GIE contribution to Inception Impact Assessment of FuelEU Maritime

GIE welcomes EU's ambition for low-emission, climate-neutral shipping and ports. We believe that today LNG as a marine fuel can meet EU's climate and air quality targets and lays the ground for the carbon neutral liquified biomethane (LBM) and liquified synthetic methane (LSM) without additional investment in assets.

LNG meets IMO targets: LNG's SOx is 1,000 times lower than the IMO 0.5% rule.

LNG reduces up to 21% GHG emissions compared with oil-based fuels over the Well-to-Wake cycle (see Annex 1). LBM and LSM can reduce them further.

LNG improves air quality in urban areas and ports: NOx is reduced by up to 95% and particulate matter by 99% compared to heavy fuel oil.

LNG is worldwide available, ensuring security of fuel supply: DG ENER reported on 7 April 2020 that in Q4 2019 LNG was the second gas source to the EU (up by 42% year-on-year). In December 2019 LNG terminals' capacities were busy almost 70%, with some terminals reaching their full regasification capacity. As global LNG markets expand, DG ENER expects new volumes in the EU from US, Russia, the Middle East, Africa and Australia (see Annex 1).

Refuelling points: LNG is very energy dense, which makes it an efficient fuel (see Annex 1). For years, LNG has been an available, flexible, safe, sustainable option and increasingly the fuel of choice for different shipping companies worldwide, both for Deep-Sea and Short-Sea transport. LNG's technology is mature for commercial use. Under the assumption of a 10-year pay-back period, LNG provides a compelling business investment case for ship owners when compared to conventional marine fuels (see Annex 1). LNG fuelled ships grew from 96 in 2016 to 175 in 2019, with extra 203 ships expected by 2026. EU bunkering installations grew to 131 in 2019 from 113 in 2018 (see Annex 1). EU authorities should boost the LNG bunkering infrastructure with, for example, lighter fiscal regime for the LNG storage, harbour taxes reduction for LNG vessels, EU funds, incentives for new LNG vessels, introduction of a 0.1% SECA area in other regions such as the Mediterranean.

LNG is affordable: LNG can reduce pollutant and CO2 emissions in the maritime at lowest cost for impacted industries, which is particularly relevant during the economic recovery from COVID crises. Its price is notably more stable for long-term hedging compared to the volatile price of other competing fuels. Considering a 10-year pay-back period, LNG is the most economical option today (see Annex 1).

Using existing assets: LBM or LSM can be fed into the existing gas grid. Gradual replacement of LNG with LBM or LSM will avoid i) devalued or stranded assets and ii) future capital intensive infrastructure. The same applies for LNG fuelled vessels, which can burn LBM or LSM with no extra CAPEX.

LBM and LSM are scalable solutions for the maritime sector, with estimated global supplies potentially exceeding the demands of shipping in the future, and likely to be commercially competitive relative to other zero-carbon fuels (see Annex 1).

Methane slip has decreased 4 times since 1990s, when gas engines were developed for local emissions (NOx, SOx). GHG emissions were not considered at the time. Since then, methane slip, where applicable, was reduced and engine manufacturers invest in R&D to further reduce the slips (see Annex 1). Methane slips depend on the engine (low or high pressure) and its operating profile. For low-pressure engines, manufacturers want to reduce them as much as technology allows. For high-pressure engines, slips are almost zero (0.2g/kWh), and 33% of the fleet uses this type of engine; this represents 84% of maritime transport capacity (see Annex 1).

LNG for power generation while at berth: LNG fueled mobile power generators are an alternative to heavy infrastructure in ports in order to bring electric wires on every single quay. There is already experience in Spain (CORE LNGas hive project) and tests are ongoing since September 2020 in Corsica (see Annex 1).

Annex 1 – References

LNG reduces up to 21% GHG emissions:

- Thinkstep study by SGMF and SEA-LNG: link

LNG is worldwide available, ensuring security of fuel supply:

- GIINGL Annual Report 2020: link

Refuelling points:

- DNV-GL & SEA-LNG "Comparison of alternative marine fuels" study: link
- SEA-LNG investment cases:
  - https://sea-lng.org/wp-content/uploads/2020/02/200224_SEALNG_Capesize_study_compressed.pdf
  - https://sea-lng.org/wp-content/uploads/2019/12/SEALNGStudyVLCC4_compressed.pdf
  - https://sea-lng.org/wp-content/uploads/2019/07/SEALNGStudyFINAL2.pdf
  - https://sea-lng.org/wp-content/uploads/2019/01/190123_SEALNG_InvestmentCase_DESIGN_FINAL.pdf
- GIE Small-Scale LNG map: link

