How does FuelEU Maritime work?

T&E explainer of the new EU shipping fuel Regulation

July 2023

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List of Abbreviations:

AFIR = Alternative Infrastructure Regulation
EC = European Commission
EEA = European Economic Area
ETS = Emissions Trading System (Regulation)
EU = European Union
FUEM = FuelEU Maritime (Regulation)
GHG = Greenhouse gas (emissions)
IMO = International Maritime Organisation
ISM = International Safety Management (code)
RED = Renewable energy Directive
RFNBO = Renewable fuel(s) of non-biological origin
TtW = Tank to wake (emissions)
VLSFO = Very low sulphur fossil oil
WtW = Well to wake (emissions)

1. What is FuelEU Maritime?

FuelEU Maritime is the first ever Regulation to drive the demand for renewable and low carbon maritime fuels by requiring a progressive reduction of the greenhouse gas (GHG) intensity of fuels used by ships and mandating a minimum uptake of specific renewable fuels. Together with the Emissions Trading System (ETS), Renewable Energy Directive (RED) and Alternative Infrastructure Regulation (AFIR), FuelEU Maritime is one of the four shipping legislation included in the EU's Fit for 55 package.

While the ETS will finally charge ships for their GHG emissions, this Regulation alone will not be enough to drive the uptake of sustainable fuels, hence the need for a separate Regulation.

In particular, FuelEU maritime aims to:

1) Progressively reduce the greenhouse gases (GHG) intensity of the energy used by ships from 2025 onwards;
2) Ensure that ships connect to shore-side electricity or use alternative zero emission technology when at berth in European ports;
3) Ensure that ships use at least 2% renewable fuels of non-biological origin (RFNBOs), also known as green e-fuels, from 2034, if a minimum of 1% uptake of RFNBOs has not been achieved by 2031 by market forces.

2. Which ships and voyages are covered by FuelEU Maritime?

FuelEU maritime will apply to 100% of energy used on voyages between European Economic Area (EEA)[1] ports and 50% of energy used on voyages between EEA and non-EEA ports. (Figure 1). A voyage is defined as any movement of a ship that takes place between two ports transporting passengers or goods for commercial purposes.[2] This definition of a voyage applies to all shipping routes except if ships call at specific neighbouring non-EU transhipment ports.

For example, normally a container ship sailing from Singapore to Algeciras/Spain via Moroccan Tanger-Med port would have to consider this travel as two separate voyages: i.e. Singapore - Tanger-Med and Tanger-Med - Algeciras, with FUEM applying only to the latter voyage. However, under the FEUM rules, unless Morocco implements comparable national shipping requirements, it is expected that any stop at Tanger-Med will not be considered as a "port call". This means that FEUM will apply to 50% of the entire end-to-end Singapore - Algeciras journey. The list of these neighbouring ports will be drawn up by the EU Commission every two years. Only the ports that are located within 300 nautical miles from the nearest EEA port and having at least 65% container

[1] For the purpose of this Regulation, EEA includes the EU27, Norway (excluding Svalbard) and Iceland.
[2] Hence any stop for the sole purpose of refuelling, repairing or other non-cargo/passenger commercial operations will NOT be considered as a "port call".

transhipment activity will be included in that list. The goal of this provision is to prevent regulatory evasion from FEUM requirements.

FuelEU Maritime will apply to ships of 5,000 gross tonnage (GT) and above, that perform commercial voyages transporting goods or passengers. This means that no fishing vessels, private yachts, service vessels (e.g. tugs, dredgers) or military vessels will have to comply.

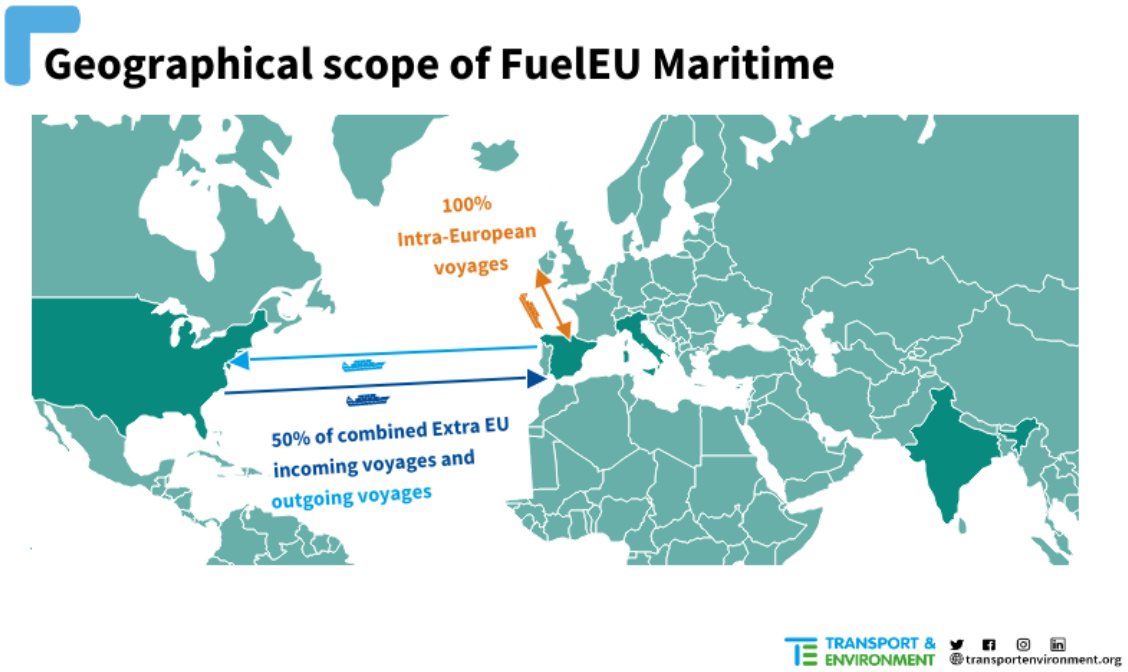


Figure 1: FuelEU Maritime's geographical scope

2.1 Are there any exemptions?

Several exemptions will apply until 2029. Member states are allowed to exclude passenger ferries travelling from a country in the EEA mainland to an island of that same country with less than 200 000 inhabitants. Specific routes to outermost regions may also be exempted. Member states may also exempt passenger ferries under public service obligation performing transnational voyages between member states that have no land borders. Passenger ships operating under public service obligation between the mainland and islands (including Ceuta and Melilla) may also be exempted until 2025.

For any ship having ice-class IC, IB, IA or IA Super or an equivalent ice class, the company may request, until 31 December 2034, to exclude the additional energy consumption.

2.2 How will the review work?

The Review of FuelEU will take place by December 31, 2027 and every 5 years after then. The Commission is specifically required to consider proposing, among others, reducing the gross tonnage threshold for regulated vessels, expanding the geographical scope of the Regulation beyond the 50% of international voyages, setting higher overall GHG intensity targets, considering to include dedicated mechanisms to promote the most sustainable and innovative fuel technologies, covering black carbon emissions, counting wind energy directly into the overall GHG intensity requirements, as well as new mechanisms to prevent regulatory evasion if any.

