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Technology Collaboration Programme on
Advanced Motor Fuels

Task 64 Final webinar
Targeted E-Fuel Technology Routes

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Projected Demand for E-Fuels and E-Chemicals

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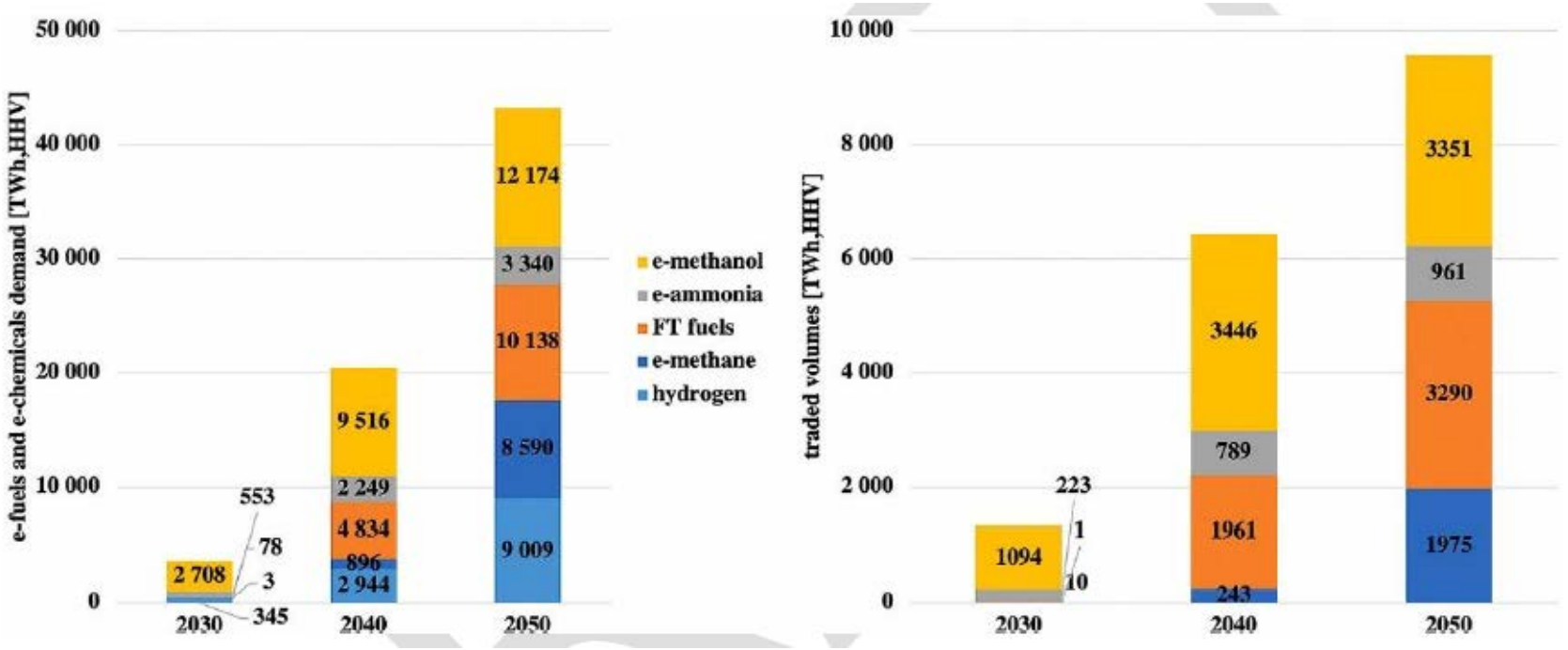
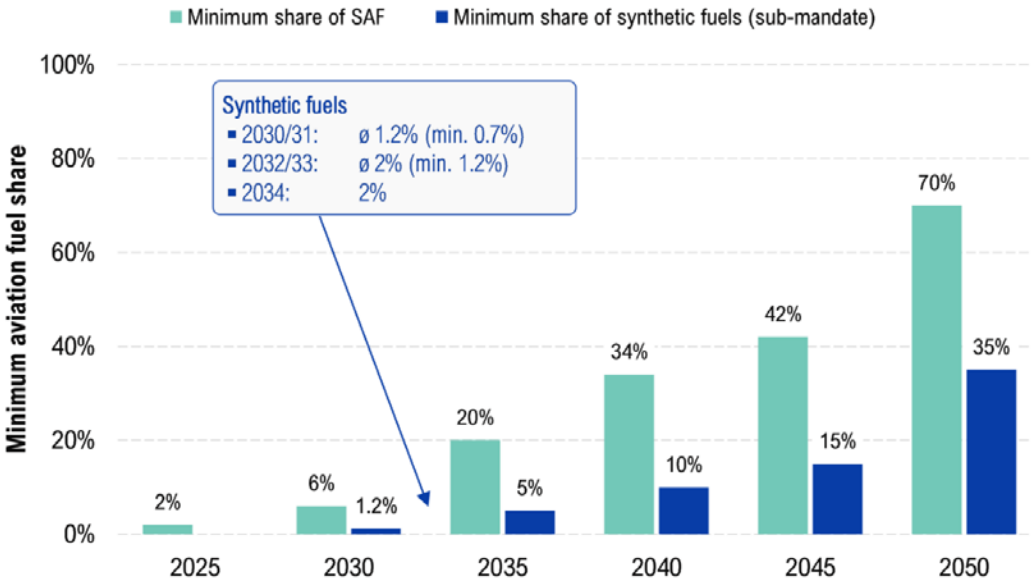
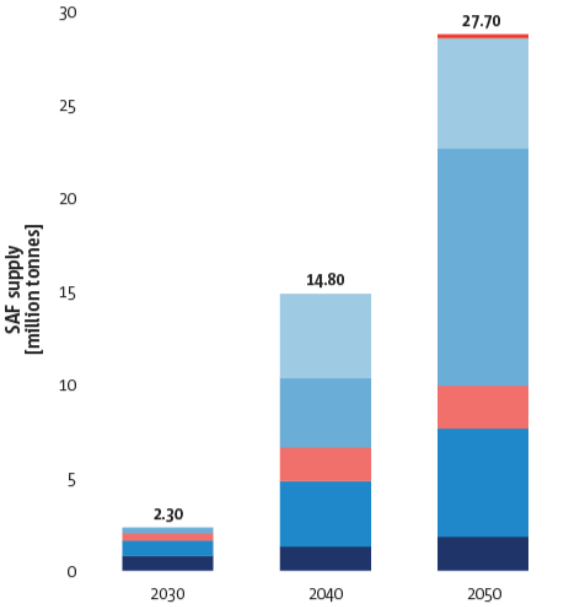


