Woodfibre LNG Facility GHG Emissions Comparison

Prepared for: **Woodfibre LNG Limited**
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Executive Summary

This briefing note provides a high-level analysis of the facility-level greenhouse gas (GHG) emissions for the Woodfibre Liquid Natural Gas (LNG) facility in Squamish, British Columbia compared to other industrial facilities. The analysis also comments on the relative benefits of LNG (natural gas) as a fuel source for electricity generation compared to other fossil fuels. The estimated annual emissions for the Woodfibre LNG facility are 129 $ktCO_2e$/year.[1] This figure was submitted as part of Woodfibre LNG's environmental impact statement to the BC government in 2015; the analysis was prepared by Golder Associates and is in line with the GHG Protocol.[2] It includes direct emissions associated with the operations of the facility including stationary fuel consumption, mobile equipment use and fugitive emissions. It presumes that the facility, when operating at full capacity, will have an annual energy throughput of 2.1 million tonnes of LNG per year.

This briefing note is specific to the direct emissions of Woodfibre's Squamish, BC LNG facility and compares it to other industrial facilities. It does not include analysis of upstream emissions.

The annual GHG emissions from the Woodfibre LNG facility represent a small fraction of the emissions by large industrial emitters in British Columbia. The largest single facility industrial emitter in BC has emissions more than 15 times the annual amount of Woodfibre's facility. According to the latest emissions statistics published by the Government of BC, Woodfibre LNG's annual emissions would not even place it in the top 25 largest single facility emitters in the province.

The emissions intensity at Woodfibre's facility is substantially lower compared to other LNG facilities. Woodfibre's GHG emissions intensity is 16% of the global average, making it substantially cleaner than other LNG facilities.[3] The replacement of coal-fired electricity with natural gas-fired electricity generation using Woodfibre LNG contributes to a substantial avoidance of GHG emissions. Using LNG from the Woodfibre facility to produce electricity would result in an estimated 45% GHG emissions reduction compared to an equivalent amount of coal-fired electricity generation. To put it in context, these avoided emissions would be equivalent to 1.5 million car trips (round trip) from Vancouver to Toronto, or 76 years worth of the annual emissions from Squamish itself.

While still a fossil fuel, natural gas has the potential to play an important role in reducing GHG emissions associated with the production of coal-fired electricity. As the International Energy Agency (IEA) states: "from an energy transitions perspective, natural gas can provide near-term benefits when replacing more polluting fuels".[4] In the IEA's World Energy Outlook for 2019, the "Stated Policies Scenario", which provides a forecast based on current climate policy commitments – including those with net-zero by 2050 targets from national governments –

[1] Golder Associates. "Appendix 5.3-1 Greenhouse Gas Methodology." 6 Jan 2015.
[2] World Resources Institute and World Business Council for Sustainable Development. "The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard" https://ghgprotocol.org/corporate-standard
[3] Globe Advisors. "British Columbia LNG Greenhouse Gas (GHG) Life Cycle Analysis." https://www2.gov.bc.ca/assets/gov/environment/climate-change/ind/lng/british_columbia_lng_greenhouse_gas_ghg_life_cycle_analysis.pdf
[4] IEA. IEA. "World Energy Outlook 2019: Executive Summary." Page 6.

predicts that LNG will meet a third of the world's growing energy demand.[5] In the IEA's most aggressive decarbonization scenario – the "Sustainable Development Scenario", which aligns with the Paris Agreement targets – natural gas still plays an important role in global energy production. Under the Sustainable Development Scenario, gas use as a flexible transition fuel increases until the late 2020s, displacing coal; however, gas projects without carbon capture utilization and storage technology then begin to decline.[6] By 2040, under the Sustainable Development Scenario, gas is still providing more than 5,000 terawatt hours of energy globally.[7]

Woodfibre LNG has an opportunity to play a critical role in meeting this need, and in doing so delivering LNG that is lower emissions than that from other facilities in Canada and around the world.

