EMISSIONS CREDITS FOR LNG (ARTICLE 6 OF THE PARIS AGREEMENT)

An emerging aspect of the LNG discussion is whether Canada could receive internationally transferred mitigation outcomes — essentially emissions reduction credits — for the climate benefits its LNG exports enable. Article 6 of the Paris Agreement provides a framework for countries to co-operate in achieving their climate targets by trading or transferring emissions reductions.[16] In particular, Article 6.2 allows nations to make bilateral agreements to share credit for emissions cuts, as long as those cuts are real, additional and properly accounted for. For a country like Canada, whose cleaner energy exports can help other countries lower their emissions, Article 6 opens the door to potentially claim some of those overseas reductions towards this country's own climate goals.[17] Nowhere is this idea more enticing — and challenging — than in the context of Canadian LNG displacing coal abroad.

The Paris rulebook set strict criteria to ensure that any traded reductions are "additional" (beyond what would happen anyway) and that there is no double counting or leakage of emissions. Simply selling LNG on the market does not automatically qualify —

Japan had signed Article 6 agreements with 27 countries and launched more than 100 pilot projects, ranging from energy efficiency to power generation conversions.

one must prove the LNG actually caused a reduction (for example, that a coal plant closed or ran less because of the LNG), and that this reduction isn't offset by higher emissions elsewhere or under another policy.

As PPF's recent report, ***The Missing Article*** notes, "liquefied natural gas (LNG) exports from Canada, despite the relatively low carbon intensity of our gas, will be challenged to meet the criteria of additionality and "leakage avoidance" required to substantiate Article 6 credits unless they are part of more complex and comprehensive arrangements."[18] In other words, Canada cannot simply claim credit for all emissions differences between gas and coal on the assumption that displacement occurred; it needs a robust framework to verify that Canadian LNG is part of a specific, negotiated strategy to cut emissions in the importing country. The reductions must be beyond the host country's baseline pledges and must not simply free up the displaced coal to be burned elsewhere (avoidance of leakage).

The solution, as recommended by Article 6 experts, is to embed Canadian LNG within comprehensive bilateral agreements for clean energy co-operation. For example, Canada could partner with a country like Japan, South Korea or India to develop a coal-to-gas transition program. In such an arrangement, Canadian LNG exports could be explicitly tied to the shutdown or conversion of specific coal-fired plants, with both countries agreeing on how to measure the resulting emissions reductions.

It is certainly possible for Canada to do so. In fact, Japan — an OECD nation with a net-zero pledge, significant coal use and an interest in hydrogen and gas as transitional fuels — has already pioneered such bilateral crediting mechanisms. Japan's Joint Crediting Mechanism (JCM), in place since before the Paris Agreement, finances low-carbon technology projects in partner countries, often including fuel-switching or renewable projects. In return, Japan receives a share of the verified emissions reductions as credits. As of 2023, Japan had signed Article 6 agreements with 27 countries and launched more than 100 pilot projects, ranging from energy efficiency to power generation conversions

For its part, Canada could negotiate an agreement where Japan would import a certain volume of Canadian LNG explicitly to replace generation from specific coal units. Canada would essentially "share" the climate benefit: Japan might count part of the reduction towards its own targets, and Canada would take credit for the rest.

This could be facilitated by Japan's existing JCM infrastructure. Similarly, South Korea, which has a coal phase-down underway and has already signed a few Article 6 memorandums of understanding, could partner with Canada on a coal-to-gas crediting scheme.

India is another critical case. While not a traditional carbon credit buyer, it has massive coal consumption and rising energy demand; it is seeking affordable ways to transition its power sector. A trilateral or bilateral approach could be envisioned: for instance, Japan and Canada together could help India add gas capacity and retire coal plants, with Japan and Canada splitting the resulting credits.

Implementing such arrangements will require Canada to establish the right policy frameworks, agreements and verification protocols. As was argued in *The Missing Article*, the federal government:

- Should negotiate Article 6.2 bilateral agreements with target countries that formalize co-operation on reducing coal emissions;
- Must co-ordinate with existing crediting mechanisms, such as Japan's;
- Must work with Canadian energy exporters and developers to pinpoint countries or regions where Canadian LNG and expertise can make the biggest dent in coal use; and
- Should set up ongoing measurement, reporting and verification protocols to track the emissions from the host country's power sector and the specific impacts of the LNG exports.

