

Survival of the Cleanest

Assessing the cost and carbon competitiveness of Canada's oil

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These acknowledgements are some of the beginning steps on a journey of several generations. We share them in the spirit of truth, justice, reconciliation, and to contribute to a more equitable and inclusive future for all of society.

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Executive summary

The future of Canada's oil industry over the medium to long term depends on its ability to compete for markets and investment capital against global producers.

Higher production costs have always been a challenge for Alberta's oilsands producers, which dominate the Canadian sector. However, in the past, enough investors have been willing to bet on rising global demand as well as OPEC's determination to maintain price discipline and companies' ability to control — and even reduce — their operating costs.

Canadian oil production has grown to more than 5 million barrels per day in 2022 from 3.7 million barrels per day in 2012. However, the future looks decidedly less rosy.

The growing climate crisis is forcing governments and investors to re-evaluate the world's reliance on greenhouse gas (GHG)-emitting oil. As investment in producing more oil slows, competition in crude markets will get a whole lot tougher, especially for higher-cost oilsands producers. Canada's oil is on average almost US\$9 more costly to produce than the global average.

In addition to being high-cost, the oilsands also rank among the most carbon-intensive production in the world. Carbon competitiveness will increasingly matter as governments and corporations pursue a net-zero future.

At the same time, many credible organizations, including the International Energy Agency (IEA), show global demand for crude will begin to decline this decade. The pace of that decline depends on how urgently the world can act to avert the most devastating impacts of climate change.

A more rapid transition will quickly erode the market for crude oil. Betting on a slower transition effectively means basing decisions on a future scenario in which the world fails to mitigate climate change.

However, all IEA scenarios show that if the current pace of clean technology improvement and climate action continues, oil demand will start declining before the end of this decade, leading to a turbulent but declining trend in oil prices. In both of the net-zero scenarios in the Canada Energy Regulator's (CER) most recent *Energy Future* analysis, oil demand peaks and begins to decline by 2030; and even in the CER's least ambitious business-as-usual scenario, demand for Canadian oil plateaus by 2035.

Some of Canada's oil assets are more competitive than others. But to put it bluntly, we face a future in which high-cost, carbon-intensive Canadian crude producers will be competing with lower-cost, less-carbon-intensive suppliers in a shrinking global market.

The industry has worked hard over the past decade to reduce costs, particularly after the deep price slump experienced in 2016. However, global competitors did the same and many Canadian producers are not on track to compete with their global peers.

Significant emissions reductions are still available to all producers globally. Some of Canada's oil assets are worth futureproofing — namely, those that can compete globally on both cost and carbon in a world of declining demand for oil. But some of Canada's oilsands are at a disadvantage due to higher carbon intensity and more expensive emission reduction costs compared to conventional assets.

Given the prospect of higher costs and growing concerns about climate change, decision-makers will have to respond.

- ! An emissions cap on the Canadian oil industry is necessary to spur investment in oil that has a lower emissions intensity and lower costs and can therefore compete favourably in global markets.
- ! Government incentives such as the federal CCUS investment tax credit are key policies to kick-start investment in large, capital-intensive solutions like CCUS, but care should be taken not to over-incentivize these projects beyond this limited tax credit.
- ! Investors will also need to account more strategically for carbon competitiveness in assessing the risk of current investments and evaluating future investments. The work of the Sustainable Finance Action Council will help with this, as will a government-backed Climate Investment Taxonomy to help guide investors with practical advice.
- ! Finally, the Alberta government must prepare for a world in which the value of its oil reserves is greatly diminished. The Alberta government must implement policies that will reduce emissions and prepare oilsands assets to survive in a world of declining oil demand. Implementing strong methane regulations that achieve a 75% reduction in oil and gas methane by 2030, and reducing the legislated oilsands emissions limit — both included in the province's emissions reduction and energy development plan — can complement key federal policies like the federal oil and gas emissions cap to incentivize investment in decarbonization.

1.! A new era for energy

Energy markets, including oil, have experienced extreme volatility in the past few years. The world saw the largest decline in demand for crude oil and refined products in history due to the COVID-19 pandemic, followed by a spike in oil prices exceeding \$100/barrel (bbl) in 2022 following the invasion of Ukraine.

For the first time in history, a range of mainstream scenarios project that global demand for oil will peak before 2030 and decline steadily afterwards. This is driven by the combined effect of more ambitious climate policies, and the large-scale market adoption of low-carbon technologies such as electric vehicles.¹ The International Energy Agency, the Canada Energy Regulator (CER) and several oil majors have published scenarios that broadly agree on this. With demand decline on the horizon, the overall value of oil assets will decline and the oil market will become more competitive. The question is how fast this decline will happen.

This paradigm shift in energy markets will have a significant impact on oil-producing companies and jurisdictions. This impact will vary with the dependence of a given economy on oil resources and the cost-competitiveness of those resources. In Alberta, about a quarter of the province's GDP comes from oil and gas production. Much of that production — 85% of Canada's oil over the last decade — was exported to the U.S.² As the U.S. accelerates efforts to decarbonize, domestic oil consumption will decline, which could reduce U.S. reliance on imports from Canada. The Canada Energy Regulator has modelled the impacts of domestic and global climate action on Canada's oil production under three different scenarios, including under current measures and if Canada, or the world achieves net zero emissions by 2050 (Figure 1).

¹ Janetta McKenzie, *The Future of Oil in the Energy Transition* (Pembina Institute, 2022).
<https://www.pembina.org/pub/future-oil-energy-transition>

² Based on mean monthly data between 2016-2022. Statistics Canada, "Table 25-10-0063-01: Supply and Disposition of Crude Oil and Equivalent."
<https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510006301>

