PacifiCan-MMRI Accelerating Circular Economy (ACE) TechBrief Report

Project title: Life Cycle Assessment to Inform Potential for Internationally Transferred Mitigation Outcomes in Canada's LNG Industry

Industry partner(s): FortisBC

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Introduction & Background:

Greenhouse gas (GHG) emissions significantly contribute to climate change, prompting an international response to mitigate their impacts [1]. The 2015 Paris Climate Accord brought together 195 nations to set Nationally Determined Contributions (NDCs) for emission reductions and introduced internationally transferred mitigation outcomes (ITMOs) as a carbon trading framework. However, many countries have struggled to meet their targets, emphasizing the need for enhanced efforts [2]. Canada is exploring the export of liquefied natural gas (LNG) to Asian markets as an ITMO initiative to replace coal-based energy generation, particularly in coal-dependent countries like China. While Canadian LNG has lower life cycle emissions compared to coal and can support emissions trading, concerns persist about the environmental impacts and national energy security [3]. Thus, a comprehensive feasibility study is necessary to assess the true costs and environmental benefits of LNG exports, employing a life cycle thinking approach to evaluate the broader impacts and ensure applicability of ITMOs in LNG trading that replace coal use.

Relevance to Circular Economy:

The study aligns with circular economy principles by promoting emission reduction and sustainable energy transitions. It evaluates LNG as a cleaner alternative to coal,. By applying life cycle assessment (LCA) and evaluating the feasibility of applying ITMOs under the Paris Agreement, it ensures measurable emission benefits. The findings support sustainable industrial practices, market-based emission reductions, and policy recommendations for cleaner energy trade. Overall, the study advances the circular economy goal by fostering low-carbon energy transitions and systematic change in international energy markets.

Methodology:

The overall methodology was developed to address the following research question:

- What is the life cycle GHG emission reduction potential of exported LNG from BC, Canada to cater to the selected end-uses in China, compared to using domestic coal?

Based on a thorough literature survey and industrial expert inputs, LNG export scenarios were defined. A life cycle impact assessment framework (Figure 1) was developed to quantify GHG emissions occurring at each supply chain stages. The life cycle environmental impact database was developed employing LCA tool with SimaPro Software. The data for the LCA were gathered from published literature, reports, and industry sources. A sensitivity and an uncertainty analysis was conducted using fuzzy logic to account for data uncertainties. Finally, LNG supply chain paths were compared against each other and recommendations were provided for ITMO generation.

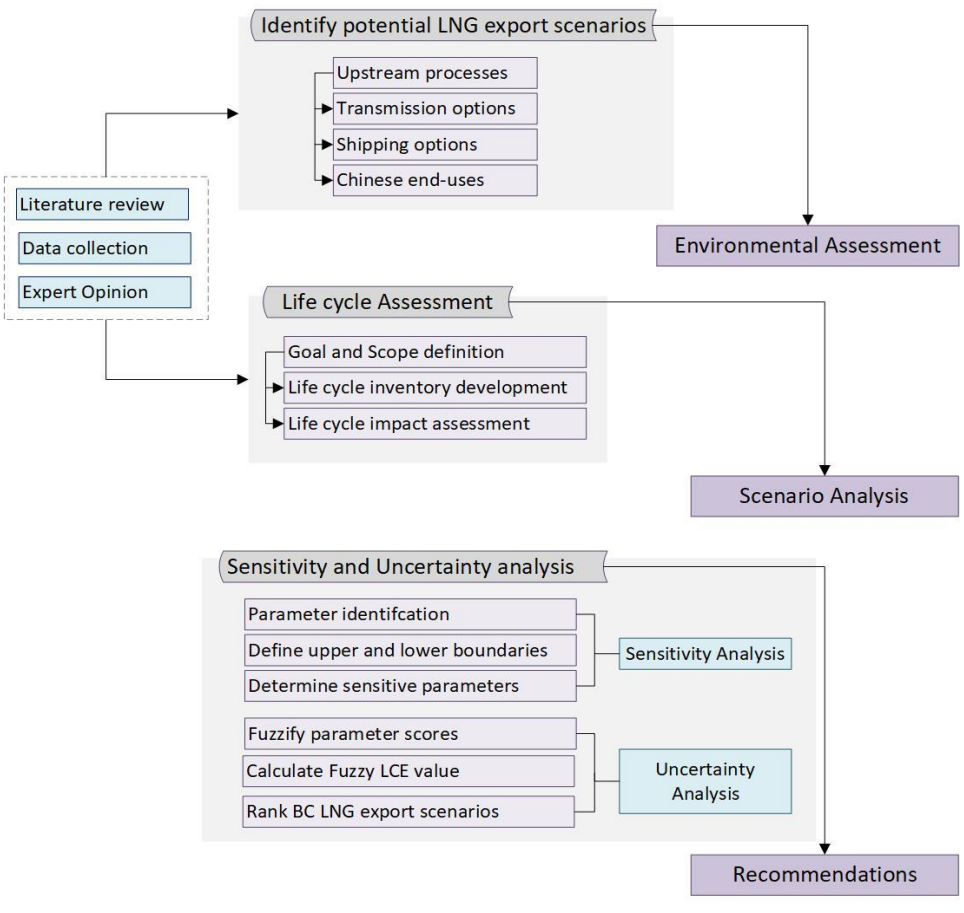

Figure 1: *Assessment framework [2]*

Results & Discussion

When generating ITMOs, emission reductions are accounted for in the emission inventory of the host country (China). Hence, the operation emission reduction resulted from replacing coal with Canadian LNG is shown in Figure 2. In all industrial use-cases, significant emission reductions can be achieved. Highest emission reduction of 67.6% is possible with replacing coal use in district heating in China.

