Development of a methodology to assess the 'green' impacts of investment in the maritime sector and projects

FINAL REPORT

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List of abbreviations and acronyms

Abbreviations	
AER	Annual Efficiency Ratio
AFS	Anti-Fouling Systems
AMP	Alternative Maritime Power
BAT	Best Available Technology
BC	Black carbon
BEP	Best Environmental Practice
BWM	Ballast Water and Sediments
CBI	Climate Bond Initiative
CFD	computational fluid dynamics
CII	Carbon Intensity Indicator
CO2	Carbon Dioxide
DG MOVE	Directorate-General for Mobility and Transport
DNSH	Do-No-Significant-Harm
EC	The European Commission
ECA	Emission Control Area
ECSA	European Community Shipowners' Association
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Index
EEXI	Efficiency Existing Ship Index
EGCS	Exhaust Gas Cleaning Systems
EGR	Exhaust Gas Re-circulation
ESPO	European Sea Ports Organisation
ESSF	European Sustainable Shipping Forum
EU	The European Union
Feport	Federation of European Private Port Companies and Terminals
GBP	Green Bond Principle
ILUC	Indirect land use change
HDV	Heavy Duty Vehicles
IHM	Inventory of Hazardous Materials
IMO	International Maritime Organisation
LNG	Liquified Natural Gas
MGO	Marine gas oil

MoS	Motorways of Sea
MRV	Monitoring, Reporting and Verification
N2	Nitrogen
NACE	The Statistical classification of economic activities in the EU
NOx	nitrogen oxides
OPS	Onshore Power Supply
OVID	offshore vessel inspection database
PtX	Power-to-X
R&D	Research and Development
R&I	Research and Innovation
RD&I	Research, Development and Innovation
ROI	Return On the Investment
SCR	Selective Catalytic Reduction
SEA	Shipyards’ & Maritime Equipment Association
SEEMP	Ship Energy Efficiency Management Plan
SOLAS	Safety of Life at Sea
SOx	sulphur oxides
SRTI	Ship Recycling Transparency Initiative
TBT	tributyltin
TEG	Technical Expert Group
ToR	Terms of Reference
TTW	Tank-to-wake
WBS	White Box System
WTW	Well-to-wake

ABSTRACT

This study examines which maritime economic activities could be considered environmentally sustainable in line with the EU Taxonomy Regulation and proposes technical screening criteria for those economic activities. The technical screening criteria determine whether an activity can be considered to substantially contribute to one of the Taxonomy Regulation's environmental objectives and not significantly harm the other environmental objectives. To inform the development of the technical screening criteria, the study first investigates the latest developments in the maritime shipping sector and examines state-of-the-art decarbonisation technologies to establish a broader context. To better understand the diversity of activities that can contribute to one of the environmental objectives, the study maps the relevant economic activities according to their NACE codes as well as their potential impacts on the environmental objectives. Based on these considerations, the study discusses the general principles for setting the technical screening criteria for the sector and proposes specific criteria. The primary focus of the study is on activities that substantially contribute to climate mitigation and adaptation objectives. The screening criteria for other environmental objectives are considered to a lesser extent. To assess the impacts of different levels of stringency of the criteria, a high level market assessment is performed discussing the impacts of different scenarios on green finance supply and demand. The need for monitoring for ensuring that potential claims of greenwashing are avoided and costs and benefits associated with it are discussed. Finally, the characteristics of shipping finance are discussed with a focus on the potential for scaling up green finance in the maritime sector.

EXECUTIVE SUMMARY

Context of the study

The European Green Deal is the cornerstone of European Union climate policy. It establishes the clear target of becoming climate neutral by 2050. To reach this ambitious goal, it will require reducing EU's GHG emissions by at least 55% by 2030 compared to 1990 levels and 90% in transport emissions by 2050. This objective is embedded in the Sustainable and Smart Mobility Strategy adopted at the end of 2020.

All transport modes including maritime sector will need to contribute to this objective. Shipping is one of the least carbon intensive ways to transport goods. However, it constitutes a significant share of the total global emissions, corresponding to 2.9% of anthropogenic CO_2 emissions. To reduce the emissions from maritime transport, the European Commission (EC) aims to propose measures, to work alongside with the ongoing work at International Maritime Organisation (IMO) level. Those measures include incorporating the maritime sector into the European Emission Trading System (ETS), the Fuel EU Maritime initiative to boost the demand for sustainable alternative fuels as well as the reviews of the directives on energy taxation, alternative fuel infrastructure, and renewable energy.

The achievement of the Green Deal objectives will require significant investments. The Green Deal reaffirms the EC's commitment to pursue green finance and investment while ensuring a just transition. The EU Taxonomy to facilitate sustainable investment plays a pivotal role in shifting capital flows towards sustainable investments. According to the Sustainable and Smart mobility Strategy, the technical screening criteria based on the Taxonomy should be defined for all transport modes by 2021.

However, the initial proposal for technical screening criteria for the Taxonomy developed by the Technical Expert Group on sustainable finance (TEG) did not include the maritime sector. While the TEG agreed that the work on maritime criteria should be prioritised, given its potential contribution to the greening of the transport sector, it could not conclude its assessment within the time available. Furthermore, according to the Taxonomy Regulation, all relevant economic activities within a specific sector (e.g. transport) should be covered if they contribute equally towards the environmental objectives, to avoid distorting competition in the market. This study was therefore launched by the Commission to fill the gap in the TEG's initial analysis and assess which economic activities and under which conditions could be considered environmentally sustainable in line with the Taxonomy Regulation. The climate mitigation and adaptation criteria for maritime shipping in the Commission 2021 Delegated Regulation supplementing the Taxonomy Regulation are based on the analysis and findings of this study. In addition, a draft final report was in January 2021 submitted to the Platform on Sustainable Finance to assist their further work.

Decarbonisation of shipping

The maritime shipping sector faces challenges in decarbonisation due to a lack of market-ready low-carbon technologies and -fuels. The stakeholders confirm that the European shipping industry is committed to taking a leading role in decarbonising the sector, highlighting that such efforts will require active contribution of all actors in the maritime value chain, including shipyards, engine manufacturers, classification societies, ports, energy companies and the fuel suppliers.

A crucial element in ensuring a pathway to carbon neutrality is the identification and scaling up of the global market of alternative fuels. The uptake of alternative fuels will be dependent on further technological innovations (i.e. new propulsion technologies with optimised energy use) and supply of such fuels and availability of bunkering infrastructure. Facilitating these developments requires appropriate regulatory framework, technological experimentation through large-scale demonstration and deployment projects and support to investments. The investments made in RD&I before 2030 will have a significant impact in the sector's ability to reach the long-term objective of climate neutrality.

The shipping sector has been successful in making continuous improvements in energy efficiency of vessels, which plays an important role in the greening of the existing fleet. The Fourth IMO GHG Study (2020) shows that the carbon intensity of the international shipping has improved by 21% and 29% (measured in Annual Efficiency Ratio (AER) and Energy Efficiency Operational Index (EEOI)) compared to 2008. However, there are still are significant improvements to be made in terms of operational- and design efficiency in the short-term perspective ranging from better hull design and propulsion efficiency devices to speed and capacity optimisation.

The current COVID-19 situation and it impact on global supply chains brings further uncertainty to the shipping sector, but can also offer opportunities for greening the fleet and striving for further efficiency gains.

Technical screening criteria for substantial contribution to climate mitigation

General principles

When setting the screening criteria for substantial contribution to the climate mitigation objective, it is important that the economic activities demonstrate consistency with the EU's mid-term and long-term climate objectives. The EU Taxonomy differentiates between the economic activities that are near-zero carbon emissions and transitional activities. As there are very few (or no) low-carbon solutions readily available for the shipping industry, most of the economic activities within the maritime shipping would qualify as transitional activities.

The transitional activities to substantially contribute to climate mitigation objective should incentivise the transition to a climate-neutral economy consistent with a pathway to limit the temperature increase to 1,5°C and should:

- have GHG emission levels that correspond to the best performance in the sector or industry;
- not hamper the development and deployment of low-carbon alternatives; and
- not lead to a lock-in in carbon-intensive assets considering the economic lifetime of those assets.

The technical screening criteria need to be differentiated to account for the diversity of the shipping sector. The sector is characterised by a variety of ship types, sizes, range of operations, trade patterns, value-chains and business models, and its international nature. As such, a one-size-fits-all approach in shipping could be challenging and could potentially prove to be counterproductive.

Shipping is a global industry, to large extent falling under the IMO regulations. Therefore, the technical screening criteria can be linked to the measures developed by the IMO, such as EEDI or the EEOI. The alignment of the EU Taxonomy with the work of the IMO would help ensure the level playing field on the shipping market. At the same time, the EU's ambitious target on climate neutrality could require significant efforts to reduce emissions from shipping going beyond what is currently proposed by the IMO.

The technical screening criteria should be technology neutral in line with the Taxonomy Regulation. The shipping stakeholders also advocate for technological neutrality, highlighting that at this stage of the development of green technologies in the maritime sector, it is important not to choose the technological pathways, as no single solution exists that can replace fossil fuels.

Due to transitional nature of the shipping activities, the technical screening criteria are proposed to be time-bound, i.e. until 2025 and beyond 2025.

Screening criteria for substantial contribution to climate mitigation until 2025

The technical screening criteria until 2025 focuses on greening of shipping operations and facilitating carbon neutral shipping. The key considerations when developing the screening criteria included compatibility with the IMO framework, ability to capture diversity of vessels and business models, support for zero emissions vessels, enabling R&D on alternative fuels and infrastructure as well as distinguishing between new-builds and retrofitting.

During the course of this study, the consultants have been advising the Commission services in developing the criteria for maritime shipping, with a main focus on climate mitigation and adaptation. The final report presents and analyses the technical screening criteria for the sea and coastal freight and passenger water transport as included in the draft Delegated Regulation supplementing the Taxonomy Regulation, published for public feedback on 20/11/2020.

The criteria in the final Delegated Regulation may differ due to the adjustments the Commission may decide to introduce following the public feedback and discussion with the Member States.

- *Zero emissions vessels: The vessels have zero direct (tailpipe) CO_2 emissions;*
- *Hybrid vessels that achieve significant GHG emissions reductions: Until 31 December 2025, hybrid vessels use at least 50 % of zero direct (tailpipe) CO_2 emission fuel mass or plug-in power for their normal operation.*
- *Enabling modal shift of freight: Until 31 December 2025, and only where it can be proved that the vessels are used exclusively for provision of coastal services designed to enable modal shift of freight currently transported by land to sea, the vessels have direct (tailpipe) CO2 emissions, calculated using the International Maritime Organization (IMO) Energy Efficiency Design Index (EEDI), 50 % lower than the average reference CO2 emissions value defined for heavy duty vehicles (vehicle sub group 5-LH) in accordance with Article 11 of Regulation 2019/1242;*
- *Supporting the best in class new vessels: Until 31 December 2025, the vessels have an attained Energy Efficiency Design Index (EEDI) value 10 % below the EEDI requirements applicable on 1 April 2022.*
- *Retrofitting of vessels to improve energy efficiency: Until 31 December 2025, the retrofitting activity reduces fuel consumption of the vessel by at least 10 % expressed in grams of fuel per deadweight tons per nautical mile, proven by computational fluid dynamics (CFD), tank tests or similar engineering calculations.*
- *For any categories above, vessels are not dedicated to the transport of fossil fuels.*

There are currently few examples of smaller battery powered ships and some ongoing R&D projects on the use of hydrogen which could qualify under the zero emission criterion. Hybrid and dual-fuel propulsion vessels can in future provide significant reduction of GHG emissions in short sea shipping. However, with 50% alternative power again today only few vessels would qualify, in particular ferries and high-speed ferries with integrated batteries. Both zero emission and hybrid and dual-fuel propulsion criteria encourage further innovations in new propulsion technologies and alternative fuels, which is crucial for achieving climate neutrality.

The criterion enabling modal shift follows the TEG proposal to set similar thresholds across modes, with an aim to promote modal shift as a greater proportion of fleets in lower carbon modes are Taxonomy eligible. To avoid greenwashing, this criterion can be used only to finance the operation with a proved potential of modal shift and not to build or retrofit ships, and ex-post monitoring could be necessary.

The ‘Best in class’ criterion is benchmarked to the IMO Energy Efficiency Design Index EEDI. The stringency of the measure has been debated, since for some segments a relatively large number of existing ships are more than compliant. In line with this, IMO has decided to strengthen Phase 3 requirements for several ship types and to bring forward their entry into effect from 2025 to 2022. The Taxonomy criterion is therefore tied to these new more stringent requirements. Based on the EEDI values attained for vessels (2013-2019), and reported in the IMO EEDI database, around 12% of all EEDI ships have an attained EEDI value 10% below of the EEDI requirements.

In view of the significant variation in the attained EEDI, an alternative approach to using a fixed percentage of the EEDI reference line could be a requirement that a vessel needs to be equal to or better than the 10% lowest EEDI scores of similar ships. However, for time being the number of registered vessels in some vessel types is too small to be statistically representative. The 10% lowest EEDI scores approach could become more practicable over the time as data availability in the IMO EEDI database improves.

Given the long lifespan of vessels, it is important that taxonomy incentivise the improvement of energy efficiency of the existing fleet. In particular, older more pollution ships could have a great energy saving potential, in best cases even more than 20%. These developments are encouraged via the retrofitting criterion.

The technical screening criteria in the draft Delegated Regulation used the same approach for assessment of emissions for all transport modes, which is based on tailpipe emissions (often called tank-to-wheel or TTW). Using the same approach for maritime shipping has the advantage that it is consistent with the approach taken in the taxonomy framework for other transport modes and is easy to use given that it is design based and does not need additional monitoring at the stage of operations. It also incentivises technological energy efficiency improvements as well as the uptake of technologies relying on fuels that potentially emit no GHG and air pollutants. However, on the other hand, zero TTW emissions fuels, as produced today, can generate significant amount of emission in the production process, often require dedicated ship designs, hydrogen- or ammonia-powered ships are not yet commercially viable and a rollout of bunkering infrastructure will take many years.

Compared to a TTW approach, a well-to-wake (WTW) approach takes the upstream GHG emissions into account and would open up the opportunities for immediate use of sustainable biofuels, synthetic methane, diesel or methanol, which can be used in conventional ships or blended with conventional fuels. In some cases, they can also use existing bunkering infrastructure, therefore having potential of immediate emission reductions. However, the WTW approach can only be implemented when financing operations, because the design of the ship may be the same as the design of a ship running on fossil fuels, and it requires ex post monitoring.

Following the TEG approach, the transportation of fossil fuels should not be eligible under the EU Taxonomy. However, this criterion could be difficult to apply to shipping because of the versatility of ships. The same dry bulk carrier can as an example, carry coal, ore, wood chips, fertiliser or grain. To avoid penalising best-in-class and zero emissions tankers and bulk carriers, which can carry versatile cargo including renewable fuels, it can be relevant to consider how to operationalise the definition of ‘dedicated’.

Screening criteria for substantial contribution to climate mitigation beyond 2025

Compared to the criteria until 2025, it is expected that the criteria will be tightened over time as new technologies are developed and currently innovative technologies become standard. The criteria should also reflect the latest developments at EU and IMO levels, as well as support continuous energy efficiency improvements, incentivise renewable and low carbon fuels and vessels.

It is recommended that after 2025, the modal shift criterion is discontinued and the new best-in-class criterion is carefully considered to avoid lock-in effect until 2030, and discontinued when commercially scalable zero emission solutions become available and shipping should no longer be considered a transitional activity. Furthermore, it is also recommended that in addition to design criteria, an operational criterion is introduced to incentivise operational means of GHG emissions reductions.

The following criteria have been proposed:

- *Zero emissions vessels: The vessels have zero direct (tailpipe) CO_2 emissions;*
- *Hybrid and dual fuel propulsions vessels that achieve significant GHG emissions reductions: Until 31 December 2030, hybrid vessels deriving at least 50% of their energy from zero tailpipe CO_2 emission fuels or plug-in power for their normal operation; OR Until 31 December 2030, hybrid and dual fuel vessels using at least 60% of their energy from non-fossil origin or electricity for their normal operation;*
- *Retrofitting of vessels to improve energy efficiency: Until 31 December 2030, the retrofitting activity reduces fuel consumption of the vessel by at least 10 % expressed in grams of fuel per deadweight tons per nautical mile, proven by computational fluid dynamics (CFD), tank tests or similar engineering calculations.*

The following two best-in-class criteria focus on different elements, the first one – on the operational performance of vessels, the second – on design of vessels.

- *Decreasing carbon intensity of the fleet – operational criterion: Until 31 December 2030, vessels that have achieved carbon intensity expressed in Energy Efficiency Operational Index (EEOI) /Carbon Intensity Indicator (CII) below certain thresholds*
- *Identification of the most energy efficient new vessels – design based criterion: Until 31 December 2030, the vessels have an attained Energy Efficiency Design Index (EEDI) value equal to or better than the 10% lowest EEDI scores of similar ships that entered the fleet in the three years prior to the time of the assessment; or the vessels have an attained Energy Efficiency Existing Ship Index (EEXI) equal to or better than the 10% lowest EEXI scores of similar ships; or the vessels have an attained EEDI or EEXI 10%*

below the EEDI/EEXI requirements applicable as from 1 January 2025, whichever value is lower (better).

Each of the criteria has its own benefits and drawbacks in terms of its use. The benefits of design criteria are that they allow ships' green properties to be assessed prior to their construction. It is thus a theoretical exercise, which enables to estimate ex-ante whether a vessel complies with a green threshold based on the estimated effects of used and new technologies. The benefits of operational criteria are that they focus on real emissions and enable ship performance to be accurately evaluated. However, it is challenging to implement in practice as the shipping sector and vessel types are highly diverse, and the operational efficiency can significantly vary from year to year (e.g. due to change in route, cargo or weather).

The proposed criteria should be carefully re-evaluated in 2025 to ensure that new developments in the shipping sector are accounted for.

Do-No-Significant-Harm criteria

Another key requirement is that economic activities need to comply with in order to qualify with the Taxonomy requirements is that "no significant harm" is caused to any of the other environmental objectives.

In the shipping sector, DNSH criteria have to ensure that no significant harm is attributed to the activities that qualify under the climate mitigation criteria, taking into account that, despite the relatively low CO_2 emissions, freight and passenger shipping can have significant negative impacts on air, water, noise and vibrations, and marine ecosystems.

Screening criteria for other environmental objectives

The maritime sector can also contribute to other environmental objectives. The initial assessment of the screening criteria for other environmental objectives identified the different activities that can be considered in the EU Taxonomy are summarised in the table below.

Substantial contribution to:	Relevant economic activities
Climate adaptation	Not relevant directly to ship operations but relevant to port infrastructure by increasing their climate resilience
Sustainable use/ protection of water & marine resources	Technologies improving water management: e.g. installation of WBS, sewage treatment
Transition to a circular economy	Recycling of ships; Recycling of waste generated on board; Reuse of dredged sediment
Pollution prevention and control	Safety islands; Noise reduction measures; Technology to reduce NO_X; Onshore power
Protection of biodiversity & ecosystems	Deterrents and other measures to protect biodiversity; Ballast water treatment and management; Support to integrated ocean management

Need for monitoring

The study identified different challenges that can lead to greenwashing. These include the lack of common definitions / framework to identify which types of investments can be identified as green, use of transitional technologies like LNG without accounting for the methane slip, and the use of EEDI without monitoring of the actual performance of ships.

To avoid any potential risk of greenwashing and ensure a level playing field, transparent monitoring and reporting plays a key role. Reporting can be performed on ex-ante and ex-post basis. An ex-ante assessment is performed when an investment is considered for eligibility as green. Once an investment is made, it should be monitored to ensure that it complies with the given criteria over time or performs as initially anticipated. Monitoring of operational performance is already in place for certain segments of the shipping sector, such as the EU MRV requirements applicable to vessels above 5000 GT.

Scaling up green finance in the shipping sector

The maritime sector is a highly capital-intensive industry, characterised by a large share of debt in the capital structures of shipping companies. Historically, debt financing from banks has provided most of the finance and it remains the primary source of finance. However, since the financial crisis of 2008 there has been a 36% decrease in shipping lending from the top 40 international banks that finance shipping, leaving the sector to obtain capital from alternative streams of finance. Banks that remain active in shipping are likely to lend to shipping companies that display strong corporate cultures and those that align their business with Basel III and upcoming Basel IV regulation, as well as other measures such as the Poseidon Principles.

Despite overall high demand for green investment opportunities in financial markets, the current landscape of green finance in the European maritime sector is limited, due in part to the nature of the shipping sector's global interconnectedness, uncertainty about technology pathways, and capital-intensive investment needs. In 2019, maritime shipping accounted globally for less than 1% of climate-aligned financing.

To support the scaling up of green finance, the challenges that the shipping companies face need to be tackled. The challenges related to financial risks and low credit ratings could be supported through credit enhancement measures. For the uptake of green measures, diversity of business models and contractual arrangements in the sector brings about a range of different incentives, which in turn promotes different financial agreements and the pursuit of different green measures.

The technological uncertainty of climate transition in the sector needs to be minimised, to avoid companies investing in assets that in few years could become stranded assets. This could be supported through further R&D and demonstration projects as well as support for promising technologies and fuels. As long as very few low-carbon solutions are readily available, it is important to finance also activities that incentivise the transition to a climate-neutral economy. It is equally crucial to consider how to facilitate the access to financing for SMEs.

Considering that notably passenger- and offshore ships, as well as other special ships, are strong industries with full value chains within Europe, ensuring their access to green finance contributes to strengthening the EU's maritime sector. A comprehensive European approach is the more important given that the Asian markets, and particularly the Chinese market, are strengthening their international positions in global supply chains and are growing increasingly dominant in the global shipping sector.

The EU Taxonomy will play a pivotal role by providing more clarity to the market participants on what can be considered green.

RÉSUMÉ EXÉCUTIF

Contexte de l'étude

Le "Pacte vert" européen est la pierre angulaire de la politique climatique de l'Union européenne. Il établit des objectifs clairs afin de parvenir à un impact climatique neutre d'ici 2050. Dans cette optique, il faudra réduire les émissions de gaz à effet de serre de l'UE d'au moins 55 % d'ici à 2030 par rapport aux niveaux de 1990, et de 90% dans le domaine des transports d'ici à 2050. Ces objectifs sont pris en compte à cet effet dans la stratégie pour une mobilité durable et intelligente, qui a été adoptée à la fin de l'année 2020.

Tous les modes de transport devront contribuer à l'atteinte cet objectif, y compris le secteur maritime. En effet, le transport maritime est l'un des modes de transport générant le moins de gaz carbonique, lorsqu'il s'agit du transport de marchandises et de fret. Cependant, le transport maritime représente 2,9% des émissions anthropiques de CO_2, ce qui constitue une part importante des émissions mondiales totales. Pour réduire les émissions du transport maritime, la Commission européenne (CE) a donc l'intention de proposer des mesures correctives, en complément des travaux en cours au niveau de l'Organisation maritime internationale (OMI). Ces mesures comprennent l'intégration du secteur maritime dans le système européen d'échange de quotas d'émissions (SEQE), l'initiative "Fuel EU Maritime" visant à stimuler la demande de carburants de substitution durables ainsi que la révisions des directives sur la taxation de l'énergie, les infrastructures de carburants alternatifs et les énergies renouvelables.

La réalisation des objectifs du Pacte vert nécessitera des investissements importants. Le Pacte réaffirme l'engagement de la Commission européenne (CE) à poursuivre ses efforts afin d'encourager les investissements 'verts' visant à l'atténuation des effets du changement climatique, tout en assurant une transition juste. La taxonomie verte de l'UE joue un rôle central dans la réorientation des flux de capitaux vers des investissements durables. Selon la stratégie pour une mobilité durable et intelligente, les critères de sélection technique basés sur la taxonomie devraient être définis pour tous les modes de transport d'ici 2021.

Cependant, la proposition initiale de critères de sélection techniques pour la taxonomie, élaborée par le groupe d'experts techniques sur la finance durable (GET), prend le parti de ne pas inclure le secteur maritime. Bien que le GET se soit accordé sur la priorité à inclure le secteur maritime dans l'étude, compte tenu de sa contribution potentielle à le verdissement du secteur des transports, les experts ont manqué de temps pour conclure leur évaluation dans les délais impartis. En outre, conformément au règlement sur la taxonomie, toutes les activités économiques pertinentes au sein d'un secteur spécifique (par exemple, le transport) doivent être couvertes si elles contribuent de manière égale aux objectifs environnementaux afin d'éviter de fausser la concurrence sur le marché. Cette étude a donc été lancée par la Commission pour combler les lacunes de l'analyse initiale du GET et d'évaluer quelles activités économiques et sous quelles conditions peuvent être considérées durables d'un point de vue environnemental conformément au règlement sur la taxonomie. Les critères d'atténuation et d'adaptation pour la navigation maritime dans le règlement délégué de 2021 de la Commission complétant le règlement sur la taxonomie sont basés sur l'analyse et les conclusions de cette étude.

En outre, un projet de rapport final a été soumis en janvier 2021 à la Plateforme pour une finance durable afin d'aider des travaux ultérieurs.

Décarbonisation du transport maritime

Le secteur du transport maritime est confronté à des défis en matière de décarbonisation en raison d'un manque de technologies et de carburants à faible teneur en carbone prêts à être utilisés sur le marché. Malgré tout, les parties prenantes confirment que l'industrie européenne du transport maritime s'est engagée à jouer un rôle de premier plan dans la décarbonisation du secteur, en soulignant que ces efforts nécessiteront la contribution active de tous les acteurs de la chaîne de valeur maritime, y compris les chantiers navals, les fabricants de moteurs, les sociétés de classification, les ports, les entreprises énergétiques et les fournisseurs de carburant.

L'identification et le développement du marché mondial des carburants de substitution est un élément crucial pour assurer une voie vers la neutralité carbone. L'adoption des carburants de substitution dépendra des innovations technologiques (c'est-à-dire des nouvelles technologies de propulsion avec une utilisation optimisée de l'énergie), de l'offre de ces carburants et de la disponibilité des infrastructures de soutage. Pour faciliter ces développements, il faudra évidemment développer un cadre réglementaire approprié, stimuler le progrès technologique par la recherche et également le financement de projets expérimentaux permettant de tester les nouvelles trouvailles, et initier une expérimentation à plus grande échelle. Les investissements réalisés dans la RD&I avant 2030 auront un impact significatif sur la capacité du secteur à atteindre les objectifs à long terme fixés par la Commission européenne.

