BRIEFING - NOVEMBER 2024

How much does LNG emit before it burns on a ship?

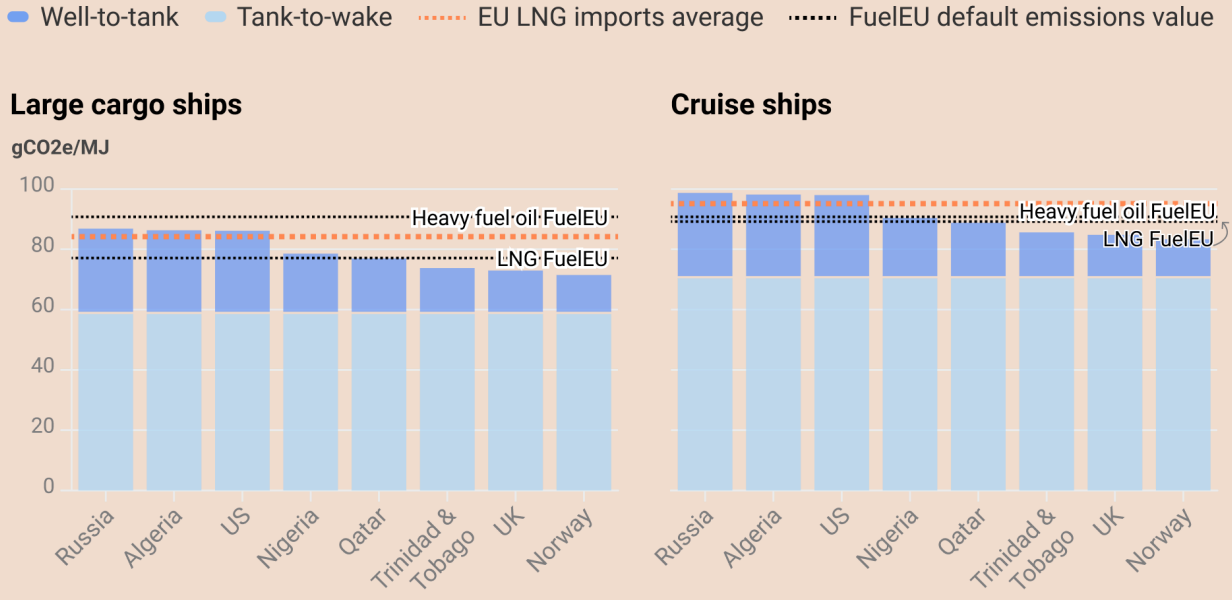
Fossil gas is almost as bad as the dirty fuels it is trying to replace

Summary

Oil and gas majors and some shipping companies present liquefied fossil natural gas (LNG) as a cleaner alternative to traditional marine fuels and a transitional fuel in shipping's decarbonisation journey. While LNG combustion emits fewer local air pollutants and less CO_2 than conventional marine fuels, unburned methane that slips from LNG engines, especially the most polluting ones,[1] commonly used in passenger and cruise ships, undermines its potential climate benefits. Whereas the uncombusted methane issue is increasingly recognised as problematic by policymakers, the upstream greenhouse gas emissions that occur during the extraction, processing, liquefaction, and transport phases of LNG remain largely off the scrutiny radar. Known as well-to-tank emissions, they vary considerably depending on the LNG production location, influencing the overall climate impact of LNG-fueled ships. To better quantify the effects of these upstream emissions, T&E commissioned Energy and Environmental Research Associates to conduct comprehensive research into the carbon-intensity and greenhouse gas emissions from the LNG supply chain for Europe's largest import sources.

High upstream emissions can make LNG worse for the climate than fuel oil

Emissions from LNG production vary significantly across countries, resulting in a high average for EU LNG imports

