Fossil gas: the greenwashing pill shipping wants you to swallow

May 2023

Shipping is responsible for about 3% of global greenhouse gas emissions – more than the total national emissions of the entire German economy. Without effective mitigation measures, maritime transport could account for 10% of CO_2 emissions by 2050. Ships have traditionally relied on refinery residues such as heavy fuel oil (HFO), or very low sulphur fuel oil (VLSFO), to power their engines, which inevitably leads to awful climate, environmental and health consequences.

Some regulatory measures combined with societal pressure have pushed shipping companies to start their green transition. But instead of switching to fuels whose green credentials can have a significant positive impact on air pollution and climate change, many ships are planning to run on fossil gas – in the form of liquefied natural gas (LNG) – and that represents a significant step back when it comes to climate change.

Shipping companies that use gas instead of traditional fuels want the public and policymakers to believe that LNG is the "*best option available today*". LNG is advertised as "*a fuel for the future*", a "*transitional fuel*", or as "*paving the way for the uptake of sustainable non-fossil fuels*". Science, however, does not agree with these statements. While LNG can have some positive impact when it comes to air quality, it often makes climate problems worse because of methane slips and leakages associated with the use of this fuel.

1. What is natural gas and how is it used in shipping?

Natural gas is a fossil fuel extracted from underground, similarly to coal and oil. Because of its low density in a "gaseous" state, natural gas is often liquefied under freezing temperatures (-162 degrees Celsius) to increase its density thus facilitating its transport, storage, and use. Hence, we generally talk about LNG. Depending on where the natural gas is sourced from, methane (CH4) accounts for 87%-96% of the energy contained in LNG.[1] Methane is also a greenhouse gas with 36 times more global warming power than CO_2 over a 100-year period.[2] In shipping, LNG can be used as a marine fuel to power the vessel, but it is also transported around by ships and then used in power plants, boilers, or gas stoves on land. In this briefing, we focus on the climate implications linked to LNG as a marine fuel.

2. Why do ships use LNG as a fuel?

The adoption of LNG as a fuel by ships stems from the fact that LNG contains less carbon and little sulphur compared to traditional marine fuels. LNG can thus lower CO_2 and sulphur oxides (SO_x) emissions that ships would normally emit. LNG marine engines are also set up in a way that emits less nitrogen oxides (NO_x) emissions.[3] LNG thus appeared as a good fuel option when global and regional air pollution regulation kicked in via Emissions Control Areas (ECA)[4] and national regimes taxing NO_x emissions.[5] And when the first global regulation tightening CO_2 emissions from ships was adopted in 2011, LNG appeared again to be a good interim solution. LNG also seemed to make sense from an economic perspective, as it was cheaper than relatively cleaner marine gasoil (MGO) that could be used to comply with sulphur regulations.

3. Why is fossil gas a false solution?

While the industry was quick to tout the benefits of LNG, a relatively damning problem was swept under the carpet, namely, methane slippages from ships associated with LNG use and leakages from on-shore infrastructure associated with LNG production, transportation and storage. If methane is released in air – even in very small amounts – its impact on climate change is disastrous. Ships that rely on gas contribute to methane emissions in different ways: directly by using LNG in the engine and indirectly through the LNG production supply chain.

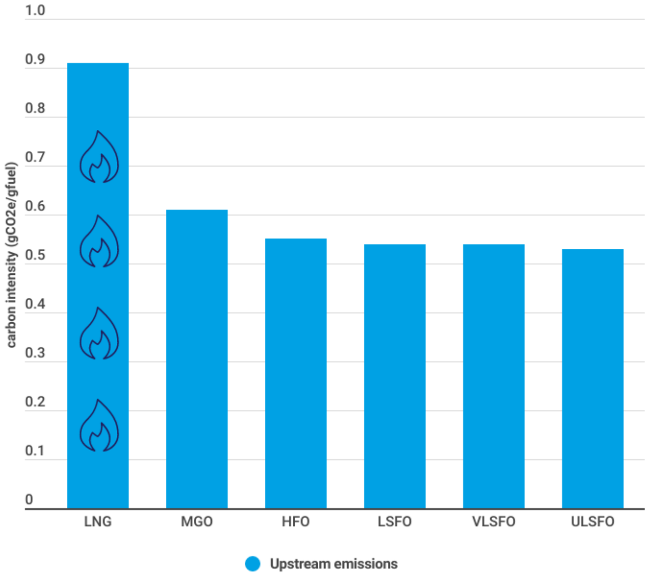
3.1. Methane slip during the production process & supply chain

