Green sails

Use of fuels like ammonia and methanol, along with key operational changes, can help shipping industry massively reduce emissions

SEEMA PRASAD

ON JULY 13, German multinational company Man Energy Solutions announced successful testing of an ammonia-run marine engine. The engine could be ready for commercial use as early as 2024, and will be followed by a retrofit package to modify existing vessels by 2025.

The breakthrough is major because ammonia—a compound of nitrogen and hydrogen with the chemical formula NH_3—is billed as the marine fuel of the future. Less than a week earlier, on July 7, the International Maritime Organization had set a target to achieve net-zero greenhouse gas (GHG) emissions by around 2050. The target by the multilateral agency that regulates global shipping is critical because the sector is responsible for nearly 3 per cent of anthropogenic GHG emissions, similar to an industrialised nation like Japan or Germany.

Shipping has grown by 250 per cent in the past four decades, as per the 2019 annual report of the United Nations Conference on Trade and Development, and is projected to grow annually at 4 per cent. Between 2008 and 2018, the size of the fleet has increased by a humongous 73 per cent. Currently, heavy fuel oil, light fuel oil (both tar-like crude petroleum products), diesel/gas oil and liquefied natural gas (LNG) are the main types of fuels used in shipping (see 'Fuelling pollution'). With the exception of LNG, all of these are heavily polluting. LNG, too, is problematic because it is primarily made up of methane—a GHG 80 times more potent that carbon dioxide (CO_2). "Methane leaks into the atmosphere throughout the LNG production and supply chain and slips directly from the ship's funnels, contributing to climate warming at a significant