Le secteur maritime a effectué avec succès des améliorations constantes dans l'efficacité énergétique des navires, qui joue un rôle important dans le verdissement de la flotte existante. La quatrième étude de l'OMI sur les gaz à effet de serre (2020) montre que l'intensité carbone du transport maritime international s'est améliorée de 21 % et 29 % (mesurée par le rapport d'efficacité annuel (AER) et l'indice opérationnel d'efficacité énergétique (EEOI)) par rapport à 2008. Toutefois, il faudra tout de même redoubler d'efforts quant à l'efficacité opérationnelle et de conception des bateaux et infrastructures à plus court terme, en encourageant par exemple la recherche sur l'amélioration de la conception de la coque, des dispositifs d'efficacité de propulsion ou de l'optimisation de la vitesse et de la capacité.

Les conséquences de la crise de la COVID-19 et son impact sur les chaînes d'approvisionnement mondiales rend la situation incertaine, et les progrès réels difficile à évaluer, mais peuvent également offrir des opportunités pour s'efforcer de réaliser de nouveaux gains d'efficacité et rendre la flotte plus verte.

Critères de sélection techniques pour une contribution substantielle à l'atténuation du climat

Principes généraux

Lors de l'établissement des critères de sélection pour une contribution substantielle à l'objectif d'atténuation du climat, il est important que les activités économiques restent cohérentes avec les objectifs climatiques de l'UE à moyen et long terme. La taxonomie de l'UE distingue les activités économiques dont les émissions de carbone sont proches de zéro et les activités transitoires. Étant donné qu'il existe très peu (ou pas) de solutions à faible émission de carbone pour l'industrie navale, la plupart des activités économiques du secteur de la navigation maritime sont considérées comme des activités transitoires.

Afin de prétendre à contribuer substantiellement à l'objectif d'atténuation du climat, les activités transitoires devraient encourager une transition vers une économie neutre sur le plan climatique, conformément à une trajectoire visant à limiter l'augmentation de la température à 1,5°C. Plus précisément elles devraient:

- Assurer un niveau d'émission de gaz à effet de serre (GES) correspondant aux meilleures performances du secteur ou de l'industrie;
- Ne pas entraver le développement et le déploiement d'alternatives à faible teneur en carbone; et
- Ne pas conduire à un verrouillage des actifs à forte intensité de carbone compte tenu de la durée de vie économique de ces actifs.

Les critères de sélection technique doivent être différenciés pour tenir compte de la diversité du secteur du transport maritime. En effet, ce secteur se caractérise par une grande variété de types de navires, de tailles, d'opérations, de modèles commerciaux, de chaînes de valeur et de modèles d'entreprises, ainsi que par sa nature internationale. Une approche unique dans le secteur maritime pourrait donc s'avérer difficile et potentiellement contre-productive.

Le transport maritime est une industrie globale, qui relève dans une large mesure des règlements de l'OMI. Par conséquent, les critères de sélection technique peuvent être liés aux mesures élaborées par l'OMI, telles que l'EEDI ou l'EEOI. L'alignement de la taxonomie de l'UE sur les travaux de l'OMI contribuerait à garantir des conditions de concurrence équitables sur le marché du transport maritime. Par ailleurs, l'objectif ambitieux de l'UE en matière de neutralité climatique pourrait nécessiter des efforts plus importants de la part de l'industrie pour atteindre les résultats actuellement envisagés par l'OMI.

Les critères de sélection technique devraient être neutres sur le plan technologique, conformément au règlement sur la taxonomie. Les parties prenantes du secteur maritime plaident également pour la neutralité technologique, soulignant qu'à ce stade du développement des technologies vertes dans le secteur maritime, il est important de ne pas choisir les voies technologiques, car il n'existe pas de solution unique pouvant remplacer les combustibles fossiles.

En raison de la nature transitoire des activités de transport maritime, il est proposé que les critères de sélection technique soient limités dans le temps, c'est-à-dire jusqu'en 2025 et au-delà de 2025.

Critères de sélection pour une contribution substantielle à l'atténuation des effets du changement climatique à horizon 2025

Les critères de sélection technique jusqu'en 2025 sont axés sur le verdissement des opérations de transport maritime et sur la facilitation du transport maritime neutre en carbone. Les principaux éléments pris en compte lors de l'élaboration des critères de sélection incluent la compatibilité avec le cadre de l'OMI, la capacité à prendre en compte la diversité des navires et des modèles commerciaux, le soutien aux navires à émissions nulles, la possibilité de mener des activités de R&D sur les carburants et les infrastructures de substitution, ainsi que la distinction entre les nouvelles constructions et la modernisation.

Au cours de cette étude, les consultants ont participé au développement des critères de sélection s'agissant de la navigation maritime, avec un accent particulier sur l'atténuation et l'adaptation aux effets du changement climatique. Le rapport final présente et analyse les critères de sélection technique pour le transport maritime et côtier de marchandises et de passagers tels qu'ils sont inclus dans le projet de règlement délégué complétant le règlement sur la taxonomie, publié pour commentaires publics le 20/11/2020.

Les critères figurant dans le règlement délégué final peuvent différer en raison des ajustements que la Commission peut décider d'introduire à la suite des réactions du public et des discussions avec les États membres.

- *Navires à zéro émission: Les navires n'ont aucune émission directe de CO2 (« pot d'échappement »);*
- *Les navires hybrides réalisant d'importantes réductions d'émissions de GES: Jusqu'au 31 décembre 2025, les navires hybrides utilisent au moins 50 % de masse de carburant à émissions directes (à l'échappement) de CO_2 nulles ou une alimentation rechargeable pour leur fonctionnement normal.*
- *Permettre le transfert modal du fret: Jusqu'au 31 décembre 2025, et uniquement lorsqu'il peut être prouvé que les navires sont utilisés exclusivement pour la fourniture de services côtiers destinés à permettre le transfert modal du fret actuellement transporté par voie terrestre vers la mer, les navires ont des émissions directes (à l'échappement) de CO2, calculées à l'aide de l'indice de conception de l'efficacité énergétique (EEDI) de l'Organisation maritime internationale (OMI), inférieures de 50 % à la valeur moyenne de référence des émissions de CO2 définie pour les véhicules utilitaires lourds (sous-groupe de véhicules 5-LH) conformément à l'article 11 du règlement 2019/1242;*
- *Soutenir les nouveaux navires obtenant les meilleurs résultats dans leur catégorie: jusqu'au 31 décembre 2025, les navires ont une valeur d'indice de conception d'efficacité énergétique (EEDI) atteinte inférieure de 10 % aux exigences EEDI applicables au 1er avril 2022.*
- *Réaménagement des navires afin d'améliorer l'efficacité énergétique: Jusqu'au 31 décembre 2025, l'activité de modernisation réduit la consommation de carburant du navire d'au moins 10 %, exprimée en grammes de carburant par tonne de port en lourd par mille nautique, ce qui est prouvé par la dynamique des fluides numérique (CFD), des essais en cuve ou des calculs techniques similaires.*
- *Pour toutes les catégories ci-dessus, les navires ne sont pas dédiés au transport de combustibles fossiles.*

Il existe actuellement quelques exemples de petits navires alimentés par des batteries et quelques projets de R&D en cours sur l'utilisation de l'hydrogène qui pourraient répondre au critère d'émission zéro. Les navires à propulsion hybride et biocarburant peuvent à l'avenir permettre une réduction significative des émissions de GES dans le transport maritime à courte distance. Toutefois, avec 50 % d'énergie de substitution, seuls quelques navires pourraient remplir les conditions requises, en particulier les ferries et les ferries à grande vitesse équipés de batteries intégrées. Les critères d'émission zéro et de propulsion hybride et biocarburant encouragent les innovations dans les nouvelles technologies de propulsion et les carburants alternatifs, ce qui est crucial pour atteindre la neutralité climatique.

Le critère permettant le transfert modal suit la proposition du GET de fixer des seuils similaires pour tous les modes, dans le but de promouvoir le transfert modal, étant donné qu'une plus grande proportion de flottes dans les modes à faible émission de carbone est éligible à la taxonomie. Pour éviter l'éco blanchiment, ce critère ne peut être utilisé que pour financer l'opération dont le potentiel de transfert modal est avéré, et non pour construire ou moderniser des navires.

Le critère du "meilleur de sa catégorie" est comparé à l'indice de conception de l'efficacité énergétique de l'OMI (EEDI). La rigueur de la mesure a été débattue, car pour certains segments, un nombre relativement important de navires existants sont plus que conformes. C'est pourquoi l'OMI a décidé de renforcer les exigences de la phase 3 pour plusieurs types de navires et d'avancer leur entrée en vigueur de 2025 à 2022. Le critère de la taxonomie est donc lié à ces nouvelles exigences, plus strictes. Sur la base des valeurs EEDI atteintes pour les navires (2013-2019), et rapportées dans la base de données EEDI de l'OMI, environ 12% de tous les navires EEDI ont une valeur EEDI atteinte 10% en dessous des exigences EEDI.

Compte tenu de la variation significative de l'EEDI atteint, une approche alternative à l'utilisation d'un pourcentage fixe de la ligne de référence de l'EEDI pourrait consister à exiger qu'un navire soit égal ou supérieur aux 10% des scores EEDI les plus bas de navires similaires. Cependant, pour le moment, le nombre de navires enregistrés dans certains types de navires est trop faible pour être statistiquement représentatif. L'approche des 10% de scores EEDI les plus bas pourrait devenir plus pratique au fil du temps, à mesure que la disponibilité des données dans la base de données EEDI de l'OMI s'améliore.

Étant donné la longue durée de vie des navires, il est important que la taxonomie encourage l'amélioration de l'efficacité énergétique de la flotte existante. En particulier, les navires plus anciens et plus polluants pourraient avoir un grand potentiel d'économie d'énergie, dans les meilleurs cas même plus de 20%. Ces développements sont encouragés par le critère de mise à niveau.

Les critères de sélection technique dans le projet de règlement délégué ont utilisé la même approche pour l'évaluation des émissions pour tous les modes de transport, qui est basée sur les émissions d'échappement (souvent appelées tank-to-wheel ou TTW). L'utilisation de la même approche pour le transport maritime présente l'avantage d'être cohérente avec l'approche adoptée dans le cadre fiscal pour les autres modes de transport et d'être facile à utiliser étant donné qu'elle est fondée sur la conception et ne nécessite pas de surveillance supplémentaire au stade de l'exploitation.

Elle encourage également les améliorations technologiques de l'efficacité énergétique ainsi que l'adoption de technologies reposant sur des carburants qui n'émettent potentiellement pas de GES ni de polluants atmosphériques. Cependant, d'un autre côté, les carburants sans émissions de TTW, tels qu'ils sont produits aujourd'hui, peuvent générer une quantité importante d'émissions dans le processus de production, et nécessitent souvent des conceptions de navires spécifiques. Par ailleurs, les navires fonctionnant à l'hydrogène ou à l'ammoniac ne sont pas encore commercialement viables et le déploiement d'une infrastructure de soutage prendra de nombreuses années.

Par rapport à l'approche TTW, l'approche WTW (well-to-wake) tient compte des émissions de GES en amont et offrirait la possibilité d'utiliser immédiatement des biocarburants durables, du méthane synthétique, du diesel ou du méthanol, qui peuvent être utilisés dans des navires conventionnels ou mélangés à des carburants classiques. Dans certains cas, ils peuvent également utiliser les infrastructures de soutage existantes, ce qui offre un potentiel de réduction immédiate des émissions.

Cependant, l'approche GET ne peut être mise en œuvre que lors du financement d'opérations, car la conception du navire peut être la même que celle d'un navire fonctionnant avec des combustibles fossiles, et elle nécessite un contrôle a posteriori.

Selon l'approche du GET, le transport de combustibles fossiles ne devrait pas être éligible dans le cadre de la taxonomie européenne. Toutefois, ce critère pourrait être difficile à appliquer au transport maritime en raison de la polyvalence des navires. Un même vraquier sec peut, par exemple, transporter du charbon, du minerai, des copeaux de bois, des engrais ou des céréales.

Pour éviter de pénaliser les pétroliers, les vraquiers les plus performants et les plus respectueux de l'environnement, qui peuvent transporter des cargaisons diverses, y compris des carburants renouvelables, il peut être utile d'examiner comment rendre opérationnelle la définition de "dédié".

Critères de sélection pour une contribution substantielle à l'atténuation du changement climatique au-delà de 2025

Par rapport aux critères en vigueur jusqu'en 2025, il est prévu que les critères soient renforcés au fil du temps, à mesure que de nouvelles technologies soient développées et que les technologies actuellement innovantes deviennent la norme. Les critères devraient également refléter les derniers développements aux niveaux de la Commission européenne (CE) et de l'OMI, ainsi que soutenir les améliorations continues de l'efficacité énergétique, encourager les carburants et les navires renouvelables et à faible teneur en carbone.

Il est recommandé qu'après 2025, le critère de transfert modal ne soit plus appliqué et que le nouveau critère "meilleur de sa catégorie" soit soigneusement étudié afin d'éviter un effet de verrouillage jusqu'en 2030, et qu'il soit abandonné lorsque des solutions commercialement évolutives à émissions nulles soit rendues disponibles ou que le transport maritime ne soit plus considéré comme une activité transitoire. En outre, il est également recommandé qu'en plus des critères de conception, un critère opérationnel soit introduit pour encourager les moyens opérationnels de réduction des émissions de GES.

Les critères suivants ont été proposés:

- *Navires à zéro émission: Les navires ont des émissions directes (à l'échappement) de CO_2 nulles;*
- *Les navires hybrides et à propulsion bicarburant qui réalisent d'importantes réductions d'émissions de GES: Jusqu'au 31 décembre 2030, les navires hybrides tirant au moins 50 % de leur énergie de combustibles à zéro émission de CO_2 à l'échappement ou d'une alimentation rechargeable pour leur fonctionnement normal; OU Jusqu'au 31 décembre 2030, les navires hybrides et à double carburant utilisant au moins 60 % de leur énergie d'origine non fossile ou de l'électricité pour leur fonctionnement normal;*
- *La modernisation des navires afin de permettre l'amélioration de leur efficacité énergétique: Jusqu'au 31 décembre 2030, l'activité de modernisation réduit la consommation de carburant du navire d'au moins 10 %, exprimée en grammes de carburant par tonne de port en lourd et par mille nautique, ce qui est prouvé par la dynamique des fluides numérique (CFD), des essais en cuve ou des calculs d'ingénierie similaires.*

Les deux critères d'excellence suivants portent sur des éléments différents, le premier sur les performances opérationnelles des navires, le second sur la conception des navires.

- *Diminution de l'intensité de carbone de la flotte - critère opérationnel: Jusqu'au 31 décembre 2030, les navires qui ont atteint une intensité de carbone exprimée en indice opérationnel d'efficacité énergétique (EEOI) / indicateur d'intensité de carbone (CII) inférieure à certains seuils.*

- *Identification des nouveaux navires les plus efficaces sur le plan énergétique - critère de conception: Jusqu'au 31 décembre 2030, les navires ont une valeur d'indice de conception d'efficacité énergétique (EEDI) égale ou supérieure aux 10% des scores EEDI les plus bas des navires similaires entrés dans la flotte au cours des trois années précédant la date de l'évaluation; ou les navires ont un indice d'efficacité énergétique des navires existants (EEXI) égal ou supérieur aux 10 % de navires similaires ayant obtenu les meilleurs résultats en matière d'EEXI; ou les navires ont un EEDI ou un EEXI de 10 % inférieur aux exigences EEDI/EEXI applicables à partir du 1er janvier 2025, la valeur la plus basse étant retenue (meilleure).*

Chacun de ces critères présente ses propres avantages et inconvénients en termes d'utilisation. Les critères de conception ont l'avantage d'évaluer les propriétés écologiques des navires avant leur construction. Il s'agit donc d'un exercice théorique, qui permet d'estimer ex ante si un navire respecte un seuil vert en fonction des effets estimés des nouvelles technologies utilisées. Les critères opérationnels présentent l'avantage de se concentrer sur les émissions réelles et de permettre une évaluation précise des performances du navire. Cependant, il est difficile de les mettre en œuvre dans la pratique, car le secteur du transport maritime et les types de navires restant très divers, l'efficacité opérationnelle peut varier considérablement d'une année à l'autre (par exemple, en raison d'un changement de route, de cargaison ou de conditions météorologiques).

Les critères proposés devront être soigneusement réévalués en 2025 afin de garantir la prise en compte des nouveaux développements dans le secteur du transport maritime.

Critères d'absence de préjudice significatif

Une autre exigence clé à laquelle les activités économiques doivent se conformer afin de se qualifier comme respectant les exigences de la Taxonomie est qu'"aucun dommage significatif" ne soit causé à l'un des autres objectifs environnementaux.

Dans le secteur du transport maritime, les critères DNSH doivent garantir qu'aucun dommage significatif ne puisse être attribué aux activités qui répondent aux critères d'atténuation du climat, en tenant compte du fait que, malgré les émissions relativement faibles de CO_2, le transport maritime de marchandises et de passagers peut avoir des effets négatifs importants sur l'air, l'eau, le bruit et les vibrations, et les écosystèmes marins.

Critères de sélection pour les autres objectifs environnementaux

Le secteur du transport maritime peut également contribuer à d'autres objectifs environnementaux. L'évaluation initiale des critères de sélection pour les autres objectifs environnementaux a permis d'identifier les différentes activités qui peuvent être prises en compte dans la taxonomie de l'UE et qui sont résumées dans le tableau ci-dessous.

Contribution substantielle a	Mesures économiques pertinentes
Adaptation aux effets du changement climatique	Ne concerne pas directement l'exploitation des navires, mais concerne les infrastructures portuaires en augmentant leur résilience au climat.
Utilisation durable/protection des ressources en eau et des ressources marines	Technologies améliorant la gestion de l'eau: par exemple, l'installation d'OTE, le traitement des eaux usées
Transition vers une économie circulaire	Recyclage des navires; Recyclage des déchets générés à bord; Réutilisation des sédiments de dragage
Prévention et contrôle de la pollution	Îlots de sécurité; Mesures de réduction du bruit; Technologie de réduction des NOX; Énergie terrestre
Protection de la biodiversité et des écosystèmes	Dissuasions et autres mesures visant à protéger la biodiversité; traitement et gestion des eaux de ballast; soutien à la gestion intégrée des océans.

Nécessité d'un suivi

L'étude a identifié différents défis qui peuvent conduire à l'éco blanchiment. Il s'agit notamment de l'absence de définitions ou de cadres communs permettant de déterminer quels types d'investissements peuvent être considérés comme écologiques, de l'utilisation de technologies transitoires telles que le GNL sans tenir compte de la fuite de méthane, et de l'utilisation de l'indice EEDI sans contrôle des performances réelles des navires.

Afin d'éviter tout risque potentiel d'éco blanchiment et d'assurer des conditions de concurrence équitables, un suivi transparent et la déclaration jouent un rôle essentiel. Les rapports peuvent être effectués sur une base ex-ante et ex-post. Une évaluation ex ante est effectuée lorsqu'un investissement est considéré comme vert. Une fois l'investissement réalisé, il doit faire l'objet d'un suivi afin de s'assurer qu'il respecte les critères fixés dans le temps ou qu'il fonctionne comme prévu initialement. Le suivi des performances opérationnelles est déjà en place pour certains segments du secteur de la navigation, comme les exigences MRV de l'UE applicables aux navires de plus de 5000 GT.

Renforcer le financement vert dans le secteur du transport maritime

Le secteur maritime est une industrie à forte intensité de capital, caractérisée par une part importante de dettes dans les structures de capital des compagnies maritimes. Historiquement, le financement par l'emprunt auprès des banques représente une part majoritaire du financement du transport maritime si ce n'est la principale source de financement. Toutefois, depuis la crise financière de 2008, les 40 premières banques internationales qui financent le transport maritime ont diminué de 36 % leurs prêts, ce qui oblige le secteur à trouver d'autres sources de financement. Les banques qui restent actives dans le secteur du transport maritime sont susceptibles de prêter aux compagnies maritimes qui font preuve d'une forte culture d'entreprise et à celles qui alignent leurs activités sur les réglementations de Bâle III et de Bâle IV à venir, ainsi que sur d'autres mesures telles que les principes Poséidon.

Malgré la forte demande globale d'opportunités d'investissement vertes sur les marchés financiers, le paysage actuel de la finance verte dans le secteur maritime européen est limité, en partie en raison de la nature de l'interconnexion mondiale du secteur du transport maritime, de l'incertitude quant aux voies technologiques et des besoins d'investissement à forte intensité de capital. En 2019, le transport maritime représentait globalement moins de 1 % du financement aligné sur le climat.

Pour soutenir le passage à l'échelle de la finance verte, il convient de relever les défis auxquels les compagnies maritimes sont confrontées. Les défis liés aux risques financiers et aux faibles notations de crédit pourraient être soutenus par des mesures de renforcement du crédit. Pour l'adoption de mesures vertes, la diversité des modèles d'entreprise et des dispositions contractuelles dans le secteur entraîne une série d'incitations différentes, ce qui favorise des accords financiers différents et la mise en œuvre de mesures vertes différentes.

L'incertitude technologique de la transition climatique dans le secteur doit être minimisée, afin d'éviter que les entreprises investissent dans des actifs qui, dans quelques années, pourraient devenir des actifs non performants. Cela pourrait être soutenu par de nouveaux projets de R&D et de démonstration ainsi que par un soutien aux technologies et aux carburants prometteurs. Tant que très peu de solutions à faible émission de carbone seront disponibles, il restera important de financer également les activités qui encouragent la transition vers une économie neutre sur le plan climatique. Il est également crucial de réfléchir à la manière de faciliter l'accès des PME au financement.

Étant donné que les navires à passagers et les navires offshore, ainsi que d'autres navires spéciaux, sont des industries fortes avec des chaînes de valeur complètes en Europe, garantir leur accès au financement vert contribue à renforcer le secteur maritime de l'UE. Une approche européenne globale est d'autant plus importante que les marchés asiatiques, et en particulier le marché chinois, renforcent leurs positions internationales dans les chaînes d'approvisionnement mondiales et occupent une place de plus en plus importante dans le secteur maritime mondial.

La taxonomie de l'UE jouera un rôle central en apportant plus de clarté aux acteurs du marché sur ce qui peut être considéré comme écologique.

1 INTRODUCTION

This report is the Final Report of the study on "Development of a methodology to assess the 'green' impacts of investment in the maritime sector and projects". The study was implemented by COWI A/S in collaboration with CE Delft and commissioned by the European Commission (EC), Directorate-General for Mobility and Transport (DG MOVE).

1.1 Study Background

Green Deal

The European Green Deal (hereafter Green Deal) is the cornerstone of European Union (EU) climate policy, and it establishes the overall objective of a climate neutral Union by 2050[1]. The Green Deal also emphasizes the need to accelerate the transition to a toxic-free environment, including through the shift to sustainable and smart mobility. In this context, the Green Deal reaffirms the EC commitment to sustainable finance, laying out a comprehensive set of measures that sets Europe on track to become the first climate neutral continent, while at the same time rejuvenating its economy, supporting a just transition, and preserving Europe's natural capital.

With the adoption of the 2030 Climate Target Plan[2], the EC propose to raise the EU's ambition on reducing GHG emissions to at least 55% below 1990 levels by 2030. This would contribute to implementing the commitment made in the Green Deal and it is in line with the objective of the Paris Agreement.

In this context, the recent Commission's Sustainable and Smart Mobility Strategy[3] defines a framework of specific EU measures allowing the transport sector to deliver the political ambitions of the European Green Deal and of the 2030 Climate Target Plan.

EU sustainable finance

In 2018, the EC published the Action Plan on Financing Sustainable Growth, setting up a roadmap to boost the role of finance in achieving a well performing economy that delivers on environmental and social goals[4]. This Action Plan builds on the recommendations provided by the High-Level Expert Group (HLEG) on sustainable finance to foster sustainable investments. The ten points of the Action Plan intend to:

- Shift capital flows towards sustainable investments, ultimately stimulating sustainable growth;
- Guide investors in incorporating financial risks related to sustainability issues in investment decisions;

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1 European Commission (2019), The European Green Deal. See: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

2 European Commission (n.d.), 2030 Climate Target Plan. See: https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en

3 Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Sustainable and Smart Mobility Strategy – putting European transport on track for the future, COM(2020)789. See: https://ec.europa.eu/transport/sites/transport/files/legislation/com20200789.pdf

4 European Commission (2020), Renewed sustainable finance strategy and implementation of the action plan on financing sustainable growth. See: https://ec.europa.eu/info/publications/sustainable-finance-renewed-strategy_en

- Increase transparency of sustainable financing and promote a long-term outlook in financial decision-making.

To this extent, the EC agreed to adopt a step-by-step process. To achieve the first objective of shifting capital flows, the Action Plan recognizes that first and foremost there is a need to develop a shared understanding of what is considered sustainable. Such a set of uniform criteria will make it possible for investors to compare investment opportunities across borders and increase confidence in sustainable financial products.

EU Taxonomy Regulation

In December 2019, the European Council and Parliament reached an agreement on the text of a proposal for a regulation 'on the establishment of a framework to facilitate sustainable investment' – the so-called Taxonomy Regulation[5]. It puts the EU at the forefront of reforms in the global financial system to better reflect the impact of sustainability issues by providing a framework to determine the extent to which economic activities can be considered environmentally sustainable.

The Taxonomy Regulation sets a framework to determine which economic activities can be considered environmentally sustainable. Article 3 of the Taxonomy Regulation establishes four compliance criteria for an activity to be considered sustainable, namely:

- the activity contributes substantially to one or more of the six EU environmental objectives defined in Article 5 (presented below);
- the activity does not significantly harm any of the other five EU environmental objectives (i.e. DNSH principle);
- the activity complies with minimum social safeguards; and
- the activity complies with technical screening criteria.

Article 5 of the Regulation further defines the following six environmental objectives:

1. Climate change mitigation;
2. Climate change adaptation;
3. Sustainable use and protection of water and marine resources;
4. Transition to a circular economy;
5. Pollution prevention and control;
6. Protection and restoration of biodiversity and ecosystems.

'Substantial contribution' to the six environmental objectives is defined in Articles 6 to 11. As a part of the assessment of 'substantial contribution' to the environmental objectives, the EC is in the process of developing technical screening criteria for each of the objectives, starting with climate mitigation and adaptation objective.

The Taxonomy can be understood as a tool for investors to identify and respond to investment opportunities that support environmental and climate policy objectives.

5 Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment of 18 June 2020. See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0852&from=EN

Technical Expert Group

Within the EU Taxonomy, the Technical Expert Group (TEG) was working on development of technical screening criteria for climate mitigation and adaptation objectives covering different prioritised economic activities. One of the priority sectors is the transportation sector. In March 2020, TEG published the revised Final Report on Sustainable Finance (supplemented by a Technical Annex)[6], which contains a list of revised and additional technical screening criteria for climate change mitigation or adaptation, assessment of significant harm to other environmental objectives and methodological statements to support their recommendations. The report did not include the economic activities within the maritime sector, although TEG agreed that this work should be further prioritised, given its potential contribution to the greening of the transport sector.

