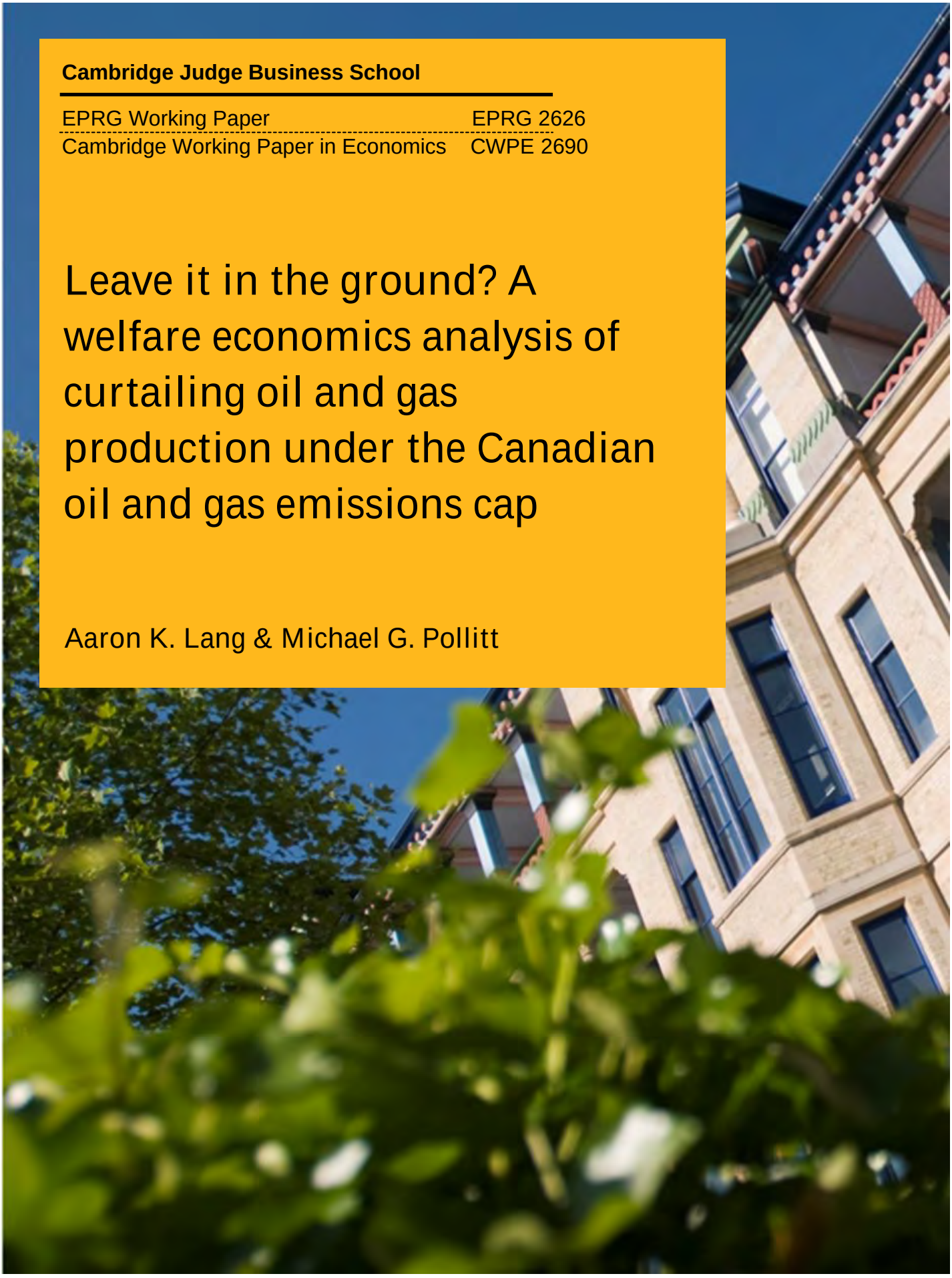


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Leave it in the ground? A welfare economics analysis of curtailing oil and gas production under the Canadian oil and gas emissions cap

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Keywords : cap-and-trade, output-based pricing system, methane regulations, emissions trading, shut-ins, curtailment, oil and gas, upstream

JEL Classification : L94

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Energy Policy Research Group - Cambridge Judge Business School

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Introduction

Canada's experience in implementing climate policy parallels that of other fossil fuel exporting countries like Australia and Norway, whose economic reliance on and political support for the fossil fuel industry has hindered the adoption of climate

[1] This builds on an MBA Individual Project undertaken by Aaron K. Lang. The views expressed in this paper are the views of the authors and should not be taken to be shared by any institution with which they are associated. All errors are their own.

policies that threaten oil and gas production levels (Hopkinson *et al.,* 2025). Data from Environment and Climate Change Canada (2026) shows that between 2020 and 2022, conventional oil, oil sands, and natural gas production and processing, which collectively make up the upstream oil and gas sector, are the source of approximately a quarter of Canada's national greenhouse gas ('GHG') emissions and represent over 80% of the emissions from the broader oil and gas sector. Despite the sector's significant contributions to Canada's GHG emissions, according to Natural Resources Canada (2024, p. 102), oil and gas (upstream and otherwise) made up 25% of Canada's exports and generated 7.7% of its nominal GDP (directly and indirectly) in 2023, making it one of the most important sectors in the Canadian economy, especially in oil and gas producing provinces.

Although the Canadian federal government has committed to several climate goals which necessitate the reduction of emissions from the upstream oil and gas sector, Harrison (2023) argues that Canada's decentralised version of federalism has complicated the implementation of climate policy. Specifically, this system has allowed provincial governments reliant on oil and gas production like Alberta to oppose to varying degrees of success certain federal policies aimed to achieve the federal government's emissions reduction goals since they were expected to negatively impact oil and gas production (because emissions growth has historically been tied to production growth) (Harrison, 2023; Dawson, 2024). Notwithstanding its historical opposition to federal carbon policies, Alberta has implemented its own carbon pricing system, which was required to be equivalent with benchmarks set by the federal output-based pricing system ('OBPS'), to reduce the emissions intensities of heavy emitting sectors (Hoekstra *et al.*, 2025). However, the administration of carbon policy at both the federal and provincial levels has been criticised for increasing the complexity of regulation with questionable efficacy in reducing emissions (Harrison, 2023; Tertzakian, 2024). It is at this intersection of competing interests, federalism, and the cacophony of regulations at the federal and provincial level we find a recent policy proposal subject to much controversy in Canada: the *Oil and Gas Sector Greenhouse Gas Emissions Cap Regulations* (2024). To fully understand why this proposed policy was controversial, we must briefly survey Canada's carbon policy landscape affecting the upstream oil and gas sector.