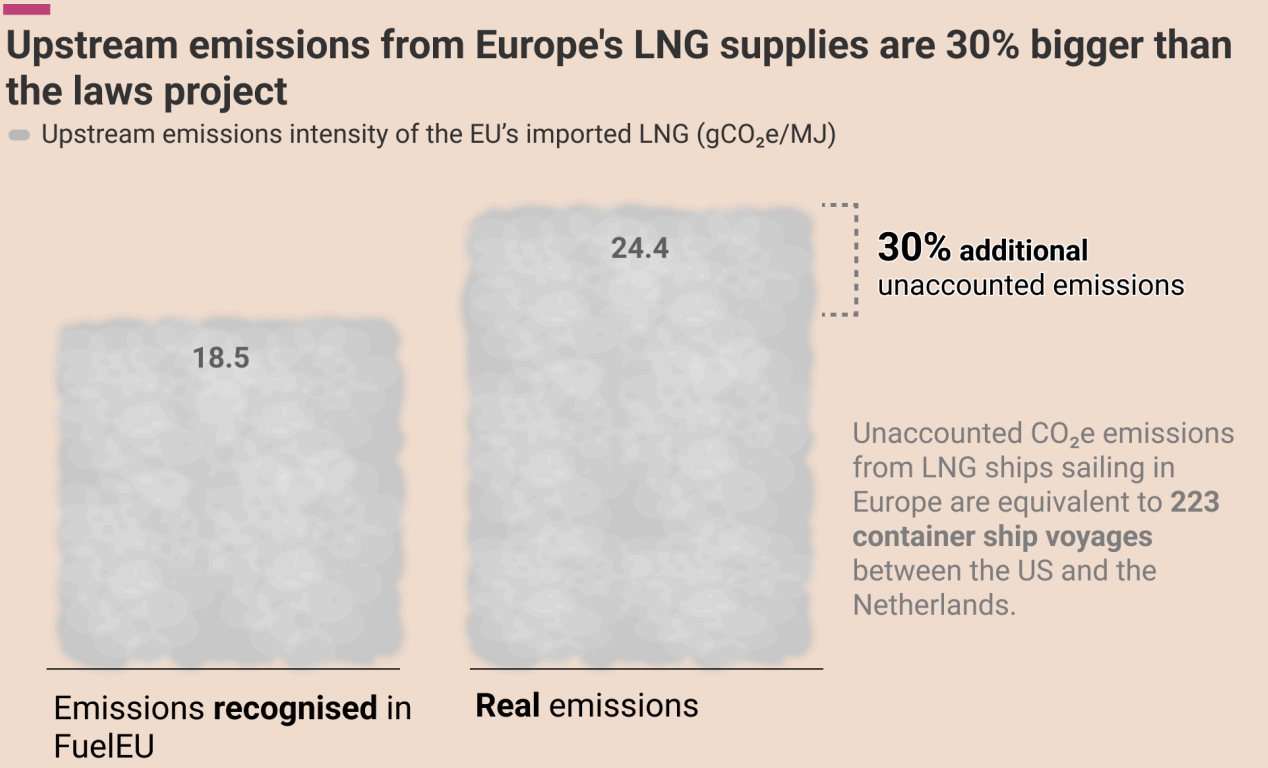


Transport & Environment and EERA analysis (2024). • TTW values from FuelEU Maritime Annex II. Scenario compares 2-stroke high-pressure LNG engines in large cargo ships with 4-stroke low-pressure engines in cruise ships.

[1] Four-stroke low-pressue engines have the highest methane slip. ICCT (2024). Fugitive and unburned methane emissions from ships (FUMES). Retrieved from https://theicct.org/wp-content/uploads/2023/11/ID-64-%E2%80%93-FUMES-ships-Report-A4-60037-FV.pdf

Overall, LNG production is concentrated in a small number of countries.[2] Due to the energy policy changes incited by the war in Ukraine, the EU increasingly relies on LNG imports to meet its natural gas demand. The US, Qatar, Russia, Algeria, Nigeria, Norway, Trinidad & Tobago and the UK together comprise 90% of EU's LNG imports, each with varying upstream emissions profiles.

The average upstream emissions of EU LNG imports, calculated based on the relative share supplied by each source, stand at 24.4 gCO_2e/MJ. EU green shipping law, FuelEU Maritime Regulation, however, underestimates this value, assuming only 18.5 gCO_2e/MJ. This discrepancy leads to 30% unaccounted upstream CO_2e emissions from LNG, equivalent to 223 container ship voyages between the US and the Netherlands.



Source:Analysis based on EERA analysis (2024) and T&E SEA model. Emissions calculated for OOCL ASIA containership voyage between Port Charleston in the US and the port of Rotterdam in the Netherlands.