Delegated Acts

The technical screening criteria to identify which economic activities are environmentally sustainable are established through Delegated Acts. In November 2020, the EC published the Draft Delegated Act for the climate mitigation and adaptation environmental objectives, including draft technical screening criteria for the maritime sector.[7] Given the need to reduce GHG emissions from the transport sector, maritime shipping with total global CO_2 emissions corresponding to 2.9%[8] represents an important transport mode for the transition to a low-carbon economy. Furthermore, the Taxonomy Regulation provides that the technical screening criteria shall cover all relevant economic activities within a specific sector and ensure that those activities are treated equally if they contribute equally towards the environmental objectives, to avoid distorting competition in the market.[9]

Climate mitigation and adaptation criteria will be adopted early 2021. The remaining criteria are planned to be adopted by the end of 2021.

Sustainable Finance Platform

The TEG work was concluded in September 2020. Further development of the EU taxonomy will take place via a new Platform on Sustainable Finance, which started in October 2020. The Sustainable Finance Platform will advise the EC on the remaining elements relevant for the development of the technical screening criteria for the EU Taxonomy.

1.2 Objectives and scope of the study

The main objective of the study is to support the EC and the Platform on Sustainable Finance in development of the EU Taxonomy for the maritime shipping sector. This is achieved by providing sector-targeted analysis and input on development of the technical screening criteria.

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[6] TEG (2020), Taxonomy: Final report of the Technical Expert Group on Sustainable Finance. See: https://ec.europa.eu/info/files/200309-sustainable-finance-teg-final-report-taxonomy_en

[7] European Commission (2020), Sustainable finance – EU classification system for green investments. See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy#ISC_WORKFLOW

[8] IMO (2020) Fourth IMO Greenhouse Gas Study, MEPC 75/7/15, https://docs.imo.org/Shared/Download.aspx?did=125134

[9] Article 19(1)(j) of the Taxonomy Regulation

The study has investigated the following:

- the technical screening criteria for the environmentally sustainable activities in maritime shipping;
- the essential characteristics of maritime shipping and port activities contributing to the six environmental objectives defined in the EU Taxonomy;
- the potential greenwashing practices in the sector and existing countermeasures to address them;
- support for establishing common standards for measuring, assessing and accounting for environmental sustainability of the investments in maritime sector.

By providing this support, the study contributes to facilitating sustainable financing within the maritime sector.

1.3 Structure of the report

The report consists of the following:

- Chapter 2 presents the methodological approach of this study;
- Chapter 3 outlines the development of the maritime shipping sector focusing on the decarbonisation of the sector and existing state-of-art technologies;
- Chapter 4 reviews the economic activities that exists in shipping and maps the environmental impacts of those activities;
- Chapter 5 presents the technical screening criteria for the climate mitigation objective as well as other environmental objectives;
- Chapter 6 discusses the risk of greenwashing and the need for monitoring as countermeasure to it;
- Chapter 7 outlines three different scenarios of the stringency of the criteria and analysis the impacts of those criteria on the financial market participants;
- Chapter 8 presents the developing of green finance in the maritime shipping sector;
- Finally, Chapter 9 summarises the key findings and discusses the way forward.

2 METHODOLOGICAL APPROACH

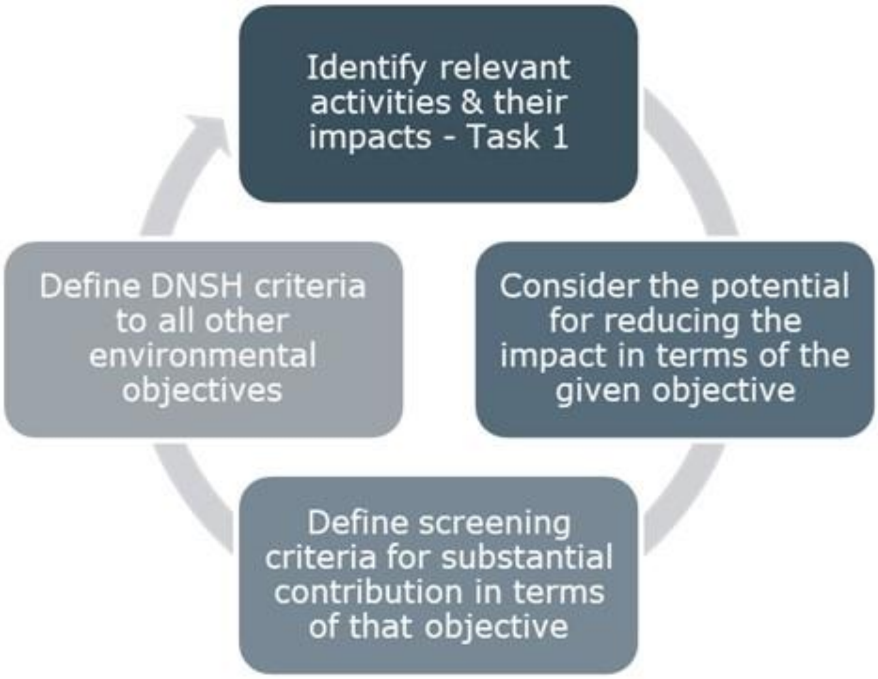
This chapter presents the methodological approach of the study including the data collection methods.

2.1 Overall approach

The overall approach builds on the TEG methodology, where the development of technical screening criteria follows the TEG's hierarchical steps (also illustrated in Figure 1):

1. Assess the impact of relevant activities on environmental objectives;
2. Consider the potential for improving/reducing the impact in terms of the given objective;
3. Define screening criteria for identifying a substantial contribution in terms of that objective and Do-No-Significant-Harm (DNSH) criteria relevant to all other environmental objectives;
4. Perform steps 2 and 3 for any activity/objective combination, which is considered relevant.

Figure 1 TEG's hierarchical steps for defining technical screening criteria



Source: COWI/CE Delft.

First, different maritime sector activities are reviewed, and their impacts are identified in Chapter 4. Then, the potential of relevant activities for improving their impact in terms of one of the six environmental objectives is examined. Once the potential for improving the impact is understood, the technical screening criteria for 'substantial' contribution in line with the Taxonomy Regulation are discussed in Chapter 5. In addition to substantial contribution, the criteria for DNSH assessment on all other environmental objectives is set. These stepwise assessments are performed for relevant shipping sector activities.

2.2 Data collection

The data collection consisted of desk research, interviews with key market participants, written inputs as well as consultation with the industry members of the European Sustainable Shipping Forum (ESSF) and Motorways of Sea (MoS) via a workshop, which took place in September 2020.

The desk research was a horizontal task informing different elements of the study, including the identification of maritime activities and their impacts, development of the technical screening criteria, existence of greenwashing practices and countermeasures as well as development of green bonds in the maritime shipping sector. The list of bibliography is presented in Appendix A - Bibliography.

The second important source of data was input received from stakeholders through interviews, written inputs, position papers and presentations. Table 1 presents the different input provided by stakeholders.

Table 1 Overview of the stakeholder input provided

Organisation	Input
European Community Shipowners' Associations (ECSA)	Interview, multiple position papers and presentation during the workshop
Danish Shipowners Association	Interview and position paper
European Sea Ports Organisation (ESPO)	Interview and position paper
SEA Europe, Shipyards’ & Maritime Equipment Association	Interview and presentation during the workshop
Federation of European Private Port Companies and Terminals (Feport)	Interview
European Dredging Industry	Interview and presentation during the workshop
Global Maritime Forum	Interview
Mærsk	Interview
Grimaldi Group	Interview
Stena Line	Interview
Carnival corporation /Holland America Line	Interview
Van Oord	Interview
Climate Bond Initiative (CBI)	Interview
Transport & Environment	Interview
ABN Amro	Interview
CICERO	Interview
Danish Ship Finance	Interview
Piraeus Bank	Interview
NYK Group	Interview
4 Greek Shipowners via ECSA	4 Written responses
Shell Shipping via ECSA	Written response
Hapag-Lloyd AG via ECSA	Written response
Danish Ship Finance	Presentation during the workshop

Green Marine Label	Presentation during the workshop
European Transport Workers' Federation	Position paper
Wartsila	Position paper

Source: COWI/CE Delft.

To ensure a wider stakeholder consultation, a workshop with the industry members from ESFF and MoS was organised on 21 September 2020. The purpose of the workshop was to present and validate the initial findings from the interviews and literature review as well as receive further input into setting the technical screening criteria. In total, 48 representatives from the industry and various Directorates-General of the EC participated in the workshop. Five industry representatives presented their positions on the inclusion of the maritime sector in the EU Taxonomy.

3 DEVELOPMENT OF THE MARITIME SHIPPING SECTOR

This chapter outlines the development of the maritime shipping sector based on the desk research, analysis of the interviews, position papers and comments provided during the stakeholder workshop. It establishes the broader context in which the maritime shipping operates as well as provides insights into how the sector is approaching the need to decarbonise, which helps to inform the development of the technical screening criteria. Finally, it presents the state-of-art of the technologies in the sector.

3.1 EU policy context

The EU aims to become the first climate neutral continent by 2050 in line with its commitment to implement the Paris Agreement. The cornerstone of EU's carbon neutrality is the European Green Deal.[10] To reach this ambitious goal, it will require reducing EU's GHG emissions by at least 55% by 2030 compared to 1990 levels, and all sectors including the maritime sector need to contribute to climate action. Prior the Green Deal, the maritime sector was not facing sector-specific GHG emissions reductions commitments, and today it is the only sector without concrete reduction commitment at the EU level.[11] As presented in the European Green Deal communication, the EC aims to review and propose to revise relevant climate related policy instruments by June 2021.[12] A major step has already been taken with the Climate Law,[13] which is expected in June 2021.

Shipping is one of the least carbon intensive ways to transport goods, however, it constitutes a significant share of the total global emissions, corresponding to 2.9%[14] of anthropogenic CO_2. Ships sailing to and from EU ports account for 140 Mt CO_2.[15] In addition, the emissions are expected to grow in the long term and there is no one single measure that could address this challenge. Currently, the CO_2 emissions from EU related international maritime activities are monitored, reported and verified at EU level through Regulation 2015/757 (hereafter MRV Regulation)[16]. However, those emissions are not covered under the current EU legislation, which is contrary to the EU's international commitment to economy-wide action under the Paris Agreement. To reduce the emissions from the maritime transport, the EC aims to propose measures alongside with the agreed measures at the International Maritime Organisation (IMO)

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10 European Commission (2019), The European Green Deal. See: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

11 European Parliament (2020), Parliament says shipping industry must contribute to climate neutrality. See: https://www.europarl.europa.eu/news/en/press-room/20200910IPR86825/parliament-says-shipping-industry-must-contribute-to-climate-neutrality

12 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions on the European Green Deal, Brussels, 1.12.2019, COM(2019) 640 final

13 European Commission (2020), Establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999. See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0080&from=EN

14 IMO (2020) Fourth IMO Greenhouse Gas Study, MEPC 75/7/15, https://docs.imo.org/Shared/Download.aspx?did=125134

15 According to EMSA, ships over 5000 GT emitted 141 Mt CO2 in 2020. This figure excludes fishing vessels, offshore support vessels as well as smaller ships, so the total emissions are higher. See: https://mrv.emsa.europa.eu/#public/emission-report

16 Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC

level. Those measures include an inclusion of the maritime sector into the European Emission Trading System (ETS), an initiative to boost the demand for sustainable alternative fuels (i.e. FuelEU Maritime) and the review of existing directives dealing with energy taxation, alternative fuel infrastructures and renewable energy.

Under the European Green Deal, the Commission recently announced plans to accelerate the shift to sustainable and smart mobility to make transport drastically less polluting and to take action in relation to maritime transport, including to regulate access of the most polluting ships to EU ports and to oblige docked ships to use shore-side electricity.[17] In a push to make all modes of transport more sustainable, the plan highlights the goal of using measures to significantly reduce the current dependence on fossil fuels by replacing the existing fleet with low- and zero emission vessels and by promoting alternative fuels. The strategy also seeks to internalise external costs, which is already underway in the shipping sector vis-à-vis the sector's inclusion in the ETS.

The Sustainable and Smart Mobility strategy recognises the current challenge to decarbonise the shipping sector due to lack of market ready zero emission technologies. Accordingly, the strategy establishes and supports preparatory and supporting activities such as the FuelEU Maritime Initiative, potentially a Renewable and Low-Carbon Fuels Value Chain Alliance, R&I initiatives (e.g. Waterborne Technology Platform).[18]

In addition to decarbonisation objectives, a zero-pollution action plan will be adopted in 2021.[19] The objectives of the action plan is to secure healthy ecosystems and a healthy living environment for Europeans, and to better prevent, remedy, monitor and report on pollution for air, water and soil. The action plan will spur efforts to drastically reduce further emissions to air and water and the broader environmental footprint from the shipping sector. For example, it will support and draw on dialogue with stakeholders under the forthcoming revisions of the Ambient Air Quality Directives,[20] which sets limits for, among other pollutants, NOx, SOx, and particulate emissions, which are typical of the shipping sector.

Furthermore, the EC has spearheaded efforts to replicate the success of existing ECAs in the Mediterranean Sea requiring urgent protection.[21] Such designation could, by 2030, cut emissions of SO_2 and NOx from international shipping by 80% and 20%, respectively, compared to the current regulations.[22] Moreover, the Commission aim to start similar work in the Black Sea area where progress is also needed.

17 European Commission (2020), Sustainable and Smart Mobility Strategy. See: https://ec.europa.eu/transport/sites/transport/files/legislation/com20200789.pdf

18 European Commission (2020), Sustainable and Smart Mobility Strategy. See: https://ec.europa.eu/transport/sites/transport/files/legislation/com20200789.pdf

19 European Commission (2020), Zero pollution action plan. See: https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_en

20 European Commission (2020), Roadmap - zero pollution action plan. See: https://ec.europa.eu/environment/system/files/2020-10/zero-pollution-action-plan-roadmap.pdf

21 European Commission (2019), Fitness check of the Ambient Air Quality Directives. See: https://ec.europa.eu/environment/air/pdf/SWD_2019_427_F1_AAQ%20Fitness%20Check.pdf

22 IIASA (2018), The potential for cost-effective air emission reductions from international shipping through designation of further Emission Control Areas in EU waters with focus on the Mediterranean Sea. See: https://iiasa.ac.at/web/home/research/researchPrograms/air/Shipping_emissions_reductions_main.pdf

3.2 Decarbonising shipping

At the international level, the IMO sets the global agenda for shipping. The efforts of the IMO to improve energy efficiency and reduce GHG emissions are crucial for achieving the decarbonisation of the whole sector. The IMO initial GHG strategy commits the shipping sector to improve the carbon intensity of international shipping by at least 40% by 2030 (compared to 2008) and to pursue efforts to improve the carbon intensity by 70% by 2050.[23] The strategy aims to realise a total annual GHG emissions reduction by at least 50% by 2050 (compared to 2008) and to phase out GHG emissions as soon as possible. The IMO's GHG emissions reduction strategy will be updated in 2023 and thereafter reviewed every five years, which could lead to introduction of more stringent targets. The requirements to the energy efficiency measures introduced by the IMO through the mandatory Ship Energy Efficiency Management Plan (SEEMP) for all ships and Energy Efficiency Design Index (EEDI) for new build ships have further supported development and utilisation of new energy efficient technologies for shipping.

Most of the shipping companies/associations that provided input to this study support the IMO’s strategy on reduction of GHG emissions from ships as the sector's central guide and goal setter. They highlight that the shipping industry is global in its core, and that regulations, framework conditions, competitiveness, sustainability and ship finance must be viewed in this light. As such, anchoring the decarbonisation strategy and goal setting at the IMO will contribute to keeping a level playing field. Other stakeholders, notably civil society organisations and some shipping companies/operators highlight that there is a need to establish more ambitious goals, as the IMO strategy is not aligned with the Paris Agreement. Accordingly, some stakeholders and segments within the sector are already now pursuing more ambitious goals than those set by the IMO, such as net-zero CO_2 emissions in 2050. For example, Maersk, the largest container ship and supply vessel operator in the world, sets a target of net-zero CO_2 emissions from operations by 2050.[24] There are also various initiatives supporting the climate objective, which have been mentioned in the interviews and identified during desk research, including:

- *Waterborne Technology Platform* – an industry focused Research and Innovation (R&I) platform, which seeks to provide and demonstrate zero-emission solutions for all main ship types and services before 2030 and decrease emissions during navigation by 50% for other ship types by 2030. This initiative aims to enable zero-emission waterborne transport before 2050.[25] This initiative will be co-funded under Horizon 2020.
- *Getting to Zero* – a collaboration of approximately 140 corporations focused on achieving the goal of there being scalable zero carbon energy solutions for international shipping available from 2030, by exploring of fuels, ships, market drivers and policies and planning to deliver visible leadership, a shared knowledge base and demonstration- and pilot projects.[26]

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23 IMO (2017), UN body adopts climate change strategy for shipping. See: https://www.imo.org/en/MediaCentre/PressBriefings/Pages/06GHGinitialstrategy.aspx

24 Maersk (2019), Towards a zero-carbon future. See: https://www.maersk.com/news/articles/2019/06/26/towards-a-zero-carbon-future

25 Waterborne (n.d.), The European research and innovation platform for waterborne industries. See: https://www.waterborne.eu/

26 Getting to zero coalition (2020). See: https://www.globalmaritimeforum.org/getting-to-zero-coalition

- *Maersk Mc-Kinney Møller Centre for Zero Carbon Shipping* - an independent research centre has been established to foster collaboration between industry, academia and authorities across the shipping sector.[27] The centre has partners such as MAN Energy Solutions, NYK Line, Siemens, and Cargill, the latter of which is working to increase the viability and scalability of biofuels for the maritime industry.[28]
- *Poseidon Principles* – a commitment to transparent annual reporting of portfolio operational carbon intensity relative to an interpretation of the IMO's Initial Strategy by financiers representing approximately 30% of the capital invested in international shipping.[29]
- *Sea Cargo Charter* – a commitment to transparent annual reporting of scope 3 / supply chain operational carbon intensity relative to an interpretation of the IMO's initial strategy by charterers and cargo owners.[30]
- *CBI, Shipping Criteria*[31] – a set of criteria used to classify that a green bond financed asset is aligned with the Paris Agreement goals.

All the interviewed stakeholders confirm that the European shipping industry is committed to taking a leading role in decarbonising the shipping sector. The EU's shipping industry accounts for around 40% of the world's tonnage shipped and controls around 60% of world's container vessels, 52% of the multi-purpose vessels, 43% of the tankers and 37% of the offshore vessels.[32] The shipping stakeholders highlight that the efforts to decarbonise the sector will require active contribution of all actors in the maritime value chain, including shipyards, engine manufacturers, classification societies, ports, energy companies and the fuel suppliers. As such, the EU Taxonomy can play a vital role in providing the right incentives for investors to finance sustainable projects within the shipping sector.

3.2.1 Current EU fleet

This section presents the current EU fleet and discusses its committed CO_2 emissions. Table 2 presents an overview of the EU MRV fleet (11,000 vessels), the CO_2 emissions and average remaining lifetime ascribed to each category of ships. The table also presents the committed emissions for the fleet for their remaining lifetime, indicating the projected progression without the introduction of climate mitigation measures.

The committed emissions are substantial, totalling 2,260 $MtCO_2$ for the existing fleet (baseline scenario), which highlights the need for the technical screening criteria to address existing vessels. However, it is relevant to consider the variance in committed emissions from the different types of vessels. In terms of committed emissions, the top seven vessels types (out of 15), contribute to 83% of total future emissions, and

27 Zero Carbon Shipping(n.d.), Mærsk Mc-Kinney Møller Centre for zero carbon shipping. See: https://zerocarbonshipping.com/

28 Cargill (2020), Cargill joins new research center that will lead the way for decarbonizing shipping. See: https://www.cargill.com/2020/cargill-joins-new-research-center-that-will-lead-the-way

29 Poseidon Principles (n.d.), A global framework for responsible ship finance. See: https://www.poseidonprinciples.org/#home

30 Sea cargo charter (2020), Aligning global shipping with society's goals. See: https://www.seacargocharter.org/

31 CBI (2020), Shipping Criteria Climate Bonds Standard. See: https://www.climatebonds.net/files/files/CBI-Shipping_Criteria%20Brochure%281%29.pdf

32 ECSA (n.d.), The European shipping industry in a nutshell. See: https://www.ecsa.eu/images/Studies/ECSA_brochure.pdf

containerships, bulk carriers and oil tankers represent about 60% of all the fuel consumption with container ships being the highest contributor (658 $MtCO_2$ / 2260 $MtCO_2$). This highlight the need to ensure that the vessels types with substantial committed emissions will be addressed in the Taxonomy.

Table 2 EU MRV fleet characteristics and committed emissions

Vessel type	No. of vessels	Mean remaining lifetime*	Total CO_2/year (MtCO2)	Committed future CO_2 (MtCO2)
Container ships	1,665	14	44.07	658
Bulk carriers	3,311	18	17.46	307
Ro-Pax	344	16	13.78	228
Oil tankers	1,686	14	17.67	227
Passenger ships	146	9	6.39	191
Chemical tankers	1,268	17	9.13	150
LNG carriers	194	21	5.46	107
Ro-Ro	257	16	5.91	97
Vehicle carriers	433	19	5.07	96
General cargo ships	1,048	16	5.88	91
Gas carriers	294	21	2.45	51
Container Ro-Ro cargo	72	17	1.43	24
Refrigerated cargo	140	9	1.78	19
Other ship types	104	16	1.03	13
Combination carriers	7	9	0.08	1
Total	10,966	n.a.	137.65	2,260

*Approximate value in years.

Source: Bullock et al. (2020), Shipping and the Paris climate agreement: a focus on committed emissions. in BMC energy.[33]

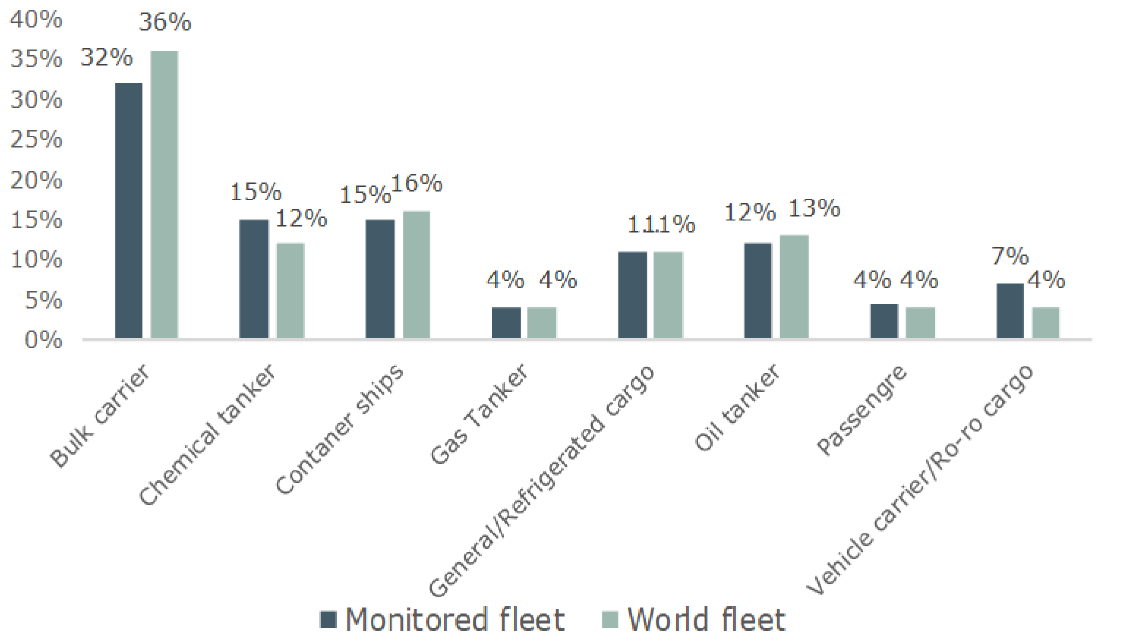
The different characteristics for the vessel types, such as size, voyage length, type of service, lifetime, play a role in determining suitable retrofits and operational measures. For example, cruise-, passenger- and ro-pax vessels generally have longer

33 Bullock et al. (2020), Shipping and the Paris climate agreement: a focus on committed emissions. in BMC energy. See: https://bmcenergy.biomedcentral.com/articles/10.1186/s42500-020-00015-2

life spans. These vessels also provide services of more time sensitive nature, compared to vessels which do not carry passengers. In this case, technical retrofits maybe be more attractive than reducing speed and may be a more likely approach to ensure GHG emission reductions. Conversely, other vessels, such as container ships, tend to already be highly energy efficient, and have a shorter lifespan, but they may be more flexible in terms of reducing speed, as no passengers needs to be considered. In this case, operational measures may be more attractive than technical retrofits.

The data in the table is based on approximately 11,000 vessels, which are reporting under the EU MRV. Comparison of the composition of vessel type between the EU MRV fleet and the global fleet, shows that that the two fleets follow the same balance between vessel types.

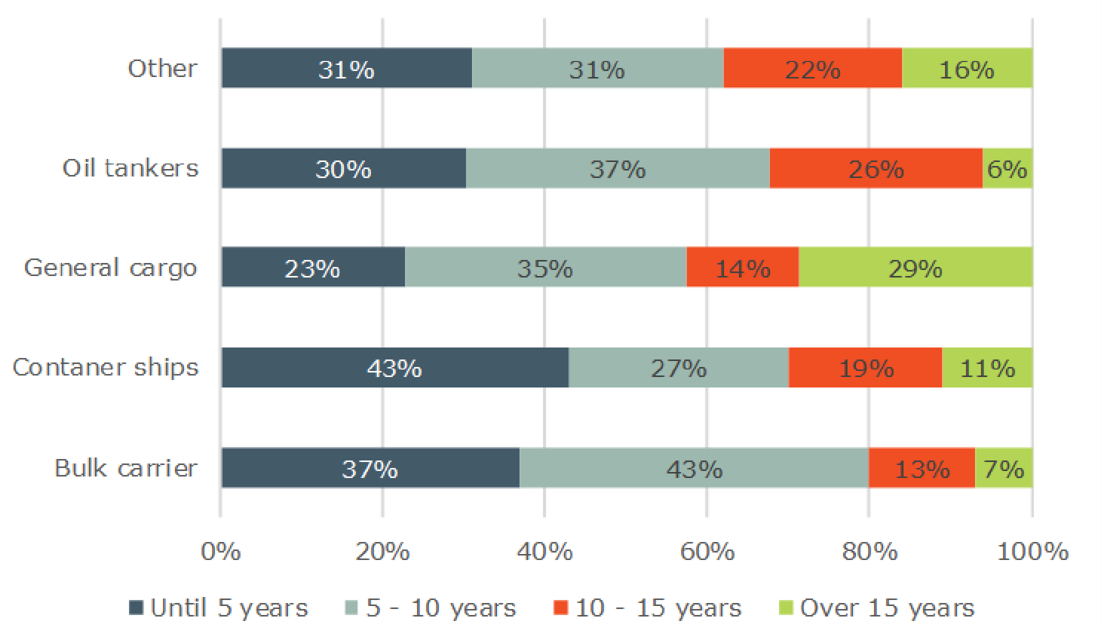
Figure 2 Composition of EU MRV fleet and the global fleet



Source: European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

While there is similar balance between the vessel types in the EU MRV fleet and the global fleet, there are some differences in the age composition. Table 2 presents an overview of the age of the vessels across vessel types for the EU MRV fleet. In general, the EU MRV fleet is younger than the global fleet in all five vessel types listed below. For example, in the EU MRV fleet 70% of container ships are under 10 years, for the global fleet 56% of container ships are under 10 years.

