

CLEANTECH REALITY CHECK



MARITIME

E-fuels for shipping: Sinking before we sail?

• What are e-ammonia and e-methanol?

E-ammonia and e-methanol are two essential near-zero emission fuels for shipping's decarbonisation.¹

While energy efficiency and the uptake of bio-based fuels will lead initial decarbonisation, these e-fuels offer significant Greenhouse gas (GHG) reductions compared to fossil fuels but require new engine technology and infrastructure.² E-ammonia is promising for long-term decarbonisation due to its carbon-free nature, but faces challenges with toxicity and NOx emissions. E-methanol has gained traction due to available dual-fuel engines and infrastructure, but its long-term scalability is constrained by limited availability of suitable carbon sources (required for methanol production), competition from sectors without carbon free alternatives i.e., aviation, and the slow development and high costs of direct air capture.

• Key take-aways

- Only two e-ammonia and two e-methanol projects with shipping explicitly targeted as an offtaker have reached final investment decision (FID). Rapid scale-up of demand for these scalable zero-emission fuels (SZEf) is critical to realise sufficient mid-term volumes.
- Fuel EU Maritime (FEUM) sets a conditional target for 2% uptake of Renewable liquid and gaseous Fuels of Non-Biological Origin (RFNBO) by 2034, and the International Maritime Organisation (IMO) has set 5% by 2030 as the goal, yet less than 0.1 million tonnes (Mt), ~6% of the required volumes to meet just the 2% target, has reached FID.
- Strengthening the Fuel EU Maritime RFNBO uptake targets and financial support to fuel offtakers to reduce the OPEX hurdle are key to drive upstream investment and ensure that the maritime industry remains competitive while leading in decarbonisation.



STRATEGIC IMPORTANCE FOR EUROPE

- > Large-scale decarbonisation: EU maritime transport represents 3-4% of EU total emissions and ~20% of global shipping emissions.
- > EU is a Maritime leader: Four of the five largest container shipping companies are European.
- > Short term: Demonstrate first production volumes of e-ammonia and e-methanol and prepare to scale the technology and infrastructure.
- > Long-run: Become a leading exporter of key technology / IP (with e-ammonia production cheaper in geographies with abundant, low-cost renewable electricity / clean hydrogen), unlocking a global market of up to €140bn p.a.

CURRENT PROGRESS OF MARITIME E-FUELS (E-AMMONIA & E-METHANOL) IN THE EU

OFF-TRACK



ON-TRACK

Status: WELL OFF TRACK e-fuels in shipping are well off track for mid-term scaling with current policy flexibility promoting non-break-through technologies such as LNG, limited public funding for OPEX over CAPEX, and uncertainty in the accounting of emissions reductions for the voluntary market all stifling demand signals, leaving vessel owners and operators unable to make the business case for long-term offtake.

<2%

of projects identified with shipping as potential end use sector have funding³

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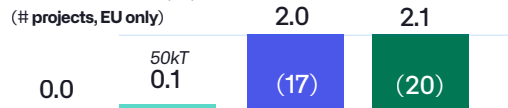
Only **two e-methanol and two e-ammonia projects** with explicit mention of shipping as an offtaker have **reached Final Investment Decision (FID)** as of Q3 2024⁴

SIGNIFICANT EFFORT REQUIRED TO REACH 2030 MARITIME TARGETS, WHILE DIVERSIFIED OFFTAKE CAN SUPPORT FIDS ONLY 20 OF 37 E-METHANOL AND 21 OF 62 E-AMMONIA PROJECTS MENTION SHIPPING OR THE TRANSPORT SECTOR AS TARGET OFFTAKE⁵

- > The e-methanol pipeline is more mature with larger projects at FID than e-ammonia.
- > However, the e-ammonia pipeline of announced projects holds significant promise, far exceeding an ambitious 5% SZEf target and is nearly 2.5x the size of the e-methanol project pipeline.

Suggested 2030 global volumes available to shipping are estimated to be 3.5Mt e-methanol and 32Mt e-ammonia based on project announcements.⁷

e-methanol (Mt)
(# projects, EU only)



< 5% E-fuels Target* (-1.9Mt)

* 5% target an illustrative threshold based on the Zero-Emission Shipping Mission for 5-10% SZEf by 2030, target volumes shown are cumulative so together they achieve the minimum 5% threshold.⁶

e-ammonia (Mt)
(# projects, EU only)