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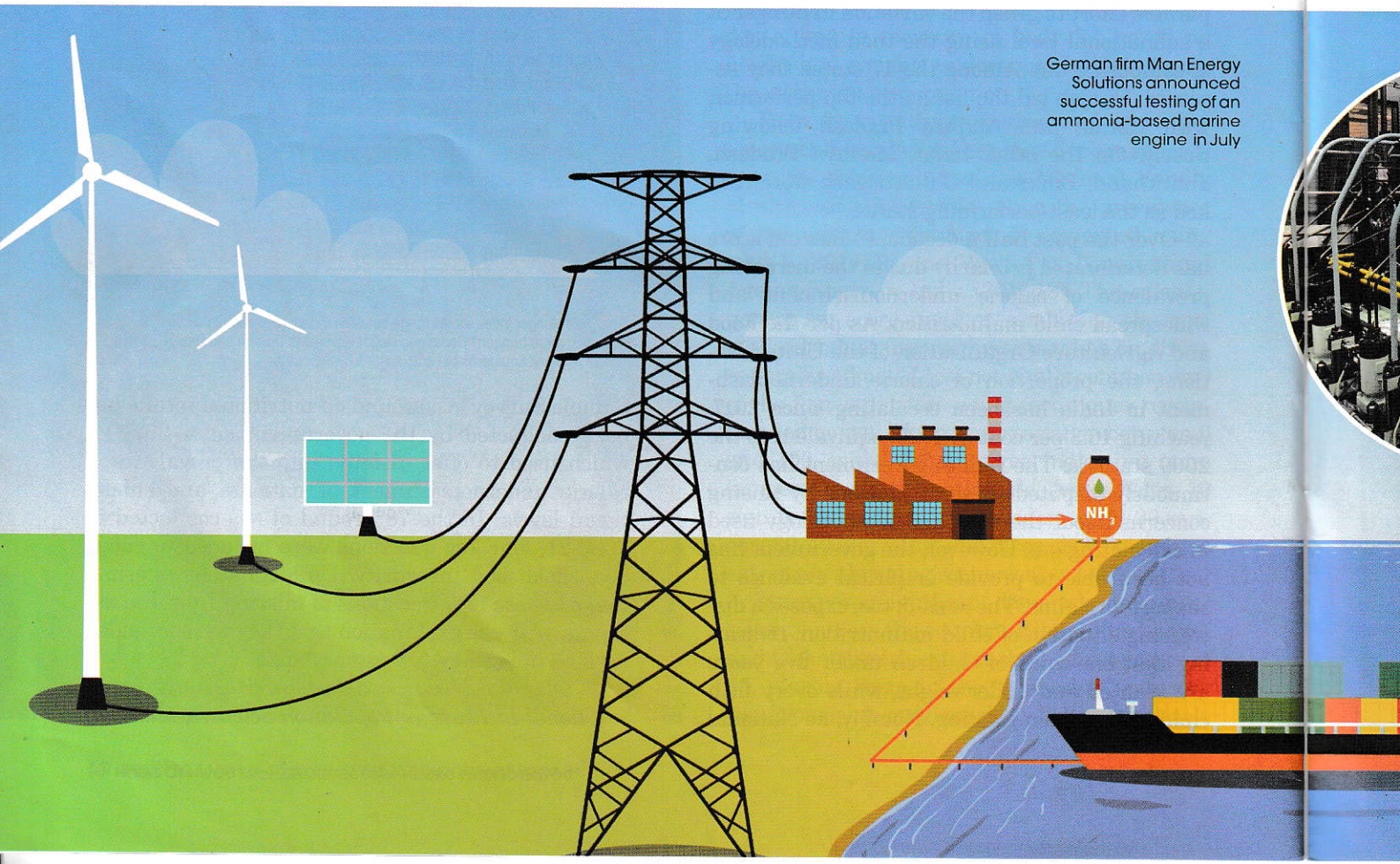
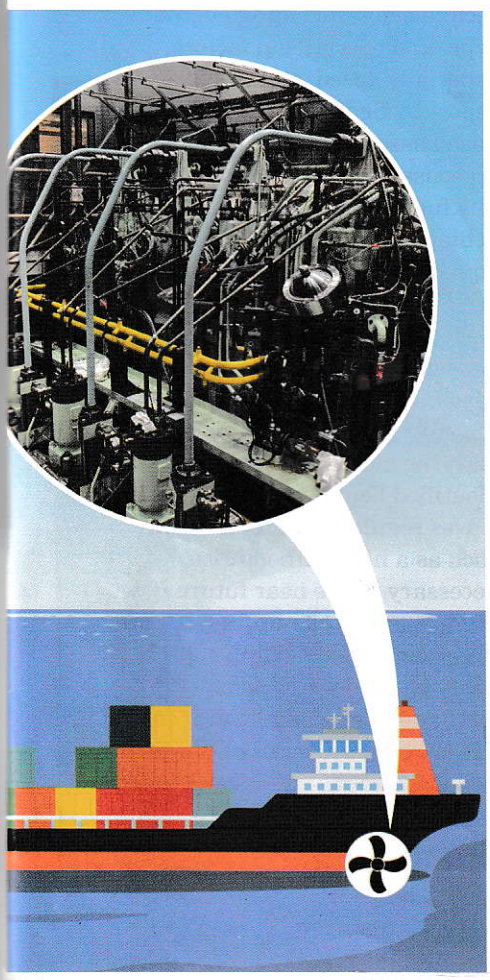


German firm Man Energy Solutions announced successful testing of an ammonia-based marine engine in July

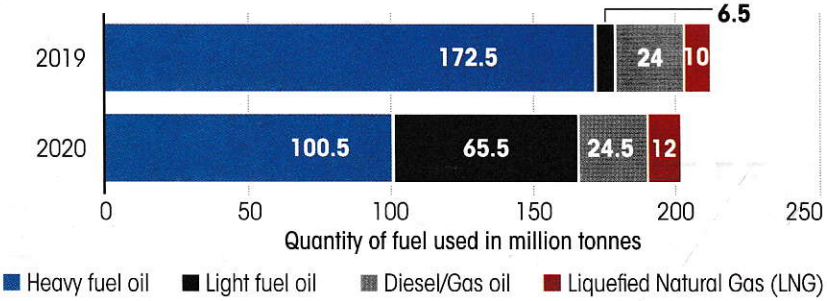
pace," says Brussels-based non-profit Transport and Environment.

