Ammonia may play a key role in climate-neutral shipping

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Climate-neutral shipping by 2050 requires immediate action. The question is which green fuels to focus on. Ammonia is one of them, according to a new report.

Today, the maritime sector accounts for three percent of the world's total greenhouse gas emissions. This figure is expected to increase, and if we are to succeed in reversing the trend, it is therefore necessary for the maritime sector to embark on the green transition quickly. And as ocean-going ships rely heavily on fuels and are unlikely to sail on batteries, the solution must be found using other methods.

This may, for example, be biogas or Power-to-X (PtX) technologies, where green power is converted into so-called e-fuels such as liquid hydrogen, ammonia, and methane, or methanol that can be used in engines. However, the question is which technology and type of green fuel are the best choice for the sector—in terms of both emissions and price.

Researchers from DTU have made calculations on this in the MarE-Fuel project, performed together with Anker Invest, Maersk Line, Copenhagen Economics, OMT, and DFDS, and with funding from the Danish Maritime Fund and Lauritzen Fonden.

"Our analysis shows that there isn't one single kind of green fuel that can solve the challenges of the maritime sector, but that a combination of several technologies is required. We've established different scenarios which can all make the maritime sector green. And we've also made calculations to find which solutions have the lowest cost," says Marie Münster, Professor of Energy System Analysis from DTU Management.

She explains that—even though the analysis pinpoints which fuels and technologies will be beneficial for the maritime sector—there are a number of challenges that the sector cannot solve itself because it requires heavy investments in technology and establishment of smart energy solutions.

Biomass cheapest

According to the analysis, the cheapest solution for the industry to achieve a reduction of emissions is initially to use green fuels produced by means of sustainable biomass—first in the form of pyrolysis oil and then in the form of bio-e-methanol. However, the analysis shows that—in the long term—there may be a shortage of sustainable biomass, as the shipping industry is not the only sector looking to exploit this biomass for energy.

"How big a role sustainable biomass can play in green shipping depends entirely on how much of it we have access to in the future. If there is plenty available, it will certainly be one of the cheapest ways to go—and we should therefore continue to focus on this technology. However, everything indicates that low-cost sustainable biomass will be in great demand, and we must consequently also focus on optimizing Power-to-X technologies, because we will need them," says Marie Münster.

"There isn't a single fuel that beats all the others. However, all the calculated scenarios indicate that—in the long term—ammonia will be essential in making the shipping industry climate neutral—if the power used is green, that is. This is because ammonia is not dependent on carbon, and the price and climate gas emissions are comparable to the other green fuels," she continues.

Ammonia for shipping industry requires more PtX plants

To produce ammonia, you must first convert green power into hydrogen via electrolysis. Only then can it be turned into liquid ammonia.

"We can see that ammonia will be one of the important green fuels for the shipping industry the closer we get to 2050. If we're to meet the need for fuel for international shipping, we must now start building more

plants that can produce electrolysis. With the current expansion rate (2019), it will—in fact—take up to 3,000 years before we have enough plants," says Professor Peter Vang Hendriksen, who is an expert in electrolysis and energy conversion at DTU Energy.

He ascertains that more electrolysis plants will be required no matter which green fuels are to be produced using Power-to-X technology. And this leads to another—by now familiar— challenge: that we need more green power.

"Electrolysis requires power. If, for example, we're only going to sail on green ammonia by 2050, and we continue at the same wind power expansion rate as today for the next 29 years, we would have to use all the new capacity to produce green ammonia for shipping. However, having cheap green power isn't enough, it must also be available most of the time to avoid having to over-dimension our production plants. Therefore, we must ensure flexible plants and preferably efficient storage of our wind and solar energy," says Peter Vang Hendriksen.

The analysis also shows that the conditions in Esbjerg (the volumes of wind and solar energy and the expected electricity prices) are actually so good that the cost of producing e-fuels is only 10 percent higher than in—for example—Dakhla in the Sahara. And this does not take into account the benefits of a high security of supply in Denmark.

"Denmark has good opportunities for producing domestic green fuel for our maritime sector if we want to. But this requires a national strategy and that we scale up significantly—especially in relation to electrolysis and PtX plants—where we need to increase the global expansion rate by a factor of more than 100 relative to today to meet the e-fuel needs of the shipping sector. The industry can't do this on its own," says Peter Vang Hendriksen.

The calculations also show that the price of producing green fuels is about four times higher than the price of the corresponding substances produced today from fossil sources. However, scaling up production capacity, gains from mass production, and improvements in technology are expected to halve the price of green fuels by 2050.

Finally, both professors point out that carbon taxes and state subsidies for new plants will be of great importance to fuel prices and competitiveness. If the development is to be driven solely by a carbon tax, the tax will be very high, and it will therefore probably need to be supplemented by other measures. Without taxes and state support, green fuels will not be able to compete with fossil fuels regardless of the technology used.

The project has developed four open source models:

- The OptiPlant model, which optimizes capacity sizes and electricity consumption from own production or via purchases from the electricity grid.
- Balance of plant models for the production plans, which calculate effectiveness and fuel production costs. The focus is on methanol and ammonia.
- The TCO model, which calculates the total costs from both the fuel side and the ship side.
- The roadmap model, which calculates possible scenarios for reducing emissions of climate gases from shipping by 2050, depending on available biomass and green power.

Provided by Technical University of Denmark

https://techxplore.com/news/2021-12-ammonia-key-role-climate-neutral-shipping.html