FuelEU Maritime public consultation

Detailed T&E briefing

September 2020

Summary

FuelEU Maritime legislation should pursue a dual goal: 1) create predictable demand for green hydrogen(-based) fuels or direct use of electricity, 2) incentivise ships to increase their energy efficiency (i.e. reduce energy consumption per transport work) and also tap into other sustainable alternative power sources that are not defined as "fuel", especially wind-assist technologies. In combination, these would help the industry to better absorb the extra costs of using expensive sustainable alternative marine fuels, incentivise innovation, reward early movers and deliver deep and steep GHG cuts.

To achieve this, we recommend a hybrid approach that combines low-carbon energy standard (LCES) and vessel energy intensity standard per transport work - dubbed in this briefing as **Carbon and Energy Intensity Standard (CEIS)**. Such a standard can be designed in a way to give the regulator the possibility to **directly** and **separately** target the necessary improvements on fuel carbon intensity, as well as vessel energy intensity.

We also recommend FuelEU Maritime legislation to adopt a full life-cycle approach, incorporating all GHG, including CO_2, CH_4 and N_2O and apply REDII sustainability criterion of 70% reduction threshold for qualifying sustainable advanced fuels. Alternative fuels that do not meet this threshold should not be allowed for regulatory compliance. In addition, we recommend all food/feed-based biofuels to be automatically excluded from the list of compliant fuels and cap the contribution of advanced (i.e. agricultural residue-based) biofuels at 1% of the onboard energy use by mass.

Lastly, we recommend implementing a robust enforcement regime, including fuel certification based on the sustainability criterion of REDII and dissuasive penalties.

1. Introduction

We welcome the EC initiative to develop an effective EU regulation to drive the uptake of sustainable alternative fuels in EU shipping. We agree with the EC assessment that creating a predictable demand in the shipping industry is essential for the investment and mass scale deployment of sustainable alternative fuels.

To ensure a right and realistic pathway to the deployment of sustainable advanced marine fuels and power sources, FuelEU Maritime regulation should choose a regulatory architecture in order to avoid lock-in with unsustainable fuels, provide enough flexibility for the variety of sustainable options and in parallel incentivise overall efficiency improvements in existing and new vessels. As such:

1. ***Prescriptive blending mandates*** undermine all of these goals and therefore should be discarded, especially after the experience of blending mandates in the Renewable Energy Directive.
2. ***Goal-based low carbon energy standard (LCES)*** - *gCO_2/kWh* - provides some degree of flexibility to shipowners, but ignores other power sources such as wind-assist and batteries[1] and does not credit energy efficiency improvements on board. However, LCES can still be valuable to provide certainty for future investments if combined with energy efficiency mechanisms.
3. ***Hybrid approaches combining energy efficiency and LCES***, as detailed in section 2.1.1. and 2.12 below, on the other hand, can provide flexibility to shipowners/operators in choosing their preferred compliance method, deliver energy efficiency improvements, but still give the regulator the ability to directly mandate LCES improvements in an appropriate time horizon.

The following sections provide further detail for T&E's recommended regulatory architecture, but also important sustainability and enforcement considerations that need to be considered in designing FuelEU Maritime legislation.

[1] This is under the assumption that FuelEU Maritime would function under the MRV architecture which (indirectly) provides on-board energy use info only via fuel consumption. Hence, energy stored in batteries is not taken on board.

2. Question 12[2] - Architecture of the regulation

2.1. Q.12a - for ships in navigation

A holistic approach is needed to ensure EU regulation fully encompasses the complexity of the shipping sector. On the one hand, EU regulation should create predictable demand for green hydrogen(-based) fuels or direct use of electricity at a pace where every ship has the possibility to choose the most optimal solution. On the other hand, ships should be incentivised to increase their energy efficiency (i.e. reduce energy consumption per transport work) and also tap into other sustainable alternative power sources that are not defined as "fuel", especially wind-assist technologies. The EU Clean Energy Package supported the principle of 'energy efficiency first', as 'the easiest way of saving money for consumers and for reducing greenhouse gas emissions'.[3] **The combination of these two goals would help the industry to better absorb the extra costs of using expensive sustainable alternative marine fuels, incentivise innovation, reward early movers and deliver deep and steep GHG cuts.**

To create such a holistic mechanism, a comprehensive vessel energy monitoring (MRV) system is needed to understand how much energy ships use for propulsion and auxiliary energy generation and associated total CO2 emitted. This should include mechanical energy derived from on-board fuel combustion, but also from electricity stored in on-board batteries, as well as wind (incl. Flettner rotors, rigid and soft sails, kite wings and airfoils) and solar.

