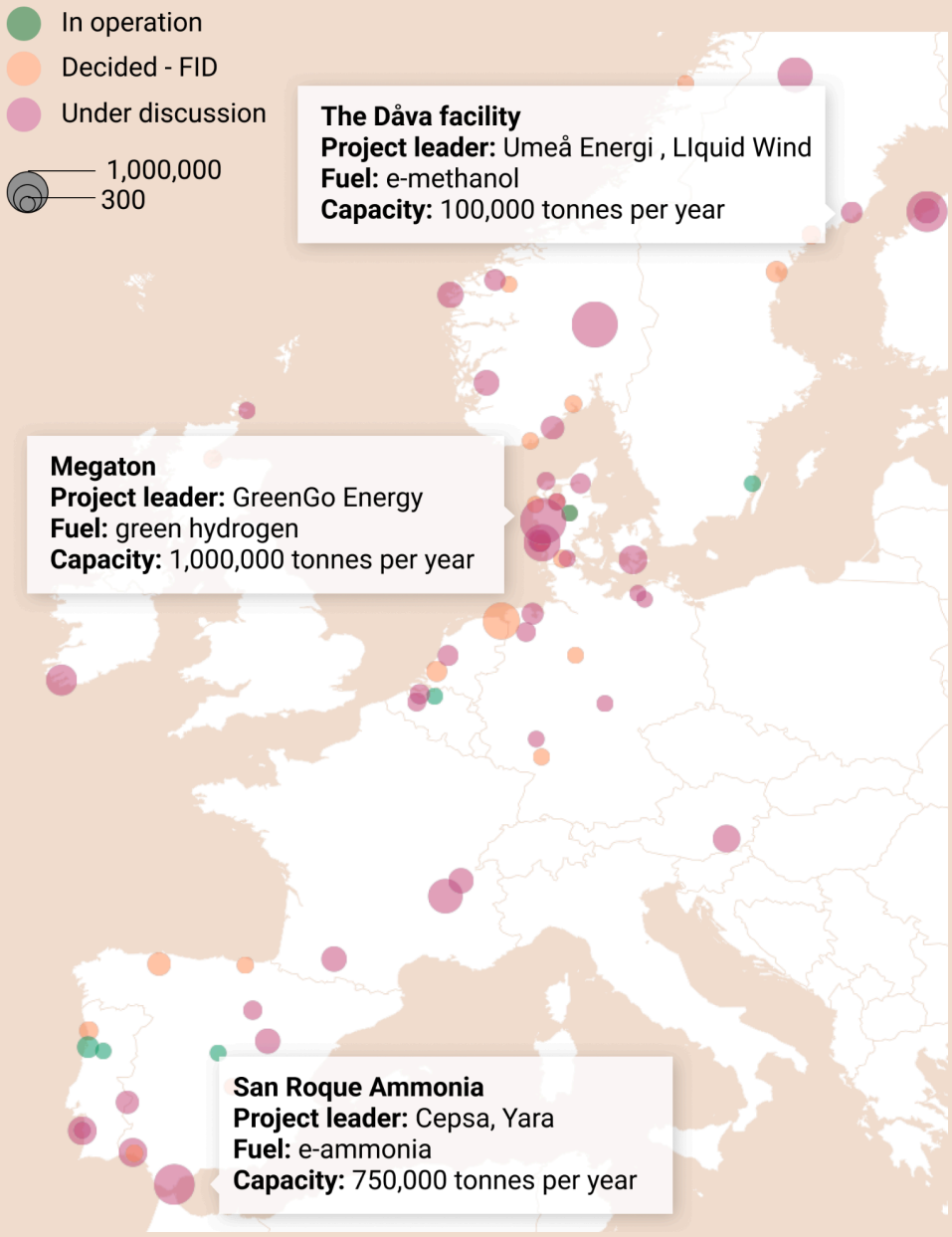
BRIEFING - May 2024

E-Fuels observatory for shipping

An overview of clean fuels projects and their supply potential to meet the needs of the European maritime industry

Summary

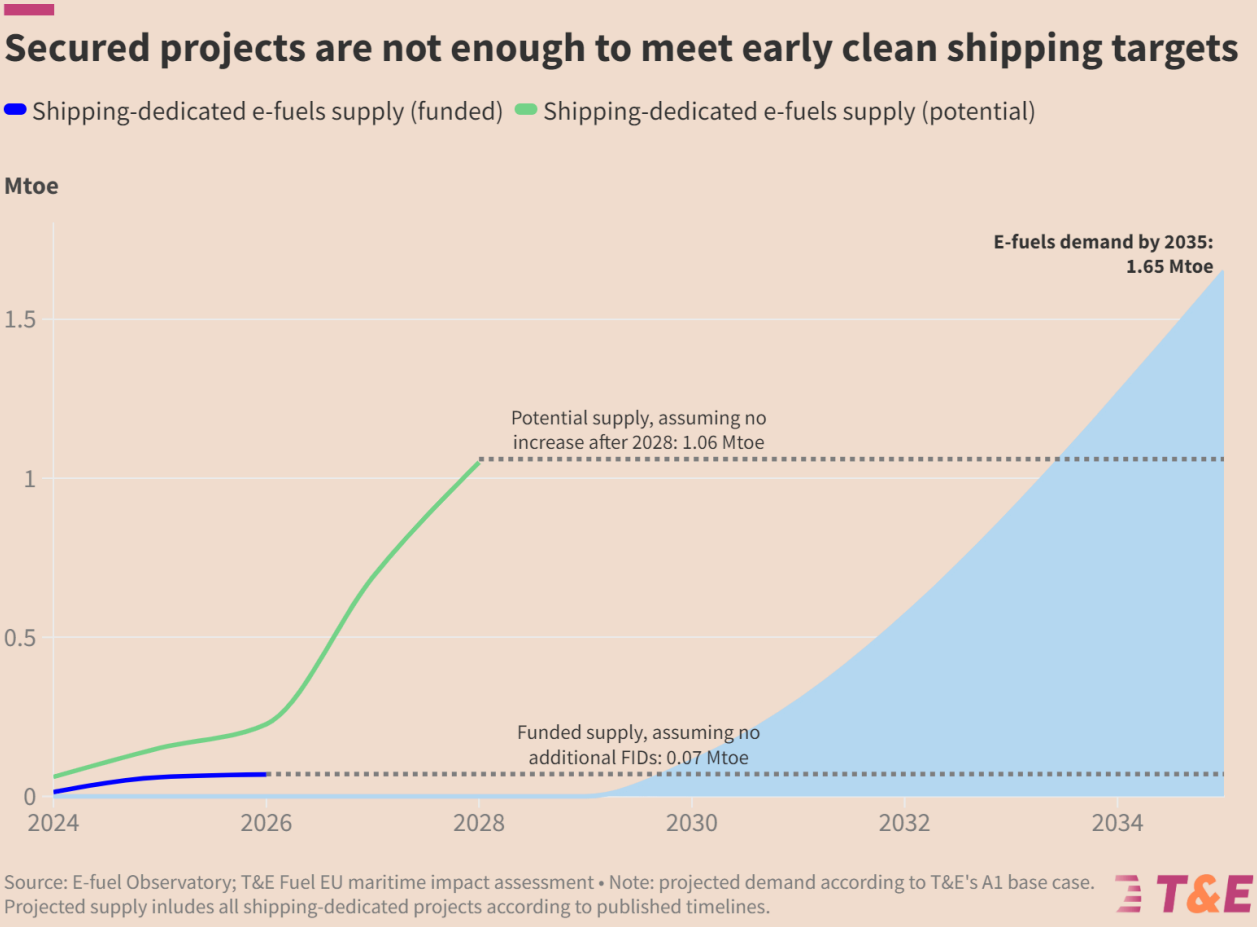
For the shipping industry to decarbonise in line with the EU climate goals, a switch to green fuels will be paramount. When the FuelEU Maritime Regulation comes into force in 2025, it will require ships to gradually increase the share of clean energy in operation. It is therefore important to ensure that enough green e-fuels are produced and made available for ships to bunker in European ports. To glean the state of play, T&E's e-Fuels Observatory surveys the state of e-fuel production in Europe for use in shipping.



Shipping e-fuels production potential in Europe

As of the beginning of 2024, T&E identified 61 e-fuels projects in development that could supply the shipping industry, with 17 specifically dedicated to the maritime sector. If all 17 projects become operational, **the total production capacity in Europe could reach 1.06 million tonnes oil equivalent (Mtoe) by 2030, and would meet 3.76% of EU shipping's total energy demand (28.2 Mtoe) under the scope of the FuelEU Maritime Regulation and the ETS Directive.**

If all these potential projects are realised on time, the supply of green e-fuels may exceed the projected demand to meet the FuelEU Maritime targets in this decade. T&E estimates e-fuels demand under FF55 package for shipping to reach only 0.11 Mtoe or 0.4% of the regulated shipping energy by 2030, as fossil LNG, biofuels and shore side electricity are projected to competitively meet the lion's share of the alternative fuel demand in this decade. However, as shown below, **currently confirmed e-fuels projects will not produce sufficient volumes to reach the 1% uptake threshold by 2031 (0.28 Mtoe) and will fall short of meeting the expected demand in later years,** as much larger amounts of green fuels will be required to meet FuelEU targets.



Comparison of potential and funded shipping-dedicated e-fuels production with the projected demand under FuelEU Maritime

It is essential to clarify that, while our mapped potential e-fuels projects are expected to be subsidised, in many instances by (inter)national programmes, the projected demand for e-fuels is based on T&E analysis of cost-effective demand under projected unsubsidised e-fuels production costs. This means that, if European e-fuels projects receive state or European Union subsidies to cut production costs, demand for e-fuels could increase and reduce or completely bridge the supply and demand gap in this decade (see figure above).

Also noteworthy, post-2030 FuelEU Maritime regulatory obligations may be significantly strengthened as the EU is expected to adopt a new 2040 climate target, which would imply an 80% absolute reduction target for shipping emissions. If translated into FuelEU Maritime obligations, this would significantly raise the demand for shipping green fuels in the coming decades, reversing the gap between the future supply and demand volumes.

According to the survey, green hydrogen and e-methanol are currently the most invested in maritime e-fuels, making up, respectively, 54% and 46% of the e-fuels volumes that have already secured funding and are dedicated to shipping. But e-ammonia has the potential to become dominant in the long run. It accounts for 77% of all shipping-dedicated fuel volumes, though none of these projects has received a final investment decision (FID) as of date.

Denmark and Spain stand out as leaders of the nascent European e-fuels industry. Denmark could produce 52% of all the surveyed potential production, with large-scale green hydrogen projects making up the lion’s share; though not all aim to exclusively supply the marine fuels market. Spain is looking to become the leading supplier to the shipping industry, aiming to produce 0.36 Mtoe or 34% of surveyed fuel volumes dedicated solely to the maritime sector. It will host the largest mapped e-ammonia project alongside an e-methanol facility.

Nearly 4% of Europe's shipping energy demand could be met by clean fuels by 2030 if project financing can be guaranteed. However, e-fuels volumes that received funding to this date comprise only 0.24% of the projected marine energy demand. On the one hand, it is likely that e-fuel producers will wait for clearer demand signs, and financial support before making (further) large investments. On the other hand, we expect shipping companies to wait for clean fuels to become available at scale and at competitive prices before engaging in fuel supply contracts. Hence, stronger long-term demand and supply signals and associated policy support are needed for more projects to overcome existing and future investment risks.

To help achieve this, T&E makes the following policy recommendations:

1. **Implement a marine e-fuels supply target of at least 1.2% in European ports at the national level,** as recommended by the Renewable Energy Directive (RED III). This could help mobilise national resources and channel limited initial production volumes to shipping, which has few other sustainable and scalable alternatives to decarbonise. It would also ensure that at least the e-fuel projects that have already received FIDs don't get delayed, putting shipping's energy transition at risk. Given that in some member states mapped e-fuel volumes, if realised on time, will deliver higher market share than the 1.2% RED III target, member states should consider going beyond the minimum RED sub-quota in their national implementation plans.
2. **Provide financial incentives for e-fuel production using maritime carbon pricing (ETS) revenues**. Maritime ETS is expected to generate up to €8 billion in annual revenues by 2030, most of which will be accumulated in national coffers. Part of these revenues can be used to kickstart the production of e-fuels in Europe that has not secured financing, by providing targeted subsidies to reduce the cost gap with fossil fuels. This could ensure that the initial supply meets the demand from the shipping sector in this decade.
3. **Align the FuelEU Maritime Regulation (FEUM) with the Commission's 2040 climate target proposal**. Although the implementation of the FF55 package may facilitate the deployment of initial green e-fuel volumes within this decade, their mass-market diffusion will necessitate greater regulatory certainty beyond 2030. Aligning FEUM with the Union's economy-wide climate objectives for 2040 and 2050, as well as introducing stronger e-fuels sub-targets, will help boost the demand for green marine fuels and reduce investment risks for further e-fuel projects over the medium and long term.
4. **Introduce binding marine e-fuels supply targets through existing EU legal instruments.** This could be achieved through the FuelEU Maritime or RED III during the future revision of these laws. The goal is to synchronise the supply and demand requirements and to ensure uniformity in ambition.