Global demand for e-fuels and e-chemicals from 2030 to 2050 (left). Projected trade volumes (right).
Source: Galimova et al. 2023

ReFuel EU Aviation





	2030	2040	2050
Electricity	0.00	0.00	0.20
Gasification+FT	0.00	4.50	5.90
PtL	0.30	3.70	12.70
Imports	0.40	1.80	2.30
ATJ	0.80	3.50	5.80
HEFA	0.80	1.30	1.80

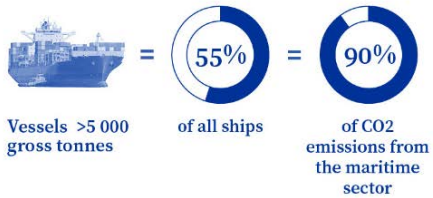
Synthetic fuels = e-fuels

ReFuelEU aviation - (sustainable-aviation.net)
Current landscape and future of SAF industry | EASA Eco (europa.eu)

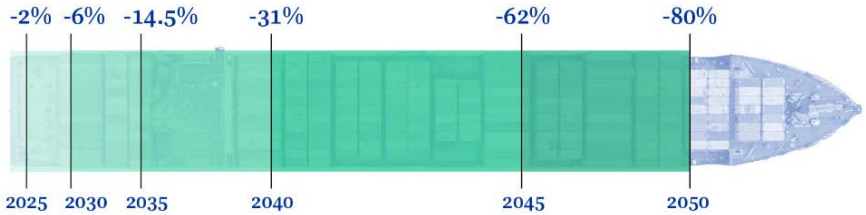
FuelEU Maritime

The FuelEU maritime regulation will oblige vessels above 5 000 gross tonnes calling at European ports (with exceptions such as fishing ships):

