

Decarbonizing the Shipping Industry: On Board with Alternative Fuels

How maritime trade can rapidly transition from heavy fuel oil (HFO) to low-carbon alternatives and reduce their environmental impact

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Introduction

Almost everything we use today has been transported by sea. According to IRENA, international shipping is responsible for up to [90%](#) of global trade and 70% of global shipping emissions. If the maritime sector were a country, it would be equivalent to the [sixth or seventh](#) highest CO₂ polluter, consuming [5%](#) of the world's oil production and 3% of annual anthropogenic carbon emissions. The global maritime industry is responsible for catastrophic air pollution in coastal communities – especially during intense port congestion where ships are waiting to dock for weeks.

To decarbonize by 2050, the shipping industry must rapidly begin adopting energy efficiency measures and clean energy fuels, such as biomethanol, green hydrogen, green ammonia, and biofuels. Learn more below about the realistic landscape of the shipping industry and what is currently viable as a sustainable solution to meet zero emissions for a green supply chain.

Moving away from the industry's standard: heavy fuel oil

[Heavy fuel oil](#) (HFO) has been the standard fuel for powering ships over the past century. HFO, or bunker fuel, is inexpensive, energy-dense, and made from the toxic and low-quality residuals of crude oil through a distillation process. HFO is significantly more polluting than gasoline and diesel, with SO₂ content up to [2,700](#) times higher, contributing to acid rain and respiratory diseases. The time is now for the shipping industry to move away from one of the most carbon-rich fossil fuels and switch to a cleaner power alternative.

What is the most promising marine fuel of the future?

Many are asking which types of alternative fuels are currently feasible for cargo vessels, tankers, and container ships. The answer to this question depends heavily on meeting the following criteria:

- Technically feasible
- High energy density
- Commercially scalable
- Affordable cost
- Safety requirements
- Low lifecycle GHG emissions

- Sufficient availability
- Infrastructure regulation
- Industry acceptance

Regarding choices for shipping companies to decarbonize, there is heated debate over the following options: liquified natural gas, methanol, ammonia, hydrogen, biofuels, and lignin-alcohol blends. This article will dive into the advantages and drawbacks of each, as well as their commercial readiness.

1. Liquified natural gas

Liquified natural gas (LNG) is the most commonly used alternative fuel in the shipping industry, with over [600](#) active ships being powered by LNG. LNG is cost-effective, reliable, and the practical choice as low/zero carbon solutions are being proven. By switching from HFO to LNG, ships have the potential to slash their emissions, with SO_x reductions by 99%, NO_x by 80%, and CO₂ by 20%. LNG also does not emit any soot, dust, or particulate matter, potentially drastically reducing air pollutants from the shipping industry. It has a high energy density of 21-24 MJ per liter and must be stored at [-260°F](#) to remain liquid.

There is some difference of opinion on whether LNG is a necessary intermediate step towards the path of green marine fuels or can be skipped altogether. LNG will help the International Maritime Organization (IMO) meet its 2030 carbon reduction goals of [40%](#) (from 2008 levels) without the need for zero or low carbon fuels, but this will not be enough to meet their stricter 2050 goals of 70% GHG reduction. While 2050 may seem like a far-off date, to the shipping industry, that is only one vessel life away. The world's largest bunkering hub, [Singapore](#), is banking on LNG, playing a significant role, and has heavily invested in LNG infrastructure for the short and medium term until zero carbon fuels are more mature for availability, affordability, and scalability.

While LNG is a step in the right direction, the major downside with LNG is that it is almost entirely comprised of methane ([90%](#)), which has [86](#) times the global warming potential than CO₂. Some studies have shown that compared to marine gas oil (MGO), LNG emits [70%](#) more GHG over the ship's lifetime, questioning the fuel's environmental friendliness. By investing in capital-intensive LNG-compatible engines (more [expensive](#) than diesel engines) and refueling infrastructure, carbon-based fuels are essentially being extended for another [20](#) years (the average life of a large seafaring vessel), making it more difficult to transition to low-carbon solutions in the future.

2. Biomethanol and e-methanol

Methanol (CH₃OH) has outstanding potential in the shipping industry and is already technically proven. Although [methanol](#) is traditionally produced from reforming natural gas or coal gasification, it can also be created from biomass feedstocks like forest residues and farming waste (biomethanol) or hydrogen (e-methanol). Some advantages methanol has is that it is a

light liquid stored at room temperature, making it easy, less costly, and safe to transport, store, and pump for direct injection as opposed to cryogenic LNG or gas like hydrogen. Green methanol has the [lowest](#) carbon footprint of all liquid fuels and can be used to power fuel cells in addition to internal propulsion engines. When producing methanol from renewable sources, CO₂ emissions are cut by [90%](#). Methanol eliminates SO_x and particulate matter and drastically reduces NO_x by [60%](#) from conventional bunker fuel. It is also [biodegradable](#), so if there is ever a spill out at sea, it will not harm marine life. Another benefit of methanol is that the required changes to the vessels, fuel storage facilities, and terminal infrastructure are minimal compared to ammonia and hydrogen.