The end result would be a win-win: host countries get cleaner energy and support in their energy transition, while Canada gets recognized credit for its contribution to global mitigation. Domestically, this can help Canada close the gap to its 2030 and 2050 targets.

By following these steps, Canada could effectively import emissions reductions while exporting its LNG. But it is important that while pursuing these opportunities that Canada not make the perfect the enemy of the good. If there are willing partners for bilateral agreements in Japan, Korea or India, Canada should make these deals as an added incentive to LNG exports, but Canada should not make reaching these agreements a precondition to substantially increasing its LNG exports to Asia. Nor should Canada wait for international progress on Article 6 architecture before signing bilateral deals with jurisdictions that are willing to do so.

Heavy Oil Exports and Global Emissions

LIFE-CYCLE EMISSIONS INTENSITY VS. GLOBAL ALTERNATIVES

Heavy oil from Canada's oil sands (bitumen) has historically been more GHG-intensive to produce than most other crudes, but ongoing improvements are significantly narrowing that gap. Canadian oil sands' emissions intensity fell by about 28 percent between 2009 and 2023.[19] Current average oil sands emissions are around 57 kg CO_2e/bbl[20], but that is still several times higher than the estimated 18–30 kg CO_2e/bbl for conventional crude oil production globally. The higher intensity stems from the nature of bitumen: it is a heavy, viscous oil requiring energy-intensive methods, such as steam injection in in-situ operations or fuel for large trucks and shovels in mining and often needs upgrading (processing to a lighter synthetic crude) before it can be sent to refineries.

Combustion of the refined fuels from any crude will emit ~400 kg CO_2e/bbl in end use, so the ~50 kg difference in upstream emissions between heavy oil sands and lighter oil represents on the order of a 10 percent difference in full life-cycle emissions.

Importantly, oil sands crude is typically in the heavy oil category, and it is most fair to compare it against other heavy crudes globally rather than against light sweet oils. Many alternative heavy oils — such as Venezuela's Orinoco Belt extra-heavy crude, Mexico's Maya, or some Middle Eastern heavy grades — have very high emissions profiles themselves. For example, Venezuela's upstream emissions are estimated at around 96 to 129 kg CO_2e per barrel. This is due to practices like excessive flaring (burning of the natural gas associated with oil extraction) and venting of associated gas, and energy-intensive extraction (Venezuela's heavy oil, like Canada's, often requires heating or diluents). Mexican heavy crude and some Gulf of Mexico or California heavy oils are also on the higher end of the spectrum, though generally not as high as Venezuela's.

While an oil sands barrel historically came with a significantly larger carbon footprint than a typical lighter crude, new technologies are quickly closing the gap. The emission intensity of Canadian heavy oil (heavy oil sands and conventional heavy) has improved by about 30 percent since 2005 to about 78 kg CO_2e/bbl, comparable to (or cleaner than) several global heavy grades. Aggressive mitigation measures such as carbon capture and solvents (see APPENDIX TWO) mean oil sands emissions could approach parity with, or even drop below, emissions of other heavy crudes by 2040–2050.

Today, producing a barrel from the oil sands does emit more GHGs than the production of most lighter oils, but it is in the same range or better than some of the world's other heavy oils. The key question for global emissions impact is: What type of oil would Canadian oil sands displace on the world market? If the answer is very high-carbon oil, such as Venezuelan crude, there would be a net emissions advantage. Understanding Canada's competitive niche — heavy oil — is important in this evaluation.