Under the federal government's *Greenhouse Gas Pollution Pricing Act* ('GGPPA'), GHG emissions are subject to a nationwide minimum price of carbon, which was set to rise to CA$170/t$CO_2$e by 2030, but has recently been reduced to CA$115/t$CO_2$e as of May 2026 (Environment and Climate Change Canada, 2021; Prime Minister of Canada, 2026). To reduce the emissions intensity of high emissions industries, like the oil and gas sector, the federal government enacted the *Output-Based Pricing System Regulations* ('OBPSR') under the GGPPA to implement an OBPS on a nationwide scale. According to Dion and Linden-Fraser (2024), an OBPS is intended to reduce emissions in carbon-heavy sectors that are exposed to international markets (like oil and gas) without making them uncompetitive against global

competitors, ultimately preventing carbon leakage, a phenomenon that may inadvertently maintain (or increase) global emissions if countries with low carbon intensities are uncompetitive in global trade relative to high carbon intensity countries. Generally, an OBPS requires the carbon price be paid if emissions from production exceeds a set benchmark, usually through buying credits, and credits can be generated by outperforming the benchmark, which can be sold (Dion and Linden Fraser, 2024). However, certain methane emissions like those caused by fugitive emissions and venting in oil and gas facilities are exempt from the federal OBPS (Government of Canada, 2018). In theory this creates an incentive for reducing emissions while mitigating unnecessary reductions in production output and maintaining the competitiveness of exports in the global market.

The GGPPA also allows equivalent provincial laws and regulations to be enacted, such as a cap-and-trade scheme or a provincial OBPS, to supersede the federal OBPSR for industrial emissions (Environment and Climate Change Canada, 2021). Notably, major oil and gas producing provinces such as Alberta, Saskatchewan, and British Columbia have opted for a provincial OBPS over a cap-and-trade system (International Carbon Action Partnership, 2025). The important point to note about the federal minimum carbon price and an OBPS is that they do not place an absolute cap on emissions which might bind at very high carbon prices if oil and gas output were to expand significantly. An OBPS is an intensity target, which means that as covered output expands so does the cap on emissions. Despite allowing for a potential increase in total emissions, a study by Bello and Onolemhemhen (2024) demonstrates that carbon pricing policies like the OBPS may have been effective in reducing the emissions intensity of some provincial economies, especially the major oil and gas producing provinces like Alberta and British Columbia, showing that some of the intended incremental improvements to emissions intensity may be occurring.

In November 2024, the federal government took a major step toward specifically addressing oil and gas emissions (both methane and non-methane) from the upstream and liquefied natural gas (‘LNG’) sectors by publishing the *Oil and Gas Sector Greenhouse Gas Emissions Cap Regulations* (2024) in Canada Gazette Part I. These proposed regulations, if enacted, would cap covered sector emissions starting in 2030 at 73% of 2026 emissions levels, with an allowance to emit over the cap by contributing to a fund or using carbon credits, forming a “legal upper bound”, which the federal government estimates to be 143 $MtCO_2e$, while Ammar *et al.* (2025) estimate it to be 160 $MtCO_2e$. Emissions allowances under the cap-and-trade system for each operator were proposed to be allocated for free per calendar year on a pro rata basis based on a rolling average of the previous three years of production (*Oil and Gas Sector Greenhouse Gas Emissions Cap Regulations*, 2024). The regulations also prohibit a covered operator’s emissions to exceed its acquired allowances, with penalties depending on the severity of the breach and revenue of the offending operator (*Oil and Gas Sector Greenhouse Gas Emissions Cap*

Regulations, 2024; Quesnel, Martz, and Boothby, 2024). This means the emissions cap was designed to ultimately limit the total amount of emissions from the sector through legal enforcement.

The upstream oil and gas sector will also be required to further reduce its methane emissions through measures like reducing venting and fugitive emissions upon the recent enactment of the *Regulations Amending the Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*, which the federal government expects will reduce methane emissions by approximately 72% from 2012 levels by 2030, below the federal government's target of 75%. This 75% methane reduction target is not explicitly enforceable like a cap-and-trade system but was expected to account for some of the emissions reductions under the *Oil and Gas Sector Greenhouse Gas Emissions Cap Regulations* (2024). Additionally, the updated methane regulations carry a range of non-compliance consequences under the *Canadian Environmental Protection Act, 1999* (Shaw, 2026). Therefore, although the methane regulations codify the reduction of methane emissions through specific regulations with an emissions reduction target, the emissions cap would have guaranteed that oil and gas emissions, both methane and non-methane, do not exceed the legal upper bound.

It was found by a few recent studies that compliance with the proposed emissions cap could ultimately force some oil and gas production to be shut in (i.e. rendered unprofitable and hence not worth producing) by 2030, resulting in a decrease in GDP (Deloitte LLP, 2024; The Conference Board of Canada, 2024; Ammar *et al.*, 2025). This potential consequence has catalysed significant advocacy efforts from the sector, calling for the removal of the regulations altogether (Baiton, 2024; Anderson *et al*., 2025). Additionally, because the emissions cap overlaps with existing carbon policies, the combined effects could induce lower carbon prices due to additional credits entering the market and result in equivalent, rather than incremental, emissions reductions when compared to simply enhancing the OBPS (Linden-Fraser, Beugin, and Sawyer, 2025; Vij, 2025). The emissions cap may also not be legally feasible to implement if it were ultimately pursued by the federal government. For instance, the Government of Alberta (2024) argued that the emissions cap encroaches on the constitutional jurisdiction of the Canadian provinces to regulate oil and gas resources if the emissions cap impacts production levels. If this argument was held up in the courts, the emissions cap would not be legally enforceable.