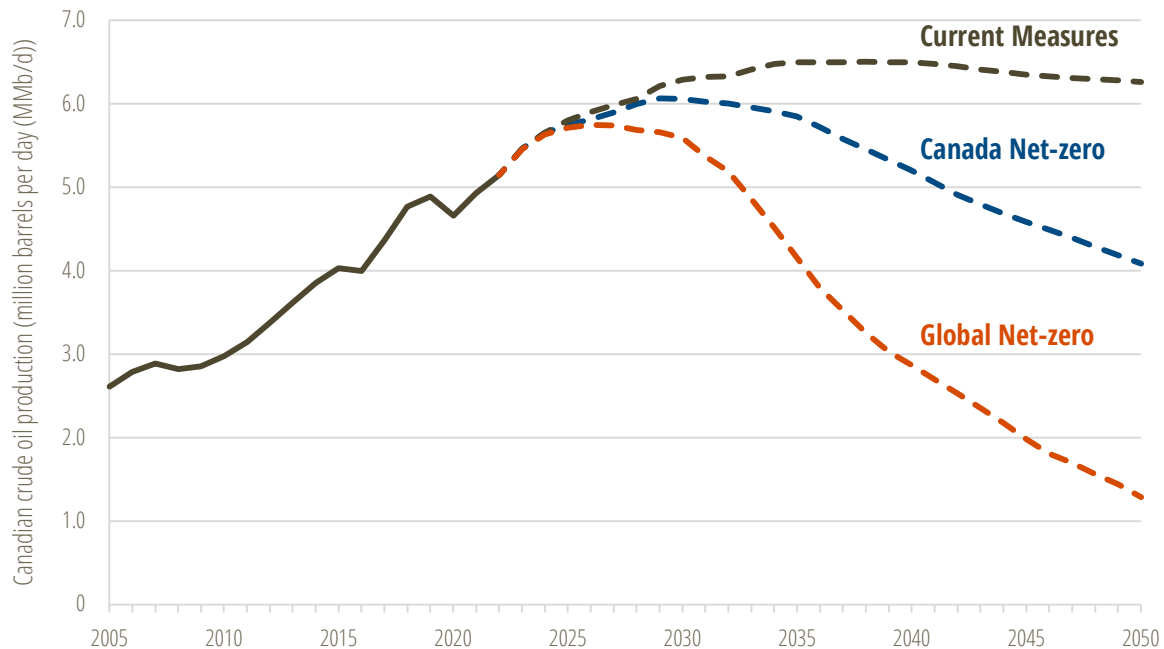


Figure 1. Canadian crude oil production under different scenarios³

Data source: Canada Energy Regulator⁴

Investors are increasingly becoming aware of transition risks, including the risk of stranded assets (that is, assets that become liabilities before they reach the end of their economic life), and are making decisions based on these risks. Producers of existing oil assets will have to consider not only the price and cost challenges, but the long-term climate change risks, which would manifest in both carbon abatement costs and demand declines. An indicator this has started is that despite record profits in the Canadian oil and gas sector in recent years, the rate of reinvestment back into the sector remains well below pre-2017 levels.⁵ This indicates investors would generally rather take profits while they can, rather than develop new oil projects.⁶

³ Economic models often estimate the future production amount that will meet expected demand, so it is common to refer to production and demand interchangeably.

⁴ Canada Energy Regulator, *Canada's Energy Future 2023*, Figure ES.8. <https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2023/index.html>

⁵ Data on this trend is available at ARC Energy Research Institute, *ARC Energy Charts*, August 28, 2023. <https://www.arcenergyinstitute.com/wp-content/uploads/230828-Energy-Charts.pdf>

⁶ A discussion of oil and gas investor expectations can be found at ARC Energy Ideas, "Bullish on Oil: An Interview with Eric Nuttall," podcast, June 13, 2023. <https://www.arcenergyinstitute.com/bullish-on-oil-an-interview-with-eric-nuttall/>

In this report we examine the Canadian oil industry's competitiveness against global crudes based on two key metrics: cost and carbon intensity.⁷ This comparison is done by matching oil cost data from Rystad Energy (where forward breakeven price is the metric for cost) with carbon intensity data from academic studies at the country level. We do the same comparison within Canada with a more detailed breakdown of major domestic oil fields. We explore the implications on Canadian oil producers in the context of oil demand decline. We end with recommendations on how both oil producing companies and governments can prepare for this not-too-distant future.

⁷ We use carbon intensity, greenhouse gas intensity, and emissions intensity interchangeably to mean emissions associated with exploration, development and production, and transportation of crude oil, but excluding refinery emissions.

2.1 Canada's oil is high-cost and high-carbon

As oil demand declines and the shift to lowest-carbon products continues, producers will compete on both cost and carbon intensity. Oil producers with assets that are currently at the lower cost and lower emissions intensity range have a competitive advantage.

Figure 2 shows the average greenhouse gas emissions intensity and cost (represented by forward breakeven price) for the top 15 producing countries, representing over 70% of global crude oil production.

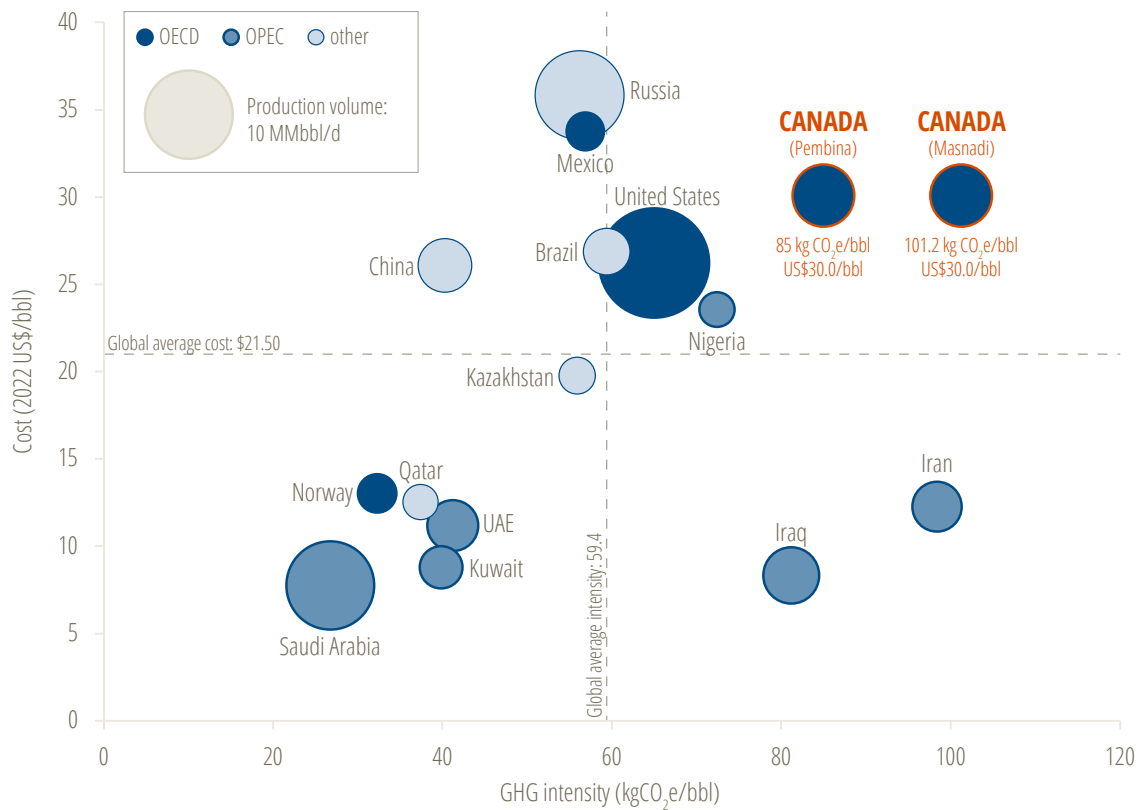


Figure 2. Average greenhouse gas emissions intensity and cost for the top 15 producing countries

Oil production in Canada (calculated both by Masnadi *et al* and by the Pembina Institute) is among the highest average emissions intensity and among the highest costs relative to the top 15 global oil producers.

Data sources: Rystad Energy UCube 2022,, Masnadi et al (2018), Pembina Institute calculations. See Appendix A.1 for details.

While the IEA report of November 2023, *The Oil and Gas Industry in Net Zero Transitions*, indicates higher emissions intensity for some of these countries, their calculation for Canada is aligned with the Pembina Institute's.⁸ Two reasons for the differences in the IEA report are the inclusion of refining, and more granular and recent methane estimates and data. Methane is notoriously difficult to estimate, as we note later, and so contributes to uncertainty in emissions intensity calculations — however, mitigating methane is also low-cost, meaning that those countries with high emissions intensity and high methane emissions will have low-cost ways to significantly reduce their emissions in the short term, whereas Canadian oilsands in particular have less methane associated with their production.

How is cost evaluated in this report?

Cost is evaluated using Rystad's *forward breakeven price* for current production, which is defined as the oil price that makes a currently producing project or field financially economic over its remaining lifetime based on remaining costs.⁹

Rystad includes operating costs, transport costs, debt payments, tax, royalties, sustaining capital costs to the end of life of the asset, and a discount rate of 10% which represents the cost of debt owed and returns expected by equity investors. While heavily discounted, end-of-life asset retirement costs are included in Rystad's methodology. Costs associated with carbon prices, other compliance costs or planned investment in emissions reductions are not included.

