BRIEFING - JULY 2025

European Shipping into the Clean Industrial Era

Part I

Strategic analysis of maritime fuels for the EU

Summary

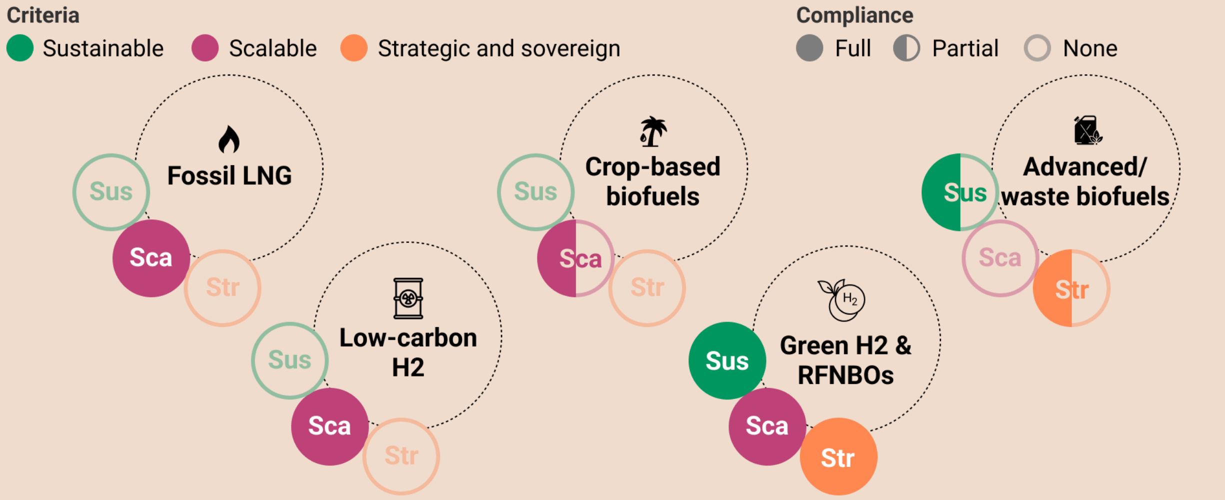
The European maritime sector is undergoing both decarbonisation and industrial renewal. What is needed now is a strategic focus. This briefing sets out T&E's vision and recommendations for the EU Maritime Strategy (EUMS) and Sustainable Transport Investment Plan (STIP), arguing that homegrown renewable hydrogen-based fuels offer the only viable long-term pathway to fully decarbonise the sector while reinforcing Europe's energy sovereignty and industrial leadership. This approach aligns with the EU Competitiveness Compass, in line with Mario Draghi's three transformational imperatives: *closing the innovation gap*, advancing a *joint decarbonisation* and *competitiveness* strategy, and *reducing dependencies to enhance security*.

At a time when investments must be strategically prioritised, the EUMS and STIP should support shipping fuels that meet three core criteria in line with Competitiveness Compass:

- **Sustainable** - ensuring real emissions reductions across the entire lifecycle, avoiding harmful trade-offs, such as land use or food security impacts.
- **Scalable** - able to meet European shipping's energy demand without technical supply constraints.
- **Strategic & Sovereign** - leveraging Europe's renewable energy potential and industrial capabilities to reduce reliance on imports and foster cross-sectoral innovation.

Key findings and recommendations:

Only green e-fuels qualify for the EU Clean Industry goals and investment support



Source: T&E. The sustainability and and scalability criteria evaluate global fuel supply, and strategic & sovereign criteria looks at European production

Fossil LNG and crop-based biofuels fail to meet the EU's strategic and environmental criteria. They risk prolonging Europe's energy dependence on imported fossil fuels and undermining climate action.

While **advanced biofuels** produced from certain European feedstocks can be sustainable, their limited feedstock availability makes them a risky choice for a European industrial strategy, where achieving scale is crucial for competitiveness.

Green hydrogen and its derivatives, such as e-ammonia and e-methanol, are the only fuels that satisfy the criteria of sustainability, scalability, and sovereignty. As a nascent industry, they require tailored policy support to enable market forces to operate effectively.