LNG is affordable:

- SEA-LNG study LNG as a Marine Fuel – Our Zero Emissions Future Starts Now: link

LBM and LSM are scalable:

- IEA Outlook for biogas and biomethane: link 1 and link 2
- SEA-LNG study with CE Delft: link

Methane slip has decreased 4 times since 1990s:

- Wartsila - Cutting greenhouse gas emissions from LNG engines: link
- SGMF: Information on and proposals for the reduction of methane slip (see below)
- GIE-Marcogaz report for the Madrid Forum – potential ways the gas industry can contribute to the reduction of methane emissions and Action Plan to reduce methane emissions: link

LNG for power generation while at berth:

- Experimentation in Corsica regarding power generation from LNG at quayside: link
- CORE LNGas Hive Project – Onshore Power Supply LNG experience (see below)

SGMF: Information on and proposals for the reduction of methane slip

Introduction

1. The Committee, at MEPC 72, adopted resolution MEPC.304(72) on Initial IMO Strategy on reduction of GHG emissions from ships (the initial strategy). The initial strategy includes candidate short-term, mid-term and long-term measures. In candidate short term measures of initial strategy, in paragraph 4.7.5 it is stated "consider and analyse measures to address emissions of methane and further enhance measures to address emissions of Volatile Organic Compounds."
2. Following discussion during the sixth intersessional meeting of the Working Group on Reduction of GHG Emissions from Ships, "the Group noted that the issue of methane slip would need further consideration including an enhanced understanding of the problem, how methane slip could be measured, monitored and controlled and which measures could be considered by the Organization to address" (MEPC 75/7/2, paragraph 38).
3. In ISWG-GHG 5/4/10, SGMF provided results of an independently peer-reviewed, Well-to-Wake analysis regarding the use of LNG as marine fuel, conducted by Thinkstep. This report details the life cycle analysis (LCA) and includes both greenhouse gas (GHG) emissions and local air pollutants Tank to Wake (TtW). The study was carried out using the latest information to provide the most comprehensive update as to the use of liquified natural gas (LNG) as marine fuel. It has been submitted to this session as document ISWG-GHG 7/5.
4. The study, which includes analysis of CO_2 and methane emissions, both slip and fugitive, concludes that on a Tank-to-Wake (TtW) basis, the use of LNG provides GHG reduction benefits of up to 28% compared with current oil-based marine fuels. Furthermore, analysis encompassing the engine technology employed reduces this benefit but still provides a GHG reduction of up to 21% over the entire life cycle on a Well-to-Wake (WtW) basis.
5. This document provides further information on methane emissions, in particular methane slip. In particular, the measures and technologies employed to reduce it together with a proposal for defining and addressing methane slip from IGF Code gas-fuelled ships on a comparative basis to other marine fuels is made.

Background

GHG emissions from LNG as a marine fuel

6. LNG consists primarily of methane and its use as a marine fuel is considered to have significant environmental advantages. On a local pollutant basis there is significantly reduced formation of NOX, SOx and Particulate Matter including Black Carbon. On a GHG basis, the CO_2 emissions are 25% to 28% lower compared to liquid fossil fuels. Any emission of methane in its supply, bunkering or use will result in a reduction of that overall GHG benefit. This is because methane has a global warming potential of 28 to 34 times that of CO_2 according to the widely recognized Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR5) utilizing the standard 100-year time frame (GWP100).
7. Once on board the ship, potential sources of methane emissions can be divided in two main categories, fugitive emissions and methane slip:
   a. fugitive emissions of methane are those where the methane is lost to atmosphere from irregular LNG operations. For example, emergency venting, containment

system failure, gasket or system leakages or any sporadic occasional operation associated with equipment maintenance and failures.

   b. methane slip specifically refers to any methane that passes to the exhaust system and is subsequently lost to atmosphere having not been combusted in the engine, boiler or turbine.

8. It shall be noted that in principle there is no deliberate direct venting of methane on board IGF Code ships during normal operations including bunkering unless there is an emergency situation that necessitates a controlled release, a reduction of system overpressure, would be such an example.