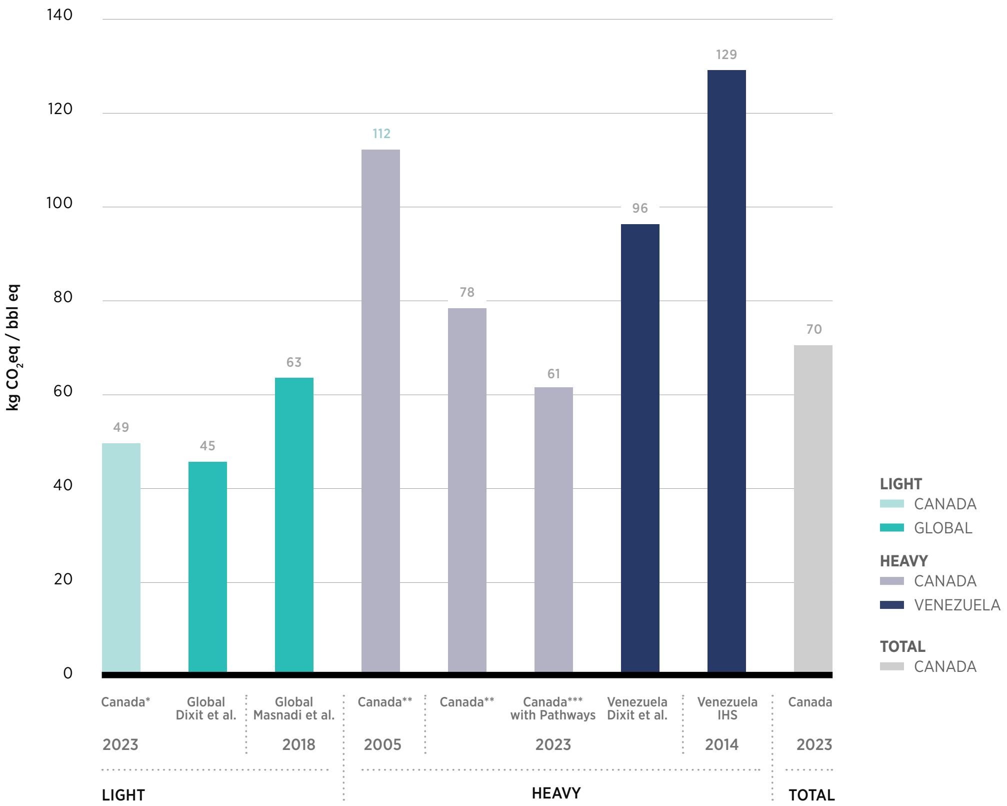
While an oil sands barrel historically came with a significantly larger carbon footprint than a typical lighter crude, new technologies are quickly closing the gap.

Canada's heavy oil is moving from being an outlier in carbon intensity to potentially being among the cleaner heavy crudes globally by mid-century.

FIGURE 4

Comparison of Canadian to international light and heavy oil LCI with historic figures, as well as alternatives.

Source: Navius Analysis commissioned for this report, 2025



* Including frontier oil emissions and pentanes plus and condensates production

** Includes conventional heavy oil and oil sands and emissions from upgrading

*** Expected future Pathways Alliance CCS GHG reductions deducted from 2023 GHGs divided by 2023 production levels

Recent life-cycle comparisons provide more insight. The Navius study calculated Canadian oil production upstream LCIs and compared them to international data as well as its own LCI in 2005. It found that Canadian light oil (mostly conventional oil) has a slightly higher upstream LCI than the global average in one estimate and somewhat lower in another.[21] In contrast, Canadian heavy oil (including conventional heavy and heavy oil sands) has a lower upstream LCI than Venezuelan heavy oil — on the order of 18 - 51 kg CO_2e/bbl compared to Venezuelan crude.

In other words, a Canadian heavy barrel might be ~18 to 51 kg CO_2e/bbl cleaner than the Venezuelan benchmark heavy barrel. This confirms that if Canada's export growth remains primarily in heavy crude, as is currently the case, and those exports displace the dirtiest heavy oils, like Venezuela's, which happens to be the main competitor for Canadian heavy, there would be a clear GHG benefit per barrel.

Crucially, the trajectory of improvements in Canada suggests its heavy oil will get cleaner still. The oil sands industry has committed to net-zero emissions for oil sands operations by 2050, with an interim target to implement major emissions reductions by 2030. If the industry's planned carbon capture and storage (CCS) projects and other technologies proceed, Navius's analysis indicates an additional 17 kg CO_2e/bbl reduction could be achieved. This could bring the carbon intensity of Canadian heavy barrel down to 61 kg CO_2e — potentially on par with the current global average for all oils.