1. Introduction

Shipping's transition to net-zero emissions will require a combination of energy efficiency improvements, electrification whenever possible, including onshore power supply, and the adoption of green fuels. While onshore power supply (OPS) and efficiency measures, such as wind-assisted propulsion, optimised vessel design, and operational improvements, can significantly reduce shipping's energy demand, they cannot eliminate emissions entirely. Given the sector's energy-intensive operations, deploying scalable green fuels will be essential to meeting Europe's climate targets. Long vessel lifecycles highlight the importance of choosing fuel technologies today that will stay relevant in the net-zero future.

2. Fossil LNG

Europe currently imports a significant portion of its liquefied natural gas (LNG), which accounted for 41% of EU gas imports in 2023. Nearly half of this came from the US, where shale gas extraction and long-distance transport result in high upstream emissions. While LNG combustion emits fewer air pollutants and CO_2 than conventional marine fuels, methane slip—where uncombusted methane escapes into the atmosphere—can make LNG more harmful to the climate than traditional fossil fuel oil. This issue has been confirmed by on-the-ground studies and measurements by Queen Mary University of London and the ICCT, as well as T&E observations.

An imported fossil fuel with significant climate impacts, LNG is not well aligned with Europe's climate, industrial, or energy security objectives. It does not meet the STIP's investment criteria and cannot be considered a viable long-term option for maritime decarbonisation.

3. Biofuels

Climate and environmental impacts of biofuels are dependent on the feedstock used. Hard learned lessons from Europe's early mistakes in biofuel policy call for a cautious approach.