3. Who is responsible for complying with FuelEU Maritime?

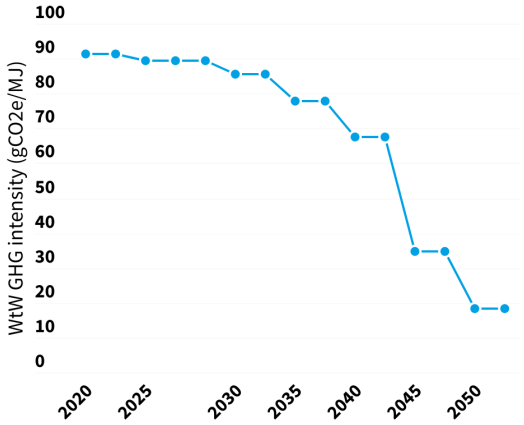
Shipping companies will be responsible for complying with FuelEU Maritime. A shipping company is defined as a shipowner or any other organisation or person that is responsible for the vessel under the international safety management (ISM) code. If a responsible company is not the entity taking the day to day decisions that affect a ship's emissions, that company can claim reimbursement for the costs incurred from the commercial operators, if specified by a contract clause for chartering the vessel. The same (i.e. costs incurred by non-compliance penalties) can be applied to fuel suppliers if they do not deliver the correct amount of fuel specified by the fuel supply contract.

4. How does FuelEU Maritime work?

Ships will have to comply with the following energy GHG intensity reduction targets: 2% from 2025, 6% from 2030, 14.5% from 2035 (up from 13% in the original European Commission proposal), 31% from 2040 (up from 26%), 62% from 2045 (up from 59%), 80% from 2050 (up from 75%).
The baseline for the calculation of the annual GHG targets is set at 91.16gCO2e/MJ (2020 GHG intensity of EU MRV fleet) (figure 2). The methodology for calculating the GHG intensity of energy used onboard by a ship is defined at Annex I; the default values of Well-to-Wake GHG intensity are given for each type of fuel at annex II, which in practice determine the eligibility timeline of various individual fuels (unless blended or co-combusted with alternative fuels) (figure 3).

Energy efficiency technologies or operational strategies (such as speed reduction) do not count towards the reduction of targets, only a fuel switch does. The use of wind-assist technologies, which can be considered as energy efficiency technology, however, can contribute to *softening* the energy GHG intensity reduction requirements through modest reward factors determined by FEUM.

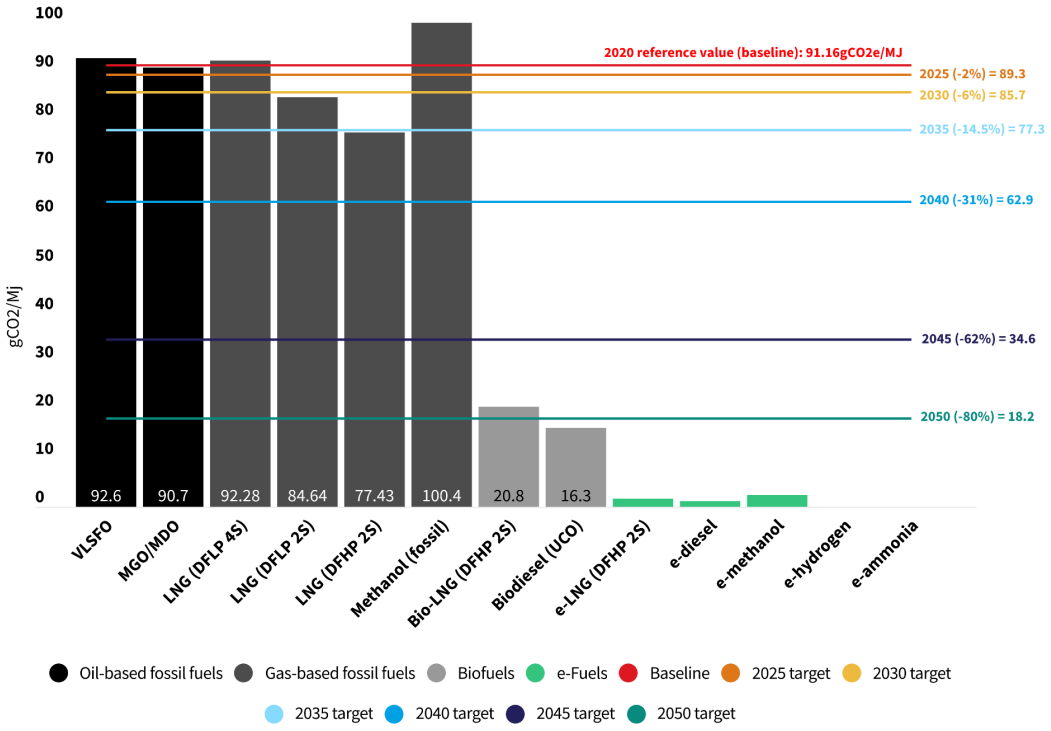
Regulatory targets set by FuelEU Maritime



FEUM	Reduction targets	GHG thresholds (gCO2e/MJ)
2020 baseline		91.16
2025-2029	-2%	89.34
2030-2034	-6%	85.69
2035-2039	-14.5%	77.94
2040-2044	-31%	62.90
2045-2049	-62%	34.64
2050+	80%	18.23

Figure 2: FuelEU Maritime regulatory pathway

Eligibility timeline for marine fuels under FuelEU Maritime Regulation



Note: T&E calculations based on the Annex to proposed FEUM Regulation and 2020 fuel mix in EU shipping (source: European Commission). Values include emissions from the share of diesel necessary as pilot fuel (e.g. 1% and 8% of fuel consumption by Otto and Diesel-cycle LNG engines; ammonia engine values tbd). It is assumed that Bio-LNG powered vessels use VLSFO as pilot fuel. E-fuels values are calculated according to the EU RFNBO delegated act's methodology, assuming production from additional renewable electricity.

Figure 3: Eligibility timeline for marine fuels under the FuelEU Maritime Regulation

4.1 How does the zero-emission berth mandate work?

FEUM requires passenger ships (i.e. ferries and cruise ships) and containerships to use shore side electricity (SSE) or alternative equivalent zero-emission energy sources at berth from 2030 onwards. This is the first ever EU mandate requiring ships to connect to SSE at berth.

However, the mandate is limited to electrical power demand (i.e., excluding heat or steam energy needs) and applies only to ships moored at the quayside (i.e. at berth), meaning that it does not apply to anchorage. Additionally, the mandate applies only to berths in ports that are part of the core and comprehensive ports networks. Another EU regulation, AFIR, mandates core and comprehensive ports to install enough SSE stations to meet the relevant electricity needs of container and passenger ships calling at those ports.

From 2030 to 2035, member states may decide to mandate ships to connect to shore side electricity in ports not covered by AFIR. From 2035, if shore side electricity is available in ports not covered by AFIR, ships will be required to use it.