The amount of methane that leaks during the production process varies depending on the gas production facilities and the gas treatment processes. Methane leakages can occur because of

[1] Other molecules that can be present in LNG in much smaller quantities include ethane, propane, and butane.
[2] Over a 20-year period, methane has 87 times more global warming power than CO_2.
[3] LNG-fitted engines can reduce NOx emissions by 20% to 80%.
[4] The list of Emission Control Areas (ECAs) can be found on the International Maritime Organization website: www.imo.org/en/OurWork/Environment/Pages/Special-Areas-Marpol.aspx
[5] Sofiane Laribi & Emmanuel Guy (2020). "Promoting LNG as A Marine Fuel in Norway: Reflections on the Role of Global Regulations on Local Transition Niches" *MDPI*. Retrieved from: www.mdpi.com/2071-1050/12/22/9476

material deficiencies, or through venting or flaring.[6] When gas is transformed into LNG, methane leaks also occur when the fuel is distributed and stored in large tanks and underground storage facilities. Methane leakages are not rare: in 2022, 3 million tonnes of methane from large leaks of gas and oil production facilities were visible through satellite images.[7] This equals about 220 million tonnes of CO_2 emissions due to methane's amplified climate impact - larger than the total national emissions of a country such as the United Arab Emirates. Methane leaks thus represent an important source of greenhouse gas emissions and by increasing demand for LNG, the shipping industry is indirectly causing more upstream methane emissions.

The LNG supply chain emits more upstream emissions than other fossil-based fuels

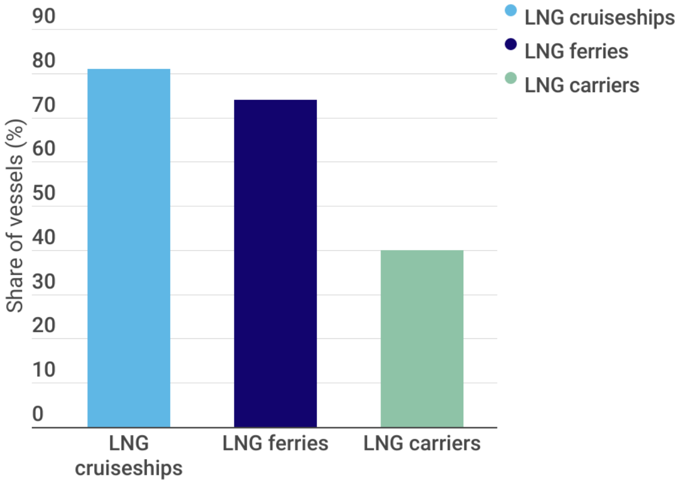


Sources: Transport & Environment; FuelEU Maritime Annex II

3.2. Methane slip on board the vessel

The amount of methane that slips in the air on board the vessel will vary depending on the type of engine used. The table in the annex provides an overview of the most popular marine LNG engines and the percentage of methane that slips from each engine type based on the amount of fuel used in operation. All of the engines listed are "dual-fuel". This means that they can use LNG as well as another fuel (typically a traditional marine fuel such as HFO/MGO or VLSFO).