1. Introduction

As part of the European Green Deal, the Fit-for-55 package has charted a path for the decarbonisation of the maritime industry. From 2024, ships are required to pay for their carbon emissions under the Emissions Trading System (ETS), while FuelEU Maritime mandates an increasing switch to cleaner fuels from 2025 onwards. In addition, the revised Renewable Energy Directive (RED III) requires at least 1% of transport energy to be supplied by Renewable Fuels of Non-Biological Origin (RFNBOs) or so-called e-fuels, and incentivizes their provision to shipping. It also sets an indicative 1.2% marine RFNBO supply target in European ports. EU laws provide room for manoeuvre and European states can choose different ways to attain their decarbonisation goals. Ultimately, however, to achieve these goals in the maritime sector, a switch to clean fuels will be required. While shipping represents about 14% of all transport emissions across the EU[1], for some maritime economies, shipping will be at the very heart of the green energy transition. With a variety of EU and national policies targeting different players in the shipping industry, there is a risk of a mismatch between the amount of e-fuel supply and demand available to decarbonise European shipping.

1.1 Policy context: EU targets and opportunities for the decarbonisation of the shipping sector

Fit-for-55 has created a framework that now needs to be adopted by the member states. The implementation of the FuelEU Maritime Regulation and the revised Renewable Energy Directive will facilitate the shipping industry's switch from fossil to sustainable alternative fuels, including those derived from green hydrogen.

On the demand side, under FuelEU Maritime, ships will have to progressively reduce the greenhouse gas (GHG) intensity of the energy used from 2025 onwards, reaching 80% reduction in 2050 compared to the 2020 baseline, as shown in figure 1.

In simple terms, vessels will have to switch to cleaner, less GHG-intensive fuels. The policy also introduces a binding sunrise clause for the uptake of 2% of green e-fuels from 2034, should market forces fail to achieve a minimum of 1% clean fuel uptake by 2031.[2] The use of RFNBOs is promoted by the multiplier of 2 until 2034, double-counting these fuels to make it easier to attain the GHG-reduction requirements and support early adopters. Figure 2 shows the projected e-fuel demand, based on FuelEU Maritime targets.[3]

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[1] T&E (2024) State of European Transport. Retrieved from https://transport2024.transportenvironment.org/sot/index.html

[2] However, Article 5, paragraph 5 of the FuelEU stipulates, that, if there is evidence of insufficient production capacity and availability of RFNBO to the maritime sector, uneven geographical distribution or a too high price of those fuels, the 2 % subtarget shall not apply. In addition, a 2% target can also be met with advanced biofuels, as per paragraph 9 of Article 5. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1805

[3] T&E (2023) The impact of FuelEU Maritime on European shipping. Retrieved from https://www.transportenvironment.org/discover/the-impact-of-fueleu-maritime/

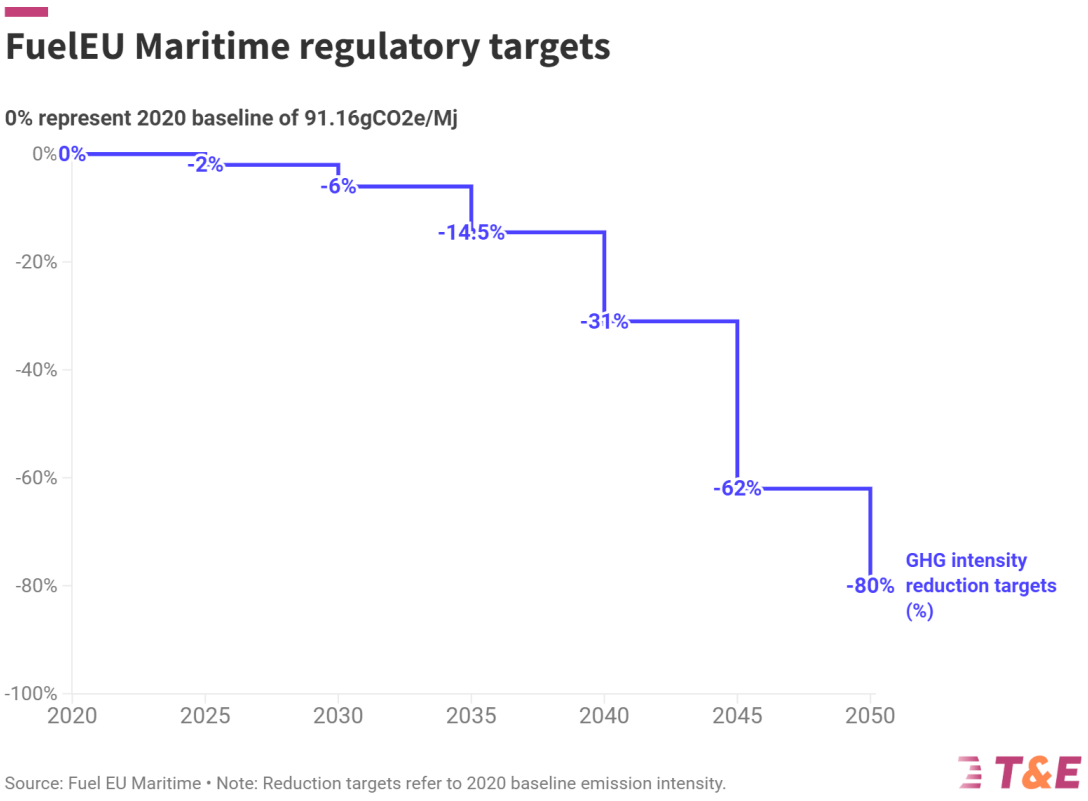


Figure 1: FuelEU Maritime GHG intensity reduction targets

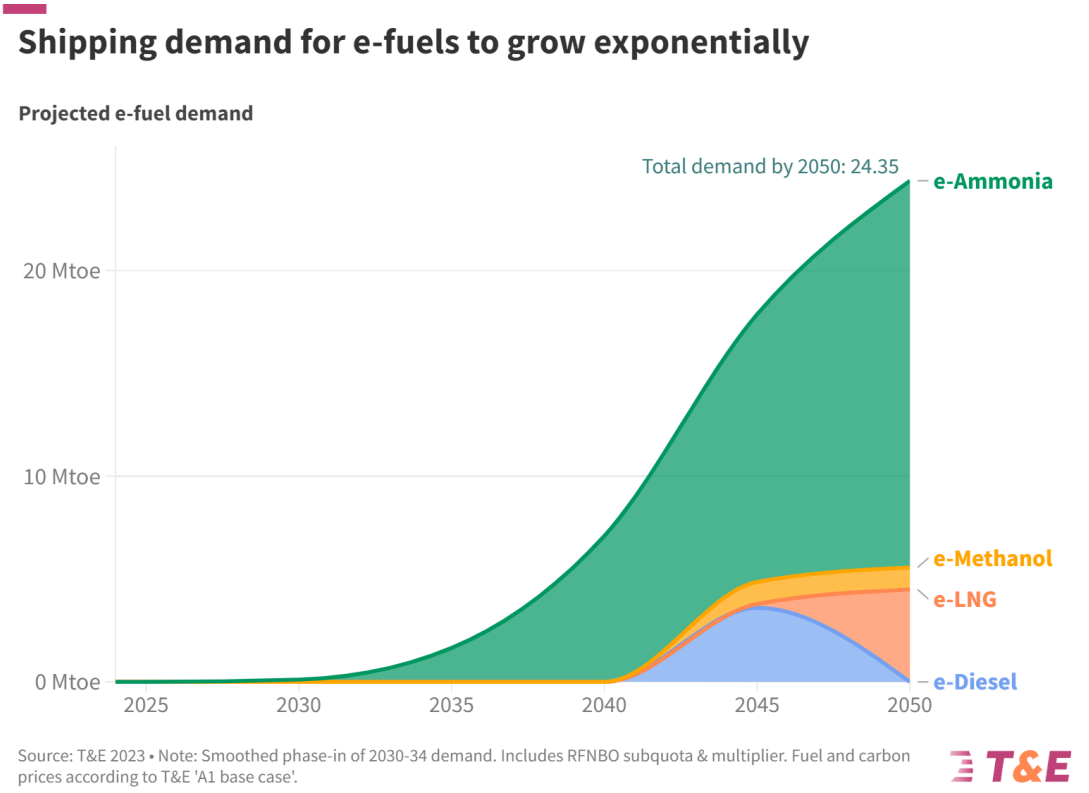


Figure 2: Projected e-fuels demand for shipping, based on FEUM targets and ETS carbon pricing[4]

[4] The projected graph assumes unsubsidised demand.

With RED III, the EU increased its 2030 target for the provision of renewable energy in transport from 14% to 29% and extended the policy scope to cover shipping fuels. Alternatively, countries can choose to reduce the carbon intensity of their transport fuels by 14.5%. All this means more renewable fuels will be needed to reach the targets. The Directive needs to be transposed into the national law by the end of May 2025.

RED III provides a legislative basis and incentives for some of these fuels to be supplied to shipping (and aviation):

- Advanced biofuels from Annex IX Part A are counted 1.2 times their energy content and RFNBOs are counted 1.5 times, meaning smaller absolute amounts are needed to meet the overall transport obligation, if these fuels are prioritised in shipping and aviation. These so-called multipliers come on top of the double counting of the energy content of these fuels applied when supplied to any transport sector.
- An "indicative subtarget" of at least 1.2% of RFNBO supply to shipping is recommended for the EU member states with maritime ports. However, it is up to the countries to decide if and how it could be implemented nationally.

Even though designed to be complementary, the two policies have some key differences:

- **The scope of eligible fuels.** RED III promotes renewable energy only, whereas FuelEU Maritime has been designed as fuel-neutral - except for the introduction of a 2% RFNBO uptake quota from 2034. As a result, FuelEU Maritime encourages a continued uptake of LNG well into the 2030s. Another difference is that FuelEU Maritime does not allow food and feed crop-based biofuels to count towards the GHG reduction targets by treating them as a fossil fuel in terms of their well-to-wake emissions. RED III, in contrast, allows the contribution of these feedstocks to the target of renewable energy in transport as long as it stays within the caps and limitations included in the RED.
- **Scope of transport sectors.** While FuelEU Maritime addresses shipping independently of the other transport modes, RED III sets a goal for transport as a whole. It leaves to the member states to choose which transport sectors should be the priority users of renewable fuels in this decade.
- **Geographical scope.** RED III applies to fuels *supplied* in EU/EEA area, while FEUM applies to fuels *used* under the FEUM geographical scope. Under RED III, a green fuel can be produced outside of Europe, but physically sold in Europe and therefore subject to EU rules. In contrast, under FEUM, fuel can be produced and bunkered outside of Europe, without being subject to the EU supply rules (such as e.g. possible RFNBO supply mandate).
- **2030 targets**. Both RED III and FuelEU Maritime set fuel GHG reduction targets for 2030. The former regulates fuel suppliers with an objective of 14.5% GHG intensity reduction by 2030. The latter regulates fuel users with a GHG intensity reduction target of only 6% by 2030.

1.2 Decarbonising shipping: the role of e-fuels

Green e-fuels have the biggest emissions reduction potential and will comply with the regulatory targets the longest. They can be scaled up and provide clean energy even for the largest vessels sailing across the oceans. While currently expensive, large-scale investment in their production will eventually bring down the costs. Biofuels are expected to have a more limited role due to competing uses in other sectors and scalability issues, as sustainable bio-feedstocks are limited.

INFO BOX: What are (these) e-fuels

RFNBOs are defined under the RED III Directive (2023), Article 2(36): "renewable fuels of non-biological origin" means liquid or gaseous fuels, the energy content of which is derived from renewable sources other than biomass.[5]

Two Delegated Acts on RFNBOs (2023) ensure that all RFNBOs are produced from renewable electricity, set their production criteria, and provide a methodology for calculating their life-cycle greenhouse gas emissions.

The updated RED III Directive (2023) stipulates that to qualify as an RFNBO, e-fuels need to reduce emissions by at least 70%, compared to fossil baseline (94 gCO2eq/MJ). In addition:

- RFNBOs will need to be produced with additional renewable electricity (except for those who start before 2028) and have in place Power Purchase Agreements with the producers of renewable energy.
- Temporal and geographical correlation clauses require that renewable electricity generated is used to produce hydrogen in the same location and month (in the same hour from 2030).
- Carbon-containing RFNBOs will be able to use fossil carbon until 2041, so long as they are carbon-priced first. After that date, only sustainable biogenic (biomass-sourced) carbon, carbon captured directly from the air (DAC), natural geological sources or RFNBO combustion will be eligible for the fuel to be considered an RFNBO.