In practical terms, ships will need to inform competent authorities about their intentions to connect to shore side electricity (SSE) or use alternative compliance mechanisms (i.e. use zero-emission tech) prior to entry in the port, and competent authorities will confirm the availability of SSE. Exemptions for not complying due to a lack of infrastructure are limited to maximum 10% of a ship's annual number of port calls.

Unlike the overall GHG intensity targets of the FEUM, alternative compliance mechanisms for berth will be accounted for only on a tank-to-wake basis. This means that if ships choose not to connect to SSE, the alternative technologies they use will need not to emit any GHG or air pollutants (i.e. SO_X, NO_X, PM) into the atmosphere. As a result, renewable fuels containing carbon atoms will not be compliant even if they could theoretically deliver zero-emission on a well-to-wake basis (e.g. e-methanol or biofuels).

5. How can shipping companies comply with the overall GHG intensity targets?

From 1 January 2025, shipping companies will be required to monitor and record information on their ships' voyages, notably the amount of each type of fuel consumed at berth and at sea, and the respective emission factors of these fuels. By 31 August 2024, companies will have to submit to accredited verifiers a monitoring plan for each of their ships; and by 31 January 2026, and every year thereafter, companies will need to submit a FuelEU report, including Bunker Delivery Notes (BDN) to provide the GHG intensity and sustainability characteristics of the fuels used.

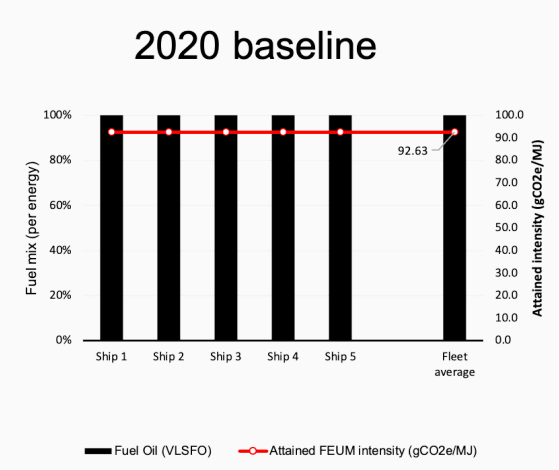
The verifier (e.g. a classification company) is then responsible for calculating the greenhouse gas intensity of the energy used on-board by ships, and to verify the compliance with the Regulation. In addition, public authorities may conduct additional checks, including on-board the vessels. To

facilitate the monitoring of compliance, the Commission will develop an electronic FuelEU database, where compliance information for each ship will be recorded. There is no legal guarantee that the FuelEU database will be merged with the existing EU MRV system. However, the Commission may present a legislative proposal to align both systems, also with the shipping ETS, within 1 year after publication of the FuelEU Maritime Regulation.

5.1. How do the pooling and banking/borrowing systems work?

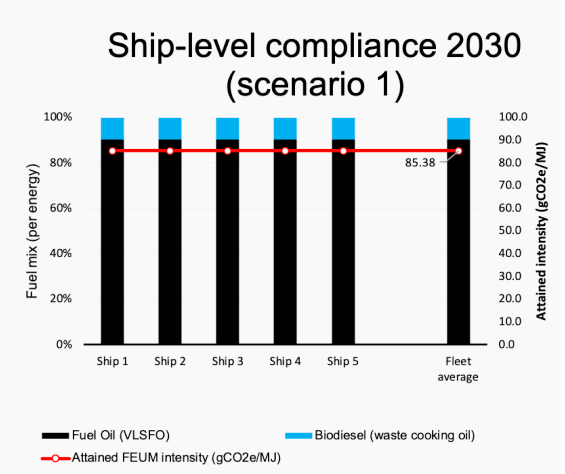
In general, FEUM requires that each ship demonstrates compliance with the GHG intensity targets. However, companies can also demonstrate compliance at a fleet level, and even among different companies, instead of individual vessel level. This is known as the ***pooling mechanism***. The goal of the pooling mechanism is to provide shipping companies with an incentive to deploy new vessels (running on (near) zero emission fuels), instead of improving the performance of existing old vessels by blending drop-in biofuels with fossil fuels.

For example, imagine a company owning/operating 5 vessels all of which currently run on very low sulphur fossil oil (VLSFO) at equal amounts. In 2020, that company would have a fleetwide 92.63 gCO_2e/MJ baseline GHG intensity if we follow the calculations methodology of the FEUM (see "2020 baseline" chart in figure 4).



In 2030, that company will need to reach 85.69 gCO_2e/MJ, i.e. 91.16 $gCO_2e/MJ_{\text{baseline}}$ * (1-6% $_{\text{2030 target}}$). By default, the company needs to demonstrate this improvement for each and every vessel it owns/operates.

To do so, the company could blend about 9.5% biodiesel (made from waste cooking oil that has about 16.30 gCO_2e/MJ) into the VLSFO in those vessels. This would make each ship's attained intensity 85.38 (gCO_2e/MJ) - enough to meet the 2030 regulatory requirement for each vessel (see "scenario 1" chart in figure 4).



However, such a strategy would not incentivise innovation in shipping propulsion technologies and leaves the industry at the mercy of unscalable biofuels because existing ships can only use fuels that have similar properties to VLSFO or MGO (i.e.

biodiesel or e-diesel). This is what happened with road transport in Europe under RED leading to significant sustainability issues.

This is the point where a ***pooling mechanism*** becomes so essential. Using this flexibility, the shipping company can decide to replace one of its old VLSFO vessels with a new dual-fuel ammonia-powered vessel and use the latter at 39%-61% e-ammonia-VLSFO co-combustion mix (assuming that the ammonia dual fuel engines will provide this broad range of fuel ratio) and

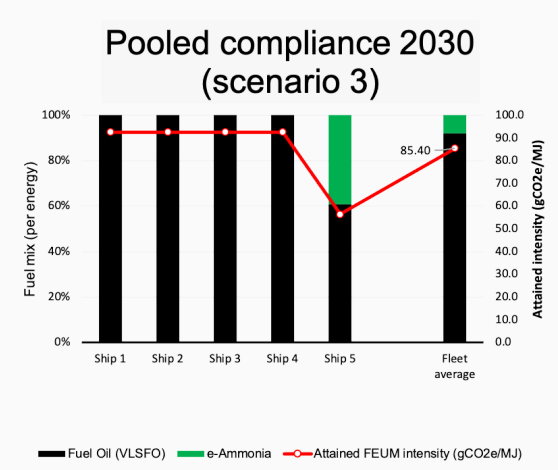


Figure 4: possible compliance strategies with FEUM

maintain the current VLSFO operational profile of the remaining four ships. If pooled together with the old four VLSFO powered vessels, this new single ammonia-powered vessel will allow the company to meet the required 85.69 gCO2e/MJ target at the fleet level (i.e. fleet average) in 2030 (see "scenario 3" chart in figure 4). In 2035 when a new threshold (i.e. 77.94 gCO2e/MJ) comes into effect, the company can simply increase the share of e-ammonia (from 39% to 80% of the energy consumption) used in the same dual-fuel ammonia vessel to meet this new target. As the targets get more stringent in the following years, the company in question will simply replace another old VLSFO ship with a new dual-fuel ammonia vessel to ensure compliance at the fleet. In other words, the pooling mechanism enables the companies to comply with FEUM by taking advantage of fleet replacement.

