



# Draft FuelEU Maritime proposal

Quantifying the risks of a climate and environmental disaster in the making

June 2021

## Summary

In July 2021, the European Commission is expected to present the first-ever legislative initiative requiring ships to progressively switch to sustainable marine fuels. However, according to this analysis, the current draft proposal of the Commission would lead to shipping mostly switching to fossil natural gas and an unsustainable amount of dubious biofuels in the foreseeable future.

The draft FuelEU Maritime initiative envisages the introduction of a goal-based fuel GHG intensity target that increases in stringency over time, requiring ship operators to reduce the carbon footprint of the energy used onboard ships. The target(s) (a.k.a. thresholds) will be expressed in Well-to-Wake (WTW) CO<sub>2</sub>-equivalent emissions to account for all the life-cycle GHG emissions (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) of the different fuels and relevant engine technologies.

There are many factors that will impact fuel/technology deployment as a result of a goal-based mechanism, not all of which is easy to quantify. This analysis assumes short and medium-term rational decision-making by shipping companies and models compliance as a function of set target levels and prices of compliant fuel options. This is because fuel costs represent the bulk of ships operating (voyage) costs and minimizing the increase in these costs will be a key driver in choosing certain alternatives over others. However, from the environmental perspective not all alternative fuels can promise a (net-)zero carbon future to shipping, because very few are both sustainable and available at scale to meet the sector's growing energy demand.

With this in mind, this analysis aims to (1) quantify the impact of a simple goal-based FuelEU targets on the shipping sector's demand for fuels, and (2) to identify the policy safeguards needed to reduce the risks associated with the switch to alternative fossil fuels and unscalable marine biofuels and the incentives needed to improve the competitiveness of green e-fuels.

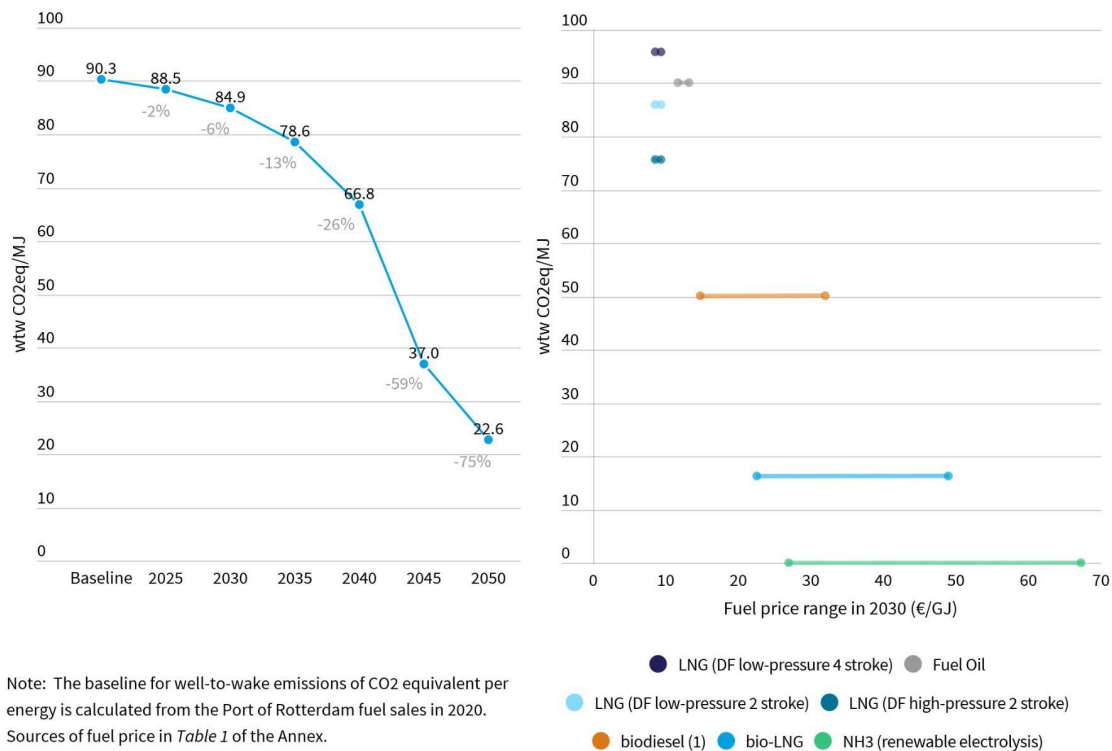
Based on the analysis, T&E concludes that the current draft of the FuelEU Maritime Regulation (dubbed "Climate Disaster Scenario" in this analysis) will not give a clear signal to the industry to invest in sustainable and scalable green fuels. To address this, T&E recommends that FuelEU Maritime regulation incorporates, among others, a sub-target or high multipliers (ideally 5) for green e-fuels, limits the pooling/credit-exchange mechanism to e-fuels only and places an explicit ban on the crop-based biofuels and on fossil natural gas as compliance options. Otherwise, European shipping might go right into a climate and environmental disaster scenario.

# 1. A simple FuelEU goal-based target to drive fossil gas and biofuels uptake

## 1.1. Assessment of the regulatory targets and cost assumptions supporting this analysis

Assessing how a goal-based target would impact the shipping fuel demand is a difficult exercise, but an essential one to get the target design right. This analysis is based on the draft of goal-based targets envisaged by the draft FuelEU Regulation with a trajectory of mandated carbon intensity improvements until 2050 (figure 1).

### Goal-based targets in the draft FuelEU Regulation



(1) Waste-based biodiesel (used cooking oil). Food-based and feed-based biofuels, for example biodiesel produced from palm or soy oil, are well above the baseline when including emissions from indirect land use change (ILUC). They do not appear on the graph and are not considered in the analysis.

