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CIMAC Position Paper

Future Marine eFuels

From the CIMAC Greenhouse Gas Strategy Group

The first edition of this CIMAC Position Paper was approved by the members of the CIMAC Council by correspondence on October 12, 2021.

GHG Reduction in Shipping

CIMAC regards the deployment of net zero or zero carbon fuels as necessary to achieve the needed long-term GHG emission reductions in shipping set out by IMO and most recently the EU. Similarly, the recently published IPCC report[1] emphasizes the urgency of pursuing a global reduction in CO_2 emissions as early as the 2020s. For coastal shipping, those fuels are equally important but there are additional options – such as batteries and fuel cells – already available or under development. However, this position paper is focusing on net zero and zero carbon fuels since they represent the biggest lever to achieve climate neutral shipping.

Drivers are needed

Due to technical and economic challenges described in this paper, drivers are needed to promote the uptake of new fuels in shipping. In this decade until 2030 the main focus of the industry will be to develop reliable propulsion, fuel supply and logistics technologies and bringing them into market at scale. The urgency in moving beyond demonstration projects is clearly stressed by the recent IPCC report. Therefore, a definite and predictable legal framework which promotes the development and scaling of (net) zero carbon fuels until decarbonization in 2050 is essential to secure the necessary high investments of the coming years. This legal framework needs to be homogenous and consistent, and ideally it is defined on a global level.

In that regard, the intention of this position paper is to indicate which eFuels are most relevant for future propulsion systems from today's point of view and comment on policy measures to promote the uptake of these fuels.

While this document tries to give a first overview, CIMAC is going to publish white papers in the near future to look into the details of different (fuel) options and technologies.

Main criteria for future marine fuels

Fundamentally, future marine fuels will have to meet a certain number of criteria to be competitive with their fossil counterparts and suitable for long-distance shipping:

- based on renewable energy sources
- high energy density
- available on a global scale within defined and standardized qualities, respective rules and regulations (well-to-wake approach[2])
- suitability for use in the engine and propulsion systems existing or expected to be developed
- availability[3] of infrastructure for production, logistic and bunkering
- cost competitive in the long term

[1] IPCC Climate Change (2021) – The Physical Science Basis
[2] CIMAC White Paper 4 I 2020 – Importance of a Well-to-Wake Approach
[3] For certain future marine fuels, existing infrastructure may still be used, while for others it needs to be adapted or newly built, creating additional costs during the transition phase.

While these requirements may limit the fuel options in the future, there is no silver bullet in sight yet. It is rather unlikely that a clear indication on one or two major fuel options in 2040 or 2050 becomes realistic within this decade. Nevertheless, it is possible to discuss the potential of eFuels as it focuses on long term viable and scalable options.

As stated in the CIMAC Position Paper "*Zero Carbon Energy Sources for Shipping*"[4] from February 2020, the contribution of sustainably produced biofuels (gas or liquid)[5] as a future zero carbon energy source for deep-sea shipping can play a role in particular for the transition period, as long as volume constraints are solved without compromising the sustainability. However, while we see biofuels as a useful bridging technology, we are not addressing them in this position paper.

Zero Carbon eFuels

In principle, zero carbon fuels have an important advantage over synthetic hydrocarbon fuels: They are obviously more cost effective than carbon-based fuels due to a lower energy intensive production route. But consideration needs to be given also to the lower energy density; this is of concern when the storage and transportation requirements are considered. Furthermore, international regulations for the safe use of these fuels in ships remains to be developed by the IMO. To assess the use of zero carbon fuels over synthetic fuels, a well to wake approach is required to ensure the net GHG emissions do not exceed those of hydrocarbon fuels.

Hydrogen

Advantages: A certifiable well-to-wake approach is possible, and hydrogen is feasible for point-to-point shipping where fuel availability can be guaranteed. Production of H_2 based on renewable energy sources requires fewer processing steps than synthetic fuels based on carbon.

Disadvantages: Hydrogen has a low volumetric energy density, high reactivity, is difficult to store and commercially viable H_2 propulsion technologies, i.e. fuel cells and hydrogen engines are anticipated to be available in the lower power range for ships between 2025 and 2030. The current combustion technology of hydrogen – in reciprocating internal combustion engines – is not yet mature and is undergoing vigorously development efforts. Respective regulatory framework must be a fore-runner which is in fact not the case. Large volumes and storage requirements as well as safety issues pose a challenge to the application of H_2 as a fuel which might limit its practical uptake and very much limits its usage in deep-sea shipping.

Ammonia

Advantages: Supply chain and regulations for ammonia already exist today, the production technology is mature, and it is relatively easy to produce. It can be used as a carbon-free energy source in both internal combustion engines and fuel cells. Dual-fuel engines will be the most promising avenue for ammonia use in the maritime sector.[6] While it is currently traded as a fertilizer feedstock, the handling and infrastructure to use it as such is already in place at many ports around the world and should allow for rapid deployment as a fuel.