Canada's heavy oil is moving from being an outlier in carbon intensity to potentially being among the cleaner heavy crudes globally by mid-century. Whether Canadian oil exports raise or lower global emissions will depend on what they replace — and how quickly Canadian producers can lower their own emissions.

A barrel of Canadian oil is very likely taking the market share of a higher-carbon barrel, rather than increasing total barrels burned.

LIKELY MARKETS AND DISPLACEMENT OF OTHER HEAVY CRUDES

Canadian heavy oil sands exports primarily go to refineries that process heavy crude — historically, this has largely meant the U.S. Midwest and Gulf Coast refineries via pipeline. In future, with new pipeline capacity to the West Coast, Canadian heavy oil may also reach Asian markets by tanker. Many refineries are configured specifically to run heavy, sour crudes (with upgrading units like cokers and desulfurization). If these refineries don't get Canadian bitumen, they will procure similar grades from elsewhere. So, as Canada increases exports of heavy oil, and particularly, oil sands bitumen (for example, via the expanded Trans Mountain Pipeline to the Pacific), those barrels can replace imports from other heavy oil producers.

The key point is that Canadian heavy is competing in the heavy oil segment of the global market. Global demand for heavy crude, used for producing diesel, marine bunker fuel, asphalt, etc., remains significant, and many complex refineries need heavy feedstock. Canada's heavy oil, especially as it becomes cleaner, could out-compete those high-carbon sources in a world that increasingly values lower emissions. Venezuela's heavy oil, which, as noted, has extremely high emissions due to flaring and inefficient operations, is a prime displacement target. The Navius study estimates that if Canadian oil sands displace Venezuelan heavy crude, upstream GHG emissions are reduced by 18 - 51 kg CO_2e/bbl, depending on which estimate for Venezuelan heavy's carbon intensity is used. If industry were to implement the Pathways Alliance Trunkline, a proposed CO_2 transportation network pipeline, the improvement would increase to 35 - 61 kg CO_2e/bbl. Other displacement targets include: Mexican Maya crude, another heavy oil with moderately high upstream emissions; Middle Eastern heavy grades like Iraq's Basrah Heavy; and certain heavy oils produced in California, which can be surprisingly carbon-intensive due to heavy steam flooding and venting in some Californian fields.

If, however, Canadian oil sands simply add to the global oil supply without displacing other sources, or if they compete against and displace a lower-carbon crude, then global emissions could increase. For instance, if Canadian heavy, produced at about 78 kg CO_2e/bbl of emissions, somehow displaced Saudi light crude, one of the lowest-GHG oils at 4–10 kg CO_2e/bbl, in a refinery diet, that would be a negative outcome for emissions. But this scenario is almost theoretically impossible — refineries that need heavy oil cannot simply substitute Saudi light in large volumes, and Saudi light is in demand for refineries configured for lighter slates. In general, heavy oil competes with heavy oil. If global climate policies put a cost on carbon intensity, Canadian heavy oil, with progressively lower emissions, could become the preferred source for heavy oil, forcing dirtier producers either to clean up or reduce output. In such a future, Canadian oil sands growth does not increase net emissions; it actually helps lower the global average emissions per barrel by crowding out the dirtiest sources.

It's worth noting uncertainties: this outcome depends on both the successful implementation of mitigation technologies in Canada (see Appendix Two) and the assumption about displacement. Critics argue that more oil supply anywhere could depress prices and marginally increase global consumption, called the "rebound" or demand effect. However, most climate-energy models project that under climate policies consistent with Paris goals, high-emissions oil will be squeezed out first. So, a barrel of Canadian oil is very likely taking the market share of a higher-carbon barrel, rather than increasing total barrels burned.

Canadian Conventional Light Oil Exports and Global Emissions

Not all Canadian oil is heavy oil sands or conventional heavy oil. A significant portion is conventional light oil and condensates, including light crude from Western Canadian sedimentary basins (e.g. the Bakken/Cardium plays), medium crude from Saskatchewan and offshore oil from Atlantic Canada, particularly Newfoundland and Labrador.