Comparison with other industrial facilities in BC

A review of the Woodfibre LNG facility's emissions finds that it compares favourably to other large single industrial facilities in British Columbia. Based on the latest information from the Province of British Columbia, Woodfibre LNG's emissions would not place it in the top 25 largest emitters in the province. In fact, the largest industrial single facility emitter in the province produces more than 15 times the emissions of the Woodfibre facility.

Considerations

- The data has been sourced from the most recent British Columbia industrial facility GHG emissions inventory, presenting GHG emissions from facilities for the year 2017 (https://www2.gov.bc.ca/gov/content/environment/climate-change/data/industrial-facility-ghg)

- The BC government mandates GHG emissions reporting for facilities that emit 10,000 tCO_2e or more per year (annual threshold is 10,000 tCO_2e) (https://projects.eao.gov.bc.ca/api/document/58869182e036fb0105768fa0/fetch/Appendix%205.3-1%20Greenhouse%20Gas%20Methodology.pdf – *Page 23*)

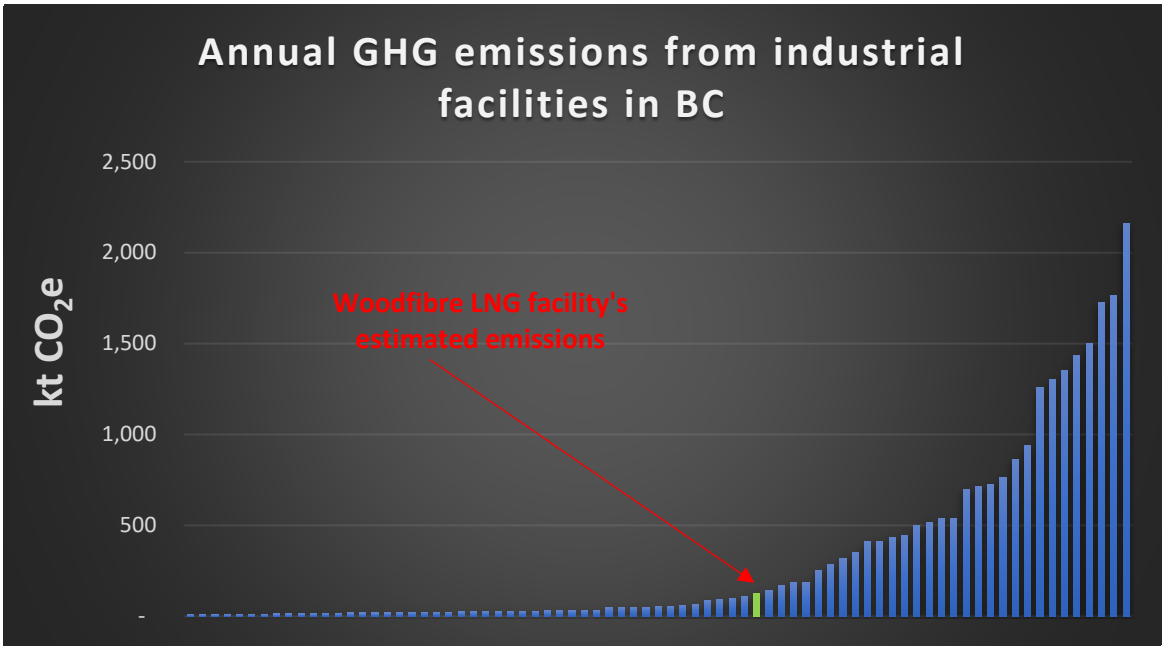
- All single industrial facilities that emitted 10,000 tCO_2e or more in 2017 have been considered for this comparison

- If linear facility operations that emitted 10,000 tCO_2e or more in 2017 were also included, Woodfibre LNG's facility emissions would not place it in the top 45 largest emitters. The largest linear industrial emitter in BC has emissions more than 24 times the annual amount of Woodfibre's facility

[5] IEA. "World Energy Outlook 2019: Executive Summary." Page 1.
[6] IEA. "Tracking power: natural gas-fired power." https://www.iea.org/reports/tracking-power-2019/natural-gas-fired-power#abstract
[7] IEA. "Tracking power: natural gas-fired power." https://www.iea.org/reports/tracking-power-2019/natural-gas-fired-power#abstract

Comparison between the Woodfibre LNG facility's carbon footprint and other industrial facilities in BC

*The Woodfibre LNG facility, once operational, is projected to emit **129 kilotonnes of direct CO_2e emissions** annually. The chart below shows how the facility's carbon footprint compares to the 2017 annual emissions from other industrial facilities in BC.*



Regional comparisons

A look at the emissions of various regional and provincial benchmarks provides insight into how Woodfibre's facility emissions fit within the overall context of GHG emissions in BC. The Woodfibre facility's emissions represent just 0.2% of BC's entire annual emissions.