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[4] CIMAC Position Paper 01 I 2020 – Zero Carbon Energy Sources for Shipping
[5] These kind of biofuels are typically called 2nd or 3rd generation biofuels.
[6] Öko-Institut (2021) – Ammonia as a marine fuel, p.34

Disadvantages: The fuel is toxic, which implies special handling requirements. To address the risks of ammonia, amendments to the IGF and IGC code are required to enable its use a fuel in shipping.[7] The use of NH_3 in internal combustion engines needs continued development with commercial ammonia expected to be available between 2025 and 2030. Lower energy density compared to a diesel reference needs to be considered. NO_x emissions would need to be handled by NO_x reduction systems already known from conventional engines. Future engine tests must minimize ammonia slip by optimizing the engine. Remaining ammonia slip and possible N_2O emissions could also be remedied by exhaust gas aftertreatments. High investments in tank and supply systems – comparable to LNG – are necessary.

Net zero carbon eFuels

Carbon-based fuels can be expected to be more expensive than zero carbon fuels due to a higher energy intensive production route[8]. The storage and transport would be less complex and therefore cheaper; also due to the fact that an existing infrastructure of fossil fuels can be used. Moreover, these fuels can be used in an existing fleet, even as a drop-in fuel[9]. For new ships, there will probably be a trade-off between fuel costs and infrastructure expenses.

eMethane

Advantages: The fuel properties are comparable to natural gas or, in liquefied form, LNG, which is why methane is also referred to as drop-in fuel. Synthetic Methane can be burned in today's gas engines and can be refueled, stored, and transported using existing gas infrastructure. For new LNG vessels it offers the opportunity to reduce the CO_2-footprint as a drop-in.

Disadvantages: In addition to the basic price disadvantage of CH_4, the investments for on-board LNG storage are also quite high for newbuilds. Consequently, losses during production, storage, handling and combustion (methane slip) must be minimized and reduced by additional measures, such as aftertreatment of engine exhaust gases.

eMethanol

Advantages: The globally established production of grey methanol and locally already green methanol offers planning security with regard to supply capacities in the near future and can already lead to reduced pollutant emissions from engine exhaust gases today. Compared to other net zero carbon fuels, CH_4O offers a relatively high energy density. Furthermore, methanol is a liquid which means it is easier to be handled in tanks which can be included in the ships structure, rather than high-pressure tanks for gases. In addition to that, the IMO has developed interim guidelines, creating an international standard for the use of methanol as a fuel.[10]

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[7] Öko-Institut (2021) – Ammonia as a marine fuel, p.45

[8] Fuels containing carbon could be produced at prices comparable to zero carbon fuels if point sources for carbon are used (point source means other CO_2-emitters with high concentration, e.g. cement plants). This becomes irrelevant on the long run, however, when direct air capture needs to be taken into account as a sustainable source for CO_2.

[9] Drop-in fuels are compatible with conventional engines and can be used without modification as a substitute for fossil fuels.

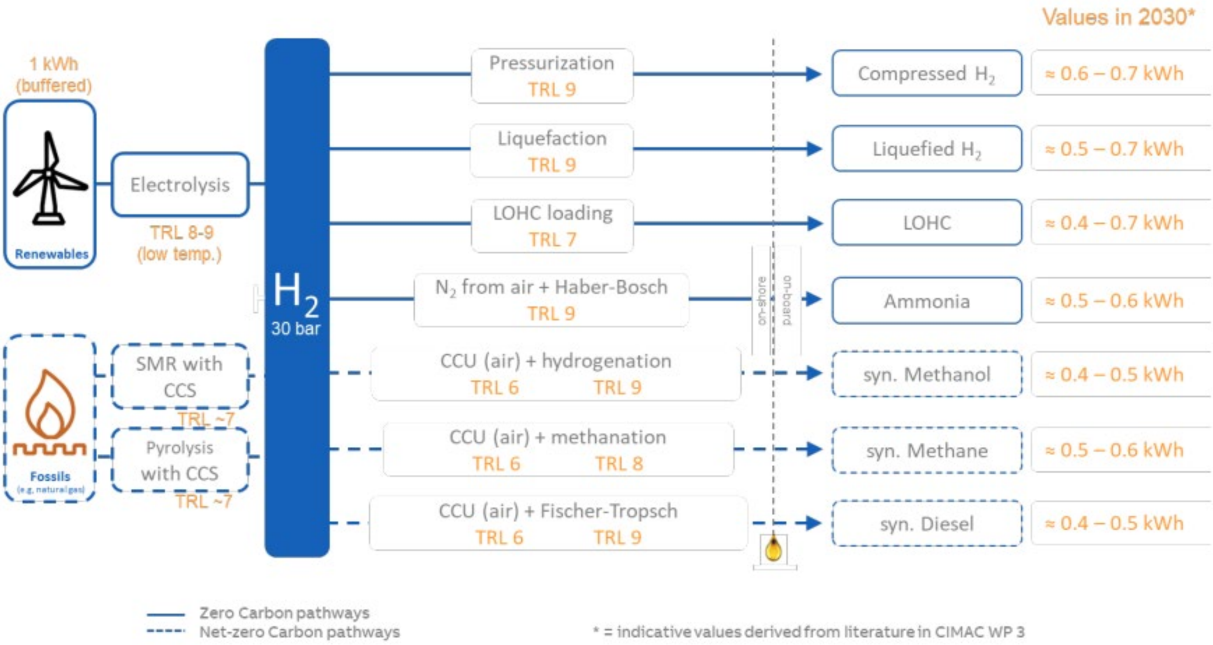
[10] DNV (2021) – Maritime forecast to 2050, p.36

