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# REDUCTION OF GHG EMISSIONS FROM SHIPS

## Key considerations to determine the well-to-tank (WtT) emission factor for liquefied natural gas (LNG) in the 2024 Guidelines on Life Cycle GHG Intensity of Marine Fuels (2024 LCA Guidelines)

**Submitted by Pacific Environment, CSC and EDF**

**SUMMARY**

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| *Executive summary:* | This document builds on document ISWG-GHG 17/3 (CSC) to complement the extensive literature review on the well-to-tank (WtT) GHG intensity of liquified natural gas (LNG) imports in the European Union, including information and literature to determine a WtT value for a global default emission factor. This document suggests two possible approaches to use measurement-based data and measurements for LNG upstream impacts, including methane emissions, complemented with a conservative default emission factor in case the data is not available, calculated as the 75th percentile of the global values, at 27.95 $gCO_2eq/MJ$. Accurate, scientifically robust, and transparent default emission factors are essential to help the IMO achieve its goals and promote the energy transition of the international shipping sector. |
| *Strategic direction, if applicable:* | 3 |
| *Output:* | 3.2 |
| *Action to be taken:* | Paragraph 19 |
| *Related documents:* | Resolution MEPC.391(81) and ISWG-GHG 17/3 |

### Introduction

1 The co-sponsors note and welcome document ISWG-GHG 17/3 (CSC) to further develop the Life Cycle GHG Assessment (LCA) framework, which focused on providing key findings of an extensive literature review on WtT GHG intensity values of LNG imports to the European Union. With this submission, the co-sponsors expand on CSC's submission, highlight key findings of global data to assess the WtT emissions from LNG, and propose two possible but different approaches to determine default emission factors, along with their proposed values.

2 IMO has set course for achieving robust mid-term objectives for GHG emissions reduction to support its long-term ambition to reach net-zero GHG emissions by or around, i.e. close, to 2050. However, to reach this goal, the foundation for securing accurate emission factors is critical. This submission calls for a globally representative, scientifically robust, and regularly updated default GHG emission factor for LNG that accounts for variations in regional production, transport pathways, and emerging data on methane emissions. This would ensure scientifically accurate, transparent, and equitable assessments for GHG reduction achieved by the mid-term measures under the IMO framework. Accurate emission factors are critical for achieving IMO's goals and influence key aspects of the shipping transition, for example:

.1 Impact on investment – even a minor change in the default upstream WtT emissions factor for LNG can have a substantial impact on accelerating the amount of zero and near-zero (ZNZ) GHG emission technologies, fuels, and/or energy sources required to meet the goals of the 2023 IMO Strategy on Reduction of GHG Emissions from Ships (2023 IMO GHG Strategy. It is critical to adopt accurate default emission factors to drive investments into assets that provide the desired emission reductions and ensure that all fuel types and/or pathways are assessed on a fair, transparent, and accurate basis;

.2 Impact on ambition – even small inaccuracies in emission factors risk large-scale impacts on ambition. Modelling suggests that a ≤5 $gCO_2eq/MJ$ underestimation in the default upstream emission factor for LNG could result in a measurable reduction in the adoption of ZNZ fuels towards 2030. For example, using the FuelEU Maritime default emission factor for LNG of 18.5 $gCO_2eq/MJ$ – which, according to recent literature, is underestimated – instead of the globally representative default value of 23.78 $gCO_2eq/MJ$ proposed in option B of this submission, would result in 1.5% of the energy required by the global fleet (around 3 million tonnes of fuel oil equivalent) not being shifted to ZNZ technologies by 2030. Underestimated default emission factors would risk delaying progress toward achieving IMO's 2030 goals, requiring more drastic measures in the future to make up for the shortfall; and

.3 Impact on governance – robust and globally representative default emission factors safeguard ambition. By adopting representative and scientifically robust default emission factors, the IMO can ensure that its regulatory framework effectively drives the transition to cleaner fuels and energy sources.

3 In order to be able to track IMO's progress in reducing GHG emissions for a specific year, such as 2030, the Organization would need two components: the weighted average of emissions derived from fossil fuels and the weighted average of emissions fuels.[1] Therefore, it becomes paramount that emission factors for fossil fuels are accurately defined with transparent methodologies that provide a clear picture of IMO's transition to ZNZ fuels and technologies. This submission elaborates on why default emission factors should be defined and how these could reflect the global supply accurately. In particular, the sections below focus on the upstream and midstream GHG intensity of LNG, known as the WtT GHG intensity.