Figure 1: Goal-based target trajectory from 2025 to 2050 in FuelEU draft proposal (left); fuel carbon intensity of marine fuels with related price ranges (right)

The envisaged regulatory trajectory is calculated on the basis of 2020 fuel mix resulting in a 90.3 gCO<sub>2</sub>eq/MJ<sup>1</sup> fleet-level baseline Well-To-Wake (WTW) fuel carbon intensity performance. For example, a 2030 GHG reduction target of -6% would require ships to keep the life-cycle GHG intensity of onboard fuel use to 84.9gCO<sub>2</sub>/MJ or below. The WTW factors for different alternative marine fuels are shown on the right-hand side of the graph, together with fuel prices ranges for 2030 using the sources documented in annex I. Among the alternative e-fuels, we have only considered e-ammonia as it is expected to be the cheapest e-fuel on the basis of production costs.<sup>2</sup>

Even though the list of alternative fuels in figure 1 is not exhaustive, it still provides a good snapshot of their relative price competitiveness at given regulatory thresholds. Notably, fossil LNG in dual-fuel high pressure (diesel cycle) engines appears to be the cheapest compliance option (0.85-0.93c€/GJ) for almost the next 2 decades. Waste-based biodiesel appears to be the second most cost-competitive option with a forecasted 2030 price ranging between 1.48-3.20c€/GJ for used cooking oil - compared to 2.69-6.72c€/GJ for green ammonia. In addition to price advantage, biodiesel is a drop-in fuel, meaning that a ship operator will be able to blend it with fuel oil in existing ships, contrary to the use of LNG or e-ammonia which requires investments in new vessels. The graph on figure 1 does not show palm oil and rapeseed oil because their WTW GHG intensity in the draft FuelEU proposal is well above the baseline when accounting for indirect land-use change (ILUC). However, this does not exclude other food and feed biofuels (e.g. soy or sunflower based) being used for compliance if they have lower ILUC factors.

Bio-LNG (liquefied biomethane) is also a drop-in fuel for LNG-powered vessels; however the price range in 2030 (2.25-4.90c€/GJ) is generally higher than biodiesel, which makes (waste-based) biodiesel blending in fuel oil a more attractive option for compliance up until mid-2040s. Given that modern LNG vessels are dual-fuel, the analysis assumes that ships would, at least initially, use biodiesel instead of more expensive biomethane to comply with the regulatory thresholds whenever needed.

## **1.2. A simple goal-based target will only drive fossil LNG and biofuels over the short and medium term, not e-fuels**

Should the European Commission propose FuelEU Maritime legislation as a simple goal-based target, expressed as a certain level of carbon intensity without any safeguards, shipping's technological transition could turn into a climate and environmental disaster. Based on the given targets, related fuel costs in figure 1, EU-related<sup>3</sup> fleet composition and its future evolution, T&E projected the evolution of EU

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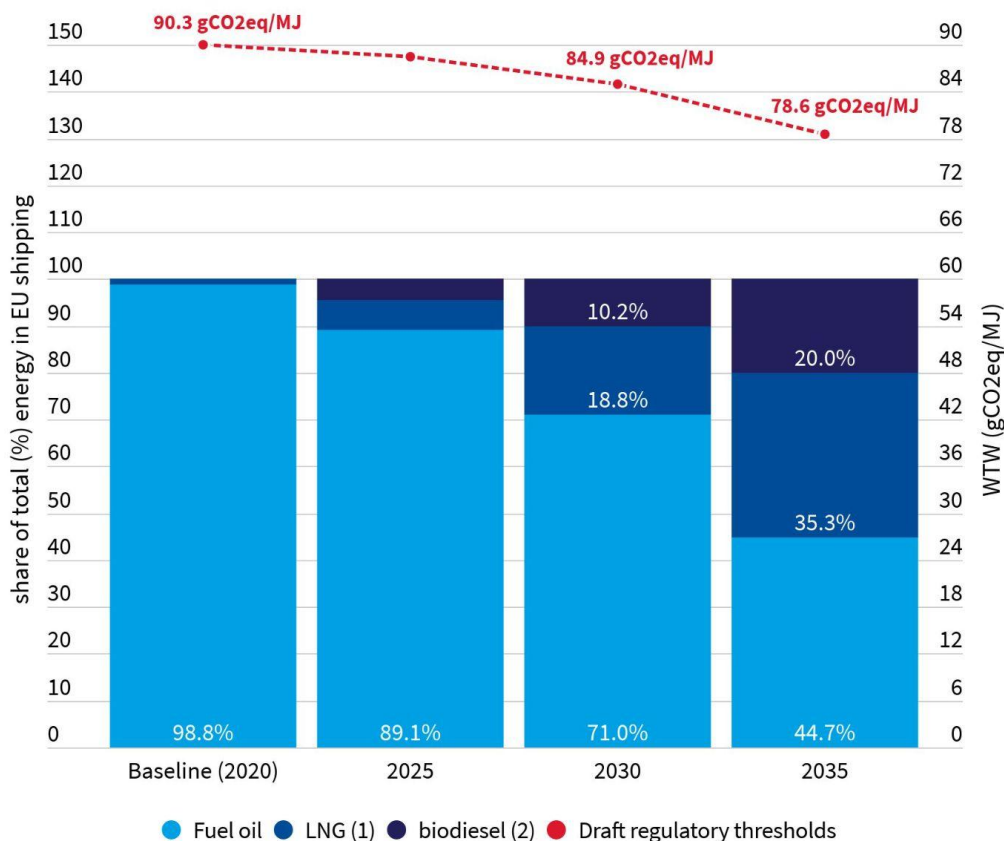
<sup>1</sup> In the absence of 2020 fuel mix data under the EU MRV regulation, the port of Rotterdam's fuel sales were used as a proxy to derive 2020 fuel mix for ships calling at European ports. 2019 EU MRV data would be less relevant due to the entry into force of the global marine sulfur content standard in January 2020, which has changed the LCA performance of marine fuels. See annex 1.

<sup>2</sup> See Figure 2 "Potential energy costs for European shipping under different e-fuel options" in "Decarbonising European Shipping." 2021. Transport&Environment.  
<https://www.transportenvironment.org/publications/how-decarbonise-shipping>

<sup>3</sup> The model used 2019 EU shipping MRV emissions, its geographical scope and fleet composition as the basis of analysis.

shipping’s fuels demand (figure 2). It is assumed that rational ship operators will choose the cheapest alternative fuel as long as its WTW carbon intensity per unit of energy is compliant with the set targets.