A majority of LNG cruise ships and ferries rely on the leakiest type of engine in terms of methane



Note: This graph shows the percentage of LNG-powered cruise ships, ferries and LNG carriers that rely on the LNG Otto Dual Fuel Four Stroke Low Pressure Engine. **Source**: Clarksons Database

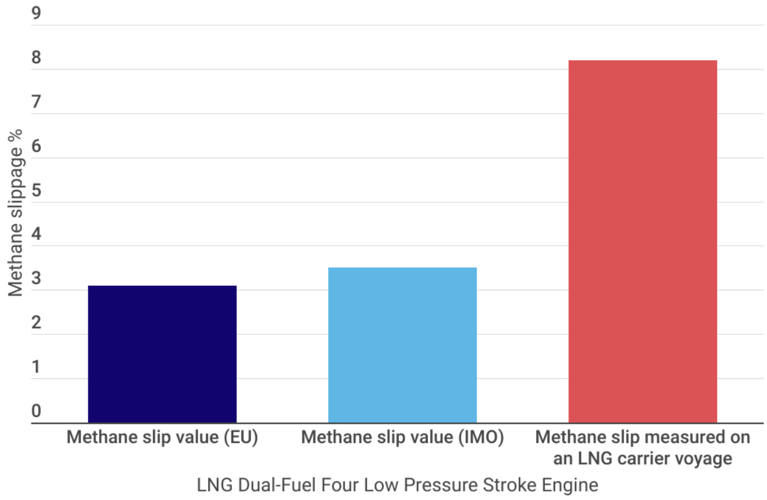
The methane slip estimates have been established on engines in controlled conditions. It is thus probable that the

[6] Gas flaring refers to the burning of excess gases to relieve pressure during the extraction and refinement process of gas. Gas venting refers to the release of gas without burning in the atmosphere.
[7] International Energy Agency (2022). "Estimated methane emissions from single events detected by satellite, 2022". Retrieved from: www.iea.org/data-and-statistics/charts/estimated-methane-emissions-from-single-events-detected-by-satellite-2022

amount of emissions is different – and likely higher – when the vessel operates at sea. In fact, independent real-world academic measurements demonstrate that methane slips from marine engines are actually much larger than the values provided by the manufacturers. This is because other parameters enter the equation such as vessel's speed and engine load. It is also important to keep in mind that big ships rely on several engines: the main engines provide the power for the vessel to move, while auxiliary engines ensure that everything works on board such as electricity. Some ships might be equipped with a combination of engines, some of which leak more methane than others.

The most popular engine for LNG-powered cruise ships and ferries is a four-stroke engine that has the highest methane slippage. It is the engine favoured by cruise ships and ferries, because of space and noise considerations as well as flexibility given changing power load. It is also used by 40% of LNG carriers and is often used as an auxiliary engine.

Standard values underestimate methane slip under real-life conditions



Sources: Transport & Environment; Paul Balcombe, Dalia A. Heggo, and Matthew Harrison. Total Methane and CO2 Emissions from Liquefied Natural Gas Carrier Ships: The First Primary Measurements. Environmental Science & Technology 2022 56 (13), 9632-9640.

INFO BOX: ARE SHIPS RELYING ON SHALE GAS?

An increasingly popular method to extract natural gas is fracking, which is used primarily in the United States, a country that is becoming a strategic gas provider to the EU. Fracking involves fracturing rocks by injecting under high pressure a mixture of water, chemicals and sand to reach new gas and oil deposits. Gas obtained through fracking is often referred to as *shale gas*. Due to numerous environmental concerns, shale gas exploration has been put on hold in many European countries. But as Europe is weaning itself off of Russian gas by signing large LNG import contracts with other countries,[8] the US fracked gas exports have started dominating Europe's LNG imports at 44%.[9] It is thus likely that a substantial part of the LNG used by ships that bunker in Europe is produced via fracking. In 2022, the US was by far the main LNG exporter to the Netherlands and the port of Rotterdam provided 328,089 tonnes of LNG as fuel to ships.[10]

---

[8] Edward Donnelly (2023). "LNG fever: European firms sign mega-contracts as US shale gas imports boom". *investigate-europe.eu*. 9 January 2023. Retrieved from: www.investigate-europe.eu/en/2023/lng-fever-mega-contracts-shale-gas-imports-us/

[9] European Commission (2022). Liquefied natural gas. Retrieved from: www.energy.ec.europa.eu/topics/oil-gas-and-coal/liquefied-natural-gas_en

[10] Ana Maria Jaller-Makarewicz (2023). As Europe tried to cut Russian ties, dependence on imported LNG deepens. Retrieved from: www.ieefa.org/resources/europe-tries-cut-russian-ties-dependence-imported-lng-deepens

4. Why gas sets shipping on the wrong transition path

Shipping's move towards LNG implies the construction of LNG-fit vessels as well as a dedicated bunkering infrastructure, which require huge investments. These investments are often justified under two pretexts.