1.3. The observatory

The IEA's 2023 Global Hydrogen Review found that only 4% of potential low-carbon hydrogen production has achieved a final investment decision (FID).[6] A more recent review for T&E found

[5] RED III (2023). Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02018L2001-20231120
[6] IEA (2023). Global Hydrogen Review 2023. Retrieved from https://www.iea.org/reports/global-hydrogen-review-2023

that most of the planned hydrogen capacity in six countries that combine good renewable sources with green hydrogen export ambitions is still at the technical feasibility stage and many conditions are still to be met for the imports to be sustainable.[7] Therefore, Europe should focus on developing its market and supply of e-fuels as a matter of urgency. Strong support for domestic production of hydrogen and e-fuels will be key to meeting at least the initial demand targets for hard-to-abate sectors like shipping.

To that end, the European shipping e-fuels observatory maps existing, confirmed, and planned e-fuels production sites across Europe. Considering their feasibility and end-use sector, the observatory allows for comparing the projected output with the estimated e-fuel demand from the shipping industry, based on current legislation. The tool provides insight into the maturity status of the different projects and regional hotspots of e-fuel production. Acknowledging the fast pace of change in this nascent industry, the observatory sheds light on the current market of European e-fuels and their potential for decarbonizing the maritime sector. It should be regarded as a "living database", updated as more information becomes available. This briefing is based on collected data as of February 2024. The full methodology, including sampling and assumptions, can be found in Annex 1.

The observatory maps 61 e-fuel projects (and 10 biofuel projects) that are specifically dedicated to or could potentially supply the shipping sector. A full list is available in Annex 2. Based on the publicly available information and bilateral communications with project developers, all projects are assigned a status:

- **In operation**: projects that are already producing e-fuels for commercial markets.
- **Decided - FID**: projects that have received a final investment decision (FID). FID is considered the central condition for the realisation of a project.[8]
- **Under discussion**: projects that are at any stage before the final investment decision, or have a lack of information on the status of operationalisation.

Where available, the stated date of operationalisation was included independently of the project status. This date is understood as preliminary, depending on the FID. The project description includes the project leader, planned capacity, fuel type, feedstock, and, where applicable and available, a CO_2 source.

[7] Transport and Environment (2024). Europe's hydrogen plans reliant on uncertain imports – report. Retrieved from https://www.transportenvironment.org/discover/europes-hydrogen-plans-reliant-on-uncertain-imports-report/

[8] Upon receiving an FID, major financial commitments are made by project stakeholders. It marks the point where capital is available to begin procurement and realisation of a clean e-fuels project. We assumed an FID is reached if it was confirmed by a public information source, via personal communication, if the construction of the plant has started or the first supply contract has been signed.

2. Mapping shipping e-fuels in Europe

The observatory paints a picture of uncertainty concerning the volumes of e-fuels produced for shipping in this decade. The majority of projects indicate willingness to supply different transport modes and other industries rather than committing to shipping only, highlighting the chicken-egg problem between demand and supply of shipping e-fuels.

2.1 How much e-fuel could be produced for shipping?

Of the 61 e-fuels projects surveyed for the observatory, **only 17 are dedicated solely to the maritime sector, amounting to 1.06 Mtoe**. Another 25 projects, with 1.9 Mtoe potential output, mention shipping as one of their possible target sectors, without clear preferences or dedicated capacities for any other customers. The remaining 19 mapped projects, amounting to 4.04 Mtoe or more than half the potential production output, do not commit further than the "general" transport sector but could in general produce maritime e-fuels. Figure 3 illustrates the e-fuel production capacity of all projects, differentiated by the likelihood to supply the shipping sector.

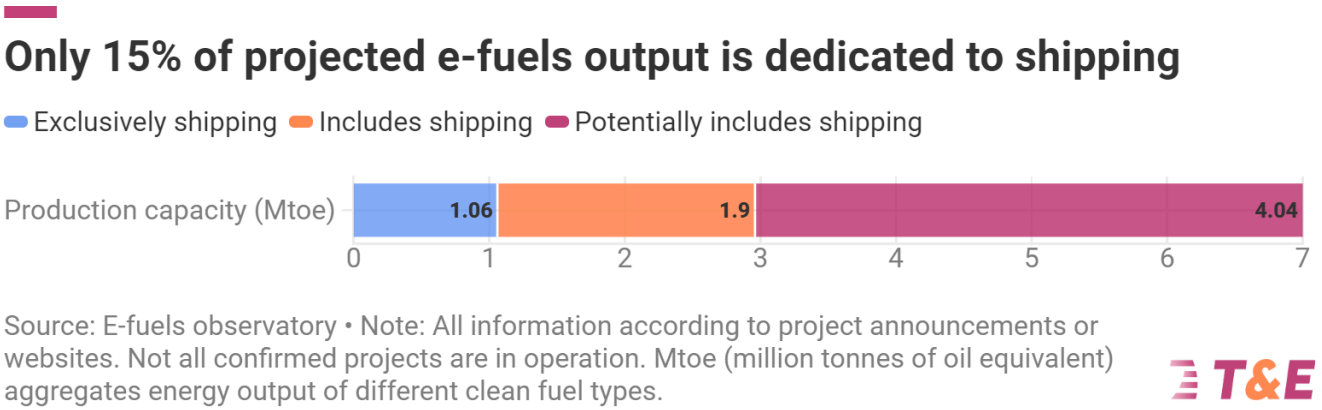


Figure 3: Shares of e-fuel production capacities by their potential to supply the maritime sector

INFO BOX: What are Mtoe?

Mtoe refers to million or mega tonnes of oil equivalent**.** The unit standardises energy across different fuel and energy types into a common metric. Referencing the energy released when burning a tonne of crude oil, i.e. its calorific value, toe (tonne of oil equivalents) offers a unified framework to compare energy consumption, production, and trades.

In line with IPCC sixth assessment report (2022),[9] one tonne of oil equivalent (toe) represents 41,900 MJ of energy, or 41,900 TJ for every mega-tonne of oil equivalent (Mtoe). A kilogram of the common marine fossil fuel VLSFO contains about 41 MJ, compared to 120 MJ per kg of liquid hydrogen, 20 MJ per kg of methanol, or 19 MJ per kg of ammonia.

The Hong Kong Express container ship reported an average consumption of about 300 kg - 12.300 MJ - of marine fuel per nautical mile in 2022. With a capacity of about 14000 twenty-foot-containers, it belongs to the category of Neopanamax containerships.[10]

In the EU policy, Mtoe is used to measure energy consumption across sectors and set energy efficiency targets. Mtoe can be used to describe and forecast total fuel demand and supply, including for RFNBOs such as green hydrogen, e-methanol, or e-ammonia.

2.2 Which e-fuels could be produced in this decade?

The number of projects for green hydrogen, e-ammonia, and e-methanol production is almost equal - 19, 21, and 21, respectively, with an aggregated production potential of 7 Mtoe. Figure 4 compares the number of projects with their potential production volume by fuel type, irrespective of their dedication to the shipping sector.

[9] IPCC (2023) AR6 Synthesis Report, Climate Change 2023. Retrieved from https://www.ipcc.ch/report/ar6/syr/
[10] IMO Nr: 9501356, fuel consumption from THETIS MRV 2022. Image: flickr @ tim.md

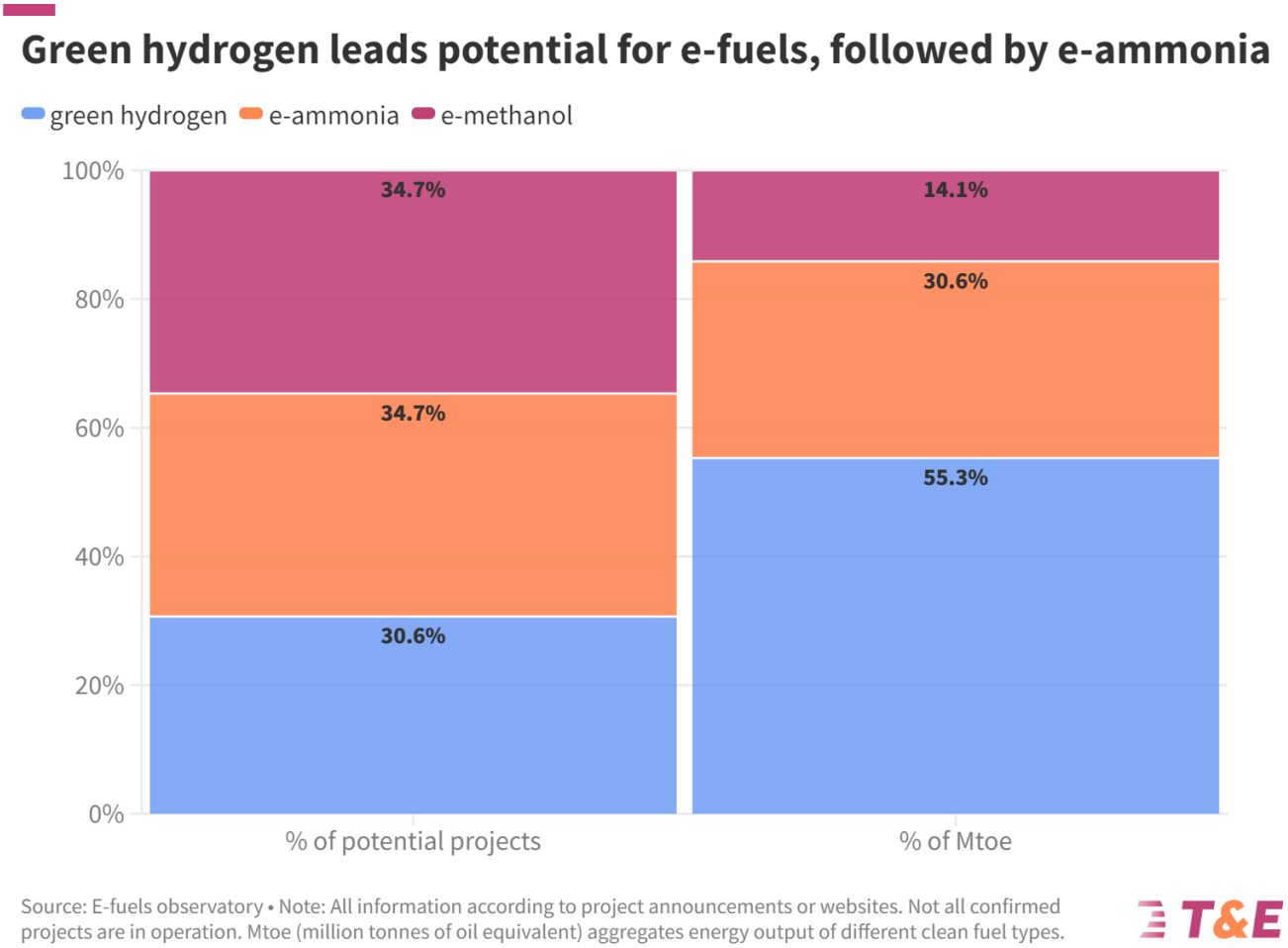


Figure 4: E-fuel production capacity of all mapped projects by fuel type

Among projects dedicated exclusively to the shipping sector, e-ammonia leads the way with 5 plants potentially producing 0.82 Mtoe of fuel. It is followed by 7 e-methanol projects, amounting to 0.18 Mtoe, and 5 green hydrogen projects with 0.06 Mtoe potential production.

Looking at projects that mention shipping as one of their potential customers, e-ammonia comes first as well, with 14 projects and 1.19 Mtoe potential fuel output. 10 e-methanol projects with 0.69 Mtoe also include shipping into their list of target customers. Only 1 green hydrogen project with a small amount of 0.009 Mtoe falls into this category.

The last category of e-fuel production sites, intending to supply the transport sector but with no specific mention of shipping, contains 13 green hydrogen plants with a potential to produce 3.81 Mtoe. There are also 2 e-ammonia projects with 0.12 Mtoe and 4 e-methanol projects with 0.11 Mtoe output.

2.3. Projects with a FID - different fuel types and commitment to shipping

Out of 61 mapped e-fuel projects, 11 have an FID and could potentially produce 0.13 Mtoe by 2026. However, **only 6 projects with FIDs are dedicated solely to shipping, amounting to 0.07 Mtoe**. Another 3 projects with FID include shipping as one of the end sectors (0.03 Mtoe), and the remaining 2 would supply the transport sector in general with the potential to produce for shipping (0.03 Mtoe). Figure 5 provides a breakdown of all mapped projects and those with FID, based on their level of commitment to shipping.