These conventional sources generally have lower upstream emissions intensity per barrel than heavy oil sands, simply because they involve less energy-intensive extraction. For instance, a light tight oil well might have an upstream emissions intensity of 20–40 kg CO_2e/bbl — mostly from drilling, pumping and processing — and Atlantic offshore barrels can be in a similar or slightly higher range, somewhere around 40 kg/bbl if not electrified.

The global average upstream intensity for light oil is estimated at around 50 kg/bbl (with large variation, including 45 and 63 kg CO_2e/bbl estimates provided above), so the production of Canadian light oil creates emissions roughly in line with that — not dramatically better, but typically not worse, either. Canada's conventional crude is around that ballpark as well, with light oils a bit below and heavier conventional or offshore a bit above.

This means that per barrel, Canadian conventional oil doesn't provide as large a GHG difference as LNG or oil sands heavy might, when compared to foreign counterparts.

The scale of Canada's conventional oil exports is also more limited. Conventional oil production in Western Canada has been relatively flat or declining in recent years, with most growth occurring in the oil sands. Aside from offshore projects, the potential for major expansion in conventional production is not as high. Newfoundland's proposed Bay du Nord project, a deepwater offshore development, might add ~200,000–300,000 bbl/day in the 2030s if it proceeds. Onshore, any growth might come from tight oil if prices incentivize drilling, but it's likely to be moderate. All of this means that the global emissions impact of Canadian conventional light oil exports is smaller than that of LNG or oil sands.

The fundamental reason the conventional segment shows little risk of increasing emissions is that few competitors are significantly "cleaner" than Canadian producers. One could argue that Norway or certain U.S. fields have slightly lower emissions due to electrification or geology, but on average, Canadian conventional light oil is already in the lower range. Meanwhile, some competitors might have higher intensities, including certain African or Middle Eastern fields with flaring and Russian fields with pipeline leaks. Canada is continuing to reduce its already low levels of methane leakage, which will make its conventional oil among the world's lowest upstream emitters by the 2030s.

Recommendations

A national game plan is needed to leverage Canada's oil and gas advantages to drive global emissions reductions, spur economic growth and align public and private sectors to execute nation-building projects more quickly.

» **Establish an energy export gameplan** to seize opportunities in displacing high-emission fuels, such as transitioning coal-dependent markets to Canadian LNG. Prioritizing international collaboration, particularly with Indo-Pacific partners, should become a cornerstone of Canada's foreign policy to facilitate their pivot from coal to cleaner LNG, thereby advancing shared climate goals. To this end, federal and provincial governments, alongside industry stakeholders, must align on export expansion priorities, targeting regions where Canadian natural gas, heavy oil, and light oil supplant dirtier substitutes like Asian coal or Venezuelan crude, while expediting infrastructure to drive economic prosperity. This emissions-reduction potential is most pronounced for LNG, underscoring the need to leverage product-level carbon competitiveness by advocating for harmonized carbon accounting and production-based intensity standards that favour low-emission producers in evolving import regimes.

Yet, pragmatism is paramount: Canada should not predicate export growth on bilateral agreements or await mature global frameworks under the Paris Agreement, lest it cede vital economic, strategic and environmental benefits to itself, its allies, and the broader fight against climate change.

» **Embrace and operationalize Article 6 mechanisms** to formalize and incentivize beneficial exports. The government should urgently develop a framework for negotiating Article 6 agreements, starting with a pilot in Japan, given its interest and existing partnership vehicles like the Joint Crediting Mechanism. This will position Canada to gain credit for emissions reductions achieved beyond its borders through bilateral or multilateral Paris Agreement Article 6.2 agreements with countries most conducive to coal-to-gas transitions and credit-sharing arrangements.

» **Advance emissions reduction efforts** to maintain and enhance the emissions intensity advantage of Canadian oil and gas exports. Continue improving Canada's performance in reducing methane emissions from conventional oil and gas production. Supplement these efforts by offering targeted incentives for CCS projects, including scaling up major CCS infrastructure (e.g., ensuring the Pathways Alliance Trunkline is economically viable and built), supporting solvent-assisted SAGD commercialization with pilot grants or tax credits, and investing in small modular reactor (SMR) research for industrial heat. These initiatives will reinforce Canada's emissions advantages, establishing its products as preferred choices for nations seeking to lower their GHG footprints.