Given this backdrop, it comes as no surprise that the Government of Canada (2025, p. 108) announced that the oil and gas emissions cap may not be implemented under the condition that "effective carbon markets, enhanced oil and gas methane regulations, and the deployment at scale of technologies such as carbon capture and storage" are in place, ultimately committing to scrapping the emissions cap altogether by signing a memorandum of understanding ('MOU') with Alberta shortly after (Prime Minister of Canada, 2025). This same MOU also relaxed the methane

reduction requirements for Alberta, setting a target to reduce methane emissions by 75% from 2014 levels by 2035 and committing to sign an agreement to recognize this new target as equivalent with the federal methane regulations (Prime Minister of Canada, 2025; Shaw, 2026).

Notwithstanding the arguments against the emissions cap, it must be asked why such a policy on a major production sector with significant potential for increased exports would be seriously considered by the federal government. Generally, it is assumed that reducing emissions is expected to enhance societal welfare, even if there is some cost to society. Therefore, if this policy is expected to cut production and reduce GDP due to its compliance mechanisms, it should cost less than the cost of emitting GHGs and therefore should be implemented despite the opposition it has received. However, if shutting in production costs more than the cost of carbon, then the government did the right thing by committing to not implement the emissions cap. By developing marginal cost curves for shutting in natural gas, conventional oil, and oil sands production, we build on previous studies by analysing the economic cost and environmental benefit of shutting in production at various emissions intensities to comply with the emissions cap to determine the scenarios where an emissions cap may be a sensible policy to reduce emissions. We then analyse the conditions under which production shut-ins to reach the intended emissions reductions under the emissions cap could theoretically be justified under an OBPS that include all GHGs (i.e. include all methane and non-methane emissions) or the methane regulations in Canada. Policy recommendations and areas of future research are offered at the end of this paper.

Methodology

The cost curves used in this study reflect the direct and indirect marginal economic cost (C_i) (expressed as nominal GDP at market prices lost (ΔGDP_i) per tCO_2e abated) to the economy caused by cutting production (i.e. oil sands, natural gas, or conventional oil) at a given production-weighted average emissions intensity (i) in 2030 to abate a quantity of GHGs from the base case emissions forecast to comply with an emissions cap (ΔGHG_i) as seen in equation (1).

$$(1)\ C_i = \frac{\Delta GDP_i}{\Delta GHG_i}$$

Following the cost-benefit rationale discussed by McKitrick (2016), C_i is compared to the previously targeted CA$170/$tCO_2e$ 2030 minimum federal carbon price (P) in 2024 dollars, which is assumed in this study to represent the marginal societal environmental cost (i.e. damage) of emitting GHGs per tCO_2e[2]. P is also assumed to

[2] We acknowledge that this value does not represent the social cost of carbon (SCC) estimated by the Canadian Government. The previously targeted 2030 minimum carbon price is used since we believe it was a useful benchmark for predicting the practical threshold in which shutting in production is cost-effective relative to emitting GHGs.

be fixed for the purpose of this study. When $C_i < P$, the marginal cost of cutting production at i is lower than the marginal environmental cost of emitting GHGs, driving society to curtail production at i. When $C_i > P$, society would rather produce at i and pay P. When $C_i = P$, society is indifferent to curtailing production at i or producing and paying P. This point is known as the indifference point, which represents the equilibrium where there is no marginal cost or benefit by shutting in or producing oil and gas at i. This study assumes that P will have no incremental effect on GDP, which simplifies the analysis but will not reflect potential negative economic consequences of the carbon price, such as those discussed by McKitrick and Aliakbari (2021). Since Environment and Climate Change Canada (2024) state that approximately 99% of upstream emissions would be covered by the emissions cap, an assumption is made that all emissions and production from the upstream sector is in scope.

The first step in building the cost curves was to construct a model to estimate the nominal GDP impact of a production cut caused by the emissions cap's legal upper bound. A recent study by Ammar *et al.* (2025, p. 8) on the emissions cap used an input-output model based on the mathematical principles provided by Ghanem (2010) and the supply and use tables for Canada's economy in 2019 provided by Statistics Canada (2022) to estimate the direct and indirect GDP impacts of an upstream oil and gas production cut driven by the emissions cap. Given the transparency and flexibility of this methodology, this input-output model was recreated for this study in MATLAB® R2024b Update 6 (The MathWorks, Inc., 2025). Although Fellows and Winter (2018) point out that input-output models have several economically unrealistic assumptions, such as no supply or budget constraints when compared to Computable General Equilibrium ('CGE') models, it is suggested that they provide similar GDP impact estimates as a CGE model when small shocks are applied.

Historical emissions data by economic sector and GHG were collected from Environment and Climate Change Canada (2026). Historical and forecasted oil and gas production were also collected from data provided by the Canada Energy Regulator (2023a). For this study, the "Current Measures" scenario is used as the base case production forecast as it assumes no further climate policies are in force after March 2023 (Canada Energy Regulator, 2023b). For simplicity, LNG is assumed to be included in the natural gas production and processing projections in this study. Additionally, a 6:1 ratio to convert from thousand cubic feet ('mcf') to barrel of oil equivalent ('boe') is used in calculations involving natural gas production to be consistent with the units for conventional oil and oil sands production. Lastly, the conventional oil production data is derived from subtracting mined and in-situ oil sands production from the total crude oil production forecast in Figure ES.8 from the Canada Energy Regulator's (2023a) "Current Measures" scenario. Although this data is collected from authoritative government sources, it may not be free of error. Notably, studies by MacKay *et al.* (2024) and Klotz *et al.* (2025) highlight that

methane emissions data provided by the Canadian government may be understated. Therefore, any material revisions to these datasets may impact the results presented herewith.

After the emissions and production data were collected, historical methane and non-methane emissions intensities between 2016 and 2022 were computed as shown on Figures 1 and 2 using data from the Canada Energy Regulator (2023a) and Environment and Climate Change Canada (2026). What is striking about Figures 1 and 2 is that it shows a downward trajectory between methane and non-methane emissions intensities for natural gas and conventional oil production over time, but a relatively flat trend across methane and non-methane emissions for oil sands production, reflecting the difficulty of reducing emissions intensities in the oil sands sector despite policy efforts.