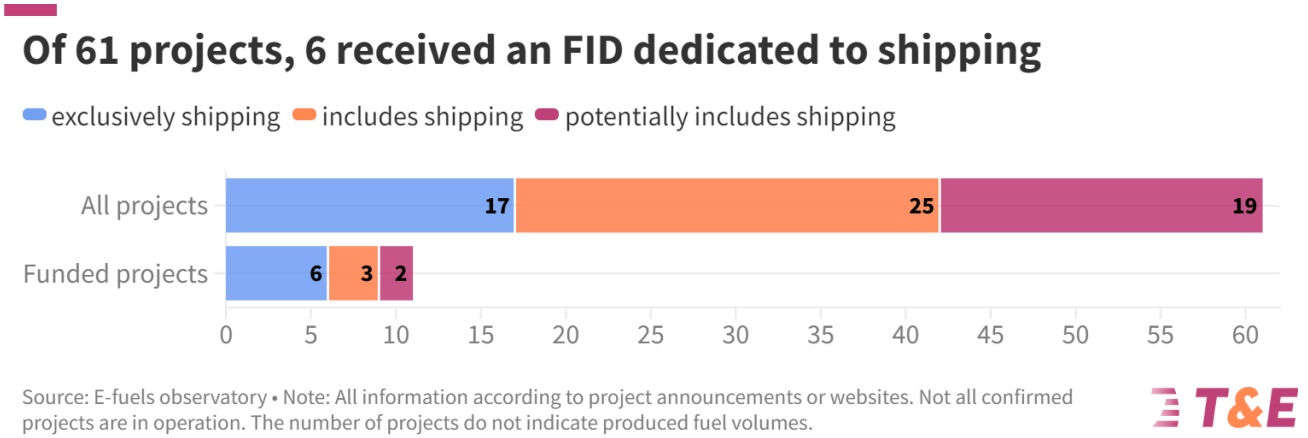


Figure 5: Share of e-fuel projects with the potential to produce clean shipping fuels by targeted consumer markets

Green hydrogen has received the most investment, with 6 confirmed projects amounting to 0.07 Mtoe production. It is followed by 3 e-methanol projects with 0.05 Mtoe output, as well as 2 e-ammonia plants amounting to 0.01 Mtoe. **As regards shipping-dedicated fuels, there are 4 green hydrogen (0.04 Mtoe) and 2 e-methanol projects (0.03 Mtoe)**, as shown in Figure 6. **No shipping-dedicated e-ammonia project has received an FID.**

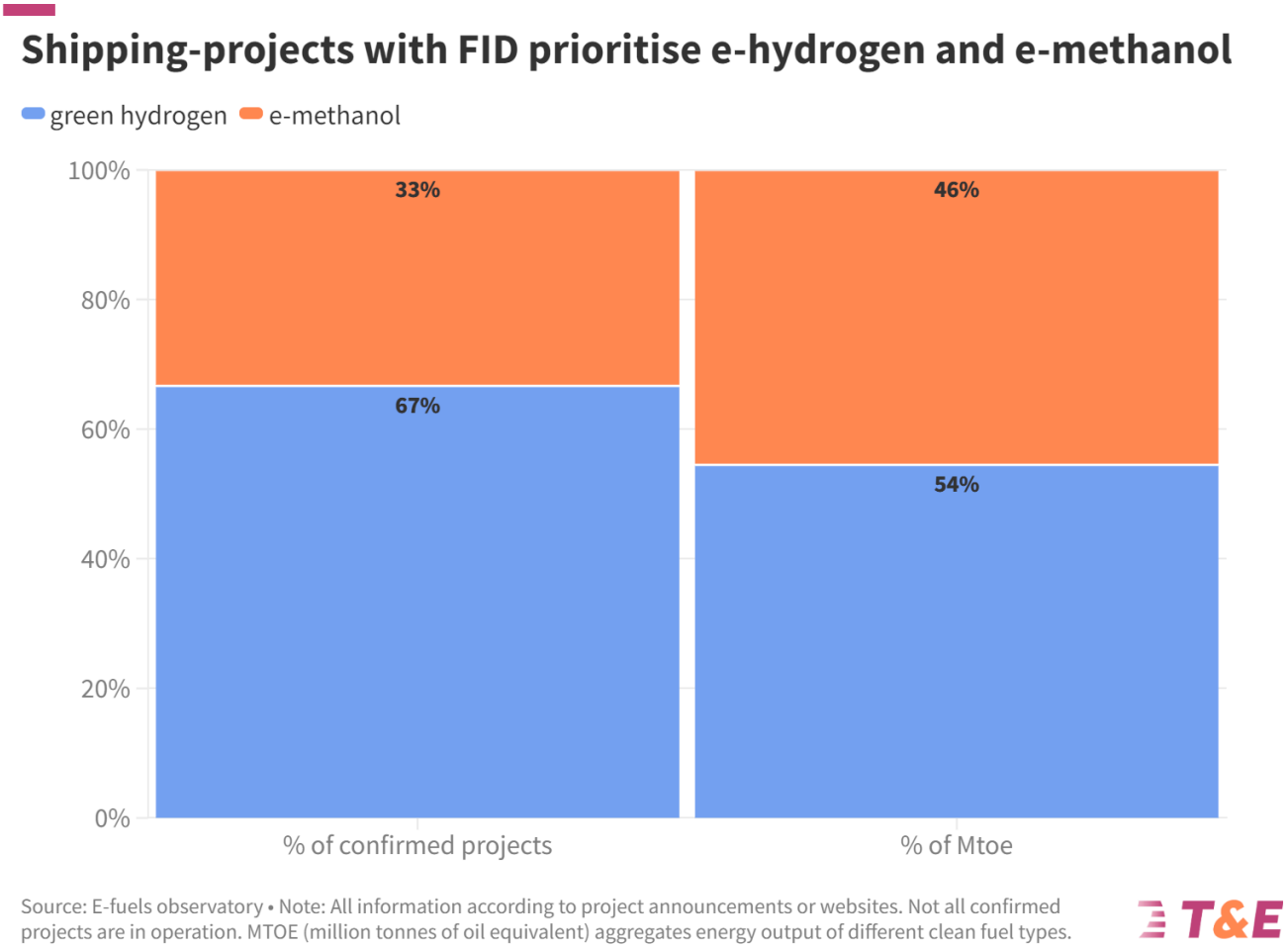


Figure 6: Production capacities by fuel type for confirmed e-fuel projects for shipping

2.4. Operational projects

None of the e-fuel projects targeting exclusively shipping are online yet. Overall, we mapped only 2 operational projects, with a total output of 0.003 Mtoe, each producing a different e-fuel. 1 e-methanol project produces 0.002 Mtoe for the wider transport and industry sectors and the other - 0.001 Mtoe of e-ammonia (including for shipping).

2.5. Uncertainty over the vast majority of projects

The total output of projects with FID and those already in operation is 0.13 Mtoe. This is a big difference from the 7 Mtoe that could be reached if all mapped projects materialised. Figure 7 compares the production capacities of all mapped projects by funding status. The vast majority - 48 out of 61 projects, or 6.87 Mtoe - that could potentially supply shipping, are still at different pre-FID stages, which indicates their commercial uncertainty - likely delays in operationalisation or even total cancellation. It also signals that, with additional incentives, significant e-fuel production for shipping could be achieved in the near future.

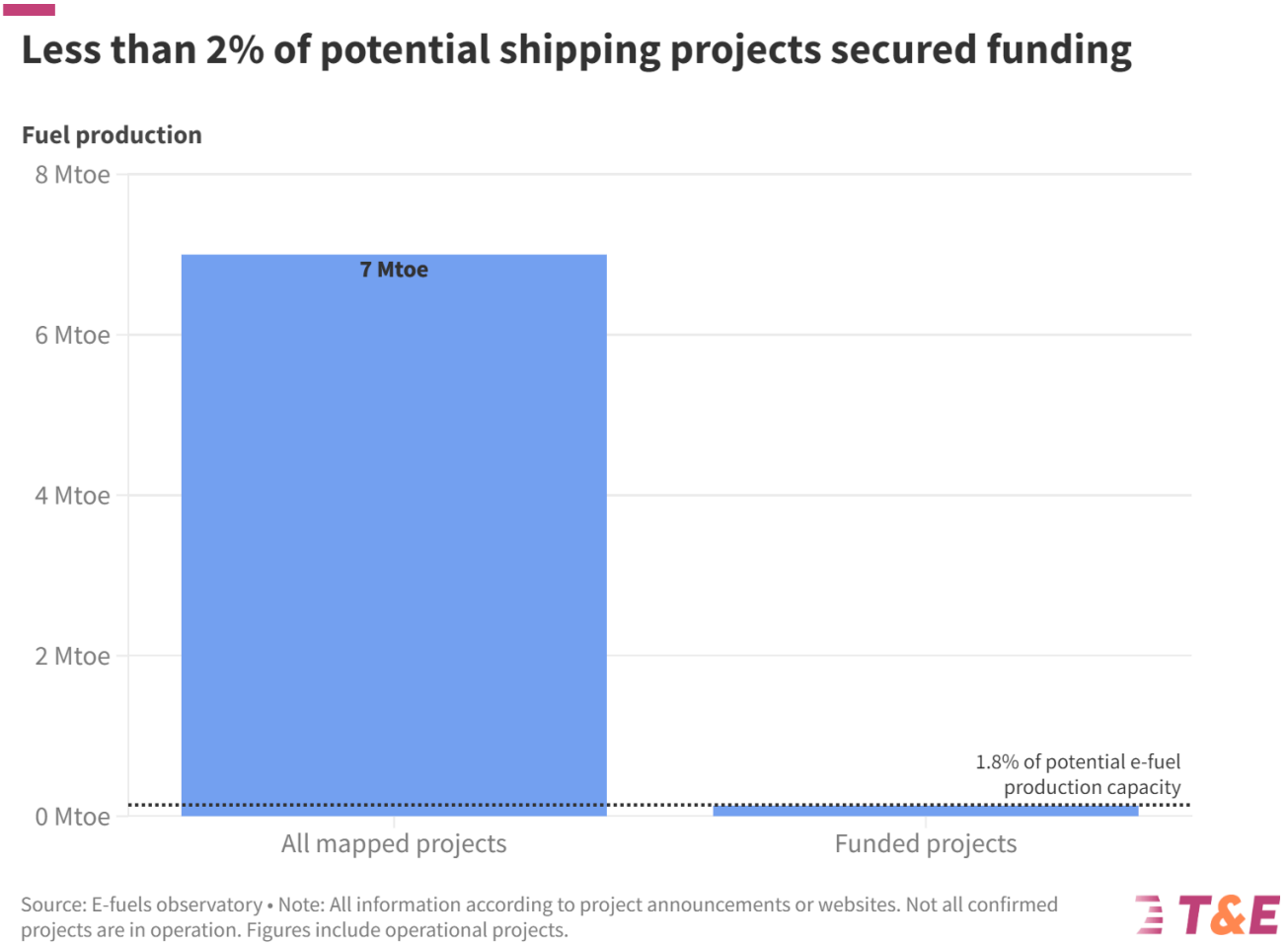


Figure 7: All mapped vs confirmed projects and their fuel production output

3. Results: meeting FuelEU Maritime targets with available e-fuels

3.1. Early demand could be fulfilled with existing projects

In the initial years, meeting the FuelEU Maritime targets may not require large volumes of e-fuels. T&E has previously modelled the e-fuel demand based on the FuelEU Maritime and ETS carbon pricing.[11] Demand is estimated to reach 0.11 Mtoe or 0.4% of all shipping energy by 2030, which is largely due to the expectation that fossil LNG, biofuels and shore-side-electricity uptake will make up the lion's share of alternative fuel demand in this decade.[12] If the e-fuel uptake does not grow to 1% of all shipping energy by 2031 (0.28 Mtoe[13]), it can activate the so-called "sunrise clause", a 2% (0.56 Mtoe[14]) RFNBO mandate from 2034. Figure 8 depicts the potential of shipping-dedicated projects to meet the predicted e-fuels demand in this decade.

[11] Transport & Environment (2023). The impact of FuelEU Maritime on EU shipping. Retrieved from https://www.transportenvironment.org/wp-content/uploads/2023/07/FuelEU-Maritime-Impact-Assessment-July-2023.pdf [9]
[12] Ibid.
[13] Based on predicted 2030 EU shipping fuel demand.
[14] Based on predicted 2035 EU shipping fuel demand.