Firstly, it is argued that LNG is the only available alternative fuel today and that can immediately reduce air pollution while long-term solutions are still being developed. The fallacy of this argument is that existing ships, that make up the majority of the total fleet, cannot use LNG without significant – and largely cost-prohibitive – retrofits.[11] Only new purpose-built LNG dual-fuel ships can run on LNG. This means that from the point of view of the total fleet, LNG's contribution to reducing air pollution is marginal as the majority of air pollution is caused by the existing fleet. Instead, a much larger amount of disease-causing sulphur oxides and particulate matter emissions could be eliminated by simply switching to relatively cleaner marine gasoil (MGO) with low (0.1%) sulphur content. Given that MGO is already compatible with existing land-based refuelling infrastructure and does not require onboard retrofits, it would be a more cost-effective solution to reduce air pollution than slowly replacing the fleet with LNG dual-fuel ships with a life-time of 25-30 years.

Secondly, LNG is touted as a "bridge fuel": the end-goal is to eventually rely on fuels such as bio-LNG (also known as liquified biomethane) or e-LNG (also known as liquified e-methane). These fuels can be used by the existing LNG vessels and bunkering infrastructure without modification. But they come with drawbacks notably in terms of availability and production costs compared to other future clean alternative fuels.

4.1. Bio-LNG | Biomethane

Biomethane can be produced from a variety of organic sources ranging from agriculture, animal fat, plants, biomass waste, sewage sludge through anaerobic digestion or gasification process. The issue is that biomethane production sources are limited if they are to be obtained in a sustainable way.[12] Biomethane becomes even less available when we take into account competing demands to replace fossil gas such as heating, cooking, or power generation.

Shipping is also an inefficient way of using limited biomethane, as ships can only use biomethane if it is liquified.[13] Liquefaction usually results in an 8% energy penalty to transform gaseous biomethane into liquid biomethane by chilling down to -162°C. This means that limited biomethane will simply be

[11] Ian Lewis (2020). "Hapag-Lloyd boxship LNG retrofit 'is still too expensive' to be viable". *Trade Winds*. 12 October 2020. Retrieved from: www.tradewindsnews.com/containerships/hapag-lloyd-boxship-lng-retrofit-is-still-too-expensive-to-be-viable/2-1-890625; Mike Wackett (2021). "Plenty of orders for new LNG-fuelled box ships, but conversions are too costly". *The Loadstar*. 14 April 2021. Retrieved from: www.theloadstar.com/plenty-of-orders-for-new-lng-fuelled-box-ships-but-conversions-are-too-costly/

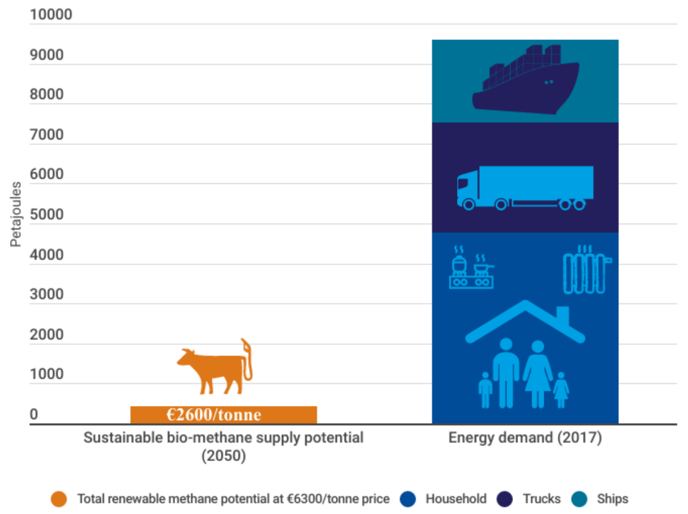
[12] Sources to produce biomethane in a sustainable way are limited, because they should not interfere with food production nor be obtained at the expense of forests that act as carbon sinks.