After historical emissions intensities were calculated, 2022 emissions intensities were then applied to forecasted production levels to estimate a base case "no abatement" emissions forecast, since the base case assumes no further emissions intensity reductions post-2022. As seen in Figures 3 and 4, emissions overall are expected to at least remain at the same level or grow with each type of production type's forecast by 2030 using the computed 2022 emissions intensities and forecasted production from the Canada Energy Regulator's (2023a) "Current Measures" scenario. Afterward, emissions intensities that would result in zero production cuts under an emissions cap were calculated by allocating a percentage of the emissions cap to different production types based on each production type's forecasted proportion of base case emissions in 2030. For methane-specific marginal cost curves, even though the *Regulations Amending the Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)* is not an emissions cap, 25% of each production type's 2012 emissions levels were used as a de facto emissions cap to test the economic viability of shutting in production to achieve the regulation's intended emissions reductions goal.

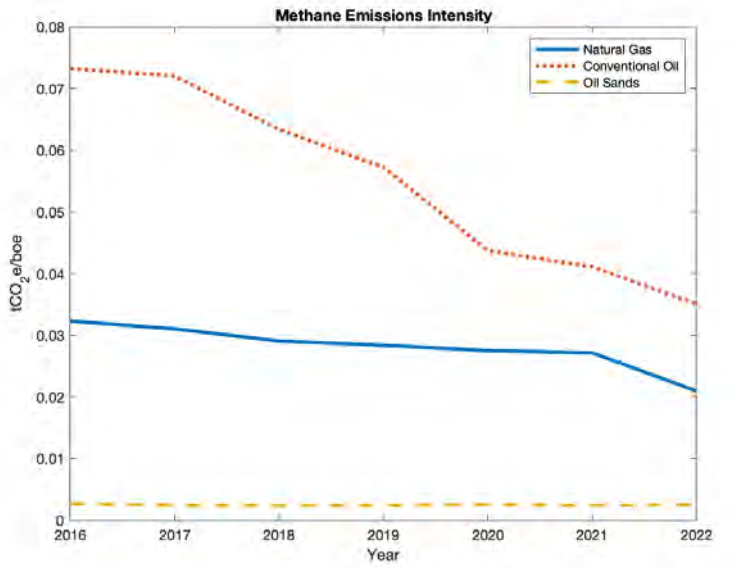


Figure 1: Historical Methane Emissions Intensity
Data Sources: Canada Energy Regulator (2023a); Environment and Climate Change Canada (2026)

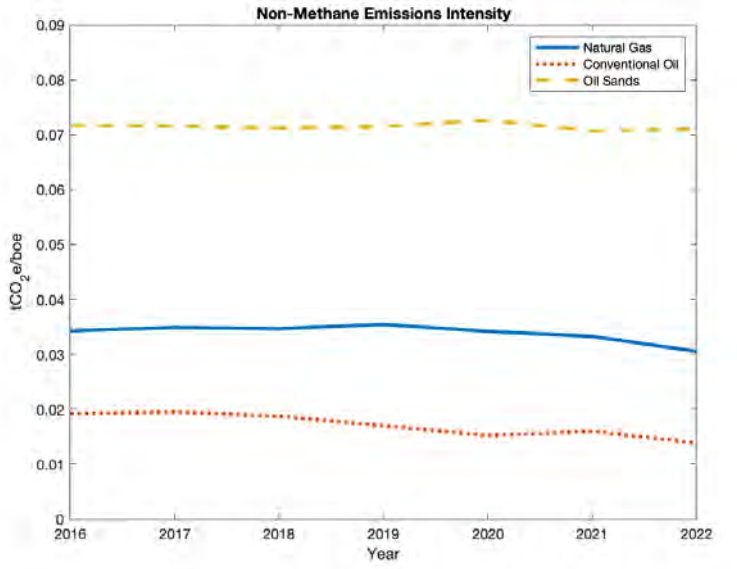


Figure 2: Historical Non-Methane Emissions Intensity
Data Sources: Canada Energy Regulator (2023a); Environment and Climate Change Canada (2026)

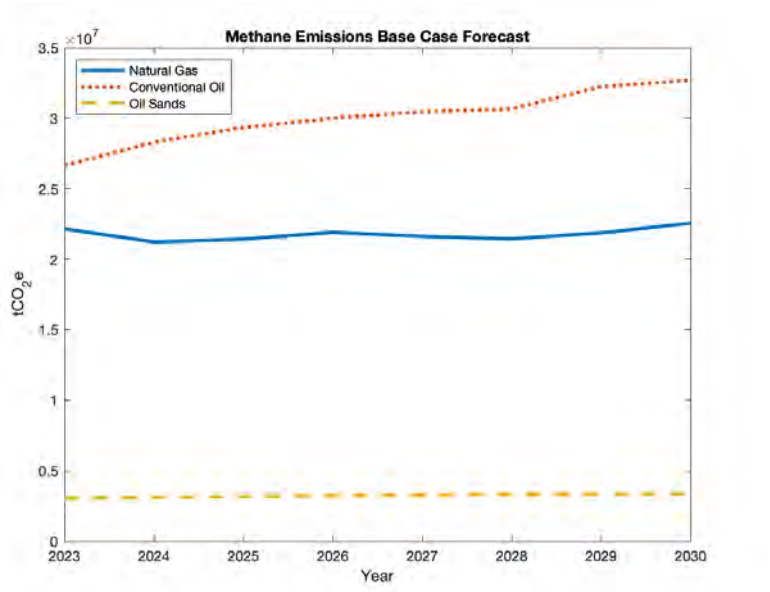


Figure 3: Base Case Methane Emissions Forecast by Production Type Using 2022 Emissions Intensities

Data Sources: Canada Energy Regulator (2023a); Environment and Climate Change Canada (2026)

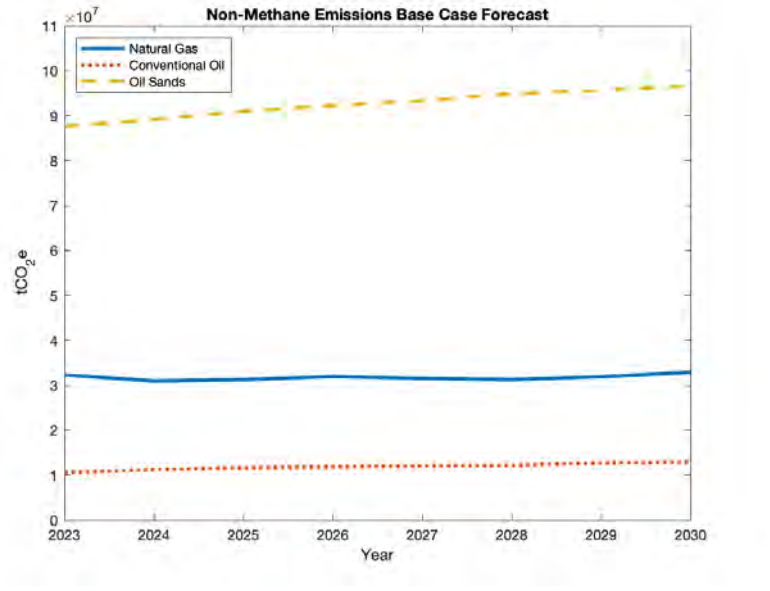


Figure 4: Base Case Non-Methane Emissions Forecast by Production Type Using 2022 Emissions Intensities