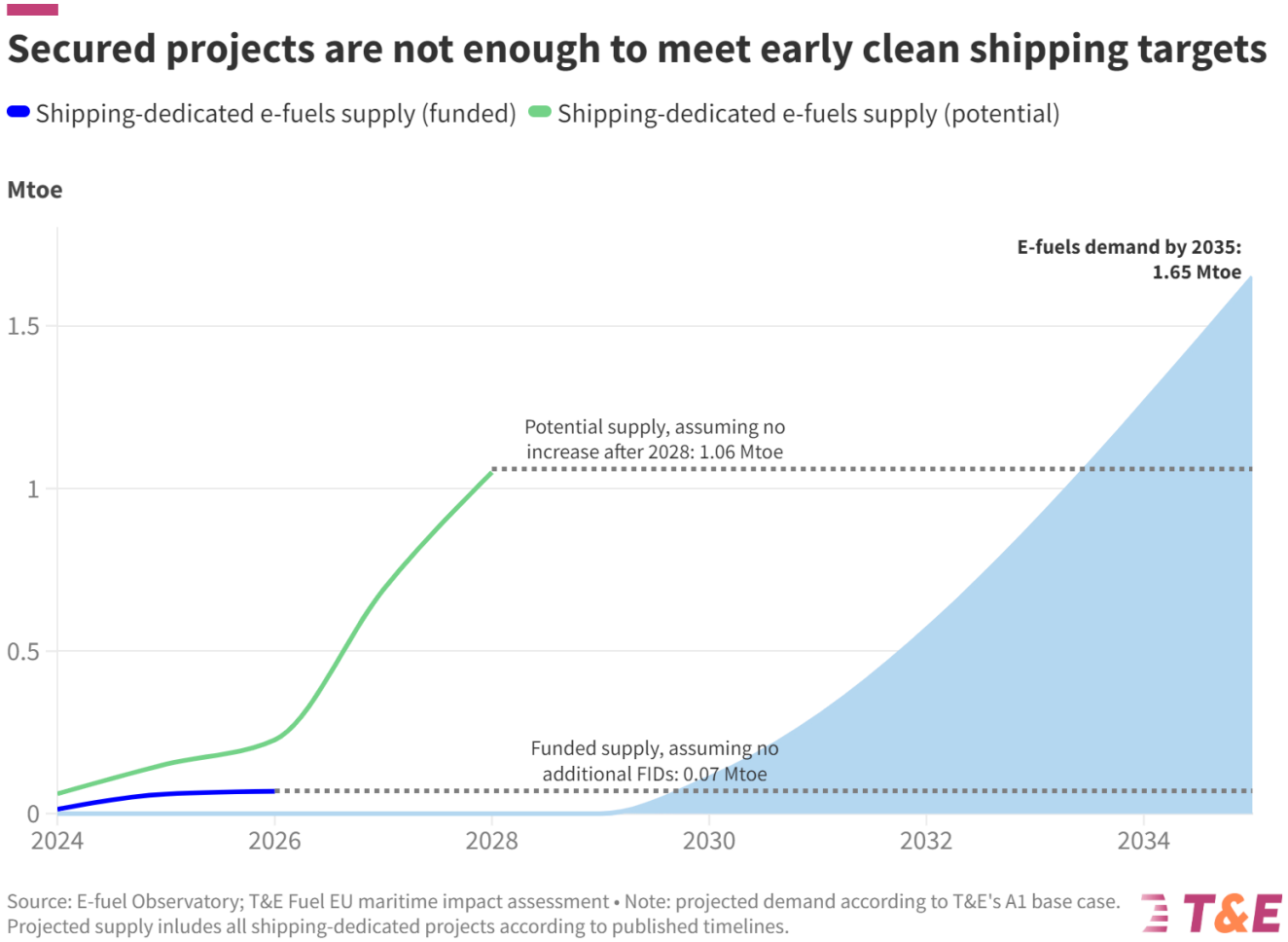


Figure 8: Comparison of potential and funded shipping-dedicated e-fuels production with the projected demand under FuelEU Maritime

It shows that shipping-dedicated projects with FID will not produce sufficient e-fuels to even reach the 1% threshold in 2031, and will fall short of meeting the regulatory targets in the later years, requiring 14.5% GHG reduction already from 2035 - a large share of which may need to be achieved with e-fuels in order to be cost-effective. As the majority of projects remain under discussion, it risks creating uncertainties regarding fuel availability.

It is essential to clarify that, while our mapped potential e-fuels projects are expected to be subsidised in many instances by (inter)national programmes, the portrayed demand for e-fuels is based on T&E analysis on cost-effective demand under projected unsubsidised e-fuels production costs. This means that, if European e-fuels projects receive state or European Union subsidies that would help them cut production costs, demand for e-fuels could increase and reduce or completely bridge the supply and demand gap illustrated in figure 8 and de-risk future investment for the early producers.

Also noteworthy is that post-2030 shipping energy targets are likely to increase significantly. The EU is expected to adopt an interim 2040 climate target, which would imply a 80% absolute

reduction target for shipping emissions. It would require FuelEU Maritime to align its ambition by strengthening regulatory obligations during the review by 2027, including a stronger e-fuels mandate. This would increase the demand for green fuels from shipping, potentially adding to uncertainties regarding their timely availability. [15]

3.2. Green hydrogen, e-methanol are closer to the market, e-ammonia could scale up in the longer run

While green hydrogen has the largest production potential among the surveyed projects, making up 55% or 3.87 Mtoe of all mapped e-fuels output (figure 4), it comprises only 5% of fuels specifically dedicated for the maritime sector, as shown in figure 9, with 0.04 Mtoe having secured funding. In contrast, e-methanol accounts for 17% of shipping-dedicated fuels' volumes, although the amount that received funding is even smaller than that of hydrogen - 0.03 Mtoe. In the long run, however, those fuels may be overtaken by e-ammonia, as it makes up 77% of maritime-dedicated fuel production capacity, though none of these projects have received a final investment decision to date.

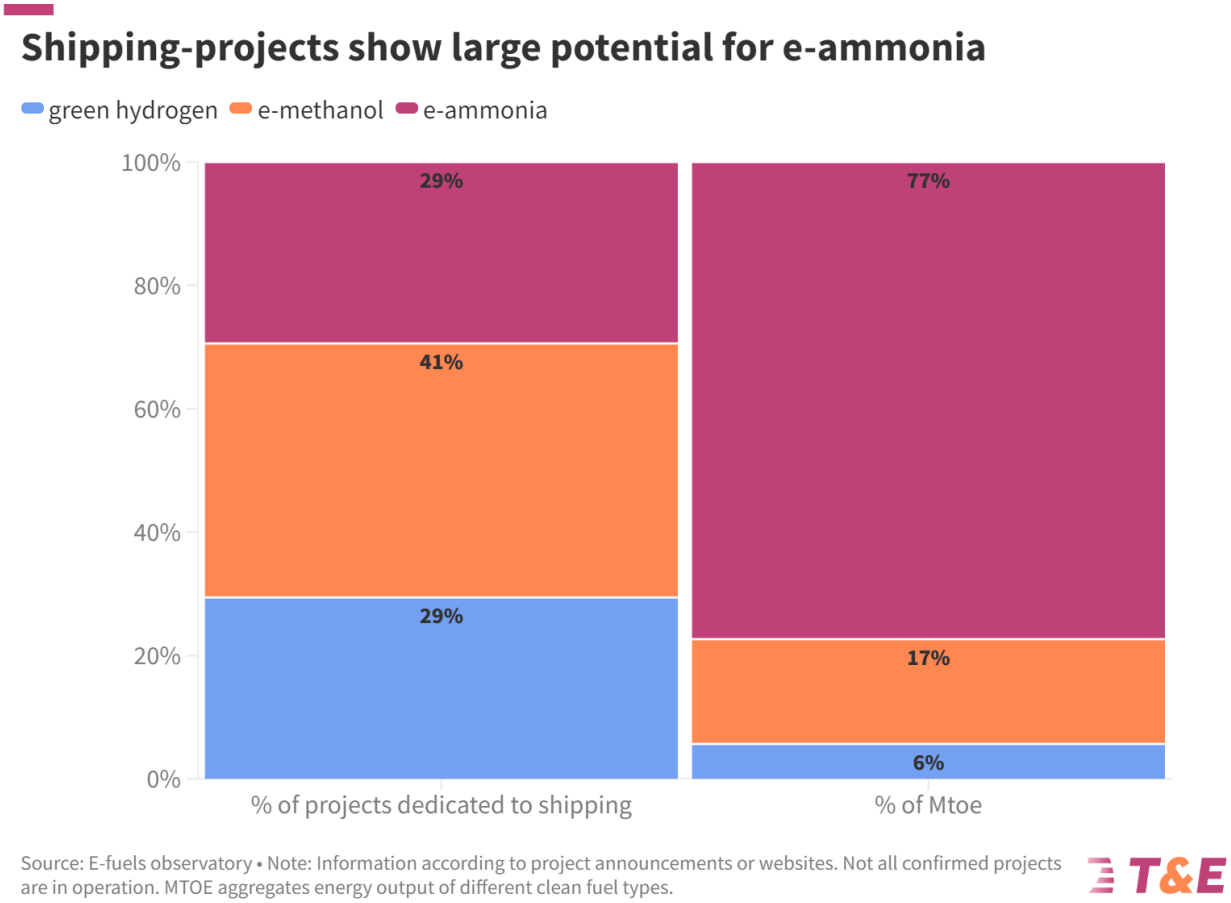


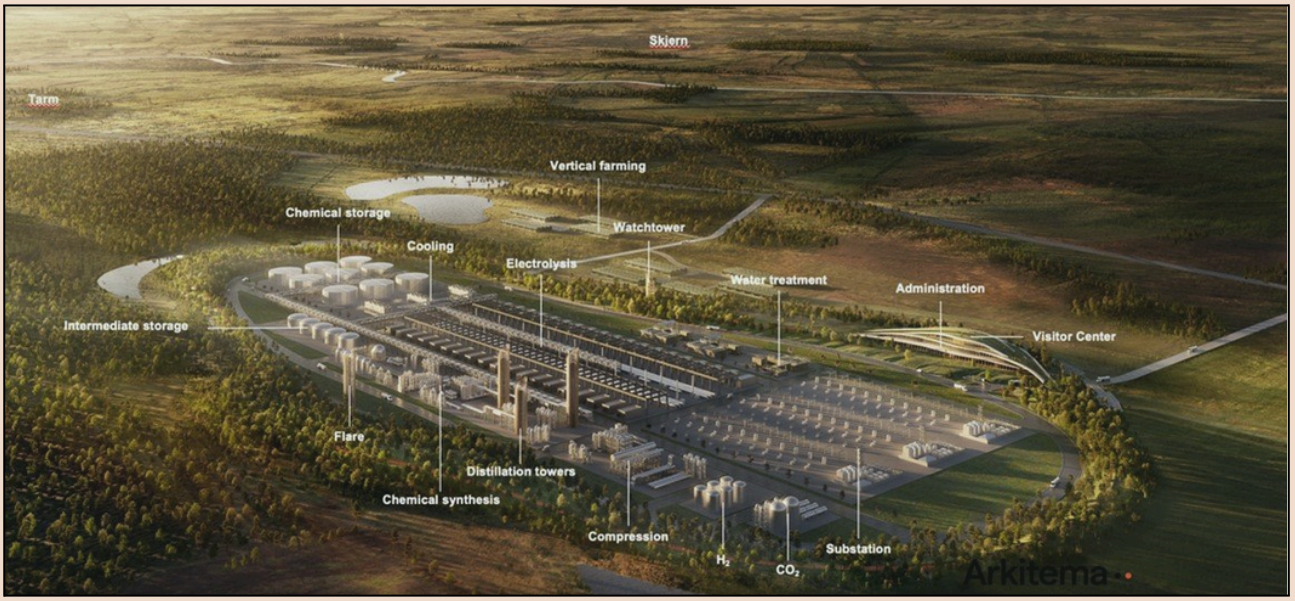
Figure 9: Production capacities by fuel type for surveyed e-fuel projects dedicated to shipping

[15] World Economic Forum (2023) Fuelling the Future of Shipping: Key Barriers to Scaling Zero-Emission Fuel Supply. Retrieved from https://www3.weforum.org/docs/WEF_Fuelling_the_Future_of_Shipping_2023.pdf

4. Noteworthy projects, hubs, and countries

Some governments, regions and one of the largest shipping operators are showcasing how to incentivise, supply, and access commercial shipping e-fuels. They provide valuable insights into best practices and further opportunities for developing and refining local, national, and European legislation.

4.1. Flagships



The biggest green hydrogen project - **Megaton**, led by the renewable energy projects company GreenGo Energy in Denmark, aims to produce 1 million tonnes or 2.87 Mtoe of green hydrogen by 2030 and become one of the largest energy parks in the world.[16] An energy park of 4,000 hectares will use solar and wind energy for electricity generation. The project announcement emphasises the close cooperation between investors, developers, and the local stakeholders from Ringkøbing-Skjern municipality throughout the process. Megaton is yet to reach the FID and lists various industries including transport as their potential end customers. More than 85% of the output is expected to be dedicated to the production of green fuel.