Considerations

- The annual emissions of industrial sectors in BC have been sourced from the 2017 provincial inventory: (https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory)

- BC's emissions are from the provincial inventory: https://www2.gov.bc.ca/assets/gov/environment/climate-change/data/provincial-inventory/2017/2017_provincial_inventory.xlsx

- The GHG emissions for municipalities (Squamish and Whistler) are from 2012, as this is the most up-to-date information (https://www2.gov.bc.ca/gov/content/environment/climate-change/data/ceei), and include emissions associated with the following sources:
    - Buildings (Residential and Commercial heating & water heating): Oil, Propane, Wood, Natural Gas, Electricity
    - Land-use Change – Deforestation for: Industrial, Hydro, Mining, Municipal, Recreation, Transportation
    - Community Solid Waste

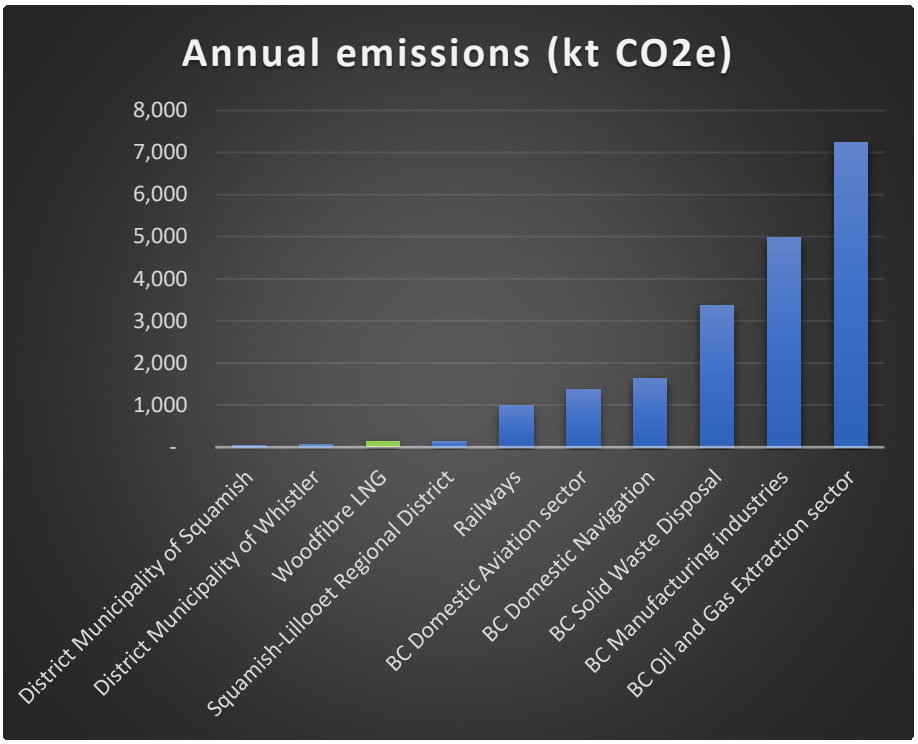
- The GHG emissions for the Regional District of Squamish-Lillooet, including Unincorporated Areas, are also from 2012, as this is the most up-to-date information (https://www2.gov.bc.ca/gov/content/environment/climate-change/data/ceei), and include emissions associated with the following sources:
    - Buildings (Residential and Commercial heating & water heating): Oil, Propane, Wood, Natural Gas, Electricity
    - Community Solid Waste

- BC Domestic Aviation sector emissions include Canadian registered airlines flying domestically within Canada and originating in BC, including commercial, private, and agricultural flights [8]

