INTERNATIONAL MARITIME ORGANIZATION

E

INTERSESSIONAL MEETING OF THE WORKING GROUP ON REDUCTION OF GHG EMISSIONS FROM SHIPS
23rd session
Agenda item 4

ISWG-GHG 23/4/15
9 October 2026
ENGLISH ONLY
Pre-session public release: ☒

FURTHER CONSIDERATION OF THE DEVELOPMENT OF THE IMO LIFE CYCLE GHG ASSESSMENT (LCA) FRAMEWORK

Accounting for fugitive and vented methane emissions from international LNG shipping

Submitted by WWF, Pacific Environment and CSC

SUMMARY

Executive summary:	The C_{fug} parameter in the tank-to-wake (TtW) equation of the *2024 Guidelines on life cycle GHG intensity of marine fuels* (2024 LCA Guidelines) (resolution MEPC.391(81)) is currently set to zero pending further methodological guidance to be develop by the Organization. New information shows that actual fugitive and vented methane emissions from LNG carriers are above zero, however, establishing a representative and conservative default C_{fug} emission factor is expected to be challenging due to the high variability of emissions. This document argues that using actual C_{fug} emission factors for LNG carriers might be more accurate than using default C_{fug} emission factors, and it would provide a direct incentive to reduce methane emissions when applied in the context of IMO measures designed to reduce GHG emissions from the sector, in accordance with the *2023 IMO Strategy on reduction of GHG emissions from ships* (2023 IMO GHG Strategy) (resolution MEPC.377(80)). This document proposes to invite submissions on how LNG carriers can demonstrate actual values for C_{fug}, such as by initiating the development of guidelines for measuring and monitoring fugitive and vented methane emissions from international LNG shipping.
Strategic direction, if applicable:	3
Output:	3.2
Action to be taken:	Paragraph 30
Related documents:	Resolutions MEPC.364(79), MEPC.377(80), MEPC.391(81), MEPC.395(82), MEPC.414(84), MEPC.415(84), MEPC.416(84); MEPC 85/7/4 and MEPC 71/INF.23

Introduction

1 MEPC 80 adopted resolution MEPC.377(80) on the *2023 IMO Strategy on reduction of GHG emissions from ships* (2023 IMO GHG Strategy). The 2023 IMO GHG Strategy states that the Organization should further develop the LCA Guidelines and continue to develop mid-term GHG reduction measures, including to "consider and analyse measures to address emissions of methane…".

2 MEPC 81 adopted resolution MEPC.391(81) on the *2024 Guidelines on life cycle GHG intensity of marine fuels* (2024 LCA Guidelines). The 2023 IMO GHG Strategy states that the levels of ambition, the indicative checkpoints, and the candidate mid-term GHG reduction measures must take into account the well-to-wake (WtW) GHG emissions of marine fuels. The 2024 LCA Guidelines are the mechanism by which shipowners will calculate the WtW GHG intensity of marine fuels, including LNG.

3 A common practice among LNG carriers is to utilize their onboard cargo as propulsion fuel. During voyages, heat ingress into the cargo tanks causes the LNG cargo to vaporize as boil-off gas (BOG), a portion of which the ship then uses as fuel.

4 Under the 2024 LCA Guidelines, tank-to-wake (TtW) methane emissions can be classified under methane slip (C_{slip}), which is the methane that escapes from the energy converter unburned, and fugitive emissions (C_{fug}), which covers the fuel that escapes between the tanks up to the energy converter which is leaked, vented, or otherwise lost in the system. Currently, the value of C_{fug} in the 2024 LCA Guidelines is set to zero, pending further methodological guidance to be developed by the Organization.

How fugitive and vented methane emissions from LNG carriers are currently handled in the 2024 LCA Guidelines

5 In the 2024 LCA Guidelines, the GHG emissions associated with the transport of LNG would likely be classified as "emissions associated with the finished fuel transport" under the e_{td} parameter of the well-to-tank (WtT) equation.[1] Fugitive and vented emissions from the transport of LNG cargo theoretically fall under the scope of the e_{td} parameter when determining the WtT emissions for ships that use LNG as a marine fuel. However, there is no sub-parameter that explicitly accounts for fugitive and vented methane emissions from the transport of LNG cargoes, which can be substantial and variable.