In 2024, Danish shipping giant [AP Moller-Maersk](#) plans to roll out a dozen large container vessels powered by carbon-neutral methanol and built by Hyundai Heavy Industries. Maersk's CEO of Fleet and Strategic Brands, [Henriette Hallberg Thygesen](#), says, "Green methanol is the only market-ready and scalable, available solution today for shipping." Maersk is the first major shipping company moving forward with a green fuel, opting for methanol produced from biogas/biomass or green hydrogen technology with carbon capture (with direct air capture being one of the biggest economic challenges with methanol). Green methanol was chosen for being the most energy-dense by volume ([16](#) MJ per liter) compared to hydrogen and ammonia and easiest to transport. Methanol is also resilient to be used in short-, medium-, and long-term scenarios and is emerging as a favorite alternative fuel among shipping companies.

Sourcing enough biomethanol and e-methanol will still be a burdensome challenge as there is no large-scale green methanol production. Maersk believes biomethanol will be rapidly scalable for the short-medium term and e-methanol for the long term. Liquid Wind is developing [ten](#) commercial-scale e-methanol plants by 2030, and Gasunie New Energy with Nouryon is building a 20 MW facility. The Methanol Institute estimates that by 2025 there will be about [one million tonnes](#) of biomethanol and e-methanol available, doubling to two million tonnes by 2030. Although renewable methanol is expensive, Maersk's environmentally conscious customers, like Amazon and Nike, are willing to pay a premium for the green value chain. There is also the option of creating biomethanol from waste streams which would be very affordable and readily available.

Singapore X-Press Feeders has also joined Maersk by ordering [16](#) small methanol container ships. Maersk and X-Press, Feeders' ships, are dual-fuel so that they can be powered by methanol and standard very-low sulfur fuel oil (VLSFO). The ferry and cruise industry also has potential use for methanol, with the Stena Line's Stena Germanica using dual-fuel to include methanol.

3. Green hydrogen and fuel cells

Hydrogen is a clean fuel, with the only byproduct being water. [95%](#) of global hydrogen is made from reforming natural gas or fossil fuels (grey hydrogen), with blue hydrogen classified as including carbon capture and green hydrogen produced from renewables. Grey hydrogen costs only [one-fourth](#) that of green hydrogen cost, making green hydrogen prohibitively expensive.

Other main issues with hydrogen are the low energy density and logistical issues. To have enough room on board, cryogenic liquid hydrogen makes the most sense for ships but must be cryogenically frozen at [-423°F](#) with an energy density of 9.1 MJ/l. Compressed hydrogen (700 bar) has the lowest energy density of only 5.6 MJ/l.

Oil mogul [Shell](#), in conjunction with SembCorp Marine Ltd, LMG Marin AS, and Penguin International, is currently testing hydrogen-powered fuel cell ships in Singapore as a flagship project. The roll-on/roll-off (RoRo) ship will be retrofitted to include a Proton Exchange Membrane (PEM) fuel cell and will be in operation for one full year.

4. Green ammonia

Green ammonia (NH₃) is a zero-carbon fuel that combines green hydrogen with nitrogen and must be stored below [-27°F](#). Both ammonia and methanol are vectors of hydrogen, with ammonia having a much [lower cost](#) of hydrogen transport compared to liquid hydrogen due to its higher energy density of 15 MJ/l. Also, for either ammonia or methanol to be zero-carbon, they must be produced by green hydrogen. In addition to green methanol, Maersk is also considering green ammonia as a top contender for the medium-long term.

Like methanol, there is already an established market and infrastructure for ammonia, with [80%](#) of ammonia being used for fertilizer; however, extensive production ramp-ups will still need to meet the maritime industry's demands. Unfortunately, green ammonia fuel is not technically feasible as there are [safety issues](#) with the ammonia combustion engine that are under development. Lloyd's Register, which is actively working on ammonia's safety issues, estimates that ammonia-fueled ships will be under deployment in [2-4 years](#). The Ammonia Energy Association suggests that by [2024-2025](#) the first phase of ammonia ships will be deployed.

5. Biofuels

Biofuels are made from biomass and are considered the [most technologically ready](#) zero-emission marine fuel option. Biofuels are an excellent short-term solution, and transition fuel with high flexibility as present-day regulation allows fuel blends up to [20%](#) without any engine modifications. Some examples of biofuels used in the shipping industry include hydrotreated vegetable oil (HVO), fatty acid methyl ester (FAME), and biodiesel, which can be used with methanol.

The challenges associated with biofuels are scalability due to increased competition leading to shortages and price hikes. Also, it should be noted that the entire lifecycle of the biofuel must be completed to determine the associated carbon emissions, as they can only be assumed zero or near zero if considering the full supply chain.

6. Lignin-alcohol blends

Lignin is a [bio-polymer](#) that adds to the rigidity of plants and is a byproduct of ethanol and pulp and paper mills. Lignin-alcohol blends are in the research and development stage but still worth mentioning. [Lignin ethanol oil](#) (LEO) is being explored by prominent names such as Maersk, Wallenius Wilhelmsen, BMW Group, H&M Group, Levi Strauss & Co., and Marks & Spencer as a viable solution for the future of sustainable shipping. Copenhagen University is also conducting laboratory experiments using this marine fuel.

Begin the voyage to derisk the shipping industry

With the largest container shipping line and vessel operator, Maersk, leading the way with green methanol, there is potential for others to begin following suit. LNG is also an available option to start reducing carbon emissions as well as mixing in biofuel blends. Instead of waiting for regulation to force a change, take this opportunity to be a climate leader and future-proof your business by being ahead of the curve and begin transitioning some of your fleet to alternative fuels.

Have questions regarding derisking your supply chain against market volatility while becoming more climate-friendly? [Contact us today](#), and one of our sustainability consultants will be happy to discuss solutions with you to build a green supply chain.