Methane slip: LNG's Achilles heel

Bryan Comer, PhD, Marine Program Lead

17 November 2022

Fuels for the climate: Is natural gas the solution to decarbonise shipping?

COP27 side event hosted by Transport & Environment and Pacific Environment

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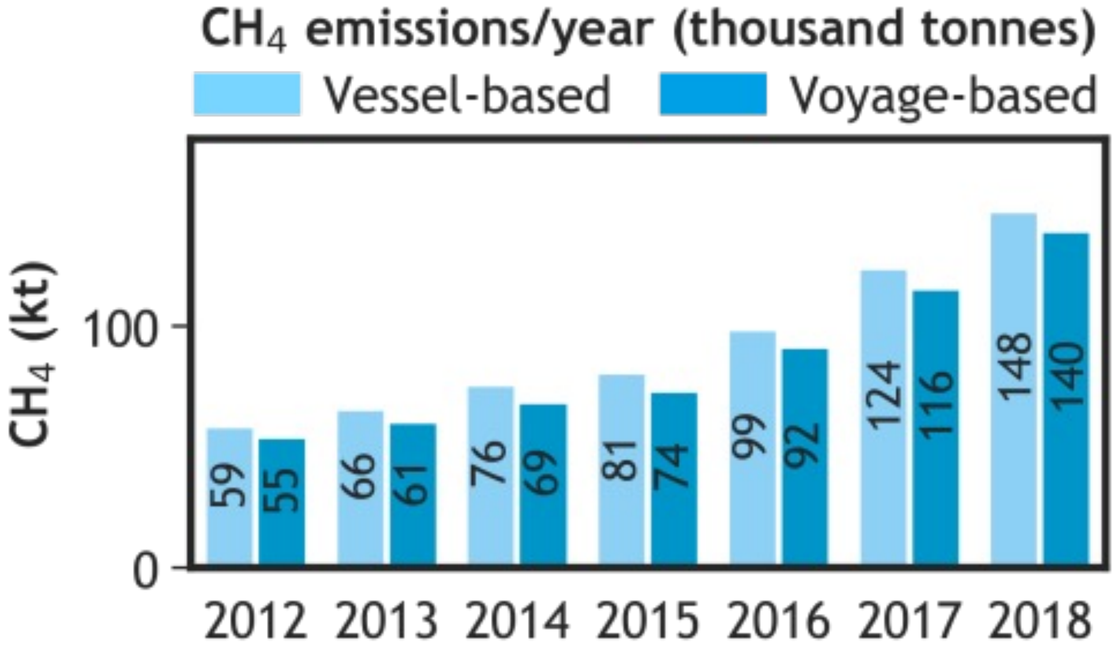
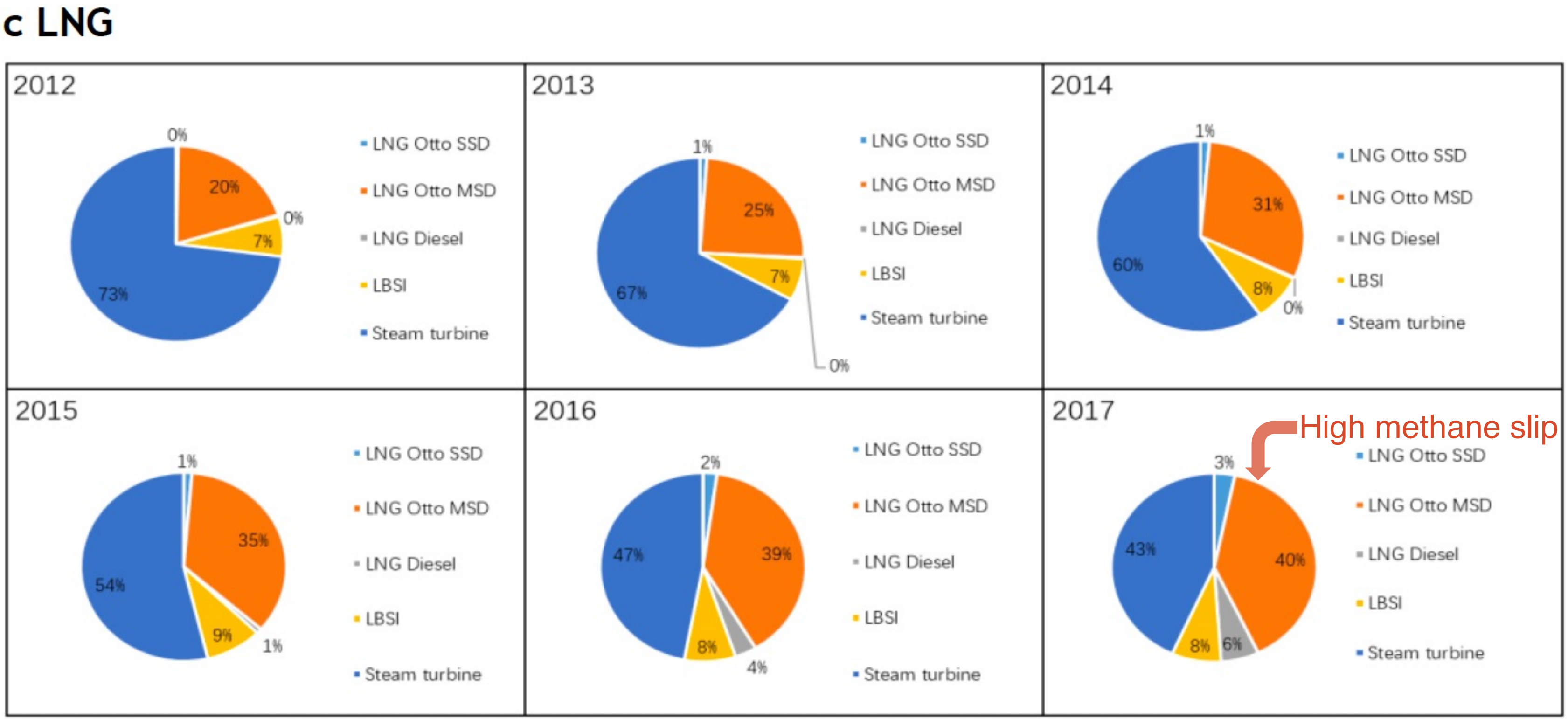
Rapid growth in methane emissions from ships