6 The fugitive and vented methane emissions profile of each LNG carrier is unique and variable, but the fugitive and vented emissions associated with the carriage of LNG as cargo are represented (at least in theory) as part of a static e_{td} parameter in the WtT equation. Therefore, shipowners have no incentive to minimize or mitigate these emissions because their efforts would not be rewarded when calculating the ship's environmental performance.

7 For LNG carriers, fugitive and vented methane emissions from their LNG cargo would more logically be classified as part of their TtW emissions under the C_{fug} parameter.

[1] The full definition of the e_{td} parameter in the 2024 LCA Guidelines as described in Equation (1) is: "Emissions associated with the feedstock transport to conversion plant, and the emissions associated with the finished fuel transport and storage, local delivery, retail storage and bunkering"

How fugitive and vented methane emissions occur on LNG carriers

8 On LNG carriers, fugitive emissions can originate from LNG cargo-handling piping and BOG fuel-supply systems. The *International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (IGC Code) paragraph 16.4.8 mandates that gas detection systems shall activate an alarm when the ambient gas concentration reaches 30% of the lower flammability limit (LFL); however, the enclosed rooms are continuously ventilated, and fugitive leaks generally do not produce sufficient methane concentration to trigger the alarm. In the absence of frequent source-level Leak Detection and Repair (LDAR) surveys, small leaks that do not trigger an alarm can remain undetected for extended periods, which may result in considerable cumulative methane emissions.

9 If the ship is unable to use all the BOG in the energy converter, some or all of the excess BOG could be reliquefied if the ship is equipped with a reliquefaction plant. Otherwise, excess BOG may be flared at the gas combustion unit (GCU) to maintain tank pressure for safety reasons. However, in situations such as those listed below, all or some of the methane in the BOG may be vented directly to the atmosphere:

.1 there is insufficient time to combust BOG in the GCU before operational events such as drydocking are scheduled;

.2 tank pressure is low and gas flow is insufficient to operate the GCU;

.3 there is no installed reliquefaction plant on board (or it cannot be used); or

.4 LNG tanks are being emptied, such as during gas-free and warm-up operations.[2]

10 Currently, there are no mandatory frameworks that incentivize ship operators to avoid, minimize, record, or report such venting events, although there are guidelines for when venting is prohibited or allowed.

11 Under the IGC Code, paragraph 7.1.3, atmospheric venting is prohibited during normal operations, and managing cargo tank pressure must be handled via tank cooling, energy converters (e.g., engines), reliquefaction plants, or the GCU. The vent mast serves as an emergency relief mechanism to prevent catastrophic structural damage, such as during a severe cargo rollover event, when tank pressure can rise rapidly. Even though the IGC Code is a mandatory instrument under SOLAS, "normal operation" is not well-defined, and non-emergency venting events still occur. For example, in the case of gas-free operation, ships may have no feasible alternatives to venting.

Data on fugitive and vented methane emissions from LNG carriers

12 Document MEPC 71/INF.23 (Republic of Korea) presented information based on 15 years' worth of data from three 138,000 m^3 LNG carriers and identified the following three main pathways for vented methane emissions, and included information on the first two:

.1 gas-free and warm-up operation;

.2 purge for fuel gas pipe; and

.3 safety valve releasing (including cargo venting valve).

[2] The gas-free and warm-up operation is carried out when the ship is due for drydocking and needs to empty its tanks for maintenance or inspections.

13 During gas-free and warm-up operations, document MEPC 71/INF.23 estimated that between 25 to 122 tonnes (t) of methane-containing fuel can remain in the tanks of a 138,000 m^3 gas carrier that cannot be utilized and must be vented. They levelized this to an average of 15 t of methane emissions per ship per year.

14 Document MEPC 71/INF.23 also quantified emissions from fuel gas pipe purging, finding that nearly 11 tonnes of methane were vented per ship per month, totalling 126 tonnes of methane per year, increasing to 141 tonnes of methane per year when combined with gas-free and warm-up operations.