Forward breakeven oil price is powerful comparative economic metric as it can be used to compare assets with different fiscal regimes and cost structures.

Meanwhile, OPEC producers in the Middle East have a significant advantage due to low production costs, high market share, and low carbon intensity. The low-cost OPEC producers in Figure 2 control 46% of global oil reserves.¹⁰ In a world where demand for oil starts to decline, low-cost OPEC producers may be in the driver's seat, able to increase production and develop new projects when prices are too low for many of their

⁸ IEA, *The Oil and Gas Industry in Net Zero Transitions* (2023), 69. <https://www.iea.org/reports/the-oil-and-gas-industry-in-net-zero-transitions>

⁹ Rystad defines the economic threshold by net present value of zero discounted at 10%. See Appendix A.1 for details.

¹⁰ BP Statistical Review of World Energy, 2022. <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>

competitors. OPEC countries have also used production cuts to increase prices¹¹ and influence geopolitics¹² in the past.

While many future scenarios indicate OPEC's market share will likely increase, even doubling in lower-demand scenarios, periodic production curtailments will likely continue to occur from time to time when they benefit OPEC.¹³

The higher carbon intensity for Canada is driven by the large share of oilsands production. Oilsands have been one of the most well-studied crudes globally and have a higher emissions intensity because of the large amounts of energy needed to produce and transport bitumen, which requires additional processing to create synthetic crude oil.¹⁴ Since 2015 when the emissions intensity data used here was published, emissions intensity performances have improved for many operators, and additional estimates and methodologies have been published that change and improve emissions estimates across the board,¹⁵ but new research continues to emerge regarding under-estimation of oil and gas emissions.^{16,17} The Masnadi study, despite its older data, is still one of the most comprehensive studies of global carbon intensity of oil. While country-level estimates may be slightly lower in 2023 than this data suggests, this does not change the overall *relative* carbon intensity of Canada's oil internationally.

¹¹ J. Forest, P. Tertzakian, "Summer 2023 Lookback: From Nuclear to Oil to Renewables," minute 17:30, ARC Energy Research, August 29, 2023. <https://www.arcenergyinstitute.com/summer-2023-lookback-from-nuclear-to-oil-to-renewables/>; Appendix C outlines the oil prices certain oil producing jurisdictions need to balance their budgets – in 2023/2024 Alberta required a higher WTI price than Saudi Arabia to balance its budget.

¹² J. Bordoff, K.E. Young, "OPEC+ Cut Shows Saudi Geopolitical Ambitions", *Foreign Policy*, April 6, 2023, <https://foreignpolicy.com/2023/04/06/saudi-opec-oil-production-cut-price-geopolitics-biden-china/>

¹³ Global Energy outlook by BP shows the global share of Middle East producers in 2050 to be higher by 48%, 97%, and 104% compared to 2019 in the New Momentum, Accelerated and Net-Zero Scenarios respectively. BP, *Energy Outlook* (2023). <https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html>

¹⁴ For more details, see Eyab Al-Aini, Chris Severson-Baker and Jan Gorski, *Getting on Track: A primer on challenges to reducing carbon emissions in Canada's oilsands* (Pembina Institute, 2022), 27. <https://www.pembina.org/pub/getting-track>

¹⁵ IHS Markit, *The Right Measure: A guidebook of crude oil life-cycle GHG emissions estimation* (2022). Available at <https://www.spglobal.com/commodityinsights/en/ci/info/1020/right-measure.html>

¹⁶ Katlyn MacKay et al., "Methane emissions from upstream oil and gas production in Canada are underestimated," *Scientific Reports* 11 (2021). <https://www.nature.com/articles/s41598-021-87610-3>

¹⁷ Sumi N. Wren et al., "Aircraft and satellite observations reveal historical gap between top-down and bottom-up CO₂ emissions from Canadian oil sands," *PNAS Nexus* 2, Issue 5, (2023). <https://doi.org/10.1093/pnasnexus/pgad140>

We estimated a more accurate average emissions intensity for Canada's oil to be 85 kgCO₂e/bbl using data from a 2022 study by IHS Markit¹⁸ — a difference of only 16%. The difference between these values doesn't necessarily represent a performance improvement from 2015 to 2021, but reflects more accurate assumptions.

However, even with this update, Canadian oil remains among the highest emitting compared to other major oil producing countries — as we see reflected in the Masnadi study. It is expected that the emissions intensities for other countries have also changed since 2015, which is also not captured in Figure 2.

Despite changes and uncertainties, we believe the emissions intensities used here are still indicative of where Canada stands relative to its peers.

In terms of costs, an alternative measure of cost-competitiveness of a country or province's oil production is *fiscal breakeven oil price*, which is the price of oil needed to balance the budget of an oil-producing country or region. Appendix C compares Alberta to Middle Eastern countries and shows that the province's dependence on oil revenues, measured as fiscal breakeven price, is actually greater than Saudi Arabia's, but less than Iran's.

This is important, because some argue that Saudi Arabia and other OPEC countries will cut production to keep prices above their fiscal breakeven price, making this a better indicator of their competitiveness than their very low production cost. But as some researchers have found,

“These assumptions proved wrong. Riyadh and its peers did not trim production as expected, thus allowing prices to plummet from \$106 per barrel in June 2014 to \$44 per barrel in January 2015. And while many oil exporters faced fiscal, stability, and other geopolitical challenges as prices fell, these difficulties were consistently less than what many analysts had anticipated, as countries' breakeven prices proved not to be critical thresholds.”¹⁹

Either way, the energy transition presents oil-producing jurisdictions like Saudi Arabia and Alberta with fiscal challenges to overcome. While those thorny problems are closely related to competitiveness questions, they are separate from the competitiveness challenges facing individual oil projects.

¹⁸ IHS Markit, *The Right Measure*.

¹⁹ M.R. Greenberg, *Fiscal Breakeven Oil Prices: Uses, Abuses, and Opportunities for Improvement* (Council on Foreign Relations, 2015), 1. https://cdn.cfr.org/sites/default/files/pdf/2015/11/Breakeven_Oil_Paper.pdf

We compare our emissions intensity and cost data to other studies in Appendix B. This includes an updated estimate of Canada's emissions intensity and a comparison to the C.D. Howe *Last Barrel Standing?* report.

2.1! The low-carbon advantage

While producers continue to compete on cost, carbon intensity is increasingly starting to matter as well. Both investors and governments are making progress towards setting and meeting climate goals. As a result, market mechanisms that place a value on low-carbon products are continuing to evolve.

For example, in 2022, the world's eighth-largest bank, HSBC, announced a new energy policy that outlines expectations for how the bank plans to engage with energy clients. In this policy, HSBC outlines in detail what types of assets will be financed, and the level of transparency and engagement expected from clients on emissions reduction plans.^{20,21} Most global banks, including Canadian ones, have commitments to reduce the carbon intensity of their lending and investment portfolios, but have not yet implemented the policies and targets to achieve those commitments.

Another effective market mechanism that will place value on low-carbon oil production is carbon pricing.²² The number of carbon pricing systems around the world is growing, with about 25% of the world's emissions now under a carbon price.²³ In Canada, the federal and provincial governments have adopted a pricing system that results in a growing levy on industrial emissions. While carbon pricing is not yet dominant in major oil and gas producing countries around the world, there is another important mechanism: border carbon adjustments, which place a price on imports — including oil — based on carbon intensity. The EU recently implemented such a mechanism. Although the initial rollout of the EU mechanism does not yet cover oil imports, there is scope to expand covered sectors in the future.