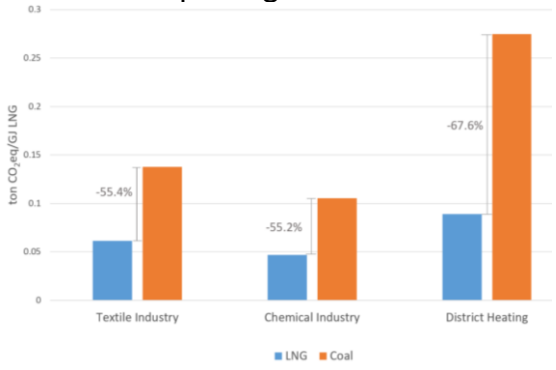

Figure 2: *Operational emissions and emission reduction of replacing coal with LNG*

Use of Canadian LNG in the textile and chemical industries result in 55.4% and 55.2% reductions respectively. Such emission reductions will benefit China greatly in achieving the NDC targets. Yet, decision should not be made focusing only the end-use stage, but overall supply chain needs to be assessed.

The emissions from natural gas extraction to liquefaction include extraction and processing, inland transmission, and liquefaction itself.. Three scenarios were assessed: the base case, a 75% methane reduction case, and a 45% methane reduction case, that resulted in total emissions - 0.0377 ton CO2-eq/GJ, 0.0365 ton CO2-eq/GJ, and 0.0357 ton CO2-eq/GJ respectively.

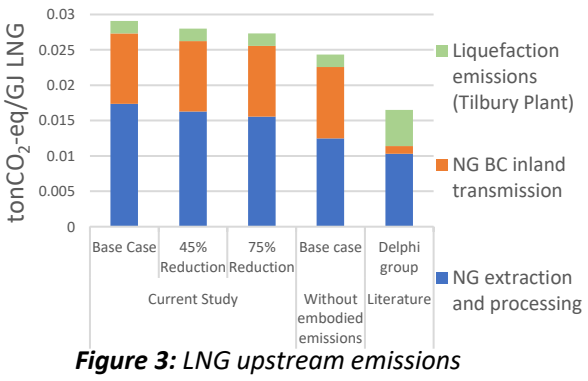

Figure 3: *LNG upstream emissions*

The reduction in upstream emissions is due to methane abatement strategies implemented in the upstream activities.

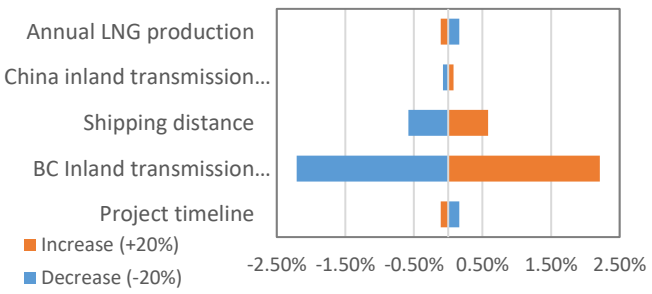

Figure 4: *Sensitivity analysis of life cycle GHG emissions*

Figure 4 depicts the variation in life cycle emissions subjected to ± 20% change in each parameter. The most sensitive parameter is BC inland natural gas transmission distance. The next most sensitive parameter is shipping distance.

The analysis shows that replacing coal with LNG can reduce GHG emissions, but Canada faces additional environmental impacts along the upstream processes. Canada benefits through the transfer of mitigation outcomes, where emissions reduced in China are credited to Canada's inventory, requiring China to adjust its own accounting for its NDCs. ITMO contracts typically last 5 to 6 years, after which the mitigation outcomes revert to China's emissions tally. This arrangement allows Canada to meet its NDC targets economically, while China gains long-term benefits.

Conclusions and Next Steps

LNG trading is rising due to demand for natural gas as a lower-emission fuel, with British Columbia (BC) positioned to export to Asian markets. The study shows that both "end-use" and upstream processes significantly contribute to GHG emissions. Replacing coal with LNG could yield substantial reductions in China, aligning with Article 6.2 of the Paris Agreement. Future research should focus on emission responsibility allocation, validation of reductions, policy frameworks for carbon offsets, and economic assessments of export scenarios to ensure effective ITMO generation.

References:

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Funding provided by:
The authors gratefully acknowledge the funding and support provided by FortisBC Inc and Mitacs Canada in carrying out this research

ACE project funding provided by: Pacific Economic Development Canada; NRC Industrial Research Assistance Program; NSERC CRSNG; Mitacs; The University of British Columbia

Document # MMRI-20022025