## Disaster Pathway: draft FuelEU maritime will mostly drive fossil LNG and biodiesel



**Note:** In this scenario, until 2023, the uptake of LNG ships is based on IHS order book. It is assumed that from 2025 the share of LNG-powered vessels among the energy consumption by the new fleet will rise up to 72%, which represents the current share of energy consumption by marine 2-stroke engines (table 6.5. in Sphera. 2021. “2nd Life Cycle GHG Emission Study on the Use of LNG as Marine Fuel.”). This assumption reflects the technical constraint of certain type of ships that are not able to be powered by 2-stroke engines. When the GHG reductions of LNG are insufficient to comply, it is assumed that biodiesel is used in the rest of the fleet to comply.

(1) In the baseline, it is considered that LNG engines are low-pressure 4-stroke (Otto cycle). From 2025, LNG ship sales are considered to be half low-pressure 2 stroke (Otto cycle), half high-pressure 2 stroke (Diesel cycle). From 2030, all LNG ship sales are considered to be high-pressure 2 stroke as Otto engines are no longer compliant.

(2) It is assumed that all biodiesel is waste-based, notably used cooking oil.

**Figure 2: Disaster Pathway: Projection of EU shipping demand under simple FuelEU goal-based targets assuming full compliance**

Due to its competitive price advantage (figure 1), any GHG intensity thresholds (targets) set below the 2020 baseline but still allowing fossil LNG as a compliant fuel will likely result in the acceleration of dual-fuel LNG propulsion uptake by the new vessels. Although the LNG engine type with the highest

methane slip (low-pressure 4-stroke - Otto) ceases to comply with the goal-based target from 2025 on, the use of fossil LNG via other engine types would remain compliant for up to two decades. Specifically, under the current draft targets, 2-stroke low-pressure engines (Otto cycle) with medium methane slippage would be compliant at least until 2030, while 2-stroke high pressure dual-fuel engines (diesel cycle) until 2040. This assumes that FuelEU uses global warming potential (GWP) of 36 for fossil methane as recommended by the IPCC 5th Assessment Report as opposed to GWP 28 as envisaged by RED II. Otherwise, even 2-stroke Otto engines might remain compliant until 2035. Either way, if the law is adopted in its current form, this would give a blank cheque to the continued use of fossil LNG well beyond what could be reasonably considered a transitional period. This draft FuelEU proposal would directly undermine the objective of the EGD to achieve climate neutrality by 2050, the objective of the EU Smart and Sustainable Mobility Strategy to deploy ocean-going zero-emission vessels by 20230 and the EU Hydrogen Strategy aiming to deploy hydrogen-based solutions, among others, in the maritime sector.

Generally, the calculations assume an upper limit of fossil LNG uptake by new vessels defined by the fact that not all ship types can operate on 2 stroke engines<sup>4</sup> and 4-stroke DF LNG engines won't be able to comply with post-2025 targets due to their higher methane slippage. Despite this LNG would still be given a huge push potentially reaching 18,8% of the total energy used in EU-related shipping in 2030, and 35,3% as soon as by 2035.<sup>5</sup> In absolute terms, this would represent 7 Mt of fossil LNG by 2030 and 11.2 Mt by 2035 (figure 3), representing a 25-fold increase compared to LNG consumption by EU shipping today.<sup>6</sup>

However, the analysis also concludes that EU-related shipping would not be able to comply with the current draft targets at fleet level even if two-thirds of new ships switch to fossil natural gas. This would require the uptake of additional alternative fuels by the rest of the fleet. As bioLNG is projected to remain expensive, we consider that blending drop-in biofuels in existing fuel oil ships would be a preferred option by the operators.<sup>7</sup> This would result in the drastic surge in waste-based biodiesel demand: from 5% of energy share in 2025 and doubling every 5 years to reach as much as 20% of EU shipping's 2035 energy demand (figure 2). In absolute terms, this would represent 5.1 Mt per year of biofuel demand by 2030 (figure 3). If one assumes that all of these biofuels are produced with used-cooking oil (UCO), then shipping's 2030 UCO biofuel demand could exceed by a factor of 3 the quantity of used cooking oil that can be produced and collected sustainably in the EU - 1.7 Mt only - by 2030.<sup>8</sup> Taking into account that European supply volumes of UCO are already insufficient to meet the existing demand of road transport

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<sup>4</sup> The LNG uptake is limited in the model to 72% of new ship sales from 2025 (date from which only 2 stroke engines comply with the target), based on the engines distribution in the market derived from Sphera study (formerly Thinkstep), table 6.5. Sphera. 2021. "2nd Life Cycle GHG Emission Study on the Use of LNG as Marine Fuel." April 15, 2021. <https://sphera.com/research/2nd-life-cycle-ghg-emission-study-on-the-use-of-lng-as-marine-fuel/>

<sup>5</sup> According to our in-house stock model of the MRV fleet from 2020 to 2050.

<sup>6</sup> As EU 2020 LNG shipping demand could not be found, we estimated it using Port of Rotterdam's 2020 share of LNG in their fuel sales. See annex 1.

<sup>7</sup> Even though the FuelEU target obligation applies at ship level, it makes sense for a ship operator to take investment decisions at fleet level. This should be made possible via a compliance pooling mechanism allowing credit exchange at fleet level and between ship operators. See "Conclusions and policy recommendations".

<sup>8</sup> See T&E Briefing "Used Cooking oil demand likely to double, and EU can't fully ensure sustainability", graph p.6, data derived from Oilworld (2020) and CE DELFT (2021).