Disadvantages: The fuel itself is toxic, requires different safety precautions, is a low flash point fuel, furthermore the energy content is only about half that of marine fuels used today.

eDiesel

Advantages: The fuel is compatible with existing technologies and current infrastructure and can be blended with fossil diesel. Without a solution for the in-service fleet, the ambitious GHG reduction targets are very difficult to be met. Thus, eDiesel can greatly facilitate the transition to CO_2-free mobility, also and especially for the existing fleet, many of which have a potential lifetime until at least 2040.

Disadvantages: Due to the additional process steps and higher energy need in production, eDiesel represents a relatively expensive eFuel. The fuel is not yet sufficiently available today, and is not expected to be before 2030. There is direct competition with the aviation industry (synthetic kerosene), but this could prove to be an advantage as the same production technology (Fischer Tropsch) is used, which could lead to positive cost scaling effects.



[11]

Political framework

IMO's Initial Greenhouse Gas Strategy for shipping in international waters aims for reduction targets of the carbon intensity of transport work of at least -40% by 2030 and at least -70% by 2050, both related to the reference year 2008. To deal with these targets on a single-vessel-level the IMO adopted in MEPC76 the measures EEXI and CII.[12] Additionally, the first intermediate yearly reduction rates for the CII are defined until 2026. Further intermediate steps are to be decided at the

[11] CIMAC White Paper 3 I 2020 – Efficiencies and Maturities of (Net) Zero Carbon Fuel Pathways
[12] IMO MEPC 76 (2021) – Further shipping GHG emission reduction measures adopted

end of 2025. Alternative fuels are currently judged according to a tank-to-wake approach. A far more sustainable well-to-wake approach is currently being discussed but not yet adopted.

On 14 July, the EU Commission presented its proposal for new regulation aiming at reducing the GHG intensity of energy used on board in a well-to-wake perspective (FuelEU Maritime). This proposal includes dedicated reduction rates of the GHG intensity every 5 years aiming for a total reduction of -75% GHG intensity of energy used on board ships in 2050 based on reference values from the year 2020. Compliance units from single vessel over-achieving reduction targets are proposed to be transferable within a fleet of ships. Further, it is proposed that ships not reaching the GHG intensity reduction targets – either individually or as part of a fleet – should pay a penalty to an EU-fund aimed at the rapid deployment of renewable and low carbon fuels in the maritime sector.

Considering the ongoing discussion on how to deal with global warming in all industry sectors worldwide, it seems necessary to find technical solutions for a complete decarbonization of the shipping sector as well. Zero and net zero carbon fuels are a game changer in this regard, as they enable a (net) zero carbon propulsion of ships. However, timing is a crucial aspect that has not been sufficiently addressed at the political level so far.

CIMAC hence takes the following position

Well-to-Wake perspective

While electrification and hybridization could probably play a greater future role in short-sea shipping and inland navigation, using synthetic fuels to reduce the carbon intensity are essential for deep-sea shipping. Due to the current variety of options, there will be not one single fuels type to gain decarbonization of the global shipping industry. For a fair judgement of their comparison of the GHG impact of these different fuel types, the regulatory framework must be based on the well-to-wake approach, and all relevant greenhouse gases (CO_2, CH_4, N_2O, etc.) must be considered. This is the only way to ensure that shipping delivers a net-reduction of GHG emissions on a global scale.[13]

Technology neutrality

To achieve the best possible solution, a technology open approach is mandatory. This includes a technology neutral approach to fuels, energy converters and auxiliary systems. Technology neutrality ensures continuous competition and thus constant improvement of technical solutions.

Fleet-level approach

To incentivize first movers to invest in new vessels and technologies, a fleet-level approach would be appropriate. This is crucial in order to promote the early uptake of new fuels and technologies, thereby allowing the shipping industry to achieve the ambitious targets in a cost-efficient way.

[13] CIMAC White Paper 4 I 2020 – Importance of a Well-to-Wake Approach

Imprint

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