Unfortunately, EU shipping MRV regulation covers the energy use and CO2 emitted only from on-board fuel combustion. This, as a result, ignores energy use from other GHG-free power sources mentioned above, but also energy savings from exhaust heat recovery systems, hull lubrication, etc. Academic research and initial deployments indicate significant GHG savings from these "non-fuel" power sources.[4]

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[2] For ease of read, the section headings and subheadings are codified to match the consultation questions. E.g. Q.12a means *part A* of *question 12*. Subheadings that don't have codings denote that there were no sub-questions in the consultation and that categorisation in this document has been made for the ease of read.

[3] https://ec.europa.eu/info/news/energy-efficiency-first-accelerating-towards-2030-objective-2019-sep-25_en

[4] See e.g. Comer, B., Chen, Ch., Stolz, D., Rutherford, D. (2019), *Rotors and bubbles: Route-based assessment of innovative technologies to reduce ship fuel consumption and emissions*, ICCT; Jonathan, K. et al. (2016), *Study on the analysis of market potentials and market barriers for wind propulsion technologies for ships*, for European

That being said, it is still possible to *indirectly* take account of these non-fuel related power sources (and savings) by using transport-work as a denominator of the vessel's overall energy/carbon intensity. To put it simply, by showing how much energy a vessel consumes to carry out a unit of transport work (e.g. 1 tonne-nm), it is possible to take account of non-fuel related power sources (or savings) of ships and associated avoided GHG emissions. We believe there are 2 ways to incorporate alternative non-fuel power and efficient vessel energy management into the framework of a goal-based energy carbon intensity standard using EU MRV as an underlying framework.

2.1.1. Option 1: combined energy efficiency and low-carbon energy standard

T&E believes that a combined goal-based carbon and energy intensity standard (CEIS) would be the most appropriate tool to trigger not only the deployment of advanced alternative fuels in the sector, but also improvements in energy efficiency. Such a standard can be designed in a way to give the regulator the possibility to *directly* and *separately* target the necessary improvements on fuel carbon intensity as well as vessel energy intensity.

CEIS can be expressed as a function of vessel energy intensity per transport work and on-board fuel carbon intensity per energy.

$$CEIS = \frac{kWh}{t{-}nm} * \frac{gCO2}{kWh}$$

Such a formula allows directly targeting the two separate terms on the right side of the equation as demonstrated by the below equation.

Commission; *Norsepower Rotor Sails confirmed savings of 8.2 % fuel and associated CO2 in Maersk Pelican project*, 2019, https://maersktankers.com/media/norsepower-rotor-sails-confirmed-savings

$$CEIS_t = \overbrace{(EI_b * (1 - a_i))}^{\text{Required vessel energy intensity (kWh/t-nm)}} * \overbrace{(ECI_b * (1 - b_i))}^{\text{Required energy carbon intensity (gCO2/kWh)}}$$

Where:

$CEIS_t$ - required carbon & energy intensity in the compliance year
EI_b - average energy intensity of vessels of the same type and size in the baseline year (kWh/t-nm)
ECI_b - average energy carbon intensity in the baseline year (gCO2/kWh)
a_i - required reduction target in the compliance year, e.g. 30% improvement target means $a_i = 0.3$
b_i - required reduction target in the compliance year, e.g. 30% improvement target means $b_i = 0.3$

Given that it would be up to the regulator to decide on individual reduction targets (expressed as a_i and b_i in the above formula), it is possible to set differentiated reduction rates for either term depending on the ship age, type and/or availability of sustainable alternative marine fuels. For example, the following time and age-based differentiation could be applied:

- The regulator could require only vessel energy intensity targets (EI) until 2025 and then vessel energy intensity (EI) + energy carbon intensity (ECI) beyond 2025.
- Much higher energy carbon intensity (ECI) targets could be set for new vessels built e.g. after 2025 (including, full ZEV mandates). Gradually such a mandate could be extended to existing fleet of certain age (e.g. <15 years) to force retrofitting existing vessels.