[13] Bryan Comer, Jane O'Malley, Liudmila Osipova, and Nikita Pavlenko (2021). "Comparing the future demand for, supply of, and life-cycle emissions from bio, synthetic, and fossil LNG marine fuels in the European Union." Page 3. Retrieved from: www.theicct.org/wp-content/uploads/2022/09/Renewable-LNG-Europe_report_FINAL.pdf

wasted if it were used on a ship as opposed to provided to households or power plants that use biomethane in a "gaseous" state.

Biomethane is also a costly fuel. While some small volumes can be produced from landfill biogas at affordable prices, these feedstocks are very limited. Other feedstocks, such as sewage, forest and agro residues, dairy and non-dairy manure results in costs up to 30 times the price ships currently pay for fossil LNG.[14]

EU 2050 bio-methane potential not even enough for households



Notes: The chart is conservative as it compares 2050 supply with 2017 demand. This supply would only be feasible at a retail price of €6300/t (excluding taxes), which is more than 10 times higher than the current LNG prices. Energy demand for households is limited to natural gas demand only.

Sources: ICCT (2018), Eurostat (2017), UNFCCC (2017).

TRANSPORT & ENVIRONMENT transportenvironment.org

Biomethane would reduce the amount of greenhouse gas emitted throughout the supply chain and on board the vessel compared to LNG of fossil origin, but they would not completely cancel those. Methane emissions linked to biogas and biomethane supply chains exist and are likely to be higher than what the International Energy Agency's previously estimated.[15] In addition, the methane slip of the engine remains, as biomethane is chemically similar to the methane of fossil origin.

4.2. E-LNG | E-Methane

E-methane can also be produced synthetically by combining green hydrogen (H2) from electrolysis with CO_2 captured from the atmosphere through direct air capture or from biogenic sources. E-methane is also known as electro-methane or e-LNG, and falls under the broad fuel category of e-fuels. When e-methane is combusted, it emits the same amount of CO_2 as LNG of fossil origin, but it can be considered "carbon neutral" if the emitted CO_2 is taken from the atmosphere in the first place. In that case, it does not add more CO_2 into the atmosphere, but it recirculates it.

The issue here stems from the fact that it is difficult to capture CO_2: the technological processes to capture CO_2 from the atmosphere – which would be a more sustainable option – are not mature enough and very costly. When it comes to obtaining CO_2 from biogenic sources, we face the same issue as biomethane in the sense that there aren't enough sources of sustainable organic matter to make it a scalable option. This implies that the cost of e-methane would be significantly higher than other potential green hydrogen-based fuels whose climate credentials would be a lot better and do

[14] Ibid. page 21
[15] Semra Bakkaloglu, Jasmin Cooper, Adam Hawkes (2022). "Methane emissions along biomethane and biogas". *One Earth*. Retrieved from: www.sciencedirect.com/science/article/pii/S2590332222002676

not need a source of CO_2 in the first place. Lastly, e-methane would still lead to methane slips/leaks leading to considerable residual emissions.

4. What are the solutions?

There are various short-term and long-term solutions that can allow ships to decrease their greenhouse gas emissions. Below is a non-exhaustive list of potential solutions.

1. **Shore-side electricity (SSE) |** SSE at ports can be deployed as of today. This allows ships to connect directly to an electricity source at the port and not rely on their engines to produce electricity for onboard operations. It is the simplest and likely the cheapest option to fully decarbonise ships at berth, which represents 6% of EU shipping emissions, and to eliminate air pollution. The latest Alternative Fuel Infrastructure Regulation (AFIR) adopted at the EU level makes it compulsory for ports to have sufficient power and connecting points for containerships, cruise ships, and ferries by 2030. Shore-side electricity is also known as cold ironing and onshore power supply (OPS).