Methane slip from engines

9. The amount of methane slip for gas-fuelled engines is affected by numerous factors and manufacturers account for these during the optimization of the engine design. It is further affected by the engine operation itself including engine speed, load and transient operations. The amount of methane slip can be quite variable, but for methane some of these factors are a function of the following:
   a. any amount of methane slip from an internal combustion engine will depend upon engine cycle, (two-stroke, four-stroke, gas turbine, boiler), engine speed, fuel (single or dual-fuel) and the thermodynamic combustion cycle (Otto or Diesel). The life cycle analysis on the use of LNG as marine fuel report by Thinkstep contains average data for current design two- and four-stroke engines and is based on the latest data from test-bed engines using the appropriate engine test cycle. Figure 1 lists these figures;
   b. typical combustion of gas in a marine engine requires high oxygen content and low temperature to maximize efficiency and produce the lowest NOX emissions. Methane can pass uncombusted to the exhaust for example having been trapped unmixed in crevices or uncombusted due to close proximity to any relatively cooler spaces sometimes found in the combustion space;
   c. engine size has an effect: a large cylinder or combustion space has fewer crevices and a smaller wall-to-surface area in comparison to that of a smaller unit, this will result in relatively lower methane slip for larger cylinders;
   d. another important parameter is the timing of the gas admission via the control system and valve overlap duration on four-stroke engines. Overlap is the period that both inlet and exhaust valves are open at the same time. Valve overlap timing is often used to allow partial cooling of engine components between the combustion cycles, but furthermore it promotes more efficient scavenging as the incoming charge air further assists the removal of the remaining exhaust gas in the cylinder. Minimizing overlap results in a decrease in methane emissions.

Power Cycle	Combustion Cycle	Fuel	Methane Slip
2 stroke	Diesel	Dual Fuel	0.1%
2 stroke	Otto	Dual Fuel	1.5%
4 stroke	Otto	Single Gas	1.3%
4 stroke	Otto	Dual Fuel	2.5%

Table 1. Typical methane slip as a percentage of specific consumption.
(Source: *Life Cycle GHG Emission Study on the use of LNG as Marine Fuel* by Thinkstep)

10. Methane slip from an engine is effectively wasted fuel, reducing efficiency and an additional expense. Since the introduction of gas-fuelled engines, engine manufacturers have implemented a range of measures to reduce methane slip. Significant improvements have been made during the last 30 years.
11. The majority of the methane reduction measures employed are related to combustion optimization. Specific areas of attention are gas admission control including valve overlap for four-stroke engines, combustion space design, fuel injection technology, combustion control and low load skip firing. Figure 1 shows the decrease of methane slip of lean-burn four-stroke gas engines and how some of these measures and technologies have effectively provided a decrease of methane slip. Furthermore, it shows the improvement in gas engine efficiency, which together with reduced methane slip provides a significant reduction in GHG emissions over the period. Similar measures and technologies have been applied to two-stroke engines.

