Emissions-free sailing is full steam ahead for ocean-going shipping

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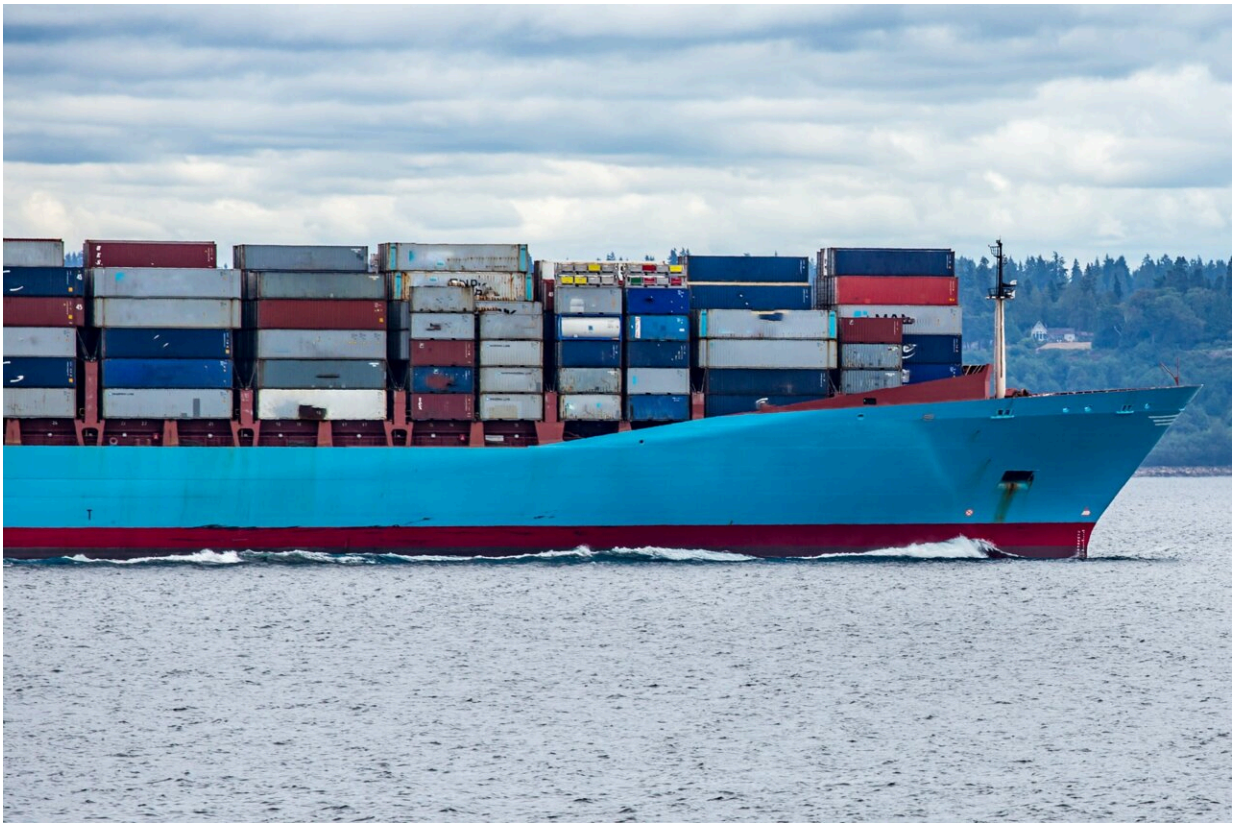

Critical to global trade, the shipping sector faces increasing pressure to reduce its carbon footprint swiftly. Credit: Ian Taylor via Unsplash

It's full steam ahead for the European shipping industry as a new wave of clean-energy tech is set to throw greenhouse-gas emissions overboard.

Shipping, while essential for trade, contributes significantly to the emissions that cause climate change. Global shipping spews out 3% of worldwide greenhouse gases (GHG). With the maritime industry responsible for transporting no less than 90% of world commerce, there is increasing pressure on the sector to reduce its carbon footprint swiftly.

"International shipping in open seas is one the major sources of all emissions in Europe," said Syed-Asif Ansar, scientist at the German Aerospace Center, DLR.

While 3% might not seem titanic in scale, growth in demand for shipping worldwide means that maritime emissions have been accelerating faster than most other sectors, he says.

Without action, shipping could be responsible for 10 to 13% of global emissions within a few decades.

Transitional fuel

Today, most ocean liners and container ships rely on diesel engines to generate electricity to propel the vessel. The International Maritime Organization (IMO), the United Nations' agency responsible for regulating shipping, aims to slash ocean-vessel emissions in half by 2050. This requires the industry to set a course towards cleaner fuels.

One approach is to jettison diesel and steer towards liquified natural gas (LNG). LNG is formed when natural gas (methane) is cooled from gaseous to liquid form, making it 600 times smaller by volume. This makes it easier to transport and store. Increasing the temperature turns it back into a gas.

