Observatorio Tecnológico del Hidrógeno

The use of hydrogen derivatives as maritime fuels: ammonia and methanol

Decarbonising maritime transport is a strategic priority and one of the greatest challenges in the fight against climate change. Although maritime **transport is one of the most energy-efficient sectors**, it is responsible for **3% of global CO_2 emissions**.

Green hydrogen and its derivatives, such as methanol (CH_3OH) and ammonia (NH_3), are emerging as **key technological pillars in the sector's energy transition** due to their properties, emission reduction potential, technological maturity, and ability to integrate into existing infrastructure.

This executive summary outlines the key findings of the report prepared by five partners of the Hydrogen Technology Observatory: the Spanish National Hydrogen Centre (CNH2), CIDAUT, Enagás, Moeve and the Polytechnic University of Madrid (UPM).

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From a technical standpoint, **methanol and ammonia** have **properties** and **emission reduction** potential that make them suitable for **use as maritime fuels**

CH_3OH

Methanol is the **hydrogen derivative with the highest volumetric energy density** and can be stored as a liquid at ambient temperature and pressure, **facilitating its integration into ships and port infrastructure**. This vector already has bunkering and storage infrastructure developed in the chemical industry and offshore operations.

Methanol can achieve **carbon neutrality** if produced with **renewable energy and biogenic CO_2**.

NH_3

Ammonia, while having a lower energy density than methanol, benefits from an **existing global logistics infrastructure** for its transport, storage, and handling—with **over 170 operational terminals worldwide**—and presents **lower storage costs than hydrogen**. However, ship designs will need to be adapted for its safe and efficient use.

Green ammonia can reduce GHG emissions by up to 90% compared to conventional fuels used to date.

Technological maturity and industrial developments in commercialization phase

Methanol and ammonia already have **industrial developments in two- and four-stroke Dual Fuel (DF) ICE engines (TRL 9)**, as well as **retrofit kits** for existing vessels

Methanol is consolidating as a short-term option, determined by the availability of biogenic CO_2, especially for **short- and medium-distance routes due to its ease of integration**. It is already **commercially used in 35 vessels** and has an **order book of 173 ships**.

Ammonia is emerging as a long-term solution, especially **for transoceanic routes**, with the development of green ammonia value chains being key to ensuring net-zero emissions. There is **one vessel in operation** to date, plus **25 new orders**, and retrofit kits are expected to be developed by 2027.

Hydrogen fuel cells and derivatives as propulsion systems are a promising alternative **for small vessels and ferries in short- and medium-distance maritime transport**

There is growing interest in **PEMFC** (Proton Exchange Membrane Fuel Cells), **SOFC** (Solid Oxide Fuel Cells), and **MCFC** (Molten Carbonate Fuel Cells), **all at commercial stages** (TRL 9), with PEMFC (low temperature) and SOFC (high temperature) being the most widely implemented in the maritime sector.

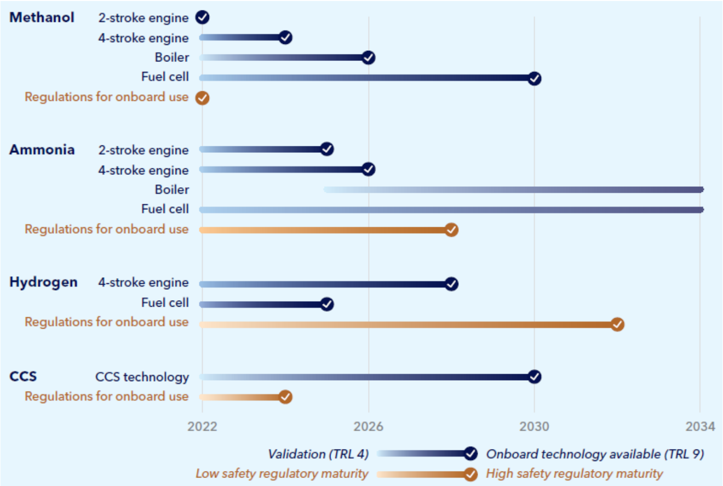
Fuel cells play a **key role in hybrid propulsion systems** in maritime transport, integrating with ICE engines or electric storage systems **to improve energy efficiency and reduce emissions**.

What are the prospects for future demand and the market?

By 2050, **half of the global fleet is expected to operate with renewable propulsion sources such as hydrogen, ammonia, and methanol**, and the other half with conventional fuels, mainly LNG, according to DNV forecasts.

Ammonia will be one of the fastest-growing fuels, with a projected share of 35–44% of the maritime fuel mix, while methanol is expected to reach between 3% and 26% of the total, according to the International Energy Agency (IEA) and engine manufacturer Everllence.

Applications of alternative fuels in the maritime sector



Source: DNV Maritime Forecast to 2050

And what about its regulatory framework?

The current framework **sets targets for emission reduction in maritime transport**, including the IMO Strategy (**20% reduction by 2030 and net zero by 2050**) and the *FuelEU Maritime* regulation, which sets **progressive GHG emission reductions and certification mechanisms**. Both regulations are expected to converge to avoid loss of competitiveness in Europe.

Regulations for the use of methanol as a fuel are already developed (MSC.1/Circ.1621) and in force. For ammonia, amendments to the IGF (International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels) and IGC (International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk) Codes are being developed, expected to come into force in 2027.

Green hydrogen and its derivatives, both methanol and ammonia, offer **viable and complementary solutions** on the roadmap to **decarbonizing maritime transport**, with **scalability, technological maturity, and integration capacity** in existing systems.

Vessels already transporting ammonia or methanol are the first candidates to be converted to propulsion by these fuels, leveraging their operational experience and reducing logistical barriers.

To maximize their potential, it will be necessary to:

- ✓ **Boost renewable production of these fuels** to ensure real climate sustainability.
- ✓ **Promote investment in propulsion technologies and safe onboard storage** and handling systems.
- ✓ **Adapt port and bunkering infrastructure** to facilitate safe and competitive supply.
- ✓ Advance in the **development of specific regulations**, especially for ammonia.

By doing this, **hydrogen, ammonia and methanol** would play a **key role in ensuring the maritime sector's transition to net-zero emissions** while maintaining the **competitiveness and sustainability of global logistics chains**.

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