- BC Domestic Navigation sector emissions include Canadian registered marine vessels fuelled domestically in BC

[8] https://www2.gov.bc.ca/assets/gov/environment/climate-change/data/provincial-inventory/bc-methodology-book_ghg-provincial-inventory.pdf

Comparison between annual GHG emissions from Woodfibre's LNG facility and regional and provincial benchmarks

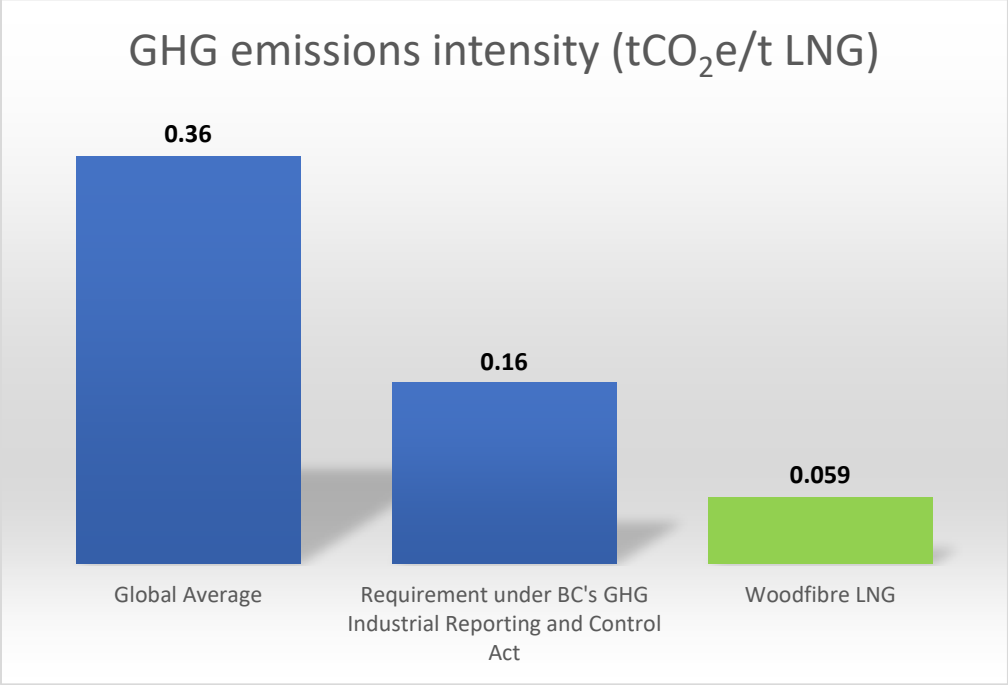


Energy comparisons

The emissions intensity of the Woodfibre LNG facility compares favourably to other LNG facilities, as well as the emissions intensity of other fossil fuels. Woodfibre's LNG facility emissions intensity is 16% of the global average for LNG plants. If Woodfibre LNG's annual throughput was used to generate electricity, it would result in an approximate 45% reduction in emissions compared to an equivalent amount of electricity generated by coal.

Woodfibre emissions intensity compared to other LNG facilities

*The emissions intensity of the Woodfibre LNG facility is **0.059 tCO_2e/tonne LNG,** which is lower than most existing LNG plants. It is also below the requirements set by BC's GHG Industrial Reporting and Control Act.*