Although LNG is still a fossil fuel, it is included in the EU Taxonomy, which lists it as a transitional fuel that will assist the switch to renewable

energy in the near future.

Fumes removal

In 2020, the Nautilus project set out to develop a new type of engine based on LNG that would halve greenhouse-gas emissions compared to diesel and entirely remove diesel exhaust fumes, which contain pollutants harmful to marine life and human health.

Taking its name from the Greek word for sailor, the Nautilus project is now building a special engine in the DLR in Germany that will run on LNG.

This engine contains a solid oxide fuel cell that turns LNG into electricity—without burning the gas—and then powers up a battery. The fuel cell and battery together propel the ship. Far more of the chemical energy from the gas goes into propulsion than if it was just burned.

"The energy conversion is not combustion, but an electrochemical conversion instead," said Ansar, Nautilus project leader. "It is far more efficient."

Solid oxide fuels exist already, but not on the scale used in shipping. They are envisioned for use in power generation plants. But the existing technology is too bulky for ships. "Weight is not the major issue on ships," said Ansar, "But volume is."

Ocean liners

Consider also that a typical ocean liner requires 40 to 60 megawatts, roughly the same power consumption as a town of about 10 000 houses. As it stands, suppliers in Europe can only provide solid oxide fuel cell

units mostly below 10 kilowatt, a fraction of what is needed.

The Nautilus project has built large fuel cells of up to 30 kilowatts, which are then combined in bundles to achieve the 40 to 60 megawatts required for ships.

The team aims to get certified onshore testing by 2024, with onboard testing by 2026, and a passenger ship powered by the engine by 2030.

The next step then will be the container ship. They're thinking big. "We don't want to power ships in niche applications," said Ansar. "We want to target the elephant in the room, which is the cargo ships, large passenger ships and other ocean liners."

And because LNG power still generates CO_2 emissions, the project is also looking further ahead to when this transitional fossil fuel will be replaced by a low-carbon alternative.

Green methane

Initially, the fuel would be blended and then replaced by a renewable form of LNG, green methane, generated using solar or wind power. Green methane does not add emissions to the atmosphere.

For now, the ambition is to gradually replace diesel engines on ships with technology that taps into fuel cells, LNG and battery storage. Further challenges involve making the units robust enough for ocean voyages, of huge scale and able to operate under different loads.

But diesel and LNG are not the only options when it comes to powering ocean-going freighters and tankers. Another project seeks to clean up global shipping by embracing the potential of ammonia to energize the shipping industry.

Ammonia is widely used in the chemical industry and is best known as the key ingredient in fertilizer. Colorless and with a pungent smell, the fact that the ammonia molecule (NH3) is rich with hydrogen makes it perfect to adapt as a fuel. When used as a fuel, the only emissions are water, with no carbon present to make CO_2.

"There is a strong focus on ammonia as a possible alternative to fossil carbon fuel for propulsion," said Andrea Pestarino at RINA consulting in Italy, "But there is no commercial engine that can be installed right now onboard a ship." He coordinates the Engimmonia project, one of a number of initiatives worldwide seeking to tap ammonia to power shipping.

Energy dense

Ammonia is a relatively energy-dense means to store and transport green hydrogen generated by renewables. Liquid ammonia packs more energy into the same volume as liquid hydrogen, and can be stored at minus 33 degrees Celsius, as opposed to minus 253 degrees Celsius for hydrogen.

"Instead of storing hydrogen, you store ammonia," said Pestarino. In practice, this means you no longer need large pressurized tanks to store concentrated hydrogen gas, but can simply hold onto chilled liquid ammonia.

Nonetheless, care is needed to ensure no leakage, since ammonia is toxic and smelly. The project is tackling a further challenge; ensuring harmful nitrous oxide gases are scrubbed from exhaust fumes when ammonia is consumed.

It's the talk of the town in shipping circles. "Ammonia is currently seen as the most efficient way to decarbonize the shipping sector, especially propulsion," said Pestarino.

Green ammonia

Engimmonia is also out to transform technologies used on land into ship-shape tech ready for sea conditions. This requires strategies to recycle waste heat for electricity and air conditioning. There are also practical challenges such as where to fit solar panels onto container ships, which have very few free surfaces as they are designed today.

Suffice it to say the ammonia itself will need to be green ammonia, generated from renewable energy sources, in the same way that LNG will ultimately have to be replaced by green methane. At the moment, ammonia is not a carbon-free alternative because fossil-fuel energy is used in its creation.

Numerous initiatives are underway to navigate the shipping industry towards decarbonization, in line with the goals of the European Green Deal, a plan to make Europe the world's first climate neutral continent.

"We're bringing all the pieces of the puzzle together to make a viable system for the shipper," said Ansar.

More information:

- Nautilus
- Engimmonia

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