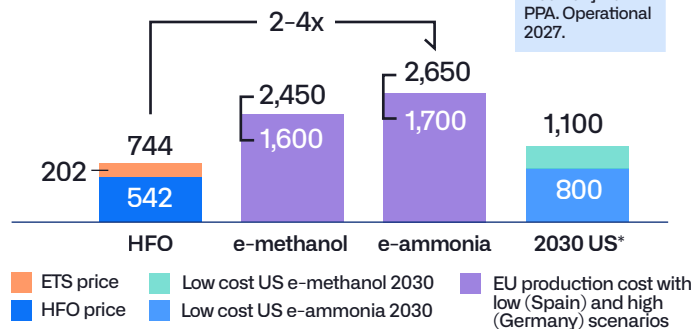


< 5% E-fuels Target* (-1Mt)

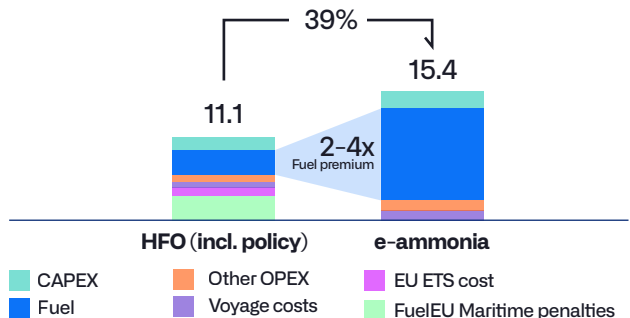
EUROPEAN PRODUCTION FACES HIGH PREMIUMS OF >2-4X EXISTING MARINE FUEL, EVEN WITH PRODUCTION IN FAVOURABLE LOCATIONS SUCH AS SOUTHERN SPAIN. LCOX IS UNCOMPETITIVE WITH U.S. PRODUCTION BENEFITTING FROM TAX CREDITS

• **LCOX⁹ e-methanol and e-ammonia,**
€/ tonne HFO eq

LCOX for new build plant. Electricity via PPA. Operational 2027.



• **Total Cost of Ownership (new build vessel)**
USD million / year



Industry perspectives emphasise the potential for costs to exceed these modelled estimates

9) LCOX stands for levelized cost of fuel.

😊 ENABLERS – WHAT IS GOING WELL

EU INDUSTRIAL LEADERSHIP

The EU comprehensive policy framework includes shipping within the EU ETS (a world first). Fuel EU Maritime (FEUM) sets progressive targets for reducing the GHG intensity of on-board energy use (complementing efficiency measures). It includes a 2% RFNBO mandate from 2034. The EU Hydrogen Bank has reserved EUR 200 million for maritime offtakers and penalties collected under FEUM in Member States' budgets must support deployment of renewable and low carbon fuels e.g., bunkering infrastructure for fueling.

MATURING TECHNOLOGY AND MARKET MECHANISMS

Global order book is growing for dual-fuel vessels capable of using e-fuels and European operators are leading the charge, the global order book stands at +25 ammonia and +250 methanol vessels. Full scale methanol bunkering is now enabled in ports of Antwerp and Rotterdam, and voluntary market coordination efforts to mobilise early volumes are underway e.g. Buyer's Alliances such as Zero Emission Maritime Buyers Alliance, alongside the piloting of emerging book & claim systems.

AMBITIOUS PROJECT DEVELOPMENT

The announced projects for ammonia production in EU with potential to supply maritime is on paper sufficient⁸ to exceed current FEUM and the higher ambition 5% SZE targets. However, maturing the pipeline depends on long-term offtake commitments, enabled by regulatory certainty and financial support to downstream operators. Sufficient capital is in the marketplace to finance new projects if the business case can be made with creditworthy offtake agreements.

☹️ BARRIERS – WHAT IS NOT GOING WELL

NEAR TERM LNG FUEL UPTAKE PERMITTED UNDER FEUM

Fuel EU Maritime not IPCC 1.5 aligned and emphasis on annual avg. GHG intensity enables uptake of more competitive LNG fuel and biofuels well into the 2030s. As such, LNG dominates new vessel order book over e-fuels, with dual-fuel vessels used as a hedge. Upstream methane leakage from near-term LNG uptake presents significant climate risk. FEUM targets for e-fuels are not currently driving the necessary upstream investments.

INSUFFICIENT OFFTAKE INCENTIVES

Producers unable to secure long term (+10yr) bankable offtake contracts due to inability of vessel operators to commit. Limited public support for OPEX vs CAPEX currently stifles the downstream business case. EU ETS missing regulatory clarity on the penalties for varying fuels and the future allocation /availability of ETS revenues to support e-fuels.