[1] Emissions targets can be calculated with the formula below:

$$GHG\ Emissions_{2030} = \sum Fuel\ volumes_{Fossil\ fuels} \times Emission\ factors_{Fossil\ fuels} + \sum Fuel\ volumes_{ZNZ\ fuels} \times Emission\ factors_{ZNZ\ fuels}$$

**Importance of default emission factors**

4 Default emission factors are an important stepping stone for a robust life cycle assessment framework while measurement-based data of upstream emissions from LNG, and other fuels, become available. Default emission factors provide a critical interim solution, ensuring consistency and comparability in emissions accounting while more precise, measurement-based data is developed. However, in order to obtain an accurate upstream emissions profile that reflects continuous improvement in the upstream and midstream processes, such as leakage mitigation and methane emissions management, the Organization needs to develop a methodology that relies on measurement-based data. Such a methodology would recognize effective emissions management as well as indirectly incentivize ZNZ fuels.

5 The co-sponsors suggest two possible approaches to implement a measurement-based methodology:

.1 Option A – the Organization could assign a default emission factor calculated as the weighted average of the WtT GHG intensity of LNG from global supply based on the 75th percentile of WtT GHG intensities of LNG. According to the most recent literature, this would be 27.95 $gCO_2eq/MJ$, based on GWP100 from IPCC AR5. In this case, the co-sponsors would recommend that measurement-based data should be allowed and incentivized under the Methodology for submission, scientific review and recommendation of default emission factors. This would encourage the measurements of site and/or source-level data and reward overperforming LNG supply. The co-sponsors prefer this approach as it includes a procedure for continuous improvement of the default emission factors as more data becomes available; and

.2 Option B – the Organization could assign a default emission factor calculated as the weighted average of the WtT GHG intensities of LNG from a global supply. According to the most recent literature, this would be 23.78 $gCO_2eq/MJ$, based on GWP100 from IPCC AR5. If the Organization decides to assign this weighted average, then the co-sponsors would recommend that measurement-based data is not allowed under the Methodology for submission, scientific review and recommendation of default emission factors, as the value already reflects a global average, accounting for over- and under-performing LNG WtT intensities. While the co-sponsors do not prefer this approach, they recognize that this could be a temporary solution to be reviewed at least annually as methane leakage monitoring becomes widespread and data at the producer level becomes available.

**A global approach is necessary**

6 The weighted average WtT GHG intensity of LNG presented in document ISWG-GHG 17/3 is only applicable to imports of LNG to the European Union. The co-sponsors, however, suggest that the default emission factors for IMO should reflect global LNG production. The study presented in document ISWG-GHG 17/3 identifies eight countries as main suppliers of LNG to Europe: Algeria, Nigeria, Norway, Qatar, Russian Federation, Trinidad and Tobago, United Kingdom and United States. However, LNG as a marine fuel would be supplied globally and the IMO should consider other countries that play a large role in producing and exporting large quantities of LNG on the global market (see tables 1 and 2)[2].

[2] Rystad Energy, 2023. Gas and LNG Analytics.

Tables 1 and 2 below provide a summary of total global LNG export per country and WtT GHG intensity.

**Table 1: Global LNG exports by country and proposed adjustments to document ISWG-GHG 17/3 ($gCO_2eq/MJ$, WtT, GWP100, AR5)**

| Country | % of total global production | Document ISWG-GHG 17/3 coverage | Suggested coverage | Document ISWG-GHG 17/3 EU imports average | Suggested global average | Suggested global 75th percentile |
|---|---|---|---|---|---|---|
| | 98% | 59% | **87%** | **22.39** | **23.78** | **27.95** |
| **United States** | 23% | Yes | Yes | 27.25 | 27.25 | 33.60 |
| **Australia** | 20% | No | Yes | - | **24.00** [3] | **27.85** [3] |
| **Qatar** | 20% | Yes | Yes | 18.06 | 18.06 | 19.92 |
| **Russian Federation** | 7% | Yes | Yes | 27.96 | 27.96 | 34.78 |
| **Malaysia** | 6% | No | Yes | - | **24.00** [3] | **27.85** [3] |
| **Indonesia** | 5% | No | Yes | - | **24.00** [3] | **27.85** [3] |
| **Nigeria** | 3% | Yes | Yes | 19.65 | 19.65 | 20.60 |
| **Algeria** | 3% | Yes | Yes | 27.41 | 27.41 | 30.74 |
| **Oman** | 3% | No | No | - | - | - |
| **Trinidad and Tobago** | 2% | Yes | No | 14.86 | - | - |
| **Papua New Guinea** | 2% | No | No | - | - | - |
| **United Arab Emirates** | 1% | No | No | - | - | - |
| **Norway** | 1% | Yes | No | 12.75 | - | - |
| **Angola** | 1% | No | No | - | - | - |
| **Equatorial Guinea** | 1% | No | No | - | - | - |