15 In March 2026, researchers from Queen Mary University of London[3], as part of the FUMES 2 project[4] carried out by the International Council on Clean Transportation (ICCT)[5], directly observed and quantified a gas-free and warm-up operation while onboard a 174,000 m^3 LNG carrier. They calculated that the ship vented 189 tonnes of methane into the atmosphere while preparing to enter drydock, which is equivalent to more than 5,600 tonnes of CO_2eq.[6]

16 In total, 83 tonnes of avoidable methane emissions were forced-vented using a compressor and a heater, while the ship simultaneously utilized the GCU and the energy converters (engines). This venting was not required to maintain the safety of the ship or the crew; instead, it was done in response to operational pressures, namely, to ensure that the ship reached the dry dock on time. After this initial forced vent, the tank pressure dropped, the ship switched to diesel fuel mode, and the remaining unavoidable 106 tonnes of methane were discharged via the final inerting vent. The Queen Mary researchers levelized this venting event to 0.08 kg of methane emissions per tonne of LNG delivered by that ship in one year.

17 The Queen Mary team also detected eight small fugitive leaks on the LNG carrier, resulting in nearly 1 kg of methane emissions per hour. While most of these leaks were fixed shortly after, they were only discovered after this LDAR survey, and the Queen Mary researchers noted that they had found similar fugitive leaks on every ship they had surveyed.

18 These results were presented by Dr. Paul Balcombe[7] from Queen Mary University of London during the "Technical seminar on methane-based fuels" held at IMO Headquarters on 12 May 2026, which can be accessed from the IMO's Future Fuels & Technology website[8].

19 Empirical evidence on fugitive and vented methane emissions from LNG carriers is scarce, and these emissions are often not accurately reflected in LCA studies. However, the evidence that has been presented to the Organization demonstrates that fugitive and vented emissions from LNG carriers are not zero and should therefore be properly accounted for.

Incentives to reduce fugitive and vented emissions

20 While most fugitive emissions that arise from leaks can be mitigated with minimal effort and at no- or low-cost to the ship operator, mitigating vented emissions depends on operational practices and the human element.

3 https://www.qmul.ac.uk/
4 https://theicct.org/pr-icct-fumes-2-project-summary-dec24/
5 https://theicct.org/
6 Assuming the 100-year GWP of methane is 29.8, according to the Sixth IPCC Assessment Report.
7 https://www.sems.qmul.ac.uk/staff/p.balcombe
8 https://futurefuels.imo.org/about/technical-seminars/technical-seminar-on-methane-based-fuels/

21 LNG charterparties may contain boil-off rate, speed, and consumption guarantees, as well as cargo delivery thresholds. Fugitive and vented methane represent cargo shrinkage. If a ship vents BOG, the owner may be liable for the loss of cargo volume and may breach the charter's performance warranties. Use of the GCU to manage tank pressure can lead to financial disputes over boil-off consumption warranties. Owners are therefore incentivized to minimize fugitive losses and venting to avoid cargo shortage claims. However, it is also known that operationally experienced ship owners or technical management companies would account for unexpected non-emergency loss of BOG when signing charter agreements and might ensure that such loss of BOG is already accounted for and will not affect the ship's commercial performance.

22 The Oil Companies International Marine Forum (OCIMF)[9] Ship Inspection Report Programme 2.0 (SIRE 2.0)[10] inspects safety management, pollution prevention, and cargo handling systems, with a focus on the human element. Within this regime, venting or fugitive leaks are considered vetting liabilities. SIRE 2.0 inspectors review the ship's alarm and event logs, which might automatically record any opening of the vent mast valves. Routine venting or failure to manage tank pressure may trigger a negative vetting observation. A poor SIRE 2.0 report renders the LNG carrier unemployable by major energy companies, incentivizing the crew to maintain equipment and avoid venting. However, inspections can only check what is recorded, and the resulting negative consequences may create perverse incentives for the crew not to record or report the venting events.

Perverse incentives that may cause vented emissions

23 Under the guidance of resolution MEPC.395(82) on the *2024 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)*, for IMO data collection system (DCS) reporting purposes, GCUs are considered a fuel consumer type, and the flowmeter method (7.3.1), the subtraction method (7.4.1), or the estimation method (7.4.2) can be used together with the corresponding LNG carbon conversion factor as listed in resolution MEPC.364(79) on the *2022 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*.

24 If excess BOG is directed to a GCU, it will be logged as fuel consumption, thereby generating reported CO_2 emissions that, for example, would count against the ship when calculating carbon intensity indicator (CII). If BOG is instead vented, it is considered a cargo loss rather than fuel consumption and does not need to be reported.