Pooling can also be used across different companies, helping to optimise the cost of investing in alternative fuelled vessels. For example, should a company choose to invest in an ammonia-capable ship and fully power it with e-ammonia in 2030, it would generate a lot more compliance units than necessary for its own fleet. This compliance surplus may then be sold (under commercial contracts) to other companies via the pooling system (figure 5).

FEUM also provides additional flexibility, called a banking and borrowing system.This system allows companies to bank (store) over-compliance for future use or borrow compliance units from the future years to be used in the current year. For example, if a ship has a GHG intensity lower (better) than what is required by the GHG target, FEUM allows it to convert this overcompliance into surplus "credits" and bank them for use in the following years. This strategy might be interesting during a year when the price of sustainable alternative fuels becomes unusually cheap (or there is a forecast of sharp increase in alternative fuel prices in the following years). Consequently, the shipping company can decide to hedge its bets, use more sustainable alternative fuels in year 1, generate surplus credits and use those credits in year 2 (or 3 or 4) without actually using alternative fuels in those years. The impact on total emissions will remain identical with or without banking.

This system can be used in the opposite direction too. For example, alternative fuels prices can become very high in year 1 but a considerable price reduction is forecast for year 2 (or the vessel/company may simply not be able to procure alternative fuels due to supply shortage in year 1). In this case, FEUM allows the company to borrow compliance units from future years, i.e. legally commit to use even more alternative fuels in year 2 enough to make up for the deficit in year 1, including a penalty of 10%.

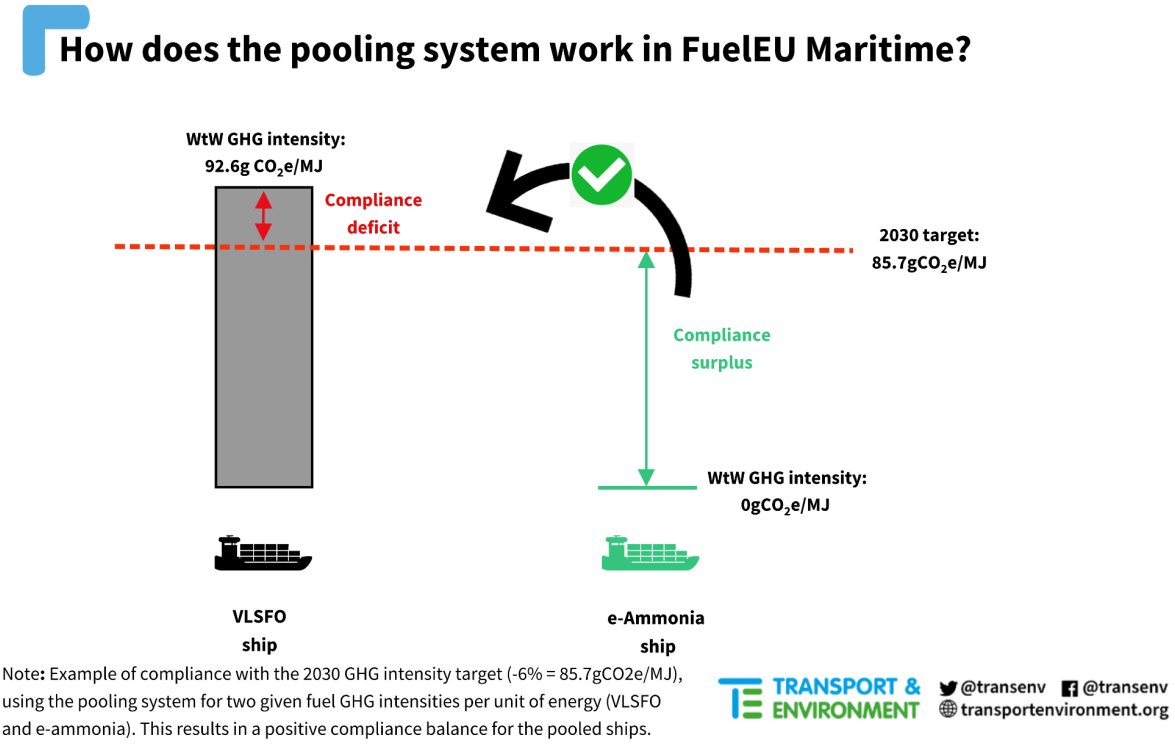


Figure 5: How does the pooling system work in FuelEU Maritime?

5.2 Can companies use any type of fuel to comply with the GHG targets?

In principle, any fuel that has a well-to-wake (WtW) GHG intensity not exceeding the targets set by article 4 (figure 2) is eligible. This means that, for example, liquified natural gas (LNG) could be used to comply with the GHG targets until 2039, despite being a fossil fuel (when used in an engine with low-methane slip).

However, there are additional requirements for other alternative fuels. Food and feed crop-based biofuels are by default given the same GHG intensity values as fossil fuels (expressed as the "least favourable fossil fuel pathway for that type of fuel"), meaning that shipping companies cannot claim GHG savings from these fuels even though in practice that can still burn relatively expensive food-based biofuels in their engines, which would be economically irrational. This "ban" on food

and feed-based biofuels is excellent news for the environment and food security, considering their high land-use change effects.[3]

In addition, RFNBOs that do not meet the Renewable Energy Directive criteria of at least 70% GHG savings compared to the fossil fuel equivalent and any other fuel that is not certified under EU legislation are considered as having WtW GHG intensity as fossil fuels. E.g. every gram of e-methanol that doesn't deliver 70% emissions reduction[4] on its own will be counted as having the same WtW GHG intensity as fossil methanol (which is worse than VLSFO).

A similar requirement is applicable to non-feed/food-based biofuels albeit with a slightly inferior reduction threshold.

Other fuels, such low-carbon hydrogen (nuclear or blue hydrogen) or derived synthetic fuels could become eligible to meet the FEUM GHG targets, provided that they have been certified to meet the 70% emissions reduction threshold under a future Directive establishing common requirements for renewable, natural gas and hydrogen fuels for the internal markets (a.k.a. EU Gas Directive).

5.3 How will companies demonstrate the attained GHG targets?

To perform the well-to-tank (WtT) and tank-to-wake (TtW) GHG intensity of the reported fuel use, ships will need to use the equations in Annex 1 of the FEUM regulation and relevant default emissions factors for each fuel. Specifically:

1. For fossil fuels, default values for WtT CO_2e emissions factors and TtW CO_2 emissions factors. Deviations from these factors are not allowed for fossil fuels.