Data Sources: Canada Energy Regulator (2023a); Environment and Climate Change Canada (2026)

Three scenarios, listed in Table 1, were run by creating vectors of i ranging from the intensities calculated from the 2022 data to intensities that would require zero production cuts. These vectors were then used to compute the production cuts required from the Current Measures forecast at each i to comply with an emissions cap, like the legal upper bound. Each production cut was first applied as a product-level exogenous output shock (q_i^E), which was then distributed across affected

industries (g_i^E) using the matrix containing the market share of outputs (D) as shown in equation (2) from Ghanem (2010, p. 8).

$$(2)\ g_i^E = Dq_i^E$$

g_i^E was then applied in equation (3) from Ghanem (2010, p. 10) to compute the direct and indirect impact on industry output resulting from an exogenous output shock:

$$(3)\ g_i^* = \left[I - D\left(I - \hat{\mu} - \hat{\beta} - \hat{\alpha}\right)B\right]^{-1} g_i^E$$

where g_i^* is the vector of the impact on industry gross output at basic prices; I is the identity matrix; $\hat{\mu}$ is the diagonal matrix making up imports as a proportion of demand; $\hat{\beta}$ and $\hat{\alpha}$ are the diagonal matrices of withdrawals and scrap as a proportion of demand; D is the matrix containing market share; and B is the matrix containing intermediate inputs as a proportion of industry output (Ghanem, 2010). For simplicity, commodity-level shocks for oil sands production were equally applied on the "synthetic crude oil" and "crude and diluted bitumen" products, while shocks on natural gas production were equally applied on the "natural gas liquids and related products" and "natural gas" products in the supply and use tables from Statistics Canada (2022). After g_i^* is computed, the nominal GDP impact at market prices at each i is calculated using equation (4) based on Ghanem (2010, p. 11):

$$(4)\ \Delta GDP_i = \sum_{j=1}^{n} \frac{GDP_j}{g_j} g_{i\,j}^*$$

where $\frac{GDP_j}{q_j}$ is the GDP to gross output ratio and j represents the industry index in the vector. GDP_j is calculated per industry using the "production approach" outlined by Ghanem and Huang (2014, p. 10). Because the GDP calculation is assumed to be in 2019 dollars, it was inflated to 2024 dollars using GDP deflators provided by the World Bank Group (2026). Similarly, the assumed 2030 carbon price (P) of CA$170/tCO$_2$e is assumed to be fixed at CA$150.96/tCO$_2$e in 2024 dollars using an assumed annual inflation rate of 2%. The nominal GDP impact of the shock (ΔGDP_i) was then used to determine the marginal economic cost per tCO$_2$e (C_i) as demonstrated by equation (1) for each production type and i. Lastly, using equations (1), (2), (3), and (4), cost curves for each production type were generated in MATLAB® by graphing C_i against i, allowing for a comparison against P at each emissions intensity of production. It must be emphasized that this analysis is sensitive to these GDP deflator and inflation assumptions. Any material change to these assumptions may change the conclusions reached in this study for cost curves that are close to the carbon price.

Table 1: Scenario Design			
Scenario	**Greenhouse Gas**	**Assumed Emissions Cap ($MtCO_2e$)**	**Basis**
Scenario 1	Methane and Non-Methane	Natural Gas: 44.1 Conv. Oil: 36.3 Oil Sands: 79.6	Ammar *et al.* (2025) estimate of the legal upper bound allocated to natural gas, conventional oil, and oil sands production based on each production type's forecasted proportion of base case emissions in 2030.
Scenario 2	Methane and Non-Methane	Natural Gas: 39.4 Conv. Oil: 32.4 Oil Sands: 71.1	Legal upper bound estimate in the *Oil and Gas Sector Greenhouse Gas Emissions Cap Regulations* (2024) allocated to natural gas, conventional oil, and oil sands production based on each production type's forecasted proportion of base case emissions in 2030.
Scenario 3	Methane	Natural Gas: 8.6 Conv. Oil: 11.5 Oil Sands: 0.6	Targeted 75% methane emissions reduction from 2012 levels applied to each production type (*Regulations Amending the Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*; Environment and Climate Change Canada, 2026).

Analysis

Figures 5 to 9[3] contain the cost curves computed from Scenarios 1 through 3 as set out in Table 1. The results of Scenarios 1 and 2, which includes the cost of abating both methane and non-methane emissions along the cost curves to comply with estimates of the emissions cap's legal upper bound, are reflected on a per-production type basis in Figures 5, 6, and 7. Each cost curve reflects a non-linear increase to the marginal cost of abatement from shutting in production as emissions intensities improve, which is driven by GDP loss from production shut-ins decreasing at a slower rate than the rate of GHG abatement. This is important, since it suggests that more carbon competitive production is more expensive to shut in. Additionally, it suggests that an emissions cap enforced through legal means could disincentivise Canadian society to make production more carbon competitive if it is not as costly on a per tonne of CO_2e basis to shut in generally less carbon competitive production.

Looking at the results across all emissions intensities for natural gas, conventional oil, and oil sands production, as seen in Figures 5, 6 and 7, it appears that there are no circumstances where it is more cost-effective to shut in production than to emit the associated GHGs from production and incur the cost of emissions. Across the range of tested emissions intensities, the cost of shutting in oil sands production is estimated to range from ~CA$777 to ~CA$949 per tCO_2e in Scenario 1 and ~CA$777 to ~CA$1,045 per tCO_2e in Scenario 2. The cost of shutting in conventional oil production is estimated to range from ~CA$970 to ~CA$1,186 per tCO_2e in Scenario 1 and ~CA$970 to ~CA$1,306 per tCO_2e in Scenario 2. Lastly, the cost of shutting in natural gas production is estimated to range from ~CA$268 to

[3] Data in the marginal cost curves contains data adapted from Statistics Canada, Supply and Use Tables, 2019. This does not constitute an endorsement by Statistics Canada of this product.