Figure 3 EU MRV fleet age composition



Source: European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

Setting appropriate criteria is further complicated by the long lifetime of vessels, as well as the different energy efficiency performance of existing vessels and new builds. Bullock et al. (2020)[34] projected the balance between existing and new built vessels in the EU MRV fleet. Based on these developments, they concluded that if all new builds from 2030 would be zero-emission vessels and if all existing ships were retrofitted in 2030–2040, it would not be possible to achieve 100% decarbonisation by 2050. This highlights the need to incentivise both technical and operational improvements as well as alternative fuels.

3.2.2 2030 perspective

The actions needed to realise the long-term goal of carbon neutrality depend on the immediate development of the sector in the short-term perspective, and the coming decade will be pivotal in ensuring a timely transition towards carbon neutrality by 2050.

Wait-and-see approach

According to feedback from stakeholders, the sector is currently in a wait-and-see mode and shipping companies are holding off on adding capacity to their fleets. The current COVID-19 crisis adds further uncertainty to the shipping sector, with the first half of 2020 seeing the lowest order volume for global shipbuilding in over 25 years.[35] With regard to the impact of COVID-19, the stakeholders had varied views. On the one hand, some interviewees expected a slowdown of the decarbonisation process in

[34] Bullock S, et al. (2020), Shipping and the Paris climate agreement: a focus on committed emissions. BMC Energy. See: https://bmcenergy.biomedcentral.com/articles/10.1186/s42500-020-00015-2

[35] SEA Europe (2020), Shipbuilding market monitoring report no. 50 (1H 2020)

the coming years due to COVID-19 (which would be levelled out on a long-term perspective). On the other hand, some interviewees suggested that the decarbonisation process will accelerate because of COVID-19 since the pressure on decarbonisation is increasing. The Fourth IMO GHG Study (2020) indicated that even though it is too early to assess the impact of COVID-19, it is expected that the GHG emissions for 2020 and 2021 will be significantly lower than projected due to lower traffic.

The wait-and-see approach from the sector also precedes COVID-19 and interviews and workshop findings highlight uncertainty in relation to which future technologies prove to be the way forward as a primary reason for withholding new investments. The high up-front costs and the long lifespan of vessels make shipping companies hesitant to pursue investments, which will prove not to align with the technology developments.

Investing in RD&I

At the same time, the investments in Research, Development and Innovation (RD&I) continue to be a cornerstone of the European Waterborne technology sector, with currently about 10% of sales invested in RD&I.[36] Some of the shipping stakeholders indicate that due to high uncertainty many shipping companies are withholding investing in new-builds and are funnelling resources towards innovation processes and Research and Development (R&D). In 2019, eight international shipping groups submitted a proposal to the IMO to establish a R&D programme with USD 5 billion over ten years to accelerate the introduction of low-carbon and zero-carbon technologies and fuels.[37]

In the coming years, the shipping stakeholders are expecting experimentation and selection of new technologies, which will create a substantial need for investment in new technological advances. In order to spur further sustainable development in the sector a mix of processes and measures have been highlighted by the shipping stakeholders. Presently, the developments within alternative fuels and new technology developments are taking place at a smaller scale, which is due to high investment costs and the risks associated with the projects. The shipping stakeholders call for the following R&I processes / measures:

- Large-scale demonstration projects / ecosystem project. While alternative fuels or new technological developments may show promise in smaller test-projects, overall transition of the sector hinges on the scalability of the solutions, which is why the sector calls for large demonstration projects. To facilitate such projects, there is need to de-risk investment in those projects.
- Experimentation and innovation should be encouraged. The findings show that the sector does not know, which alternative fuels or technological developments will prove to be feasible solutions. Therefore, the sector calls for room to experiment and innovate. To facilitate such processes, trial and error approaches should be encouraged, without companies risking being penalised for solutions, which fail to meet the goals, as this may deter companies from testing new solutions.

[36] SEA Europe (2020), Shipbuilding market monitoring report no. 50

[37] Marine Environment Protection Committee (2019), Reduction of GHG emissions from ships. See: https://www.ics-shipping.org/docs/default-source/Submissions/IMO/final-imrb-submission-to-mepc-75.pdf?sfvrsn=6

Carbon neutral vessels

The development of carbon neutral vessels is an important steppingstone towards a carbon neutral fleet in 2050. Due to the 25-35-year lifespan of vessels, stakeholders hope to see the first carbon neutral vessel by 2030 as deployment of zero-carbon ships by 2030 will be necessary to achieve the 2050 reduction target. A coalition of maritime stakeholders has publicly committed to building zero-emission vessels by 2030.[38]

Continuous improvement of energy efficiency

The shipping sector has been successful in making continued improvements in the energy efficiency of vessels. The Fourth IMO GHG Study (2020) shows that the carbon intensity of the international shipping has improved by 21% and 29% (measured in Annual Efficiency Ratio (AER) and Energy Efficiency Operational Index (EEOI)) compared to 2008. Even though there have been substantial energy efficiency improvements, the shipping stakeholders believe that there are still significant improvements to be made in the short-term perspective. One shipping company states that in the short term, energy efficiency measures will be their primary means to meet the GHG reduction goals set by the IMO, while several shipping companies state that a combination of energy efficiency measures and other actions would be their primary means to meet the short term GHG reductions. For further elaboration on the CO_2 reduction potential, please refer to Section 3.2.3 on the state-of-the-art technologies and Table 2 on the measures to reduce CO_2 emissions.

The majority of shipping stakeholders mention that there are substantial potential GHG reductions, which could be realised through optimisation of operational processes. The sector sees operational efficiency improvements as "low-hanging fruits", which can be targeted in the short term. An example, which has been highlighted, is the waiting times in and around ports, where vessels now loiter outside ports before they can unload. To facilitate improvements in the operational measures, the sector calls for operational standards to complement the technical standards, such as EEOI. Other measures to improve operational processes include digital solutions to ease communication between shipping companies and ports and optimised route planning and better utilisation of data, for example optimised use of Just in Time Arrival data.

A used and recommended measure to improve operational processes is through speed reduction. As it is, shipping companies are already lowering speeds, with the majority of ships having reduced their speed by 15% - 20% (compared to 2008) in order to increase energy efficiency and reduce fuel consumption.[39] However, there are still substantial reductions to gain through further optimisation of speed. A review study examined several research articles on speed optimisation and found that the potential CO_2 reduction on average is between approximately 15%-35% (some articles suggesting up to 60%). The CO_2 reduction potential of speed optimisation is also based on the relation between reduced speed and emission reductions. For example, a speed reduction of 10% can contribute to a CO_2 emission reduction of around 20%, showing an exponential relation between speed optimisation and CO_2 reduction.

[38] Global Maritime Forum (2020), Getting to zero coalition. See: https://www.globalmaritimeforum.org/getting-to-zero-coalition

[39] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

Emissions at berth

Emissions occurring when the ships were at berth (anchored or navigating in EEA ports) amounted to around 6% of the total CO2 emissions as reported under the MRV. In addition, emissions of sulphur oxides (SOx), nitrogen oxides (NOx), and particulate matter (PM) significantly contributed to air pollution in coastal areas and port cities, where ship engines are still being used to produce the necessary power during the port visit.[40] While the situation is improving with the use of cleaner fuels, air quality remains an important area of concern for port cities. This is also recognised by the industry; in the past five years, air quality ranked first among the top 10 environmental priorities according to ESPO environmental report.[41]

3.2.3 2050 perspective

A crucial element in ensuring a pathway to a carbon neutral sector is the identification and scaling to the global market of alternative fuels. The uptake of alternative fuels will also be dependent on further technological innovations (i.e. carbon neutral vessels, optimised energy use, optimised operational performances, new propulsion technologies, carbon capture and storage technologies). Facilitating these developments requires technological experimentation through large-scale demonstration projects, a trial-and-error approach to new technological developments and support of experimentation and innovation relating to alternative fuels should be incentivised. As such, the investments made in RD&I before 2030 will have a significant impact in the sector's ability to reach the long-term objective of climate neutrality.

Several alternative fuels are under development and being tested on a smaller scale such as electricity, biofuels, methanol, ammonia and hydrogen. The shift from fossil fuels to low- or zero-carbon fuels is becoming an increasingly salient political and regulatory priority in the EU. Since the adoption of the IMO Strategy on reduction of GHG emissions from ships in 2018, the shipping sector has been debating the advantages and disadvantages of different fuels in terms of decarbonisation as well as overall sustainability, without a clear conclusion to date. There is therefore a need to ensure technology neutrality and to facilitate the development of alternative and sustainable fuels through R&I initiatives. In the following section, the types of alternative fuels are further elaborated.

3.3 State-Of-The-Art Technologies

Under both a short- and long-term perspective, the uptake and continued development of state-of-the-art technologies plays an essential role in decarbonising the maritime sector. This section thus presents an overview of different technologies that reduce CO_2 emissions as well as discusses the developments of alternative fuels for maritime shipping.

3.3.1 Measures reducing co_2 emissions

The desk research indicates that there are different energy savings potential depending on the type of measures implemented and types of ships. Bouman E.A. et al. (2017) conducted a comprehensive review of the state-of-the-art technologies, assessing their potential for reducing GHG emissions from shipping. The table below presents the identified technologies and their CO_2 reduction potential.

[40] See EEA, 2017, 'Aviation and shipping — impacts on Europe's environment', European Environment Agency Report No 22/2017, in particular section 4.2.: https://www.eea.europa.eu/publications/term-report-2017

[41] https://www.espo.be/media/Environmental%20Report-WEB-FINAL.pdf

Table 3 Overview of measures and their potential for CO2 reductions

Type of measure	Main measure	Short description	Potential CO_2 reduction
Hull design	Vessel size	Economy of scale, improved capacity utilization	4–83 %
	Hull shape	Dimensions & form optimization	2–30%
	Lightweight materials	High strength steel, composite	0.1–22%
	Air lubrication	Hull air cavity lubrication	1–15%
	Resistance reduction devices	Other devices/retrofit to reduce resistance.	2–15%
	Ballast water reduction.	Change in design to reduce size of ballast.	0–10%
	Hull coating	Distinct types of coating	1–10%
Power & propulsion system	Hybrid power/propulsion	Hybrid electric auxiliary power and propulsion	2–45%
	Power system/machinery	(Incl. e.g. variable speed electric power generation)	1–35%
	Propulsion efficiency devices		1–25%
	Waste heat recovery		1–20%
	On board power demand	On board or auxiliary power demand (e.g. lighting)	0.1–3%
Alternative energy sources	Wind power	Kite, sails/wings	1–50%
	Solar power	Solar panels on deck	0.2–12%
Operation	Speed optimization	Operational speed, reduced speed	1–60%
	Capacity utilization	At vessel and fleet level (fleet management)	5–50%
	Voyage optimization	Advanced weather routing, route planning and voyage execution	0.1–48%
	Other operational measures	Trim/draft optimization, Energy management, Optimized maintenance	1–10%

Source: Bouman E.A. et al. (2017), State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. Transportation Research, http://www.smartmaritime.no/Customers/Mate/SmartMarin/Handlers/FileFeed.ashx?itemId=363&languageId=1&filename=Bouman%202017%20State%20of%20the%20art%20technologies-review.pdf

The study findings indicate that there is a great variety in the CO_2 reduction potential of different technologies. Firstly, this is due to the spread in findings across a number of the reviewed articles. Secondly, the spread in findings is also due to the diverse nature of shipping sector and vessels.[42] Consequently, the potential CO_2 reduction is indicative, and the impact of each technology is contingent on a variety of factors, such as the vessel type, existing measures, the effect of combining measures (e.g. lower speed and air lubrication) and others.

In the following text, each of the four categories of measures mentioned in Table 3 are briefly discussed.

Hull design measures

One of the main measures under hull design is optimising ships' design by using economies of scale to continuously build larger and larger ships. Oil tankers increased in size in the 1960s and 1970s, and in the 1980s and 1990s containerships and bulk carriers were built in increasingly large sizes, a trend that continues to date.[43] Increasing the vessel size reduces emissions per unit of transport work and optimises hull shape for reduced drag, which can significantly reduce power consumption, and consequently emissions. Under this category of measures, there are additional technologies, such as light-weighting, hull coating and air lubrication, which can contribute to improving the performance of hulls further, but their potential as a single measure is limited. As such, those measures are often combined with other technical and operational measures to achieve greater energy savings.

Large vessels are more fuel-efficient but require more fuel in absolute terms than smaller ships.[44] From a decarbonisation perspective, mega ships may become a challenge for the carbon neutrality, as ships commissioned in the coming decade may still be in operation in 2050, by when they still will require substantial amounts of fossil fuels to remain in operation, if they are not retrofitted to alternative fuels.

Furthermore, the added value of continuing vessel enlargement is being questioned, with some analysis indicating that the point of maximum growth may be reached, as mega ships stresses other parts of the sector, for example, through infrastructural requirements to ports and challenges in supply chain capacity.[45]

Power and propulsion system

Some of the measures under this category, notably technical solutions aimed at improving efficiency, have over the last decades seen considerable improvements and the technologies are rather mature.[46] Additional improvements are feasible, but more likely to happen incrementally. Conversely, notably hybrid solutions are a more novel technology and the early stage of technological developments limits the potential reductions in the near future. However, this may change as the technology matures. Furthermore, the impact of hybrid solutions is also contingent on the segments in which it is implemented, as it currently is more feasible to apply this technology in

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42 RINA (2018), Verifying percentage improvements of energy saving methods, ISWG-GHG 4/3/4 See: https://docs.imo.org/Shared/Download.aspx?did=112159

43 Tran, N.K., & Haasis, H.D. (2015), An empirical study of fleet expansion and growth of ship size in container liner shipping. In International Journal of Production Economics, Vol. 159

44 IMO (2020) Fourth IMO Greenhouse Gas Study, MEPC 75/7/15, See: https://docs.imo.org/Shared/Download.aspx?did=125134

45 International Transport Forum (2015), The Impact of Mega-Ships. See: https://www.itf-oecd.org/sites/default/files/docs/15cspa_mega-ships.pdf

46 Bouman E.A. et al. (2017), State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. Transportation Research

short sea shipping, where the vessels have frequent access to ports, such as ferries and to ships with a large variation in power demand, such as tugs.

Alternative energy sources

As was mentioned earlier in this section, the impact of the technologies is contingent on a variety of factors. This is especially the case for solar- and wind power technologies. These technologies appear to be most efficient for smaller ships and on shipping routes where there is a high likelihood for solar incidence and wind potential. Furthermore, the amount of energy that can be generated by these measures is constrained by the surface area they occupy, which may not be available in certain segments, such as container ships. Comparing the observations in solar and wind power, one can see that wind power shows a higher potential (up to 18% for some ship types and potentially more when they slow-steam)[47], whereas solar power's total contribution is limited and may possibly be very low.

Operation

The last category concerns operational measures, which intuitively may appear out of place in a list of state-of-the-art technological measures. However, as Table 3 shows, operational measures can contribute with substantial CO_2 emissions reductions, and novel approaches and optimisation processes are thus relevant to consider alongside technological measures.

The shipping industry is continuously seeking new ways to optimise efficiency and minimise the use of fuel in order to reduce operational costs. Lowering speed is swiftly implementable, and reducing the speed decreases the water resistances, which call for less fuel to be used during sailing. Other measures, such as capacity utilisation and voyage optimisation shows promise for further improvement as well. For example, in the EU MRV data, a variation of 60% in EEOI value for identical ships was observed, which was related to speed, total amount of cargo carried, and the share of laden voyages.[48] This highlights the impact of operational use of vessel, and the potential benefits of optimising operational performance.

There is also a call for the sector to digitalise as digital solutions can contribute to improving and uncovering new ways to enhance operational efficiency. For example, the use of IoT solutions can facilitate better management of cargo by improving information connectivity.[49] IoT solutions can also improve Just-in-Time-Arrival technologies.

3.3.2 Alternative fuels

Several of the technologies mentioned in the above sections, are established or even mature technologies. However, the maritime sector cannot rely on these technologies alone, and in order to decarbonise, there is a need to develop the use of alternative

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47 CE Delft, Tyndall Centre, Fraunhofer ISI, Chalmers University (2016) Study on the analysis of market potentials and market barriers for wind propulsion technologies for ships. See: https://www.cedelft.eu/en/publications/1891/study-on-the-analysis-of-market-potentials-and-market-barriers-for-wind-propulsion-technologies-for-ships

48 European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

49 DCSA (n.d.), IoT Gateway Connectivity Interface. See: https://dcsa.org/standards/iot-connectivity/

fuels. Many alternative fuels are still in early development, and there is much uncertainty and divided opinion on the subject.[50] The FuelEU Maritime initiative is addressing these concerns and examines the market barriers that hamper use of alternative fuels and uncertainty around the market readiness of the alternative fuels.[51]

The following text outlines the main alternative fuels currently considered in the maritime shipping sector, including ammonia, methanol, hydrogen, biofuels and e-fuels.

Ammonia

Ammonia is produced from hydrogen through the addition of nitrogen. The nitrogen is captured from the air trough air distillation or oxidative processes (residual nitrogen recovered from burnt air). The hydrogen, which is being used today, typically stems from hydrocarbons, such as natural gas or coal, and is as such derived from fossil fuel. However, if the hydrogen can be derived from renewable sources, for example through electrolysis (based on renewable energy), ammonia would become climate neutral.[52]

Hydrogen in itself is an alternative fuel, and if hydrogen is produced from renewable sources, it is worth to understand what the benefits are for further transforming it into ammonia. One advantage is that the storage of ammonia is more feasible, as it requires less space (a litre of liquid ammonia contains around 50% more hydrogen than the same volume of liquid hydrogen[53]) and it liquefies at higher temperatures (-34°C, compared to approximately -250°C for hydrogen), thus reducing the need for cooling and insulation.[54]

Last, it is worth to note that ammonia is toxic, and while more research is needed, shipping stakeholders point out that ammonia is likely to be used in segments with fewer people, such as container and carrier shipping, and not in passenger shipping.

Methanol

Methanol is the 'simplest' alcohol, which have the lowest CO_2 and highest hydrogen properties of any liquid fuel. Methanol, like ammonia, can be produced in several ways, through both sustainable sources (e.g. biomass, sustainably produced hydrogen) and through conventional sources (e.g. natural gas or coal).[55] Currently, methanol is primarily produced through natural gas, and it is a widely used in the chemical industry. Accordingly, there is a well-established production industry in place. However, for methanol to offer substantial GHG reductions, it has to be produced from

50 See the alternative fuels database at https://sustainablepower.application.marin.nl/

51 European Commission (2020), CO2 emissions from shipping – encouraging the use of low-carbon fuels. See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12312-FuelEU-Maritime-

52 Psaraftis, H.N., Zachariadis, P. (2019), Sustainable Shipping. A Cross-Disciplinary View. Chapter 13. Springer. See: https://link.springer.com/book/10.1007%2F978-3-030-04330-8

53 T&E (2018), 'Roadmap to decarbonising European Shipping'. See: https://www.transportenvironment.org/sites/te/files/publications/2018_11_Roadmap_decarbonising_European_shipping.pdf

54 OECD (2018), Decarbonising maritime transport. Pathways to zero-carbon shipping by 2035. See: https://www.itf-oecd.org/decarbonising-maritime-transport

55 DNV GL (n.d.), Alternative fuels and technologies. See: https://www.dnvgl.com/maritime/alternative-fuels-and-technologies-in-shipping/index.html

sustainable biomass or hydrogen. However, the production of sustainable hydrogen is not yet available at a large scale.

As methanol produced from natural gas is already an established industry, storage of methanol, both on and off ship, is a proven technology, and there is currently a small number of vessels that run on methanol. However, existing methanol vessels commonly use methanol derived from non-sustainable sources. A solution could be to purchase biogas certificates to establish that the methane is produced from sustainable sources.

Hydrogen

As it was described in the sections on ammonia and methanol, these options are dependent on availability of sustainable hydrogen. However, most hydrogen today is derived from natural gas. Sustainable hydrogen[55] from electrolysis and renewable energy is the basic building block for a range of fuels. For more information on conversion between the various fuels, see the section below on Power to X.

When burned, hydrogen is GHG and SOx free, and emits small amounts of NOx. If used in a fuel cell, it only emits water. However, as electrolysis requires substantial amounts of energy and the energy for production is drawn from grids which need to be based on renewable energy.[56] Several shipping stakeholders have therefore highlighted that the development of viable alternative fuels is contingent on the overall green transition of the energy sector.

Another challenge for hydrogen relates to the handling of the fuel. Liquid hydrogen boils at -253°C, which would require heavily insulated (cryogenic) pressure tanks for storage. Furthermore, depending on the pressure, the size of the tanks needs to be 10–15 times larger than those of conventional liquid fuels.[57] Lastly, as it the case of ammonia and methanol, the appropriate safety measures need to be developed to ensure safe operation.

Biofuels

Biofuels are all fuels, which are derived from biologically renewable sources (e.g. biomass, plants, animal waste) and have been transformed into liquid/gaseous fuels. Three main processes exist for the production of biofuels:

1. First generation (conventional), which is sourced primarily from crops such as wheat, sugar cane, barley, corn, potato, and partly from animal fats and vegetable oils, such as soy, palm and rape seed. The outcome is bioethanol and biodiesel, which blend well with petroleum-based fuels and work well in

56 Psaraftis, H.N., Zachariadis, P. (2019), Sustainable Shipping. A Cross-Disciplinary View. Chapter 13. Springer. See: https://link.springer.com/book/10.1007%2F978-3-030-04330-8

57 DNV GL (2015). The fuel trilemma: Next generation of marine fuels. See: https://issuu.com/dnvgl/docs/the_fuel_trilemma/31

internal combustion engines.[58] In the EU, the use of the first generation biofuels is being phased out with a mandatory cap introduced by 2030 by the Renewable Energy Directive (RED II).[59]

2. Second generation, which is sourced from non-food crops and organic waste, such as agricultural and forestry waste and municipal solid waste. The outcome is bioethanol and biomethane. Second generational biofuel has the benefit of not competing for sources with the food sector, and lower costs of materials. However, processing can be cumbersome and more expensive than for conventional biofuel.[60]
3. Third generation, which is sourced from materials which have been engineered to be used for biofuel, such as algae (micro and macro). The outcome is biodiesel, biomethane, and bio hydrogen. Third generation is still in early stages of development, compared to the other options, however, it is touted to become more used, as it offers several benefits: It is most efficient in terms of land-use, there is no competition with the food sector, and algae has the potential to produce more energy per acre, compared to other options.

Generally, the benefits of biofuels are that the fuels blend well with conventional fossil fuels, and that storage, on and off ship, is a proven technology. Notably, biodiesel is well suited to substitute conventional marine diesel oil and marine gasoline oil, while liquefied biogas is suitable for substituting LNG.

There are some challenges related to biofuels as well. Notably the scarcity of resources, meaning biofuels will contribute to the energy mix, but very likely not to the extent required to cover the shipping sector. And as the resource is limited, some stakeholders argue that biofuels are better used in the aviation sector[61], where there are less options to develop alternative fuels, compared to the shipping sector. Moreover, production of biofuel material could lead to e.g. forest clearing and thus, imply the undesired ILUC effect. Other challenges are potentially linked to the use of biofuels such as to increase or air pollutants or a non-favourable trade-offs between GHGs reduction and air pollution.

The recast Renewable Energy Directive supports the supply of renewable and low carbon fuels for the land (road and rail) and indirectly for the aviation and maritime transport sector, via the use of multipliers. The Directive must be transposed by the Member States into national legislation by 30 June 2021. Its impact on the use of renewable and low carbon fuels in maritime remains still uncertain at this stage. The Commission has initiated the process for revising the REDII Directive, one objective

[58] Chye, J.T.T. et al. (2018), Bioenergy and Biofuels, Chapter 3. Taylor Francis. See: https://www.researchgate.net/profile/Yien_Jun_Lau/publication/323662614_Biofuel_production_from_algal_biomass/links/5bbc4b4d4585159e8d8f1b5c/Biofuel-production-from-algal-biomass.pdf

[59] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, 21.12.2018. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

[60] DNV GL (2015). The fuel trilemma: Next generation of marine fuels. See: https://issuu.com/dnvgl/docs/the_fuel_trilemma/31

[61] There are some ongoing initiatives at EU level for use of advanced biofuels in aviation, see: https://www.bio4a.eu/

being to promote development and use of such fuels in hard-to-decarbonise sectors such as heavy-duty transport, aviation and shipping.[62]

Power to X

Power to X (PtX) is a technology that use different renewable energy sources and CO_2 to produce other fuel types such as liquid fuels. For the maritime industry, methane, methanol and ammonia could be PtX fuels. These will be developed as e-methane, e-methanol and e-ammonia, which are the terms used for the PtX alternatives of these fuels. There are numerous alternative PtX production paths and (in principle) all known fuels can be manufactured chemically. The current production paths are both highly energy demanding and very costly, but expectations are that significant progress will be made in the next 10-15 years leading to significant cost reductions. Currently the technologies to be applied in the production of alternative maritime fuels such as e-ammonia and e-methanol are not yet determined. Both ammonia and methanol require different engine technologies and new fuel infrastructures. There are, however, already today a few vessels using fossil-based methanol (not the e-methanol type), and a first ammonia propelled vessel is expected in 2024. Today, the costs of producing PtX fuels are as mentioned, much higher than conventional fuels, but in the production process hydrogen is used and as the price on sustainable hydrogen declines. This will also make the PtX fuels for the maritime industry become more competitive. Nevertheless, the market for e-methanol and e-ammonia is not expected to have any significant market share until 2035-2045, unless there will be a significant pressure to reduce CO2 emissions.

As noted, the development in green (sustainable) hydrogen is a prerequisite for the PtX alternatives for the maritime industry to become viable. In addition, since the energy consumption of the entire production chain of PtX is significant, the amount of renewable power increases.

62 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12553-Revision-of-the-Renewable-Energy-Directive-EU-2018-2001

4 ECONOMIC ACTIVITIES IN THE MARITIME SECTOR

Due to the complexity of the maritime sector, its international character, supporting infrastructure and variety of stakeholders involved, it is crucial to understand what type of economic activities exist in the sector, which environmental impacts those activities have and which of those activities can be considered as 'environmentally sustainable'. As such, this chapter aims to map economic activities in the maritime shipping sector and ports.