UNCLEAR FEUM POOLING ADDITIONALITY GUIDANCE

The lack of guidance under the FEUM pooling mechanism for dealing with surplus compliance and how to account for the potential allocation to the voluntary market risks the double-counting of emissions reductions. This uncertainty stifles integrity and limits the downstream demand signals for emissions reductions within the supply chain, eroding shipping companies' ability to harness willingness-to-pay and recover fuel switching costs.

📅 ACTION AGENDA – WHAT NEEDS TO BE DONE

1 Create markets by providing short-term demand certainty

Make agreed FuelEU Maritime e-fuels sub targets binding to create stronger near-term demand. Ensure adequate mechanisms are in place to mobilise demand to a point of 10-15-year offtake commitment. RFNBO multiplier to be energy-based versus GHG-intensity to achieve earlier cost advantages for e-fuels and a greater incentive.

2 Enable the downstream business case through OPEX orientated support

Direct funding for vessel operators and guarantees for OEMs adopting e-fuels is necessary to stimulate demand signals and reduce the risks taken by first movers leading e-fuel adoption. Mobilise the revenues from the maritime ETS with targeted allocation to e-fuels via competitive subsidy mechanisms e.g., EU Hydrogen Bank and Green Market Makers such as H2Global Foundation required to remove funding uncertainty.

3 Support supply chain demand signals with regulatory clarity for insets

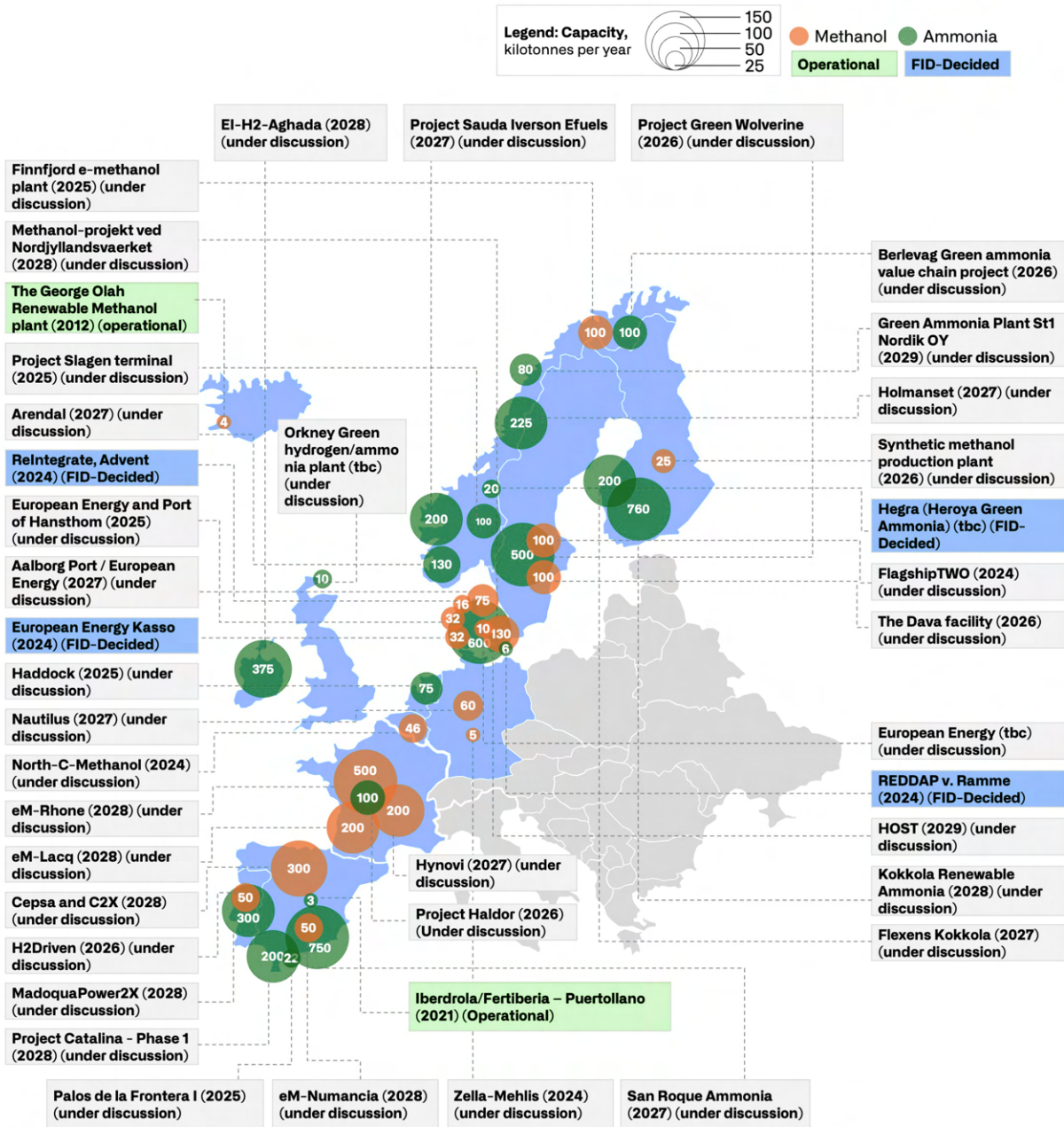
FEUM must provide a clear reporting system for surrendering over compliance and selling insets (within value chain emissions reductions) on the voluntary market. Enabling companies to credibly sell insets and comply with additionality principles is essential to market integrity and harnessing demand from ambitious cargo owners. EU regulators should engage the shipping value chain and seek to add an option during the FEUM 'Verification Period' for companies to 'retire' surplus compliance.