²⁰ HSBC, *HSBC Energy Policy* (2022). <https://www.hsbc.com/-/files/hsbc/our-approach/risk-and-responsibility/pdfs/221214-hsbc-energy-policy.pdf>

²¹ Reclaim Finance, "Oil and Gas Policy Tracker." <https://oilgaspolicytracker.org/>

²² Manar Nacer, "Gorgon 1 Project Development: What effect does a carbon tax have on the project's development economic viability?" *S&P Global*, March 22, 2023. <https://www.spglobal.com/commodityinsights/en/ci/research-analysis/gorgon-1-project-development-what-effect-does-a-carbon-tax-hav.html>

²³ World Bank, *State and Trends of Carbon Pricing* (2022). <http://hdl.handle.net/10986/37455>

As investors integrate emissions metrics into their financing and risk policies, oil companies with the lowest emissions, lowest cost, and credible paths to net-zero production will have an advantage. As investors start to align their policies with climate commitments, and carbon pricing evolves, there will be increasing pressure to shift to lower-carbon fuels, and this includes differentiating between higher and lower carbon intensity crude.

3.! Some of Canada's projects are more competitive than others

The national average alone doesn't tell the whole story in any country. There are differences between oil fields in terms of cost structures, physical properties, and emissions profiles. This results in a wide range of cost and carbon competitiveness for individual fields within a country.²⁴ Figure 3 shows this range for 36 major producing fields in Canada representing about 62% of all Canadian production including 92% of Alberta's production and all offshore production. Most of the smaller conventional oil fields in Alberta and Saskatchewan are excluded here due to a lack of accurate emissions data.

The assets with the lowest cost and lowest carbon intensity are currently the most competitive. These have a much better starting position to compete in a world where demand for oil is expected to decline. The fields that will be most competitive globally in the future will be those that manage to reduce both costs and carbon intensity to remain or to become among the lowest sources on both scales. As Figure 3 below shows, the majority of Canada oil assets are above the global average for both cost and carbon intensity.

To determine the carbon intensity and breakeven costs at the field level in Canada, we used the Oil Production Greenhouse Gas Emissions Estimator (OPGEE V2.0) to model well-to-refinery emissions for 36 projects in Canada, representing 62% of total liquids production. To ensure our analysis is robust, we compared it to peer-reviewed research that was co-published by industry and academics. Our results are consistent. See Appendix B for more details.

²⁴ Cathy Crawford and Kevin Birn, "Understanding the GHG intensity of Crude Oil: The challenge of averages," *S&P Global*, December 18, 2019. <https://www.spglobal.com/commodityinsights/en/ci/research-analysis/understanding-the-ghg-intensity-of-crudeoil.html>

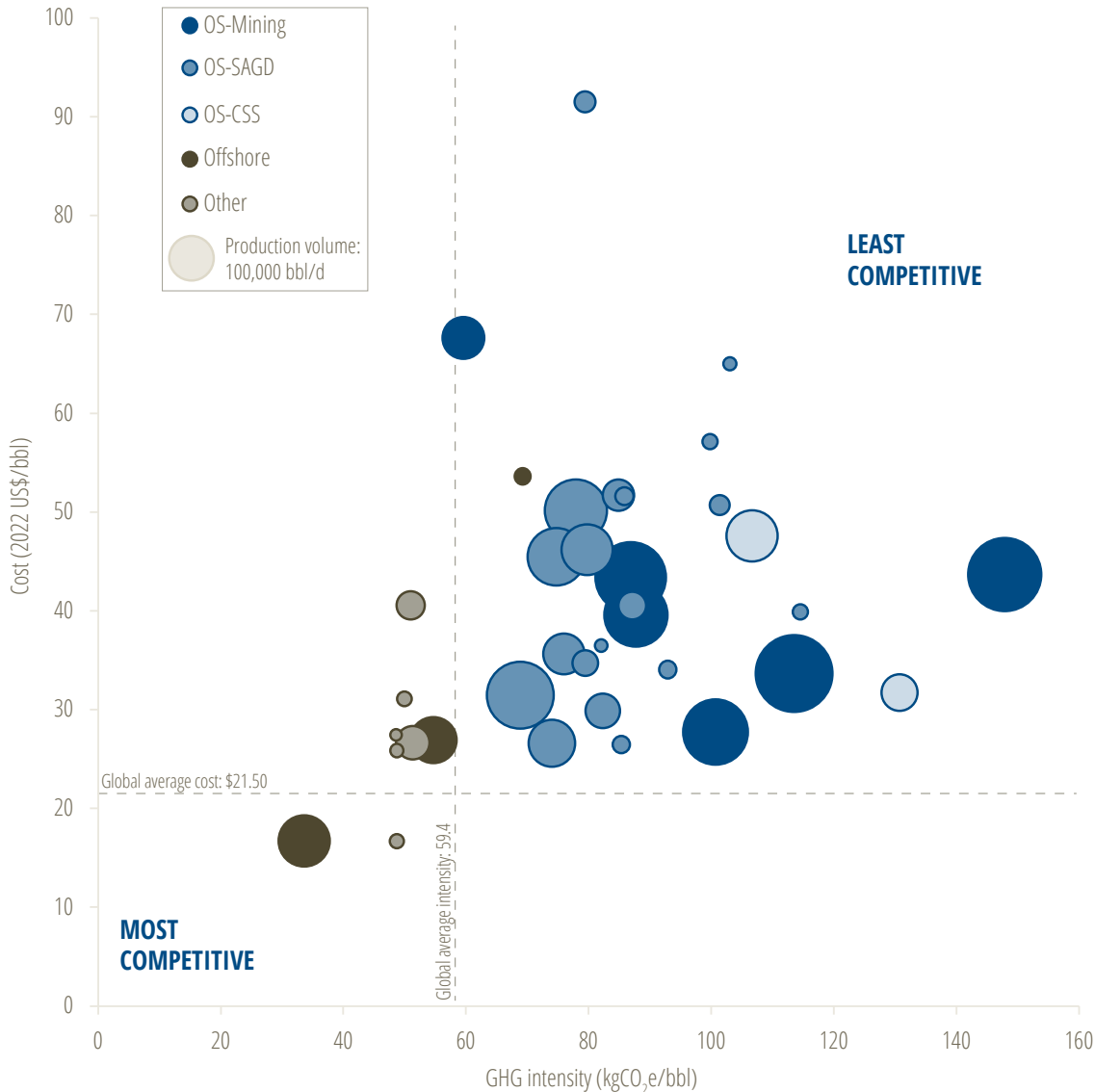


Figure 3. Carbon intensity and cost for 36 major producing Canadian oil fields

Oilsands fields have large variability in cost and carbon performance, while a handful of conventional and offshore fields are competitive. Most of the conventional oil fields are not included due to a lack of accurate emissions data.

Data sources: Rystad Energy UCube 2022, OPGEE V2.0.(2018) See Appendix A.2 for additional details.

3.1! How low can costs really go?

Between 2015 to 2021 oil producers across the globe reduced costs to remain profitable or reduce losses at low oil prices. They did this by improving efficiencies and reducing or deferring costs. These cost reductions were not unique to Canadian or U.S. crudes,

though some producers reduced costs more than others. But starting in 2021 and into the coming few years, costs across all types of crude production are expected to increase, largely due to inflation. This will wipe out much of the cost reduction achieved since 2015. When this is combined with the fact that drastic cost reductions have already taken place across the globe since 2015, there is reason to doubt whether further major cost reduction opportunities still remain.