→ to **reduce** the **greenhouse gas intensity** of the energy used on board as follows



Annual average carbon intensity reduction compared to the average in 2020



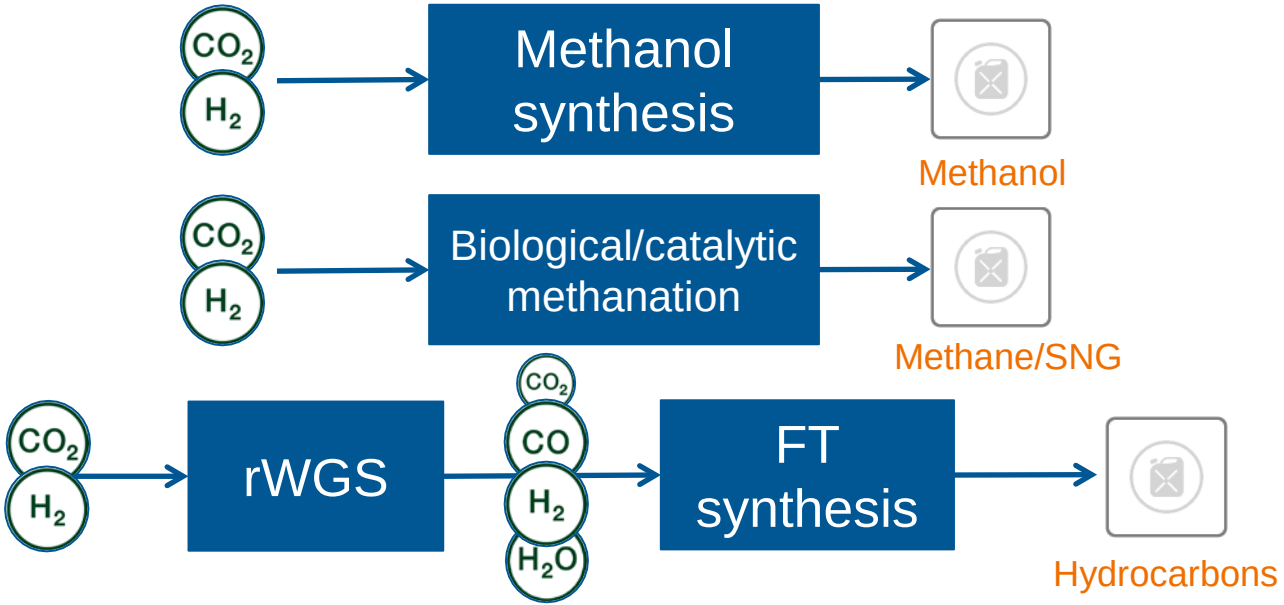
E-fuels needed for marine transport to reduce carbon intensity:

- Methanol
- Ammonia
- E-diesel

Special reward (double counting) for e-fuels 2025 2033

Fossil-sourced CO2 captured from power stations in RFNBO (e-fuel) production counts as zero emissions until 2036, and until 2041 for all other fossil industrial sources.

Main pathways to e-fuels and chemical intermediates by CCU



E-fuel project in Finland, 2021-2023

- VTT has developed patented catalyst and reactor and process technologies for RWGS and FT
- In E-fuel project, VTT's patented catalyst and reactor and process technologies for RWGS and FT were further developed with high temperature SOE for H_2 supply and CO_2 capture and purification
- The whole production chain was demonstrated in bench scale in the project. The produced paraffinic hydrocarbons were upgraded to e-fuels and e-diesel was tested in an off-road tractor.
- The lowest possible production cost for e-jet was estimated to be ~ 3000 EUR (USD) /ton
- Funded by Business finland and companies.

Photo: Visa Noronen

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Country Specific Strategies of Different Countries?