The rationale for such a differentiation would be that it might be economically unviable to retrofit the old (>15 years) legacy fleet to run on sustainable/scalable yet expensive alternative green fuels, such as green H_2 or NH_3. But in order to ensure that everybody contributes to decarbonisation, they should at least be required to improve their energy efficiency (technically[5] and operationally), which in many cases would actually deliver cost cuts to operators.[6] For the relatively new fleet and future newbuilds,

[5] Analyses show that ships built between 1985-2005 had worse energy efficiency than the period preceding or following those years. CE Delft & UMAS, *Study on methods and considerations for the determination of greenhouse gas emission reduction targets for international shipping* (2019).
[6] Graichen, J. (2019), *Impact of slow steaming for bulk carriers - Assessment of the impacts on transport costs for different ship sizes,* Oeko Institut.

however, retrofitting or pre-installing H_2/NH_3 propulsion systems is expected to be feasible and cost-effective.[7] Therefore, it would be sensible to require the relatively new fleet and future newbuilds to drive the deployment of alternative marine fuels, while the oldest legacy fleet still contributing to climate efforts via energy efficiency improvements.

All the data required for this regulatory option is available, directly or indirectly, under the EU MRV regulation and can be implemented with relative ease. Minor revision to MRV could be required, specifically, requiring ships to convert in their annual reporting the total fuel consumption to energy consumption (in e.g. kWh) using a pre-defined conversion factor(s).

2.1.2. Option 2: energy efficiency credits under low-carbon energy standard

An alternative method is to incorporate a vessel energy intensity (efficiency) adjustment factor to a goal-based low-carbon energy standard (LCES). This can be implemented using the below formula.

$$ECI_t = ECI_b * (1 - c_i * \frac{EI_{t-1}}{EI_b})$$

Where:

ECI_t - energy carbon intensity in the compliance year (gCO2/kWh)
ECI_b - average energy carbon intensity in the baseline year (gCO2/kWh)
c_i - required reduction target in the compliance year, e.g. 30% improvement target means $c_i = 0.3$
EI_{t-1} - vessel energy intensity in the year preceding the compliance year (kWh/t-nm)
EI_b - average energy intensity of vessels of the same type/size in the baseline year (kWh/t-nm)

Such a mechanism would provide the regulator with the ability to set requirements for the fuel/energy carbon-intensity (ECI) improvements, but allow shipowners/operators to reduce their required ECI targets if they improve the vessel's overall energy efficiency per transport at the same time. This would reward early movers in technological innovation and ensure that early investments are incentivised. The impact on absolute GHG reduction would be positive, too.

In practice, under this method the regulator would set the overall energy carbon intensity (ECI) reduction targets (c_i in the equation above), but the required reduction levels would be automatically adjusted downward proportionate to the same ship's overall energy efficiency improvements in the same period (compared to fleet average baseline). For example, the regulator could set a 50% energy carbon intensity (ECI) improvement target for 2030. If ship A improves its energy intensity (efficiency)

[7] Lindstad, E. (forthcoming), *Fuels and engine technologies with focus on GHG and Energy utilization*, SINTEF; UMAS & Lloyd's Register (2020), *Techno-economic assessment of zero-carbon fuels*.

per transport work by 20% between 2018 and 2029 (baseline and the year preceding the target year), then its ECI target for 2030 would be reduced proportionately and be 40% improvement instead.

All the data required for this regulatory option is available, directly or indirectly, under the EU MRV regulation and can be implemented with relative ease. Minor revision to MRV could be required, specifically, requiring ships to convert in their annual reporting the total fuel consumption to energy consumption (in e.g. kWh) using a pre-defined conversion factor(s).

2.2. Q.12b - for ships at berth

European shipping emitted about 6% of its total CO2 while at berth. Coupled with considerable air pollution, at-berth GHG emissions have significant impact on the environment and climate and should be tackled as a matter of urgency.

Shore-side electricity (SSE) is technologically advanced and can be deployed in many cases. It is the simplest and likely the cheapest option to fully decarbonise ships at berth, but also eliminate air pollution. But the reality is that not all ports might be able to provide it, e.g. small islands that serve as the major touristic destinations that receive large cruise ships. Ships' at-berth energy demand can be larger than those islands' entire energy system. So, a more flexible regulatory architecture could be preferable: i.e. a goal-based zero-emissions berth standard.