~CA$328 per tCO_2e in Scenario 1 and ~CA$268 to ~CA$361 per tCO_2e in Scenario 2, the lowest of the three production types.

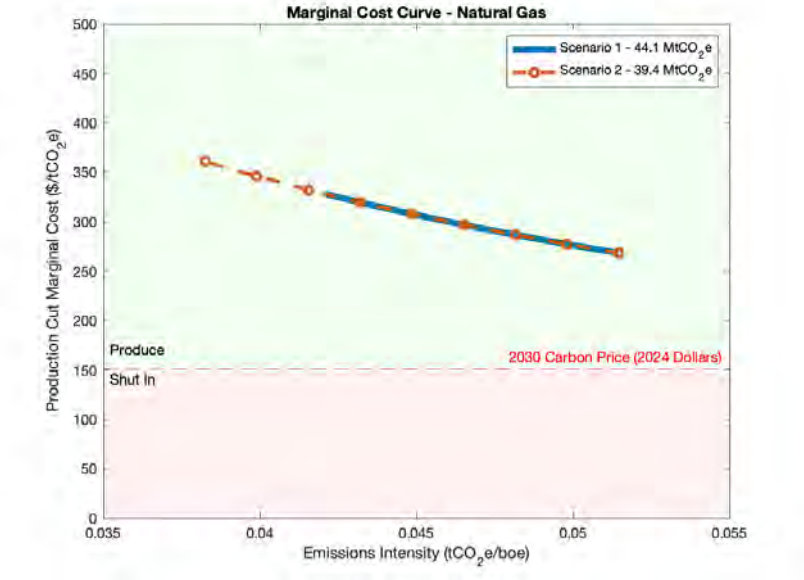


Figure 5: Scenario 1 and 2 Natural Gas Marginal Cost Curves
Data Sources: Statistics Canada (2022); Canada Energy Regulator (2023a); *Oil and Gas Sector Greenhouse Gas Emissions Cap Regulations* (2024); Ammar *et al.* (2025); Environment and Climate Change Canada (2021; 2026); World Bank Group (2026)

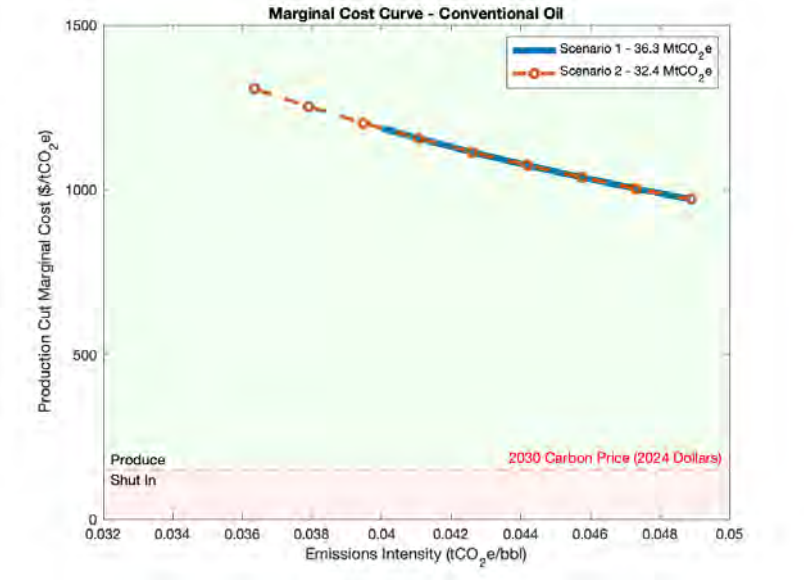


Figure 6: Scenario 1 and 2 Conventional Oil Marginal Cost Curves
Data Sources: Statistics Canada (2022); Canada Energy Regulator (2023a); *Oil and Gas Sector Greenhouse Gas Emissions Cap Regulations* (2024); Ammar *et al.* (2025); Environment and Climate Change Canada (2021; 2026); World Bank Group (2026)

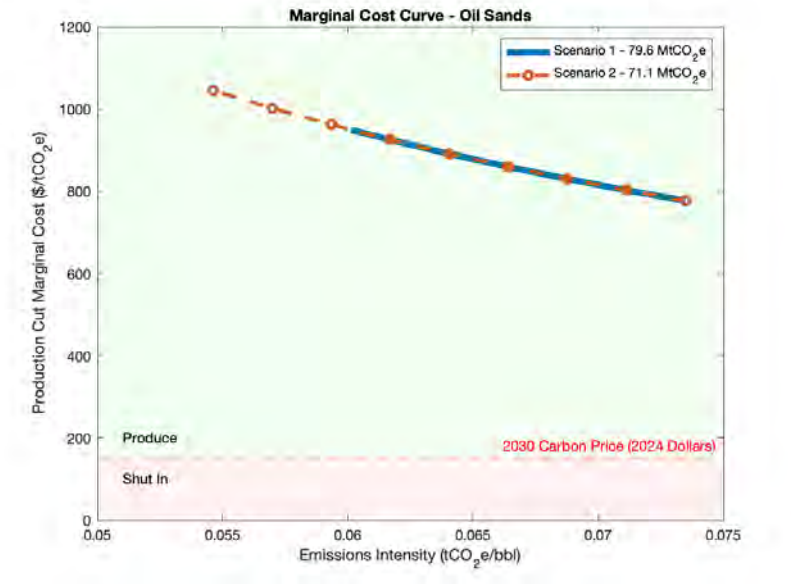


Figure 7: Scenario 1 and 2 Oil Sands Marginal Cost Curves
Data Sources: Statistics Canada (2022); Canada Energy Regulator (2023a); *Oil and Gas Sector Greenhouse Gas Emissions Cap Regulations* (2024); Ammar *et al.* (2025); Environment and Climate Change Canada (2021; 2026); World Bank Group (2026)