**Table 2: Global LNG exports by country and proposed improvements to document ISWG GHG 17/3 ($gCO_2eq/MJ$, WtT, GWP20, AR5)**

| Country | % of total global production | Document ISWG-GHG 17/3 coverage | Suggested coverage | Document ISWG-GHG 17/3 EU imports average | Suggested global average | Suggested global 75th percentile |
|---|---|---|---|---|---|---|
| | **98%** | **59%** | **87%** | **40.59** | **37.87** | **42.08** |
| **United States** | 23% | Yes | Yes | 48.20 | 48.20 | 51.01 |
| **Australia** | 20% | No | Yes | - | **38.00** [3] | **42.64** [3] |
| **Qatar** | 20% | Yes | Yes | 21.45 | 21.45 | 25.24 |
| **Russian Federation** | 7% | Yes | Yes | 57.07 | 57.07 | 62.02 |
| **Malaysia** | 6% | No | Yes | - | **38.00** [3] | **42.64** [3] |
| **Indonesia** | 5% | No | Yes | - | **38.00** [3] | **42.64** [3] |
| **Nigeria** | 3% | Yes | Yes | 34.90 | 34.90 | 34.90 |
| **Algeria** | 3% | Yes | Yes | 36.76 | 36.76 | 40.63 |
| **Oman** | 3% | No | No | - | - | - |
| **Trinidad and Tobago** | 2% | Yes | No | 24.59 | - | - |
| **Papua New Guinea** | 2% | No | No | - | - | - |
| **United Arab Emirates** | 1% | No | No | - | - | - |
| **Norway** | 1% | Yes | No | 20.21 | - | - |
| **Angola** | 1% | No | No | - | - | - |

7 The analysis in document ISWG-GHG 17/3 covers around 59% of the global LNG supply. Notably, other large producers such as Australia, Indonesia and Malaysia contribute to the expanded scope when considering global supply. The top eight LNG exporting countries (listed above) included in the analysis in this submission represent 87% of the global LNG exports (Rystad Energy, 2023).

[3] For Australia, as per ICCT, 2020, paragraph 10. Due to the limited data currently available for upstream emissions attributed to LNG production in Malaysia and Indonesia, as discussed in paragraphs 10 and 11 of this document, the co-sponsors suggest using the same value as Australia.

**Latest scientific literature illustrates that some countries have higher GHG intensity values while others are not represented in the literature**

8 There are regional differences in GHG intensities across LNG exporting countries. For example, natural gas reservoirs in Australia tend to have higher $CO_2$ content[4], and the LNG shipping distance to end users plays an important role[5]. In the case of LNG exported from Australia, the average upstream GHG emissions of LNG were found to be 24 $gCO_2eq/MJ$, including emissions from international transport to final consumers[6].

9 While the export of LNG is predicted to increase in both Indonesia and Malaysia[7], only limited data is currently available on local strategies for managing upstream emissions of LNG production. Recent studies on LNG production in Indonesia estimate that emissions intensities are around 18% higher than IPCC estimates for the region[8].

10 There is no certainty that the WtT GHG intensity of LNG in the Asia-Pacific region would generally be lower than the average value for Australia (24 $gCO_2eq/MJ$) or the global average (23.78 $gCO_2eq/MJ$) at this time. Therefore, the Organization should take a conservative approach until more research and data become available.

**Studies show globally underestimated WtT emission values**

11 Recent literature and studies show that the WtT GHG intensity of LNG has been underestimated globally. As noted in document ISWG-GHG 17/3, there has been a recent uptick of literature and studies on WtT LNG GHG intensity. New available research has shown that previous studies had misaligned quantification methodologies, while the more recent literature is finally converging on a WtT approach to GHG intensity[9].

12 For example, the impact of methane emissions across the natural gas supply chain has been assessed in literature and various industry reports. Modelling the climate impacts of natural gas-based hydrogen with a 1.5% methane emissions rate across the supply chain, compared to an 8% methane emissions rate increased the GHG intensity of hydrogen production by ~50 $gCO_2eq/MJ$, highlighting the importance of keeping methane emissions low[10]. Reported methane emission rates by the oil and gas industry from the natural gas supply chain in the United States have also been potentially underestimated historically, as low as 60% compared to measurement-based and peer-reviewed values[11].