Looking just at North American crudes, Figure 4 shows how development costs hit a low point in 2020, but started to rise and are expected to increase and then decline again slightly by 2025. Several factors influence the higher costs: increased oil market confidence driving an increase in capital expenditure to maintain or grow production, the resumption of capital spending on deferred projects, and inflationary cost pressures on materials and services.

Focusing on the oilsands, Figure 4 shows they are on track to do a better job of maintaining the prior years' cost reductions than their North American peers.

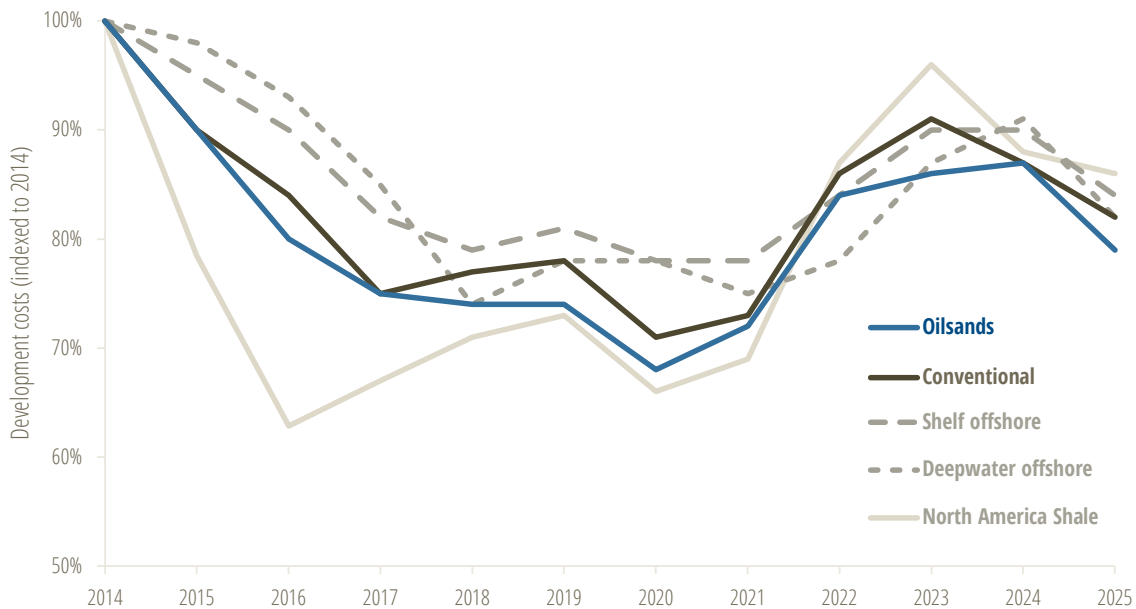


Figure 4. Changes in development costs of oil assets

Per-barrel costs are rising back to near-2014 levels.

Includes capital, operating and exploration expenditures per flowing barrel.

Data source: Rystad Energy, UCube, February 2023.

3.2! Carbon competitiveness improving, but slowly

Oil companies around the world are increasing their commitment to reducing emissions. When it comes to carbon competitiveness, both the starting point and the cost of reducing emissions are important. The graphs above (Figures 2-3) show that many of Canada's oil assets are unfortunately starting at a disadvantage.

Some oil fields have less expensive ways of achieving emissions reductions than others. Emissions reductions at oilsands projects are generally more expensive than for other global assets, or even Canada's conventional oil assets. This is because most of the emissions from oilsands come from fuel combustion (Figure 5), and reducing fuel combustion emissions is expensive. A group of Canada's largest oilsands producers (Pathways Alliance) has identified carbon capture and storage (CCS) as the largest single opportunity to reduce GHG emissions from the oilsands. CCS is, however, also one of the highest-cost ways to reduce emissions.

For conventional oil fields and U.S. shale oil, the major source of emissions is methane that is vented, leaked, or flared during production, processing and transportation (Figure 5). Reducing methane emissions is very cost-effective compared to carbon capture and storage.²⁵

²⁵ Jan Gorski and Eyab Al-Aini, *Waiting to Launch: Third quarter 2022 update* (Pembina Institute, 2022). <https://www.pembina.org/reports/waiting-to-launch-q3-2022-update.pdf>

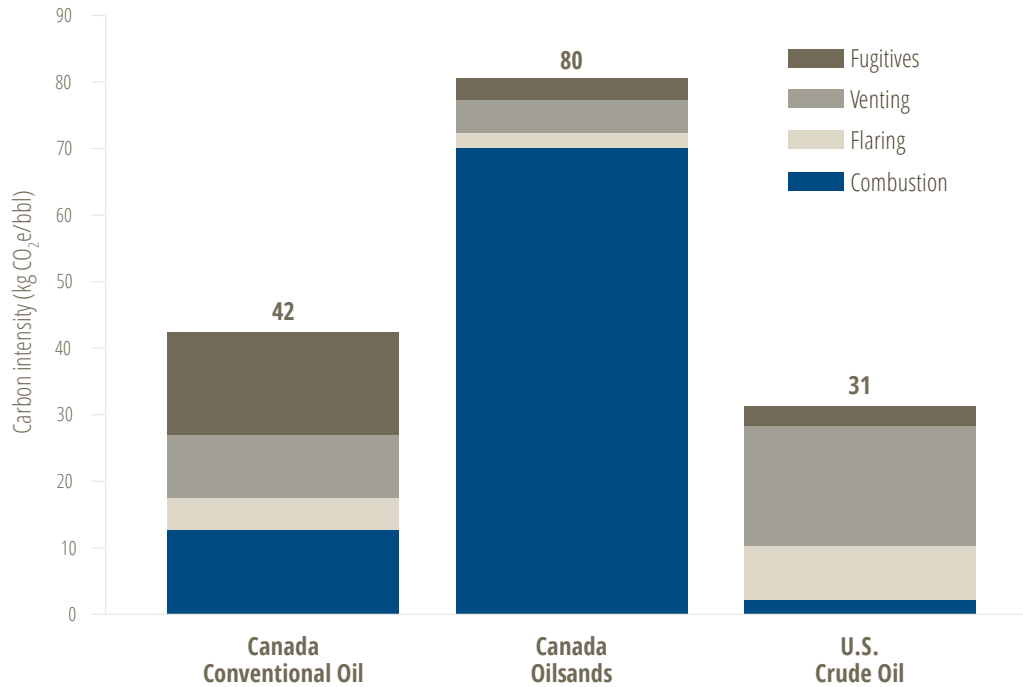


Figure 5. Average emissions intensity and source of emissions from Canadian oilsands, Canadian conventional oil, and U.S. oil production

Source: Adapted from Canadian Climate Institute and Pembina Institute²⁶.

The difference in carbon competitiveness is clear in the timelines and scale of emissions reduction commitments from different oil producers. Twelve major global oil and gas producers have committed to achieving near-zero methane emissions by 2030, a significant commitment. ExxonMobil announced in late 2021 that it will achieve net-zero greenhouse gas emissions from its Permian Basin operations by 2030;²⁷ a few months later, the company formally announced that it has a new goal of reaching net-zero emissions for all its operated assets globally by 2050.²⁸

²⁶ Janetta McKenzie and Scott MacDougall, *Comparing Canadian and American Financial Incentives for CCUS in the Oil Sector* (Canadian Climate Institute and Pembina Institute, 2023), 12.

