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# Pacific Northwest Liquefied Natural Gas (LNG) Project

## Review of Related Upstream Greenhouse Gas (GHG) Emissions Estimates


**Summary**

The Canadian Environmental Assessment Agency (the Agency) sought the following advice from Environment and Climate Change Canada (ECCC) as an expert department for the Pacific Northwest (PNW) LNG Project: an analysis of the upstream emissions associated with the PNW Project.

The proposed PNW LNG project near Prince Rupert, British Columbia (BC) is a relatively large project that will produce 19.2 megatonnes (Mt) of LNG per year, using natural gas turbines to run its liquefaction compressors. Phase one of the project is expected to come on line in 2020, producing 12.8 Mt of LNG per year, and Phase two will come on in two years later, adding an additional production capacity of 6.4 Mt of LNG per year. The proponent has estimated GHG emissions in the Environmental Impact Statement for the project of 5.2 Mt per year of $CO_2e$, after Phase 2, at full build. The Project is estimated to have a direct GHG emission intensity of between 0.22 and 0.27 t $CO_2e$/t LNG.

For the purposes of this review, "upstream" is defined as all natural gas sector stages before the coastal liquefaction facility – that is, natural gas production, processing, and pipeline transmission. This analysis does not try to determine whether there is any incremental natural gas production that would result from development of the PNW LNG project or whether it will use natural gas production that would have otherwise occurred. The upstream GHG emissions estimates would thus represent the maximum possible incremental GHG emissions.

**Using several sources as set out in the table below, ECCC projects that the upstream GHG emissions in Canada associated with the natural gas production, processing and transmission of the natural gas used by the PNW LNG project will range from 6.5 to 8.7 megatonnes/year of $CO_2e$, or about 160 to 210 Mt of GHG over the 25-year lifetime of the project.** These are rough estimates, given the inherent uncertainties in the current analysis.

The table below summarizes several sources of upstream emissions estimates for the PNW LNG project. Two estimates are provided based on the projected GHG emissions from the natural gas production, processing, and pipeline transmission sub-sectors from ECCC's most recent GHG projections in the current measures reference scenario (a business-as-usual scenario), which will be published in Canada's Biennial Report. One that assumes 100% of the gas is supplied from BC sources, and a second that assumes 75% supply of gas from BC and 25% from

Alberta, respectively. Estimates are also provided using the Pembina Institute's BC Shale Scenario Tool and using information from the British Columbia LNG Greenhouse Gas Life Cycle Analysis report (2014). The Pembina and BC studies do not break out each stage in a consistent fashion, so only a total upstream number is included. The emission factors for each methodology and info on year-to-year variability for the ECCC model are included in the Annex.

The approaches presented all estimate GHG emissions from the natural gas stages upstream of the LNG project using a similar methodology, although with some different assumptions for individual components of the calculation.

| ***Annual Emissions (Mt $CO_2e$)*** | **ECCC Emissions Forecast (2030) Gas supply: BC: 100%** | **ECCC Emissions Forecast (2030) Gas supply BC:75% AB:25%** | **Pembina BC Shale Scenario Tool (2030)** | **BC LNG GHG LCA report (2030)** |
|---|---|---|---|---|
| **Transmission** | **0.4** | **0.6** | **6.5** | **7.2** |
| **Production & Processing** | **7.7** | **8.1** | | |
| **Total Upstream** | **8.1** | **8.7** | **6.5** | **7.2** |

**ECCC Emissions Forecast use most recent projected GHG emissions in the current measures reference scenario.**

GHG emissions along the entire life-cycle of the natural gas and LNG related to the PNW project may be relevant to decision-making on the project, since GHG emissions contribute to global climate change, rather than having a local impact. In addition to project GHG emissions and upstream GHG emissions in Canada, there will also be indirect GHG emissions from electricity generation, which may occur in BC or in other jurisdictions. Finally, the project may have impacts on industrial activity and related GHG emissions outside of Canada, which may be positive or negative. However, due to limited time for this analysis and lack of reliable data and methodologies, **the current analysis is restricted only to the natural gas sector lifecycle stages upstream of the LNG project**. The analysis also does not assess the significance of GHGs from the direct project or upstream natural gas stages or their contribution to global climate change.