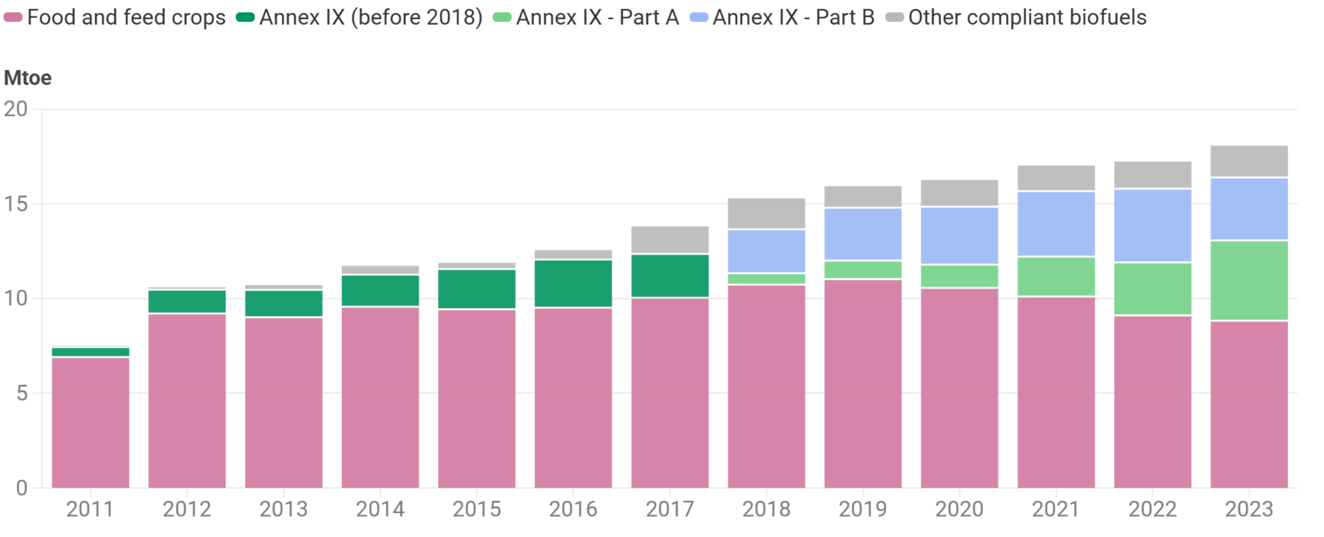
3.1 Food and feed crop-based biofuels

These biofuels are derived from conventional crops such as palm, soy, or rapeseed. Following the adoption of the Renewable Energy Directive (RED) in 2010, EU demand for crop oils surged, mostly sourced from South America and Asia. In 2022, virgin vegetable oils made up nearly two thirds of the EU's biodiesel consumption. These fuels have been linked to deforestation, land use change, habitat destruction, and food security concerns, and are estimated to emit up to three times more CO_2 than the fossil fuels they replaced in the case of palm oil.[1] Around 4 million hectares of forests have likely been cut out as a result of palm and soy biofuels in the last decade. In response to the dire environmental impacts, RED II (2018) introduced a freeze and gradual phase-out of palm-based biodiesel, removing it from renewable targets by 2030. While other crops, such as soy and rapeseed, are still to be addressed in the RED, the FuelEU Maritime and ReFuelEU Aviation Regulations, adopted in 2023, classify all food and feed crop-based biofuels as fossil, meaning no GHG savings can be claimed from their use. This crucial safeguard must be preserved across EU policy to prevent high-risk biofuels from undermining climate goals.

3.2 Advanced and waste biofuels

Historically, road transport has been the lead market for advanced biofuels. However, as the use of crop-based biofuels has been increasingly discouraged in the EU, advanced and waste biofuels have been promoted across different sectors. From 2011 to 2022, their use in the EU grew 13 times.

Advanced and waste feedstocks made 40% of all EU biofuels in 2023

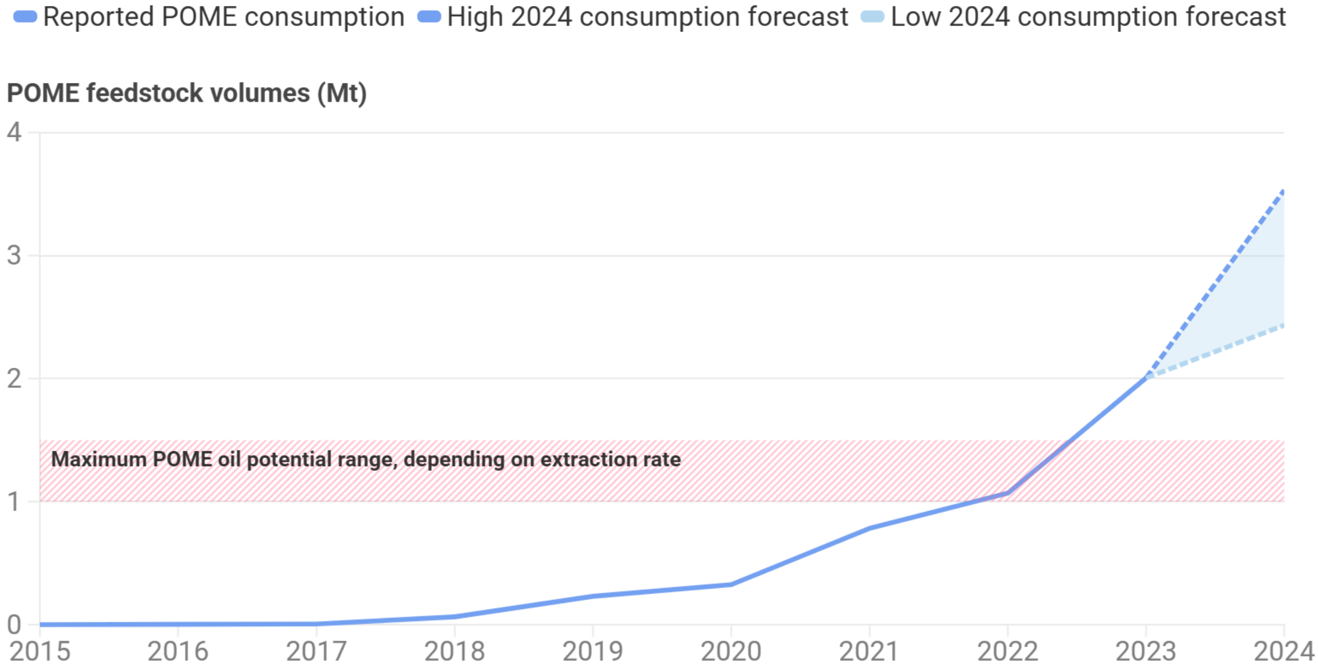


Source: T&E, based on data from SHARES (2024)

[1] Taking into account projected indirect land use change (ILUC) emissions, unaccounted for in the Renewable Energy Directive.