Companies world over are experimenting with cleaner fuels, the most promising being green ammonia ("green", "renewable" or "e" prefixes denote that the process of the gas' production is almost completely renewable and carbon-free). For the sector to become net-zero, "Renewable ammonia could represent as much as 43% of the mix in 2050, which would imply the use of about 183 Mt of renewable ammonia for international shipping alone–a comparable amount to today's ammonia global production," states a 2021 report by the International Renewable Energy Agency (IRENA). "Several studies, including ones conducted on the UK Department of Transport, show that ammonia is the best way to decarbonise marine vessels. Engine manufacturers are pushing ammonia as a fuel for the future," Nishatabbas Rehmatulla, principal research fellow, University College London Energy Institute, tells *Down To Earth* (DTE).



Fuelling pollution

Except LNG, all fuels used in shipping are heavily polluting

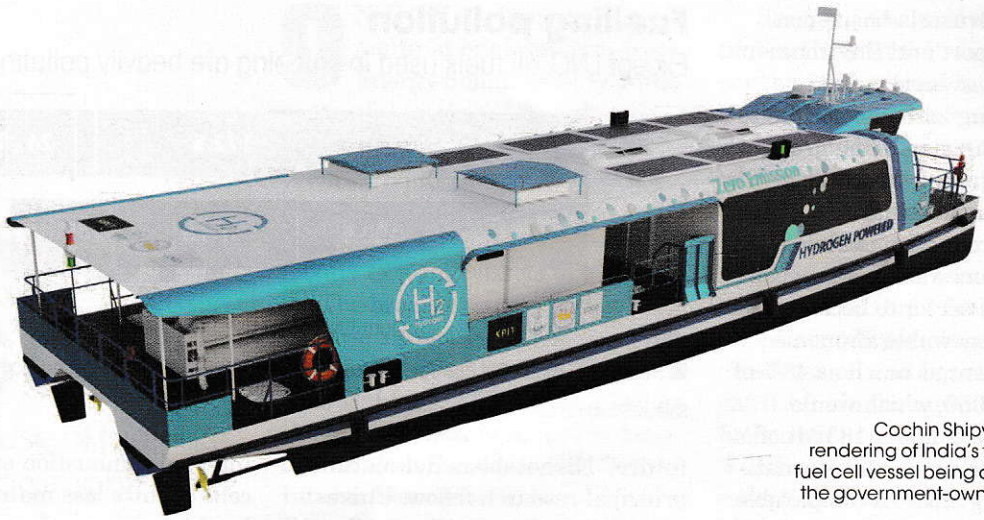


Source: Statista 2023

To make ammonia, nitrogen needs to be separated from air. For this, air is first compressed and purified to remove CO_2 and water vapour, and then cooled to separate nitrogen, oxygen and other elements. Nitrogen is then combined with hydrogen to produce ammonia. Over 95 per cent of hydrogen produced globally, including that used in the production of ammonia, comes from fossil fuel reforming technologies, states a 2018 paper in *International Journal of Hydrogen Energy*.

Hydrogen (H_2) itself is a fuel of interest in maritime shipping and, unlike ammonia, hydrogen fuel engines are available in the market since 2022. It is used in fuel cells to power an electric motor to propel the ship. Similarly, internal combustion engines can burn hydrogen, either in pure form or in a mixture with conventional diesel fuels, to provide propulsive power to ships. "Fuel cells can fit in the same engine space currently used for internal combustion engines. They are smaller and lighter than batteries and relatively smaller than electronic marine engines. Compared to internal combustion engines, fuel cells require less maintenance, have lower operating costs lower, and are quieter, which can benefit marine mammals and other wildlife," Bryan Comer, Marine Program Lead at the International Council on Clean Transportation, tells DTE. Closer home, the government-owned Cochin Shipyard Limited, the largest shipbuilding and maintenance facility in India, has started construction of a hydrogen fuel cell catamaran vessel. Trial runs have been completed and the vessel will eventually be used in Varanasi for short-distance commute in riverine waters for up to 50 passengers.