**Analysis**

PNW LNG is one of 21 liquefied natural gas (LNG) production and export terminals proposed for the coast of British Columbia. It is a relatively large facility projected to produce 19.2 Mt of LNG per year at full capacity. Natural gas will be liquefied and shipped via LNG carriers to foreign markets. The facility's direct GHG emissions of 5.2 Mt/year are high compared to other smaller proposed projects as the PNW project will use natural-gas-driven turbines to drive the compressors that liquefy the natural gas.

At the request of a responsible authority, ECCC reviews the information submitted by the proponents as part of a federal environmental assessment (EA) to confirm that greenhouse gas (GHG) emissions are clearly estimated and will be mitigated to the extent possible. Typically, the scope of LNG project environmental assessments extends to the liquefaction facility and immediate auxiliary construction and operations such as storage facilities and marine tanker loading. Emission sources upstream of the project, i.e., which occur in earlier parts of the natural gas supply chain (such as from well site operations and gas gathering, natural gas processing, and natural gas transmission pipelines) are currently not included as part of the project scope and may be evaluated by various other means such as other federal or provincial EA or permitting processes.

The natural gas supply stages upstream of the PNW LNG project include the natural gas transmission pipeline (TransCanada's proposed 900 km Prince Rupert Gas Transmission pipeline project, which received a provincial EA certificate in November 2014) and the natural gas production and processing stages of the natural gas life-cycle.

Estimating GHG emissions from upstream stages with greater accuracy would require detailed knowledge of the facilities producing, processing and transporting the natural gas and their GHG emissions. For the PNW project, the proponent has indicated that the feedstock natural gas for liquefaction would be supplied via TransCanada's proposed 900 km Prince Rupert Gas Transmission pipeline project that would link the facility with the proposed North Montney Mainline (that in turn will connect to TransCanada's existing system NGTL system, which spans the BC-Alberta border.) It is not clear what exactly the natural gas mix would be to supply the PNW LNG facility, although it will likely be principally BC shale gas from the Montney basin. BC officials currently assume that either 100% of the gas to LNG projects is supplied from BC natural gas production and processing, or that the split is 75% BC gas supply and 25% Alberta gas supply.[1]

[1] The proponent has advised Environment and Climate Change Canada that they have further details on the project's intended natural gas supply sources in the Montney basin, which could lead to lower estimates of upstream GHG emissions.

This analysis does not quantify the amount of incremental natural gas production for the PNW project, if any, so the upstream numbers presented do not necessarily represent an incremental GHG emission. The amount of natural gas that a proposed LNG plant will use does not necessarily correspond to a certain number of new wells; the plant may use existing production capacity that would have otherwise been sold elsewhere. Also, LNG facilities operate for decades and it is likely that changes in natural gas supply as well as in upstream mitigation practices will have an effect on GHG emissions over the lifetime of the facility. For example there may be increased usage of underground injection for storage of $CO_2$ (especially if production increases in basins such as the Horn River with high $CO_2$ content in the extracted natural gas), electrification of gas production operations, or reductions in methane emissions due to more stringent requirements for leak detection and repair, equipment standards, or well completion practices. This analysis is not able to take these changes into account.

The approaches used in this analysis all estimate GHGs using a similar methodology, although with some different assumptions for individual components of the calculation. The mass of LNG produced by the PNW project is used as a proxy for the natural gas supplied to the LNG project, plus a shrinkage factor of 8% to account for gas consumed by the PNW facility turbines. The mass of natural gas is converted to a volume. The GHG emission factors express GHG emissions as tonnes of CO2e emitted for each unit of volume of natural gas produced, processed or transmitted by pipeline. These emission factors are multiplied by the volume of gas which is supplied to the PNW LNG project to calculate the GHG emissions from each upstream stage.