Under a goal-based zero-emissions berth standard, using SSE could be a default option. However, exemption from default option can apply only if SSE is not ***technicaly*** feasible **and/or** if ships could demonstrate implementing equivalent technical options to eliminate all emissions (GHG and non-GHG alike).

Such a zero-emissions berth mandate should be complemented with a stringent SSE (or equivalent) infrastructure mandate under the AFID: i.e. ports being required to provide either SSE or other equivalent zero-emissions energy bunkering infrastructure for ships. The EU could also establish an interface for the cooperation between ports and ships in order to identify the at-berth energy demands of ships and agreeing on the best infrastructure investments.

3. Question 13 - Regulatory scope

3.1. Q.13a - Ship types and credit system

By definition all economic sectors and transport modes servicing those sectors should contribute to climate efforts, including the deployment of sustainable alternative fuels/energy. However, given the technical diversity of ship types, the introduction timeline of new technologies might have to differ. Therefore, instead of the regulator deciding on the timeline of regulation for individual ship types, a flexible credit exchange system can be established to act as a cushion for technology/fuel deployment in different ship classes.

Such a credit exchange system could also provide flexibility to shipowners/operators to manage the decarbonisation of their fleet. For example, companies that are keen to deliver full zero-emissions vessels in the near future can overachieve the regulatory requirements in specific (new) ships, and use overachievement credits to balance out underachievements in the old legacy fleet.

3.2. Q.13b - Geographical scope

Alternative sustainable fuels/energy are currently more costly to produce than conventional fossil fuels. However, according to literature, production costs can be significantly reduced with the economies of scale in supply.[8] In order to justify large-scale land-based investments in alternative fuel production and bunkering infrastructure, there is a need to ensure demand predictability in shipping. This can be achieved either by requiring, in a goal-based manner, *large uptakes* of green electricity, hydrogen or ammonia by a *small number of ships* in a small geographical scope, or by a *gradually increasing* fuel uptakes by a *larger number of ships* in a larger geographical scope. We are of the opinion that the latter would be a more cost-effective and fair way to incentivise the uptake of sustainable advanced marine fuels and distribute the efforts among many actors.

For this reason, we recommend that FuelEU maritime regulation applies to the full scope of the EU MRV regulation in order to unleash economies of scale in land-based industries. In parallel, it is essential to ensure robust sustainability criteria and exclude food-based biofuels from the scope, as explained below, in order to avoid wide-scale deployment of unsustainable fuels.

[8] E.g. see Ash, N. and Scarbrough, T. (2019, *Sailing on Solar Could green ammonia decarbonise international shipping?*, Ricardo Energy & Environment.

4. Question 14 - Sustainability and scalability of fuels

Alternative fuels for maritime transport are multiple. But not all alternative fuels are equally sustainable or scalable. Some alternatives have been demonstrated to have even worse environmental or climate impact than the current liquid fossil fuels.[9,10] We consider renewable electricity, renewable hydrogen and ammonia to be the cleanest alternative fuels to be supported for decarbonising the shipping sector.

4.1. Life-cycle emissions and sustainability criteria

Carbon intensity improvements must be measured on a life-cycle basis and should cover emissions from on-board combusions and slippage, as well as emissions and leakages during the production/extraction (directly and indirectly), transportation, refining and bunkering. Unfortunately, the current RED and FQD methodologies to calculate GHG emissions **do not include** Indirect Land Use Change emissions of biofuels.

In addition to LCA, FuelEU Maritime initiative should be consistent with the REDII criteria and contain a sustainability criterion of -70% GHG emissions compared to the fossil fuel emissions. Meaning the alternative fuels that do not meet -70% threshold on a life-cycle basis should not be allowed for compliance purposes. Under the regulatory architecture of a LCES or LCES component of CEIS as explained in section 2.1.1. above, alternative fuels that offer more than -70% life-cycle GHG improvements will be credited with proportionately higher savings. This would incentivise the use of the best performing fuels. Compared to a volume mandate, the LCES and CEIS would enable a competition for best performing technologies while giving clear market signals and incentives for the cleanest fuels. On the contrary, a volume or energy mandate doesn't provide a special value to the fuels with the highest savings. The only important condition is to pass the GHG threshold. A volume mandate is thus more likely to drive the cheapest fuel options, but not the ones which deliver the highest GHG savings. An approach based on the carbon intensity of the energy will require robust GHG accounting for each fuel technology, as well as a robust impact assessment to avoid driving additional volumes of unsustainable alternative fuels.[11]