Conclusion

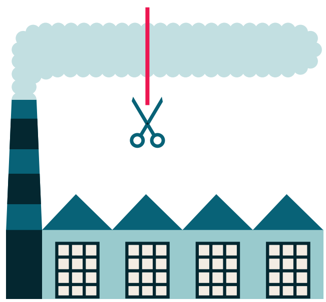
While uncertainties and legitimate concerns remain, this analysis strongly indicates that Canadian LNG and oil exports, accompanied by high environmental standards, are unlikely to increase global GHG emissions and can actually support global emissions reductions.

This conclusion runs somewhat counter to the simplistic narrative that "more oil and gas equals more emissions." The reality, as demonstrated, is more nuanced; it matters *which* oil and gas, and *what* they replace.

Canadian LNG, with its world-leading low life-cycle carbon intensity and delivered to coal-dependent countries, emerges as a clear climate win: it can cut emissions roughly in half per unit of electricity compared to coal, potentially helping to accelerate coal phase-out in Asia and avoiding hundreds of megatonnes of CO_2 annually by mid-century.

Canadian oil sands heavy crude, historically viewed as a high-carbon source, is rapidly cleaning up its operations and, in a scenario where it substitutes for the world's dirtiest heavy oils, can also yield a net reduction in emissions per barrel.

Even Canada's conventional oil, while a smaller player in growth terms, is produced with rigour on methane and flaring so that it generally outperforms crude from many other basins.



By continuing to control domestic emissions and engaging in international climate co-operation, Canada can expand its role as an energy exporter while aligning with global climate objectives.

Climate change is ultimately indifferent to where emissions occur; a tonne of CO_2 avoided in Asia by using Canadian LNG has the same benefit as a tonne avoided in Canada. By pursuing agreements to formally credit Canada for emissions reductions enabled by its exports, Canada can bolster the case for continued responsible production while keeping within the spirit of global climate commitments.

Fossil fuels, including LNG, oil sands and conventional oil, will continue to be part of the world's energy system in the near- to mid-term. As long as that remains true, sourcing those fuels from cleaner suppliers is not only a valid mitigation strategy, our data demonstrates it's also good for the planet.

By continuing to control domestic emissions and engaging in international climate co-operation, Canada can expand its role as an energy exporter while aligning with global climate objectives.

APPENDIX **ONE**

EMISSIONS REDUCTION TECHNOLOGIES FOR LNG

Although natural gas is much cleaner than coal at the point of combustion, the full life-cycle emissions of LNG can be further improved through technology and best practices. Canada has been proactive in this area, implementing measures to ensure that exported LNG is produced and delivered with a minimal GHG footprint.

Key mitigation technologies and practices include:

- **Electrification of liquefaction:** Liquefying natural gas (cooling it to LNG) is energy-intensive. Many LNG terminals worldwide burn a portion of the gas to fuel compressors, but projects in B.C. plan to use hydroelectric grid power for liquefaction, drastically cutting emissions at this stage. For example, LNG Canada's design uses electric motors powered by clean electricity for auxiliary power, targeting only about 0.15 tCO_2e/tonne LNG for the liquefaction process, while other proposed and other construction projects (Cedar, Woodfibre, and Ksi Lisims) will be fully electrified, compared to ~0.3–0.6 tCO_2e/tonne at a typical LNG plant that uses solely gas turbines with looser methane controls and warmer climates.
The planned Woodfibre LNG, Cedar LNG and Ksi Lisims LNG projects have even lower projected emissions intensities. These emissions savings come at a relatively modest cost since B.C.'s hydro power is abundant and affordable. In practice, hydro-electrifying LNG plants is one of the most cost-effective decarbonization steps.
- **Waste heat recovery and energy efficiency:** For LNG facilities that do use some gas-driven equipment (such as backup generators or older plants without full electrification), capturing waste heat and optimizing energy use can further trim emissions. Measures like using waste heat from gas turbines to drive other processes or improving insulation and process efficiency typically pay for themselves through fuel savings.
- **Methane leak detection and repair:** As noted, minimizing methane leakage is vital for LNG's climate advantage. Canada's upstream gas sector employs robust leak detection and repair programs, as mandated by federal and provincial regulations. By continuously monitoring and promptly fixing leaks in wells, pipelines and processing facilities, methane emissions are kept very low. Studies show that a large fraction of methane leaks can be eliminated at no net cost (the lost gas that is captured can be sold),