**ECCC GHG Forecast**

ECCC used the projected GHG emissions from the natural gas production, processing, and pipeline transmission sub-sectors from ECCC's most recent GHG projections in the current measures reference scenario (a business-as-usual scenario), which will be published in Canada's Biennial Report. The emission forecast is determined based on GHG emission information in Canada's National GHG Inventory and projected production forecasts from the National Energy Board, which build in assumptions about natural gas supply mixes. The emission factors used for the natural gas production and processing sector in Canada are based upon Clearstone Engineering's 2014 work for ECCC. Clearstone Engineering was commissioned by Environment Canada to provide oil and gas sector data and emission factors to be used for the purposes of emissions inventory, internal analyses and models.

The two ECCC emission forecast cases use average emission factors applicable for each province for each of the upstream stages: natural gas production, processing, and pipeline transmission sub-sectors, and these emission factors were used to calculate the upstream emissions for this analysis. Forecasts are available only until 2030, not for the full 25-year

expected lifetime of the PNW LNG Project. The forecast GHG emissions for 2030 were used in the summary table to align with Pembina's July 2015 PNW report and to ensure that emissions estimates are provided for the facility after Phase 2, at full build-out.

ECCC used the projected GHG emissions from the natural gas production, processing, and pipeline transmission sub-sectors from ECCC's most recent GHG projections in the current measures reference scenario (a business-as-usual scenario) to generate upstream GHG emission estimates for the PNW LNG project using two scenarios (a) assuming 100% of the gas is supplied from BC sources, and b) assuming 75%/25% supply of gas from BC and Alberta, respectively. For the 100% BC gas supply scenario, ECCC estimates the upstream emissions from the PNW project to be 8.1 Mt of $CO_2$e per year after 2022, which includes 0.4 Mt of $CO_2$e per year from the natural gas transmission pipelines and 7.7 Mt of $CO_2$e per year from the natural gas production and processing part of the natural gas supply system. For the 75% BC / 25% Alberta gas supply scenario, ECCC estimates the upstream emissions from the PNW project to be 8.7 Mt of $CO_2$e per year after 2022, which includes 0.6 Mt of $CO_2$e per year from the natural gas transmission pipelines and 8.1 Mt of $CO_2$e per year from the natural gas production and processing part of the natural gas supply system. More detailed year-by-year analysis for the 2020-2030 period is shown in the Annex. The same emission factors are used through the time period so there is little variability in the GHG emissions for a given throughput of natural gas.

**The Pembina / Navius Research BC Shale Scenario Tool**

Earlier this year, the Pembina Institute released their BC Shale Scenario Tool, which is a model that predicts GHG emissions upstream of LNG facilities, and contains a range of project-specific inputs. Emission factors used are based upon Clearstone Engineering's 2014 work or the GHGenius model. The Pembina tool, which was developed with modelling support from Navius Research, is a useful and robust tool. The Pembina tool sets a default gas supply mix (*i.e.* the natural gas production basins that supply the LNG project, such as the Montney or the Horn Rover) but allows the user to change the assumptions about the gas supply mix. The tool has different emission factors for natural gas production/processing stage which vary based on the level of $CO_2$ in the raw natural gas, which is assumed to be vented to the atmosphere, but which do not account for differing emissions from the production or processing facilities' GHG emission mitigation in the various basins. The tool can be used on an incremental basis to account for any number of LNG facilities coming on line in various years.

In their July 2015 report, Pembina used the tool to estimate the upstream emissions associated with the PNW LNG project. They conclude a 2030 emissions level of 6.5 Mt of $CO_2$e per year. A

break-down of production, processing or transmission emissions is not provided. ECCC reproduced this analysis by utilizing Pembina's model and verifying its results. In their analysis, they assume a 65/20/15% Montney, Horn River, conventional natural gas supply mix respectively in 2030. They also provide an alternative scenario assuming significant improvements to environmental technologies and practices such as electrification or upstream carbon capture and storage. In this scenario the 2030 upstream emissions were about half of the business-as-usual scenario. For the purposes of this analysis, ECCC has assumed the current state of environmental technologies and practices.

**British Columbia LNG GHG Life Cycle Analysis**

In early 2014, the BC Ministry of Environment's Climate Action Secretariat released an LNG GHG life cycle analysis prepared for them by Globe Advisors. The study aimed to understand the impact of BC liquefaction plants on global GHG emissions. It used the GHGenius model to estimate GHG emissions, which makes assumptions about the natural supply mix similar to those used in the Pembina tool.