[9] Globiom: the basis for biofuels policy post-2020.
https://www.transportenvironment.org/publications/globiom-basis-biofuel-policy-post-2020
[10] Natural gas in vehicles - on the road to nowhere.
https://www.transportenvironment.org/publications/natural-gas-vehicles-%E2%80%93-road-nowhere
[11] REDII national implementation - How member states can deliver sustainable advanced transport fuels, T&E, 2020,

For short-lived climate pollutants (SLCPs), such as methane, assessing their Global Warming Potential (GWP) over a shorter time frame of 20 years in parallel to an assessment over 100 years provides valuable policy insights into the best way to reach our overall emission reduction goals. SLCPs can have a huge climate impact in the short-term which is not revealed by statistics that only consider a 100-year GWP. For example, methane is 86-87 times more polluting than carbon dioxide over a 20-year time, but from a 100-year perspective it is 34-36 times more polluting than CO_2. As a result, processes that have high methane emissions (e.g. LNG dual-fuel ships) are perceived as less damaging to the climate than they are in reality, when only looking at the GWP100 (even though they are still worse than HFO/MGO ships even from GWP100 perspective).[12] If and when methane is considered as a transport fuel, dual accounting of both GWP100 and GWP20 is crucial. This will reveal the huge potential in emissions savings that will result from tackling these SLCPs and guide policy decisions that can significantly contribute to emission reduction efforts over the next 30 years to 2050.[13]

To conclude, compliance with the FuelEU Maritime regulation should be based on WTW LCA. Only fuels with 70% reduction potential compared to fossil fuel equivalents on LCA basis should be qualified. In calculating the LCA, 20GWP should be used.

4.2. Excluding and capping biofuels

Because of the sustainability issues associated with crop-based biofuels , we recommend excluding all fuels (liquid and gaseous) produced from agricultural crops from the scope of the future regulatory framework. The amount of advanced biofuels that is available at sustainable levels for the transport sector is extremely limited. The REDII provides already a specific target for advanced biofuels produced from feedstocks listed in Annex IX part A and limits the contribution of feedstocks listed in part B. The amount of sustainable waste feedstocks (waste oils and fats) available is extremely limited and most of it is already used in FAME biodiesel production for the road sector. This leaves shipping with only limited types of other feedstocks (e.g. agricultural residues). Because of the important energy demand in shipping, existing and future competing uses (e.g. aviation) as well as sustainability issues with current classification of advanced biofuels, it seems important to cap the contribution of advanced biofuels (part A and B) in the shipping framework. Such a limit could be set at e.g. 1% of the

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https://www.transportenvironment.org/sites/te/files/publications/2020_01_REDII_general_implementation_briefing.docx_.pdf

[12] Pavlenko, N. et al, (2020), *The climate implications of using LNG as a marine fuel*, ICCT.

[13] For more details on T&E's position on the Global Warming Potential of methane, see our position here: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12231-Union-inventory-system-global-warming-potentials-and-internationally-agreed-guidelines-to-be-used-in-reporting/F510071

overall volume of fuel consumed on board of ships. A specific impact assessment will be needed to determine the maximum contribution. More information about the sustainability issues with the RED framework for advanced biofuels here.

Instead, EU legislation should support new fuels such as renewable electricity, renewable hydrogen and ammonia which can be scaled up over time to meet the demands of the sector. It will be crucial for the EU to develop a robust sustainability and accounting framework for electrofuels at EU level, in order to ensure a sustainable uptake of these fuels in the maritime sector.

4.3. Multipliers for green electricity-based fuels

More and more research concludes that shipping will have to rely on green electricity-based fuels/energy for long-term decarbonisation.[14] Renewable electricity-based fuels, however, do come with different expended energy intensities (i.e. the amount of energy needed to produce 1kWh of fuel) and production costs (i.e. €/kWh of fuel).

From the environmental and energy transition perspective, the cheaper and the less energy intensive the e-fuel/energy, the better. For that reason, it is appropriate for the regulator to incentivise the uptake of the least energy intensive and cheapest green e-fuel/energy possible.