When production curtailment occurs to abate emissions, the same percentage decrease in production (i.e. output) is applied on emissions. Therefore, when a production type's output contribution is large relative to its emissions in the product mix, and its GDP to gross output ratio is comparable to other products, the GDP cost per tonne will generally be much larger than if the opposite were true. This is the reason why conventional oil production is the most expensive on a per tCO_2e basis relative to other product types. We observe in the 2019 supply and use tables provided by Statistics Canada (2022) and 2022 emissions data provided by Environment and Climate Change Canada (2026) that oil sands extraction make up the majority of the output contribution on an industry-wise and product-wise basis across oil and gas extraction and oil sands extraction, while only making around half of the total emissions coming from those sectors in 2022 (note that these proportions do not take into account oil, natural gas, and CO_2 transmission). Conversely, natural gas (i.e. natural gas and natural gas liquids) provides a lower output contribution, but approximately 30% of the emissions from the upstream oil and gas sector. Conventional oil has the smallest contribution to GHGs, making up nearly 20% of the total emissions from the sector, but have a higher output contribution than natural gas production. Therefore, it is generally expected that shutting in conventional oil production to abate emissions will be the most expensive option as it has the highest relative emissions-adjusted output and therefore the highest GDP cost per tonne, followed by oil sands, with natural gas production being the least costly to shut in.

Our estimates are lower than the CA$1,800 to CA$2,100 per tCO_2e for shutting in oil and gas production estimated by The Conference Board of Canada (2024) or the CA$2,887 per tCO_2e estimated by Exner-Pirot (2025). This difference could be a

result of our focus on direct and indirect economic impacts from shutting in production as well as only accounting for the economic impacts of reducing output on a commodity-specific basis, rather than an industry-wide or aggregate basis. It is possible that if we accounted for additional economic impacts beyond direct and indirect impacts the estimated costs could be higher. Despite these differences in estimates, if an emissions cap were to be enforced and resulted in curtailing oil and gas production, it could have an overall net-negative impact on society in all tested emissions intensity scenarios assuming an environmental cost of emissions of CA$150.96/t$CO_2$e, which is the estimated 2024 value of the assumed CA$170/t$CO_2$e 2030 federal minimum carbon price.

Given that this analysis is done on an input-output model based on 2019 supply and use tables from Statistics Canada (2022), any changes to the structure of the economy since 2019 could result in significant changes from the results presented here. For example, if an exogenous output shock to natural gas production theoretically impacts the economy less in 2030 than it does in 2019, then it is possible that some natural gas production could be justifiably curtailed provided that the GDP cost per tCO_2e falls below the 2030 carbon price. Conversely, the emergence of Canada's LNG export sector may be a structural factor that makes shutting in natural gas production more expensive to the Canadian economy in the future. Additionally, the input-output model does not reallocate spending after an exogenous shock is applied, resulting in estimating a gross, rather than net, economic impact (Fellows and Winter, 2018). Therefore, the direct and indirect impacts of shutting in production may be exaggerated relative what may occur in the real economy. If a more sophisticated model were used, like a CGE model, and induced impacts were accounted for, it could compute different marginal costs for curtailing production than the costs presented here, especially for natural gas.

Since the emissions cap is expected to work in tandem with the methane emissions reduction regulation, cost curves for specifically abating methane emissions were generated separately. The results of Scenario 3, which treated the methane reduction goal of 75% as a de facto legal upper bound for the purposes of modelling the marginal cost curve, are shown in Figures 8 and 9. The cost curves reveal a similar non-linear marginal cost increase as methane emissions intensities improve across all production types as Figures 5 to 7. Additionally, it is observed that there is no circumstance across all tested emissions intensities where the marginal cost of shutting in to specifically abate methane emissions is lower than the carbon price. The oil sands cost curve is notably the most expensive, with costs ranging from ~CA$23,068/t$CO_2$e to ~CA$83,875/tCO_2e, which goes beyond the y-axis scale in Figure 8, and had to be illustrated in Figure 9. Although these values may seem very high, given the already low amount of methane emissions from the oil sands sector, the cost of shutting in will be disproportionate when compared to the environmental costs of emissions due to the sector's relatively large contribution to the Canadian economy and small contribution to overall methane emissions. Therefore, the federal

government must avoid scenarios where producers are forced to shut in production to comply with the regulations if the required technological solutions are not available given its disproportionate economic cost.

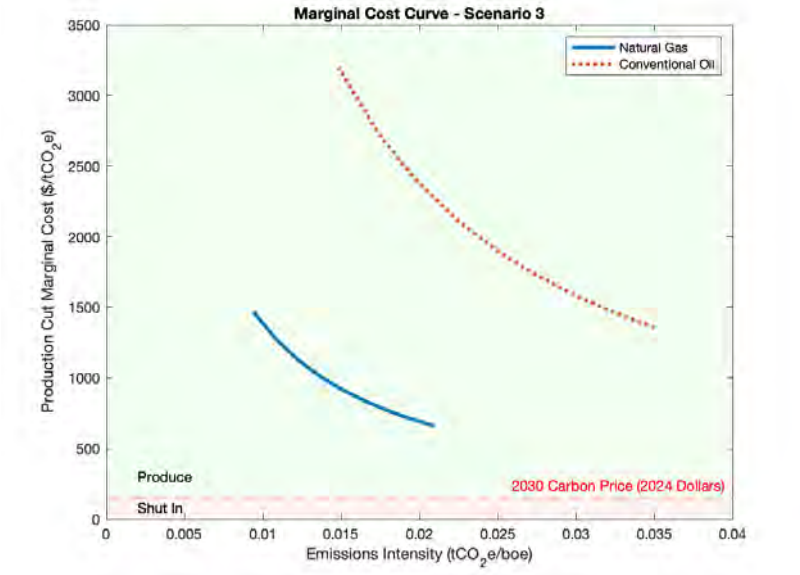


Figure 8: Methane Marginal Cost Curves Without Oil Sands

Data Sources: Statistics Canada (2022); Canada Energy Regulator (2023a); *Regulations Amending the Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*; Environment and Climate Change Canada (2021; 2026); World Bank Group (2026)