- Methane emissions from LNG-fueled ships have more than doubled in recent years.
- Why? Methane slip.
- Methane slip refers to CH_4 that escapes unburned from marine engines.



Faber et al. (2020). *Fourth IMO Greenhouse Gas Study 2020*. Available at the International Maritime Organization website, https://www.imo.org/en/OurWork/Environment/Pages/Fourth-IMO-Greenhouse-Gas-Study-2020.aspx. See Figure 76.

High methane slip engines consumed 40% of LNG marine fuel in 2017, up from 20% in 2012.



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For ships that trade with the EU, most LNG was used in high methane slip engines in 2019

- Half of the LNG consumed was in high methane slip engines in 2019.
- We predict even more in 2030.

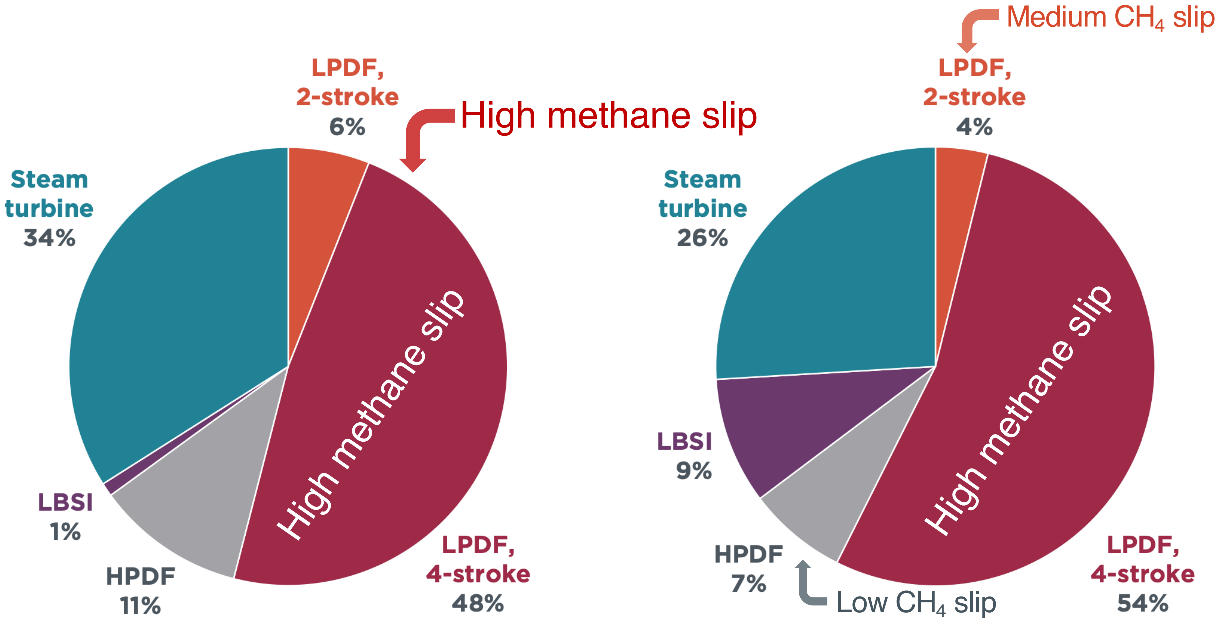
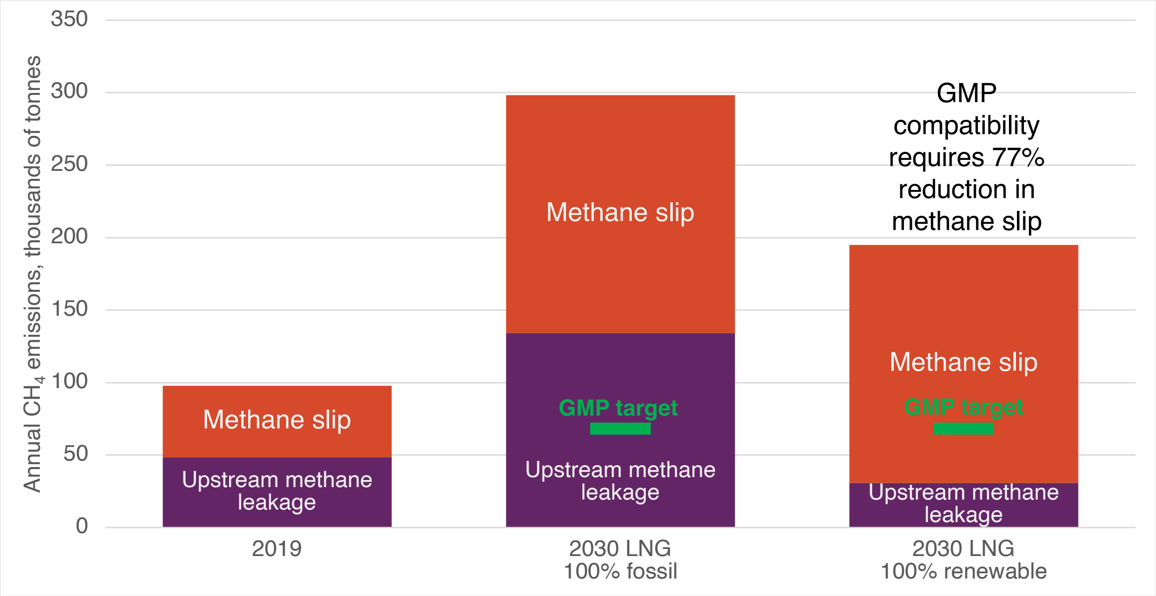