Reaching beyond Europe, the International Maritime Organization (IMO) is currently developing default emission factors for shipping fuels. Country-specific and up-to-date emissions reporting is critical to avoid setting misleading standards that obscure LNG's true climate impact. Notably, despite growing evidence and opposition from scientific and civil society groups, LNG is increasingly viewed as the preferred "alternative" fuel for new

[2] Australia is excluded from this analysis because it does not supply the EU. Statista (2024). Countries with largest liquefied natural gas (LNG) export capacity in operation worldwide as of October 2023. Retrieved from https://www.statista.com/statistics/1262074/global-lng-export-capacity-by-country/

ship orders. Almost 1,200 LNG-powered vessels are sailing globally, and close to 1,000 are in the order books. If this trend continues, by 2030, over 10% of the energy used by the global maritime fleet could come from fossil gas.

To ensure that LNG emissions across the full value chain are properly accounted for at the EU and IMO, we propose the following policy actions:

1. **Revise EU emission standards to accurately reflect upstream methane emissions**. The new EU Methane Regulation requires detailed reporting of fossil gas' carbon footprint. Based on this new data, the well-to-tank methane emission factor in the FuelEU Maritime Regulation should be adjusted to properly reflect upstream methane emissions.

2. **Establish realistic upstream LNG emissions values at the IMO**, based on reliable and recent scientific data, as the organization is currently developing default emission factors for shipping fuels.

3. **Standardise fuels' emissions reporting at the IMO**, with mandatory regular and granular reporting for each stage of the fuels' value chain.

4. **Ensure that the IMO Global Fuel Standard (GFS) accounts for shipping emissions on a well-to-wake basis**, to achieve shipping decarbonisation targets in line with the IMO greenhouse gas reduction strategy.

1. What are the well-to-tank emissions?

When it comes to emissions from liquefied natural gas (LNG) or any other fuel used for ship propulsion, the focus has been traditionally largely placed on combustion emissions, otherwise known as tank-to-wake (TTW) emissions.[3] LNG produces less pollutants and CO_2 than conventional marine fuels.[4] However, the methane slip, which takes place when uncombusted methane gets into the atmosphere, has challenged the status of LNG as a "cleaner alternative" or "transitional" fuel for shipping decarbonisation.[5] Scientific research shows that LNG might end up more damaging to the climate than fossil fuel, especially for passenger and cruise ships, traditionally using four-stroke low-pressure engines, known to have the highest methane slip.[6]

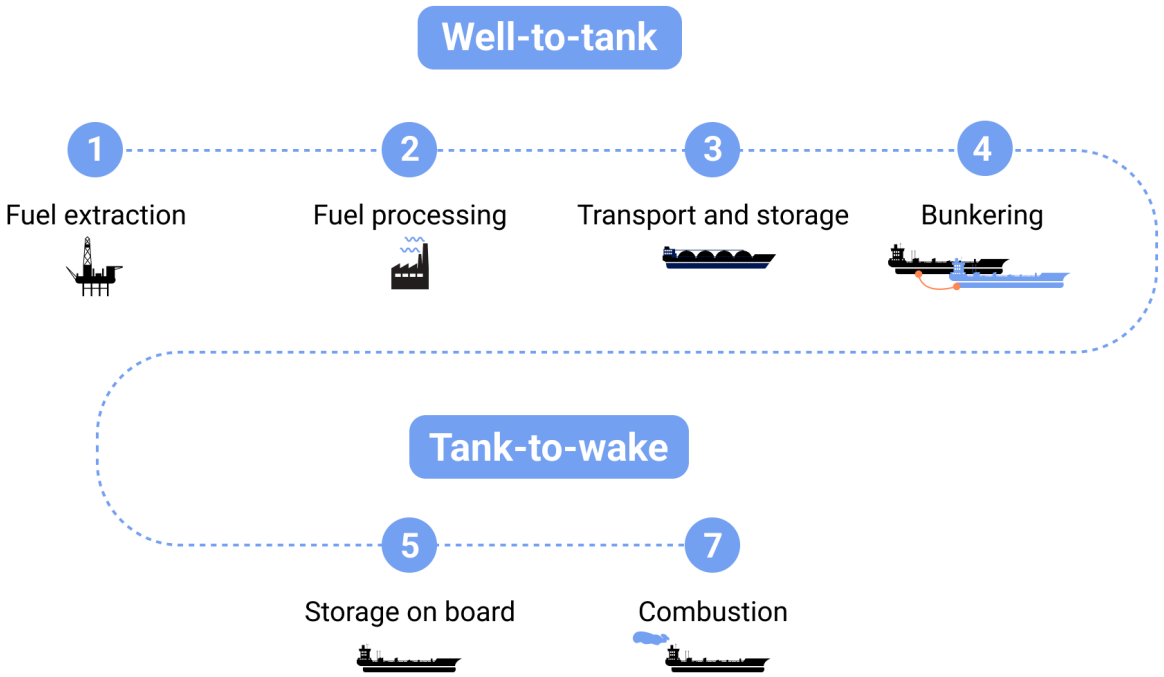
However, one topic that has received little attention is the emissions from LNG *before* it even reaches the ship. The so-called well-to-tank (WTT) or upstream greenhouse gas (GHG)