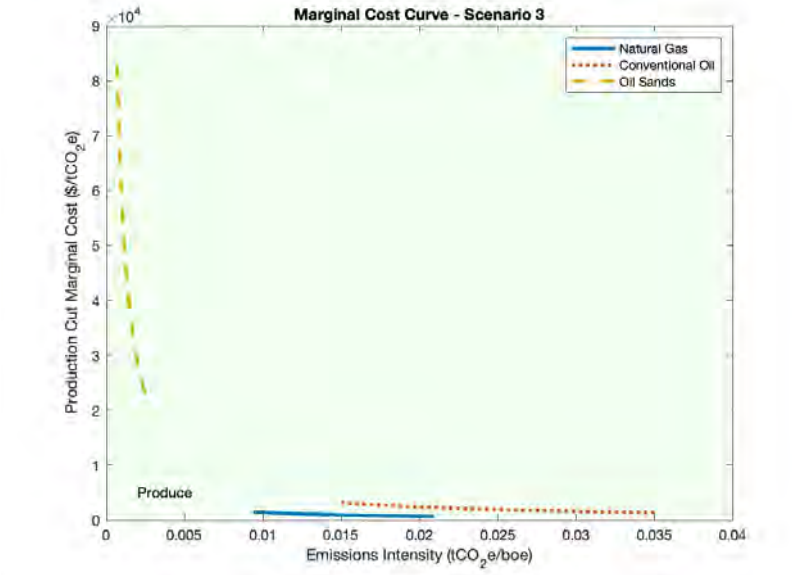


Figure 9: Methane Marginal Cost Curves With Oil Sands

Data Sources: Statistics Canada (2022); Canada Energy Regulator (2023a); *Regulations Amending the Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*; Environment and Climate Change Canada (2021; 2026); World Bank Group (2026)

Recall that methane emissions from fugitive emissions and venting in oil and gas facilities are exempt from the federal OBPS. In 2020, it was estimated by Environment and Climate Change Canada (2022) that ~92% of oil and gas methane emissions are caused by fugitive emissions and venting. It is also estimated that a significant proportion of methane emissions are concentrated in upstream oil and gas activity as demonstrated by MacKay *et al.* (2024, Fig. 3). As a result, most methane emissions in the upstream sector are likely not included in the federal OBPS as currently conceived. Therefore, the marginal cost analysis on the emissions cap presented in Figures 5, 6, and 7 could only be applied to determine if production shut-ins could theoretically be justified under an OBPS that includes all methane emissions, including fugitives and venting, within an emissions intensity target. Under such an OBPS, similar conclusions can be reached as under the emissions cap, that no oil and gas production can be justifiably shut in at the estimated 2024 value of the CA$170/t$CO_2$e 2030 carbon price across the range of tested emissions intensities. Hypothetically, if shutting in production were economically justified under an OBPS, it may have mixed effects on improving emissions intensities since output will also decrease commensurate with emissions reductions. For production shut-ins to enhance the production weighted average intensity of natural gas production in Canada, it would require facilities with high emissions intensities to be shut in before more efficient facilities, which could result in maximising societal welfare and reducing the overall emissions intensity of oil and gas production in Canada.

Conclusion

In this study, we constructed marginal cost curves of shutting in oil and gas production at various emissions intensities in MATLAB® to understand under which circumstances an emissions cap may be more cost effective to reduce GHG emissions and the conditions under which production shut-ins could be justified under an OBPS or the currently enacted methane regulations. Using an estimated 2024 value of the fixed CA$170/t$CO_2$e 2030 carbon price and an input-output model based on 2019 supply and use tables, we find that it may not be cost-effective to shut in natural gas, oil sands, and conventional oil production relative to emitting methane and non-methane GHGs across the range of tested emissions intensities to comply with the emissions cap. Specifically, the marginal cost of shutting in natural gas is the least costly, being much closer to the carbon price than the cost of shutting in oil sands and conventional oil production. Although our findings suggest that it is unlikely any oil and gas production would ever be shut in to abate emissions unless the carbon price is higher, we believe further investigation into the welfare economics of shutting in some natural gas production is warranted, given the proximity of our results to the carbon price. For example, because the input-output model used in this study assumes uniform production cuts across each commodity type at an economy-wide scale, it may not reflect the results of a more probable scenario where companies under the emissions cap would likely shut in their dirtiest

and least profitable production facilities first. Therefore, the true marginal cost of shutting in natural gas production at a given aggregate emissions intensity may indeed be lower than estimated in this study and potentially be below the assumed carbon price. Additionally, if the emissions intensity of natural gas exceeds the maximum tested emissions intensity in this study, the cost of shutting in some production may cost less than the cost of production-related emissions. Conversely, the structure of the Canadian economy may change with the growth of Canada's LNG export sector, potentially making natural gas production more expensive to curtail in the future. More advanced economic modelling could potentially bring clarity to the welfare economics of curtailing natural gas production.

It is worth mentioning that this study does not analyse the effects of a floating carbon price on the "produce or shut in" question as we focused exclusively on a fixed minimum carbon price as the proxy for the environmental cost of greenhouse gas emissions. Since emissions allowances under the emissions cap are allocated for free, there is no inherent cost basis or minimum cost on them. The price will therefore likely be set by the market, which may be determined by the marginal cost of abatement to be compliant with the cap. Since the 2030 carbon price is a federal minimum carbon price, naturally, if the price of emission allowances under the emissions cap rises above this point then some oil and gas production could justifiably be curtailed in accordance with the results in Figures 5 through 7. However, this outcome might not meaningfully reduce emissions across the Canadian economy relative to less costly policy alternatives given that the emissions cap was meant to work in tandem with the existing OBPS policies currently in force in Canada. Specifically, a study from Linden-Fraser, Beugin and Sawyer (2025) suggest that that the industrial carbon price in certain carbon markets, such as Alberta, could be effectively below the federal minimum price due to an oversupply of credits based on current unused credit inventories and potential additional OBPS credits generated, thus reducing or even eliminating the incentive for non-oil and gas producing industries to reduce their emissions and therefore muting the incremental impact of the emissions cap on total nationwide emissions.

In conclusion, we generally believe that the federal government has made a prudent policy decision to not enforce the emissions cap. We also believe that the recent reduction of the 2030 federal minimum carbon price to CA$115/t$CO_2$e announced by the Prime Minister of Canada (2026) strengthens our findings, given that the gap between the cost per tonne of shutting in versus the cost of emissions has widened. Although the methane regulations do not enforce a specific emissions reduction target like the emissions cap, we recommend that the federal government takes care to avoid inadvertently causing industry to curtail production in the absence of affordable technology to abate methane emissions. We welcome further research in developing shut in marginal cost curves with alternative economic models to test the robustness of this analysis, especially for natural gas production.

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