Link: <https://www.transportenvironment.org/sites/te/files/publications/UCO%20briefing%202021.pdf>

and aviation, additional demand for biodiesel for shipping clearly poses supply and sustainability issues. This is also considering that there are not so many other sustainable feedstocks that can be used for producing shipping biofuels. If not based on UCO, maritime demand could also drive the use of problematic feedstocks like Palm Fatty Acid Distillates (PFAD) or Crude Tall Oil (CTO) that are already being used in other sectors of the economy.<sup>9</sup>

As a result, in addition to a huge fossil LNG uptake in shipping, the current draft would give a dangerous push to biofuels:

- Even if all current EU production of UCO - 1.3Mt in 2019 - were diverted to shipping, it would still fall short to cover ship operators' needs by 2025. In addition, this would deprive other sectors from advanced biofuels supply, for example from its current use in road transport or future needs in aviation where even fewer sustainable fuel options exist than in shipping;
- Due to the EU's limited domestic production potential of waste-based advanced biofuels, additional shipping demand would further increase already disproportionately high imports. 5.1 Mt/year of shipping demand for UCO biodiesel in 2030 would add to the already high EU demand forecast for road transport and aviation - 6.3 Mt/year in 2030. To satisfy EU total demand, as much as 9.7 Mt of used cooking oil imports would be needed, a six-fold increase compared to current imports to the EU across all sectors (1.5 Mt in 2019). Recent analysis concludes that only 3.1-3.3 Mt of UCO could be sustainably supplied to Europe by 2030. This is based on an increase of the EU+UK production up to 1.7 Mt (from 1.3 Mt today), and maintaining the same import levels as today (1.5 Mt).<sup>10</sup>
- Beyond the ethical issue of importing huge quantities of biofuel feedstocks from third countries that need them for their own decarbonisation, it also means that crop-based biodiesel could sneak its way into the supply chain. Although in theory WTW carbon intensity performance (under the current draft) of biofuels produced from palm oil and rapeseed oil do not allow compliance with the targets<sup>11</sup>, already today, avoiding fraud along the UCO supply chain proves difficult to ensure in a context of increasing imports. The EU Court of Auditors has warned that voluntary schemes under current RED II legislation<sup>12</sup> cannot guarantee that all the UCO imported into Europe is actually 'used' and member states recently asked for additional supervision of the biofuels supply chains.<sup>13</sup> Since ships sail internationally, they can easily refuel outside of the EU. Therefore, the risk of fraud on the sustainability credentials of biofuels would be even greater in

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<sup>9</sup> See T&E Briefing "RED II and advanced biofuels". Link:

[https://www.transportenvironment.org/sites/te/files/publications/2020\\_05\\_REDII\\_and\\_advanced\\_biofuels\\_briefing.pdf](https://www.transportenvironment.org/sites/te/files/publications/2020_05_REDII_and_advanced_biofuels_briefing.pdf)

<sup>10</sup> Oilworld (2020) and CE DELFT (2021)

<sup>11</sup> When accounting for indirect land-use change (ILUC), biodiesel produced from palm oil and rapeseed oil have a WTW of 307gCO<sub>2</sub>eq/MJ and 115gCO<sub>2</sub>eq/MJ respectively, well above heavy fuel oil (88gCO<sub>2</sub>/MJ).

<sup>12</sup> Current RED II allows fuel suppliers to report lower WTW emissions for biofuels than the RED default values, provided these biofuels meet sustainability criteria and other limits imposed in the RED and the new values are approved by certification schemes.

<sup>13</sup> Joint statement on improving supervision for the use of renewable energy in the Renewable Energy Directive.

Link:

<https://www.permanentrepresentations.nl/permanent-representations/pr-eu-brussels/documents/publications/2021/05/25/joint-statement-on-improving-supervision-in-the-red>



shipping than what experienced today in road transport, and extremely difficult for the regulator to control. In fact, the impact assessment underpinning the draft FuelEU Maritime regulation concluded that in the long-term crop-based feedstocks would make up the majority of shipping's demand for biofuels (see annex 4).

## The draft FuelEU will incentivise fossil LNG and dubious biodiesel imports

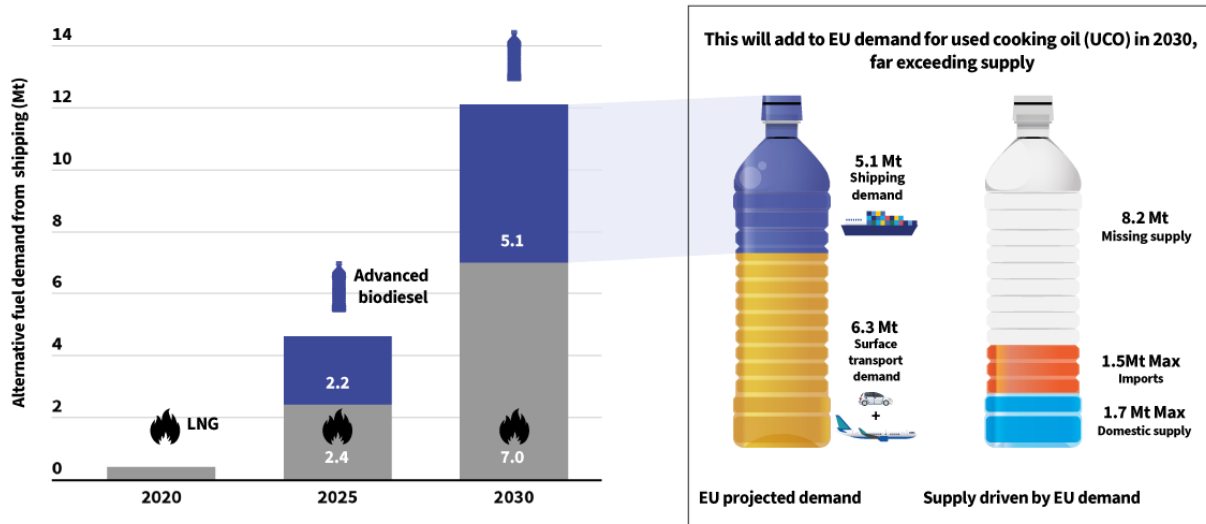


Figure 3: LNG and biodiesel demand in shipping in Climate Disaster Pathway

## 2. Regulatory remedies to mitigate the risks of a simple goal-based target under FuelEU Maritime

### 2.1. Promote the use of e-fuels to contribute to the FuelEU goal-based target

There are possible regulatory remedies to avoid shipping falling onto a climate and environmental Disaster Pathway as a result of a simple goal-based target. A fully technology-neutral approach, without the right safeguards, will fail to address market barriers standing in the way of deploying sustainable and scalable alternative fuels, such as e-fuels, which are crucially needed to achieve shipping's decarbonisation by 2050.