In many EU countries, the volumes of oily food crops such as palm oil are increasingly replaced by its processing by-products, such as Palm Oil Mill Effluent (POME), or degraded oils, such as Used Cooking Oil (UCO). For instance, POME consumption in Ireland rose 26 times in 2023 alone. Whilst genuine waste oils should be used for biofuel production, their domestic availability in Europe is limited. The rapid increase in the use of advanced and waste-based feedstocks, mostly imported from Asia, has raised concerns due to opaque supply chains, weak certification systems, and discrepancies between reported availability and exports in producer countries. T&E has highlighted the risk of fraudulent and unsustainable practices, such as the mislabeling of virgin oil or fake sustainability declarations. In Ireland, these concerns led to the removal of incentives for POME use.

POME use in EU and UK biofuels, nearly double the maximum global potential in 2023



Source: T&E, based on data from EU SHARES, UK RTFO and UN Comtrade • Extrapolated 2024 consumption range based on Jan-Aug 2024 feedstock import increase. Maximum POME potential range based on crude palm oil supply, more details in Methodology. POME biofuels volumes converted to feedstock volumes based on standard yields from GREET.

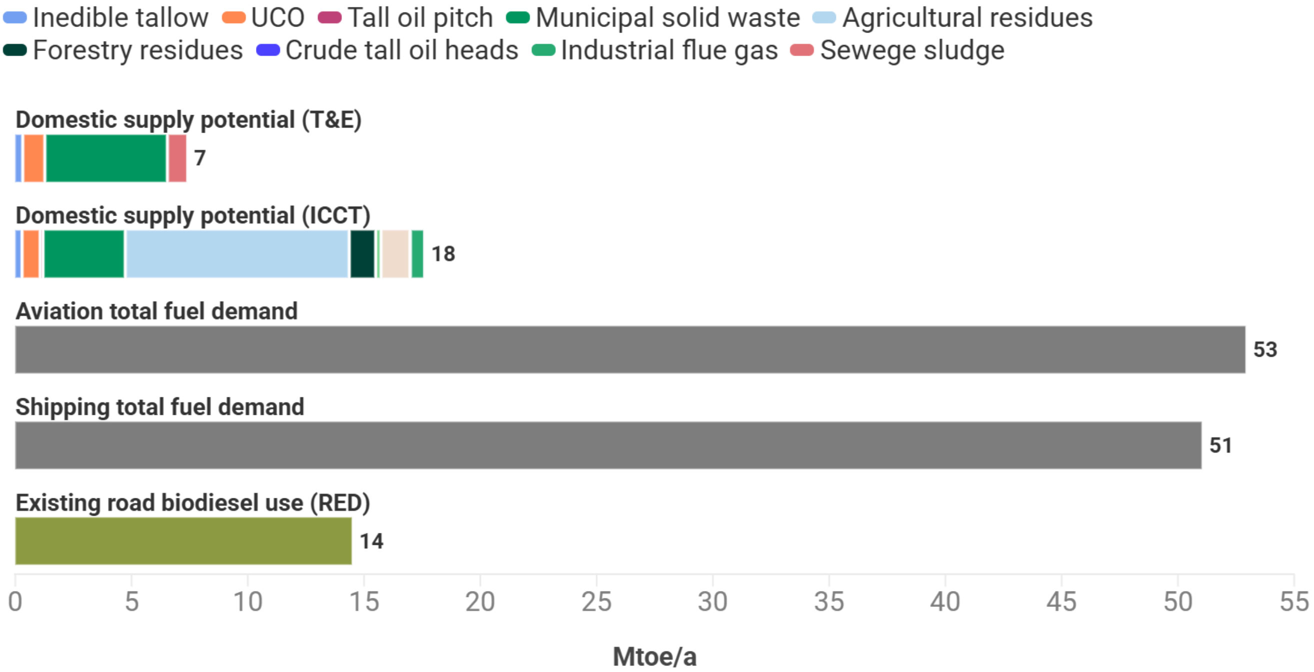
Other waste feedstocks, such as animal fats, are already largely used for animal feed or oleochemicals. Diverting them to biofuel production risks increasing emissions elsewhere. Therefore, waste oil biofuel use should be limited to the domestically collected UCO and animal fats categories 1 and 2.