But ammonia has a major advantage over hydrogen—one cubic metre of liquid ammonia contains three times more energy than compressed hydrogen. This, however, does not negate the importance of hydrogen. Production of all sustainable marine fuels will require hydrogen made from renewable energy such as wind or solar. "In the medium to long term, green H_2-based fuels will be the foundation of a decarbonised international shipping sector. By 2050, shipping will require a total of 46 million tonnes (Mt) of green H_2. Of this total, 73% will be needed for the production of e-ammonia, 17% for e-methanol



Cochin Shipyard Limited's rendering of India's first hydrogen fuel cell vessel being developed by the government-owned company

and 10% will be used directly as liquid hydrogen through FCs [fuel cells] or combusted through ICEs [internal combustion engines]," states the IRENA report.

OTHER CONTENDER

Besides ammonia, green methanol is touted as a solution to clean emissions from shipping. "Currently there are two lobbies in shipping decarbonisation—the LNG lobby and the methanol lobby. The industry prefers the latter since the former is not completely clean," Ajit Seshadri, visiting professor at the Marine Engineering Department, VELS University, Chennai, tells DTE.

Green methanol is of two kinds: bio-methanol (derived from biogas, solid organic waste and bagasse) and e-methanol (made from hydrogen produced from renewable electricity and CO_2 captured using direct air technologies or directly from power plants). Methanol is more suited for use in a wide range of vessels and for longer voyages because it has higher volumetric energy content than alternative fuels like ammonia or hydrogen, and requires less frequent refills.

A 2023 analysis by Bloomberg New Energy Finance says that giant shipping and logistics firms have all ordered green methanol ships. These include Denmark's Maersk (25 ships); Taiwan's Evergreen Marine Corporation of Taiwan (24 ships);China-based COSCO shipping (12 ships); French carrier CMA GCM (9 ships), and South Korea's top carrier HMM (9 ships). The orders have doubled from 37 in 2022 to 82 in 2023 for methanol-powered vessels, the majority of which are container ships, the most common sea-freight transport, the analysis adds.

Experts even say that methanol has certain advantages over ammonia, which is toxic to humans and wildlife. "Making sure e-ammonia is handled properly with correct bunkering and community acceptance of storing it at ports where people are close are other concerns. However, methanol has no toxicity risk as a breathing hazard. The other question for ammonia is how much nitrous oxide (NO_2) will be emitted during combustion, since it is a climate pollutant with a warming potential 300 times more than CO_2," warns Comer.

Though shipping is a hard-to-abate (or difficult to decarbonise) industry, as per the US Department of Energy, due to "wide spectrum in vessel types and sizes, the large amounts of energy they use, and the inherently global nature of maritime transport that necessitates working across geographies", three factors determine the sector's long-term strategy to decarbonise: fuel type; shipboard technologies, including engine type; and operational factors, especially speed, states a 2023 report by Seas At Risk, a Belgium-based association of environmental organisations from Europe. But for any fuel to be sustainable, it "must achieve zero or near zero CO_2 equivalent emissions on a life cycle 'well-to-wake' basis," says Comer. "Ultimately, none of the zero-emission options in their current specifications completely satisfied the shipowner's requirements, with the most significant gap identified being voyage costs. This leaves regulatory intervention, such as a high carbon price, necessary in the near future if we are to ensure take-up," says "Zero Emission Vessels 2030", a 2017 study on the feasibility of methanol, ammonia, hydrogen and batteries by University College London. DTE

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