2. Deviation from TtW non-CO2 emissions factors (e.g. for CH_4 or N_2O) is permitted provided that the new values are certified through laboratory testing or derived from direct emissions monitoring systems. If laboratory testing is used, certifiers will need to follow relevant test cycle standards. T&E understands that the EU is not planning to develop its own test cycles and will rely on standard(s) developed by the International Maritime Organisation (IMO). There is currently a discussion whether or not IMO's nitrogen oxide (NOx) test cycle could be used for the purpose of laboratory certifying methane slips (CH_4) and nitrous oxide (N_2O) emissions from ship engines.

   However, there is a mounting concern that IMO's NO_x test cycle might not be suitable for this purpose because the standard does not reflect the real-world operational profile of vessels. The IMO standard assumes that ships spend most of their time on higher loads

[3] See 2023 IFEU study and T&E briefing on the carbon and food opportunity costs of biofuels in Europe
[4] Vis-à-vis the 94gCO2e/MJ baseline value determined by the EU Renewable Energy Directive. This is known as the GHG reduction criteria of RFNBOs.

(around 75% MCR), while in reality ships sail largely at lower loads. And given that CH_4/N_2O emissions appear to be higher at lower engine loads, the IMO's NOx test cycle seems to be an inappropriate standard for laboratory certification of CH_4 and N_2O factors.

3. The WtT CO_2e emissions factors for biofuels, RFNBOs and low-carbon gases should either follow the default values provided by the FEUM or use actual values certified according to the relevant EU legislation (RED and EU Gas Directive).

5.4 Does FuelEU Maritime reward the use of wind-assist technologies?

The design of the FuelEU Maritime targets does not consider energy efficiency improvements; only a fuel switch can lower the GHG intensity of the energy used onboard by a ship. However, a reward factor is applied to ships that make use of wind-assisted propulsion, practically reducing the amount of alternative fuels that ships would otherwise have to use to meet the regulatory targets. This system is designed to increase the economic attractiveness of wind-assist technologies.

5.5 How does the FuelEU Maritime reward the use of battery-electric technologies?

FEUM considers electricity as zero-emission by default, regardless of the electricity source. This gives in practice a bonus on the use of direct electricity by ships, both to power a ship at berth or for charging the batteries for propulsion. Ships using electricity as main propulsion, typically ferries, could generate significant compliance surplus and sell it to other companies via the pooling system.

5.6 How to ensure green fuels are available for shipping companies?

While FUEM applies to shipping companies, fuel suppliers are not exempt from obligations. The EU Renewable Energy Directive sets a target on Member States to ensure the supply of biofuels or RFNBOs reaches 5.5% in the EU overall transport demand by 2030; and that sufficient volumes of RFNBOs shall be supplied to meet at least 1% (or 0.5% without double-counting) of the EU transport demand by 2030.

When it comes to shipping, a multiplier of 1.2 will apply when fuel suppliers deliver advanced biofuels. A multiplier of 1.5 will apply when RFNBOs are supplied to ships (and planes). In practice, this means that each MJ of RFNBOs supplied to a ship will count 1.5 times towards the RED target, which should incentivise the supply of RFNBOs to the maritime sector as opposed to road transport. The RED also includes a non-binding target that asks Member States with seaports to ensure that at least 1.2% RFNBOs are supplied to ships in their ports.

Additionally, under the EU Alternative Fuels Infrastructure Regulation (AFIR)[5], member states are required to develop and submit to the EU Commission national policy frameworks by 1 January 2025. These frameworks will have to include an overview of the state of play, perspectives, and planned initiatives for the deployment of infrastructure for other alternative fuels/energy, such as hydrogen, ammonia, methanol and electricity. This should provide further clarity on the geographical availability of green fuels.

6. How does FuelEU Maritime promote the use of RFNBOs?

The EU Commission had initially designed FEUM as a fuel-neutral (sometimes called technology-neutral) legislation putting all sustainable and non-sustainable fuels on equal footing. A fully technology-neutral approach would have left little chance for green hydrogen-based fuels (RFNBOs/e-fuels) to kick-in before the late 2030s, mainly due to their high costs compared to other low-carbon fossil alternatives (e.g. fossil LNG) and biofuels. For this reason, co-legislators (the European Parliament and Council of the European Union) decided to add dedicated mechanisms to support the uptake of RFNBOs. The decision was to mandate a 2% subtarget of RFNBO use from 2034 onwards and an incentive to use RFNBOs with a multiplier of 2 until 2034. Multiplier of 2 means that every tonne of RFNBO will count twice to the achievement of the overall GHG intensity targets. Both instruments take advantage of the pooling system, which allows companies to exchange units of compliance between themselves.

The mandate shall apply if the share of RFNBOs in the total European shipping's energy use is below 1% in 2031.

However, there are some exceptions. If the Commission's monitoring of RFNBO uptake shows evidence of insufficient production capacity and availability of RFNBOs to the maritime sector, uneven geographical distribution or too high prices of RFNBOs, the RFNBO subtarget will not apply.

The Commission will monitor the use of RFNBOs in EU shipping demand and publish the share annually, at the latest 18 months after the end of the reporting period (i.e. by mid-2027 for the first compliance year in 2025). This will provide a clear picture of the uptake of RFNBOs in shipping in the coming years, and inform future reviews of the legislation.

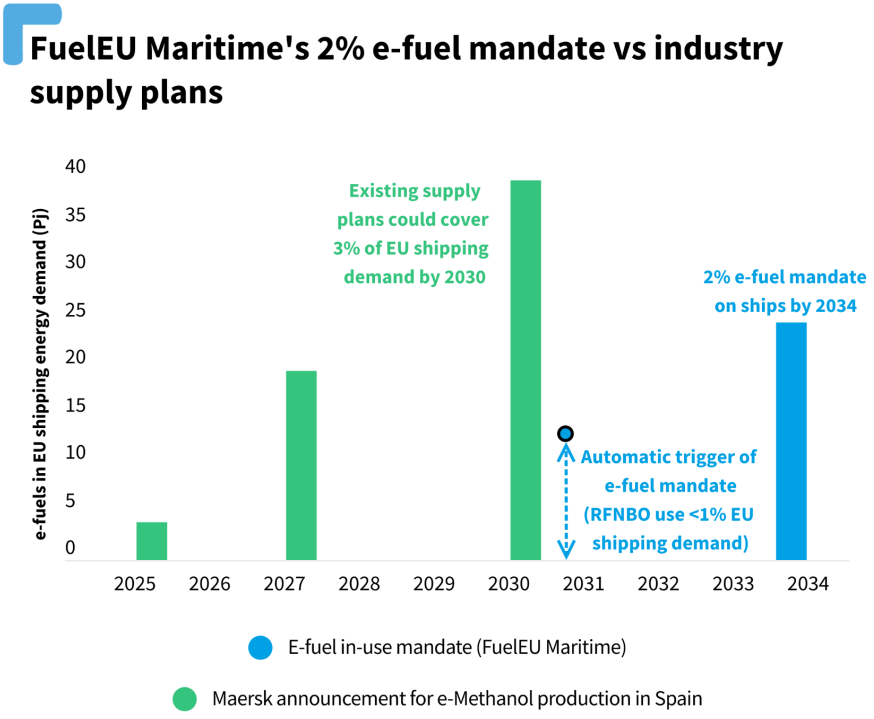
6.1 Are there any exemptions?