Figure 5. LNG fuel consumption by engine type for ships on voyages to, from, and between EU ports in 2019 (left) and predicted for 2030 (right).

Comer et al. (2022). *Comparing the future demand for, supply of, and life-cycle emissions from bio, synthetic, and fossil LNG marine fuels in the European Union*. Available at the ICCT website, https://theicct.org/publication/lng-marine-fuel-sep22/

LNG is incompatible with the COP26 Global Methane Pledge

- We expect demand for LNG marine fuels to triple between 2019 and 2030.
- If 100% fossil LNG is used, methane emissions will also triple by 2030.
- If 100% renewable LNG is used, methane emissions will double by 2030, primarily because of methane slip.
  - Note: we expect renewable LNG to cost 7x more than fossil LNG in 2030.
  - The assumed 2030 renewable LNG fuel mix and supply curve are included in the appendix.



Methane emissions from LNG-fueled ships calling on EU ports in 2019 and two 2030 scenarios compared with the COP26 Global Methane Pledge target of cutting global methane emissions at least 30% by 2030.

Adapted from Comer et al. (2022). *Comparing the future demand for, supply of, and life-cycle emissions from bio, synthetic, and fossil LNG marine fuels in the European Union*. Available at the ICCT website, https://theicct.org/publication/lng-marine-fuel-sep22/