This is because under the current draft proposal, sustainable and scalable green technologies, especially green hydrogen and green ammonia, would be treated on equal basis with fossil gas and unsustainable and/or unscalable biofuels. As nascent fuels, green hydrogen and ammonia are more expensive and require investments in new vessels equipped with fuel cells or e-ammonia engines.<sup>14</sup> Additional port-side

<sup>14</sup> First e-ammonia enabled large vessels are expected to be put at sea by 2025 -

<http://www.koreaherald.com/view.php?ud=20201006000301>; the Danish shipowner DFDS is aiming to deploy a

infrastructure costs would add to the risks of their deployment. Without tailor-made incentives as part of the forthcoming FuelEU Maritime Regulation, green hydrogen and green ammonia (but also other e-fuels) will not be cost-competitive against fossil gas and biofuels and will unlikely be adopted by the industry.

### **2.1.1. Set a 50% minimum contribution of sustainable marine e-fuels to the regulatory targets**

The most straightforward way to provide predictability and demand guarantees for the deployment of green hydrogen(-based fuels) in shipping is to mandate a sub-target for green e-fuels. We would strongly recommend a sub-target requiring at least half of the GHG intensity improvements to come from green e-fuels, and specifically green hydrogen and ammonia. For example, the current draft mandates a -6% GHG intensity improvement by 2030. If half of this reduction were to come from green ammonia, this would equal to:

- About 2.8 Mt or 51 PJ e-ammonia per year,
- About 8.8 GW additional renewable electricity capacity, and
- About 4.5 GW electrolyser, or a little more than 10% of the EU goal for green hydrogen production in 2030 (40 GW).

For comparison, T&E's initial analysis found feasible up to 85 PJ or 4.6 Mt of e-ammonia sustainable domestic EU supply for shipping demand by 2030.<sup>15</sup> Thus, setting a sub-target at 50% for sustainable e-fuels appears realistic with regards to the potential uptake of e-fuels in shipping by 2030.

### **2.1.2. Introduce a multiplier to boost e-fuels' cost-competitiveness (as an alternative or complementary to a sub-target)**

Considering that the main barrier to the uptake of e-fuels is the price (in addition to availability in the immediate future), FuelEU Maritime must give priority to e-fuels for compliance with the target. Although green ammonia is the most competitive e-fuel for deep-sea shipping, and in spite of future cost reductions, it is still a more expensive option today than fossil LNG or biofuels.

The introduction of multipliers on e-fuels can help improve e-hydrogen fuels' competitiveness vis-à-vis biofuels. Figure 4 below aims to visualise how the use of multipliers can boost e-fuels' attractiveness. For example, with a multiplier of 2 on e-ammonia, a share of 3.1% of ammonia in the total energy demand would be sufficient to comply with the 2030 target, whereas 5.9% would be required without the bonus given by a multiplier. Moreover, the advantage of applying a multiplier is that it increases the cost effectiveness of e-ammonia to comply (right part of figure 4).

However, for the tool to be effective, FuelEU Regulation should introduce multipliers of at least 4. Smaller multipliers would not be sufficient to make e-ammonia cost competitive, especially compared to the

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ferry powered by green hydrogen fuel cells by 2027:

<https://www.dfds.com/en/about/media/news/hydrogen-ferry-for-oslo-copenhagen>

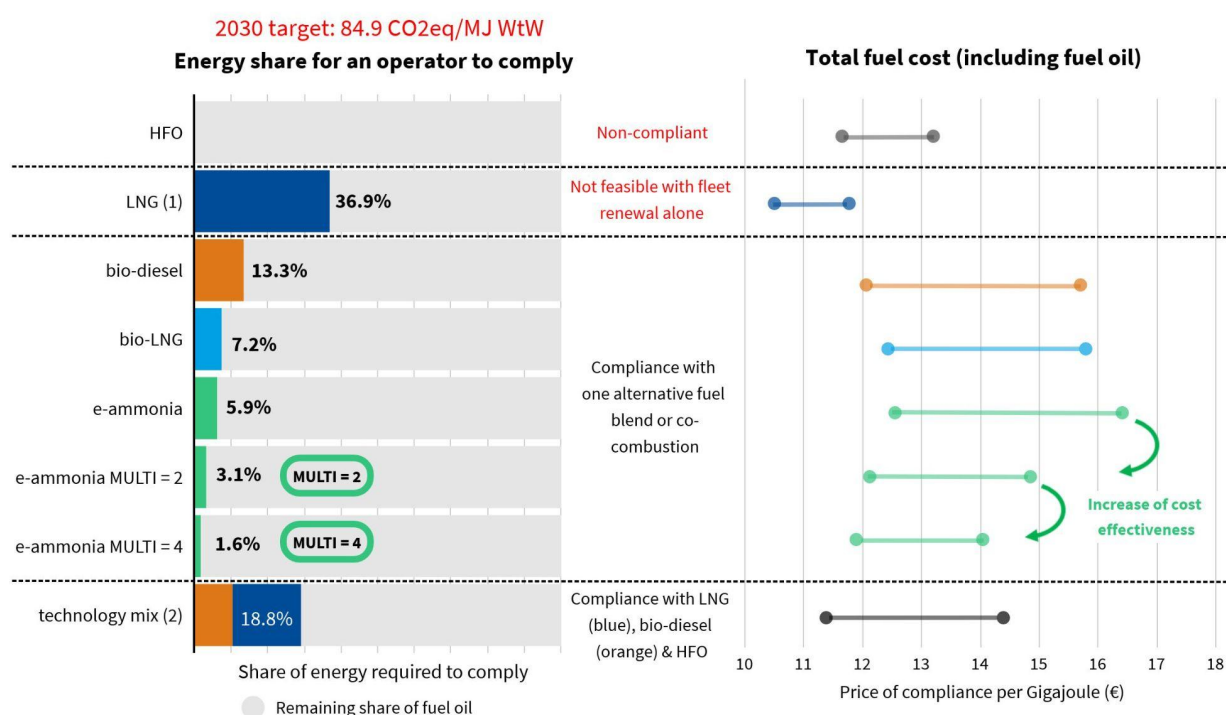
<sup>15</sup> 85 PJ e-ammonia could represent between 5 to 7% of EU-related shipping demand by 2030, depending on energy efficiency measures. See "Decarbonising European Shipping." 2021. Transport&Environment.