Battery-electric ships do not have to use RFNBOs; a ship using electricity for auxiliary power needs or for hybrid battery-electric propulsion will be required to use a smaller volume of RFNBO to meet the RFNBO subtarget.

[5] See T&E explainer of the revised Alternative Fuels Infrastructure Regulation for shipping (2023)

Ships may not use RFNBOs if they use at least 2% of advanced biofuels instead, or low-carbon hydrogen (-based) fuels (e.g. from nuclear) delivering equivalent emissions reductions. However, problematic feedstocks such as used cooking oil or animal fats cannot be used as a substitute for RFNBOs.

The RFNBO mandate gives a strong signal for early investments in green hydrogen-based fuels, in a sector that still almost entirely relies on fossil fuels. Despite the target being small, it means that the use of RFNBOs in shipping might kick-start in this decade. The below graph puts supply and demand into perspective. With Maersk's recent announcement[6] to produce 2 million tons of e-methanol in Spain, up to 3% of European shipping demand for RFNBOs in shipping could already be covered by 2030 by this investment alone. A list of other investments in green hydrogen and e-fuels is available here[7].



Note: Analysis assumes no regulatory-driven energy efficiency gains by the sector until 2050 and full shore-side electricity use by all vessels at berth.
Source: *Decarbonising European Shipping Technological, operational, and legislative roadmap, T&E, 2021.* Calculations for Maersk announcement assumes 200k, 1M and 2M tonnes e-methanol production by 2025, 2027 and 2030 respectively (https://www.lavanguardia.com/economia/20221103/8592023/maersk-inversion-emetanol-hidrogeno-verde-galicia-andalucia-empleo.html).

Figure 6: FuelEU Maritime's 2% mandate vs industry's supply plans

[6] See Reuters article: Maersk agrees on project with Spain to make e-methanol for its fleet

[7] See part III of T&E 2023 briefing "Why an e-fuel mandate for ships?"

6.2 What is a multiplier and how does it work?

Starting from the entry into force of the Regulation in 2025, until the end of 2033 (in line with the potential entry into force of the RFNBO subtarget), a multiplier of 2 will apply to the use of RFNBOs when complying with the GHG targets. This means that the volume of RFNBOs required to comply with the GHG reduction target is roughly halved compared to other fuels of an equivalent GHG intensity, thereby bringing down the high initial costs of using e-fuels. Operators can also 'sell' their excess compliance balance if they use RFNBOs to over-comply with the GHG targets.

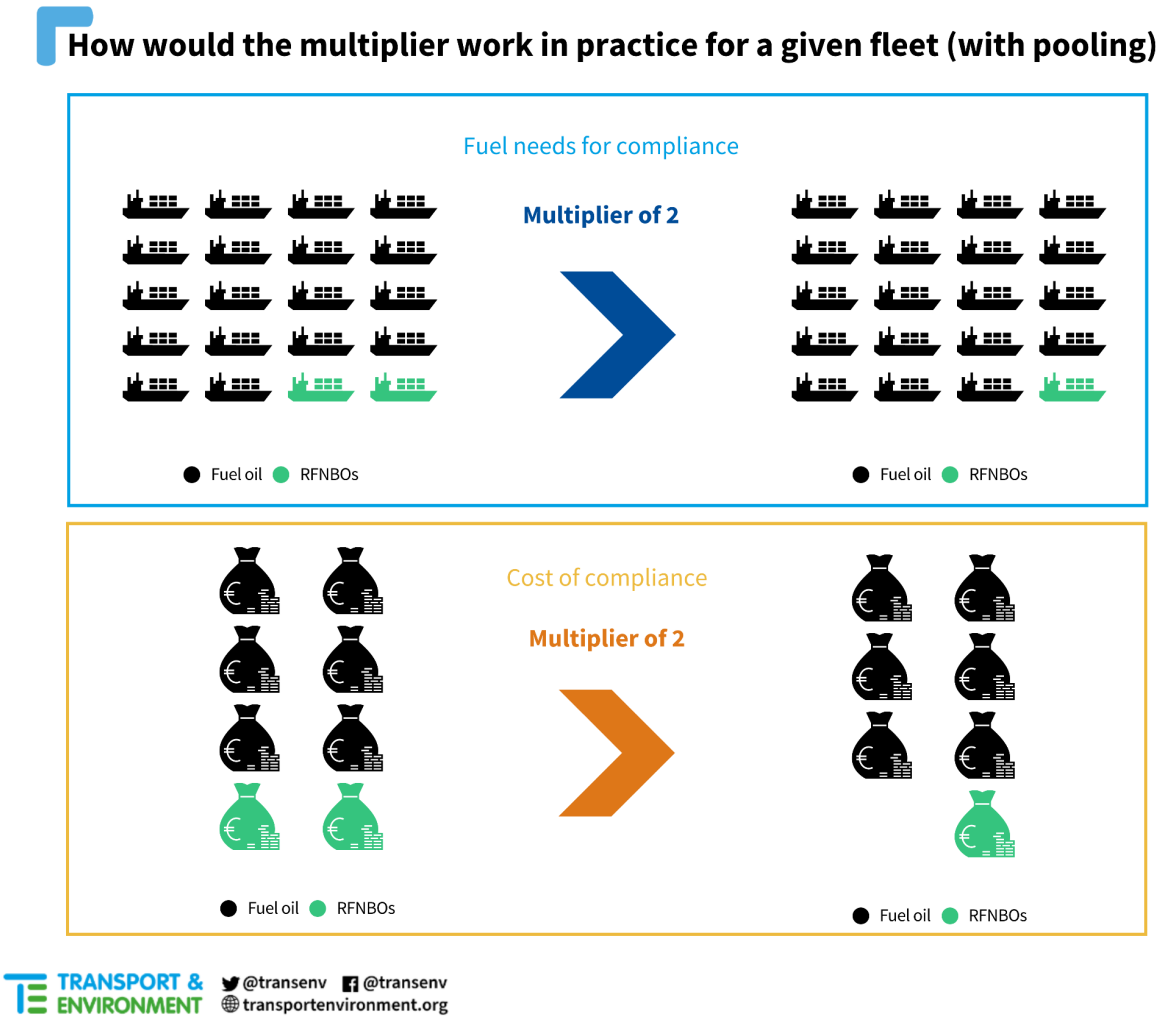


Figure 7: How would the multiplier work in practice for a given fleet?

The below table demonstrates how the multiplier allows for GHG intensity reduction of the ship vis-à-vis the baseline scenario. Let's take an example. Let's take a ship using e.g. 5000 MJ of energy per year and running on a very low sulphur fuel oil (VLSFO) with 92.63 gCO_2e/MJ emissions intensity emitting a total of 463.2kg of CO_2e a year. This amount is calculated by taking the total energy use and multiplying it by the CO_2e intensity per MJ, adjusting the measurement units to kg,

i.e. 5000 x 92/1000 = 460kg. We can also find the cost of running a ship on VLSFO by multiplying its price per MJ by the total amount of energy it uses. In this instance it is 0.0124 x 5000 = 62 EUR.