4.1 Maritime economic activities

Boundaries

The maritime sector has an international character and is closely connected to other transport and production sectors. To avoid economic activities that fall between different taxonomies, it is therefore important to set boundaries prior to the identification of a detailed list of economic activities in the maritime sector.

The ships themselves are the core component, which is necessary for freight and passenger water transport. Ports/terminals, yards and suppliers are necessary to support the operation of the ships. Economic activities in the ports, terminals, yards and economic activities executed by suppliers, which are directly related to the ships are part of the list of economic activities in the maritime sector. The fuel bunker operation is for example an economic activity in the maritime sector, while the fuel production is not part of the list. A number of important economic activities in the maritime sector are further explained below.

Freight and passenger water transport & marine fishing

There exist several types of vessels and mobile assets in the maritime industry. Different ship types are destined for dry cargo transport, liquid cargo transport, passenger transport, pleasure, fishing, marine construction and other working vessels. All these types of vessels are part of the maritime industry and undertake economic activities.

Ships are not able to operate without equipment on board. This equipment can have various purposes. There are for example systems or technologies on board, which are required for power and propulsion, but there also exist systems for the reduction of ship waste, noise, greenhouse gas and air polluting emissions and other pollution. The use and maintenance of this equipment is part of the operation of the ship and therefore not considered as an independent economic activity in the maritime sector. The installation of the equipment is part of the newbuilding process of the ship. The production of the equipment is outside the scope of the maritime economic activities. The same reasoning applies to systems and equipment for automation and digitalization on board, in ports and for communication between ships and ports.

Construction of ports and terminals

Ships are also not able to operate without a location for cargo handling, fuel supply, stores supply and crew change. Although these activities sometimes take place at sea, they mainly take place in ports and terminals. The construction and retrofitting or expansion of both ports and terminals are therefore part of the maritime economic activities. This also includes the construction of infrastructure for low carbon water transport such as infrastructure supporting the offshore wind power sector, fuelling or charging facilities. Dredging of the ports and facilities for cargo handling, cargo transhipment, waste reception and water supply are important functions for every port and terminal to be able to provide proper service to ships and their crew. Dredging and the construction of these facilities are part of the construction of ports and terminals and must therefore be included in this economic maritime activity.

Service activities incidental to water transportation

Ships need to comply with the legislation. A distinction can be made between legislation at global, continental, country and port level. Therefore, ships and crews are audited by several parties such as classification societies, clients and port state control. These audits can be seen as maritime economic activities and take place during sailing time, at anchorage and in ports/terminals.

Bunkering activities

Bunker operation can take place both in ports and at sea. In ports this can be done by ship-to-ship bunkering, shore-to-ship bunkering and truck-to-ship bunkering. At sea this can only be done by ship-to ship bunkering. The fuel bunker supply, a required bunker barge and the storage location of the fuel in port can be seen as maritime economic activity. The production of the fuel is on the other hand outside the scope of maritime activities since the fuels can also be used in other industries.

Delivery of products to the ships such as stores, provisions and water are directly related to and necessary for the operation of the ships and can be considered as maritime economic activities.

Activities in ports/terminals

Cargoes (or passengers) are loaded and discharged in ports/terminals. This is directly related to the operation of the ships and are considered as an economic activity in the maritime sector. The cargo is often transferred to other types of transport methods such as trains and trucks. Other transport types are not seen as maritime activities, although these activities take partly place in ports and terminals. Transhipment with, for example, cranes pipelines and hoses are maritime economic activities, but could also be considered part of either the rail or road transport economic sectors.

Other economic activities, which can take place in ports/terminals, are maintenance of the ports/terminals, shore power supply and waste collection.

Activities at yards

Yards are necessary for newbuilding, maintenance and retrofitting of ships. Yards are often positioned at favourable locations such as in or near ports. Without the work, which is executed on yards, there are no ships operating in the world. It is therefore necessary to see the work at yards intended for newbuilding of ships as well as maintenance and retrofit as a maritime economic activity. It can, however, also be considered as part of the construction sector, and a distinction between the activities, which are specifically on the maritime shipping sector and those which are relating to the way ships are built or retrofitted. There is not a clear line between these, though.

Demolition

The last economic activity of the ship is the recycling process at the end of her lifetime. This is similarly to the construction of the ships not considered as a core maritime activity but could rather be considered as part of the construction sector.

4.2 Environmental impact of activities

The above-mentioned economic maritime activities have an environmental impact on noise, emissions, air and water pollution and waste both in the air, ashore and under water. As such, the table below presents the environmental impacts associated with the given economic activities.

Table 4 Environmental impact of activities

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
Sea and coastal freight water transport (NACE H50.2.0)	Directly contributing activities Cargo ships • Tankers - Liquefied gas tankers - Chemical tankers - Oil tankers - Other liquid tankers • Bulk Carriers - Bulk dry - Bulk dry/oil - Self-discharging bulk dry - Other bulk dry - General cargo • Dry/Cargo	Ships emit different type of GHG emissions, which have an impact on climate change. While CO2 represent 98% of all GHG emissions, the sector emits more and more CH4 and emits a substantial amount of BC. Design efficiency depends on the vessel type: X - Y g CO2 equivalent per deadweight ton nautical mile Operational efficiency depends on the vessel type: X - Y g CO2 equivalent per deadweight ton nautical mile63	NA	All ships have a different impact on the use and protection of water and marine resources. The influence is dependent on the ship type, the ship design, the operational profile and the amount of people on board. See examples of the impacts under pollution prevention and control.	Carrying out maintenance of ships and demolition at the end of their lifetime in such a way that is has no negative impact on people and environment.	Ships emit air pollutants (NOx, SOx, PM, BC) which have an impact on the air quality. Ships have an impact on the water quality because of water pollution due to hull coating, discharge water of open loop exhaust gas cleaning systems, discharge of waste at sea. Grey water, black water and bilge water which is discharged at sea may contain pollution which can adversely affect the water quality.	Ships cause noise and vibrations due to the propulsion system and other systems on board Exchange of ballast water causes dispersion of invasive species. Ships impact species safety and habitats, e.g. through collision with mammals and through anchoring, which may have a localised impact on certain habitats such as shallow reefs.

[63] For LNG carriers: X – Y g CO2 equivalent per cubic meter nautical mile; General cargo ships: X – Y g CO2 equivalent per carried deadweight ton nautical mile; Container/ro-ro cargo ships: X-Y g CO2 equivalent per cubic meter nautical mile; for combination carriers, as the mass of the cargo on board: X – Y g CO2 equivalent per deadweight ton nautical mile.

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
	- General cargo ship - Refrigerated cargo ship - Other dry cargo • Ro-Ro cargo ships • Container ships	Commission Implementing Regulation (EU) 2016/1928					
	Offshore - Offshore supply - Other offshore Other work vessels - Research - Towing/Pushing - Dredging - Other activities	Ships emit GHG, which have an influence on the climate change impact. No EEDI exist for the offshore and other work vessels.					
Sea and coastal passenger water	Directly contributing activities Passenger ships64	Ships emit different type of GHG emissions, which have	NA	All ships have a different impact on the use and protection of water and marine	Carrying out maintenance of ships and demolition at	Ships emit air pollutants (NOx, SOx, PM, BC) which	Ships cause noise and vibrations due to the propulsion system

[64] Other recreational vessels are not included here.

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
transport (NACE H50.1.0)	- Passenger - Ferry - Cruise - Ro-ro passenger ships[65]	an impact on climate change. While CO_2 represent 98% of all GHG emissions, the sector emits more and more CH_4 and emits a substantial amount of BC. Design efficiency: X - Y g CO_2 equivalent per deadweight ton nautical mile.[66] Operational efficiency: X - Y g CO_2 equivalent per deadweight ton nautical mile. Commission Implementing Regulation (EU) 2016/1928.		resources. The influence is dependent on the ship type, the ship design, the operational profile and the amount of people on board. See examples of the impacts under pollution prevention and control.	the end of their lifetime in such a way that is has no negative impact on people and environment.	have an impact on the air quality. Ships have an impact on the water quality because of water pollution due to hull coating, discharge water of open loop exhaust gas cleaning systems, discharge of waste at sea. Grey water, black water and bilge water which is discharged at sea may contain pollution which can adversely affect the water quality.	and other systems on board. Exchange of ballast water causes dispersion of invasive species. Ships impact species safety and habitats, e.g. through collision with mammals and through anchoring, which may have a localised impact on certain habitats such as shallow reefs.
Marine Fishing (NACE A3.1.1)	Directly contributing activities Fishing - Fish catching	Ships emit GHG, which have an impact on climate change. A distinction can be made	NA	All ships have a different impact on the use and protection of water and marine	Carrying out maintenance of ships and demolition at the end of	Ships emit air pollutants (NO_x, SO_x, PM, BC) which	Ships cause noise and vibrations due to the propulsion system

[65] For ro-pax ships, as the number of passengers and as the mass of the cargo on board, determined as the actual mass or the number of cargo units (trucks, cars, etc.) or occupied lane meters multiplied by default values for their weight: X – Y g CO_2 equivalent per deadweight ton nautical mile

[66] For cruise and passenger ships design efficiency is measured in: X – Y g CO_2 equivalent per gross tonnage nautical mile.

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
	- Other fishing	between design and operational efficiency of different types of vessels.		resources. The influence is dependent on the ship type, the ship design, the operational profile and the amount of people on board. See examples of the impacts under pollution prevention and control. Bycatch during fishing affects marine resources.	their lifetime in such a way that is has no negative impact on people and environment.	have an impact on the air quality. Ships have an impact on the water quality because of water pollution due to hull coating, discharge water of open loop exhaust gas cleaning systems, discharge of waste at sea. Grey water, black water and bilge water which is discharged at sea may contain pollution which can adversely affect the water quality.	and other systems on board. Exchange of ballast water causes dispersion of invasive species. Ships impact species safety and habitats, e.g. through collision with mammals and through anchoring, which may have a localised impact on certain habitats such as shallow reefs.
Construction of water projects (NACE F42.9.1)	Enabling activities Construction and expansion of ports and terminals	The construction and/or expansion of ports and terminals causes greenhouse gasses at these locations which has an impact on climate change	Preparation of ports and terminals for sea level rise and dredging of ports and terminals have an im-	Impact on sustainable use and protection of water and marine resources: Design and construction of quays in such a way that rainwater, including (chemical) waste cannot enter the port from the quay.	Use of sustainable purchased materials and equipment has an impact on the transition to a circular economy.	The construction and/or expansion of ports and terminals causes air pollution (NOx, SOx, PM, BC) at these locations and in case the construction is not according plan it can also cause oil	The construction and/or expansion of ports and terminals causes noise which has an impact on the protection of biodiversity & ecosystems

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
			pact on climate adaption.	Oil, fuel and cargo spill prevention Drawing up discharge limits for ships in ports		and fuel spill. This have an impact on pollution prevention and control.	
Service activities incidental to water transportation (NACE H52.2.2)	Enabling activities Surveys by classification societies and other inspection service entities • Surveys by classification societies • Inspections from other entities	This activity itself has almost no climate change impact, but the travel distance and travel method from the surveyor who perform the audit/survey can have an impact on climate change.	This activity has no or little impact on climate adaption.	This activity has no or little impact on sustainable use and protection of water and marine resources.	This activity has no or little impact on a transition to a circular economy.	This activity itself has almost no impact on pollution and prevention control, but the travel distance and travel method from the surveyor who perform the audit/survey have impact on air pollution (NOx, SOx, PM, BC) and air quality.	This activity itself has almost no impact on the protection and restoration of biodiversity & ecosystems, but the travel method of the surveyor can cause noise and vibrations.
Service activities incidental to water transportation (NACE H52.2.2)	Enabling activities Automation and digitalization • On board • In ports and terminals • Between ships, ports and terminals	Voyage optimization and weather routing can have a positive impact on fuel consumption and thereby on greenhouse gas emissions. Automation and digitalisation in	This activity has no or little impact on climate adaption.	Automation and digitalization can have a positive impact on the reduction of oil, fuel and cargo spills during operations in ports.	This activity has no or little impact on a transition to a circular economy.	Voyage optimization and weather routing can have a positive impact on fuel consumption and thereby on air pollutant emissions. Automation and digitalisation in ports and between	Automation and digitalization can optimize and reduce the time of ships spend in ports which can have a positive impact on the noise in ports caused by ships.

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
		ports and between ports and ships can have a positive impact on fuel consumption in ports and thereby on the amount of greenhouse gas emissions in ports.				ports and ships can have a positive impact on fuel consumption in ports and thereby on the amount of air pollutant emissions in ports.	
Service activities incidental to water transportation (H52.2.2)	Enabling activities Delivery of products - Stores - Provisions - Water	This activity itself has almost no climate change impact, but the transport method and transport distance of the products can have an impact on climate change.	This activity has no or little impact on climate adaption.	This activity has no or little impact on sustainable use and protection of water and marine resources. It only has to be ensured that the products are delivered safely on board.	Items which can contribute to a circular economy: Direct return of packaging upon delivery of products, reuse and recycling of materials, avoidance and minimization of plastic, prohibition of individually packed products and single-use plastics	This activity itself has almost no impact on pollution and prevention control, but the transport method and transport distance of the products can have impact on air pollutions (NOx, SOx, PM, BC) and air quality.	This activity itself has almost no impact on the protection and restoration of biodiversity & ecosystems, but the transport method of the products can cause noise and vibrations.

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
Wholesale of liquid and gaseous fuels (G46.7.1) or (G47.3)	Enabling activities Fuel bunker supply - Truck-to-ship - Shore-to-ship - Ship-to-ship	Bunker ships or trucks emit GHG, which have an impact on the climate change impact. The amount of GHG is dependent on the type of fuel which the vehicles use.	This activity has no impact on climate adaptation.	Usually this activity has no impact. Only in case of a fuel spill it can cause a negative impact on sustainable use and protection of water and marine resources	This activity has no impact on a circular economy	Usually this activity has no impact. Only in case of a fuel spill it can cause a negative impact on pollution and prevention control.	Usually this activity has no impact. Only in case of a fuel spill it can cause a negative impact on the protection and restoration of biodiversity & ecosystems.
Cargo Handling (NACE H52.2.4)	Enabling activities Cargo handling - Loading of cargo/passengers - Discharging of cargo/passengers - Transhipment of cargo to another transport method before loading or after discharging	Port/terminal equipment required for cargo handling activities can have a direct or indirect impact on GHG: • Direct impact from emissions at the port/terminal • Indirect impact from emissions which are emitted during the production of electricity required for the cargo handling process.	This activity has no impact on climate adaptation.	Usually this activity has no impact. Only in case of a cargo spill during the cargo handling process it can cause a negative impact on sustainable use and protection of water and marine resources	Sustainable purchasing of the equipment required for cargo handling will have a positive impact on a circular economy.	Usually this activity has no impact. Only in case of a cargo spill during the cargo handling process it can cause a negative impact on pollution and prevention control	Usually this activity has no impact. Only in case of a cargo spill during the cargo handling process it can cause a negative impact on the protection and restoration of biodiversity & ecosystems.

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
Distribution of electricity (NACE D35.1.3)	Enabling activities Providing shore power to vessels during berthing time at port/terminal	Providing shore power has a direct and indirect impact on GHG: An indirect impact. Depending on the production method, GHG are emitted at the production location A direct impact. Because of the use of shore power ships do not have to use their own generators anymore which have a reduction of GHG in the port/terminal as result.	This activity has no impact on climate adaption.	This activity has no impact on sustainable use and protection of water and marine resources.	Production of electricity by a 'green' method have a positive impact on a circular economy	Providing shore power has a direct and indirect impact on pollution and prevention control: An indirect impact. Depending on the production method, air pollutants (NOx, SOx, PM, BC) are emitted at the production location A direct impact. Because of the use of shore power ships do not have to use their own generators anymore which have a reduction of air pollution (NOx, SOx, PM, BC) in the port/terminal as result.	By providing shore power, ships do not need to use their own generators at berth which has a reduction of noise in port/terminal as result.
Repair of other equipment (NACE C33.1.9)	Enabling activities Maintenance of the port/terminal, including all equipment.	Repairing quays for shore power installation influence the amount of greenhouse gasses in port which has an	Impact on climate adaption: Preparing quays for	Impact on sustainable use and protection of water and marine resources: Design/modification of quays in such a	Use of sustainable purchased materials and equipment has an impact on the transition	Preparing quays for shore power installations influence the amount of air pollution (NOx, SOx, PM,	Shore power reduce noise in ports

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
		impact on climate change.	sea level rise Dredging of port	way that rainwater, including (chemical) waste cannot enter the port from the quay. Oil, fuel and cargo spill prevention Drawing up discharge limits for ships in ports	to a circular economy.	BC) in the port/terminal which has an impact on pollution Oil, fuel and cargo spill prevention avoid air and water pollution Safe storage and handling of cargo avoid air and water pollution	
Waste collection (NACE E38.11)	Enabling activities Waste collection related to: - MARPOL Annex I - MARPOL Annex II - MARPOL Annex III - MARPOL Annex IV - MARPOL Annex V - MARPOL Annex VI	Treatment and processing of waste in a sustainable and environmentally friendly way has an impact on the GHG.	This activity has no impact on climate adaptation.	Collecting of all type of ship waste and the promotion of disposal ashore can have an impact on the amount of waste discharged at sea which has an impact on the protection of water and marine resources	Reuse and recycling of waste has an impact on the transition to a circular economy	Treatment and processing of waste in a sustainable and environmentally friendly way has an impact on the air pollution (NOx, SOx, PM, BC)	Collecting of all type of ship waste and the promotion of disposal ashore can have an impact on the amount of waste discharged at sea which has an impact on the protection of the ecosystem.

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
Building of ships and boats (NACE C30.1)	Enabling activities Newbuilding of a ship	Shipbuilding as an industrial activity has a potential direct/indirect impact on GHG emissions.	The construction of ships which are built for dredging purposes has an impact on climate adaption	Shipbuilding as an industrial activity has an impact on water consumption. The construction of ships which are specially built for research to the protection of water and marine resources, biodiversity and ecosystems can have a positive impact to sustainable use/ protection of water & marine resources	Shipbuilding as an industrial activity has an impact on generation of waste and recycling.	Shipbuilding as an industrial activity has a direct/indirect impact on emissions of pollutants. The construction of ships which are specially built to remove plastic from the sea has a positive impact pollution and prevention control	The construction of ships which are specially built for research to the protection of water and marine resources, biodiversity and ecosystems has a positive impact to sustainable use/ protection of water & marine resources
Repair and maintenance of ships and boats (NACE C33.1.5)	Enabling activities Repair and maintenance of ships and boats	Repair and maintenance of ships which are used for extracting renewable energy at sea have a climate change impact	Repair and maintenance of ships which are used for dredging purposes have an impact on climate adaption	Repair and maintenance of ships which are used for research to the protection of water and marine resources, biodiversity and ecosystems have an impact to sustainable use/ protection of water & marine resources	This activity has no impact on the transition to a circular economy	Repair and maintenance of ships which are used to remove plastic from the sea have an impact on pollution and prevention control	Repair and maintenance of ships which are used for research to the protection of water and marine resources, biodiversity and ecosystems have an impact to sustainable use/ protection of water & marine resources

NACE	Type of activity/ Economic activity	Climate change impact	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
Materials recovery (E38.32)	Enabling activities Scrapping of the vessel	There is a direct impact on climate change when equipment is used to scrap the vessel which emits GHG.	This activity has no impact on climate adaptation.	The way waste materials are processed during the demolition process has an impact on sustainable use and protection of water and marine resources.	Items which can have an impact on the transition to a circular economy: Reuse and recycling of materials Demolition in an environmentally friendly way without children labour	There is a direct impact on pollution and prevention control when equipment is used to scrap the vessel which emit air pollution (NOx, SOx, PM, BC).	Scrapping of ships can cause noise for the local environment.

4.3 Coverage of activities by the Draft Delegated Act 2020

The maritime sector activities presented above are classified according to NACE codes. This is in line with the TEG approach proposed for the EU Taxonomy, where the technical screening criteria is set for specific economic activities or group of economic activities. Some economic activities that are relevant for the maritime sector can also be classified under different sectoral taxonomies. For example, manufacturing of shipping equipment is classified under the Manufacturing sector taxonomy (in line with respective NACE) and the technical screening criteria reflects the sectorial specificities. This is done to ensure sectorial alignment. Table 5 maps the identified activities to the NACE and identifies where these activities fall under the Draft Delegated Act 2020.

Table 5 Overview of the identified activities, their NACE and link to the Draft Delegated Act 2020

Activity	NACE Code	Draft Delegated Act 2020 coverage
Freight vessels	Sea and coastal freight water transport (H50.2.0)	6. Transport, 6.10. Sea and coastal freight water transport
Passenger vessels	Sea and coastal passenger water transport (H50.1.0)	6. Transport, 6.11. Sea and coastal passenger water transport
Repair and maintenance and Retrofit of (part of) the ship	Repair and maintenance of ships and boats (C33.1.5)	6. Transport, 6.12. Retrofitting of sea and coastal freight and passenger water transport
Construction and expansion of ports and terminals/ other infrastructure	Construction of water projects (F42.9.1)	6. Transport, 6.16. Infrastructure for water transport
Construction and expansion of ports and terminals/ other infrastructure	Architectural and engineering activities and related technical consultancy (F71.1)	6. Transport, 6.16. Infrastructure for water transport
Construction and expansion of ports and terminals/ other infrastructure	Technical testing and analysis (F71.20)	6. Transport, 6.16. Infrastructure for water transport
Providing shore power to vessels during berthing time at port/terminal	Distribution of electricity (D35.1.3)	4.9 Transmission and distribution of electricity
Newbuilding of a ship	Building of ships and boats (C30.1)	3. Manufacture, 3.3 Manufacture of low carbon technologies for transport

Waste collection	Waste collection (E38.1)	5.Water, sewerage, waste management and remediation, 5.5. Collection and transport of non-hazardous waste in source segregated fractions
Automation and digitalization	Service activities incidental to water transportation (NACE H52.2.2)	3. Manufacture, 3.3 Manufacture of low carbon technologies for transport, if they can enable the compliance with criteria presented in 6.11 and 6.12
Maintenance of the port/terminal, including all equipment.	Repair of other equipment (C33.1.9)	3.Manufacture, 3.5. Manufacture of other low carbon technologies
Scrapping of the vessel	Materials recovery (E38.32)	5.Water, sewerage, waste management and remediation, 5.9. Material recovery from non-hazardous waste
Surveys by classification societies Delivery of products	Service activities incidental to water transportation (H52.2.2)	NACE code is covered by the Draft Delegated Act 2020, but not the specific activity
Marine fishing vessels	Marine Fishing (A3.1.1)	Not covered by the Draft Delegated Act 2020
Fuel bunker supply	Wholesale of liquid and gaseous fuels (G46.7.1) or (G47.3)	Not covered by the Draft Delegated Act 2020, but could be considered under 4.14. Transmission and distribution networks for renewable and low-carbon gases
Cargo handling	Cargo Handling (H52.2.4)	Not covered by the Draft Delegated Act 2020

Source: COWI/CE Delft.

This study focuses on the sea and coastal freight and passenger transport, manufacturing and retrofitting of vessels as well as maritime infrastructure and ports, which are covered by the following NACE codes:

- H50.1 Sea and coastal passenger water transport
- H50.2 Sea and coastal freight water transport
- H52.22 Service activities incidental to water transportation
- C33.15 Repair and maintenance of ships and boats
- F42.91, F71.1 or F71.20 Construction of water projects

5 TECHNICAL SCREENING CRITERIA

This chapter presents the findings on establishing the technical screening criteria for the maritime shipping sector, taking into account the approach established by the TEG. The chapter covers the climate mitigation criteria until 2025 and beyond 2025. It also discusses the economic activities that can contribute to other environmental objectives and presents the potential screening criteria for those objectives. First, a set of general principles for establishing screening criteria are set out followed by more specific considerations and finally the specific element included for each of the environmental objectives.

5.1 General principles

The maritime shipping is already one of the least CO_2 emissions intensive transport modes. Despite of that, decarbonising the shipping sector remains an important element for achieving the EU’s long-term objective of becoming carbon neutral by 2050 because the total energy consumption despite the low CO_2 intensity lead to significant emissions. Due to the current lack of alternative fuels and low carbon technologies, it is also a sector that will require significant efforts and R&D to achieve climate neutrality. As such, the inclusion of the maritime sector in the EU Taxonomy becomes crucial to incentivise the transitioning of the sector as well as to ensure access to sustainable finance.

Environmentally sustainable activities

For a maritime activity to be classified as 'environmentally sustainable', it must fulfil four requirements:[67]

- the activity contributes substantially to one or more of the six EU environmental objectives;
- the activity does not significantly harm any of the other five EU environmental objectives;
- the activity complies with minimum social safeguards; and
- the activity complies with technical screening criteria.

The technical screening criteria will determine whether an activity can be considered to substantially contribute to one of the environmental objectives and not significantly harm the other environmental objectives.

There are two types of substantial contribution that can be considered:

- Economic activities that make a substantial contribution based on their own performance; and
- Enabling activities that, by provision of their products or services, enable a substantial contribution to be made in other activities.

[67] Regulation (EU) 2020/852 of the European parliament and of the council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation, Article 3.

Substantial contribution to the climate mitigation objective

When setting the screening criteria for substantial contribution to the climate mitigation objective, it is important that the economic activities demonstrate consistency with the EU's mid-term and long-term climate objectives. The economic activities should incentivise the achievement of at least 55% GHG emissions reduction target by 2030 and the climate neutrality by 2050.

The EU Taxonomy differentiates between the economic activities that are near-zero carbon emissions (e.g. clean or climate neutral mobility) and transitional activities. A transitional activity can be considered an activity for which there is no technologically and economically feasible low-carbon alternative.[68] For the transitional activities to substantially contribute to the climate mitigation objective, the activities should incentivise the transition to a climate-neutral economy consistent with a pathway to limit the temperature increase to 1,5°C; and should:

- have GHG emission levels that correspond to the best performance in the sector or industry;
- not hamper the development and deployment of low-carbon alternatives; and
- not lead to a lock-in in carbon-intensive assets considering the economic lifetime of those assets.

Looking at the maritime shipping activities, there are very few (or none) low-carbon solutions readily available for the shipping industry, especially for the deep-sea shipping. As such, some of the economic activities within the maritime shipping could qualify as transitional activities, if those activities incentivise the transition to a climate-neutral economy as presented above.