<https://www.pembina.org/reports/comparing-canadian-and-american-incentives-ccus-oil-sector.pdf>.

Pembina’s calculations of 85 kgCO₂e/bbl in this report (compared to 80 kgCO₂e/bbl in Figure 5) are based on more granular data from Rystad and methods from S&P Global.

²⁷ ExxonMobil, “ExxonMobil plans for net zero emissions in Permian Basin operations by 2030,” media release, December 6, 2021. https://corporate.exxonmobil.com/news/news-releases/2021/1206_exxonmobil-plans-for-net-zero-emissions-in-permian-basin-operations-by-2030

²⁸ This goal no longer includes Exxon’s share in Canadian Montney and Duvernay assets as those assets were sold by Exxon in 2022. ExxonMobil, “ExxonMobil announces sale of interests in Montney and Duvernay Canadian assets,” media release, June 28, 2022. https://corporate.exxonmobil.com/news/news-releases/2022/0628_exxonmobil-announces-sale-of-interests-in-montney-and-duvernay-canadian-assets

Many Canadian oil production facilities face a disadvantage in that they are carbon intensive to begin with and it will be more expensive to reduce emissions. By contrast, U.S. shale producers and many international competitors are already starting ahead and have a cheaper and easier path to reducing emissions even further.

This isn't to say the future is bleak for all of Canada's oil assets. There are competitive facilities where investments to reduce emissions make sense. But equally, it must be acknowledged that high-cost and high-carbon Canadian facilities may not survive a long-term decline in oil demand while competing against global assets that are already lower cost and lower carbon, and have a less expensive pathway to further reduce emissions.

4.! Recommendations

While some of Canada's oil production facilities are better placed to compete in a shrinking global marketplace, others are too high-cost and high-carbon to become competitive. Investors need to carefully evaluate their investment decisions in these facilities. They must ensure that they provide support to facilities that have a chance at surviving in a more competitive market, not ones that are likely to become stranded assets.

- ! Government incentives such as the federal CCUS investment tax credit are key policies to kick-start investment in solutions like CCUS, but care should be taken not to over-incent these projects over and above this limited tax credit, especially in the context of transition risk.
- ! An emissions cap on the Canadian oil industry is necessary to spur investment in oil that has a lower emissions intensity and lower costs and can therefore compete favourably in global markets.
- ! Investors also need to account for both cost and carbon competitiveness when assessing the risk of their current investments and evaluating future investments. The work of the Sustainable Finance Action Council will help with this,²⁹ as will a government-backed Climate Investment Taxonomy to help guide investors.³⁰
- ! The Alberta government must implement policies that will reduce emissions and prepare oilsands assets to survive in a world of declining oil demand. Implementing strong methane regulations that achieve a 75% reduction in oil and gas methane by 2030, and reducing the legislated oilsands emissions limit — both included in the province's emissions reduction and energy development plan — can complement key federal policies like the federal oil and gas emissions cap to incentivize investment in decarbonization.
- ! Both the federal and the Alberta government must urgently develop policies and make investments to advance new economic sectors that will see growth in a net-zero world.

²⁹ Government of Canada, "Sustainable Finance Action Council." <https://www.canada.ca/en/department-finance/programs/financial-sector-policy/sustainable-finance/sustainable-finance-action-council.html>

³⁰ Jonathan Arnold et al., "Canada's oil and gas sector, the road to net zero and regional fairness," *Canadian Climate Institute*, September 20, 2023. <https://climateinstitute.ca/publications/canadas-oil-and-gas-sector-the-road-to-net-zero-and-regional-fairness/>

Getting these choices right will be important to futureproof Canada's oil assets as much as possible and ensure the sector stays as economic as possible in a world that is shifting away from fossil fuels.

Appendix A.1 Methodology

A.1.1 Country-level analysis

The average greenhouse gas emissions intensity and cost (forward breakeven price) for the top 15 producing countries is shown in Figure 2.

Scope of projects selected: Fields that are not producing or in development were not included, as with the production volume data used.

Production volume: Country-level liquids production data for 2021 is sourced from Rystad.⁵¹ The top 15 oil producing countries accounted for ~72 million barrels per day or ~81% of all global oil production for year 2021.

Emissions intensity: The data used for the country-level upstream emission intensity is from the global oil intensity study by Masnadi (2018).⁵² The average country values were reported in gCO₂e/MJ. To make the units consistent in this report, we converted the values to kgCO₂e/bbl using a lower heating value of 5,766 MJ/bbl (Table 1 below). In reality, the heating value of different crude types varies with individual crude properties, and each country has a blend of various types of crudes, so this is a simplification.

The Masnadi data provides an important comparison of global crudes using the same methodology. We estimated a more accurate average emissions intensity for Canada's oil to be 85 kgCO₂e/bbl using data from a 2022 study by IHS Markit⁵³ — a difference of only 16%. The difference between these values doesn't necessarily represent a performance improvement from 2015 to 2021, but reflects more accurate assumptions.

The global volume-weighted average emissions intensity is 10.3 gCO₂/MJ, equivalent to 59.4 kgCO₂e/bbl using the lower heating value conversion above.

⁵¹ Rystad Energy, UCube 2022.

⁵² Mohammad S. Masnadi, Hassan M. El-Houjeiri, Dominik Schunack et al., "Global Carbon Intensity of Crude Oil Production," *Science* 361, no. 6405 (2018). <https://doi.org/10.1126/science.aar6859>

⁵³ IHS Markit, *The Right Measure: A guidebook of crude oil life-cycle GHG emissions estimation* (2022). Available at <https://www.spglobal.com/commodityinsights/en/ci/info/1020/right-measure.html>

Table 1. Upstream carbon intensity for top 15 global oil producing countries

Country	Production volume weighted average emissions intensity	
	gCO ₂ e/MJ	kgCO ₂ e/bbl
Canada	17.6	101
Iran	17.1	98
Iraq	14.1	81
United States	11.3	65
Brazil	10.3	59
Mexico	9.9	57
Russia	9.7	56
Kazakhstan	9.7	56
UAE	7.2	41
China	7.0	40
Kuwait	6.9	40
Qatar	6.5	37
Norway	5.6	32
Saudi Arabia	4.6	37
Global Average	~ 10.3	~ 59

Data source: Masnadi et al

Forward breakeven price: The average country breakeven price shown in Figure 2 as aggregated from all underlying oil liquid assets from Rystad Energy UCube database for producing fields in 2021. Rystad’s forward breakeven price includes a discount rate of 10%. Cashflows include all future revenues, and costs including production, transportation, general, and capital as well as taxes and royalties. Rystad calculates breakeven price for each individual asset in each country as a weighted average based on remaining resource in the underlying producing assets. All breakeven prices in this report are in 2022 U.S. dollars per barrel of Brent.

GHG emissions boundary: As the focus of this study is the impact on Canada’s oil and gas production emissions, the analysis boundary includes upstream emissions (all activities related the exploration, drilling, production, processing) as well as transportation of crude oil from the oil field to the refinery entrance gate. Emissions

associated with refining, refined products transportation, distribution and end use were not included.

A.2! Canada field-level analysis

The carbon intensity and cost (breakeven price) for 36 major producing oil fields in Canada is shown in Figure 3.

Methodology

Scope of projects selected: The fields shown in Figure 3 are for 36 projects which represent 3.3 million barrels per day or 62% of Canada’s total liquids production. These fields have the most reliable operational and emissions data, and include oilsands, primary and offshore fields. Table 2 below shows a summary of the fields included in Figure 3.