Now, let's assume that a vessel is going to use 8% RFNBO, say e-methanol with a WtW intensity of 2.54 gCO_2e/MJ in order to respect the 2030 (-6% = 85.69 gCO_2e/Mj) GHG intensity target and analyse the emissions balance under 3 scenarios.

Under **compliance scenario 1**, the ship owner decides to introduce a share of 8% renewable fuels of non-biological origin (RFNBOs) into the ship's fuel mix. It means that 400 MJ (5000 MJ x 8%) will now come from e-methanol, while the remaining 92% of energy still comes from VLSFO (i.e. 4600 MJ). To find the total CO_2 emissions of this new fuel mix, we simply follow the above-mentioned methodology for each fuel separately and then add them up:
For VLSFO: 4600 x 92.63 / 1000 = 426.1kg;
For e-methanol: 400 x 2.54 / 1000 = 1.02 kg.
The total adds up to 427.1 kg, which we then use to calculate the overall CO_2e intensity of the ship's fuel mix. This is done by dividing the total amount of CO_2e emissions by the total energy (not forgetting to adjust the units back from kg to g of CO_2e):
(427.1 x 1000) / 5000 = 85.4 gCO_2e/MJ, which is a 7.8% decrease compared to using 100% VLSFO and respects the 2030 target.
To calculate the cost of running a ship on such a mix of fuels, we need to multiply the price of each fuel per MJ by the amount of energy it has been used to produce and add them up:
For VLSFO: 0.0124 x 4600 = 57.3 EUR;
For e-methanol: 0.0534 x 400 = 21.4 EUR.
Total: 78.7 EUR.
Now we can calculate the price per MJ of our new fuel mix: 78.7 / 5000 = 0.016 per MJ. This constitutes an increase of 0.004 EUR/MJ compared to the baseline scenario.[8]

Compliance scenario 2 demonstrates the effect of the multiplier of 2 applied on RFNBOs. It allows the ship to account for more than the actual energy content *originally* consumed because the amount of RFNBOs used is counted twice, i.e. 400MJ of e-methanol x 2 = 800MJ. While the absolute amount of CO_2e emissions remains the same (427.11 kg), because multiplier applies only to denominator of the equation and NOT to the numerator, the CO_2e intensity changes because of increased total, i.e. denominator (4600MJ VLSFO + (400MJ e-methanol) x 2 = 5400MJ). So, 427.11 x 1000/5400 = 79.10 gCO_2e/MJ. We can see that the multiplier reduces the ship's GHG emissions intensity by 14.6% (almost twice as much) compared to using 100% VLSFO and well beyond what is required to meet the 2030 target. In this case, a ship might use this over-compliance as a "surplus credit" and either bank it for future use, or sell it to other vessels/companies. Cost-wise, while the absolute amount stays the same (78.6 EUR), due to the aforementioned increase in denominator, the multiplier reduces the price of fuel per MJ: 78.6 / 5400 = 0.015 EUR/MJ.

[8] Our assumed 2030 price for e-methanol is 53.4 EUR/GJ and for VLSFO 12.45 EUR/GJ.

If a ship doesn't want to use more RFNBO than what is strictly necessary to meet the 2030 regulatory requirement and is not interested in banking or selling surplus credits, it might use the multiplier to reduce the actual amount of e-methanol combusted while still arriving at an identical overall emissions intensity reduction as in the compliance scenario 1. This is demonstrated in the **compliance scenario 3**. In this scenario, instead of keeping the original amount of e-methanol use (i.e. 400Mj) constant, a ship can use half as much e-methanol (i.e. 200Mj) but count it twice because of the multiplier 2. In this case however, a ship will need to use a bit more VLSFO (i.e. 4800Mj) than in scenario 2 in order to meet its total 5000Mj energy needs. Everything else stays the same and when we repeat the above-mentioned methodology: (4800 x 92.63 /1000) + (200 x 2.54 /1000) = 445.13kg of CO_2e, but the CO_2e intensity is still comparable to scenario 1 because of the multiplier: 445.13 x 1000/5200 = 85.60. This scenario leads to the lowest cost of the fuel mix out of the 3 scenarios: (0.0124 x 4800) + (0.0543 x 200) = 70.5 EUR. Dividing it by 5200 we get the figure of 0.014 EUR/MJ. While still higher than in the baseline scenario, we can see that multiplier bridges a part of the cost gap between the RFNBOs and non-sustainable fuels. It is important to note that, in the real world, shipping companies would use just enough of RFNBOs, adjusted by a multiplier of 2, in order to meet the set targets; in other words, they won't use more than necessary.

This demonstrates the effect and the purpose of the multiplier - to make RFNBOs economically more attractive than other alternatives (e.g. biofuels and LNG) and to incentivise their speedier uptake.

		Total energy use (Mj/year)	Fuel GHG Intensity (gCO2/MJ)	Total CO2 (kg)	GHG intensity change vis-à-vis baseline	Total costs (€)	Costs (€/MJ)
Baseline	VLSFO	5,000	92.63	463.15		62 €	0.012 €
Compliance input	e-methanol share	8%	2.54				
	Multiplier	2					
Compliance scenario 1 | without a multiplier	VLSFO	4600	92.63	426.10		57.3 €	
	e-methanol	400	2.54	1.02		21.4 €	
	Total	5000	85.42	427.11	-7.78%	78.7 €	0.016 €
Compliance scenario 2 | with a multiplier but original e-methanol volumes	VLSFO	4600	92.63	426.10		57.3 €	
	e-methanol	400	2.54	1.02		21.4 €	
	Total	5400	79.10	427.11	-14.61%	78.7€	0.015 €
Compliance scenario 3 | with a multiplier but reduced e-methanol volumes	VLSFO	4800	92.63	444.62		59.8 €	
	e-methanol	200	2.54	0.51		10.7 €	
	Total	5200	85.60	445.13	-7.6%	70.5 €	0.014 €

Table 1: Explanation of RFNBO multiplier in simulated compliance scenarios with 2030 target.

6.3 What are the available RFNBO compliance options for shipping companies?

In general, four main options of compliance can be identified for shipping companies (the list is non-exhaustive)[9]:

1. Purchasing a new ship able to run on e-hydrogen, e-ammonia or e-methanol, running it fully or partially on RFNBOs, and banking or pooling the compliance surplus. Any RFNBO use above 2% of the ship's energy use can be pooled within the same company (figure 4);

2. Blending in small shares of RFNBOs compatible with existing ships, such as synthetic e-methane in LNG-powered ships, or synthetic diesel in diesel ships or ships with LNG/methanol/ammonia/hydrogen dual-fuel engines. However, these fuels are expected to be more expensive than using e-hydrogen and e-ammonia;

3. Retrofitting the auxiliary engine of an existing ship to run it on e-methanol, in order to meet at least 2% RFNBOs of that ship's total energy consumption;

4. Instead of itself using RFNBOs, entering the pooling system with other companies to buy missing compliance units from companies willing to sell their surplus RFNBO compliance units.