Comparison of GHG emissions associated with the generation of electricity

Considerations

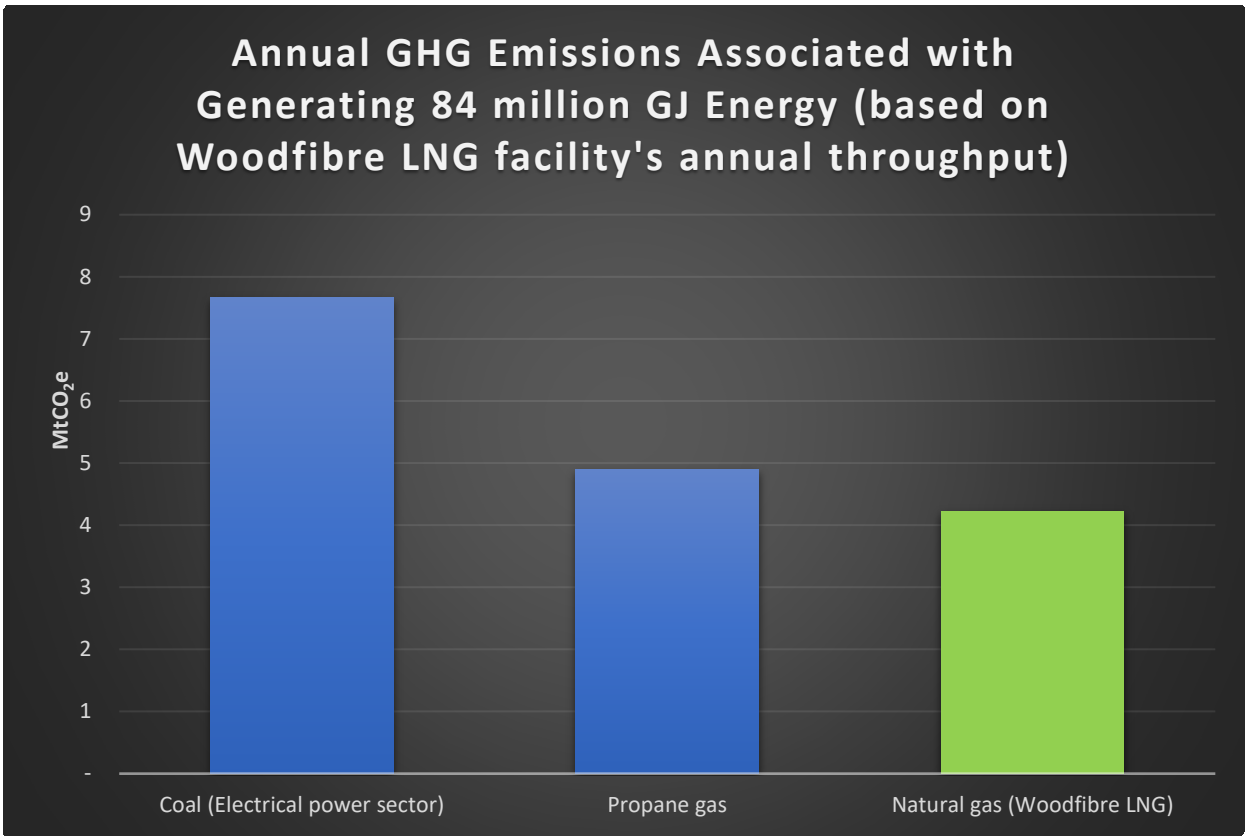
- The emissions associated with each fossil fuel considered have been calculated using a hypothetical situation where the respective fossil fuel is used to produce an equivalent amount of electricity to what one year of Woodfibre LNG's expected throughput would generate

- Emission factors for fuel types (coal, propane and natural gas) have been taken from the US Environmental Protection Agency's (EPA) *Emission Factors for Greenhouse Inventories*[9]

- The EPA's *Greenhouse Gas Equivalencies Calculator* was used to estimate the GHG emissions associated with passenger vehicle usage. A weighted average combined fuel economy for cars and light trucks was used.[10]

[9] https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf
[10] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

*The Woodfibre LNG facility will have an annual throughput of **2.1 million tonnes of LNG**. Natural gas produces **a lower amount of GHG emissions** compared to other fossil fuels on an energy basis.*



Based on the use of one year of LNG throughput from Woodfibre's LNG facility to generate electricity, approximately **3.5 million tCO_2e** of emissions would be avoided if displacing coal-fired electricity.[11] This is equivalent to an approximately **45% reduction in GHG emissions** compared to coal-fired electricity generation.