[3] Energy & Environmental Research Associates (EERA) (2024). Well-to-Tank Carbon Intensity of European LNG Imports.
[4] ICCT (2020). The climate implications of using LNG as a marine fuel. Retrieved from https://theicct.org/wp-content/uploads/2021/06/LNG-as-marine-fuel-working-paper-02_FINAL_20200416.pdf
[5] T&E (2022). Methane at Sea: Finding the Invisible Climate Killer. https://www.transportenvironment.org/articles/methane-finding-the-invisible
[6] Paul Balcombet et al (2024).Total Methane and CO2 Emissions from Liquefied Natural Gas Carrier Ships:The First Primary Measurements. Retrieved from https://pubs.acs.org/doi/pdf/10.1021/acs.est.2c01383; ICCT (2023). Fugitive and unburned methane emissions from ships (FUMES).

emissions contribute significantly to this fuel's overall climate impact. WTT includes emissions produced during the extraction, liquefaction and transport of LNG from its source up to the point of use, including bunkering. Together with TTW emissions, this system represents the lifecycle emissions of a fuel.

Lifecycle emissions of LNG

Each stage of the fossil fuel life cycle generates greenhouse gas emissions and pollutants



Source: T&E

2. Emissions data from LNG production vary highly across countries

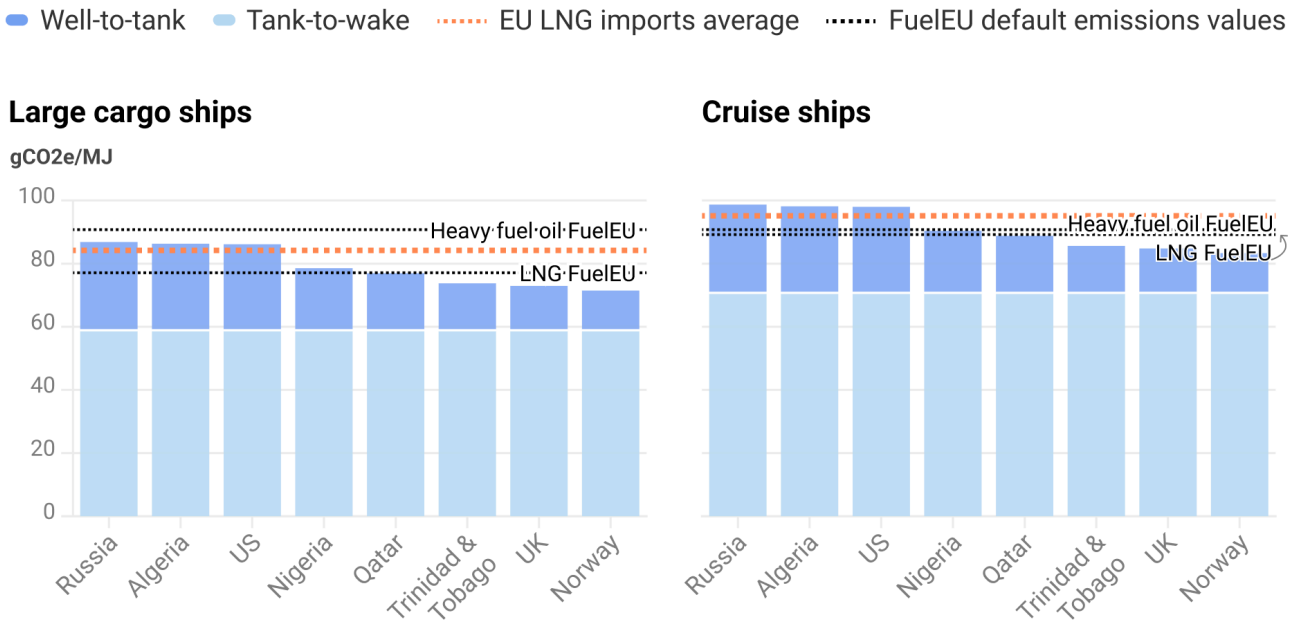
To better quantify the effects of LNG's upstream emissions, T&E commissioned Energy and Environmental Research Associates (EERA) to conduct comprehensive research into the carbon-intensity and greenhouse gas emissions from the LNG supply chain for Europe's largest import sources.