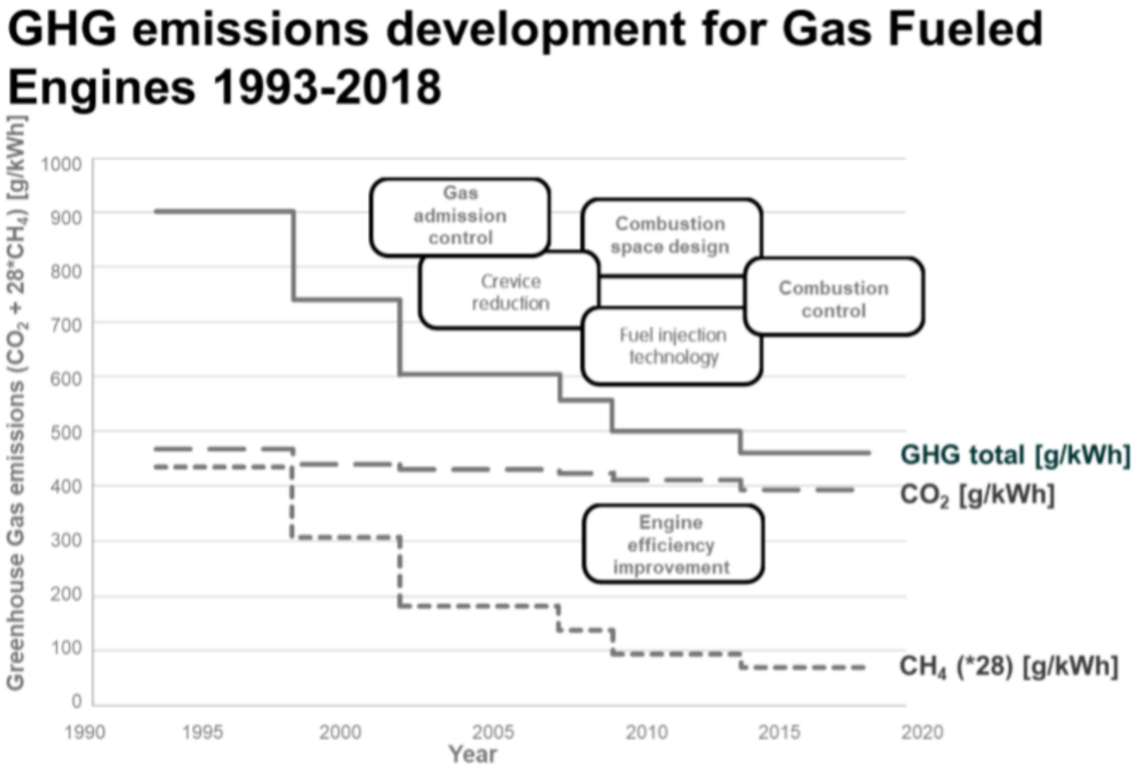

Figure 1. Example of efficiency improvement and methane slip development on medium speed four-stroke Otto combustion low-pressure gas engines and some of the enabling technologies.
(Sources: Wärtsilä, MAN ES, Caterpillar and WIN GD)

12. Engine manufacturers continue to invest in R&D with the aim to further reduce methane slip. The following technologies may further contribute to lower slip:
    a. exhaust gas aftertreatment, i.e. removing methane from the engine's exhaust gas by means of an oxidation catalyst has been studied by engine manufacturers and other parties for some time. The challenge is to trap and convert the unburned methane

from the hot exhaust gas efficiently and this requires an even hotter temperature for an effective catalyst but can lead to rapid catalyst deactivation. Viable solutions may not be expected to become available within a short time frame.

b. adding a proportion of hydrogen to the combustion process is also being investigated, this improves the combustion and decreases methane slip. Challenges are the higher combustion pressures and temperatures achieved leading to a negative effect on NOX formation.

Discussion

13. SGMF supports initiatives to further reduce methane slip and welcomes the introduction of regulatory measures to drive this development. Methane may best be assessed by means of a CO2-equivalent approach. Any regulatory measure to drive the reduction of methane slip should be technologically neutral and utilize a goal-based approach. Since the issue of methane slip has highlighted the attention for CO2 reduction for marine fuels as a whole, it should be recognized that any such measures should be considered in perspective to the immediate and significant benefits LNG provides for local emissions.
14. Any engine optimization for emissions control will result in fundamental compromises i.e. balancing methane slip with engine efficiency and NOx formation. MARPOL Annex VI currently sets standards for NOx emissions. As an example, CO2 and any CO2-equivalents could be considered by EEDI, this would allow the engine manufacturers to optimize engines with respect to NOx, CO2 and methane.
15. EEDI requires that the CO2 emissions from the combustion process are calculated by means of fuel related carbon factors and specific fuel consumption using data gained from the technical file based on test-bed data. Methane slip could be measured with standardized methods (NOx Technical Code 2008, Appendix III, 3.3 and ISO 8178-1:2017) during the parent engine certification test on the test bed. The CO2 emission would then be complemented with the methane slip figure, using the appropriate factor. This results in an EEDI value in CO2-equivalent per transport work.
16. Including the methane slip in the current EEDI framework by changing the calculation to a CO2-equivalent basis would provide a direct comparison between the GHG emissions from different prime movers and thus be implemented as a short-term measure (group A "that can be considered and addressed under existing IMO instruments"). The resulting CO2-equivalent could then be compared to required EEDI and if needed to be supplemented with other efficiency measures.
17. Another method of regulating methane slip could be the setting of methane emission limits for the various types of gas-fuelled engines. SGMF is of the view that such a method would not focus on the reduction of both CO2 and methane emissions in combination and considering the variability in engines it would be time-consuming to develop baseline emissions and set targets.
18. Based on the considerations in paragraphs 13 to 17, SGMF finds that the use of a CO2-equivalent is the most appropriate way to address methane slip from engines in a timely and goal-based manner. The CO2-equivalent should be used in EEDI calculations and any other future regulation where GHG emissions play a role.
19. Experience from SGMF's members has illustrated that the consistent and precise measurement of methane slip is currently somewhat elusive. However, going forward this will probably be essential in order to address the issue in a meaningful and constructive way. If the Organization undertakes to develop and implement measurement standards, SGMF and its Members would be pleased to contribute technical expertise to those efforts.

Proposal

20. Add methane slip to CO2 emissions to form a CO2-equivalent to be used in EEDI calculations and for other CO2 reduction regulations and guidelines.

Action requested by the Working Group

21. The Group is invited to consider the information and comments contained in this submission and to take action as appropriate.