Using multipliers is one way to incentivise the uptake of green e-fuels/electricity under the FuelEU Maritime initiative. In practice, this would mean that e.g. the impact of using an X amount of green liquid hydrogen would be multiplied in order to achieve the required regulatory target.

Multipliers can be determined as a function of energy intensity of the relevant e-fuel/energy, as suggested by the table 1.

Renewable Fuels/energy	Fuel energy intensity (kWh/kWh)[15]	Multipliers
liquid e-H2	1.84	2.50

[14] UMAS & Lloyd's Register (2020), *Techno-economic assessment of zero-carbon fuels*; Ash, N. and Scarbrough, T. (2019, *Sailing on Solar Could green ammonia decarbonise international shipping?*, Ricardo Energy & Environment; Korean Registry, *Forecasting the Alternative Marine Fuel - Ammonia*, 2020;
[15] Transport & Environment, 2017.

liquid e-Ammonia	1.84	2.50
liquid e-Methane	2.39	1.75
liquid e-Gasoil (marine)	2.88	1.00
Electricity	1.05	4.00

Table 1: e-fuel energy intensity and relevant multipliers.

4.4. Enforcement and compliance

Achieving the objectives of the FuelEU Maritime initiative will require stringent enforcement and compliance. In practice, ship owners/operators, as regulated entities, will have to demonstrate that the fuel/energy they used to comply with the goal-based targets comply with the EU sustainability rules. How? The sustainability of renewable transport fuels has typically been monitored by means of certification schemes: Fuel suppliers need to demonstrate that the delivered fuels significantly reduce carbon emissions and comply with all applicable criteria (e.g. no production on high carbon stocks for biofuels). Under the proposed carbon and energy intensity reduction goals, ship owners/operators would also need to use sustainability certificates attached to their bunker delivery notes.

However, there are lessons to be drawn from the biofuels debacle and the certification of the sustainability of first generation biofuels produced from food and feed crops.[16] First of all, certification schemes are only as credible as the sustainability criteria that underpin them. For example, the certification of biofuels like palm oil did not take into account the Indirect Land Use Changes. As a result, the carbon footprint of biofuels was severely underestimated. Secondly, certification schemes for biofuels have suffered in the past of insufficient verification procedures. For example, a certification scheme for waste-based biofuels like used cooking oil (UCO) needs to be able to trace the source of the waste throughout the supply chain. Too often, verification procedures have been a paper exercise with fraud as a result.[17] Moreover, the governance structures of certification schemes have not been transparent and been marked by conflicts of interest.

16 https://www.transportenvironment.org/news/sustainable%E2%80%99-biofuels-certification-challenged-eu-auditors

17 https://www.euractiv.com/section/all/news/industry-source-one-third-of-used-cooking-oil-in-europe-is-fraudulent/

T&E sees a major role for electrofuels like hydrogen and ammonia as zero-emission fuels for the shipping. But given the nascent state of the electrofuels industry, sustainability criteria and certification schemes for renewables-based hydrogen and ammonia is still missing. The revised Renewable Energy Directive has tasked the European Commission to develop by the end of 2021 a framework on how to ensure that so-called Renewable Fuels of Non-Biological Origin (RFNBO) are produced with additional renewable energy. Discussions with stakeholders are ongoing about a methodology that assesses the greenhouse savings of these RFNBO and how to ensure that they are produced with additional renewable energy. In the absence of such a methodology to assess the greenhouse gas savings and other sustainability criteria, there are currently no certification schemes for such zero-emission fuels that are produced inside the EU. Moreover, some of these electrofuels may be cheaper to import from outside the EU, but verification of whether these fuels from outside the EU are produced with additional renewable energy - as required by the Renewable Energy Directive - will be challenging.

T&E calls on the European Commission to closely coordinate the work on FuelEU Maritime initiative with the ongoing discussions on sustainability criteria for Renewable Fuels of Non-Biological Origin under the Renewable Energy Directive. Enforcement and compliance must be an integral part of those discussions and can provide a sound basis for a carbon and energy intensity standard for the shipping sector to deliver meaningful emission reductions.

To sum up, stringent and ambitious sustainability criteria and effective certification schemes for renewables-based electrofuels can boost an emerging electrofuels industry in the EU and help incentivise more bunkering in the EU, provided weaknesses observed with current certification schemes are closed. In the mid to long-term this would help the EU's climate diplomacy to promote its superior environmental and climate standards in other regions as well.