This reduction in emissions is equivalent to:

- Taking around **700,000 passenger vehicles** off the road for a year[12]
- Roughly **5% of BC's annual GHG emissions**[13]

[11] https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf
[12] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator (Weighted average combined fuel economy of cars and light trucks have been considered)
[13] https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory

- Roughly **1.5 million passenger vehicles** completing a round trip from Toronto to Vancouver[14]
- Roughly **57 million passenger vehicles** completing a round trip from Vancouver to Whistler[15]
- The entire annual emissions from the **Municipality of Squamish** for around **76 years**

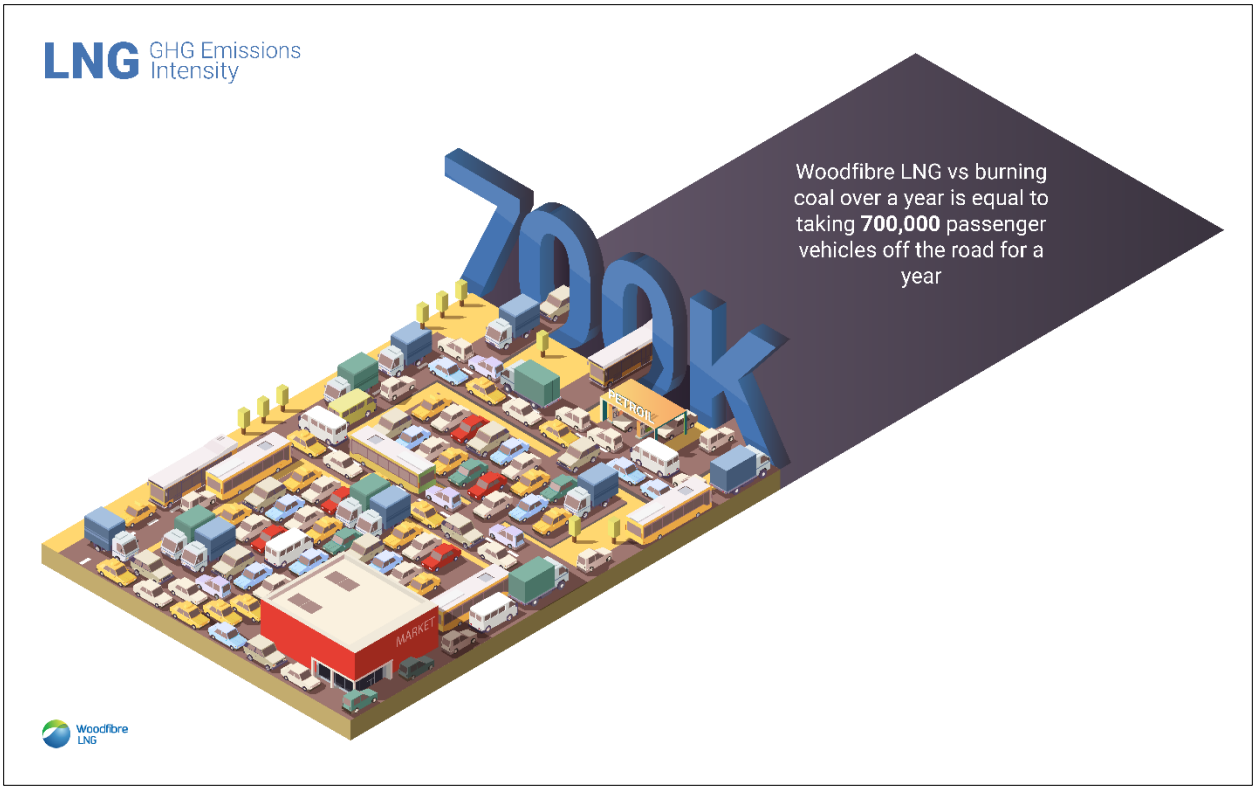
Summary

LNG produced by Woodfibre has the potential to reduce greenhouse gas emissions by replacing coal in the production of electricity in Asia. Directly replacing coal-powered electricity with Woodfibre LNG provides a 45% reduction in GHG emissions in the production of the same amount of electricity. While LNG's carbon advantage over other fossil fuels such as coal is well known, what is less known is how Woodfibre's facility compares to other LNG production facilities. Woodfibre's facility compares favorably to other LNG facilities both in BC and globally, operating at a lower emissions intensity and providing a distinct advantage in producing less emission-intensive LNG.