For gaseous biofuels like biomethane, most cheaper feedstocks (e.g. landfills) are already used by land-based industries. These sectors have existing infrastructure and can use biomethane in gaseous form. In contrast, shipping requires liquefaction, adding at least a 10% energy penalty due to the need to cool methane to -160°C.

More advanced waste-biofuel pathways remain uncertain: municipal solid waste and sewage sludge might be sustainable ways of producing biofuels, but they require technologies that do not exist at a large scale yet (gasification, pyrolysis, hydrothermal conversion). Moreover, growing recycling and reuse rates mean these feedstocks will only become scarcer over time.

Altogether, truly sustainable biofuels are expected to be scarce in Europe (and globally) and far from sufficient to meet the long-term needs of shipping. As a result, biofuels fail to meet the core criteria of sustainability, scalability, and European strategic autonomy. While limited volumes of certain waste-based biofuels may play a transitional role in decarbonising maritime transport, they cannot serve as the foundation of Europe's Clean Industrial Strategy. The STIP should focus on supporting fuel technologies that can deliver genuine, large-scale decarbonisation while reinforcing European industrial sovereignty.

Domestic advanced biofuels can be sustainable, but little potential to underpin a genuine Clean Industrial Strategy



Source: T&E. Based on ICCT (2024), Availability of biomass feedstocks in the European Union to meet the 2035 ReFuelEU Aviation SAF target, and T&E (2024), The Advanced and Waste Biofuels Paradox in House T&E Analyses. Biodiesel supply analysis is for the year 2035.

4. E-fuels

4.1 Low-carbon hydrogen

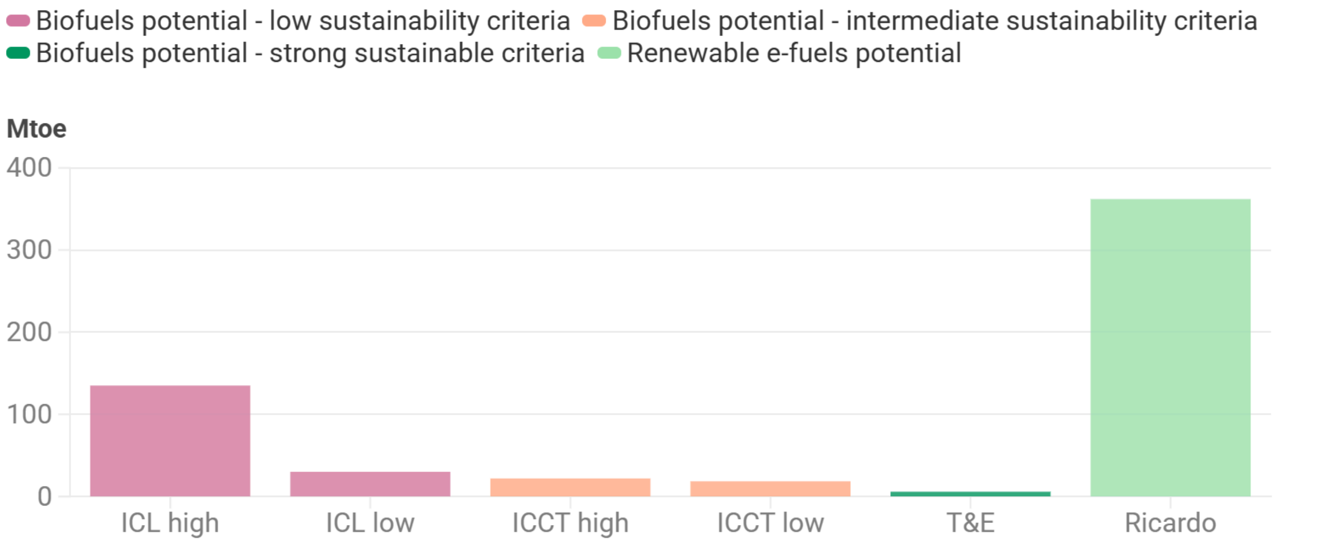
Low-carbon hydrogen is produced using non-renewable energy sources. For example, blue hydrogen is derived from fossil gas through the Steam Methane Reforming (SMR) process, combined with Carbon Capture and Storage (CCS). While blue hydrogen could offer emissions reductions compared to fossil fuels, it still relies on fossil methane, which is problematic for reasons described in section 1 of this briefing. Furthermore, its effectiveness rests on overly optimistic assumptions about the capture rate of CCS.