Emissions from natural gas processing were grouped together with liquefaction facility emissions, so ECCC adjusted emission factors to extract the gas processing emissions during the upstream stage from those which occur at the LNG facility, to be consistent with the other approaches. Due to the above needed adjustment, this study is less appropriate to use as a reference for an analysis of upstream-only emissions. The break-down of production, processing and transmission emissions are not clearly provided in the 2014 study. Given the adjustment by ECCC to allow calculation of an upstream-only stage, the breakdown by natural gas sub-sector is less certain so has not been included. After adjustment, the resulting upstream emissions are estimated at 7.2 Mt of $CO_2e$ per year associated with the PNW LNG project. The GHGenius model is based on data from existing facilities and does not include an emission projection, so no year-to-year data are available.

***Sources***

*British Columbia LNG Greenhouse Gas Life Cycle Analysis. British Columbia Ministry of Environment - Climate Action Secretariat. February 2014.*

*British Columbia Shale Scenario Tool – Technical Report. Pembina Institute. June 2015.*

*Calibrating LNG Export Life Cycle Assessment. Canadian Institute of Resources Law. Coleman et al. 2015.*

*Pacific Northwest LNG Implications. Pembina Institute. July 2015.*

*Upstream Oil and Gas Emissions Inventory, Volume 1: Overview of the GHG Emissions Inventory, report for Environment Canada, Clearstone Engineering, March 2014.*

**Annex: Emission factors by upstream stage and year-to-year variability of ECCC emission estimates**

| Emission Factors (tonne of $CO_2e$ per tonne of LNG produced) | | | | |
|---|---|---|---|---|
| Upstream Stage | ECCC Emissions Forecast Gas supply (BC) | ECCC Emissions Forecast Gas supply (Alberta) | Pembina BC Shale Scenario Tool | BC LNG GHG LCA report |
| Gas Production | 0.16 | 0.26 | *Breakdown not available* | *Breakdown not available* |
| Gas Processing | 0.21 | 0.20 | | |
| Gas Transmission | 0.02 | 0.04 | | |
| **Total Upstream** | **0.39** | **0.50** | **0.33** | **0.35*** |

*adjusted to include gas processing in upstream stage

| Year | Annual Upstream Emissions (Mt $CO_2e$) | | |
|---|---|---|---|
| | ECCC Emissions Forecast Gas supply - BC: 100% | ECCC Emissions Forecast Gas supply: BC:75%, AB:25% | Pembina BC Shale Scenario Tool |
| 2020 | 5.5 | 5.8 | 3.6 |
| 2021 | 5.5 | 5.8 | 3.6 |
| 2022 | 8.1 | 8.7 | 5.5 |
| 2023 | 8.1 | 8.7 | 5.6 |
| 2024 | 8.1 | 8.7 | 5.7 |
| 2025 | 8.1 | 8.7 | 5.8 |
| 2026 | 8.1 | 8.7 | 5.9 |
| 2027 | 8.1 | 8.7 | 6.1 |
| 2028 | 8.1 | 8.7 | 6.2 |
| 2029 | 8.1 | 8.7 | 6.3 |
| 2030 | 8.1 | 8.7 | 6.5 |

| Year | Annual Upstream Emissions (Mt $CO_2e$) | | | | | |
|---|---|---|---|---|---|---|
| | ECCC Emissions Forecast Gas Supply: BC: 100% | | | ECCC Emissions Forecast Gas Supply: BC:75%, AB:25% | | |
| | Production | Processing | Transmission | Production | Processing | Transmission |
| 2020 | 2.3 | 2.9 | 0.3 | 2.6 | 2.8 | 0.4 |
| 2021 | 2.3 | 2.9 | 0.3 | 2.6 | 2.8 | 0.4 |
| 2022 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |
| 2023 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |
| 2024 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |
| 2025 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |
| 2026 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |
| 2027 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |
| 2028 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |
| 2029 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |
| 2030 | 3.4 | 4.3 | 0.4 | 3.9 | 4.2 | 0.6 |