Finally, the EU should implement robust enforcement mechanisms, including penalties for non-compliance. Ideally, such a penalty would apply each excess tonne of CO2 that was emitted due to non-compliance, be dissuasive (e.g. >€100/tonne_CO2) and increase considerably in case of repeated non-compliance.

5. Question 15 - Emissions scope - greenhouse gases

Traditionally, CO_2 has been the only contributor to climate change in shipping. However, with the deployment of LNG ships, methane (CH_4) emissions is becoming an increasingly important climate pollutant for shipping (fig. 1).

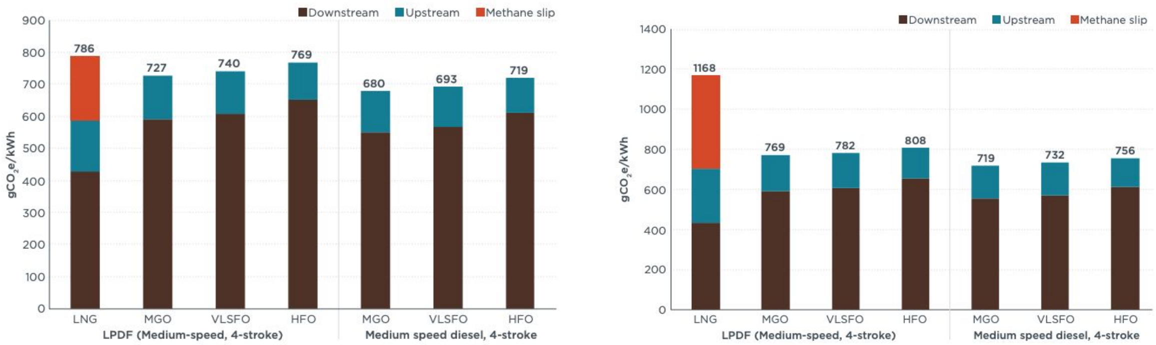

Figure 1: Life-cycle GHG emissions by fuel type for engines suitable for cruise ships, (left: 100-year GWP; right: 20-year GWP).[18]

Currently ships also emit very small amounts of nitrous oxide (N_2O) from existing marine engines, which is a very potent greenhouse gas. It is expected that N_2O may be produced in similar or greater quantities to existing machinery/fuel in future ammonia combusting machinery designs for marine applications. The academic community has studied ammonia catalysis for a number of candidate applications, some of which claim to have ~100% N_2O removal rates, depending on the parameters used.[19] N_2O emission control is also a common step in many industrial/chemical processes (e.g. nitric acid production) and ostensibly, there are a number of mature solutions (catalysts) capable of removing N_2O from these processes.[20] The most recent research concluded that it is likely that a selective catalytic reduction (SCR) system could be designed to address N_2O and NO_x in combination.[21]

Even though the literature and experience from other sector give confidence that N_2O from NH_3 engines could be controlled using aftertreatment systems, it is still essential to incorporate any potential N_2O emissions in the life-cycle GHG emissions from alternative marine fuels, including from NH_3 combustion in marine engines.

[18] ICCT, 2020. Accessible at:
https://theicct.org/sites/default/files/publications/LNG%20as%20marine%20fuel%2C%20working%20paper-02_FINAL_20200416.pdf

[19] See e.g. Pels J.R., Verhaak M.J.F.M. (2000) Selective Catalytic Reduction of Nitrous Oxide with Hydrocarbons using a SO2 Resistant Fe/zeolite Catalyst. In: van Ham J., Baede A.P.M., Meyer L.A., Ybema R. (eds) Non-CO2 Greenhouse Gases: Scientific Understanding, Control and Implementation. Springer, Dordrecht.

[20] See e.g. https://www.topsoe.com/processes/nitrous-oxide-removal

[21] *Ammonfuel – An Industrial View Of Ammonia As A Marine Fuel*, Contributors: Alfa Laval, Hafnia, Haldor Topsøe, Vestas, Siemens Gamesa, August 2020.

To conclude, any goal-based target should be holistic and incorporate all life-cycle greenhouse gas emissions, including CO_2, CH_4 and N_2O from shipping and be expressed in CO_2 equivalent terms. In doing so, GWP20 should be used to calculate the climate impact of maritime emissions.

Further information

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