Country Specific Strategies (1/2)

- **Brazil:** Aim to keep the high level of renewables in its energy matrix.
- **China:** Hydrogen is expected to play an essential role in China's pathway towards the target of Carbon Neutrality before 2060. Methanol, gasoline, and aviation fuels are included in the e-fuel projects.
- **Denmark:** The use of e-methanol is important for the shipping industry.
- **Finland:** Focus on e-methane, e-methanol, paraffinic fuels and e-diesel. CCU (carbon capture and utilization) is regarded more positive than CCS due to the storage issues.
- **Germany:** The PTx/e-fuels opportunities have been addressed. The goal is to have hybrid multi-fuel refineries and to be a leading provider of hydrogen technologies by 2030. Many projects on methanol as key product or intermediate, as well as Fischer-Tropsch routes and methane are considered (often with renewable carbon source).
- **Japan:** For e-fuels, the focus is on hydrogen and ammonia. The important uses for e-fuels are considered to be aviation, shipping and heavy-duty transport

Country Specific Strategies (2/2)

- **Switzerland:** The Federal Offices for energy and for civil aviation push the development of sustainable aviation fuels (SAF). The goal is to scale-up SAF in Switzerland. A national hydrogen strategy will be published in 2024.
- **United States:** Net zero carbon e-fuels intended for use in hard-to-electrify transportation subsectors (trucks, offroad, aviation, marine). SAF is regarded as an important e-fuel, mainly ATJ and HEFA. E-methanol is also of interest as it is a commodity chemical for various applications and is easy for transportation. Otherwise, e-fuels aren’t assumed to play a major role in the near future as their production is too tiny in comparison to other projects. In the U.S., the inflation reduction act (IRA) incentivizes the production of clean hydrogen, SAF, and clean fuels (with the latter two including e-fuels).
- **Europe:** Four IPCEIs ('Important Project of Common European Interest') on hydrogen. 22 EU countries and Norway jointly design and coordinate these IPCEIs. For the EU one can refer to the RED Delegated act for RFNBOs and the requirements for hydrogen production.

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Commonalities and Differences?

Commonalities among the strategies of different countries

- **Renewable Energy Focus:** Many countries are aiming to increase the share of renewable energy sources including the development and utilization of biofuels, e-fuels, and hydrogen derived from renewable sources.
- **Technological Development:** There is a strong emphasis on R&D to improve technologies related to the production, distribution, and utilization of e-fuels including advancements in catalysts, fuel synthesis processes (such as FT) and further downstream processes (such as methanol to olefins or jet), and new producing routes. The final costs shall also be considered, mainly for developing countries (such as syngas fermentation).
- **Decarbonization Goals:** All countries are motivated by goals related to decarbonization and reducing carbon emissions. E-fuels are seen as a potential pathway to achieve these goals, particularly in hard-to-abate sectors (e.g. aviation, shipping, heavy-duty).
- **Diversification of Fuel Sources:** There is a recognition of the need to diversify fuel sources to enhance energy security and resilience. This includes exploring multiple types of e-fuels such as methanol, methane, ammonia, and hydrogen.

Differences among the strategies of different countries

- **Prioritization of Specific e-Fuels:** Prioritization based on domestic resources, technological capabilities, and needs of their industries. E.g. Brazil focuses on synergies with biofuels (e.g. ethanol, biodiesel, synthetic fuels), and develops the solar and wind sources, while China emphasizes methanol and Japan hydrogen, methane and ammonia.
- **Target Sectors:** Some countries focus on transportation, including aviation, shipping, and heavy-duty transport, while others also consider industrial and chemical manufacturing.
- **Policy Emphasis:** Each country has its own policy framework and incentives to promote the development and adoption of e-fuels.
- **International Collaboration and Trade**: Some countries, particularly those with limited domestic resources or land area, may rely on international collaboration and trade to access e-fuels (e.g. overseas production sites and partnerships).

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While there are common approaches among countries on the development of e-fuels, the specific strategies and priorities are shaped by each country's circumstances, resources, and policy landscape.