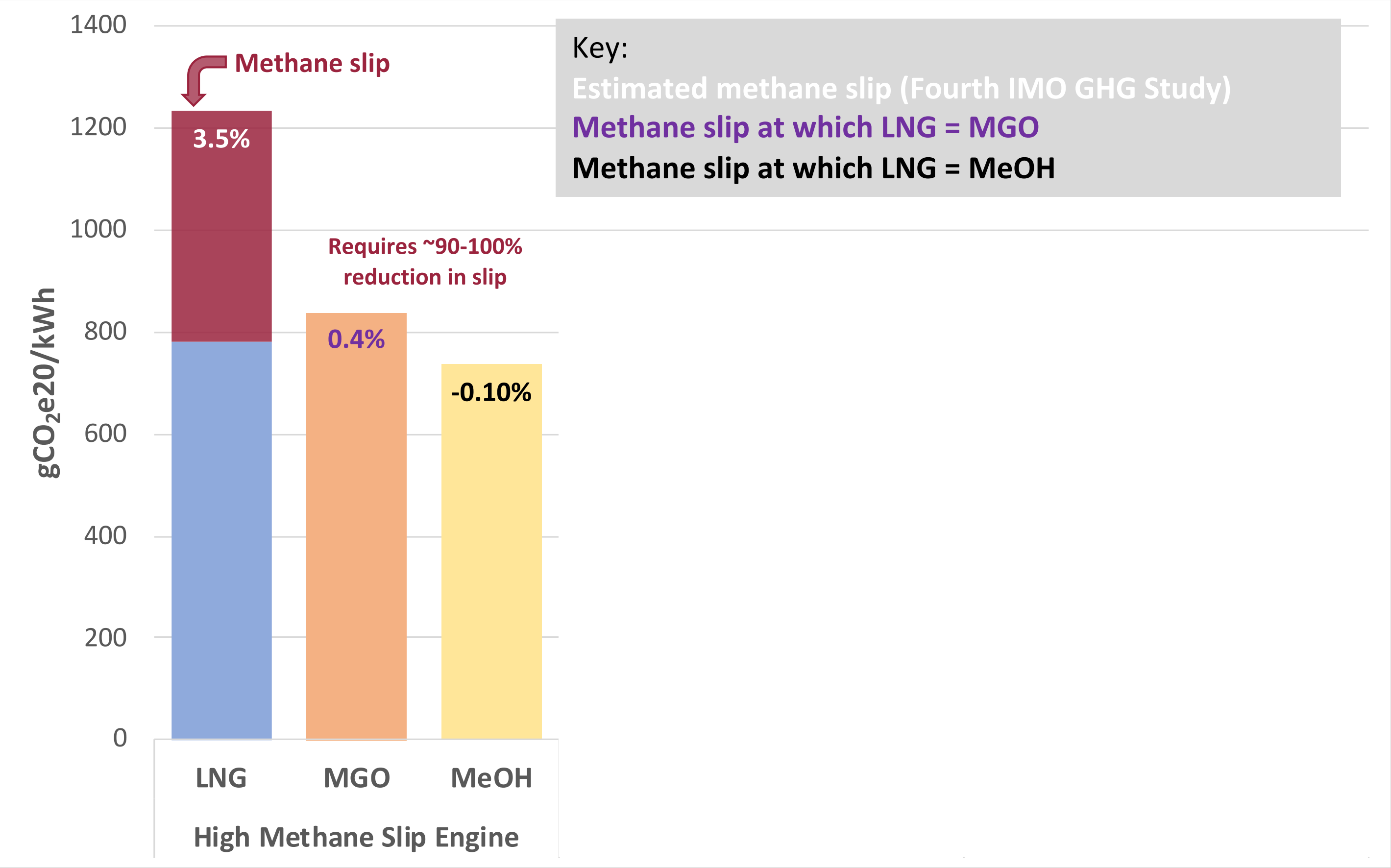
Methane slip reductions needed for LNG to emit roughly the same life-cycle emissions as marine gas oil (MGO) and methanol (MeOH)

Assumptions based on:
Faber et al. (2020).
Fourth IMO GHG Study 2020

and

Comer and Osipova (2021).
Update: Accounting for well-to-wake carbon dioxide equivalent emissions in maritime transportation climate policies

In this slide, we calculate and compare well-to-wake carbon dioxide equivalent emissions based on the 20-year global warming potentials (GWP20) of carbon dioxide, methane, nitrous oxide, and black carbon. The same chart is reproduced in the appendix using GWP100, for comparative purposes. Given methane's atmospheric lifetime of 10-12 years, and global efforts to limit additional near-term warming to below 1.5°C, we use GWP20 in this analysis.