<u>CORE LNGas Hive Project and LNGHIVE2 Strategy for LNG Bunkering in Spain and Onshore Power Supply running on LNG.</u>

CORE LNGas hive project and LNGHIVE2, are an initiative co-financed by the European Commission through the Connect Europe mechanism (CEF). The objective of the project is defined in four goals:

1. To advance the decarbonisation process in the Iberian Peninsula
2. To contribute to the reduction of pollutant emissions in maritime transport.
3. To promote the use of this alternative fuel not only on ships but also in port areas.
4. To Roll-out an integrated, safe and efficient logistics chain for the supply of liquefied natural gas (LNG) as fuel in the transport sector, especially at sea, in the Iberian Peninsula.

The projects, led by Puertos del Estado, have 47 partners from Spain and Portugal: 8 public institutions; 13 port authorities and 26 industrial partners such as shipping companies, LNG operators and suppliers of different services within the value chain and 81 stakeholders. The total budget amounts to 138.5 million euros.

These projects include 39 activities carried out by the partners for the adaptation of infrastructure and logistics, the adaptation and new construction of LNG-powered ships and their commercial development in order to offer small-scale supply and fuelling services.

Among other activities, the development of a portable LNG-powered Onshore Power Supply project stands out.

The objective of this activity is the development of an onshore mobile LNG electric generator unit intended to supply power to a vessel when berthed. The electrical power needed to keep running HVAC, lighting, and any other on-board equipment while docked is to be provided by this onshore side generator, allowing the shutdown of auxiliary diesel generators.

Reducing emissions produced by vessel diesel engines can be achieved by shore to ship power supply system. This solution represents an alternative to on-board power generation for vessels operation at port when berthed. As it is a portable solution, it can be moved to any port to provide this service upon the vessel's request. Beside the benefits stated above regarding the harmful emission reduction, other advantages like noise reduction and financial benefits by increasing machinery lifetime should be taken into consideration.

The onshore generator unit is LNG fuelled, expecting therefore a reduction in emissions of NOx, SOx, particles matter, CO_2 and CH_4 in comparison to the use of vessel's auxiliary diesel generators. Three tests have been carried out in the ports of Barcelona, Vigo and Tenerife. For the port of Barcelona the estimated reduction in emissions for L'Audace ro-ro ship during the stay in Barcelona port, considering that:

- The ship made 50 scales in 2014, averaging 9 hours each, giving a total time of 449,4hours per year at port.
- The on-board generator NOx emissions are 12g / kWh at 800rpm.
- 2 auxiliary of 648 kW are installed on-board, of which only operates one.
- The sulphur (S) content in fuel is 1.5 %

Tabla 1 Emission Reductions NOx and SOx

L'Audace ro-ro ship	Current situation (using onboard generator)	Proposed onshore LNG generator supply	Expected annual reduction
Annual SOx emission	92,6 Tn	0 Tn	92,6 Tn
Annual NOx emission	3,5 Tn	0,5 Tn Approx.	3 Tn

Moreover, the noise level is reduced, as LNG engines are designed under an Otto cycle, which as general rule, generates less noise and vibrations than an equivalent diesel engine.

Once the gas generator is installed in the quay, measurements of the atmospheric emissions (CO2 and CH4) of the engine will be carried out, following the same methodology used for the study in diesel engines, in order to be able to compare the results.

At preliminary level, and according to the real data provided by the partner by Guascor-Dresser Rand the comparison of emissions of a diesel engine vs gas engine of equal power (850 kW) of this company is:

Tabla 2 Comparison of emissions of a diesel engine Vs gas engine of equal power

	DIESEL		GAS	
Rpm	1800	1500	1800	1500
Pme bar	11,26	12,3	11,26	12,3
Co2 g/m_n^3	230	225	180	172
NOx mg/m_n^3	2400	2800	500	500
Particulate matter mg/m_n^3	50	65	20	20

According to the theoretical data the reduction of atmospheric emissions in the generator engine to LNG will be significant, so the project will be very useful to reach the limits of air quality in the environments of the ports. The proposed solution is flexible for all ports, wharves or ships, so we can consider that it is a project exportable to other European ports.

Thanks to the CORE LNGas hive project, LNGHIVE2 and other private initiatives derived from the development of these projects that have carried out the adaptation and new construction of LNG-powered ships, projects such as the one mentioned OPS are actively supported from the ports, around 2 million tons of CO2 will be reduced in the maritime sector over the next ten years. As an example, the CO2 emitted by a cruise ship is the equivalent of 20,000 cars driving 10,000 kilometers per year. Large ports such as Barcelona are already benefiting from LNG ships and cruises that dock there, improving the air quality of both the port and the city.