The differences between upstream emissions vary largely among countries - from an average of 12.57gCO_2e/MJ[7] in Norway to 27.96gCO_2e/MJ in Russia, significantly impacting the final well-to-wake (WTW) climate performance of LNG. Even greater differences can be observed between individual data sources on national LNG WTT emissions - ranging from 1.61gCO_2e/MJ in Norway to 54.58gCO_2e/MJ in Algeria. While the variability in the emissions intensity can be partly attributed to contextual factors, such as methods of fuel extraction, local production conditions, equipment, and distance from the EU, the lack of standardisation of GHG reporting practices strongly impacts the accuracy and comparability of data.

[7] CO_2e includes emissions from carbon dioxide (CO_2), methane CH_4, and nitrous oxide N_2O.

High upstream emissions can make LNG worse for the climate than fuel oil

Emissions from LNG production vary significantly across countries, resulting in a high average for EU LNG imports



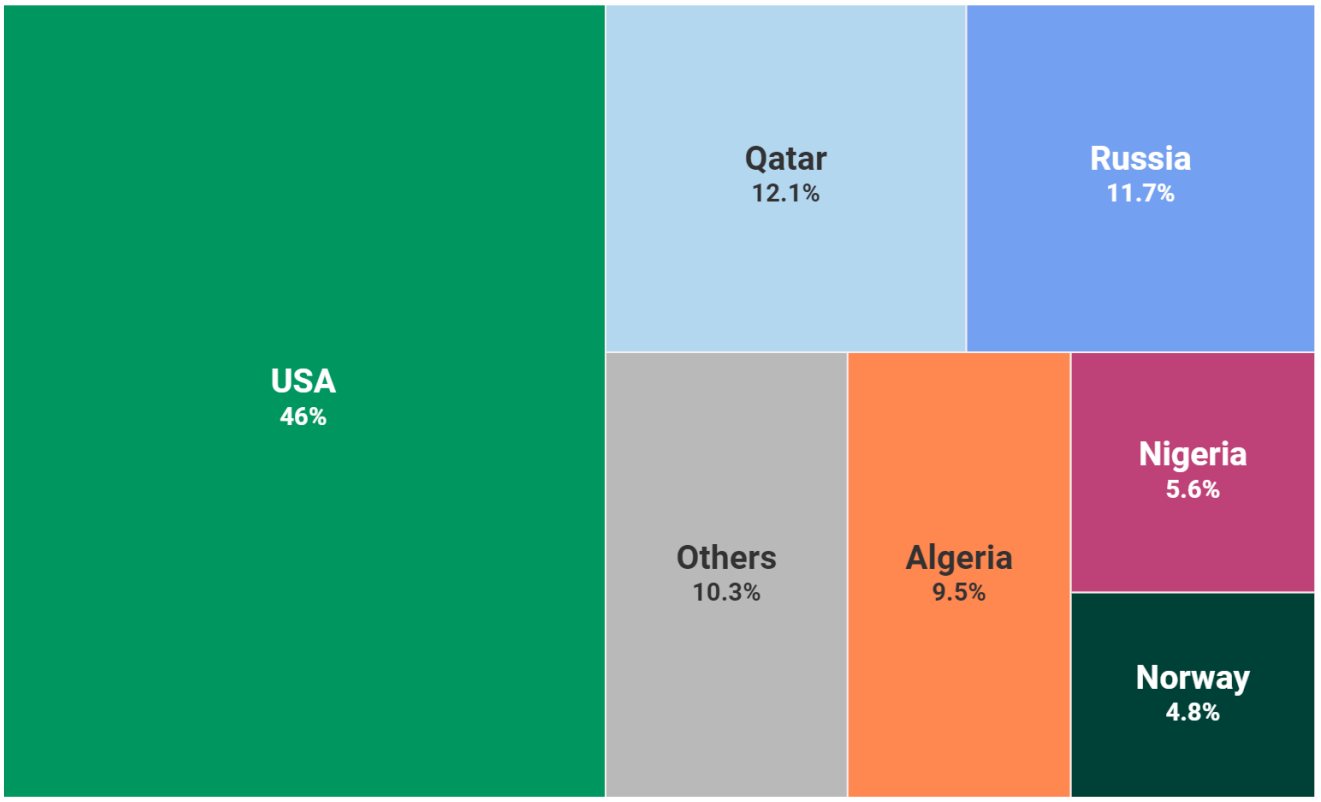
Transport & Environment and EERA analysis (2024). • TTW values from FuelEU Maritime Annex II. Scenario compares 2-stroke high-pressure LNG engines in large cargo ships with 4-stroke low-pressure engines in cruise ships.

