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Green Hydrogen-based fuel

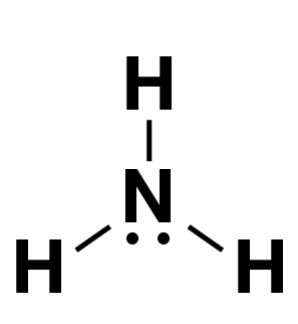
The trend towards e-ammonia and e-methanol

22 March 2022

New use cases for ammonia and methanol as fuel

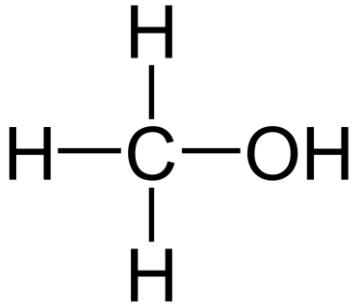
Ammonia

- Colourless gas with a distinct pungent smell
- Natural gas is used to produce conventional ammonia
- **Today**, ammonia is primary used for the **production of fertiliser**
- **Future use cases** of ammonia could include **maritime shipping** or as fuel in **industrial processes**



Methanol

- Colourless watery liquid
- **Fossil fuels (mostly natural gas)** is used to produce conventional methanol
- **Methanol is a toxic alcohol that is used as a chemical building** block for hundreds of everyday products, including plastics and paints but also as fuel
- **Future use cases** could include **maritime shipping**



Synthetic fuels are key decarbonisation option for long-haul transport, shipping & aviation

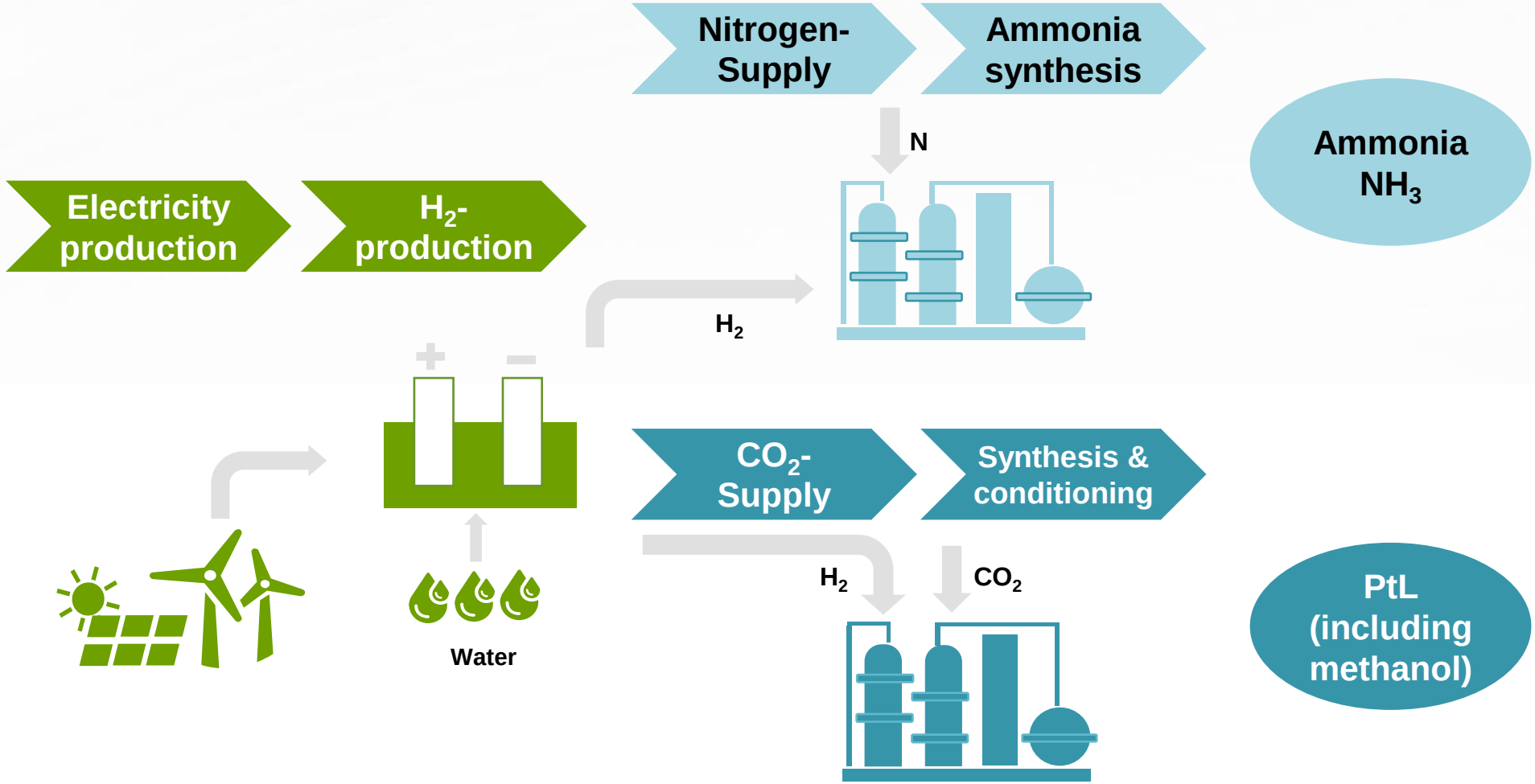
Direct electrification is the most efficient way to decarbonise transport.