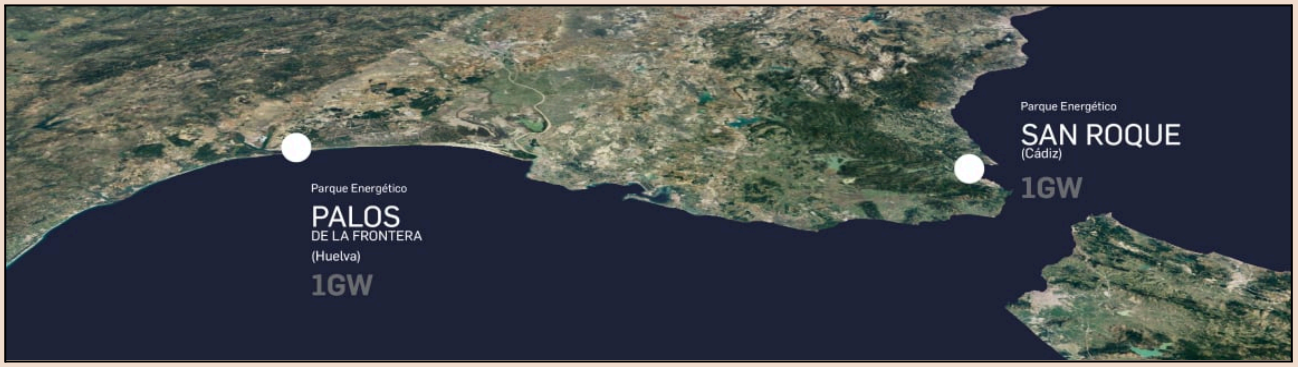
Out of green hydrogen projects that have already received an FID, **HyDeal España** stands out as the largest, with 150,000 tonnes or 0.43 Mtoe of green hydrogen produced by 2031, with multiple sectors, including transport (albeit no specific mention of shipping) as potential customers. Originally planned to produce 330,000 tonnes per year from 2028,

[16] GreenGo (2023). GreenGo Energy develops a 4GW, 8 billion EUR green energy park in Ringkøbing-Skjern municipality. Retrieved from https://www.greengoenergy.com/news/megaton1

Hydeal España illustrates the risk of projects being scaled down and delayed even after receiving FID due to uncertainty in offtake and profitability.[17]

The largest e-ammonia project we mapped, **San Roque Ammonia**, is aimed exclusively at the shipping industry, with 750,000 tonnes or 0.33 Mtoe of e-ammonia produced annually by 2027, if the FID is received. It is developed by the Spanish oil and gas company Cepsa together with Norwegian Yara, one of the world's largest ammonia producers.

4.2. Large regional hubs



In Spain, the aforementioned **San Roque Ammonia** plant forms part of the **Andalusian Green Hydrogen Valley**, launched by Cepsa, in combination with another project, **Palos de la Frontera**, developed by Cepsa, Fertiberia, and Iberdrola, which should become operational in 2025, producing 0.01 Mtoe of e-ammonia per year for shipping (among other transport and industry sectors), if an FID is received.

To position Andalusia (Spain) as a hub of green energy production and a centre for the development of the hydrogen value chain, Cepsa, and Yara have signed an agreement to create a green hydrogen corridor between the ports of Algeciras and Rotterdam, linking southern and northern parts of Europe.[18] Another joint venture between **Cepsa and C2X**, a Maersk-backed green fuel startup, has been recently announced as a new addition to the Andalusian Valley. The project plans to produce 0.14 Mtoe of e-methanol a year in Spain's port of Huelva by 2028 if an FID is secured.

[17] Argus (2023) Giant Spanish green hydrogen project lowers ambitions. Retrieved from https://www.argusmedia.com/en/news-and-insights/latest-market-news/2489195-giant-spanish-green-hydrogen-project-lowers-ambitions

[18] CEPSA. Andalusian green hydrogen valley. Retrieved from https://www.cepsa.com/en/businesses/commercial-clean-energies/green-hydrogen/andalusian-valley

Denmark is another example of an e-fuel hub in the making, especially around the municipality of Esbjerg, which is known as a metropolis of green energy. With a vast potential for wind energy expansion and a strategic location in the North Sea, the port of Esbjerg is looking to host numerous renewable energy and power-to-x production sites and develop the infrastructure necessary for e-fuel distribution and exports.

We have listed three e-fuel projects in Esbjerg - **European Energy Måde** by European Energy, **H2 Energy Esbjerg**, led by H2 Energy Europe, and **HØST,** led by CIP. The first project is looking to supply green hydrogen to ships already in 2024, as it has an FID in place. H2 Energy Esbjerg will also produce green hydrogen, starting in 2027, but is looking at a wider pool of industries, including transport. The project is still under discussion. Finally, HØST will produce e-ammonia for fertiliser and fuels industries at a large scale - 600,000 tonnes per year (0.266 Mtoe) - once operational in 2029, if the FID is reached.

4.3. National leaders

4.3.1. Spain and Denmark - top potential European e-fuel producers

Denmark stands out as an ambitious leader in the European e-fuels market, with 14 projects potentially producing 3.6 Mtoe or 52% of the surveyed volumes. Several large-scale green hydrogen projects take up the lion's share - 3.2 Mtoe - of Denmark's planned output. Spain and Portugal follow as second and third top potential producers, albeit with significantly smaller amounts - the former taking up 9% of all potential production with 8 projects, and the latter 8% of potential production with 4 projects. Denmark also has the most funded e-fuels capacity, 0.04 Mtoe, albeit only 0.01 Mtoe is dedicated solely to shipping.

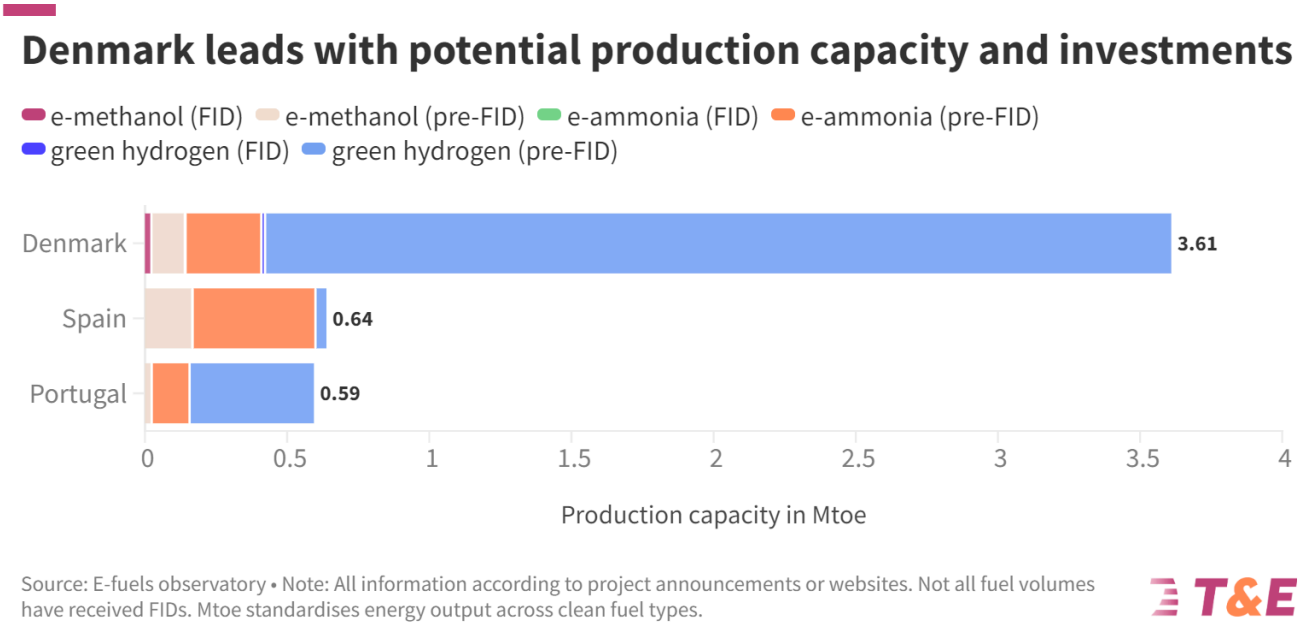


Figure 10: Top 3 countries with the largest e-fuel production plans

Looking at shipping-dedicated projects, the country picture is quite different and the volumes of fuels are significantly lower. Spain leads with a large e-ammonia project and a smaller one producing e-methanol. Finland comes second with an e-ammonia project and Norway follows third, though its three hydrogen projects are the only ones with FID as of today (figure 11). The absence of ammonia engines, bunkering infrastructure and standardised IMO safety rules impedes the faster development of e-ammonia projects, as cited by some stakeholders during our research outreach. This is especially relevant given that shipowners themselves are interested in developing e-fuel projects.

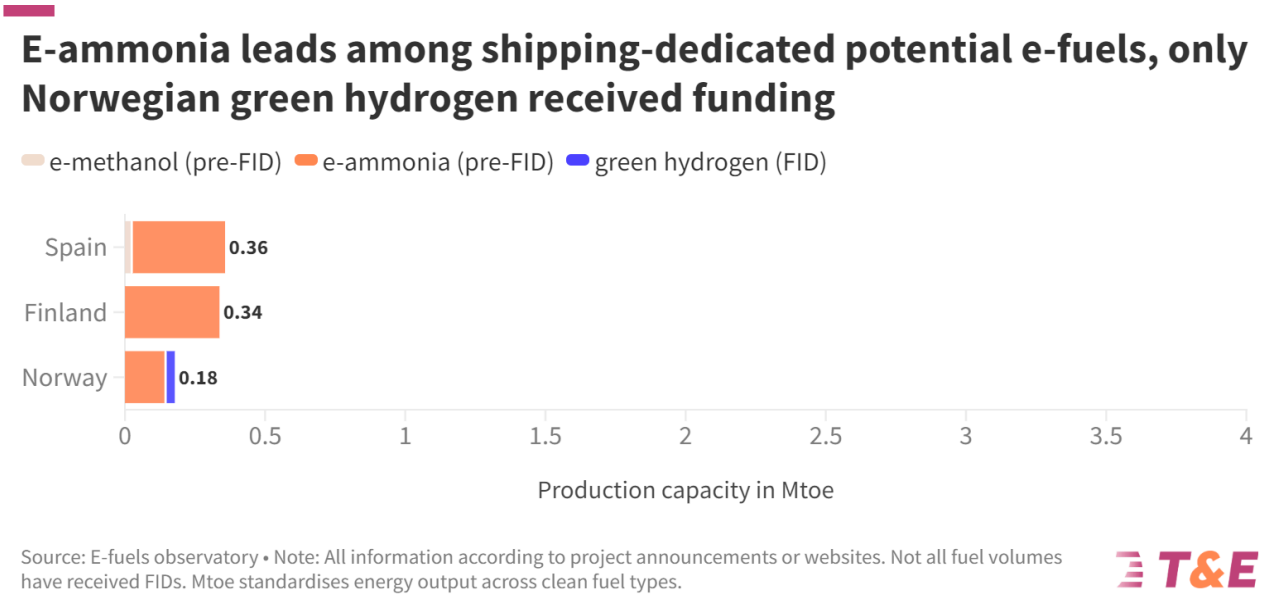


Figure 11: Top 3 countries with the largest shipping-dedicated e-fuel production plans

While there is a lot of uncertainty regarding the e-fuel production scale-up in Europe in this decade, and even less so for shipping e-fuels, the list of top countries reveals that the Iberian peninsula and the North Sea region have the most potential to host e-fuel production sites. They are well suited for renewable energy generation and can become hubs for the production, bunkering, and onward transportation of e-fuels.

4.3.2. E-fuels can meet a sizeable share of national ship refuelling by 2030

Comparing countries' ability to meet their shipping energy needs with e-fuels projects based in their territory gives a diverse picture, as shown in figure 12. For example, Finland could replace almost 90% of its current marine fossil fuel sales with only one large e-fuel project, which, while still in a pre-FID stage, would be entirely dedicated to the shipping industry. Spain, in contrast, could potentially supply 7% of its current marine fuel sales with the planned e-fuels, despite leading the overall potential shipping e-fuels producers list. This is because the current marine fuel market share varies significantly between the member states.[19]

Overall, the figure 12 shows that if the current shipping-related e-fuels projects reach FID and become operational on time, in some European countries they would already deliver far more than the suggested 1.2% RFNBOs supply target for shipping under RED III. This potential could be seized by the member states during the transposition of the RED III into national laws, where they can choose to implement a higher mandate for e-fuels in shipping.

[19] Estimates for shipping fuel needs are based on the EU emissions reports to the UNFCCC for 2021. More detailed methodology can be found in the Annex I.