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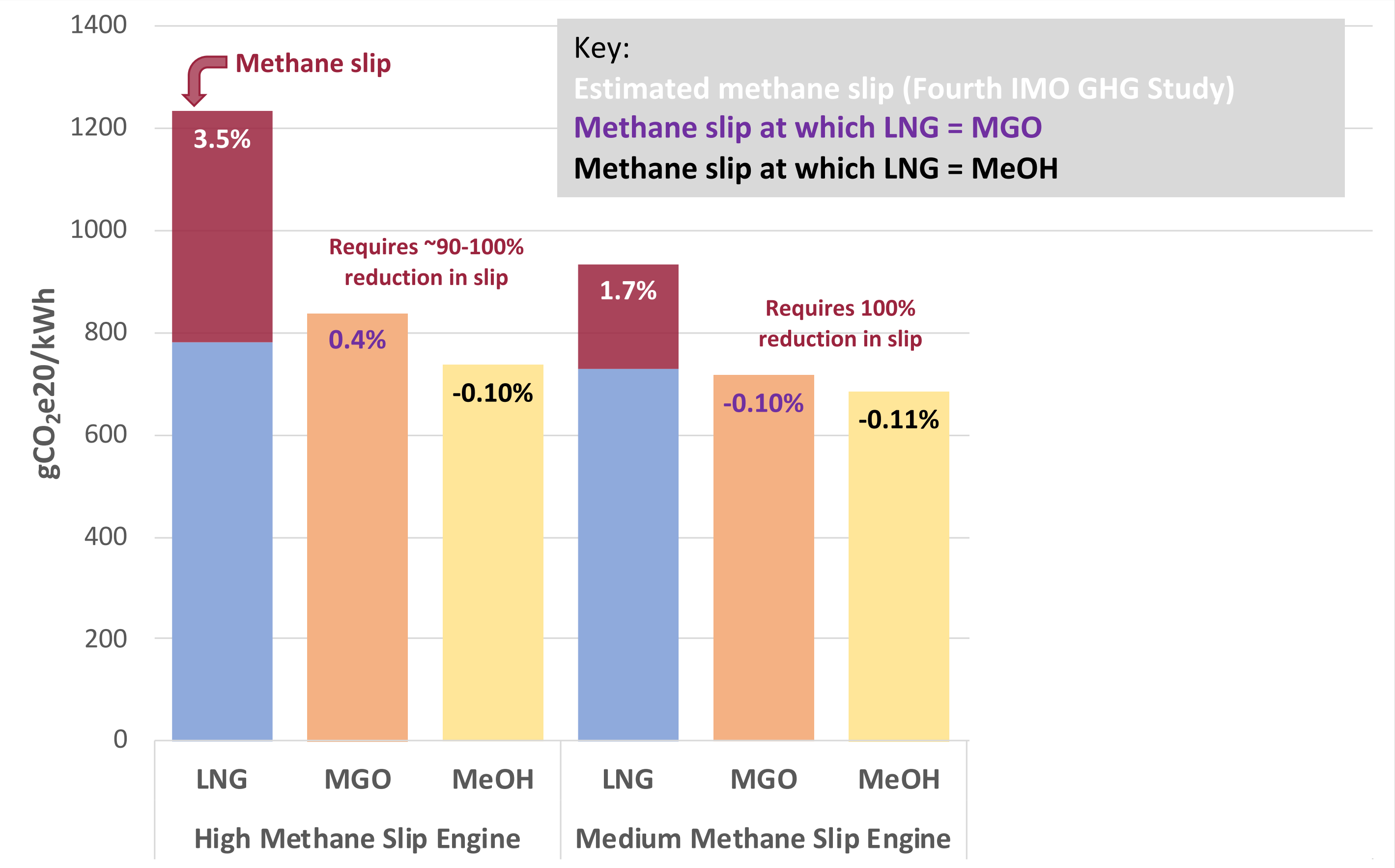

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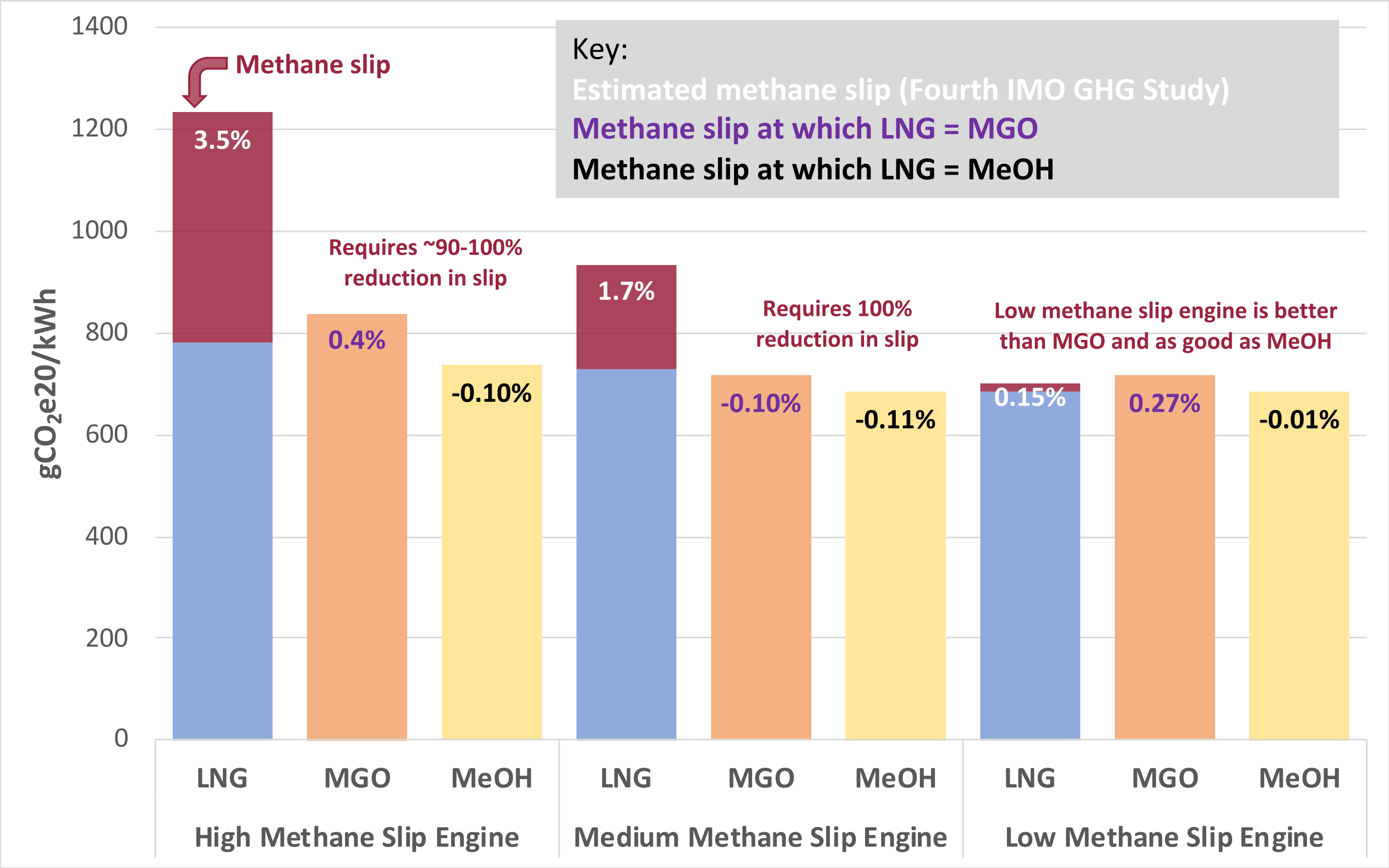

