Environment and Climate Change Canada
Environnement et Changement climatique Canada

Pacific NorthWest LNG Limited Partnership —

Pacific NorthWest LNG Project

Review of Related Upstream Greenhouse Gas Emissions Estimates

September 2016

Canada

This page intentionally left blank.

Contents

Summary

This document provides an estimate of the upstream greenhouse gas (GHG) emissions associated with the proposed Pacific NorthWest LNG Project (the Project). The analysis does not try to determine whether there is any incremental natural gas production that would result from the Project, or whether it will use natural gas production that would have otherwise occurred. The upstream GHG emissions estimates thus represent the maximum possible incremental GHG emissions.

The Project, a liquefied natural gas facility on Lelu Island near Prince Rupert, British Columbia, is a relatively large project that will produce 20.52 megatonnes of liquefied natural gas 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 13.68 megatonnes of liquefied natural gas per year; a possible Phase two could add an additional production capacity of 6.84 megatonnes of liquefied natural gas per year.

Environment and Climate Change Canada estimated the upstream GHG emissions in Canada associated with the production, processing and transportation of natural gas to the Project. The GHG emissions projections and production projections used by Environment and Climate Change Canada for this review include the estimated future impacts of existing policies and measures that have been implemented as of September 2015. A number of important measures and targets to reduce GHG emissions from the oil and gas sector have been announced since that time, including the Government of Canada's commitment to reduce methane emissions from the oil and gas sector by 40% to 45% below 2012 levels by 2025. While this analysis focuses on policies implemented as of September 2015 and does not reflect the impact of additional federal, provincial or territorial measures announced or under development, it is recognized that future improved practices will mitigate emissions.

Environment and Climate Change Canada estimates that the upstream GHG emissions in Canada associated with the natural gas production, processing and transmission of the natural gas used by the Project could range from 8.8 to 9.3 megatonnes of carbon dioxide equivalent per year in 2030, or about 220 to 235 megatonnes of carbon dioxide equivalent over the 25-year lifetime of the Project. These are rough estimates, given the inherent uncertainties in the current analysis.

Introduction

As part of its January 27, 2016 announcement of interim principles, the Government of Canada has committed to undertake an assessment of upstream greenhouse gas (GHG) emissions associated with projects undergoing an environmental assessment (1).

The Pacific NorthWest LNG project (the Project) is one of 19 liquefied natural gas (LNG) production and export terminals proposed for the coast of British Columbia (B.C.). It is a relatively large facility projected to produce 20.52 megatonnes (Mt) of LNG per year at full capacity. Natural gas will be liquefied and shipped via LNG carriers to foreign markets.

Analysis

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 review covers all GHG emissions, including fugitives, venting, flaring, combustion, and other sources. The GHG emissions from these sources contain carbon dioxide, methane and nitrous oxide. These constituents of GHG emissions were added together taking into account their respective global warming potentials. The scope of this review does not extend to indirect upstream emissions, such as those related to land-use changes and those generated during the production of purchased inputs including equipment and grid electricity. Those emissions have only been considered if they are not distinguishable from direct upstream emissions.

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

GHG emissions associated with the natural gas production and processing stages are influenced by the formation from which the gas is extracted. For the Project, the proponent has indicated that the feedstock natural gas for liquefaction would be supplied via TransCanada's proposed 900 kilometers *Prince Rupert Gas Transmission* project that would link the facility with the proposed *North Montney Mainline* project (that in turn will connect to TransCanada's existing *NOVA Gas Transmission Ltd.* system, which spans the B.C.-Alberta border). It is not clear what the exact natural gas mix would be to supply the Project, although it will likely be B.C. shale gas from the Montney basin. B.C. officials currently assume that either 100% of the gas to LNG projects is supplied from B.C. natural gas production and processing, or that the split is 75% B.C. gas supply and 25% Alberta gas supply.