Pink hydrogen, produced with nuclear energy, is technically carbon-free but falls short of EU decarbonisation and industrial goals. Like renewable hydrogen, it should meet strict sustainability criteria, including additionality, which would require new nuclear capacity rather than diverting existing grid electricity. Yet, nuclear plants are costly and slow to build compared to renewable projects. They also face legal, political, and waste management opposition in many EU countries. As such, pink hydrogen lacks the scalability, cost-effectiveness, and deployment speed needed to support Europe's energy transition. Low-carbon hydrogen, therefore, does not meet the core criteria supporting Europe's clean energy and industrial ambitions.

4.2 Green hydrogen

Green hydrogen, produced via electrolysis powered by 100% renewable electricity, offers the highest decarbonisation potential with minimal lifecycle emissions uncertainty. Unlike biofuels or blue hydrogen, it relies on abundant feedstocks with fewer competing uses, making it the most scalable clean fuel. Crucially, it can be generated from Europe's own renewables, reinforcing EU energy sovereignty. With expertise in electrolysers, wind power, and RFNBOs, Europe is well-positioned to lead the green hydrogen economy and drive industrial innovation, yet another added value compared to biofuels.

At least 3 times more potential for e-fuels production in Europe than available biomass for biofuels



Source: Transport & Environment, based on data from the Imperial College of London (2021), the ICCT (2024) and Ricardo (2022). • Potential is displayed for the EU27+UK for 2050. ICL scenarios exclude imported volumes. ICCT and T&E scenarios were inflated by 15% to account for the UK. The e-fuels potential is only based on the potential for renewable electricity and does not account for other parameters, such as carbon sourcing.

Hydrogen can either be used directly as a shipping fuel or be further converted into other e-fuels that have higher energy density and are easier to store and transport.

However, the market for hydrogen and its derivatives as fuels in shipping is still emerging, which presents both challenges and unexplored opportunities that require tailored policy support to stimulate development and growth.

4.3 E-ammonia

E-ammonia, synthesised from abundant atmospheric nitrogen and green hydrogen, has the potential to become the most price-competitive e-fuel for shipping due to its carbon-free composition. It also has a higher energy density compared to hydrogen and is liquid in mild conditions, making it easier to transport and store. While less likely to be widely used in passenger shipping segments due to its high toxicity, ammonia presents a promising solution for green cargo shipping.

Ammonia transportation via ships and utilisation in the industry is an old and developed market, but ammonia use as a fuel is new. Engine manufacturers such as WinGD, MAN, and Wärtsilä are currently developing ammonia-compatible engines, and while the initial communicated test results have been positive, the emission risks of nitrous oxide, ammonia, and nitrogen oxides are still to be resolved in the operational environment. Nitrous oxide emissions, formed during ammonia combustion due to incomplete reactions, are especially concerning, given their extremely high global warming potential - 273 times that of CO_2.