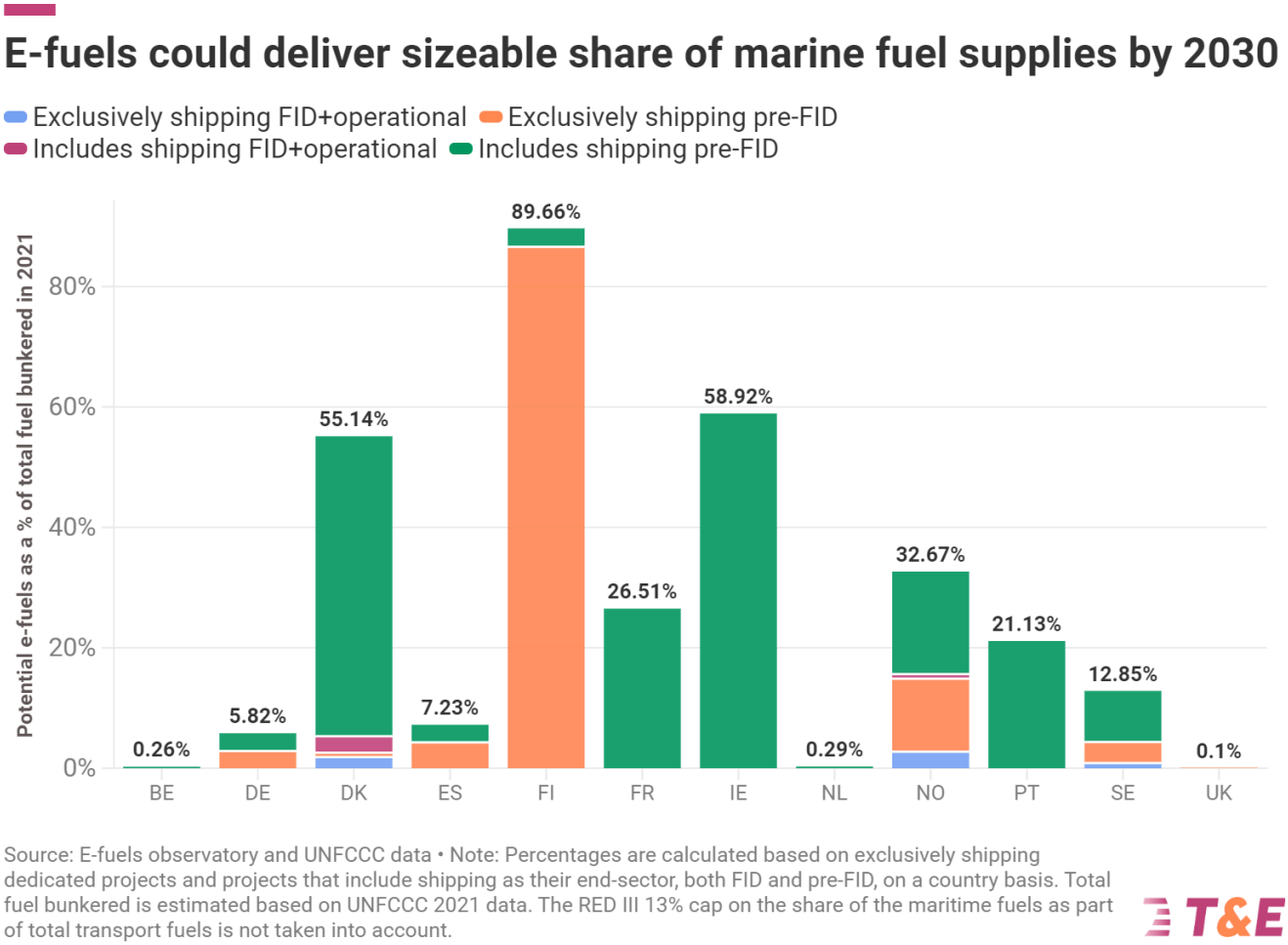


Figure 12: Potential e-fuels volumes by end sector and investment certainty, portrayed as a share of the shipping fuels sales in selected countries

4.4. The power of the first big mover

Denmark's Maersk has made clear their bet on green methanol. Their first large methanol container vessel was launched in 2023 and another 24 are in the order books, to be delivered by 2027. To ensure enough fuel volumes, Maersk has signed several offtake agreements for e-methanol supply, with one of the projects located in Europe. **European Energy Kassø** in Southern Denmark aims to start production of 32,000 tonnes or 0.02 Mtoe of e-methanol in 2024, part of which will supply Maersk's ships.

Originally, the production was planned to start in 2023, but even with investment security, e-fuel projects often get delayed.[20] Overall, however, the projects that receive FID and/or Hydrogen Bank funding are almost guaranteed to materialise (not least due to costly completion bonds).

While some companies will resolve e-fuel supply and demand issues themselves, others will follow the big players and the market. The number of methanol ships is growing: the 2023 global order book shows that 138 new methanol ships were ordered, more than a threefold increase compared to 2022.[21] This example demonstrates the power that the large industry players have over the development of the e-fuels market and the choices of the other shipping companies. Nonetheless, fossil-gas-powered LNG vessels still dominate the order books and will make up a substantially larger share of new additions to the global fleet than methanol well beyond this decade under the current policies.[22]

Besides major shipowners, big fuel producers have a key role to play in scaling up the production of e-fuels. However, searching for the world's oil and gas majors behind the e-fuels projects, we found only one by Exxon Mobil, aiming to produce 0.04 Mtoe of e-ammonia for shipping by 2025 in Slagen, Norway. While the project is of significant scale, it is still in a pre-FID stage. Therefore, while big oil and gas companies are increasingly considering their role in the green transition, their direct involvement in the e-fuels projects surveyed is largely missing.

5. Policy recommendations

The Observatory shows that the currently developed shipping-dedicated e-fuels projects could meet almost 4% of EU shipping's total energy demand (28.2 Mtoe) if operationalised.[23] However, only 0.24% of this potential production capacity has received funding as of today. To provide investment security and chart the path for the decarbonisation of European shipping, T&E proposes the following recommendations to national and EU policy-makers.

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[20] While 2022 Clean Hydrogen Monitor data reported 257 projects with plans to come online in 2024, 2023 version reports only 196 after accounting for revised timelines. Retreived from CLEAN HYDROGEN MONITOR ; Energy Watch (2024). European Energy raises bet on PtX: "People from all over the world are reaching out to us". Retrieved from https://energywatch.com/EnergyNews/Cleantech/article16893480.ece

[21] DNV (2024). Maritime decarbonization efforts propelled as orders for alternative-fueled vessels grow. Retrieved from https://www.dnv.com/news/maritime-decarbonization-efforts-propelled-as-orders-for-alternative-fueled-vessels-grow-251921/

[22] Transport & Environment (2024). State of European Transport: Ships. Retrieved from https://www.google.com/url?q=https://transport2024.transportenvironment.org/sot/topics/ships/index.html&sa=D&source=docs&ust=1714990334612211&usg=AOvVaw1-ti3p-FK288jpAxdRBo_x

[23] As per the scope of the FuelEU Maritime Regulation and ETS Directive.

5.1. RED III: national implementation of an RFNBO for shipping sub-target of at least 1.2%

RED III sets a general target for transport decarbonisation, but the member states have the freedom to decide how the provision of renewable energy is split among the transport subsectors. To help kickstart the production and supply of e-fuels to shipping in time to meet the targets and ensure that the e-fuel projects that have already received FIDs follow through, countries could transpose the RED III's indicative 1.2% marine RFNBO subtarget into mandatory national requirements on fuel suppliers. It would also direct e-fuels to the hard-to-abate shipping sector, preventing their inefficient use on the road, which is already on a fast-track of electrification due to increasingly mature battery technologies. Based on our e-fuels Observatory, many projects are potentially targeting road transport uses, reducing the certainty of supply to shipping, which does not have scalable decarbonisation alternatives.

The observatory also shows that shipping-related e-fuels projects have the potential to deliver far more than the suggested 1.2% target for RFNBOs in some countries. Going for higher ambition for RFNBOs in shipping has two added benefits: A higher than 1.2% e-fuels target for ships would not only help achieve the RED III minimum 1% RFNBO target for the whole transport sector under RED III; member states could also use a higher RFNBO subtarget for shipping to meet the 5.5% advanced fuels target, which includes both Annex IX Part A biofuels and RFNBOs. In doing so, member states can alleviate the pressure on the limited waste and residue feedstocks listed under Annex IX Part A, which are needed to produce these advanced biofuels. Previously, T&E had called for a 2% RFNBO in transport target, thereby keeping the Annex IX Part A subtarget limited to 3.5% (same level as in 2018 RED II).[24]

5.2. Dedicated financial incentives to kick-start the production of e-fuels

The cost of CO_2 allowances under the ETS will not make e-fuels competitive against their fossil alternatives. The Commission intends to earmark roughly €1.7bn for shipping via the Innovation Fund (IF), adding to the Hydrogen Bank, which will award fixed premium subsidies for green hydrogen production bids. After a successful first Hydrogen Bank auction, with some maritime off-takers, the Commission has announced provisional terms for the second auction, to be launched by the end of 2024. This round is expected to include a dedicated basket for projects with off-takers in the maritime sector (concrete budget is still to be confirmed),[25] allowing e-fuels to be better channelled to the shipping industry. Additionally, contracts for difference for shipping decarbonisation projects through the IF could address the cost gap for the pioneering

[24] Transport & Environment (2023) What the EU's new Renewable Energy Directive means for clean fuels in Europe. Retrieved from https://www.transportenvironment.org/articles/what-the-eus-new-renewable-energy-directive-mean-for-clean-fuels-in-europe

[25] European Commission, DG CLIMA. Retrieved from https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/competitive-bidding_en#ref-2024-auction-for-renewable-hydrogen-production--draft-terms-and-conditions-tcs

projects and account for the ETS' volatile carbon price. The majority of ETS revenues, however, will go back to the member states. They should invest part of these revenues into the decarbonisation of the sector, for example, by investing in e-fuels projects via the *auction-as-a-service* programme under the Hydrogen Bank. These targeted financing measures will be crucial for bringing down the supply-side costs of e-fuels, providing additional investment security to develop new e-fuels projects. Such new projects will be needed to meet the growing demand for affordable clean e-fuels and boost their production beyond the 1.2% ambition of RED III in line with decarbonisation targets beyond 2030.

5.3. FuelEU Maritime alignment with the 2040 climate target

According to FuelEU Maritime, shipping will have to reduce its GHG emissions by 31% by 2040. However, to get in line with the EU's 2040 climate goal, shipping should deliver at least 80% emissions reduction. FuelEU Maritime GHG reduction targets should therefore be increased accordingly during the review by the end of 2027. As part of this, stronger and progressively growing e-fuels sub-targets should be introduced in the FuelEU Maritime, thereby raising the demand for e-fuels from 2030 and signalling the need for their steeper production increases in the following decades. Such a regulatory "kick" would provide more certainty for the sector, help unlock investments and offtake guarantees by shipping companies and allow more projects to materialise.

5.4. Binding e-fuels supply targets in the FuelEU Maritime or RED III

E-fuel suppliers are incentivised by the RED III to target shipping, as energy content supplied to this sector counts 1.5 times the national obligation. The adoption of the aforementioned 1.2% RFNBO subtarget by 2030 could also help channel these fuels to the shipping sector. However, to provide shipping decarbonisation with the long-term perspective, ensure that shipping does its fair share for the climate and that e-fuels supply meets the demand in the long term, an EU-wide marine e-fuels supply obligation could be introduced in the future revision of FuelEU Maritime or the RED, mirroring the demand side target (recommendation 5.3.). It would also help achieve a level playing field between EU ports and provide supply and sustainability certainty for the shipping operators, as well as producers.

Further information

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Annex 1: Methodology

The information was collected and confirmed via desk research with references to e-fuels databases such as DNV Alternative Fuels Infrastructure tool, 2023 data from the Methanol Institute, International Energy Agency's Hydrogen map and online research. Investigations of national and EU energy strategies, as well as projects by known fuel producers were performed. To confirm project information and fill in the missing data, project operators were contacted via surveys and bilateral calls where possible.

Selection process

Several criteria were applied to e-fuel projects that fall under the scope of our analysis:

- Projects need to be identifiable through public sources, such as press releases, project websites, or company reports.
- Projects need to consider shipping as an end user. We included projects that made either of these references: 1) name the shipping sector or even a specific shipping company as a consumer, 2) indicate shipping as (one of the) the target sector(s), 3) aim to provide to the general transport sector, which shipping is a subset of. Projects dedicated to specific transport modes other than shipping or to industrial/agricultural consumers were not considered and not included in the observatory, even if the e-fuels produced could be used by shipping in the future.
- Projects need to be designed for commercial production.
- Projects' feedstock needs to be derived from dedicated wind, solar, geothermal, or renewable grid electricity (we have also included 3 projects planning to use nuclear power, recognising that the fuels they produce may not qualify as RFNBOs).
- "Green hydrogen-ready" and non-zero emission projects are not considered.

Fuels in focus

For the e-fuels observatory, fuels with the biggest potential to provide a long-term decarbonisation solution for shipping have been selected, taking into consideration their production readiness, investment up-to-date, and future price estimates.[26]

- Green hydrogen in its pure form may play a limited role as shipping fuel, but it will serve as a base for the production of e-ammonia and e-methanol.
- E-ammonia is seen as one of the most promising and the least costly e-fuels over time, due to the absence of carbon atoms. Provided that safety and potential nitrous oxide emission issues are overcome, it has the potential to become one of the preferred choices for shipping companies.