The Woodfibre facility is a relatively small contributor to emissions in BC compared to other forms of heavy industry. Once operating, it would not rank in the top 25 largest single facility emitters in the province. Woodfibre's LNG facility delivers LNG at a lower emissions intensity than other comparable facilities, and by displacing coal, can reduce GHG emissions in other countries.

[14] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
[15] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

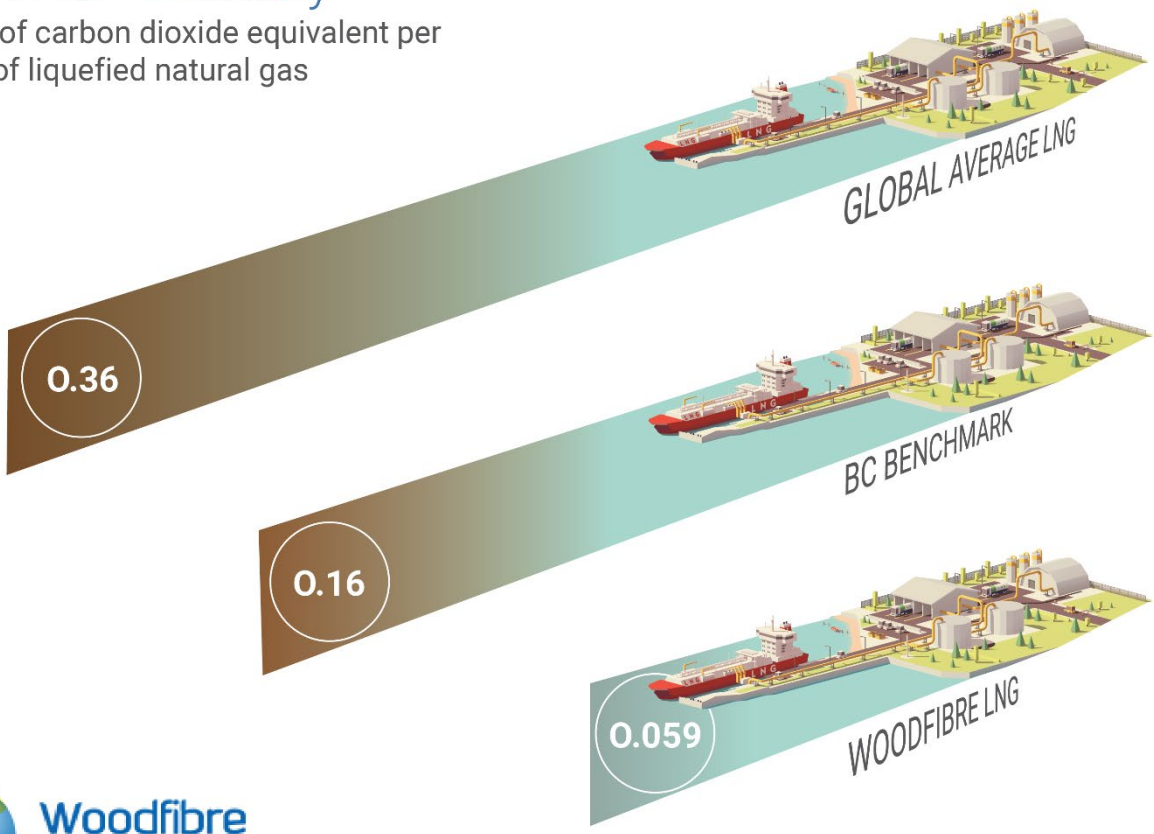
Appendix: Graphics




LNG GHG Emissions Intensity
Woodfibre LNG vs Burning Coal over a year is equal to avoiding **76 years** of emissions from the Municipality of Squamish
76 years
SQUAMISH
Woodfibre LNG

LNG GHG Emissions Intensity

Tonne of carbon dioxide equivalent per tonne of liquefied natural gas



Woodfibre LNG


WOODFIBRE
LNG
VS
BURNING
COAL
OVER A YEAR IS EQUAL TO AVOIDING
3,000,000
TRIPS FROM
VANCOUVER
TO TORONTO
Vancouver
Toronto