The viability of e-ammonia as a clean shipping fuel will, first of all, depend on successful engine development and emissions mitigation. Therefore, to accelerate development progress and build confidence in this fuel, regulatory and financial support should be coupled with the requirement for manufacturers to publicly disclose real-world emissions data from engine testing.

Beyond its use in shipping, ammonia is widely used in other sectors. More than 70% of current ammonia demand comes from the fertiliser industry, where it plays a vital role in supporting food production. The rest is used in industrial processes, including the manufacturing of chemicals, plastics, and pharmaceuticals. These sectors are also undergoing decarbonisation and are increasingly interested in switching to fossil-free e-ammonia.

Maritime demand for e-ammonia can positively spill over into broader industrial decarbonisation. It would help scale up production capacity and infrastructure, lower the cost of green ammonia across sectors, and strengthen the resilience of supply chains. This cross-sectoral uptake would not only support shipping's climate goals but also enhance access to sustainable ammonia for agriculture and the chemical industry.

4.4 Carbon-containing RFNBOs

E-methanol is a potential long-term solution, particularly suited to passenger vessels and ferries where ammonia safety risks may limit acceptance. E-methanol is currently the most commercially advanced e-fuel, with methanol ships already in operation and a growing orderbook, especially in the containership segment. The fuel is liquid at ambient conditions and relatively easy to handle with minor modifications to existing fuel infrastructure. E-methanol is also easier to store onboard compared to hydrogen or ammonia. However, its production is more energy-intensive and requires CO_2, adding complexity and future cost uncertainty. Beyond use in shipping, methanol is also widely used in the chemical industry and, similarly to ammonia, has the potential for positive spill-over effects into other sectors in the case of increased use in shipping.

Small amounts of **e-diesel** will be available as a by-product of e-kerosene production. While unlikely to scale as a primary marine fuel due to high production costs, it can be used as a pilot fuel for ammonia, methanol or hydrogen engines, necessary due to a high ammonia ignition temperature.

E-methane will become an option for ships already equipped with LNG engines. With a large number of LNG vessels entering operation over the next five years and continued growth in new-build orders, e-methane could help preserve these assets in a decarbonising market. If realistic GHG emission factors are applied to fossil LNG and biomethane under the FuelEU - effectively disincentivising their use - and methane slip is successfully eliminated through technological improvements, e-methane could enter the EU fleet's e-fuel mix. Although its production costs are lower than those of e-methanol, e-methane's long-term role in maritime decarbonisation depends on improved technologies for CO_2 capture and sourcing, alongside regulatory climate safeguards.