<https://www.transportenvironment.org/publications/how-decarbonise-shipping>



cheapest biofuel options in the market. Based on T&E calculations, under a 2030 FuelEU regulatory threshold (target) of 84.9 gCO<sub>2</sub>/MJ (or -6% compared to 2020 baseline), green ammonia can become more cost-effective than waste-based biofuels to comply, if a multiplier of 4 is applied. Since the analysis is limited to fuel costs only and does not take into account additional CAPEX for ammonia-powered vessels and bunkering infrastructure costs, a multiplier of 5 could be a safer option to account for non-fuel costs. Nonetheless, it is important to note that high multipliers might still not change the cost-competitiveness balance between e-ammonia and fossil LNG (see figure 4); hence the need for additional safeguards.

## Compliance costs - multipliers can boost cost-effectiveness of e-fuels for operators in 2030



**Note:** This graph shows how multipliers can incentivize e-fuels by boosting their cost effectiveness for compliance per operator. This simplistic approach only includes fuel costs - carbon mark-up is excluded. Price range based on the difference between conservative and optimistic cost assumptions. See Table 1 for sources.

(1) LNG (DF high-pressure 2 stroke) at 75.71 gCO<sub>2</sub>e/MJ well-to-wake (WtW). We calculate the maximum share from LNG could be 18.8% from a fleet turn-over model.

(2) LNG and biofuel from Climate Disaster Scenario. See Figure 2 for LNG technology mix, resulting in 83.62 gCO<sub>2</sub>e/MJ WtW

**Figure 4: Impact of using multipliers on e-fuels' compliance costs**

## 2.2. Equip the FuelEU Maritime target with a pooling compliance mechanism that rewards exclusively e-fuels ships

The draft FuelEU Maritime Regulation system does incorporate a credit exchange mechanism, which is a positive development. This would provide companies flexibility to comply with the regulatory thresholds at the fleet level, when choosing their favoured compliance options. Theoretically, this could help companies to deploy full zero-emission hydrogen and ammonia vessels as opposed to marginally

improving the existing fleet via biofuel blending. This is positive. However, FuelEU should limit credit trading to e-fuels ships only so as not to give any further boost to fossil LNG. Otherwise, ships using fossil LNG with 2-stroke engines would be able to sell their excess credits until 2030-2040 (i.e. as long as their WtW GHG intensity over-complies with the FuelEU target), which would further boost their already advantageous price-competitiveness. Limiting credit trading to e-fuels ships only would allow progressive companies investing in e.g. green hydrogen/ammonia to overcomply and to be rewarded for that by overcompliance credit sales, which could in turn help other ships/companies to comply. This could encourage market operators to start renewing their fleet increasingly with e-fuels ships already from the entry into force of the first target in 2025.

### **2.3. Adopt explicit safeguards to counter risks of unsustainable fuels uptake**

In addition, FuelEU Maritime needs strong safeguards against unsustainable fuels that could be driven in the short-medium term. Therefore, T&E recommends that in parallel with e-fuels specific incentives, the FuelEU Regulation should also:

- Explicitly exclude the use of first generation biofuels and fossil gas from the scope of compliant fuels. This can be done in a technically straightforward way under the goal-based design: feed and crop-based fuels and fossil natural gas could be required to apply the same life-cycle carbon-factor as the average fuel in the baseline year of 2020 (i.e. 90.3 gCO<sub>2</sub>eq/MJ). Practically this would mean that ships get no emissions reductions credits for using first-generation biofuels or fossil natural gas.
- Apply RED II sustainability criteria to all advanced fuels, i.e. waste-based biofuels and Renewable Fuels of Non-Biological Origin (RFNBOs). This would effectively create a two-step approach and filter out fuels that could claim for emissions saving under the goal-based approach. For example, if an alternative fuel delivers e.g. only 10% emissions reduction compared to baseline fuel, it will not get any reduction credit if the ship partially or fully switches to that fuel. It would be treated as using baseline fossil fuel and using a baseline life-cycle carbon factor.
- Mandate an EU-wide system of high penalties for non-compliance. These should be set at a level that makes non-compliance with the goal-based target prohibitive for ship operators. Based on e-ammonia prices today, the penalty levels should be defined at least 4 to 6 times higher than heavy-fuel oil prices. On the contrary, if a “pay to comply” mechanism were to be introduced in FuelEU - as it is envisaged by the current draft, this will further disincentivise ship operators from pursuing new innovative solutions as it would be much easier for shipowners, to pay annual fees - especially in the non-liner market - than making actual investments in zero-emission vessels.

Last but not least, setting more stringent goal-based thresholds/targets should be taken with caution. If the use of multipliers on e-fuels could further drive the cost-effectiveness under stricter energy carbon intensity targets, setting more stringent targets bears considerable risks in case e-fuels supply is insufficient to meet demand. In the short-term, it could result in an even more drastic uptake of biofuels than described in the Disaster Pathway (figures 2 and 3). Therefore, the smart use of multipliers and excess credit sales are needed to enable for more ambitious targets beyond 2030 that could be achieved by sustainable and scalable fuels.

### 3. Conclusions and recommendations

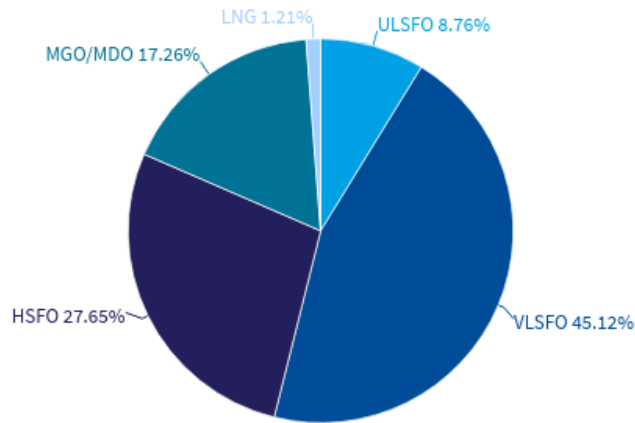
This analysis demonstrated that depending on the design of the goal-based measure, the FuelEU Maritime initiative could lead to the uptake of unsustainable and/or unscalable fuels contrary to the goals of the European Green Deal, EU Hydrogen Strategy and EU Smart and Sustainable Mobility Strategy. A simple goal-based standard will likely result in a sharp LNG and biofuels uptake in the short-medium term. Because a simple technology-neutral approach would reward marginal carbon intensity improvements via cheap but fossil LNG and drive a disproportionate demand for drop-in biofuels as the target gets stricter. In addition to scalability issues, this would also raise enforcement challenges with regard to the sustainability of biofuels. Therefore, stringent sustainability safeguards are needed to prevent unintended consequences.