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Options to reduce methane emissions from medium and high methane slip engines

	Engine Optimization (20%)	Methane Oxidation Catalysts (70%)	Direct gas injection (90%+)
How	Optimize combustion.	Convert CH_4 to CO_2 and H_2O.	Inject gas into the cylinder at high pressure.
Tradeoff	Increased NO_x emissions.	Additional capital, operating, and maintenance costs.	Requires NO_x aftertreatment, increasing capital, operating, and maintenance costs.
Limitation	Could require expensive exhaust aftertreatment technologies for NO_x compliance.	Pilot fuels and lubrication oils contain contaminants that can render MOCs ineffective.	High costs of retrofitting, including downtime.
Verdict	**Plausible**	**Unlikely**	**Unlikely**

Our advice

For new ships:

1. Consider ships with **low methane slip engines** if you choose to use LNG **but be warned:**

   a. researchers are measuring real-world methane slip from in-use marine engines using drones, helicopters, and on-board measurements which could lead to refined (potentially higher) assumptions for methane slip;

   b. other sources of methane, including leaks from fuel tanks and cargo tanks on ships are also being measured and could also be regulated in the future.

   Note: See the FUgitive Methane Emissions from Ships (FUMES) project coordinated by the ICCT in partnership with Explicit ApS and the Netherlands Organization for Applied Scientific Research (TNO): https://theicct.org/maritime-shipping-fumes-march2022-statement/

Video Credit: Jörg Beecken, Explicit ApS, October 12, 2022

Our advice

For new ships (continued):

2. Consider ships with **dual-fuel methanol engines**. They're available today and avoid methane emissions from the ship.
3. Consider ships with **wind-assisted propulsion** and **hull air lubrication**; these are also available today.
4. Plan on buying **zero-emission vessels** that use **fuel cells** and **batteries** within the next several years.

Our advice

For existing LNG-fueled ships:

1. Run engines at **optimal engine loads**. Methane slip is highest at low engine loads due to poor combustion.
2. For dual-fuel engines, **use distillate fuels** for low engine load operations and when in port.
3. **Use shore power** in port. If you don't already have a ship-side shore power connection, install one. You'll need it to trade with the EU in the coming years.
4. Test out **batteries and fuel cells** for slow speed (low engine load) operations and to avoid in-port emissions.
5. Consider **wind-assisted propulsion** retrofits.
6. If they become available, **consider methane slip reduction retrofits**.

Final thoughts

Ultimately, until methane is regulated, ships can legally use high methane slip engines.

The EU is regulating methane starting in 2025 under FuelEU Maritime.

The UN International Maritime Organization is developing guidelines to enable regulating methane from international shipping, perhaps as early as 2027.

Questions or comments?
bryan.comer@theicct.org

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Appendix

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Supplement to slide 5: Assumed supply curve (left) and resultant fuel mix (right) for 100% renewable LNG 2030 scenario