Trade-off between stringency and coverage

One of the elements to consider when setting the technical screening criteria, is the trade-off between the stringency of the criteria for substantial contribution or level of 'greenness' of activities and the need to support the greening of the large share of the shipping fleet. Ultimately however, the technical screening criteria need to be set in accordance with the Taxonomy Regulation. The Taxonomy Regulation and its criteria are a tool for incentivising the transition by setting out the performance level required for economic activities to be on a transition pathway consistent with keeping temperature increase to 1.5°C. The shipping stakeholders highlight that the technical screening criteria should be designed to ensure that the largest possible part of the global fleet are incentivised to move in the right direction. This is particularly relevant due to the financial and operational lifetime of a ship, which is often 20-30 years. Many ships built in the past and coming years will therefore still be operational in 2050. The interviewed stakeholders argue that to have a real impact on shipping's GHG emissions, it is crucial to incentivise the transitioning of the whole fleet and to avoid incentivising only few best performers. As such, the screening criteria should encourage the shipping sector to take the necessary steps towards carbon neutral future by taking into account the technological capabilities and specificities of the sector.

In case the screening criteria is too stringent, the applicability of the EU Taxonomy could be too limited as it discourages the stakeholders from pursuing greening. As indicated by the shipping stakeholders, if a significant share of the market would not be

[68] Regulation (EU) 2020/852 of the European parliament and of the council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation, Article 10.

able to meet the criteria, it could have a direct negative impact on the cost and the availability of finance for the European shipping industry. They also emphasise that the EU shipping industry predominantly comprises of SMEs, which are reliant on commercial bank lending. Thus, access to competitive financing in Europe is crucial for its viability. The stakeholders highlight that an inclusion of the shipping sector in the Taxonomy should be conducted in a manner that maintains the competitiveness of the European shipping industry vis-à-vis non-EU competitors.

Financing assets or operations

Green finance instruments can either be used to finance assets or to finance operations. This distinction is relevant for the type of screening indicators that can be used. Investments in assets can use criteria relating to the design or to the technical properties of the asset. For ships, criteria can be based on the design energy-efficiency, for example. For operations, design criteria may not reflect the true operational energy-efficiency. However, when assets can be used in multiple ways, and use different types of fuels, it will not be possible to apply criteria relating to how the asset will be used, because that may not be known at the time of financing. In contrast, when operations are financed, indicators relating to the operational performance may be used. For ships, this can for example be the operational carbon intensity or the lifecycle greenhouse gas emissions of the fuels used.

No one-size-fits-all approach

Another important element when setting the screening criteria is the applicability of the criteria to the maritime activities. The shipping sector is characterised by a diversity of ship types, sizes, range of operations, trade patterns, value-chains and business models, and its international nature. All interviewed stakeholders highlight that a one-size-fits-all approach in shipping could be challenging and could potentially prove to be counterproductive. The stakeholders express the need for a more holistic approach that takes into account the specificities of each segment and technological possibilities. For example, batteries can be used for the short-sea shipping, whereas they will most likely never become feasible for the deep-sea shipping. As such, the technical screening criteria could be differentiated to account for this diversity.

Furthermore, studies show that a combination of many measures is needed to ensure sufficient reductions. One study found that the baseline emissions (i.e. future emissions from existing vessels) in the EU MRV fleet is 2260 $MtCO_2$, but that there is a potential to reduce committed emissions by 65%.[69] However, this reduction potential is based on the combination of multiple measures across operational, technical, alternative fuel parameters. The study further concludes that to maximise the potential savings, a combination of measures should be applied. Additionally, studies point to the potential use of current technologies and operational measures, which can contribute to significant GHG emission reductions.[70]

69 Bullock et al. (2020), 'Shipping and the Paris climate agreement: a focus on committed emissions.' in BMC energy. See: https://bmcenergy.biomedcentral.com/articles/10.1186/s42500-020-00015-2

70 Bouman E.A. et al. (2017), State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. Transportation Research. See: http://www.smartmaritime.no/Customers/Mate/SmartMarin/Handlers/FileFeed.ashx?itemId=363&languageId=1&filename=Bouman%202017%20State%20of%20the%20art%20technologies-review.pdf

Global nature of the industry

Shipping is a global industry, which is regulated by the IMO, who sets the global agenda for reducing GHG emissions from shipping. To avoid any distortion of competition and variations in efforts, the shipping stakeholders argue for the alignment of the EU Taxonomy with the work of the IMO. Thus, the technical screening criteria can be linked to the standards developed by the IMO such as EEDI or the EEOI. At the same time, the EU's ambitious target on climate neutrality will require significant efforts to reduce emissions from shipping going beyond what is currently proposed by the IMO. The criteria can thus be linked to the measures developed by the IMO, but should reflect the EU's ambition.

Avoiding lock-in effect

When setting the criteria for the short term (until 2025) and beyond, it is as previously noted important to consider the long lifetime of shipping vessels to avoid any potential lock-in effects in carbon intensive technologies. One of the aspects to consider for the screening criteria is how the new build vessels that have recently entered and that will enter the market in the coming decade can be retrofitted for alternative fuels to reach the neutrality objective by 2050. As indicated in Section 3.3.2 on alternative fuels, there are different retrofitting potential depending on the fuels used, e.g. biofuels can be blended with the conventional fossil fuels, whereas hydrogen requires heavily insulated (cryogenic) pressure vessels for storage.

Technological neutrality

Another relevant issue to consider when setting the technical screening criteria is whether any specific low carbon technologies should be incentivised. The shipping stakeholders advocate for technological neutrality, highlighting that at this stage of the development of the maritime shipping sector, it is important not to choose the technological pathways, as no single solution exists that can replace the fossil fuels. Instead, the maritime shipping stakeholders through the interviews and published position papers argue that that the technical screening criteria should focus on carbon-intensity and energy efficiency of vessels while enabling R&I into alternative fuels and technologies. Technology neutrality principle is also applied it the Taxonomy Regulation.

Life cycle considerations

Emissions can be evaluated on a life-cycle basis (often called well-to-wake or WTW, i.e. over the entire value chain from production of the fuel until its conversion into useful energy) or on conversion into useful energy (often called tank-to-wake or TTW or tailpipe emissions). The Commission has decided to use the TTW approach for all modes of transport in the technical criteria for climate mitigation in the Delegated Act 2020. Using the same approach for maritime shipping has the advantage that it is consistent with the approach taken in the taxonomy framework for other transport modes, that it incentivises energy efficiency improvements as well as the uptake of technologies relying on fuels that potentially emit no GHG and air pollutants, and that a mere inspection of the ship can determine whether the criteria are met or not – in other words, meeting the criteria does not depend on information about how the fuel has been produced. In line with this decision, screening criteria for maritime shipping consider TTW emissions.

The life cycle considerations are embedded in the EU Taxonomy Regulation (Article 14, 12(1a), 11 (a) and 9) and as such are part of the considerations when setting the technical screening criteria and defining DNSH criteria. The shipping stakeholders support the lifecycle approach, including both decarbonisation and sustainability aspects, and highlight the importance to consider what is technologically and commercially possible for the sector. Preparatory work has commenced also in the IMO to support the uptake of alternative low- and zero-emission fuels in shipping, with the EU advocating a lifecycle (well-to-wake) approach to GHG emissions.

The main reason for stakeholders to support assessment of emissions on a WTW basis, is that the production of zero-carbon fuels like hydrogen can emit much CO_2 when e.g. produced from steam-reforming natural gas (probably the most common way to produce hydrogen on an industrial scale) and even higher emissions when using coal instead of natural gas.

The choice between TTW and WTW is also connected with the way the screening criteria are set up, in particular whether they are based on design or operational performance, and the choice between financing assets or operations, as discussed above. In road transport, vehicle manufacturers are required to ensure compliance with CO_2 limits based on design. In maritime targets could be set also directly for operators and it would therefore be possible to take WTW emissions into account.

5.2 Screening criteria for climate mitigation until 2025

In order to set the technical screening criteria for climate mitigation until 2025, the key considerations are discussed below and then criteria are proposed in the next section.

5.2.1 Key principles and considerations

Compatibility with IMO framework

For ships that only perform voyages falling in the scope of the EU MRV Regulation, indicators and metrics coming from the EU MRV Regulation can be applied without creating any distortion of competition. However, for the ships navigating globally, the shipping stakeholders argue that the Taxonomy should be compatible with the work at the IMO, which is applicable not only to the EU market, but globally. As such, the criteria could be linked to the indicators and metrics used by the IMO such as EEDI and EEOI. The IMO has currently proposed two new measures to address carbon intensity: Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII).[71] Those two measures are particularly relevant for the criteria beyond 2025, as such, they are further discussed in Section 5.3.

Zero emissions vessels

Vessels that have zero tailpipe emissions can be considered as ‘green’ under the climate mitigation criteria. These vessels will still need to ensure that they fulfil the DNSH criteria, though. It is a shared ambition to develop the first carbon neutral vessel for deep sea activities by 2030. Due to current technological developments, only very few zero emissions vessels are available in the market and those are electrical vessels for short sea shipping (e.g. ferries, tugboats). As such, it may be relevant to focus on R&D activities before 2025 to ensure that those efforts are incentivised under the technical screening criteria.

WTW vs TTW

Above it is stated that vessels with zero tailpipe emissions can be considered 'green'. When evaluating emissions on a TTW basis, this requires the use of non-carbon fuels

[71] IMO (2020), IMO working group agrees further measures to cut ship emissions. See: https://www.imo.org/en/MediaCentre/PressBriefings/pages/36-ISWG-GHG-7.aspx

such as hydrogen and ammonia, as well as electricity stored in a battery or taken from the grid when vessels are berthed. Most other fuels and energy sources contain carbon and emit CO_2 when converted into useful energy. This means that ships with zero tailpipe emissions have to be specially designed ships, which cannot be operated on other fuels.

Furthermore, in some cases, e.g. when using ammonia in an internal combustion engine, a pilot fuel is required to ignite the ammonia. This fuel is often diesel so that the ship has significantly lower tailpipe emissions but not really zero.

Enabling R&D on alternative fuels and infrastructure

Shipping stakeholders highlight the need and importance of substantial R&D activities and consider the development of an alternative fuel based solutions to be an unmissable milestone in decarbonisation of the sector. They argue that under a short-term perspective, no specific alternative fuel / technology should be incentivised as more time is needed to for the technologies to develop. It is expected that by 2025-2030 the technologies will become more mature and the technological pathway to decarbonisation in shipping will become clearer. By that time, it may be relevant for the Taxonomy to consider incentivising the alternative fuels / technologies that show most potential.

Shipping stakeholders furthermore highlight that innovations should not be penalised, if investments do not succeed to achieve the intended results. For example, if investments are made with the intention to develop 'green' solutions but fail to deliver the desired results, the penalisation of such activities would hamper experiments and innovation.

Distinguishing between newbuilds and retrofitting

The shipping stakeholders point out that it is particularly important to distinguish between new builds and retrofitting, arguing that both types of activities should overall be incentivised under the Taxonomy. Stakeholders consider retrofitting and particularly the continued improvement of energy efficiency to be the primary course of action for meeting short-term GHG emission reduction targets. For example, in their interview, one shipping stakeholder mentioned their internal programme, which systematically looks for new technologies with potential to reduce energy use (new propellers, hull, hardware, software, etc.). The programme has been in use for 20+ years and it has achieved a 40% reduction in energy use between 2008 and 2020 (growth in industry has kept the total emissions the same for many years and only recently are absolute emissions being reduced).

Retrofitting existing vessels to run on alternative fuels is typically considered to not be economically feasible. However, shipping companies are currently testing dual fuel- and hybrid engines in pilot projects and are working towards further development and use of these engines.

Operational improvements

The majority of the interviewed shipping stakeholders state that there are substantial potential GHG reductions, which could be realised through optimisation of operational processes. Several shipping companies consider improvement of operational efficiency, together with technical energy efficiency measures, to be the pathway towards reaching the short term GHG reduction goals. Highlighted measures include slow-steaming (lowering speed), optimised route planning and reduction of waiting time in and around ports. For the reduction of waiting time in ports, stakeholders point to the following measures: optimisation of ship port interface, optimisation of communication between ships and ports, optimisation of just-in-time arrivals, and optimisation of the structure for agreement between shipping companies and cargo owners. The latter refers to the practice for agreements between shippers and cargo owners: if ships arrive late to the port, they must compensate the cargo owner. This incentivises shipping companies to increase speed and wait outside the port for up to several days, leading to much wasted time and extra fuel use for waiting outside ports. There are systems, which challenge this practice, for example, the virtual arrival system InterTanko, which enables agreements between ship and cargo owner based on the principle that if money is saved, it is shared between ship and cargo owner, and if there are delays, ship and cargo owner shares the expenses as well.

Furthermore, to optimise operational processes, stakeholders point to the development and optimisation of digital tools and optimised use of data for tools such as fuel pilots and AI programs. Shipping stakeholders perceive optimisation of operational processes to be low-hanging fruit, as it is cost-efficient and can provide significant reductions within a short timeframe.

Transitional fuels (LNG)

As zero emissions technologies and alternative fuels are still in development, transitional technologies could be incentivised in the short term to ensure the overall greening of the shipping sector. Shipping stakeholders are pointing to LNG as a transitional fuel. However, its role in the decarbonisation of the shipping sector is controversial as, despite its smaller CO_2 footprint and its contribution to other environmental objectives such as sulphur emission reductions, it is a fossil fuel. In addition, the existence of a methane slip, which is currently not accounted for, can further question its climate benefits and its role as a transitional fuel.[72] A methane slip is the unintended release of unburned methane, which slips from the engine due to poor fuel utilization due to low operational fuel–air ratios.[73] There is no standard regulations for the methane slip, but it is increasingly questioned whether the CO_2 reductions are cancelled out by the release of methane.[74] Some findings indicate that one of the main drivers for LNG is not specifically CO_2 reductions, but its contribution to sulphur emission reductions.[75] Accordingly, shipping stakeholders agree that while it may be considered a transitional fuel it is not a transformative fuel (i.e. not an alternative fuel). This is aligned with the EIB's position paper on 2021-2025 climate roadmap, which recognises the role of LNG as a transitional maritime fuel.[76]

Some shipping stakeholders furthermore highlight that LNG vessels may be more easily retrofitted to use alternative fuels such as ammonia, propane and methanol, as the

72 ICCT (2020), The climate implications of using LNG as a marine fuel, Working Paper 2020-02. See: https://theicct.org/sites/default/files/publications/Climate_implications_LNG_marinefuel_01282020.pdf

73 Ushakov, S. et al. (2019), Methane slip from gas fuelled ships: a comprehensive summary based on measurement data. See: https://link.springer.com/content/pdf/10.1007/s00773-018-00622-z.pdf

74 Lindstad, E. et al. (2020), Decarbonizing Maritime Transport: The Importance of Engine Technology and Regulations for LNG to Serve as a Transition Fuel.

75 European Commission (2017), Study on the Completion of an EU Framework on LNG-fuelled Ships and its Relevant Fuel Provision Infrastructure. Lot 3: Analysis of the LNG market development in the EU. See: https://ec.europa.eu/transport/sites/transport/files/2015-12-lng-lot3.pdf

76 EIB (2020), Climate Bank Roadmap. See: https://www.eib.org/attachments/strategies/eib_group_climate_bank_roadmap_en.pdf

steel in the tanks would face similar requirements. [77] Furthermore, LNG installations and propulsion systems can be easily adopted to bio and synthetic LNG. Bio and synthetic LNG could be used as drop-in fuels or fully replace the LNG, as such reducing the CO_2 emissions and avoiding air pollutants. One of the key concerns, however, raised by the civil society organisation in relation to the use of the bio and synthetic LNG in shipping is availability of the supply of these fuels.

Difference between short-sea & deep-sea shipping

Short-sea shipping will likely decarbonise faster due to frequent access to ports and the shorter distances they cover. Electrification of ferries, for example, is underway and even fairly progressed in some European countries, namely Norway where more than half of the fleet is expected to become electric within the next few years. Battery solutions are expected to contribute to decarbonisation of short-sea shipping. Due to the expected faster transition of short-sea ships and the limited number of bunker locations, a shipping stakeholder points out that they have an important role as incubator for new fuel options. On the other hand, deep sea shipping is easier to make more efficient due to relatively low carbon footprint, however its full decarbonisation is challenging. Shipping stakeholders believe that batteries for deep sea will not be feasible solutions before 2050 (if ever) and can only support and be used for optimization. The Commission Sustainable and Smart Mobility Strategy[78] sets a milestone for zero-emission ocean-going vessels being ready for market by 2030.

Some shipping stakeholders argue that due to its nature, short sea shipping has limited international competition. Deep-sea operations are more likely to face international competition from companies. Some stakeholders also agree that land-based transport is a competitor for short-sea shipping and there is a potential gain from modal shift to sea transport.

Differences between passenger and freight specificities

Shipping stakeholders generally agree that there is a difference between freight and passenger transport. Passenger ships (ferries) are for example more likely to be electric due to the shorter distances covered, following the same conditions as short-sea ships. One shipping stakeholder points out that non-essential ships / transport should be treated to higher standards, e.g. cruise ship travel should not be labelled as green. Such ships are currently being refitted to e.g. land-based electric supply (cold ironing, while berthed), which reduces the CO_2 levels as well as local pollutant, although it does not remove them entirely.

[77] LNG retrofits (2020), The time is now. See: https://www.hellenicshippingnews.com/lng-retrofits-the-time-is-now/

[78] Communication from the Commission To The European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on Sustainable and Smart Mobility Strategy – putting European transport on track for the future, Brussels, 9.12.2020, COM(2020) 789 final. See: https://ec.europa.eu/transport/sites/transport/files/legislation/com20200789.pdf

Non-eligible activities

Most stakeholders urge for caution to be exercised when determining which economic activities should not be covered by the EU Taxonomy. The shipping companies/operators consider it too early to determine, which activities should not be included and believe it can lead to premature blacklisting of some activities. In any case, it is not the purpose of the Taxonomy Regulation to exclude activities (the only exception being power generation from solid fossil fuels, see Art.19.3 of the Regulation). The TEG recommended that transportation of fossil fuels should not be eligible under the EU Taxonomy.[79]

5.2.2 Technical criteria until 2025

Based on the considerations mentioned above, this section presents the technical screening criteria for the sea and coastal freight and passenger water transport until 2025 as included in the draft Delegated Regulation published for public feedback on 20/11/2020[80] (hereinafter draft Delegated Act 2020). The focus here is on greening of shipping operations and facilitating carbon neutral shipping, as such, most of the discussion below focusses on vessels.

5.2.2.1 Vessels that have zero tailpipe CO_2 emissions

Draft Delegated Act 2020: the vessels have zero direct (tailpipe) CO_2 emissions;

This criterion entails eligibility of all vessels that have zero tailpipe CO_2 emissions. Currently, there are few ships that would qualify under this criterion. The only ships in the EU MRV Database 2019 that reported zero emissions also had zero hours at sea. There are some examples of smaller ships that have zero-tailpipe emissions (e.g. ForSea Ferries that operate in Norway and the electric ferry Ellen in Denmark, Molslinjen electric ferry from 2021)[81,82], but the numbers are small. In Scandinavia, the zero emissions ferries (mostly battery powered) are supported through public procurement. In the Mediterranean Sea, Grimaldi introduced 12 ro-ro cargo vessels using lithium batteries to ensure zero emissions operations inside the ports. However, these ships use conventional fuel at sea so cannot be considered 'zero-tailpipe' for all their operations. Despite of small numbers of zero emissions vessels, this criterion encourages further innovations in new propulsion technologies and alternative fuels, which is crucial for achieving climate neutrality.

There are also ongoing R&D projects on the use of hydrogen for zero-emissions vessels, however, it is still at a prototyping stage.[83]

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[79] TEG (2020), Final Report on the EU Taxonomy. See: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf

[80] EC (2020), Draft Delegated Regulation on climate mitigation and adaptation technical screening criteria. See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy#ISC_WORKFLOW

[81] The motorship (2020), Battery hybrid power for double-ender. See: https://www.motorship.com/news101/ships-and-shipyards/battery-hybrid-power-for-double-ender;

[82] Waterborne (n.d), Prototype and full-scale demonstration of next generation 100% electrically powered ferry for passengers and vehicles. See: https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/e-ferry

[83] Waterborne (n.d), The final step to zero emissions marine transport powered entirely from renewables. See: https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/hyseas-iii

5.2.2.2 Hybrid and dual fuel propulsions vessels that achieve significant GHG emissions reductions

Draft Delegated Act 2020: Until 31 December 2025, hybrid vessels use at least 50 % of zero direct (tailpipe) CO_2 emission fuel mass or plug-in power for their normal operation.

Hybrid and dual-fuel propulsion vessels can provide significant reduction of GHG emissions, and as such, should be recognised under the EU Taxonomy without specifying which technology should be used. Hybrid vessels can achieve fuel savings by using batteries, whereas dual-fuel propulsion systems are suitable for both conventional and alternative fuels. To ensure that no specific technology is signalled out, the criteria can be based on the expected energy savings or expected CO_2 reductions. The criterion specifies that emission fuel mass or plug-in power is calculated for normal operation. While the Taxonomy does not specify it, we consider that normal operation includes when vessels are berthed in ports.

For the hybrid vessels, the study conducted by EMSA (2020) on electrical energy storage for ships provides a good basis for understanding the potential of batteries for shipping.[84] The study indicates that there is a lot of variation in the fuel savings (electricity use) that batteries can achieve, see Table 6. Most ships have a minimum of 5% and the upper range is at 10%-100% fuel saving potential. It also depends on the size of the batteries installed. Up to 100% fuel savings (electricity use) are associated with vessels used for short-sea shipping such as ferries and high-speed ferries. The payback time on the higher initial investments through operation cost savings varies from one to eight years. It can be argued that a payback time of one year does not require additional incentives as it makes good economic sense. Another study points to CO_2 emission reduction of 2% to 45% when hybrid auxiliary propulsion is used.[85]

It is also important to recognise only the most ambitious ships under this criterion. As such, the threshold of a total fuel saving of 10% or more relative to the standard ship, as a result of integrating battery power in the ship design, could be eligible under the retrofitting criterion that focuses on reduction of fuel consumption (see the criterion on *Retrofitting of sea and coastal freight and passenger water transport*).[86]

[84] EMSA (2020), Study on Electrical Energy Storage for Ships. See: http://emsa.europa.eu/emsa-documents/latest/item/3906-electrical-energy-storage-for-ships.html

[85] Bouman E.A. et al. (2017), State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. Transportation Research. See: http://www.smartmaritime.no/Customers/Mate/SmartMarin/Handlers/FileFeed.ashx?itemId=363&languageId=1&filename=Bouman%202017%20State%20of%20the%20art%20technologies-review.pdf

[86] This criterion could also be applied for inland waterways vessels since the reasoning is the same.

Table 6 Summary table with typical values with regard to application feasibility and benefit of batteries

Ship type	Fuel savings potential (%)	Payback time (years)	Main battery function considered	Factors which can maximize benefit
Ferry	Up to 100	Less than 5	All electric where feasible	Low electricity costs, high port time, low crossing distance
Offshore supply vessel	5 – 20	2 – 5	DP – Spinning reserve	Low power and energy needs for backup
Cruise	< 5	Highly variable	Hybrid operating in all electric, ticket to trade	Ability to operate in all electric mode for extended period
Offshore drilling unit	10 – 15	1 – 3	Spinning reserve and peak shaving	Closed bus, large battery size
Fishing vessel	3 - 30+	3 – 7	Hybrid load levelling and spinning reserve	Diesel sizing relative to loads
Fish farm vessel	5-15 %	3-7	Hybrid load levelling and spinning reserve	Diesel sizing relative to loads
Shuttle tanker	5 – 20	2 - 5	DP – spinning reserve	Low power and energy needs for backup
Short-sea shipping	Highly variable	Highly variable	All electric or many hybrid uses	Vessel and duty cycle dependent
Deep-sea vessels	0 – 14	Highly variable	PTO supplement	Highly variable, detailed duty cycle analysis
Bulk vessels with cranes	0 – 30*	0 - 3	Crane system hybridization	Integration with genset sizing
Tugboats	5 - 15 (100 if all electric)	2 - 8	All electric or many hybrid uses	Detailed duty cycle analysis
Yachts	5 – 10	Highly variable	Silent operation, spinning reserve	Detailed duty cycle analysis
High speed ferry	Up to 100	3 - 6	All electric or hybrid	Detailed duty cycle analysis
Wind farm support vessels	5 – 20	2 - 5	DP – Spinning reserve	Low power and energy needs for backup

Source: EMSA (2020), Study on Electrical Energy Storage for Ships. See: http://emsa.europa.eu/emsa-documents/latest/item/3906-electrical-energy-storage-for-ships.html

As indicated in Section batteries (for full electric operations) are more suitable for short sea shipping, whereas the deep-sea shipping faces greater challenges when it comes to decarbonisation due to long distance voyages.

In line with the choice for TTW emissions (see Section 5.2.1), an alternative to hybrid propulsion could be dual fuel propulsion where one of the fuels has zero tailpipe emissions. These fuels do not contain carbon. Examples are ammonia and hydrogen. Ships could be designed with electric propulsion and have one or more generators running on those fuels. Alternatively, ammonia-powered ships requiring diesel as a pilot fuel in an internal combustion engine would also qualify.

The Draft Delegated Act 2020 specifies that at least 50% of the fuel by mass should be from zero-tailpipe fuels. Because the gravimetric energy density of hydrogen is about three times as high as that of marine gas oil (MGO) and the energy density of ammonia is about half the value of MGO,[87] this means that the threshold for the share of energy derived from these fuels ranges from 33% in the case of ammonia to 75% in the case of hydrogen. Consequently, the reduction in TTW CO_2 emissions would also range from 33% to 75%. It would be more internally consistent to use the same percentage as for battery power, i.e. 50%, and set the criteria on the basis of the energy content rather than the fuel mass. In that case, the incentives would be provided in a technology neutral way as all fuels are treated similarly.

In terms of the criterion proposed in the Draft Delegated Act for hybrid vessels that at least use 50% of zero tailpipe CO2 emission fuel mass or plug-in power, only few vessels would qualify under it. Particularly, hybrid vessels with batteries such as ferries and high-speed ferries could reach above 50% of zero tailpipe emission criterion. Other zero emissions fuels such as ammonia and hydrogen are still in early stages of development as also explained in Section 3.3.2, as such, only few pilot projects would qualify in the short term. Clarksons Research (2020) identified that only 1.1% of the world fleet uses alternative fuels[88] (as of 1st November 2020), which primarily consists of LNG.[89] No hydrogen or ammonia vessels were identified in the world fleet by Clarksons Research. At the same time, as indicated earlier, the criterion could recognise the demonstration and R&I projects within hybrid and dual fuel propulsion vessels.