On the contrary, if equipped with dedicated tools, FuelEU Maritime could kick-start the deployment of renewable-based e-fuels in shipping by 2030 and help decarbonise the sector by 2050 as envisaged by the EGD. These safeguards are the following:

1. **The FuelEU Maritime initiative must give a clear and predictable investment signal for the production and deployment of e-fuels in shipping.** This could be done either by adopting a clear sub-target for green hydrogen-based fuels or by providing multipliers to companies using them, or ideally a combination of both options:
  - a. **Option 1: The FuelEU Maritime regulation sets a minimum share of 50% green hydrogen and hydrogen-based fuels** to contribute to the GHG intensity reduction efforts under the FuelEU targets.
  - b. **Option 2: The FuelEU Maritime regulation introduces a multiplier of 5 for sustainable e-fuels**, specifically green hydrogen and ammonia, to boost their competitiveness vis-a-vis advanced biofuels. Smaller multipliers are unlikely to be effective.
2. **The FuelEU Maritime Regulation system must incorporate a credit exchange mechanism.** This would help the companies to deploy full zero emission hydrogen and ammonia vessels as opposed to marginally improving the existing fleet via biofuel blending. **However, credit trading should be limited to e-fuel ships only.** The desired outcome is for progressive companies investing in e-fuels to overcomply and to be rewarded for that by overcompliance credit sales, which can in turn help other ships/companies to comply.
3. **Explicitly exclude the use of first generation biofuels and fossil gas** from the scope of eligible fuels.
4. **As a minimum, apply sustainability and greenhouse gas emissions saving criteria of the Renewable Energy Directive (RED)** for all advanced fuels, i.e. waste-based biofuels and RFNBOs, in order to be eligible for emissions reductions under the goal-based mechanism.
5. **Ensure strict enforcement of the Regulation with high penalties.** There should be no “pay to comply” mechanism, but high penalties making non-compliance cost prohibitive.

# ANNEX I - Methodological assumptions in T&E analysis

## Baseline fuel mix 2020 - energy shares



Note: From Port of Rotterdam fuel sales in 2020



Figure 5: 2020 fuel mix baseline (energy shares)<sup>16</sup>

Fuel name	Range	fuel price (€/t)	Fuel price (c€/MJ)	Source
Fuel Oil	<b>min</b>	478	1.17	CE DELFT, (p68) range 15-17 USD/MMBtu
Fuel Oil	<b>max</b>	542	1.32	
bio-diesel	<b>min</b>	549	1.48	IEA, <a href="#">Indicative shipping fuel cost ranges</a> , 18 USD/GJ
bio-diesel	<b>max</b>	1190	3.20	ICCT range max HVO waste FOGs (0.039 USD/MJ)
ammonia	<b>min</b>	501	2.69	Ash, N., Davies, A., & Newton, C. (2020). <a href="#">Renewable electricity requirements to decarbonise transport in Europe with electric vehicles, hydrogen and electrofuels</a>
ammonia	<b>max</b>	1251	6.72	UMAS-LR, <a href="#">Techno-economic assessment of zero-carbon fuels</a> . Upper bound 82\$/GJ

<sup>16</sup> "Rotterdam Bunker-Sales-2017-2020." n.d. Link: <https://www.portofrotterdam.com/sites/default/files/bunker-sales-2017-2020.pdf?token=sLHJ0dbM>

LNG	<b>min</b>	419	0.85	<a href="#">CE DELFT</a> (p70) 2030 range 11-12 USD/MMbtu
LNG	<b>max</b>	457	0.93	
bio-LNG	<b>min</b>	1127	2.25	<a href="#">CE DELFT</a> (p70) 2030 range 29-63 USD/MMbtu
bio-LNG	<b>max</b>	2448	4.90	