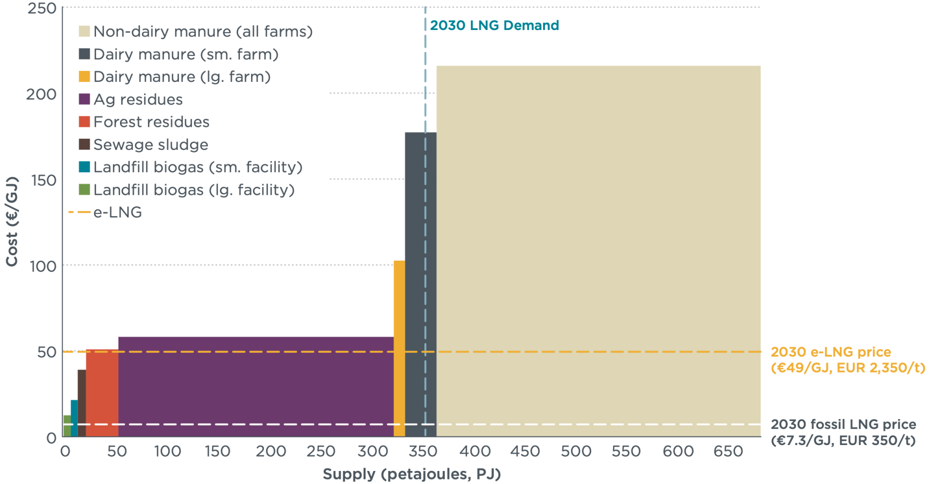

Figure 10. Estimated 2030 supply curve for bioLNG by production pathway, plus estimated 2030 prices for fossil and e-LNG (horizontal lines), compared to estimated 2030 LNG marine fuel demand for ships trading with the European Union (vertical line).

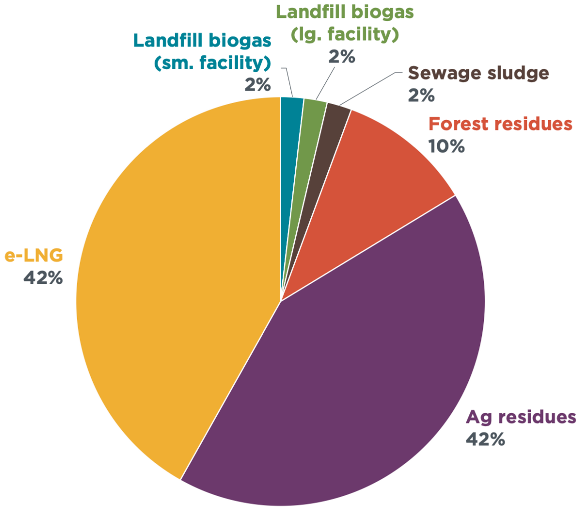

Figure 11. Projected mix of renewable LNG feedstocks to supply 2030 EU marine LNG demand under a €50/GJ subsidy scenario.