and most remaining fixes are low-cost (on the order of <$20/tonne CO_2e). Canada's regulations (and industry practices) have already achieved major methane reductions. For instance, B.C. producers cut methane by ~51 percent from 2014–2022, with additional reductions projected by 2030. Emerging technologies (like satellite monitoring and continuous sensors) are further improving leak detection. Keeping methane emissions near zero is critical to maximize LNG's advantage over coal, and of Canadian LNG over other basins, and Canada is essentially making this a reality through regulation and technology.

- **Use of clean power and fuel in upstream operations:** In addition to electrifying LNG terminals, efforts are underway to electrify parts of the upstream gas production (e.g. electric compressors on pipelines, using grid power for gas processing plants). Many gas processing facilities in B.C. have tie-ins to the BC Hydro grid, reducing or eliminating on-site combustion emissions. A cold climate is another natural advantage — less energy is needed for refrigeration when the ambient temperature is low, which slightly lowers LNG plant energy use. Together, these factors contribute to Canada's LNG having an unusually small emissions profile from wellhead to port.
- **Carbon capture and storage (CCS):** Applying CCS at LNG facilities is another tool to reduce emissions, though generally as a supplement to electrification. It is, of course, possible for CCS to be implemented at natural-gas-fired power plants, which would reduce the end-use emissions intensity of natural gas, but there are also proposals from large Canadian producers such as Tourmaline, ARC Resources and Petronas to capture carbon from distributed sources in upstream natural gas production and sequester it underground.

In combination, these technologies and practices mean Canadian LNG can be produced with a remarkably low GHG footprint. Powering LNG operations with clean electricity and minimizing methane leaks are largely already in place in Canada, making its LNG among the "cleanest" in the world.

APPENDIX **TWO**

EMISSIONS MITIGATION TECHNOLOGIES FOR OIL SANDS

To achieve the scenario where oil sands barrels become much cleaner, a suite of technological pathways is being pursued.

Key mitigation technologies for oil sands include:

- **Carbon capture and storage (CCS)**: CCS is critical for deep emissions cuts in oil sands upgrading and extraction. It involves capturing CO_2 from large point sources (like hydrogen production units at upgraders, natural gas-fired steam generators in SAGD facilities or refinery processes) and permanently sequestering it underground. Canada has early successes to build on: Shell's Quest project in Alberta has been operating since 2015, capturing about one Mt CO_2 per year from an upgrader's hydrogen unit. Building on this, the Pathways Alliance is proposing a massive CCS trunkline and storage hub in Alberta's oil sands region by 2030 that would collect CO_2 from multiple facilities and inject it into deep geological formations. With widespread CCS, an oil sands facility could cut 60–90 percent of its process emissions (depending on how much of the operation's emissions are captured). For example, capturing CO_2 from boilers, upgraders, and other high-concentration streams could remove the majority of the 73 kg/bbl emissions. CCS does add cost (currently quite high), but Canada is incentivizing it via carbon pricing and an investment tax credit. The impact of CCS, if implemented, is to directly and significantly lower the life-cycle emissions per barrel, making oil sands much more competitive in a carbon-constrained world.
- **Electrification and fuel switching:** Oil sands operations consume a lot of energy, particularly heat for producing steam in in-situ projects (SAGD – steam assisted gravity drainage) and electricity for mining operations (for shovels, trucks and upgrading). By switching these energy inputs from fossil fuels to low-carbon sources, emissions can be slashed. One bold proposal is to use SMRs — advanced

nuclear reactors — to produce steam and electricity for oil sands sites. Studies indicate an SMR could reliably supply the steam needed for SAGD with near-zero emissions, virtually eliminating the combustion emissions from those operations. Short of nuclear, there are near-term electrification options. Already, some mining operations use electric conveyors and are piloting electric haul trucks. Fuel-switching to hydrogen (produced from natural gas with CCS or from electrolysis) is another idea for providing heat with lower emissions. In summary, shifting the source of energy for oil sands extraction and processing from fossil fuel combustion to non-emitting sources (nuclear, renewables or grid electricity with CCS) is a major decarbonization lever. It could eliminate a large portion of the ~73 kg/bbl that comes from burning natural gas for steam and power.