5.2.2.3 Modal shift of freight

Draft Delegated Act 2020: until 31 December 2025, and only where it can be proved that the vessels are used exclusively for provision of coastal services designed to enable modal shift of freight currently transported by land to sea, the vessels have direct (tailpipe) CO2 emissions, calculated using the International Maritime Organization (IMO) Energy Efficiency Design Index (EEDI), 50 % lower than the average reference CO2 emissions value defined for heavy duty vehicles (vehicle sub group 5-LH) in accordance with Article 11 of Regulation 2019/1242;

[87] DNVGL (2019) Comparison of Alternative Marine Fuels, Report No.: 2019-0567, Rev. 3, https://safety4sea.com/wp-content/uploads/2019/09/SEA-LNG-DNV-GL-Comparison-of-Alternative-Marine-Fuels-2019_09.pdf

[88] This is classification proposed by Clarksons Research, whereas the study does not consider LNG as alternative fuel.

[89] Clarksons Research (2020), Figures include alternative fuels indicated below used for propulsion in merchant vessels.

The Green Deal Communication highlights the importance of multimodal transport and encourages the modal shift from inland freight to rail and waterways.[90] The Sustainable and Smart transport Strategy sets a target to increase transport by inland waterways and short sea shipping by 25% by 2030 and by 50% by 2050. This criterion aims to incentivise this modal shift from road to sea.

The TEG also recognised that an important contribution to meeting GHG targets and reducing environmental pressures from the transport sector could come from a modal shift from road to rail and waterborne freight transport. To recognise the potential of modal shift for carbon savings, the TEG proposed to set similar thresholds across modes and assuming that this would indirectly promote modal shift because a greater proportion of fleets in lower carbon modes are Taxonomy eligible.[91] The TEG has proposed a threshold of 50% lower than average reference CO_2 emissions of Heavy-Duty Vehicles (HDV) for road freight transport activities. Under this threshold, most shipping operations would be eligible until 2025 and as such, it can lead to greenwashing claims. However, this risk of greenwashing is addressed by the fact that the criterion is designed in such way that the vessels that qualify should be only those that are used exclusively for provision of coastal services designed to enable modal shift of freight currently transported by land to sea.

The development of the average EEOI for each ship type has generally decreased since 2008, e.g. for general cargo it decreased from 16 to 11.9 g CO_2 / t.km, and for bulk carriers from 6.2 down to 3.8 g CO_2 / t.km.[92] General cargo is the least efficient ship type with an average of 11.9 g CO_2 / t.km, which is significantly lower than the average of road freight vehicles, which operate with 56g – 200g CO_2/t.km.[93]

In practice, even though there is a significant potential to reduce emissions by shifting transport modes, there appears to be very limited scope for substitution between road and sea transport, unless additional financial support is provided for such modal shift to happen. In the cases where support was provided, significant benefits could be achieved as illustrated by projects like Med Atlantic Ecobonus, Marebonus and Marco Polo Programme II, shifting freight from road to sea.[94] Generally, shipping predominantly transports heavy commodities (fuel, ore). For container products, the cross-price elasticity is the highest at 0.68 in short-sea (feeder) container transport. De Jong (2003) also found very low cross- elasticities of demand, regardless of whether price- or time-elasticities were analysed.

[90] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions on the European Green Deal, Brussels, 1.12.2019, COM(2019) 640 final

[91] TEG (2020), Taxonomy: Final report: of the Technical Expert Group on Sustainable Finance, Technical Annex, p.324. See: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy-annexes_en.pdf _en

[92] IMO (2020), Fourth IMO Greenhouse Gas Study, MEPC 75/7/15, https://docs.imo.org/Shared/Download.aspx?did=125134

[93] Example of emissions of various heavy duty vehicles can be found in: ACEA (2020), CO2 emissions from heavy-duty vehicles. See: https://www.acea.be/uploads/publications/ACEA_preliminary_CO2_baseline_heavy-duty_vehicles.pdf

[94] Med Atlantic Ecobonus (n.d.). See: http://mae-project.eu/downloads; Marebonus (n.d.). See: http://www.ramspa.it/en/marebonus; Marco Polo Programme II (2020). See: https://ec.europa.eu/inea/sites/inea/files/cefpub/mp_ii_report_superfinal2020_metadone_0.pdf

Differently from other criteria, this criterion is applied to the characteristics of the operation rather than to vessel itself, because at the time a vessel is bought, it cannot be ascertained that it will actually reduce road transport. Only when investments are used to finance the operation of ships, instead of the building or retrofitting of ships, it may be possible to apply this criterion and ex-post monitoring could be necessary. The criterion is thus highly specific to cases and is therefore only applicable for few projects such as improvements for Ro-Ro services.

The criteria could be improved by ensuring that the actual EEOI is used to confirm the performance of the vessels instead of EEDI.

5.2.2.4 The most energy efficient new vessels

Draft Delegated Act 2020: until 31 December 2025, the vessels have an attained Energy Efficiency Design Index (EEDI)[95] value 10 % below the EEDI requirements applicable on 1 April 2022[96].

Ships of certain types have to comply with the EEDI, see also Text box 1, which sets a minimum standard for the ships' technical energy efficiency: Regulation 21 of MARPOL Annex VI that entered into force in January 2013, requires the attained EEDI of certain categories of ships not to exceed the required EEDI. The required EEDI is thereby differentiated according to ship's size and ship type by using a reference line value, which represents an average EEDI value of ships delivered in the preceding ten years (from 1 January 1999 to 1 January 2009). The attained EEDI is calculated according to the formula as laid down in the *2018 Guidelines on the method of calculation of the attained EEDI for new ships* (Resolution MEPC.308(73)).

So far, Phase 0 to Phase 3 have been differentiated, with requirements tightening every five years (see Table 7).

Table 7 Reduction factors (in percentage) for the EEDI relative to the EEDI Reference line

Ship Type	Size	Phase 0 1 Jan 2013 - 31 Dec 2014	Phase 1 1 Jan 2015 - 31 Dec 2019	Phase 2 1 Jan 2020 - 31 Dec 2024	Phase 3 1 April 2022 and onwards - advancements[97]	Phase 3 1 Jan 2025 and onwards
Bulk carrier	20,000 DWT and above	0	10	20		30
	10,000–20,000 DWT	n/a	0-10*	0-20*		0-30*

95 Energy Efficiency Design Index. See: http://www.imo.org/fr/MediaCentre/HotTopics/GHG/Pages/EEDI.aspx

96 The Draft Delegated Act 2020 refers to 1 January 2022. However, in November 2020, IMO decided at MEPC 75 to delay slightly the starting date of the advanced EEDI phase 3 – 1 April 2022.

97 EEDI requirements applicable on 1 April 2022 as agreed by the Marine Environment Protection Committee of the International Maritime Organization on its seventy-five session

Ship Type	Size	Phase 0 1 Jan 2013 - 31 Dec 2014	Phase 1 1 Jan 2015 - 31 Dec 2019	Phase 2 1 Jan 2020 - 31 Dec 2024	Phase 3 1 April 2022 and onwards - advance-ments[97]	Phase 3 1 Jan 2025 and on-wards
Gas carrier	15,000 DWT and above	0	10	20	30	
	10,000 – 15,000 DWT	0	10	20		30
	2,000–10,000 DWT	n/a	0-10*	0-20*		0-30*
Tanker	20,000 DWT and above	0	10	20		30
	4,000–20,000 DWT	n/a	0-10*	0-20*		0-30*
Container ship	200,000 DWT and above	0	10	20	50	
	120,000 – 200,000 DWT	0	10	20	45	
	80,000 – 120,000 DWT	0	10	20	40	
	40,000 – 80,000 DWT	0	10	20	35	
	15,000 – 40,000 DWT	0	10	20	30	
	10,000– 15,000 DWT	n/a	0-10*	0-20*	15-30*	
General Cargo ships	15,000 DWT and above	0	10	15	30	
	3,000–15,000 DWT	n/a	0-10*	0-15*	0-30*	
Refrigerated cargo carrier	5,000 DWT and above	0	10	15		30
	3,000–5,000 DWT	n/a	0-10*	0-15*		0-30*
Combination carrier	20,000 DWT and above	0	10	20		30
	4,000–20,000 DWT	n/a	0-10*	0-20*		0-30*
LNG carrier	10,000 DWT and above	n/a	10**	20	30	

Ship Type	Size	Phase 0 1 Jan 2013 - 31 Dec 2014	Phase 1 1 Jan 2015 - 31 Dec 2019	Phase 2 1 Jan 2020 - 31 Dec 2024	Phase 3 1 April 2022 and onwards - advancements[97]	Phase 3 1 Jan 2025 and onwards
Ro-ro cargo ship (vehicle carrier)***	10,000 DWT and above	n/a	5**	15		30
Ro-ro cargo ship***	2,000 DWT and above	n/a	5**	20		30
	1,000–2,000 DWT	n/a	0-5* **	0-20*		0-30*
Ro-ro passenger ship***	1,000 DWT and above	n/a	5**	20		30
	250–1,000 DWT	n/a	0-5* **	0-20*		0-30*
Cruise passenger ship*** having non-conventional propulsion	85,000 GT and above	n/a	5**	20	30	
	25,000–85,000 GT	n/a	0-5* **	0-20*	0-30*	

Source: Resolution MEPC.203(62) (MEPC 62/24/Add.1, Annex 19); MEPC 251(66) (MEPC 66/21, Annex 12).
* Reduction factor to be linearly interpolated between the two values dependent upon ship size. The lower value of the reduction factor is to be applied to the smaller ship size.
** Phase 1 commences for those ships on 1 September 2015.
*** Reduction factor applies to those ships delivered on or after 1 September 2019, as defined in paragraph 43 of regulation 2.
n/a: No required EEDI applies.

To comply with the EEDI, ships can use engines with reduced power, can use optimized ship designs (e.g. optimized hull shape) or use innovative measures, like for example air lubrication or wind propulsion systems (see 2013 Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI).

The stringency of the measure has been debated at length, since for some segments a large number of existing ships turned out to be more than compliant with the requirement for new ships at the time the measure entered into force. For example, analysis of container ships showed that most of the ships built after 2015 have already overtaken EEDI Phase 3, and oil tankers have achieved EEDI Phase 2.[98] In line with this, at MEPC 74, amendments were agreed to strengthen Phase 3 requirements and to bring forward the entry into effect date of Phase 3 from 2025 to 2022 for several ship types.

[98] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

These amendments were adopted at MEPC 75 in November 2020. The amendments when bringing forward the entry into effect date of Phase 3 from 2025 to 2022 are visible in Table 7.

Text box 1 Energy Efficiency of ships through EEDI & EEOI

The international Convention for the Prevention of Pollution from Ships, also called MARPOL, contains chapter 4 related to regulations on energy efficiency for ships to MARPOL Annex VI regarding emissions. The regulations in this chapter make mandatory the Energy Efficiency Design (EEDI) for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. The regulations apply to all ships of 400 gross tonnage and above and built after the 1st of January 2013.

The EEDI for new ships is a technical measure aimed to promote the use of more energy efficient equipment and engines. The EEDI requires a minimum energy efficiency level per capacity mile (e.g. tonne-mile) for different ship type and size segments.

The SEEMP for all operating ships contains a list of measures to optimize the energy efficiency of a ship without major (conversion) costs. The Energy Efficiency Operational Index (EEOI) is part of the SEEMP and can be used to monitor the energy consumption of a ship and a fleet during a certain period. The EEOI can be found in the MEPC.1/Circ.684. The efficiency of fuel use can be measured while the vessel is in operation by assessing the effect of, for example, improved voyage planning, a new propeller, more frequent propeller or hull cleaning or heat recovery systems.

Sources: DNV.GL (n.d.), Environmental compliance services. See: https://www.dnvgl.com/services/environmental-compliance-services-42085
The Environment and Transport Inspectorate (n.d), IEEC and SEEMP. See: https://www.ilent.nl/onderwerpen/aanvragen-certificaten/ieec-en-seemp
IMO (n.d). See: https://www.imo.org/en

The attained EEDI values of different ship types vary significantly. Large oil tankers, for example, just meet the required EEDI, whereas most containerships are much better than the required EEDI (MEPC/ING.3.Add.1) in phase 1 and phase 2.

Using the EEDI as a reference point to identify best performing ships, as required for transitional activities in Article 10 of the Taxonomy Regulation, satisfies the general principle mentioned by several stakeholders, that the criteria should be based on existing methodologies and global standards. Using the existing measure therefore reduces the burden for compliance with the criteria and respects the global nature of the shipping industry.

The criterion in the draft Delegated Act requires that the vessels have an attained EEDI value 10% below the EEDI requirements applicable as from 1 April 2022. Based on the EEDI values attained for vessels (2013-2019), and reported in the IMO EEDI database, around 12% of all EEDI ships would comply with such a level of stringency. However, the percentage of compliant ships varies significantly per ship types: respectively 1% of the bulk carriers, 11% of the gas tankers, 23% of the tankers, 13% of the containers and 37% of the general cargo ships, which are ranked according the EEDI currently comply with this criteria.[99] Since newbuilding ships take into account the EEDI requirements, which are becoming increasingly strict, it is possible that this share will increase in the coming years. For other types of vessels, such as refrigerated cargo carriers, combination carriers, LNG, ro-ro (vehicle carriers), ro-ro cargo,

[99] The analysis is based on the EEDI IMO Database (2020) provided by the EC.

ro-ro passenger ships and cruise ships, the number of registered vessels is too small to be statistically representative.

In view of the significant variation in the attained EEDI, an alternative approach to using a fixed percentage of the EEDI reference line could be a requirement that a vessel needs to be equal to or better than the 10% lowest EEDI scores of similar ships that entered the fleet in the three years prior to the time of the assessment. This approach would need a mechanism of constant (at least annual) updates of reference values to ensure universal application. It could become more practicable over the time as data availability in the IMO EEDI database improves.

As earlier described, only 1% of the bulk carriers, which are ranked according to the EEDI currently comply with the criteria (10% below the EEDI requirements applicable as from 1 April 2022). This results in bulk carriers being disadvantaged compared to the other ship types under this technical criterion. However, the applied level is equal to Phase 3, which becomes legal limit to the new bulk carriers already in 2025. Since new built ships take into account the future EEDI requirements, the share of bulk carriers compatible with taxonomy criterion should increase in coming years – in line with the main objective of the taxonomy.

It is also important to note that the EEDI does not cover offshore supply vessels and other work vessels (research, towing/pushing, dredging), as such these vessels will not be covered by a criterion where EEDI is used. Other ships may not have an EEDI, because they are not required to have one. This applies to ships built before 2013 and for small ships (the actual threshold varies between ship types – see Table 7). Ships built before 2013 can, in principle, calculate their EEDI and some have done so. Also, the IMO is in the process of adopting a regulation that would require all ships to calculate their design efficiency, using an indicator very similar to the EEDI, called EEXI. Ships below the size threshold can, in principle, also calculate their EEDI or EEXI. However, for these ships there is no established reference line, so it is not possible to compare the EEDI with a historical or a required value.

One of the concerns raised during the interviews was that the EEDI is a theoretical design index of how a ship is going to perform under certain conditions. However, when a ship is in operation, the conditions may be different, and the ship could perform below the given EEDI. This can lead to potential greenwashing claims. As such, some stakeholders recommended to monitor the performance of ships with the EEOI, which can measure the efficiency of fuel use during a certain period, see also discussion on monitoring in Section 6.2. Moreover, the IMO is developing new performance measures for vessels (see more on this in Section 5.3.1 below), which may even better reflect actual operational measures. Currently these measures are not in place and reference values can also not (yet) be established based on the new measurements.

5.2.2.5 Retrofitting of sea and coastal freight and passenger water transport

Draft Delegated Act 2020: Until 31 December 2025, the retrofitting activity reduces fuel consumption of the vessel by at least 10 % expressed in grams of fuel per deadweight tons per nautical mile, proven by computational fluid dynamics (CFD), tank tests or similar engineering calculations.

The improvement of energy efficiency of the existing fleet is considered a low hanging fruit that can support the overall greening of the shipping in the short term. This can be achieved through improvement in technical design and operational measures (optimising the ship port interfaces, lowering speed, optimising cargo load). The potential achievements of the energy savings depend on many factors, including the type of the ship, its state, technologies used. For example, older more polluting ships could have a greater energy saving potential after retrofitting compared to newer ships. As such, setting the threshold for reducing fuel consumption is challenging.

A potential challenge for the implementation of short- and medium-term retrofits, could be that shipping companies are less willing to invest in retrofitting measures for vessels with shorter remaining life. However, it is important that existing vessels will also be addressed. IMO is proposing the EEXI, which would implement the EEDI criteria retroactively, so that vessels built before 2013 also need to comply with the EEDI criteria. Regulations / policies such as this can help overcome the barrier for investment in retrofits. A design aspect of or speed reductions, such as engine power limitations, can also become a relevant element in this context.

Different technologies exist that can help to improve the energy efficiency of ships. Those technologies can have different energy saving potentials, see Table 8. A study conducted by Ecofys (2015) identified that it is possible to achieve 13%-20% of energy savings with high investments, between 5-10% with medium investments and less than 5% with low investments.[100] More recent projects and studies indicate even greater potential for energy savings. For example, a study on three different ships concluded that energy savings between 11% and 27% can be achieved with a Return On the Investment (ROI) of less than 3 years.[101] The ODFJELL project reduced fuel consumption by more than 20% due to installation of new propeller blades as well as achieved 10% fuel savings due to regular hull cleaning and polishing.[102] However, the reported energy saving potential is individual and dependent on the specific vessels and their current levels of energy efficiency.

To what extent the savings potentials can be generalised remain somewhat uncertain. Similarly, a wide range of savings can be achieved by introducing wind assisted propulsion systems. One study points to the CO_2 savings from 1% to 50%. The Rotor-DEMO project enhanced a propulsion system by using wind as an auxiliary propulsion measure.[103] The fuel savings achieved are expected to be up to 30%. In another project, where Flettner rotor was used, fuel consumption was reduced by 20%.[104] The Ecofys (2015) study, although dated back to 2015 is interesting due to the broad set of categories of potential improvements. It serves as a good indicator of the relative potential concerning different types of investments and improvements of vessels.

When setting a threshold for energy efficiency savings from retrofitting activities, it is important to ensure that is not too stringent in order to incentivize the overall greening of the fleet. If the threshold is set at the higher end of energy saving potential (e.g. at 20%), only very few vessels would qualify. It should also make economic sense (e.g. not too long ROI) for the shipowners to retrofit their vessels. As such, given the available technologies and other measures, 10% energy efficiency savings

[100] Ecofys (2015), Study on energy efficiency technologies for ships, Inventory and technology transfer. See: http://publications.europa.eu/resource/cellar/302ae48e-f984-45c3-a1c0-7c82efb92661.0001.01/DOC_1

[101] The Green Ship of the Future (2020), The Retrofit project. See : https://greenship.org/wp-content/uploads/2020/05/GSF-Retrofit-Project.pdf

[102] ECSA (2020), Ship Financing, ANNEX to the ECSA general remarks on the Taxonomy Report by the European Technical Expert Group on Sustainable Finance.

[103] Waterborne (n.d.), Norsepower rotor sail solution demonstration project. See: https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/rotordemo

[104] B,Comer, C.Chen, D.Stolz, D Rutherford. (2019), Rotors and bubbles: Route-based assessment of innovative technologies to reduce ship fuel consumption and emissions). See: https://theicct.org/sites/default/files/publications/Rotors_and_bubbles_2019_05_12.pdf

seems as a realistic threshold until 2025. There is also no/limited apparent risk of greenwashing in relation to this criterion.

Due to significant GHG emissions reduction potential of hybrid and dual fuels propulsion systems (see the discussion in the hybrid criteria), those vessels will likely qualify under this retrofitting criterion of 10% energy efficiency of fuels.

Table 8 Overview of energy efficiency measures

Main category	Measure	Efficiency gains	Ease of installation	Payback time	Investment
Hull	Bow optimisation	10%	all ship types short	Short (<3 years)	Medium
Main Engines	Wind power	20%	only special ship types	long (>15 years)	High
Propellers and Rudders	Ducted propeller	10%	all ship types except ferry and cruises	medium (4-15 years)	Medium
Propellers and Rudders	Contra-rotating propellers	13%	only special ship types	long (>15 years)	High
Propellers and Rudders	Wheels	10%	all ship types except ferry and cruises	Short <3 years)	Medium
Control Systems	Waste heat recovery	8%	New build only	Medium (4-15 years)	Medium
Propellers and Rudders	Rudder bulb	4%	all ship types except ferry and cruises	Medium (4-15 years)	Low
Propellers and Rudders	Post swirl fins	4%	all ship types except ferry and cruises	Short (<3 years)	Low
Hull	Hull coating	5%	All ship types	Short (<3 years)	Low
Hull	Air lubrication	9%	New build only	Medium (4-15 years)	Medium
Propellers and Rudders	Twisted rudder	3%	all ship types except ferry and cruises	Medium (4-15 years)	Low

Main Engines	Main engine design	3%	all ship types except ferry and cruises	Medium (4-15 years)	Low
Auxiliary engines	Common rail upgrade	-	All ship types	Medium (4-15 years)	Very low
Main engines	Common rail upgrade	0.3%	All ship types	Medium (4-15 years)	Very low

Source: Ecofys (2015), Study on energy efficiency technologies for ships, Inventory and technology transfer. See: http://publications.europa.eu/resource/cellar/302ae48e-f984-45c3-a1c0-7c82efb92661.0001.01/DOC_1.

5.2.2.6 Exclusion of vessels and infrastructure dedicated to fossil fuels

This criterion follows the recommendation from TEG that transportation of fossil fuels should not be eligible under the EU Taxonomy.[105] TEG assessed that even though there are short-term benefits in improving GHG emissions from the transportation of fossil fuels, it cannot be concluded that these activities will make a 'substantial' contribution to climate change mitigation. Thus, as an overarching principle, the transportation of fossil fuels should not be eligible under the EU Taxonomy. The same principle is also mainstreamed to other EU financial instruments and EIB Climate Roadmap.

However, this criterion could be difficult to apply to shipping because of the versatility of ships. The same dry bulk carrier can carry coal, ore, wood chips, fertiliser or grain, for example. Similarly, a products tanker may carry chemicals or biofuels. Therefore, with the possible exception of crude oil tankers, it will be difficult to not to cover investments in ships ex-ante on the basis of this criterion. In contrast, when money is raised to finance operations of ships, this criterion can be applied and should be tied to monitoring that ships are indeed not used to transport fossil fuels. In addition, the shipping organisations argue that excluding vessels due to their cargo will penalising shipowners through financial means for activities they do not have control over and disincentivises them from pursuing low carbon vessels.

To avoid penalising best-in-class and zero emissions tankers and bulk carriers, which can carry versatile cargo including renewable fuels, it can be relevant to consider how to operationalise the definition of 'dedicated'. For example, the EIB climate roadmap defines "dedicated" as built and acquired with the explicit intention to predominantly transport or store fossil fuels over the life of the project. Similar criterion could be applied for shipping. As indicated above, it will however be challenging to assess ex-ante whether the vessels will be dedicated explicitly for transportation of fossil fuels, as such ex-post monitoring may be needed in this case. Ex-post monitoring could help to assess what type of cargo was carried and avoid greenwashing claims.

[105] TEG (2020), Final Report on the EU Taxonomy. See: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf

5.3 Screening criteria for climate mitigation beyond 2025

In this section, the main principles and considerations for the setting the technical screening criteria beyond 2025 are discussed for the sea and coastal freight and passenger water transport. Based on these considerations, the criteria beyond 2025 is proposed.

5.3.1 Key principles and considerations

The EU Taxonomy Regulation requires that the technical screening criteria are regularly reviewed especially regarding the transitional activities. It is also expected that the criteria will be tightened over time as new technologies are developed and currently innovative technologies become standard. Moreover, in line with EU and IMO strategies, new policies will be introduced to further incentivise the decarbonisation of maritime transport, e.g. inclusion of the maritime shipping into the EU ETS. Taking all this into account, the technical screening criteria beyond 2025 are expected to be more stringent compared to the criteria proposed until 2025.

Decarbonisation is not linear

One of the elements that should guide the development of the criteria beyond 2025 is the technological and fuel advancements and their uptake by the shipping sector. The shape of the curve that defines the rate of carbon intensity reduction between 2012 and 2050 depends on assumptions applied; however, there is no strong justification for one or another.[106] Some of the interviewed shipping stakeholders highlight that the decarbonisation does not follow a linear trajectory. New technologies and fuels usually have a slow initial uptake and as the costs and technology risks are being reduced, the technologies become available for the larger market. This reinforces the uptake of the new technologies and fuels. As such, the stakeholders argue that an exponential decarbonisation curve instead of a linear trajectory could be normally expected.

Aside from the uptake following an exponential path, the expectation of a linear development is further challenged by the 25-30-year lifetime of vessels. On a global scale, there are currently around 3,000 vessels in the orderbooks from 2020-2023.[107] These vessels will to a large extent run on fossil fuels or renewable and low-carbon drop-in fuels and will be used, on average, for more than two decades. Added to this, is the large share of existing vessels and the expected growth of the maritime shipping sector, which further stresses the rate of decarbonisation and make it hard to foresee a linear progression of total emissions.

Following developments at IMO

Another important element for the technical screening criteria is the measures developed at the IMO level as mentioned also in the previous section. In 2023, the IMO is planning to revise its GHG emissions reduction strategy and between 2023 and 2030, so-called mid-term measures will be adopted under the strategy, which may include market based measures and implementation programmes for the effective uptake of alternative low-carbon and zero-carbon fuels. Consequently, the criteria beyond 2025 should take into account with the updated GHG reduction strategy and the adopted

[106] CBI assumes linear trajectory, https://www.climatebonds.net/files/files/CBI%20Certification%20-%20Shipping%20Background%20Paper%281%29.pdf

[107] Bullock et al. (2020), Shipping and the Paris climate agreement: a focus on committed emissions. in BMC energy. See: https://bmcenergy.biomedcentral.com/articles/10.1186/s42500-020-00015-2

measures. In addition, the criteria should reflect the EU's ambition of climate neutrality by 2050. As such, where needed, the stringency of the criteria should be adjusted to reflect the EU's targets.

In November 2020, the IMO agreed on new mandatory measures to cut GHG intensity of existing ships by requiring combining both technical and operational approaches to achieve reductions.[108] Building on already existing measures (EEDI and SEEMP), the IMO proposed two measures:[109]

- Technical requirement to reduce carbon intensity based on EEXI; and
- Operational requirement to reduce carbon intensity based on CII.

EEXI will be calculated for every ship and it will indicate the ships' design energy efficiency compared to a baseline. The EEXI will be determined ex-ante by means of a technical analysis of a ship. In contrast, the CII is an indicator of the carbon intensity of a ship that will be determined ex-post. While the EEXI of a ship is fixed over its lifetime unless the ship undergoes major conversions, the CII may vary from one reporting period to the other. The operational requirement will determine the annual carbon intensity reduction factor that is needed in order to achieve continuous improvement of ships. The attained CII will be documented and verified against the required annual operational CII, and based on that, the operational carbon intensity rating A, B, C, D or E will be determined. The rating will be recorded in the SEEMP, and if the rating is low for three consecutive years, a corrective action plan will be required to show how the vessels will improve its operational efficiency and achieve C or above rating.