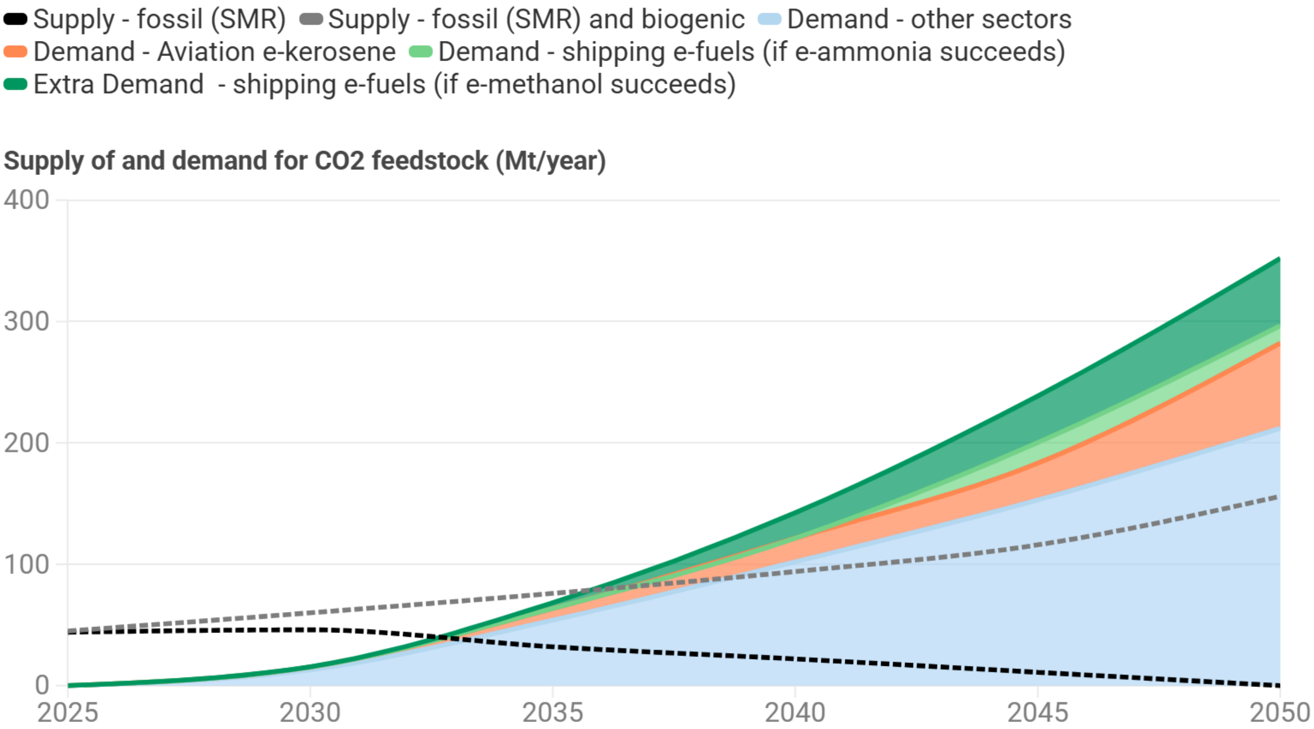
4.5. Carbon sources for e-fuels

Under the EU rules, three major sources of CO_2 can be used for RFNBO production: fossil carbon from ETS installations, biogenic CO_2 and direct air capture (DAC).

The eligibility of fossil carbon from ETS installations for the production of carbon containing RFNBOs will end in 2041, but it is still available for the frontrunner e-fuel projects. To ensure regulatory coherence across fuel categories, the same fossil carbon phase-out date should apply to the production of low-carbon fuels as well.

In the short and medium term, biogenic carbon will be available for carbon-containing fuels. However, it will face an increasing shortage of supply due to competing uses as fossil carbon is phased out. T&E cautioned that the carbon demand for producing RFNBO and low-carbon fuels will begin to exceed the biogenic carbon supply already by the mid-2030s.

EU's CO2 projected demand far outstrips supply without DAC



Source: T&E (2024) based on internal analysis and Ricardo (2022).
Other sectors: SNG, methanol, benzene, plastics, concrete, greenhouses. Aviation scope: ReFuelEU, no demand management.

DAC of atmospheric carbon will, therefore, be essential to support the scalable production of carbon-containing e-fuels. The Commission has already identified DAC as a fundamental element of its Industrial Carbon Management Strategy. However, this technology is not advancing at a sufficient speed to match the growing demand for sustainable carbon feedstock, of which RFNBOs are only a part. Without policy measures to stimulate demand for DAC, Europe will struggle to secure a sufficient supply of sustainable carbon.

5. Technology neutrality principle: a focused approach

The principle of technology neutrality in transport policies has primarily been used to justify continued investment in internal combustion engines (ICE) in road transport. In the maritime sector, ICE will remain relevant and enable the use of multiple alternative fuels. Therefore, technology neutrality in onboard engine technologies should be maintained.

However, the technology neutrality principle cannot justify equal support for fuels with vastly different climate impacts, scalability and local production potential. Europe's clean transition cannot afford to spread investment across unsustainable or imported fuels.

To succeed, STIP should directly support fuels that meet the triple criteria of sustainability, scalability, and energy sovereignty. For Europe, these are renewable hydrogen-based e-fuels.

Further information

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