6.4 How does the compliance with the RFNBO subtarget relate to compliance with the overall GHG target?

The two requirements do overlap positively with each other: using at least 2% RFNBOs in 2034 will also help shipping companies to meet the GHG intensity reduction targets. RFNBOs must deliver at least 70% GHG savings.

7. What are the penalties?

If companies do not comply, they will have to pay a penalty but will not have to comply with GHG targets after then. This essentially means that FEUM allows a pay-to-comply mechanism. However, the penalty factor grows by 10 percentage points if a shipping company does not comply two years in a row. Thus if a company is non-compliant for 3 consecutive years, this would mean a 30% increase in the penalties, 4 years of non-compliance would mean a 40% increase of the penalty and so on. Member states can also decide to expel a ship for not paying the penalty for two consecutive years, but are not required to do so.[10]

[9] For further details, see part IV of T&E 2023 briefing "Why an e-fuel mandate for ships?"
[10] Specific calculations of penalties can be found under Annex V of FuelEU Maritime

Shipping companies are responsible for the payment of the penalty, but may conclude a contract with the commercial operator that makes them liable for reimbursing the penalty to the company, when the purchase of the fuel or operation of the vessel is under control of the commercial operator. Similarly, a commercial contract with fuel suppliers could make fuel suppliers liable to pay the penalty if they default on their compliant fuel supply commitments.

However, FEUM does not mandate the existence of these liability clauses in the commercial contracts, neither with charterers nor with fuel suppliers.

Revenues from penalties go to Member States' budgets and will need to be used to support the deployment of renewable and low carbon fuels by stimulating the production, construction of bunkering facilities or electric connection in ports, and development of innovative technologies. Member states will have to publish a report by 2030 on the use of revenues.

8. Will FuelEU Maritime drive the decarbonisation of EU shipping?

While FuelEU Maritime is a good starting basis for the decarbonisation of European shipping, the Regulation is not in line with the Paris Agreement.

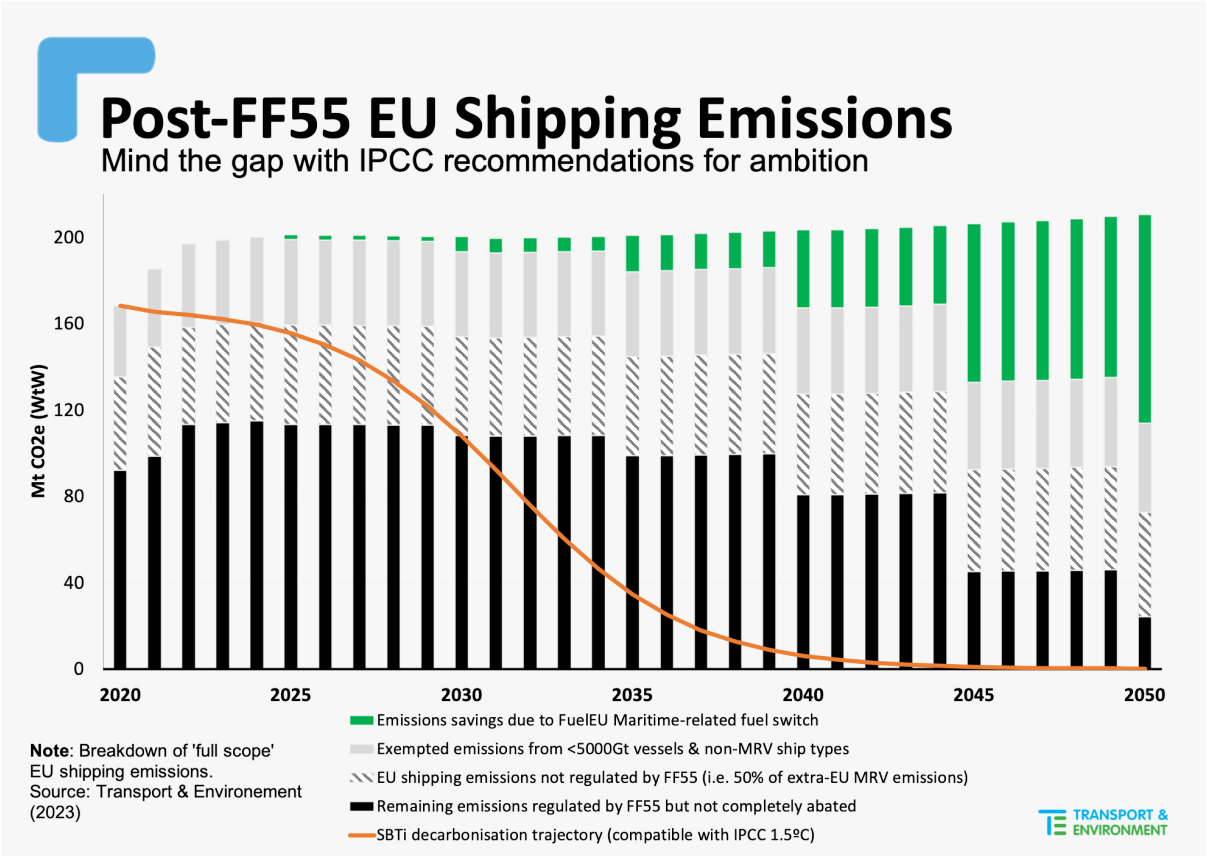


Figure 8: post-FF55 EU emissions emissions

As it is evident from the figure 8, FEUM as it was adopted will not lead to a full decarbonisation of the EU maritime transport and it is certainly not in line with the 1.5°C temperature goal of the Paris Agreement. The next revision of FEUM should aim to fill that gap.

9. What does FuelEU Maritime mean for future global shipping fuel standards?

The Commission will have to examine any future IMO regulation on GHG standards or global greenhouse gas intensity limits to consider possible alignment of FuelEU Maritime with that measure. If appropriate, the Commission may also propose to amend the Regulation while making sure that any possible alignment with a potential IMO regulation does not hinder the attainment of the Union's climate goals.

Further information

- Transport & Environment (2023), Modelling The Impact Of FuelEU Maritime On EU Shipping.
- Transport & Environment (2022), FuelEU Maritime: T&E analysis and recommendations. How to drive the uptake of sustainable fuels in shipping
- Transport & Environment (2022), The small price to pay to clean up shipping. Analysis of how consumer goods prices would be impacted by shipping decarbonisation measures
- Transport & Environment (2022), Why we need an e-fuel mandate for ships (Q&A Briefing and Dashboard)
- Final text of the FeulEU Maritime can be access via this link:

  https://www.europarl.europa.eu/meetdocs/2014_2019/plmrep/COMMITTEES/TRAN/AG/2023/05-24/1278138EN.pdf

Further information

Name: Chiara Mingozzi
Title: Junior shipping analyst
Transport & Environment

Name: Inesa Ulichina
Title: Shipping policy officer
Transport & Environment
inesa.ulichna@transportenvironment.org

Name: Faïg Abbasov
Title: Shipping programme director
Transport & Environment
faig.abbasov@transportenvironment.org
Mobile: +32(0)483717928