Direct electrification are suitable for short distances while **synthetic fuels** are more suitable for **long distances**.

E-ammonia and e-methanol are main decarbonisation options.

E-kerosene is currently perceived as main decarbonisation option

Green hydrogen is the main input for the production of e-ammonia and e-methanol



Advantages and disadvantages of e-ammonia and e-methanol

e-Ammonia

- \+ No carbon emissions
- \+ Ammonia becomes liquid already at -33°C, which makes it significantly easier to produce and transport as fuel compared to hydrogen (-245°C)
- \+ Ammonia infrastructure is already in place
- − Low energy density (13 MJ/L $_{LHV}$), 2-3 times lower compared to conventional maritime fuels requiring larger tank
- − Ammonia is a toxic and corrosive gas with a pungent odour
- − Ammonia emits nitrous gases (NOx)

e-Methanol

- \+ Infrastructure and engine technology are already in place
- \+ Methanol can be handled and transported under normal temperatures and pressure, and it's been a used for decades as a base chemical in many industries
- \+ Methanol is a clear, colourless liquid that quickly dissolves in water and biodegrades rapidly. The environmental effects of a large methanol spill would be much lower than those from an equivalent oil spill.
- − Low energy density (16 MJ/L $_{LHV}$)
- − Toxicity and corrosiveness
- − High costs
- − (Carbon emissions)

Policy and regulation are set to increase demand for e-ammonia and e-methanol

- **Shipping accounts for about 2-3% of the world's GHG emissions**, and 80% of these emissions come from long-haul ships
- In shipping, e-fuel demand potentially faces a surging demand, as **a carbon levy** at the global level is being considered by the International Maritime Organisation at a $100/t$CO_2$. On EU level, the European Commission (EC) plans to **include shipping in the Emission Trading System** gradually from 2023 to 2026.
- In 2021, the EC published **Fuel EU Maritime**. The proposal sets out **GHG intensity targets** for fuels: Annual average carbon intensity has to decrease by 2% in 2025 and by 6 % in 2030 and then further by 5-year periods till 2050, when carbon intensity should be 75% compared to 2020. All GHG emissions count (full lifecycle), not just those used by the ship.

Recent developments in PtX shipping

Ammonia ships (fuel cells)

Fraunhofer IMM, ShipFC consortium

Pilot phase: 2021-22, First vessel by 2023

Green e-methanol container vessel (dual-fuel)

Maersk, Hyundai, European Energy

12 vessels ordered starting 2024, 16,000 m³ fuel tank (Asia-Europe)

LOHC-shipping

Hydrogenious, Østensjø

MW-scale commercial product by 2025; 4 vessels à 50,000 DWT by 2035

Liquid hydrogen (tanker barges, ferries , etc.)

HyShip Consortium

First vessels by 2024

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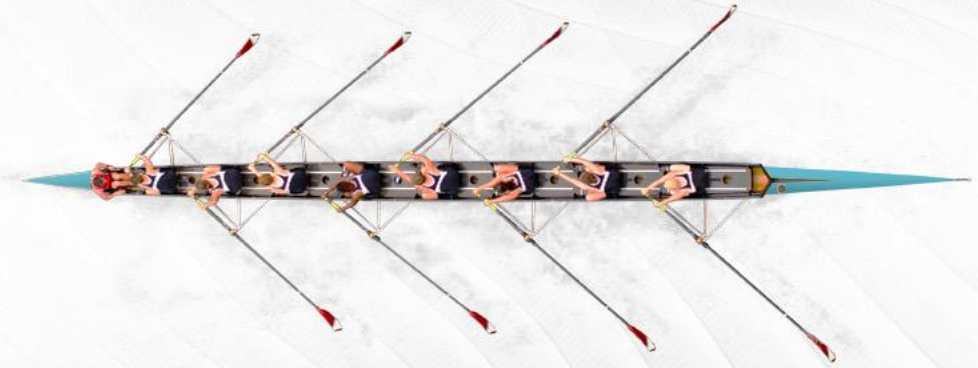

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