3. Where does the European LNG come from?

The EU relies heavily on natural gas imports.[8] After Russia's invasion of Ukraine, the EU gas supplies shifted away from Russian pipeline gas to increased LNG imports. Today, LNG constitutes 41% of EU gas imports.[9] Almost half of those come from the US (46% in 2023). Overall, eight countries comprise 90% of the EU's LNG imports in 2023: US, Qatar, Russia, Algeria, Nigeria, Norway, UK, Trinidad & Tobago.

[8] Eurostat (2024). Natural gas supply statistics. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_supply_statistics
[9] Strategic perspectives (2024). EU gas insight. Retrieved from https://strategicperspectives.eu/eu-gas-insight/

Top LNG importers to the EU



Source: Energy & Environmental Research Associates analysis (2024). Results for 2023.

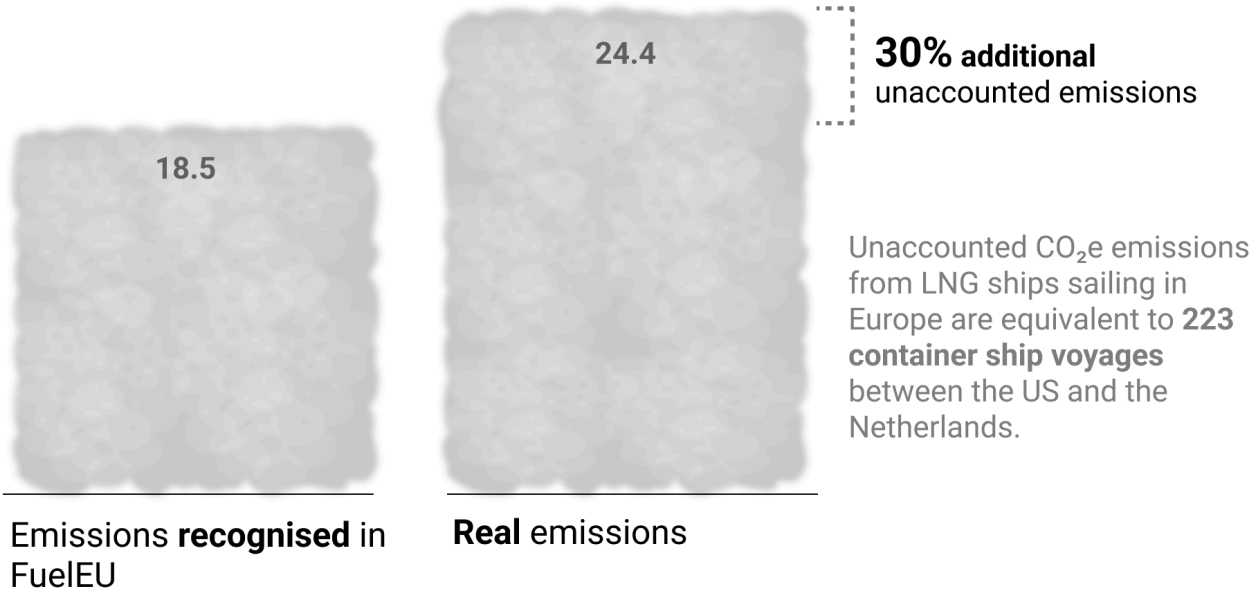
4. EU and IMO laws should reflect the real LNG climate impact