The fields not included are those with production rates lower than 5,000 barrels per day. These are mostly conventional oil fields. These fields have less accurate emissions, and are harder to match between different datasets. While the volume of production from each individual asset is small, collectively these fields present a major data gap in easily accessible data. This gap has been recognized in many academic studies of oil emission intensity.

Table 2. Summary of projects individually modelled

Recovery Method	Production (kbpd)	Number of projects
OS-CSS	215	3
OS-SAGD	1,316	19
OS Mining-SCO	1,041	4
OS Mining-PFT	360	2
Offshore	273	3
Other	123	5
Total	3,328	36

CSS: Cyclic steam stimulation: steam is injected in vertical oilsands wells (in-situ); most common in the Cold Lake area.

SAGD: Steam-assisted gravity drainage: steam is injected into horizontal oilsands well pairs in-situ to produce bitumen from underground reservoirs that cannot be reached using surface open-pit mining.

OS Mining: Oilsands mining: includes 1) older fields with upgraders that produce synthetic crude oil (SCO), which is then shipped via pipeline; and 2) newer mines where paraffinic froth treatment (PFT) uses solvents to remove impurities from

mined bitumen, which is then shipped via pipeline.

Other: Includes primary and enhanced oil recovery methods where no steam injection is used

Forward breakeven price: 2021 data sourced from Rystad Energy UCube.

Emissions: The Oil Production Greenhouse Gas Emissions Estimator (OPGEE V2.0) was used to model the well-to-refinery emissions (upstream, on-site upgrading and transportation emissions up to refinery gate) for each project/field individually.³⁴ The input parameters used in OPGEE and the source of the data is summarized in Table 3 below. Operational data for Alberta in 2021 was sourced from the Alberta Energy Regulator (AER) reports ST39 and ST53.^{35, 36} Offshore data was sourced from the Canada-Newfoundland and Labrador Offshore Petroleum Board 2020/2021 report.³⁷ Where more accurate data exists, such as the 2021 study by Sleep et al, the OPGEE model was updated to reflect those values.

Table 3. Summary of key input parameters used for individual fields

Field type/ subtype	OPGEE input parameter	OPGEE input line	Units	Data Source
Oilsands In-Situ	API gravity	1.3.1 (9)	API	Sleep et al, 2021
	Steam-to-oil ratio (SOR)	1.4.8		AER ST53, 2021
	Oil production volume	1.2.5	bbl/day	AER ST53, 2021
Oilsands Mining (with upgrader)	API gravity	1.3.1(32)	API	Sleep et al, 2021
Oilsands Mining (without upgrader)	API gravity	1.3.1 (9)	API	Sleep et al, 2021
	Oil production volume	1.2.5	bbl/day	AER ST39, 2021

³⁴ Hassan M. El-Houjeiri, Mohammad S. Masnadi, Kourosh Vafi et al., *Oil Production Greenhouse Gas Emissions Estimator (OPGEE V2.0)*, (Stanford Doerr School of Sustainability Environmental Assessment and Optimization Group, 2017). <https://eao.stanford.edu/research-project/opgee-oil-production-greenhouse-gas-emissions-estimator>

³⁵ Alberta Energy Regulator, *Statistical Series 39: Alberta Mineable Oil Sands Plant Statistics, Monthly Supplement* (2021). <https://www.aer.ca/providing-information/data-and-reports/statistical-reports/st39>

³⁶ Alberta Energy Regulator, *Statistical Series 53: Alberta In-Situ Oil Sands Summary* (2021). <https://www.aer.ca/providing-information/data-and-reports/statistical-reports/st53>

³⁷ Canada-Newfoundland & Labrador Offshore Petroleum Board, *2020-21 Annual Report* (2021). <https://www.cnlopb.ca/wp-content/uploads/ar2021e.pdf>

Oilsands Mining (all types)	Upgrading variables	2.1.3.1	various	AER ST39, 2021
Onshore Conventional	Oil production volume	1.2.5	bbl/day	Rystad Energy
Offshore	Oil production volume	1.2.5	bbl/day	CNLOPB
	Gas-to-oil ratio (GOR)	1.4.1	scf/bbl oil	
	Water-to-oil ratio (WOR)	1.4.2	bbl water/bbl oil	
	Water injection ratio	1.4.3	bbl water/bbl oil	
	Gas lifting injection ratio	1.4.4	scf/bbl liquid ratio	
	Gas flooding injection ratio	1.4.5	scf/bbl oil	
All onshore fields	Indirect emissions (natural gas, diluent), transportation	Table 2.5 ³⁸	gCO ₂ eq/MMBtu	Sleep et al, 2021
	Transport distance	1.7.2	mile	Sleep et al, 2021

Production volume: 2021 data sourced from Rystad Energy UCube, which includes both project or field names as well as child or asset level sub-field name. Given that operational and production information is also publicly available at the project/field level, field matching was done at the project level to double-check production volumes. The difference between Rystad and regulator sources for liquids production volumes for year 2021 was within 1%.

Results

Results for emissions intensity for each field are summarized, with forward breakeven price, in Table 4 below.

³⁸ The upstream natural gas intensity of 6.4 g CO₂e/MJ assumed in the analysis is a low estimate given evidence that methane emissions are underreported.

Table 4. Individual project carbon intensity (modelled) and forward breakeven price

Project name	Company	Carbon intensity, 2021 (kg CO ₂ e/bbl)	Breakeven price, 2022 (US\$/bbl)
Hangingsstone Expansion	Greenfire Resources	79	92
Fort Hills	Suncor	61	68
Hangingsstone	Athabasca Oil Corporation	103	65
Great Divide	Connacher	100	57
White Rose	Cenovus Energy	69	54
Leismer	Athabasca Oil Corporation	86	52
Sunrise	Cenovus	85	52
Tucker	Strathcona Resources	101	51
Firebag	Suncor	78	50
Cold Lake	Imperial	107	48
Surmont	ConocoPhillips	80	46
Foster Creek	Cenovus	75	45
Syncrude Mildred Lake/Aurora	Suncor	148	44
Kearl	Imperial	87	43
Long Lake	CNOOC	87	41
Cold Lake (Primary)	CNRL	51	41
MacKay River	PetroChina	115	40
Suncor OSP	Suncor	88	40
BlackGold	Harvest Operations	82	37
Christina Lake	MEG	76	36
MacKay River	Suncor	79	35
Athabasca Oil Sands Project	CNRL	114	34
Orion	Strathcona Resources	93	34
Primrose and Wolf Lake	CNRL	131	32
Christina Lake	Cenovus	69	31
Peace River (Primary)	Baytex	50	31
Kirby	CNRL	82	30
Horizon	CNRL	101	28
Jackfish	CNRL	74	27

Project name	Company	Carbon intensity, 2021 (kg CO ₂ e/bbl)	Breakeven price, 2022 (US\$/bbl)
Hibernia	ExxonMobil	55	27
Pelican Lake (Primary)	CNRL	51	27
Athabasca (Primary)	Headwater Exploration	49	27
Lindbergh	Strathcona Resources	85	26
Athabasca (Primary)	Deltastream Energy	49	26
Clearwater (Primary)	Spur Petroleum	49	17
Hebron	ExxonMobil	34	17

Appendix B.1 Comparisons to other studies

B.1.1 Comparison of costs to C.D. Howe *Last Barrel Standing?* report

A recent report by C.D. Howe Institute states that “legacy oil sands production is more resilient in the face of potential global demand reductions than is commonly understood.”³⁹ The report argues that oilsands can withstand short waves of low oil prices due to low operating costs, which have come down since 2016.

