

What's the Green Fuel of the Future for Shipping?

Shipping is the backbone of the global economy, carrying more than 80% of the world's traded goods. But it also accounts for almost 3% of man-made carbon dioxide emissions. If the world's ships are going to hit targets for reducing emissions, they'll need to start burning clean fuel by 2030. The question is, which one(s)?

1. What are the front-runners?

Shipping's fuel of the future must produce lower or zero emissions, but also have enough power to propel gigantic vessels around the globe and be storable, transportable and affordable. Here are the main candidates so far:

- Ammonia
 - Pros: Doesn't produce any CO2 emissions when made cleanly, which can be done by combining so called green hydrogen with nitrogen from the air
 - Cons: Much less energy dense than traditional fuel oils so would need about three times as much space to contain the same amount of energy, a problem for ship designers; it's also toxic for humans and aquatic life
- Hydrogen
 - Pros: Powerful enough to send rockets into space and can be made without emitting CO2; can be used in a ship's internal combustion engine or in a fuel cell
 - Cons: Needs to be stored at either -253 degrees Celsius (-423 Fahrenheit) or under high pressure, so another major headache for shipbuilders; it's also potentially explosive
- Liquefied Natural Gas, or LNG
 - Pros: Well-known, readily available, lower CO2-emitting alternative to oil-based fuels that some ships already use
 - Cons: Still a fossil fuel so it's not carbon neutral, needs costly infrastructure and causes methane emissions; bio and synthetic LNGs are also on the table
- Biofuels
 - Pros: Made from substances including vegetable oils and compatible with several commercial marine engines and fuel infrastructure
 - Cons: Generally more expensive than fossil fuels and a major increase in production would be needed to meet maritime demand, although lignin fuels (based on biomass and alcohols) may be price competitive
- Methanol

- Pros: Liquid at ambient temperature so it can be stored in regular, non-pressurized tanks; can be made cleanly and is already in use in some ships
- Cons: Less energy dense than oil-based fuels and the clean version is expensive
- Nuclear
- Pros: Zero emissions, extremely power dense and is already used by some ships
- Cons: Fail-safe mechanisms are now built into reactor designs, according to ship classification society Lloyd's Register. However, concerns about safety and security make them unappealing to governments.

2. What about renewables and other options?

Today's batteries lack the energy density to power globe-trotting ships on their own. A large container ship would need the power of 10,000 Tesla S85 batteries every day, according to the International Chamber of Shipping. That's not to say electricity won't have its place. The world's largest electric ferry has entered service in Norway, while Asahi Tanker has ordered two vessels completely powered by lithium ion batteries. Wind power can also be used as a fuel supplement. Maersk Tankers has fitted rotor sails -- giant pillars on deck -- to an oil tanker, saving about 8% of fuel. Cargill plans to add so-called wing sails to some of its cargo fleet. Carbon capture and storage on vessels has also been mooted. Tanker owner Stena Bulk has teamed up with the oil industry to study its feasibility, while Japan's K-Line plans to deploy a small-scale CO2 capture demonstration plant on one of its ships.

3. Why the urgency?

Because the overwhelming majority of vessels burn oil-derived fuels. The International Maritime Organization, shipping's regulator, is targeting a 50% reduction in greenhouse gas emissions from 2008 levels by 2050 -- an effective 85% cut in CO2 emissions for every nautical mile traveled by each ship when increased trade is factored in. Design and operational modifications can help, but ultimately ships must start using cleaner fuels. The IMO, a United Nations agency with responsibility for the safety and security of shipping as well as pollution by ships, has also set a target of carbon neutrality by 2100 and in November approved new emissions rules. These were criticized by some for being too weak and inconsistent with the aims of the Paris Agreement on climate change.

4. How much will this cost and who's paying?

About \$1 trillion to \$1.4 trillion of investment will be needed between 2030 and 2050, according to University Maritime Advisory Services, of which the vast majority will be on land. This highlights a chicken-and-egg situation: Shippers are happy to build vessels provided they can guarantee the fuels will be available, but energy companies don't want to provide fuels unless there's a market ready for them. In 2019, banks set up the Poseidon Principles as a framework for financing shipping. They require investors to align their lending books with a decarbonization target. The majority of signatories failed to hit the goal in the group's first report. Meanwhile, shipping is looking to create its own \$5 billion climate research fund, financed by a mandatory \$2/ton levy on marine fuel over a 10-year period.

5. What's happening on the ground/in the water?

There are more than 100 zero-emission pilot and demonstration projects, many in Europe, according to the Getting to Zero Coalition, an industry group including more than 140 companies. It estimates that zero-emission fuels will need to make up 5% of the fuel mix by 2030 to put international shipping on course to align with the Paris Agreement's goals. Maersk, the world's biggest container line, says all of its new vessels from now will have to be capable of running carbon-neutral fuels as well as traditional oil-based products. It's shunning LNG in favor of lignin fuels, ammonia and methanol. Maersk is in a group that's looking to establish a supply chain for green ammonia for ship-to-ship bunkering in Singapore. The European Union has set a target for zero-emission, ocean-going ships to be market-ready by 2030 and plans to include maritime transport in its carbon market, which imposes pollution limits on participants such as factories. In other developments:

- Biofuels
- Oil giant Exxon Mobil plans to sell marine biofuel oil
- Uniper and Neutral Fuels will provide biofuel at Fujairah, a major Middle Eastern fuel hub for ships
- A joint venture including Trafigura plans to expand sales of biofuels
- GoodFuels has supplied Volkswagen, Stena Bulk and others with marine biofuel
- Co.'s CEO expects biofuels to make up 10-15% of marine fuel mix by 2030 and 20-25% by 2050, if technology continues to be adopted and "regulation goes the right way"
- Ammonia
- A Suezmax tanker ordered by Avin International is to be the first ammonia-ready vessel in the world
- Eastern Pacific Shipping will retrofit some ships to run on ammonia and methanol and build new vessels to run on the fuels
- Euronav is working with a South Korean shipyard to ensure two new oil tankers it acquired will have the option of running on ammonia
- A group including Mitsui E&S Holdings Co. will jointly develop ammonia-powered ships
- A partnership including Lloyd's Register and Samsung is working on an ammonia-fueled tanker design
- Lloyd's Register approved two ultra-large container ship projects
- Finnish company Wartsila is testing ammonia in a marine engine
- Hydrogen & Methanol

- Engie and ArianeGroup will develop hydrogen production equipment and promote the gas as a clean marine fuel
- Maersk plans to run a small container ship on carbon neutral bio-methanol or sustainable e-methanol in 2023
- Uniper and two other firms have partnered to develop green methanol as a maritime fuel in Europe
- A demo ship running on liquid green hydrogen, operated by Wilhelmsen, is expected to be operational from 2024
- Linde will supply liquid hydrogen to Norwegian ferry operator Norled
- LNG
- As of March, there were 444 LNG-powered ships in operation and on order, and more that were LNG ready, according to ship classification society DNV (figures exclude LNG carriers and inland waterway vessels)

Use of LNG as a marine fuel is expected to grow steadily through this decade, displacing nearly 700,000 barrels per day of demand for oil-based marine fuel by 2030, according to Wood