The table below summarizes several sources of upstream emissions estimates for the Project for a number of potential scenarios. Estimates were adjusted to reflect a revised production value provided by the proponent, increasing projected LNG production from 19.2 megatonnes of liquefied natural gas per year at full capacity to 20.52 megatonnes of liquefied natural gas per year at full capacity. Two estimates are provided based on the projected GHG emissions from the natural gas production, processing, and pipeline transmission sub-sectors from Environment and Climate Change Canada (ECCC)'s most recent GHG projections in the *with current measures* reference scenario (a business-as-usual scenario), which was published in *Canada's Second Biennial Report on Climate Change* (2). The first estimate that assumes 100% of the gas is supplied from sources in B.C. The second assumes 75% supply of gas from B.C. and 25% from Alberta.

Estimates are also provided using the Pembina Institute's *B.C. Shale Scenario Tool* (3) and using information from the *British Columbia LNG Greenhouse Gas (GHG) Life Cycle Analysis* report (4). For the *B.C. Shale Scenario Tool*, estimates include both the model's default gas mix along with a 100% Montney basin gas source. The *B.C. Shale Scenario Tool* and the *British Columbia LNG Greenhouse Gas (GHG) Life Cycle Analysis* report do not break out each stage in a consistent fashion, so only a total upstream number is included.

	Annual 2030 Emissions[1] ($Mt CO_2$ eq)				
	ECCC Emissions Forecast[2] **Gas supply: 100% B.C.**	**ECCC Emissions Forecast[2]** **Gas supply: 75% B.C. 25% AB**	***Pembina B.C. Shale Scenario Tool*[3,4]** **Gas supply: Default gas mix**	***Pembina B.C. Shale Scenario Tool*[3,4,5]** **Gas supply: 100% Montney**	**B.C. LNG GHG LCA report[3]**
Transmission	0.5	0.6	6.9	5.6	7.7
Production & Processing	8.3	8.7			
Total Upstream	**8.8**	**9.3**	**6.9**	**5.6**	**7.7**

[1] Emissions forecasts reflect policies implemented as of September 2015 and do not reflect the impact of additional federal, provincial or territorial measures announced or under development. Future measures, including the Government of Canada's commitment to reduce methane emissions by 40% to 45% from 2012 levels by 2025, will reduce the emissions forecasts in the future.

[2] The ECCC Emissions Forecast uses the most recent projected GHG emissions in the *with current measures* reference scenario.

[3] Estimates for this scenario were adjusted to account for revised facility production which increased from 19.2 Mt of LNG per year to 20.52.

[4] The global warming potential of methane in the *B.C. Shale Scenario Tool* is 21. As a result, the GHG estimates using this tool are lower than they would be if the tool used the more updated value of 25, which is the value used in the other scenarios.

[5] This scenario was run by the Pembina Institute at the request of ECCC to reflect a gas supply of 100% Montney.

The mass of LNG *produced* by the Project is used as a proxy for the natural gas *supplied* to the Project, plus a shrinkage factor of 8% to account for gas consumed by the facility turbines. The

mass of natural gas is converted to a volume. The GHG emission factors express GHG emissions as tonnes of CO_2 eq 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 Project to calculate the GHG emissions from each upstream stage. The emission factors for each methodology and information on year-to-year variability for the ECCC model are included in the Annex of this review.

Incremental natural gas production was not quantified and the upstream numbers presented do not necessarily represent incremental GHG emissions. The amount of natural gas that a proposed LNG facility would use would not necessarily correspond to a certain number of new wells; the plant could use existing production capacity that would have otherwise been sold elsewhere.

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 basin with high CO_2 content in the extracted natural gas) or electrification of gas production operations, both of which would mitigate emissions. The Government of Canada's commitment to develop and implement regulations to reduce methane emissions from the oil and gas sector by 40% to 45% below 2012 levels by 2025 will result in reductions of methane emissions from upstream gas operations (5). While this analysis focuses on policies implemented as of September 2015 and does not reflect the impact of additional federal, provincial or territorial measures announced or under development, it is recognized that future improved practices will mitigate emissions.

Electrification of upstream production and processing operations also has the potential to reduce upstream GHG emissions. In its *Climate Leadership Plan*, the province of B.C., commits to explore further electrification of the Montney basin with the expectation that between 1.6 Mt of CO_2 eq and 4.0 Mt of CO_2 eq can be avoided (6).