- **Solvent-assisted extraction:** A game-changing innovation for in-situ oil sands, SAGD is the use of light hydrocarbon solvents (such as propane, butane or natural gasoline) either in combination with steam or in place of some steam. These techniques dramatically reduce the steam-to-oil ratio needed to recover bitumen. If less steam is needed, less natural gas is burned, hence fewer emissions. Pilot projects by companies like Cenovus Energy, Imperial Oil and Suncor Energy have shown very promising results. According to the Canadian Energy Research Institute, using solvents could reduce GHG emissions by 34–40 percent for a given SAGD operation, while also lowering operating costs because fuel use drops so much.[22] In fact, these solvent methods can improve production (solvents can help "swell" the bitumen and coax it out more efficiently) and reduce water handling costs. For example, a 40 percent emissions cut would take a 70 kg/bbl operation down to ~42 kg/bbl — a substantial improvement. If solvent-assisted processes become standard, the oil sands in-situ sector's emissions could plummet, and because the process saves fuel, the abatement cost is effectively below $0/tonne (meaning it's profitable). This is a prime example of an innovation that aligns environmental and economic incentives.

In combination, the technologies above could potentially cut oil sands extraction emissions by well over 50 percent by 2050 (and nearer to 100 percent with full implementation of net-zero solutions). This would enable a barrel of oil sands crude in 2050 to be a low-carbon barrel by today's standards. Canada's industry appears to be heeding this call, investing heavily in these solutions (the Pathways Alliance companies plan to spend tens of billions of dollars on CCS and other tech by the 2030s). If successful, Canada could transform its oil sands from being seen as a high-carbon source to being a model for low-carbon oil production.

APPENDIX **THREE**

EMISSIONS MITIGATION TECHNOLOGIES FOR CONVENTIONAL OIL

The conventional oil sector is adopting mitigation measures that include:

- **Methane leak detection and repair (LDAR):** This is arguably the biggest lever for conventional operations because many conventional oil wells have associated gas and various equipment that could leak methane. Canada's regulations now require frequent LDAR checks, which has helped Canada to achieve a 45% reduction in methane intensity from 2012 levels. Companies are using advanced tools like infrared cameras, drones and satellites to find and fix leaks. As mentioned, a huge portion of methane emissions can be fixed at zero or negative cost, so it's economically sensible. The more we drive methane leakage to zero, the more confident we are that a Canadian barrel's footprint is fully minimized.
- **Electrification of equipment:** On shore, this means connecting pumpjacks, compressors and processing facilities to the electrical grid where possible, instead of using gas engines or diesel generators. As grids get cleaner (and Canada's grid is mostly clean or getting cleaner), this directly cuts emissions. For example, using a grid-powered electric submersible pump in an oil well instead of a gas-powered pump eliminates combustion emissions at that site. In remote areas, even solar panels with batteries can run small pumps, an option some companies deploy. For offshore platforms, which currently generate electricity by burning gas or diesel on site, a big opportunity is to power them from shore via submarine cable.

- **Improved flaring practices:** Canada already has low flaring intensity by international standards, but the goal is to get to zero routine flaring (the burning of the natural gas associated with oil extraction). That means any associated gas produced with oil should be captured and either used (for power, re-injected or sent to market) or not produced in the first place. Alberta and Saskatchewan have gas conservation rules that have made flaring relatively rare except for safety situations. By 2030, essentially no routine flaring should occur in Canadian onshore operations. Ending flaring is one of the cheapest emissions cuts (because you can often monetize the gas), and Canada has shown it can be done at scale.
- **Carbon capture for processing facilities:** In conventional oil, there are not as many large point sources as there are in oil sands, but there are some — like gas processing plants that strip out CO_2 or centralized facilities. Those can implement CCS in some cases. However, most conventional oil production emits CO_2 in diffuse ways (small engines, etc.), which are harder to capture. So, CCS will likely play a minor role here relative to the above measures.

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