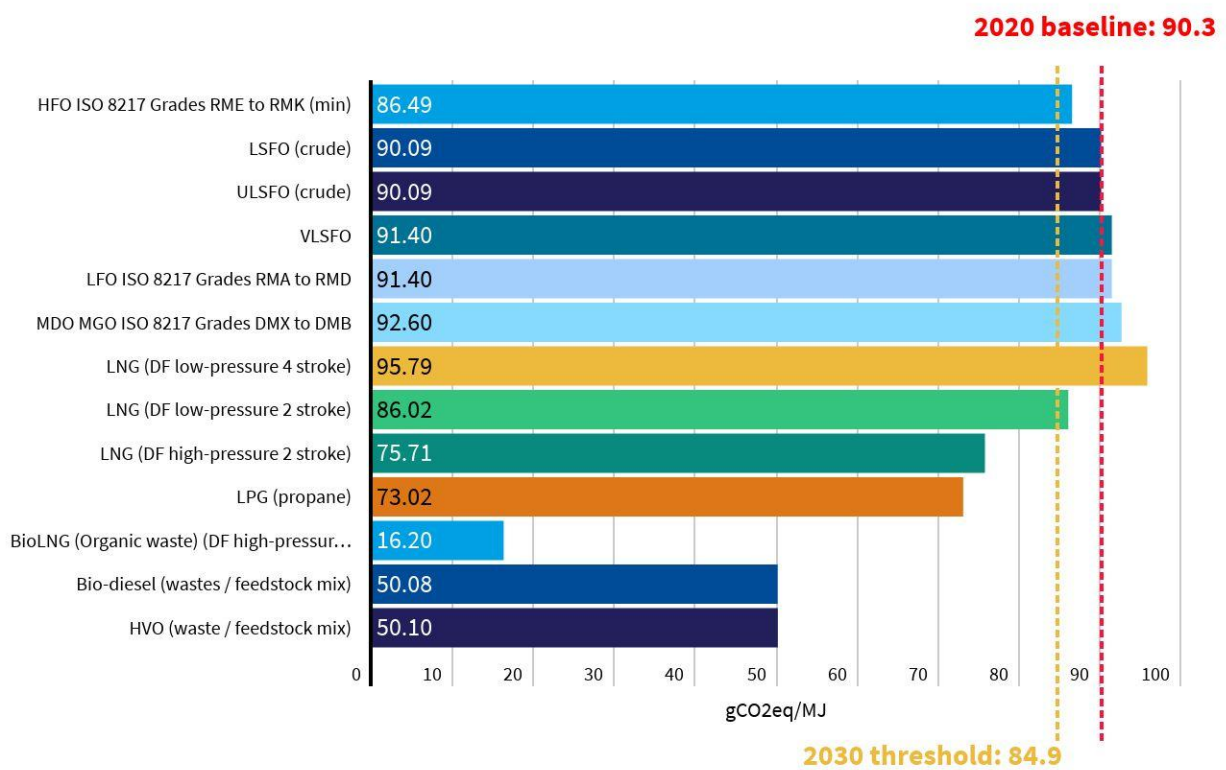
**Table 1: Price assumptions for 2030**

1 USD = 0.82 EUR ([source](#))

1 MMBtu (Metric Million British Thermal unit) = 1055.05585 MJ ([source](#))

Fuel prices do not include carbon mark-up (i.e. carbon pricing).

## Well-to-Wake carbon intensity of marine fuels



**Note:** T&E compilation based on the draft FuelEU Maritime Regulation. Baseline was estimated by T&E using 2020 Rotterdam fuel sales data as a proxy. Analysis assumes CH<sub>4</sub> GWP of 36 as per IPCC 5AR; however, if GWP 28 were chosen, WtW intensity of LNG in low-pressure DF 2 stroke engines would be **83.26 gCO<sub>2</sub>eq/MJ**.

**Figure 6: Well-to-Wake carbon intensity of different marine fuels**

## Annex II - Alternative fuels uptakes in FuelEU Impact Assessment

The Commission impact assessment underpinning the draft FuelEU Maritime regulation envisages large uptake of biofuels by the maritime sector (figure 6). The relative share of biofuels is similar to the conclusions of this study. However, the impact assessment does not mention the uptake of fossil LNG despite the draft law not explicitly excluding it from the compliance list and WTW values for fossil natural gas makes the technology the cheapest compliance option with the envisaged regulatory thresholds all the way up to 2040. It is also unclear whether biofuels were zero-rated in the impact assessment or whether residual WTW emissions were assigned to them.

Table 2 Share of renewable and low carbon fuels in maritime energy use in navigation and at berth

Share of renewable and low carbon fuels in maritime energy use (in %)	Baseline		PO1		PO2		PO3	
	2030	2050	2030	2050	2030	2050	2030	2050
Total	0.3%	1.4%	8.6%	86.9%	8.6%	89.5%	8.6%	88.8%
<u>biofuels</u>	0.1%	1.3%	6.0%	39.0%	6.2%	47.8%	6.1%	42.4%
<u>bio-LNG</u>	0.0%	0.0%	1.2%	14.2%	1.2%	16.8%	1.2%	15.4%
<u>e-liquids</u>	0.0%	0.0%	0.2%	16.3%	0.0%	13.4%	0.1%	15.8%
<u>e-gas</u>	0.0%	0.0%	0.0%	6.5%	0.0%	4.9%	0.0%	5.6%
<u>hydrogen</u>	0.0%	0.0%	0.0%	7.9%	0.0%	4.8%	0.0%	7.2%
<u>ammonia</u>	0.0%	0.0%	0.0%	0.5%	0.0%	0.2%	0.0%	0.4%
<u>methanol</u>	0.0%	0.0%	0.0%	0.3%	0.0%	0.1%	0.0%	0.2%
<u>electricity</u>	0.1%	0.1%	1.3%	2.1%	1.2%	1.4%	1.2%	1.9%
<i>of which at berth</i>	0.1%	0.1%	1.2%	1.0%	1.2%	1.0%	1.2%	1.0%

Source: PRIMES-Maritime, E3Modelling; Note: hydrogen in this table covers both hydrogen used in fuel cell vessels and direct use of hydrogen.

**Figure 7: Fuel mix assumptions for 2030-2050 under various policy options in European Commission's impact assessment for FuelEU Maritime (PO1 - prescriptive approach; PO2 - goal-based mechanism; PO3 - goal-based mechanism with pooling/credit-exchange mechanism)**

The Commission impact assessment also concludes that in the long-term the majority of marine biofuels will be supplied by crop-based feedstock (figure 7), which is contrary to a common sense of weaning the economy of crop-biofuels.



Table 5 Biomass feedstock consumption by type (in Mtonnes)

Feedstock consumption	PO1		PO2		PO3	
	2030	2050	2030	2050	2030	2050
<b>Part A</b>						
Perennial crops	0.0	6.3	0.0	7.7	0.0	6.9
Annual crops	0.3	33.6	0.3	40.8	0.3	36.4
Forestry products	3.1	14.4	3.2	18.4	3.1	15.9
Forestry residues	1.4	11.7	1.5	14.7	1.5	12.8
Wood waste	1.8	6.7	1.8	8.0	1.8	7.2
Agricultural residues	1.5	15.4	1.5	18.6	1.5	16.8
Manure	1.2	2.8	1.2	3.3	1.2	3.0
<b>Part B</b>						
Non-agricultural oils	0.80	1.4	0.83	1.8	0.82	1.6

Source: PRIMES Biomass model, E3Modelling

**Figure 8: Estimation of biomass feedstock consumption for 2030-2050 under various policy options in European Commission's impact assessment for FuelEU Maritime (PO1 - prescriptive approach; PO2 - goal-based mechanism; PO3 - goal-based mechanism with pooling/credit-exchange mechanism)**

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