GHG emissions along the entire life-cycle of natural gas and LNG related to the 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 the Project GHG emissions and upstream GHG emissions in Canada, there will also be indirect GHG emissions from electricity generation, which may occur in B.C. 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 lack of reliable data and methodologies, the current analysis is restricted only to the natural gas sector lifecycle stages upstream of the 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.

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 *with current measures* reference scenario (a business-as-usual scenario), of *Canada's Second Biennial Report on Climate Change* (2). The emission forecast is determined based on GHG historical emission data in Canada's National GHG Inventory and the energy price and production forecasts from the National Energy Board (7), 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 on the work of Clearstone Engineering Ltd., commissioned by ECCC to provide oil and gas sector data and emission factors to be used for the purposes of emissions inventories, development of emissions projects, internal analyses and models (8).

A number of recently announced provincial government policies, such as those outlined in Alberta's *Climate Leadership Plan* (9) and British Columbia's *Climate Leadership Plan* (6), will have an impact on Canadian GHG emissions, but were not reflected in *Canada's Second Biennial Report on Climate Change* as the details of these policies were not available at the time of publication. Alberta's *Climate Leadership Plan* includes a commitment to cap emissions from oil sands facilities at 100 Mt in any year, reduce methane emissions from oil and gas operations by 45% by 2025, set performance standards for large industrial emitters, and apply a carbon levy to fuels. British Columbia's *Climate Leadership Plan* includes a commitment to launch a strategy to reduce upstream methane emissions by 45% by 2025, to develop regulations to enable carbon capture and storage projects to proceed and commits to take action to electrify upstream natural gas projects.

On March 3, 2016, First Ministers adopted the *Vancouver Declaration on Clean Growth and Climate Change*, in which they commit to develop a concrete plan to achieve Canada's international climate commitments and become a leader in the global clean growth economy (10). The Government of Canada has also committed to reduce methane emissions from the oil and gas sector by 40% to 45% below 2012 levels by 2025. While this analysis focuses on policies implemented as of September 2015 and does not reflect the impact of additional federal, provincial, or territorial measures announced or under development, it is recognized that future improved practices will mitigate emissions. As measures to meet targets are implemented, they will be incorporated into future emissions projections and future upstream GHG reviews.

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 Project. The forecast GHG emissions for 2030 were used in the summary table to align with a the Pembina Institute's *Pacific Northwest LNG Implications* report (11) and to ensure that emissions estimates are provided for the facility after Phase 2, at full build out.

ECCC generated upstream GHG emission estimates for the Project using two scenarios (a) assuming 100% of the gas is supplied from B.C. sources, and b) assuming a 75%/25% supply of gas from B.C. and Alberta, respectively. For the 100% B.C. gas supply scenario, ECCC estimates the upstream emissions from the Project to be 8.8 Mt of CO_2 eq per year after 2022, which includes 0.5 Mt of CO_2 eq per year from the natural gas transmission pipelines and 8.3 Mt of CO_2 eq per year from the natural gas production and processing stages of the natural gas supply system. For the 75% B.C. / 25% Alberta gas supply scenario, ECCC estimates the upstream emissions from the Project to be 9.3 Mt of CO_2 eq per year after 2022, which includes 0.6 Mt of CO_2 eq per year from the natural gas transmission pipelines and 8.7 Mt of CO_2 eq per year from the natural gas production and processing stages of the natural gas supply system. More detailed year-by-year analysis for the 2020-2030 period is shown in the Annex.

The B.C. Shale Scenario Tool

In 2015, the Pembina Institute released their *B.C. Shale Scenario Tool* (the Pembina tool) (3), 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 on the work of Clearstone Engineering Ltd. (8) and the GHGenius model (12). The Pembina tool, which was developed with modelling support from Navius Research, sets a default gas supply mix (*i.e.* the natural gas production basins that supply the LNG project, such as the Montney basin or the Horn River basin) and allows the user to change various factors, such as policy scenarios or raw gas supply sources which have varying levels of formation CO_2. The Pembina tool uses a global warming potential of 21 whereas the ECCC GHG Forecast uses a global warming potential of 25. The Pembina tool can be used on an incremental basis to account for any number of LNG facilities coming on line in various years (13).