The average WTT emissions intensity of the EU's imported LNG is calculated on the relative share of key importers to the EU and stands at 24.40 gCO_2e/MJ.[10] In stark contrast, the EU's clean shipping fuels law - FuelEU Maritime Regulation - assumes this value to be by **default** 18.5gCO_2e/MJ. **This represents over 30% difference between the default (attributed by regulation) and the actual emissions values**. It could result in 2,731 tonnes of unreported CO_2e emissions per year for a single large LNG-powered containership.[11] Across all LNG-fuelled ships operating in Europe, the total unaccounted CO_2e emissions could exceed 811 thousand tonnes annually, equivalent to over 223 containership voyages between the US and the Netherlands.[12]

[10] EERA (2024). Well-to-Tank Carbon Intensity of European LNG Imports.
[11] T&E analysis based on 2023 MRV data.
[12] Analysis based on T&E SEA model. Emissions calculated for OOCL ASIA containership voyage between Port Charleston in the US and the port of Rotterdam in the Netherlands.

Upstream emissions from Europe's LNG supplies are 30% bigger than the laws project

Upstream emissions intensity of the EU's imported LNG (gCO_2e/MJ)



Source:Analysis based on EERA analysis (2024) and T&E SEA model. Emissions calculated for OOCL ASIA containership voyage between Port Charleston in the US and the port of Rotterdam in the Netherlands.

FuelEU Maritime stipulates that emissions factors should be amended when new scientific and technical data become available. Given the evolving geopolitical landscape and Europe's changing energy outlook, this revision should be prioritised, as the Regulation will start applying in 2025, requiring shipowners to begin accounting for the emissions of the fuels they use.

Meanwhile, the International Maritime Organization (IMO) has yet to establish its fuel emissions accounting system and the default emission factors for different fuels, including LNG. To minimise unaccounted emissions, it is critical that the IMO assess fuels on a life-cycle basis, combining upstream emissions with those onboard the vessel. Regarding the emission factors, the above findings highlight the risk of adopting unrepresentative default values and underscore the need to thoroughly consider the specificities of LNG production in major exporting countries. To that end, it is crucial that these countries provide transparent and up-to-date information on their LNG upstream emissions.