[26] Based on Transport & Environment (2023). The impact of FuelEU Maritime on European shipping. Retrieved from https://www.transportenvironment.org/discover/the-impact-of-fueleu-maritime/

- E-methanol production has already received significant investment from major shipping players. Among orders for new-build ships capable of sailing on e-fuels, e-methanol ships are the most prominent.
- Biofuels will have a limited role in decarbonizing the shipping industry as they are not scalable and supply is already outpaced by demand from other sectors.[27] However, in the early years, blending advanced biofuels from waste biomass with fossil fuels will be a likely compliance strategy for shipping companies. The mapped projects include bio-methanol, bio-diesel, and bio-e-methanol production sites. As these biofuels are not sustainably scalable to meet shipping demand[28], they are not included in the aggregate demand & supply figures and the associated analysis.
- E-LNG and e-diesel are not covered by the observatory. We envisage potential e-kerosene by-products, e-diesel, and e-LNG projects to be included in future iterations.

National fuel bunkering calculations

Estimates for shipping fuel needs are based on the EU emissions reports to the UNFCCC for 2021. UNFCCC data on maritime emissions are based on the fuel sales data from each country. To convert CO_2 emissions into fuel sales, 80% of emissions were associated with Very Low Sulphur Fuel Oil (VLSFO), which has a CO_2 to fuel ratio of 3.151 by mass, and 20% with MGO Marine Gasoil (MGO), with a ratio of 3.206. We have then converted estimated fuel volumes in kt to Mtoe.

Limitations

The observatory features 61 e-fuels and 10 biofuels projects that could supply the shipping industry. While the list is considered representative of trends in e-fuel production, it is not comprehensive or exhaustive and is a work in progress.

To maintain a common information standard, the observatory relies on publicly available information and refers to interviews only to clarify uncertain details. It only includes projects where information on key parameters was identifiable: fuel type, production volume, potential end-use sector(s), electricity feedstock, estimated timeline of FID, or the start of the operations. Projects were not included in the observatory where these elements were impossible to establish through public information or contacts with the project operators.

The timelines of projects are of central relevance when assessing the volumes of e-fuels available for shipping in this decade. This information may change, as project plans and timelines are often delayed or altered. The observatory displays the status of projects as of their addition to the database.

[27] Transport & Environment (2023): Biofuels and e-fuels in trucks will make it harder for aviation and shipping to go green. Retrieved from https://www.transportenvironment.org/discover/biofuels-and-e-fuels-in-trucks-will-make-it-harder-for-aviation-and-shipping-to-go-green/

[28] Transport & Environment (2023). Biofuels: From unsustainable crops to dubious waste? Retrieved from https://www.transportenvironment.org/discover/biofuels-from-unsustainable-crops-to-dubious-waste/

Many projects state multiple transport modes as potential target customers. As neither end-use sectors, nor the proportions of e-fuel that would go to shipping are clear, we have assumed two scenarios, where either full production capacity would go to shipping or would be entirely supplied to other sectors. Partial production for shipping was not considered.

Annex 2: List of projects

Project Name	Project leader	Country	Status	Date	End Use	Fuel	Volumes (Mtoe)
Green Fuels for Denmark	Ørsted	Denmark	Under discussion	2025	Includes shipping	Green hydrogen	0.00860
BTL2030	VTT	Austria	Under discussion	2027	Potentially includes shipping	Biofuel	0.12596
North-C-Methanol	North CCU Hub	Belgium	Under discussion	2024	Includes shipping	E-methanol	0.02091
-	ReIntegrate, Advent	Denmark	Decided - FID	2024	Exclusively shipping	E-methanol	0.00760
-	European Energy and Port of Hanstholm	Denmark	Under discussion	2025	Includes shipping	E-methanol	0.01521
Vordinborg Biofuel	Vordingborg Havn	Denmark	Under discussion	2025	Includes shipping	Biofuel	0.14259
European Energy Kassø	European Energy	Denmark	Decided - FID	2024	Includes shipping	E-methanol	0.01521
Aalborg Port/ European Energy	Aalborg port/ European Energy	Denmark	Under discussion	2027	Includes shipping	E-methanol	0.03565
Metanol-projekt ved Nordjyllandsværket	Aalborg Forsyning, Reno-Nord, CIP	Denmark	Under discussion	2028	Potentially includes shipping	E-methanol	0.06179
Fertiberia/Iberdrola - Puertollano	Fertiberia, Iberdrola	Spain	In operation	2021	Includes shipping	E-ammonia	0.00133
-	Cepsa and C2X	Spain	Under discussion	2028	Includes shipping	E-methanol	0.14259
Project Sauda Iverson Efuels	Trafigura, CIP, Hy2gen	Norway	Under discussion	2027	Includes shipping	E-ammonia	0.09243
Project Catalina - Phase I	CIP, Enagás, Naturgy, Fertiberia, Vestas	Spain	Under discussion	2028	Includes shipping	E-ammonia	0.14331
HySynergy	Everfuel	Denmark	Decided - FID	2024	Potentially includes shipping	Green hydrogen	0.00860

European Energy Måde	European Energy	Denmark	Decided - FID	2024	Exclusively shipping	Green hydrogen	0.00459
H2 Energy Esbjerg	H2 Energy Europe	Denmark	Under discussion	2027	Potentially includes shipping	Green hydrogen	0.28660
HØST	CIP	Denmark	Under discussion	2029	Includes shipping	E-ammonia	0.26655
H2Driven	Dourogás	Portugal	Under discussion	2026	Includes shipping	E-methanol	0.02377
Eco Bunkers	PRIO	Portugal	Operational	2006	Includes shipping	Biofuel	0.10040
MadoquaPower2X	Madoqua Renewables, Power2X e Copenhagen Infrastructure Partners	Portugal	Under discussion	2028	Includes shipping	E-ammonia	0.11995
Green H2 Atlantic	EDP, Galp, ENGIE, Bondalti, Martifer, Vestas Wind Systems A/S., McPhy and Efacec	Portugal	Under discussion	2025	Potentially includes shipping	Green hydrogen	0.02866
Green hydrogen Mobility Project	Fusion Fuel	Portugal	Under discussion	-	Potentially includes shipping	Green hydrogen	0.40814
Conseil1	Hy2Gen	Germany	Under discussion	2024	Potentially includes shipping	Green hydrogen	0.00089
Nautilus	Hy2Gen	Germany	Under discussion	2027	Exclusively shipping	E-methanol	0.02852
"Airpark Laage" (hydrogen)	Apex Energy Teterow GmbH and East Energy Verwaltungs GmbH	Germany	Under discussion	2027	Potentially includes shipping	Green hydrogen	0.00086
H4Chem-EI	BASF	Germany	Decided - FID	-	Potentially includes shipping	Green hydrogen	0.02293
Zella-Mehlis	ZASt	Germany	Under discussion	2024	Potentially includes shipping	E-methanol	0.00333
The George Olah Renewable Methanol plant	CRI	Iceland	Operational	2012	Potentially includes shipping	E-methanol	0.00190

Advanced Methanol Rotterdam (AMR)	Gidara	Netherlands	Decided - FID	2025	Potentially includes shipping	Biofuel	0.04278
Advanced Methanol Amsterdam (AMA)	Gidara	Netherlands	Under discussion	2025	Potentially includes shipping	Biofuel	0.04159
Cromarty hydrogen Project	Storegda	United Kingdom	Under discussion	2026	Potentially includes shipping	Green hydrogen	0.00012
Finnfjord e-methanol plant	Carbon Recycling international (CRI), Stratkraft ,Finnfjord	Norway	Under discussion	2025	Potentially includes shipping	E-methanol	0.00190
FlagshipONE	Ørsted	Sweden	Decided - FID	2025	Exclusively shipping	E-methanol	0.02377
Södra biomethanol plant	Andritz, Södra	Sweden	Operational	2019	Potentially includes shipping	Biofuel	0.00238
Glocal Green Innlandet AS	Glocal Green Innlandet	Norway	Under discussion	2025	Includes shipping	Biofuel	0.03565
Hellesylt hydrogen Hub	Flakk Gruppen, Hexagon Composites, Hyon, TAFJORD, Fiskerstrand, Gexcon, SINTEF	Norway	Decided - FID	2024	Exclusively shipping	Green hydrogen	0.00136
FlagshipTWO	Sundsvall Energi	Sweden	Under discussion	2024	Exclusively shipping	E-methanol	0.00190
The Dava facility	Umeå Energi	Sweden	Under discussion	2026	Exclusively shipping	E-methanol	0.00190
Synthetic methanol production plant	St1	Finland	Under discussion	2026	Includes shipping	E-methanol	0.01188
-	European Energy	Denmark	Under discussion	-	Exclusively shipping	E-methanol	0.00475
Port of Aabenraa	Linde Gas A/S, Port of Aabenraa	Denmark	Under discussion	2025	Potentially includes shipping	Green hydrogen	0.02150
Orkney Green hydrogen/ammonia plant	Eneus Energy, Hammars Hill Energy	United Kingdom	Under discussion	-	Exclusively shipping	E-ammonia	0.00433

Project Slagen terminal	ExxonMobil	Norway	Under discussion	2025	Exclusively shipping	E-ammonia	0.04443
HyTech Hafen Rostock	RWE	Germany	Under discussion	2026	Exclusively shipping	Green hydrogen	0.03332
Hegra (Heroya Green Ammonia)	Yara Clean Ammonia	Norway	Decided - FID	-	Includes shipping	E-ammonia	0.17770
Hamina Fintoil biorefinery	Fintoil	Finland	Operational	2022	Potentially includes shipping	Biofuel	0.000078
Kokkola Renewable Ammonia	Hy2gen, Plug Power	Finland	Under discussion	2028	Exclusively shipping	E-ammonia	0.33763
San Roque Ammonia	Cepsa, Yara	Spain	Under discussion	2027	Exclusively shipping	E-ammonia	0.33319
EI-H2 - Aghada	Zenith Energy, EI-H2	Ireland	Under discussion	2028	Includes shipping	E-ammonia	0.16660
Arendal	North Ammonia	Norway	Under discussion	2027	Includes shipping	E-ammonia	0.04443
Flexens Kokkola	Flexens, KIP Infra	Finland	Under discussion	2027	Potentially includes shipping	E-ammonia	0.08885
Palos de la Frontera I	Fertiberia, Iberdrola, Cepsa	Spain	Under discussion	2025	Includes shipping	E-ammonia	0.01022
Project Green Wolverine	Grupo Fertiberia	Sweden	Under discussion	2026	Includes shipping	E-ammonia	0.23101
Haddock	Ørsted, Yara	Netherlands	Under discussion	2025	Includes shipping	E-ammonia	0.03332
HyFuelUp	CoLAB BIOREF	Portugal	Operational	2022	Includes shipping	Biofuel	0.00048
Project HyDeal España	ArcelorMittal, Enagás, Grupo Fertiberia and DH2 Energy	Spain	Decided - FID	2031	Potentially includes shipping	Green hydrogen	0.42992
Berlevåg Green ammonia value chain project	Varanger Kraft, Aker Clean hydrogen	Norway	Under discussion	2026	Includes shipping	E-ammonia	0.04443

eM-Rhone	Elyse Energy	France	Under discussion	2028	Includes shipping	E-methanol	0.07130
-	Veolia and Metsä Fibre	Norway	Under discussion	2024	Potentially includes shipping	Biofuel	0.01433
Green Ammonia plant	St1 Nordik OY	Norway	Under discussion	2029	Potentially includes shipping	E-ammonia	0.03554
Project Haldor	Haldor Topsoe, Aquamarine	Germany	Under discussion	2026	Includes shipping	E-ammonia	0.04865
REDDAP v. Ramme	Skovgaard Energy, Topsoe	Denmark	Decided - FID	2024	Includes shipping	E-ammonia	0.00076
BENORTH2 (ABoroa power plant)	Northega	Spain	Under discussion	2024	Potentially includes shipping	Green hydrogen	0.03439
Herrenhausen sewage works	Aspens	Germany	Under discussion	2024	Potentially includes shipping	Green hydrogen	0.00373
Vitale	pHYnix	Spain	Under discussion	2024	Potentially includes shipping	Green hydrogen	0.00416
hydrogen Hub Agder	Glencore Nikkelverk AS +++	Norway	Decided - FID	2025	Exclusively shipping	Green hydrogen	0.02293
Bodø hydrogen	GreenH	Norway	Decided - FID	2026	Exclusively shipping	Green hydrogen	0.0086
Holmaneset	Fortescue	Norway	Under discussion	2027	Exclusively shipping	E-ammonia	0.1004
eM-Lacq	Elyse Energy	France	Under discussion	2028	Includes shipping	E-methanol	0.09506
eM-Numancia	Elyse Energy	Spain	Under discussion	2028	Exclusively shipping	E-methanol	0.02377
Hynovi	Vicat	France	Under discussion	2027	Includes shipping	E-methanol	0.09506
Megaton	GreenGo Energy	Denmark	Under discussion	2030	Potentially includes shipping	Green hydrogen	2.86615