Shipping is off track to meet its breakthrough goal of 5-10% use of scalable, zero-emission fuels. This is a global challenge, but European industry and policymakers have a key role to play as first movers in the transition and by providing a truly ambitious voice at the IMO. While first steps have been taken, greater ambition and more urgent action is both justified and necessary.

Johannah Christensen, CEO of Global Maritime Forum



40+ ANNOUNCED SHIPPING E-FUELS PROJECTS (~6.8 MTPA) IN EUROPE



Notes: Map is not exhaustive of all e-fuels projects in Europe, projects are placed in respective countries but not always on their respective location.
Source: T&E e-fuels Observatory for Shipping

Abbreviations: LCOX- Levilised Cost Of X (fuel) | SZEF – Scalable Zero Emission Fuel | FEUM - Fuel EU Maritime | ETS – Emissions Trading System | HFO – Heavy Fuel Oil | BAU – Business as usual | ZEMBA – Zero Emissions Maritime Buyers Alliance | IMS – Member States | OEMs – Original Equipment Manufacturers | RFNBO - Renewable Fuels of Non-Biological Origin | GMM - Green Market Makers

Notes & Sources: Analysis by Systemiq undertaken for Breakthrough Energy and Cleantech for Europe. Analysis based on prior completed analysis by Systemiq for MPP relating to EU PtX LOCX, Transport & Environment E-fuels for Shipping Observatory, MPP Global Project Tracker, RMI (2024), Oceans of Opportunity, Getting to Zero Coalition (2024): Climate action in shipping: Progress towards Shipping's 2030 Breakthrough.

- 1) e-ammonia and e-methanol have been the focus of this assessment as they are both derivatives of hydrogen, other scaleable zero emission fuels (SZEF) will play a role in near term decarbonisation e.g., bio-methane and e-methane. This document's emphasis on e-methanol and e-ammonia does not exclude or imply that they are the sole solutions for decarbonizing the maritime industry.
- 2) Ammonia Fuel & Methanol Fuel - Alternative Shipping Fuels, Fuel for Thought Knowledge Hub, Lloyds Register.
- 3) <2% of projects identified in the Transport & Environment e-fuels for shipping European observatory includes renewable hydrogen, e-ammonia and e-methanol.
- 4) Recent survey by Lloyd's Register Maritime Decarbonisation Hub and ZEMBA found 69% of respondents globally ranked the maritime sector as their number one focus for the deployment of e-fuels indicating significant appetite from producers to facilitate maritime offtake Lloyd's Register, ZEMBA (2024) Availability of E-fuels and E-fuel-capable Vessels from 2027–2030
- 5) project pipeline reflects only projects identified with explicit mention to supply maritime sector or transport more broadly. Projects are identified by T&E e-Fuels observatory which surveys the state of e-fuel production in Europe for use in shipping and identifies projects with potential supply the maritime sector based on minimum commitment to supply the transport sector in general. These projects are compared to the overall European project pipeline provided by MPP Global Projects Tracker
- 6) The demand split is modelled at a ratio of two-to-one methanol to ammonia based on an extrapolation of demand for the two fuels in 2030 from existing methanol and ammonia vessel orders, following approach by RMI in RMI (2024) Oceans of Opportunity drawing from DNV Alternative Fuels Insights (AFI) platform.
- 7) RMI (2024) Oceans of Opportunity.
- 8) Total cost of ownership modelling completed on basis of new build ammonia vessel entering operation in 2027 and using 100% ammonia only. 8) Unlikely projects will reach operational by 2030 due to project maturation and construction timelines and while there is enough e-ammonia in the pipeline to meet the targets, the problem is there aren't sufficient vessels that can take this volume