In their *Pacific Northwest LNG Implications* report, the Pembina Institute used the Pembina tool to estimate the upstream emissions associated with the Project (11). They conclude a 2030 emissions level of 6.5 Mt of CO_2 eq per year. Adjusted for the revised production value, the estimate would be 6.9 Mt CO_2 eq per year. A break-down of production, processing or

transmission emissions is not provided. ECCC reproduced this analysis by utilizing the Pembina tool and verifying its results. In their analysis, they assume a 65%, 20%, and 15% Montney basin, Horn River basin, and conventional natural gas supply mix in 2030, respectively. 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.

The proponent has provided ECCC with information indicating that there is likelihood that much or all of the gas supplied to the Project would be sourced from the Montney basin, which has lower formation CO_2 than other basins. As the Department's emission factors are applied provincially and cannot be applied to individual basins, the Pembina Institute was asked to run a special scenario with their *BC Shale Scenario Tool* whereby 100% of the gas is sourced from the Montney basin. This resulted in estimates of upstream emissions of 5.6 megatonnes of carbon dioxide equivalent (adjusted for the revised production value). Annual emissions for this scenario are provided in the Annex. As noted, should electrification of Montney production occur, emissions would be further reduced.

British Columbia LNG GHG Life Cycle Analysis

In early 2014, the B.C. Ministry of Environment's Climate Action Secretariat released an LNG GHG life cycle analysis report prepared for them by GLOBE Advisors (4). The study aimed to understand the impact of B.C. liquefaction plants on global GHG emissions. It used the GHGenius model (12) 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 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_2 eq per year associated with the Project. Adjusted for the revised production value, the estimate would be 7.7 Mt CO_2 eq per year. The GHGenius model is based on data from existing facilities and does not include an emissions projection, so no year-to-year data are available.

Bibliography

1. **Government of Canada.** Interim Measures for Pipeline Reviews. *Government of Canada.* [Online] January 27, 2016. [Cited: September 6, 2016.] http://news.gc.ca/web/article-en.do?mthd=tp&crtr.page=1&nid=1029989&crtr.tp1D=930.

2. —. Canada's Second Biennial Report on Climate Change. *Environment and Climate Change Canada.* [Online] February 10, 2016. [Cited: September 6, 2016.] https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=02D095CB-1.

3. **Pembina Institute.** B.C. Shale Scenario Tool. [Online] Pembina Institute, June 15, 2015. [Cited: September 6, 2016.] http://www.pembina.org/pub/BCShaleTool.

4. **GLOBE Advisors.** *British Columbia LNG Greenhouse Gas (GHG) Life Cycle Analysis.* s.l. : BC Ministry of Environment, Climate Action Secretariat, 2014.

5. **Government of Canada.** Reducing methane emissions from Canada's oil and gas industry. [Online] Environment and Climate Change Canada, March 10, 2016. [Cited: September 6, 2016.] http://news.gc.ca/web/article-en.do?nid=1039219.

6. **Government of British Columbia.** Climate Leadership Plan. *Climate Leadership - Government of British Columbia.* [Online] [Cited: September 6, 2016.] http://climate.gov.bc.ca/tile/read-bcs-climate-leadership-plan/.

7. **National Energy Board.** Canada’s Energy Future 2016: Energy Supply and Demand Projections to 2040. *National Energy Board.* [Online] January 2016. [Cited: September 6, 2016.] https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016/index-eng.html.

8. **Clearstone Engineering Ltd.** *UOG Emissions Inventory - Volume 4 - Compendium of Factors and Terminology.* 2014. v3.1.

9. **Government of Alberta.** Climate Leadership Plan. *Government Projects, Priorities and Consultations.* [Online] [Cited: September 6, 2016.] http://www.alberta.ca/climate-leadership-plan.cfm.

10. **First Ministers.** Vancouver Declaration on clean growth and climate change. *Canadian Intergovernmental Conference Secretariat.* [Online] March 3, 2016. [Cited: September 6, 2016.] http://www.scics.gc.ca/english/conferences.asp?a=viewdocument&id=2401.