25 Similarly, if a ship is fitted with a reliquefaction plant, the excess BOG can be reliquefied and returned to the cargo tank. But a reliquefaction system may require substantial electrical power, which can increase fuel consumption and raise the ship's reported GHG emissions. An operator who allows venting avoids this auxiliary fuel burn, lowering their documented fuel consumption and appearing more efficient on paper than a ship operating zero-venting reliquefication systems.

Establishing a conservative and representative default C_{fug} emission factor may be challenging

26 GESAMP-LCA WG, in the report of its fourth meeting (MEPC 85/7/4, paragraph 6.23), proposed that the Committee agree to replace the existing template for TtW default emission factor submission in appendix 5 to the 2024 LCA Guidelines with the new template presented in annex 4 of its report. That template includes one table (table 8) that includes details on the

9 https://www.ocimf.org/

10 https://www.ocimf.org/programmes/sire-2-0

methodology for the measurement and the ship that was measured, including ship type, and another table (table 9) to report proposed values for C_{fug}, with a place to record "fugitive emissions class" where the submitter can differentiate, e.g., by energy converter, re-liquefaction equipment, or ship type. Although it is not yet clear how C_{fug} emission factors will be differentiated across ship types or equipment, following the established procedures, it is anticipated that GESAMP-LCA WG will recommend one or more conservative and representative default C_{fug} emission factors before the 2024 LCA Guidelines are operationalized. But a conservative value may not be representative, and actual values for C_{fug} could be more appropriate.

27 A similar point was made in its report with regard to C_{slip}. In paragraph 5.14.6 of document MEPC 85/7/4, GESAMP-LCA WG stated that the large variation in the C_{slip} values for the LNG_4s_MS_OttoDF energy converter type implied that a conservative default emission factor may not be representative, and that actual certified TtW emission factors would be more appropriate, as provided for in section 10 (Actual emission factors) of the 2024 LCA Guidelines. GESAMP-LCA WG noted that newly adopted guidelines on measuring and reporting methane emissions from ships (resolutions MEPC.414(84)[11], MEPC.415(84)[12] and MEPC.416(84)[13]) could be used for such purposes.

28 Similar guidelines to account for TtW C_{fug} emission factors have not yet been developed, but from the limited literature available on the topic, it can be understood that fugitive and vented emissions from LNG carriers would also show a large variation, influenced by variables such as ship type, size, age, containment system design, age-related insulation degradation, tank operating pressure and temperature, cargo slushing, geographic area of operation, availability of reliquefaction plants, GCU combustion efficiency, BOG consumption and generation rates, gas-free and warm-up procedures, heel management practices, maintenance and condition of the equipment, voyage profile and dwell times, etc. Such high variation means that using actual emission factors for fugitive and vented methane emissions from LNG carriers would also be more appropriate than relying on (likely) unrepresentative but conservative default C_{fug} emission factors.

Proposal

29 In light of the information presented above, the co-sponsors propose that the Working Group:

.1 note the data on fugitive and vented emissions from LNG carriers presented in paragraphs 11 to 18;

.2 note the challenges of developing a conservative and representative default C_{fug} emission factor value for LNG carriers as described in paragraphs 25 to 27;

.3 recommend that the Committee invite interested Member States and international organizations to submit proposals on how LNG carriers can demonstrate actual C_{fug} emission factors, such as by initiating the development of guidelines for measuring and monitoring fugitive and vented methane emissions from international LNG shipping; and

11 *2026 Guidelines for test-bed and onboard measurements of methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines* (resolution MEPC.414(84))

12 *Guidelines for engine load monitoring (ELM) and calculation of emission values* (resolution MEPC.415(84))

13 *Guidelines for continuous emission monitoring systems (CEMS) used to quantify methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines* (resolution MEPC.416(84))

.4 recommend that the Committee agree to forward this document to GESAMP-LCA WG to assist in their evaluation of how to establish a conservative and representative value for C_{fug} for ships that use cargo as fuel, such as LNG carriers.

Action requested of the Working Group

30 The Working Group is invited to consider the information provided in this document, in particular the proposals in paragraph 29, and take action as appropriate.