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Supplement to slide 8:
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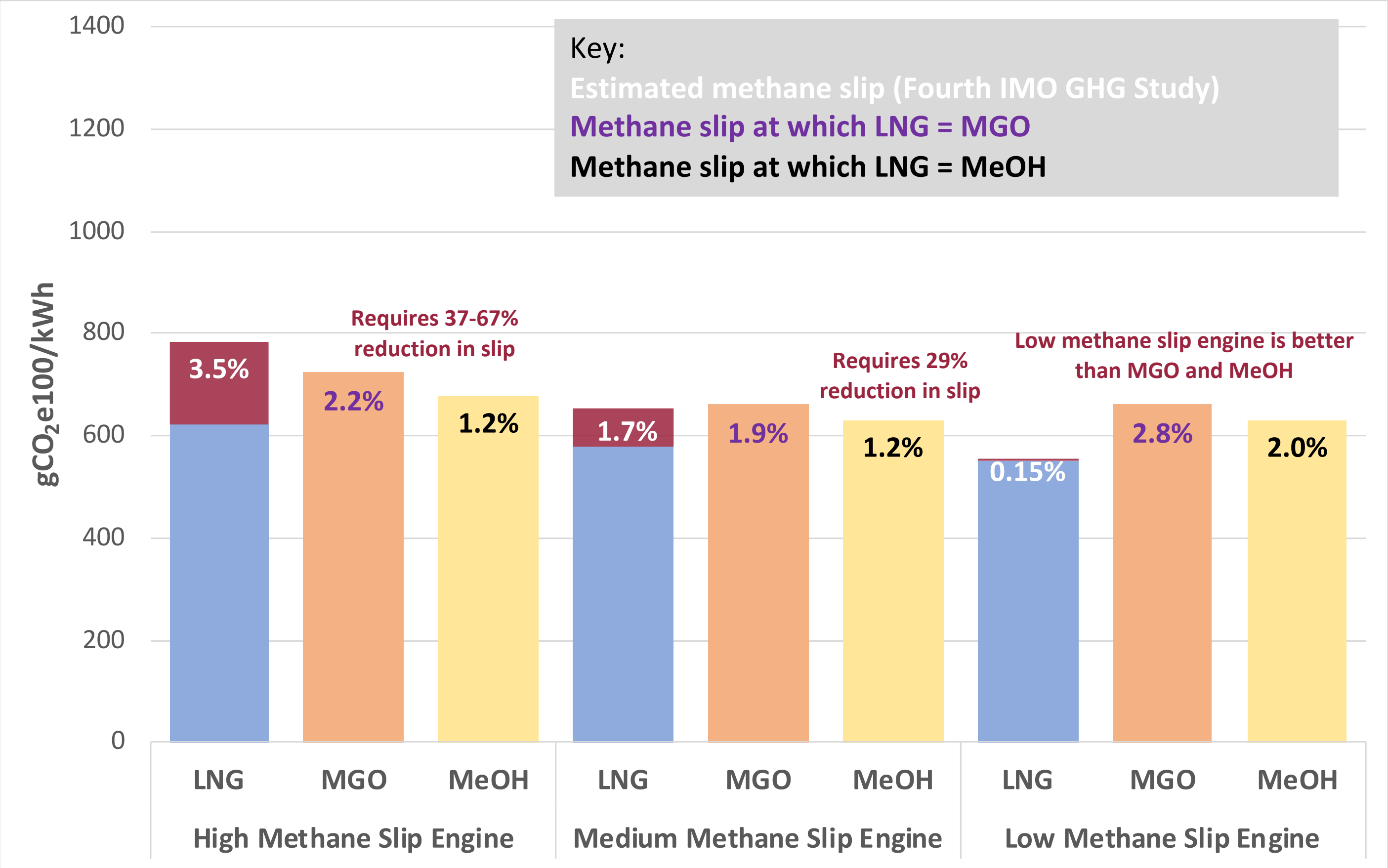
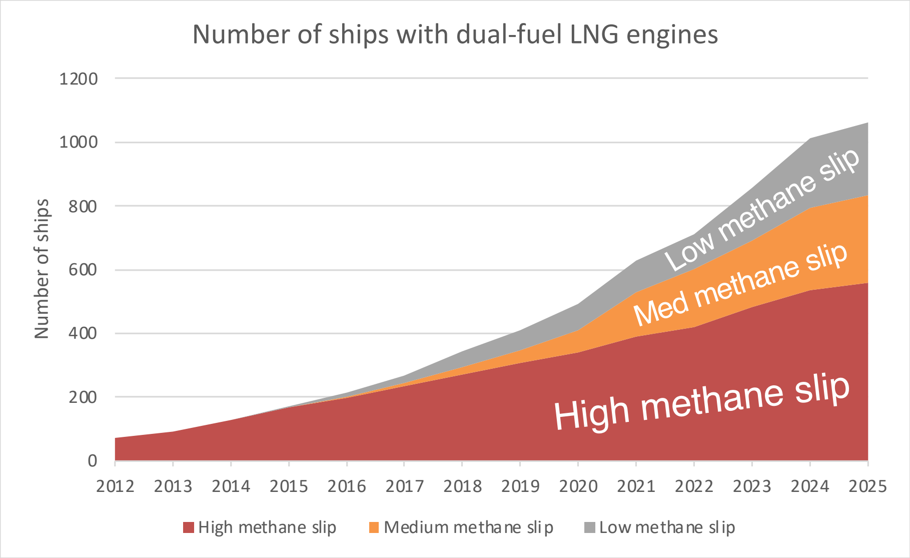
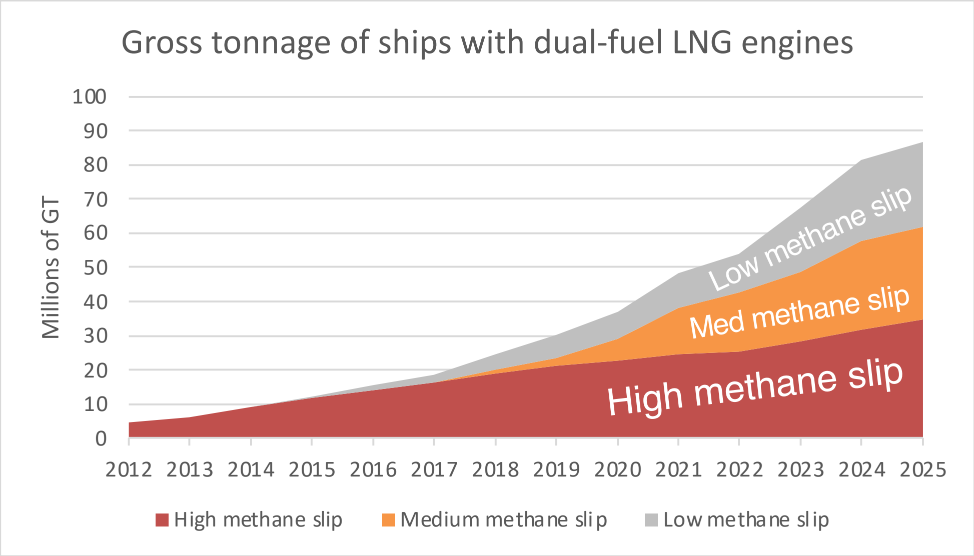


Cumulative trends in dual-fuel LNG engine uptake





2012-2022: Installed
2023-2025: Installed + Ordered

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Source: 2022 ICCT analysis of IHS ship characteristics data