11. **Pembina Institute.** *Pacific Northwest LNG Implications.* s.l. : Pembina Institute, 2015.

12. **(S&T)2 Consultants Inc.** *GHGenius - A model for lifecycle assessment of transportation fuels.* [Online] (S&T)2 Consultants Inc. [Cited: September 6, 2016.] http://www.ghgenius.ca/.

13. **Maximilian Kniewasser, Matt Horne.** *B.C. Shale Scenario Tool: Technical report.* s.l. : Pembina Institute, 2015.

14. **Stantec Consulting Ltd.** Environmental Impact Statement and Environmental Assessment Certificate Application Authorship - 7 Greenhouse Gas Management. *Canadian Environmental Assessment Agency.* [Online] February 2014. [Cited: September 6, 2016.] http://www.ceaa-acee.gc.ca/050/documents/p80032/98681E.pdf.

15. **Pacific NorthWest LNG.** From Pacific NorthWest LNG Ltd. to the Canadian Environmental Assessment Agency re: Pacific NorthWest LNG Project and Interim Approach for Federal Environmental Assessments. - See Reference Document #89. *Canadian Environmental Assessment Agency.* [Online] February 2, 2016. [Cited: September 6, 2016.] http://www.ceaa.gc.ca/050/documents/p80032/104791E.pdf.

Annex — Emission Factors by Upstream Stage and Year-to-Year Variability of ECCC Emission Estimates

	Emission Factors (tonnes of CO_2 eq per tonne of LNG produced)				
Upstream Stage	**ECCC Emissions Forecast** **B.C. Gas supply**	**ECCC Emissions Forecast** **Alberta Gas supply**	***B.C. Shale Scenario Tool*** **65% Montney** **20% Horn River** **15% conventional**	***B.C. Shale Scenario Tool*** **100% Montney**	**B.C. LNG GHG LCA report**
Gas Production	0.16	0.26	*Breakdown not available*		
Gas Processing	0.21	0.20			
Gas Transmission	0.02	0.04			
Total Upstream	**0.39**	**0.50**	**0.33**	**0.27**	**0.35***

***adjusted to include gas processing in upstream stage**

	Annual Upstream Emissions (Mt CO_2 eq)			
Year	**ECCC Emissions Forecast** **Gas supply: 100% B.C.**	**ECCC Emissions Forecast** **Gas supply: 75% B.C. 25% AB**	***B.C. Shale Scenario Tool*** **Gas supply: 65% Montney 20% Horn River 15% conventional**	***B.C. Shale Scenario Tool*** **Gas supply: 100% Montney**
2020	5.9	6.3	3.8	3.2
2021	5.9	6.2	3.8	3.2
2022	8.8	9.3	5.9	4.8
2023	8.8	9.3	6.0	4.9
2024	8.8	9.3	6.1	5.0
2025	8.8	9.3	6.2	5.0
2026	8.8	9.3	6.3	5.1
2027	8.8	9.3	6.5	5.2
2028	8.8	9.3	6.6	5.3
2029	8.8	9.3	6.7	5.5
2030	8.8	9.3	6.9	5.6

Year	Annual Upstream Emissions ($Mt CO_2 eq$)					
	ECCC Emissions Forecast Gas Supply: 100% B.C.			ECCC Emissions Forecast Gas Supply: 75% B.C. 25% AB		
	Production	**Processing**	**Transmission**	**Production**	**Processing**	**Transmission**
2020	2.4	3.1	0.4	2.8	3.0	0.4
2021	2.4	3.1	0.4	2.8	3.0	0.4
2022	3.6	4.6	0.5	4.2	4.5	0.6
2023	3.6	4.6	0.5	4.2	4.5	0.6
2024	3.6	4.6	0.5	4.2	4.5	0.6
2025	3.6	4.6	0.5	4.2	4.5	0.6
2026	3.6	4.6	0.5	4.2	4.5	0.6
2027	3.6	4.6	0.5	4.2	4.5	0.6
2028	3.7	4.6	0.5	4.2	4.6	0.6
2029	3.7	4.6	0.5	4.2	4.6	0.6
2030	3.7	4.6	0.5	4.2	4.6	0.6