The key differences are that the C.D. Howe report uses historical royalty data to predict the future resilience of oilsands projects to low Western Canadian Select crude prices; assumes no discounting; and uses Canadian dollars. Our analysis uses breakeven Brent oil prices in U.S. dollars, and assumes a 10% discount rate to recognize the cost of debt and equity.

Overall, we agree with C.D. Howe that should there be another temporary oil price drop for one to two years, Canada’s oilsands assets will be able to survive in that time. This is because oilsands projects are designed to operate for many decades, so companies have a reason to keep the projects operating if they expect prices to recover. However, sustained lower oil prices could force companies to divest, write down, or even reduce production from fields with higher breakeven price, because they do not provide the returns expected by shareholders in the long term.

Canada and the U.S. have a high breakeven price compared the lowest price fields globally. In a lower oil demand world, the race will be between individual oil fields. The ones with the lowest breakeven price and lowest emission intensity will have the advantage.

³⁹ G. Kent Fellows, *Last Barrel Standing? Confronting the myth of “high cost” Canadian oil sands production* (C.D. Howe Institute, 2022), 20. https://www.cdhowe.org/sites/default/files/2023-01/Commentary_635.pdf

B.2! Comparison of country-level emissions intensities to IHS data

The country-level emissions intensities shown in Figure 2 are from a 2018 study that uses 2015 data and includes global assumptions that may not be accurate for some fields in Canada. It cited a Canadian emissions intensity of 101 kg CO₂e/bbl. We estimated a more accurate average emissions intensity for Canada's oil to be 85 kg CO₂e/bbl using data from a 2022 study by IHS Markit⁴⁰ — a difference of 16%. The difference between these values doesn't necessarily represent a performance improvement from 2015 to 2021, but reflects more accurate assumptions.

Even with this update, Canadian oil remains among the highest emissions compared to other major oil producing countries. It is expected that the emissions intensities for other countries have also changed since 2015, which is not captured in Figure 2. Given higher breakeven prices and higher emissions intensity, Canadian oil production is at a long-term disadvantage on both carbon and cost.

B.3! Comparison of field-level emissions intensities to recent studies

We also compared our analysis of individual fields to results published with specific field data provided by industry. Table 5 below compares our results to two published papers that cover six major oilsands fields. The results from this analysis for five of six fields was within -1% to +7%. For one field our analysis showed 14% higher emissions than the Sleep et al 2021 study, which used lower land use and fugitive emissions numbers.

Furthermore, some variability is expected as each study is using operational data from different baseline years. Changes in production volumes, electricity imported/exported, higher use of diesel for mines that expand further from the extraction plant as well as changes in overall operational plans will affect emissions.

⁴⁰ IHS Markit, *The Right Measure: A guidebook of crude oil life-cycle GHG emissions estimation* (2022). Available at <https://www.spglobal.com/commodityinsights/en/ci/info/1020/right-measure.html>

Table 5. Comparison of the carbon intensity of selected fields between this report and published research

	Carbon intensity by source (gCO ₂ e/MJ)			Difference
	Masnadi et al, 2023 ⁴¹	Sleep et al, 2021	This report	
Year of data	2018	2018	2021	
Field 1	15.6		15.5	-1%
Field 2	13.4		14.4	7%
Field 3		9.9	11.5	14%
Field 4		17.1	17.5	2%
Field 5		10.8!	N/A!	N/A
Field 6		11.9	11.8	-1%

⁴¹ Mohammad S. Masnadi, Kyle McGaughy, Jillian Falls and Tyler Tarnoczi, “LCA model validation of SAGD facilities with real operation data as a collaborative example between model developers and industry,” *iScience* 26 (2023). <https://doi.org/10.1016/j.isci.2022.105859>

Appendix C. Comparison on fiscal breakeven oil price

Another metric for comparing competitiveness is the fiscal breakeven oil price, which is the price of oil needed to balance the budget of an oil producing country or region. Comparing Alberta to Middle Eastern countries shows that the province's fiscal breakeven price is actually higher than many Middle Eastern countries. Alberta's budget is more dependent on oil revenues than Saudi Arabia, but less dependent than Iran.

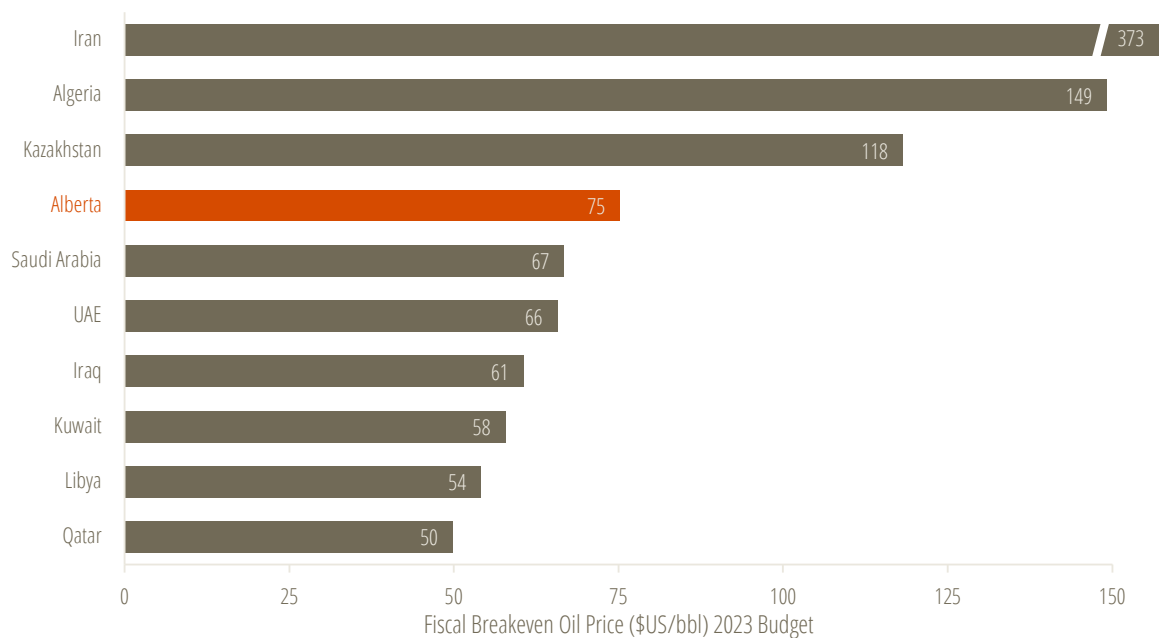


Figure 6. Fiscal breakeven price for different major oil-producing economies

Data sources: Government of Alberta,⁴² International Monetary Fund⁴³.

⁴² Alberta fiscal breakeven oil price is for budget year 2023-2024 which projects a surplus of \$C2.3 billion at WTI oil price of 79 \$US/bbl, and a net annual budget impact of \$630 million for every \$1 change in WTI oil price. Government of Alberta, "2023-2024 Budget." <https://www.alberta.ca/budget-documents.aspx#23-24>

⁴³ International Monetary Fund, "Regional Economic Outlook: Middle East and Central Asia October 2022 (2022) Breakeven Oil Prices." <https://data.imf.org/regular.aspx?key=63078822>

Note: Kuwait's fiscal breakeven oil price is before the compulsory 10% revenue transfer to the Future Generations Fund including investment income.