2. **Speed reduction** | If a ship slows down, it uses less fuel and thus emits fewer greenhouse gas emissions. Current estimates show that if a vessel reduces its speed by 10% it would consume 27% less fuel and equally fewer emissions.[16] Speed reduction is also known as slow steaming.

3. **Wind-assisted propulsion technology** | Using the power of wind allows a vessel to use less fuel and thus emits fewer greenhouse gas emissions. Wind-based solutions are not limited to soft or rigid sails but also include towing kites, wind turbines, hull sails etc. The deployment of these technologies on different types of vessels will lead to various greenhouse gas reductions that range from 2% to 13%.

4. **Green hydrogen e-fuels** | E-fuels are fuels produced from hydrogen. Hydrogen itself is considered *green* when it is obtained via an electrolysis process powered with renewable electricity. Depending on the ultimate chemical mix, e-fuels can come in various shapes and can be divided into two broad categories.
   a. The first category are the ones that do not contain carbon atoms (liquid or compressed e-hydrogen and e-ammonia). E-ammonia is synthesised by combining green hydrogen with nitrogen captured from the atmosphere. These fuels are likely to be cost-competitive in the future, but they do require a specific type of engine, onboard storage tanks, and bunkering infrastructure.
   b. The second category of e-fuels are produced by combining hydrogen and CO_2. Because it is challenging and expensive to obtain CO_2, they tend to be more expensive. They are compatible to a certain extent with current vessels, fuel tanks, and bunkering infrastructure. As mentioned above, e-methane is compatible with LNG ships and bunkering infrastructure. Another example is e-methanol which can be used in methanol-powered ships, as well as in

[16] CE Delft, The ICCT, Miki Tsimplis (2012). "Regulated slow steaming in maritime transport: An assessment of options, costs and benefits". page 7. Retrieved from:
www.ce.nl/wp-content/uploads/2021/03/CE_Delft_7442_Regulated_Slow_Steaming_Maritime_Transport_DEF_1330615818.pdf

existing HFO/MGO vessels after some modifications. Similarly, e-diesel is compatible with traditional vessels and fuel bunkering infrastructure.

Further information

Name: Constance Dijkstra
Title: Shipping Campaigner – LNG & Biofuels
Transport & Environment
constance.dijkstra@transportenvironment.org
Mobile: +32(0)49343277

Annex: Methane slip per engine type

Engine Type	Engine Type (alternative name)	CH4 Slip (% of fuel)[17]	LNG vessels relying on this type of engine in fleet
LNG Otto Dual Fuel Medium Speed	Otto Cycle Dual Fuel Four-stroke Low Pressure	3.1%[18]	• 81% of LNG cruise ships • 74% of LNG ferries • 40% of LNG carriers
LBSI (Lean Burn Gas Engine)	N/A	2.6% [19]	• 20% of LNG ferries
LNG Otto Dual Fuel Slow Speed	Otto Cycle Dual Fuel Two-stroke Low Pressure D	1.7%[20]	• 73% of LNG carriers • 45% of LNG container ships
LNG Diesel Dual Fuel Slow Speed	LNG Diesel Dual Fuel Two-stroke High Pressure	0.20%[21]	• 48% of LNG container ships • 27% of LNG carriers

[17] European Commission (2021). "Proposal for a Regulation of the European Parliament and the Council on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC". Annex II. Retrieved from: www.eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021PC0562
[18] Ibid
[19] Transport & Environment (2021). "FuelEU Maritime: T&E analysis and recommendations: How to drive the uptake of sustainable fuels in European shipping". Retrieved from: www.transportenvironment.org/wp-content/uploads/2022/02/TE-Report-FuelEU-Maritime-1.pdf - page 42
[20] European Commission (2021). "Proposal for a Regulation of the European Parliament and the Council on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC". Annex II. Retrieved from: www.eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021PC056
[21] Ibid