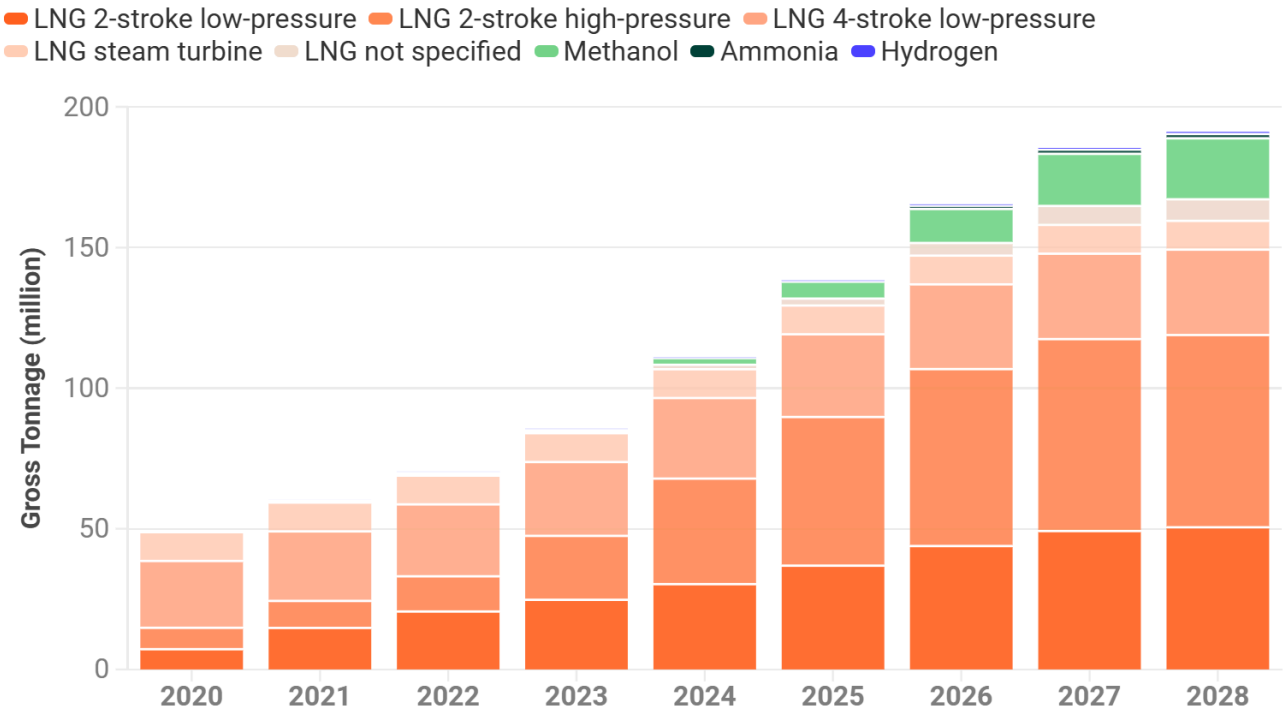
5. LNG ships are on the rise

Disclosing real emissions from LNG is especially important given that despite the backlash from the scientific community and civil society, LNG is widely (and increasingly) regarded as a cleaner alternative to fuel oil for powering ships. Today, almost 1,200 LNG-powered vessels are

sailing globally,[13] and close to 1,000 are in the order books. Although methanol-powered ship orders surged in 2023, LNG remains the unequivocal leader in "alternative" propulsion technology and the demand for this marine fuel is ever-growing.[14] By 2030, over 10% of the energy used by the global maritime fleet could come from fossil gas.[15]

LNG dominates ship engine uptake over green fuel technologies

Current fleet & orderbooks



Source: Transport & Environment (2024) based on Clarkson's World Register database.
This graph only takes into account the main engine.

[13] T&E analysis of 2023 MRV data, including dual-fuel LNG/VLSFO ships.
[14] Ship & Bunker (2024). Analysis: understanding the global orderbook in terms of conventional alternative bunker fuel demand. Retrieved from https://shipandbunker.com/news/world/993795-analysis-understanding-the-global-orderbook-in-terms-of-conventional-alternative-bunker-fuel-demand
[15] T&E analysis based on Clarksons data.

6. Policy recommendations

The shipping industry increasingly relies on liquefied natural gas, seen as a cleaner alternative to traditional marine fuels. However, depending on the geographical location where LNG is produced, high upstream emissions from extraction, processing and transport can make this fuel far worse for the climate than the current EU laws assume - even more harmful than heavy fuel oil. To effectively address emissions from LNG and ensure shipping's alignment with decarbonisation goals, we recommend the following EU and IMO policy actions:

1. **Update EU emission standards to accurately represent actual upstream methane emissions**. The new EU Methane Regulation requires detailed reporting of fossil gas' carbon footprint. Based on this real-time monitoring data, as well as the latest scientific research, the well-to-tank methane emission factor in the FuelEU Maritime Regulation should be updated accordingly.

2. **Set realistic LNG WTT emissions values at the IMO** in the Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), responsible for developing default emission factors for shipping fuels at the IMO, who have already started the process.

3. **Standardise fuels' emissions reporting through the IMO**, including annual reporting and the definition of separate values for each step of the fuel value chain.

4. **Ensure that the IMO Global Fuel Standard (GFS) considers shipping emissions on a WTW basis** including all steps across the fuel value chain, to avoid unreported emissions and align with the GHG reduction strategy.

Further information

Inesa Ulichina

Shipping Policy Officer

Transport & Environment

inesa.ulichina@transportenvironment.org

Mobile: +32 (0) 491 37 89 49