13 The impact of different LNG pathways in the United States, from extraction to bunkering, is well captured by the International Council on Clean Transportation (ICCT).[12] Based on ICCT's study, the WtT methane emissions vary between 2.7% to 5.4%, excluding flash losses, i.e. 100% of boil-off gas (BOG) is assumed to be captured at the production site, while 95% at import terminals. Accordingly, LNG pathways result in a variation of WtT emissions between 72.1 and 92.3 $gCO_2eq/MJ$. Higher upstream methane emissions rates would increase the overall climate impact of LNG used as shipping fuel. And measurements

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4 El-Houjeiri, H., Montfort, J.-C., Bouchard, J. & Przesmitzki, S., 2018. Life Cycle Assessment of Greenhouse Gas Emissions from Marine Fuels: A Case Study of Saudi Crude Oil versus Natural Gas in Different Global Regions. Journal of Industrial Ecology, pp. 374-388.
5 Thinkstep, 2019. Life cycle GHG emission study on the use of LNG as marine fuel.
6 ICCT, 2020. The climate implications of using LNG as a marine fuel.
7 IGU, 2023. World LNG Report.
8 Herlina, L., Rani, D. S., Susantoro, T. M. & Haris, A., 2024. Indonesia's Country-Specific Emission Factor Based on Gas Fuels for Greenhouse Gas Inventory in the Energy Sector.
9 Lindstad, E. & Rialland, A., 2020. LNG and Cruise Ships, an Easy Way to Fulfil Regulations—Versus the Need for Reducing GHG Emissions. Sustainability, pp. 12-13.
10 Bauer, C. et. al 2022. On the climate impacts of blue hydrogen production. Sustainable Energy & Fuels, Volumen 6, pp 66-69.
11 Alvarez, R. A., Zavala-Araiza, D. & Lyon, D. R., 2018. Assessment of methane emissions from the U.S. oil and gas. Science, Volumen 361, pp. 186-188.
12 ICCT, 2013. Assessment of the fuel cycle impact of liquefied natural gas as used in international shipping.

from the United States gas industry have shown higher upstream methane leakage rates (2.4%) than previously reported by the United States Environmental Protection Agency (EPA) (default value of 1.4%).[13]

14 A default emission factor that considers the latest peer-reviewed literature data and analyses, even if conservative at times, better reflects a fuel's emission profile than relying on underestimated lower emission factors. Additionally, data from advanced satellite monitoring instruments are becoming increasingly available. MethaneSAT, a methane-detecting satellite launched in March 2024 by MethaneSAT, LLC, a wholly owned subsidiary of EDF, is already providing methane emission estimates from global oil and gas producing areas with unprecedented resolution and precision. As accurate measurement-based emissions quantification becomes available, it is important that a methodology be put in place to update the WtT default values of LNG to motivate improvements in LNG production and methane emissions management that help reduce LNG's GHG intensity over time.

15 The proposed conservative emission factors in paragraph 5 of this document, option A (calculated using the 75th percentile of WtT GHG intensities of global supply) for LNG GHG intensity should be reviewed and updated on a biannual basis to reflect the industry efforts to manage methane emissions and the impact of multi-lateral global pledges.

**Key considerations**

16 This document proposes using a conservative approach to avoid underestimating LNG's WtT GHG intensity. Based on the latest scientific data and analyses, the co-sponsors recommend that the Organization set the default WtT GHG intensity factor for LNG at the 75th percentile (27.95 $gCO_2eq/MJ$) to reflect recent literature and actual emissions. This approach incentivizes measurement-based data and rewards overperforming LNG supply, aligning with the 2023 IMO GHG Strategy and its levels of ambition.

17 Alternatively, the Organization could set the default emission factor at the global weighted average (23.78 $gCO_2eq/MJ$), reflecting global production. However, this value must be reviewed at least annually as new measurement-based data becomes available. If the global weighted average (23.78 $gCO_2eq/MJ$) is adopted, measurement-based values should not be allowed, as the default already accounts for overperforming production.

18 The WtT default emission factor should include methane emissions, such as methane slippage, BOG, operational venting, emissions during transport, and be globally representative, scientifically robust, and regularly updated to reflect advances in methane management and production efficiency. International studies and methodologies should guide lifecycle assessments for accurate and equitable emissions reporting.

**Action requested of the Committee**

19 The Committee is invited to take note of the information provided, consider the proposals set out in paragraph 5 and to forward this document to the GESAMP Working Group on Life Cycle GHG Intensity of Marine Fuels (GESAMP-LCA WG) to assist in their review of potential default emission factors for WtT emissions from LNG that may be included in appendix 2 of the 2024 LCA Guidelines (resolution MEPC.391(81)).

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[13] Alvarez et. al, 2018. Assessment of methane emissions from the U.S. oil and gas supply chain