Developments at EU level

As part of the implementation of the European Green Deal, the Commission aims to develop a basket of measures to ensure that maritime transport fairly contributes to the increased EU climate objectives. One of these measures is the proposed inclusion of the shipping into the EU ETS. The European Parliament proposed the inclusion of ships of 5,000 gross tonnage and above into the EU ETS, as such, expanding the scope of the system and setting a pricing mechanism for the emissions from ships.[110] This will create further incentives for the shipping companies to reduce their emissions. In the European Parliament's proposal, revenues collected from auctioning of allowances are to be allocated to an 'Ocean Fund', which is planned to support initiatives on energy efficiency and innovative technologies such as alternative fuels.

Another measures is the FuelEU Maritime initiative that aims at addressing market barriers and uncertainty in relation to the market readiness of renewable low carbon technologies.[111] Under the FuelEU Maritime initiative, the EU may introduce requirements for ships to use renewable or low-carbon fuels, which need to have lower lifecycle GHG emissions than conventional fuels. It also aims to mandate the use of on-

[108] IMO (2020), IMO working group agrees further measures to cut ship emissions. See: https://www.imo.org/en/MediaCentre/PressBriefings/pages/36-ISWG-GHG-7.aspx

[109] Ibid.

[110] European Parliament (2020), Parliament says shipping industry must contribute to climate neutrality. See: https://www.europarl.europa.eu/news/en/press-room/20200910IPR86825/parliament-says-shipping-industry-must-contribute-to-climate-neutrality

[111] European Commission (n.d.), CO_2 emissions from shipping – encouraging the use of low-carbon fuels. See : https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12312-FuelEU-Maritime-

shore powers instead of running ship engines to produce the necessary power during the port visit, allowing to remove emissions of carbon and pollutants when the ships are at berth. The FuelEU Maritime addresses the need to increase the share of renewable low carbon fuels in the maritime shipping to support the objective of achieving the overall GHG emissions target of at least 55% by 2030.

Some of the eligible fuels will be so-called drop-in fuels, i.e. fuels that can be blended with fossil fuels or that can be used in existing engines without modifications to tanks, piping or engines. Other fuels will require specially designed new ships or modifications to existing ships. These latter fuels include liquefied hydrogen and ammonia, as well as methanol, which according to some observers offer the most cost-effective solution to decarbonising shipping (see also Section 3.3.2).[112] Consequently, it could be envisaged to create special categories for ships able to run on these fuels.

Finally, as part of the Green Deal Communication, the EC announced that the Alternative Fuels Infrastructure Directive (AFID)[113] is expected to be revised in 2021, which may have some implications on the development of the alternative fuels infrastructure for maritime shipping. Other important measures with possible implication for maritime transport include the revision of the Energy Taxation Directive and the Renewable Energy Directive.

WTW or TTW

As explained in Section 5.2.1, the shipping screening criteria until 2025 evaluate emissions on a TTW basis. This has the advantage that it is consistent with the approach taken in the taxonomy framework for other transport modes, that it incentivises energy efficiency improvements and the use of fuels that potentially have zero GHG emissions and very low or zero air pollutant emissions, and that a mere inspection of the ship can determine whether the criteria are met or not – in other words, meeting the criteria does not depend on information about how the fuel has been produced.

The disadvantage of a TTW approach, however, is that zero-emission fuels or energy sources can generate significant amounts of emissions in the production process. For instance, hydrogen can be produced by steam reforming methane, coal or lignite and in all those cases CO_2 is emitted during the production process. It can also be produced by electrolysis powered with renewable electricity, in which case there are hardly any lifecycle CO_2 emissions. The TTW approach does not take these differences into account. As a result, the TTW approach may result in a mere shift of emissions from the maritime sector to other sectors. If those other sectors are located in countries with less stringent climate policies, the impact on global emissions may be negative.

A second disadvantage is that the fuels that have zero TTW emissions often require dedicated ship designs. Hydrogen- or ammonia-powered ships have not yet been commercially demonstrated. Because of the properties of these fuels, they are expected to be more expensive than conventional ships. Moreover, if these ships can only sail on

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[112] IMO (2020) Fourth IMO Greenhouse Gas Study, MEPC 75/7/15, https://docs.imo.org/Shared/Download.aspx?did=125134

Frontier Economics; UMAS and CE Delft, 2019, Reducing the Maritime Sector's Contribution to Climate Change and Air Pollution: Scenario Analysis: Take-up of Emissions Reduction Options and their Impacts on Emissions and Costs, London: UK DfT.

[113] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure, L 307/1, 28.10.2014

those fuels, ship owners may be reluctant to have them built when ammonia or hydrogen are not available in sufficient quantities in ports globally. Currently, there is no bunkering infrastructure for those fuels.

Compared to a TTW approach, a WTW approach has several advantages. First, it takes the GHG emissions into account that occur during production, transport and conversion into useful energy. This means that there is no risk of emissions shifting to other sectors. Second, it opens that way to carbon-containing fuels like sustainable biofuels, synthetic methane, diesel or methanol (PtX). These fuels can sometimes be used in conventional ships or blended with conventional fuels. In some cases, they can also use existing bunkering infrastructure, making it less risky for ship owners to order ships that can sail on those fuels.

The disadvantage of a WTW approach it that it requires information about the production processes of fuels and the inputs into these processes. This also means that a mere inspection of a ship cannot establish whether the criteria are met or not. A connected disadvantage is that the WTW approach can only be implemented when financing operations, because the design of the ship may be the same as the design of a ship running on fossil fuels.

Energy efficiency improvements

As indicated in Section 5.2, improving energy efficiency of the existing fleet will remain an important measure to support the overall greening of the shipping beyond 2025. In addition, reducing the energy demand of vessels is vital for promoting the use of more expensive alternative fuels. Energy savings can be achieved through improvement in both technical design and operational measures. New technologies that provide significant energy efficiency improvements such as wind assisted propulsion systems should be further incentivised.

By using wind assisted propulsion, part of the required power is covered by the available wind. Potential options for wind assisted propulsion are rotors, wing sails, towing kites and wind turbines. This results in less fuel consumption causing a reduction of GHG, air pollutant emissions and oily related waste. In the right conditions a fuel saving up to 18% is possible on specific ship types and sizes.[114] Furthermore, wind assisted propulsion also contributes to pollution and prevention control, offering clean and pollution free propulsion techniques.

Another technology that may remain eligible for inclusion in the Taxonomy is air lubrication. This technology has the potential to reduce energy demand by some 4-8% but is, despite its decades-long history, a technology in development.[115] It is conceivable that other technologies or hull shapes will be developed in the next decade.

Renewable and low-carbon fuels

The IMO has made the large-scale development and deployment of carbon-neutral fuels a core part of its GHG strategy. This is driven by the understanding that these fuels are essential for phasing out GHG emissions from ships, the ultimate goal of the strategy. The shipping stakeholders agree that it would be premature to focus on one specific alternative fuel or technology, as more time is needed to ensure development

[114] CE Delft (2016), Study on the analysis of market potentials and market barriers for wind propulsion technologies for ships

[115] ABS (2019), Air lubrication technology. See: https://ww2.eagle.org/content/dam/eagle/advisories-and-debriefs/Air%20Lubrication%20Technology.pdf

and testing of current options, e.g. biodiesel, methanol, ammonia, ethanol, biogas, synthetic fuels, hydrogen and waste/biomass. Furthermore, it is also estimated that a future scenario could be that the shipping sector will be based on a multi fuel system with 3-4 different fuels.[116] However, by 2030 one or a few renewable and low-carbon fuels will probably be scalable to the sector, and in the period 2025-2030, it may be relevant to consider how the technical screening criteria could recognise the alternative fuels that show the most potential.

The development of alternative fuels necessitates a substantial demand for renewable electricity, either in Europe or abroad. As mentioned in Section 5.5, Transport & Environment estimate that a full decarbonisation of EU-related shipping by 2050 would require 11-53% additional renewable electricity generation across the EU28 (compared to 2015 levels).[117] This impact is estimated based on the most energy efficient technology, whereas less energy efficient alternative fuels such as e-methane and e-diesel would require around 42% and 53% respectively. CE Delft (2020) projects 25% - 30% additional renewable electricity globally.[118] In the support of alternative fuels, it is therefore essential to consider the impact on the renewable energy sector.

Vessels capable of sailing on renewable and low-carbon fuels

The shipping stakeholders aim to develop the first carbon neutral vessel for deep sea activities by 2030. The current plans do not indicate whether these vessels will be conventional vessels sailing on renewable and low-carbon drop-in fuels, or vessels sailing on fuels like ammonia or hydrogen, which require new types of equipment. In the latter case, these vessels could qualify in the taxonomy. Depending on how this development will progress and which vessel types can apply zero-emission technologies, this can lead to more stringent emission criteria post-2025.

Enabling infrastructure

The technical screening criteria should also continue to incentivise investments to the bunkering infrastructure for renewable and low-carbon fuels, which will become more prominent after 2025. The supply of some fuels will require dedicated infrastructure. In addition to increasing complexity, indications show that whichever alternative fuel(s) will be the pathway fuel, it will likely be less energy intensive than fossil fuel, which would require more bunkers hubs and more stopovers in the planning of routes, and some shipping stakeholders foresee the need to build bunker infrastructure in places where there is little activity today. Some stakeholders argue that the development of an alternative fuel and the supportive infrastructure must happen concurrently, and one stakeholder finds it relevant to overinvest in infrastructure to allow for experimentation with alternative fuels.

Strategic design for retrofitting

The shipping stakeholders estimate that by 2025-2030 it will likely become clearer, which alternative fuels show most potential. When it becomes more clear which fuel will be the route to zero-emission vessels, new-builds can incorporate strategic design

[116] DNV GL (2020), Maritime Forecast to 2050. Energy Transition Outlook.

[117] T&E (2018), Roadmap to decarbonising European Shipping. See: https://www.transportenvironment.org/sites/te/files/publications/2018_11_Roadmap_decarbonising_European_shipping.pdf

[118] CE Delft (2020), Availability and costs of liquefied bio- and synthetic methane. See: https://cedelft.eu/en/publications/2431/availability-and-costs-of-liquefied-bio-and-synthetic-methane

choices to enable more seamless retrofits at a later stage by developing adaptive fuel systems. Strategically designing ships with specific retrofits in mind will facilitate a swifter and economically feasible scaling of zero-emission vessels after 2030.

Dual fuel ships

The lifetime of a ship is on average 25-30 years. The installed engines are generally used throughout the complete lifetime of the ship. Most of the engines are still suitable for conventional fuels, such as heavy fuel oil and marine gasoil. A few types of engines are duel fuel engines, which means that they are suitable for both conventional fuels and an alternative fuel. Although, it is not yet clear how the maritime alternative fuel market will develop the coming years, engine manufacturers are preparing for this transition. HERCULES is an example of a long-term R&D programme to develop new technologies for marine engines.[119] This program is a joint venture of two major European engine manufactures, which together hold 90% of the world's marine engine market. Phase two of this programme is targeting at a dual fuel large marine engine, optimally adaptive to its operating environment.

In the Maritime Forecast to 2050, DNV GL has examined 30 different pathways to decarbonisation. In an analysis of different fuel / engine systems they find that dual-fuel LNG engines and fuel system are consistently the most robust choice (compared to conventional marine fuel internal combustion engines, marine fuel internal combustion engines with scrubbers (EGCS), and dual fuel ammonia engines).[120] Lloyd's Register and UMAS (2020) conclude that a transition pathway will depend on hydrogen, ammonia or biofuels.[121] The EC's projects increased use of biofuels and hydrogen.[122]

5.3.2 Discussion on design vs operational criteria

The literature review and interviews with shipping stakeholders show that there is an ongoing debate on the differences between and relevance of design and operational criteria. The debate is centred around the reliability of design criteria and the challenges related to practical use and comparability of operational criteria.

When contrasting the two types of criteria, it shows that they measure different elements and incentivise different behaviours. For example, a design criterion, such as one tied to EEDI for new ships, is a technical measure aimed to promote the use of more energy efficient equipment and engines. Conversely, an operational criterion, such as EEOI, can be used to monitor the carbon intensity of a ship and a fleet during a certain period. As such, one promotes continuous improvement of energy efficiency technologies on new ships, while the other incentivises behavioural changes, the further uptake of energy efficiency measures or the uptake of alternative fuels to meet certain carbon intensity requirements. In other words, design criteria target assets and installation of new technologies, while operational criteria target behaviour and in situ use of new technologies and renewable fuels.

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[119] Waterborne (n.d.), Fuel flexible, near-zero emissions, adaptive performance marine engine. See: https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/hercules

[120] DNV GL (2020), Maritime Forecast to 2050. Energy Transition Outlook.

[121] Lloyd's Register and UMAS (2020) Zero-Emission Vessels: Transition Pathways

[122] European Commission (2018) A Clean Planet for all: A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, IN-DEPTH ANALYSIS IN SUPPORT OF THE COMMISSION COMMUNICATION COM(2018) 773

Benefits and drawbacks of design criteria

The benefits of design criteria are that they allow ships' green properties to be assessed prior to their construction or financing decision. It is thus a theoretical exercise, which enables to estimate ex-ante whether a vessel complies with a green threshold based on the estimated effects of used and new technologies.

The primary challenge of design criteria is that in real life there is always a difference in estimated emissions and real emissions. This is generally reported by shipping stakeholders and found in the desk research as most ships tend to operate a lower speeds than design speed. A possible action to address this is to supplement or combine ex-ante estimations with ex-post operational monitoring of ships.

For a further discussion on the benefits and challenges related to design criteria, see Section 5.2.2 on the criterion for the most energy efficient new vessels.

Benefits and drawbacks of operational criteria

The benefits of operational criteria are that they focus on real emissions and enable ship performance to be accurately evaluated. They thus enable to assess the actual carbon savings and set thresholds in compliance with a decarbonisation trajectory, which matches EU policy objectives. By applying ex-post monitoring, operational criteria can be used to incentivise necessary behavioural changes and uptake of relevant technologies. Furthermore, analysis shows that decarbonisation by 2050 is not feasible without changes to operational practices,[123] and it is therefore relevant to incentivise such change.

However, despite its benefits, there are several challenges linked to the use of operational criteria. Firstly, there is an issue of granularity. The majority of the consulted shipping stakeholders agree that an operational criterion is very challenging to implement as the shipping sector and vessel types are highly diverse. This calls for highly tailored monitoring requirements that take into account that vessels are not easily comparable. Secondly, there is also a need to establish new monitoring and reporting practices, although some are already implemented (EEOI, AER) and others are being developed (e.g. CII) (for more detailed discussion on this matter, see Section 5.3.1. Thirdly, there are several factors influencing operational performance, which are not fully controllable by ship operators/owners. Such factors include the impact of weather/seasonal changes, changes to voyages, new routes, the impact of different cargo (e.g. different weight, density, properties). Consequently, operational performance can vary from year to year.

There are possible ways to address some of the challenges linked to operational criteria. For example, monitoring of operational performance is already in place for certain segments of the shipping sector, such as the EU MRV requirements applicable to vessels above 5000 GT, for which data has been collected in 2018 and 2019.[124] As experience with monitoring operational performance grows, and lessons are learned from new tools, a stronger base for comparing with past performances and taking into account yearly variances is being developed.

[123] IMO (2020), IMO working group agrees further measures to cut ship emissions. See: https://www.imo.org/en/MediaCentre/PressBriefings/pages/36-ISWG-GHG-7.aspx

[124] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

Another example of a possible way to address some of the challenges is through establishing processes that are flexible enough to account for yearly variances, while keeping ships on a decarbonisation trajectory. As an example, IMO has proposed to combine operational measure (CII) with an individual ship's management plan (SEEMP). The yearly operational performance is assessed against its required annual operational targets. Based on the vessel's performance, measured against the performance requirements for the ship, a rating from A-E is determined. The yearly rating is recorded in the SEEMP, and if the rating is low (D or E rating) for three consecutive years, a corrective action plan will be required to show how the vessels will improve its operational efficiency.

Financial incentives of design- and operational criteria

The design- and operational criteria establish different incentives for change. For the shipping sector, it is especially relevant in the light of different contractual arrangements between shipowners and ship operators. For example, in bulk/tramp shipping, the shipowner/operator is often contractually under the instructions of a charterer through a time charter contract. The charterer is thereby the party determining the vessel's itinerary, type of cargo, cargo quantity, service speed and fuel consumption and inter alia pays for the fuel and the port expenses for the duration of the contract. In this case, the shipowner/operator is not fully in control of operational performance of a vessel. In other cases, the shipowner may not be in charge of operational performance, while in some cases the shipowner and ship operator will be the same.

It may be relevant to differentiate between type of criteria based in the role of the company, which seeks to obtain green finance. On the one hand, for a shipowner, who is not responsible for the operational performance, it will be relevant for the financial institutions to apply design criteria. On the other hand, for ship operators or companies, which are responsible for performance, it will be relevant for the financial institutions to apply operational criteria or both. Ideally, the type of criterion should be determined by matching the criterion with the appropriate incentive for those seeking to obtain green finance. Section 5.1 on financing assets or operations elaborates further on the incentives related to design- and operational criteria.

Furthermore, due to external factors that influence the operational performance and uncertainty whether the real emissions would be in line with the estimated performance of the ship, using operational criteria constitute a higher risk for financial institutions. A situation may occur where a vessels was ex-ante eligible, but fails to meet the operational criterion. To mitigate this risk, a sound but sufficiently flexible ex post monitoring framework is needed for operational criteria. If a ship fails to meet operational criteria, green label may need to be retracted.

Combining design- and operational criteria

As discussed above, the design- and operational criteria effectively measure different performance elements, and incentivise different changes. One focuses on assets (design criteria) and the other one focuses on operations (operational criteria). Furthermore, the relation between design and operational performance varies across the sector and their comparison is not straightforward. For some segments, the operational performance is likely to exceed the design index, and for other segments the design index is likely to exceed the operational performance.[125] Consequently, it is challenging to draw straight lines between the two. As such, the design and operational criteria are not substitutable and should be considered complementary measures.

Combining the two types of criteria requires linking design criteria thresholds with equivalent/minimum operational performance thresholds. For that design criteria would need to become available also for ships constructed before 2013. The IMO is working on EEXI, which is the equivalent of EEDI for all vessels constructed before 2013. The IMO is also working towards establishing global operational criteria with the CII, which is set to apply for all vessels above 5000 GT. As a part of the CII approach, a yearly A-E rating will be set for all ships, and this rating will be made increasingly stringent towards 2030. With such design-and operational criteria that apply to the global fleet, design criteria could be complemented with the operational criteria. For example, it could be required that for maintaining their EEDI or EEXI based green credentials, vessels should operate above A and B level.

Before applying a combined criterion, it would be important to understand how the design (EEDI/EEXI based) and operational (CII based) criteria compare between them and, based on monitoring data, stress test these for compatibility and consistency. Further to this, it is also important to note that the effectiveness of the implementation of the EEXI and CII will be reviewed by IMO by 1 January 2026, and as such, it may not be fully clear how effective the two measures are before the criteria beyond 2025 will be adapted.

5.3.3 Technical criteria for climate change mitigation beyond 2025

Based on the considerations mentioned above, this section presents the potential technical screening criteria for the sea and coastal freight and passenger water transport beyond 2025. As indicated above, it is expected that the criteria will be tightened over time, as such the proposed criteria below reflects this approach. In addition, it is recommended that after 2025, the modal shift criterion is discontinued and the new best-in-class criterion is carefully considered to avoid lock-in effect until 2030, and discontinued as soon as commercially scalable zero emission solution become available and shipping is not considered a transitional activity. Finally, the proposed criteria should be carefully re-evaluated in 2025 to ensure that new developments in the shipping sector are accounted for.

5.3.3.1 Vessels that have zero tailpipe CO_2 emissions

Proposed criterion: the vessels have zero direct (tailpipe) CO_2 emissions;

Similar to the criterion until 2025, vessels that have zero tailpipe emission should be incentivised beyond 2025. It is expected that by 2025 there will be more vessels that use electricity, especially for short sea shipping. As mentioned in the previous section, for deep sea shipping, the EC and stakeholders expect to see the first carbon neutral vessel by 2030. Even if limited number of vessels will qualify under this criterion in short-term, it provides the right incentives for the market to support low carbon vessels.

[125] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

5.3.3.2 Hybrid and dual fuel propulsions vessels that achieve significant GHG emissions reductions

Proposed criteria:

Until 31 December 2030, hybrid vessels deriving at least 50% of their energy from zero tailpipe CO_2 emission fuels or plug-in power for their normal operation;

OR

Until 31 December 2030, hybrid and dual fuel vessels using at least 60% of their energy from non-fossil origin or electricity for their normal operation;

Hybrid and dual fuel vessels can achieve significant GHG emissions reductions through the use of alternative fuels and electricity, as such they should be recognised beyond 2025. The use of renewable fuels should also be incentivised. To account for these types of fuels, two criteria for hybrid fuels are proposed.

The first criterion proposed, is similar to the criterion until 2025, where hybrid vessels that derive at least 50% of their energy from zero tailpipe CO_2 emission fuels or plug-in power are eligible. The criterion follows the TTW approach. The only difference in this criterion is the focus on 'energy' instead of 'fuel mass'. As elaborated in the criterion until 2025, this change incentivises technological neutrality and ensures that alternative fuels are treated similarly.

The second criterion requires that '60% of their energy is from non-fossil origin or electricity'. This change allows for the use of renewable (e.g. biofuels, bio LNG) and low carbon fuels instead of just zero emissions fuels. It also takes into account the WTW approach. Renewable and low-carbon fuels may become available in the coming decades, especially when demand for such fuels is increased through targeted policy measures under the FuelEU Maritime initiative as well as EU ETS. These fuels have in common that they are not of fossil origin. As these fuels may not be available in sufficient quantities, shipping companies may prefer flexible solutions like dual or multi-fuel engines or hybrid systems. This option may become less relevant if EEOI based best-in-class criterion (see below) will be applied, because both incentivise the use of renewable and low carbon fuels.

One of the important elements to consider in the second criterion is how to ensure that the eligible vessels are actually using renewable and low carbon fuels to the extent possible and not significantly relying on fossil fuels. This is particularly important due to fuel price sensitivity as current fossil fuel prices are significantly lower compared to renewable and low carbon fuels. One way to ensure that renewable and low carbon fuels are used is to monitor their consumption through the EU MRV, although only information about the total fuel consumption is made publicly available under the current system. For ships outside the scope of the EU MRV (work ships and ships below 5000 GT), a new reporting mechanism would need to be established, possibly in conjunction with the EU MRV.

After 2030, it may be relevant to consider setting a more stringent criterion for use of renewable and low carbon fuels in hybrid and dual fuel vessels, e.g. requiring that vessels derive at least 70% of their energy in practice from renewable and low-carbon fuels. This would depend on the availability of renewable and low-carbon fuels, their price and on the existence of policies aiming to incentivise their use.[126]

5.3.3.3 Retrofitting of sea and coastal freight and passenger water transport

Proposed criterion: Until 31 December 2030, the retrofitting activity reduces fuel consumption of the vessel by at least 10 % expressed in grams of fuel per deadweight tons per nautical mile, proven by computational fluid dynamics (CFD), tank tests or similar engineering calculations.

Improving energy efficiency of the existing fleet will remain an important element in decarbonising shipping, as elaborated in Section 5.2.2. As such, the criterion for energy efficiency improvement should be continued beyond 2025.

The potential achievements of the energy savings depend on many factors, including the type of the ship, its state, technologies used. As such, setting the threshold for reducing fuel consumption is challenging. Table 8 presents existing technologies and measures that can improve energy efficiency of vessels. The energy saving potential varies from 5% to up to 30% including both technical and operational measures. Some projects and studies indicate greater potential for energy savings with such technologies like wind assisted propulsion. However, a higher improvement target (compared to the criterion until 2025) would be justified if new efficiency-improving technologies become mature. Based on recent studies of energy-efficiency measures, it is not considered likely to happen. As such, it is proposed to keep the improvement percentage at the same level as prior to 2025.

5.3.3.4 Best-in-class criteria

The following two proposed criteria focus on different elements, the first one – on the operational performance of vessels, the second – on design of vessels. The second criterion could be supplemented with the operational CII requirements once these requirements are established by IMO.

Decreasing carbon intensity of the fleet – operational criterion

Proposed criterion: Until 31 December 2030, vessels that have achieved carbon intensity expressed in Energy Efficiency Operational Index (EEOI) /Carbon Intensity Indicator (CII) below certain thresholds;

Another approach to consider is to use a reduction of the operational carbon intensity of the fleet over time to achieve climate neutrality by 2050. This criterion focuses on the operation of vessels and allows for identifying the best performing vessels during their operation and therefore allows to benefit from both - design and operational carbon abatement measures.

There are several measurement frameworks and trajectories available, such as those developed by the CBI or the maritime emissions trajectory in the 2030 Climate Target Plan. For instance, the CBI proposes[127] a set of technical screening criteria that can be used to label bonds as 'green' under the CBI certification scheme. For the vessels to qualify as green, they have to demonstrate that the expected carbon intensity of the vessel is aligned with the decarbonisation trajectory for specific vessel type and size. The CBI uses the median values for EEOI and AER for specific categories/sizes starting

[126] The same reasoning could be applied to inland waterway vessels.

[127] CBI (2020), Shipping. See: https://www.climatebonds.net/shipping

from 2020 and declining in a linear way to achieve neutrality by 2050. The thresholds for EEOI/AER values are presented in the table below. These values could be used for developing the technical criteria linked to carbon intensity of different vessels.

Carbon intensity linked criteria can reward best-in-class performing vessels and incentivise further efficiency improvements without favouring a specific technology. For example, the threshold for carbon intensity can be met through technical measures (installing wind assisted propulsion) or using lower intensity fuels (biofuels).

Operational carbon intensity can be measured using various metrics such as EEOI and AER. Table 9 provides an overview of the main elements of these measures. The EEOI and AER are preferred metrics for measuring operational carbon intensity, as they reflect GHG emissions of ships in real operating conditions.

Table 9 Overview of pros & cons of different carbon intensity metrics

Metrics	Main pros and cons
EEOI	Enables comparison of ships with different operational production units Measure all GHG emissions of ships in real operating conditions Data available for EU fleet through MRV on annual basis
AER	Enables comparison of ships with different operational production units (via proxy for transport work) Assumes ships are fully loaded on all miles travelled during the year Measure all GHG emissions of ships in real operating conditions Data available for the global fleet and IMO's Data Collection System enables AER to be calculated for all ships 5000 GT and above

Source: CBI (2020) The Shipping Criteria for the Climate Bonds Standard & Certification Scheme.

Table 10 CBI Shipping Criteria: fleet type and size specific AER and EEOI values for each decade starting from 2020 to 2050. For Ferry-pax only, Cruise, and Ferry RoPax, the denominator is GT instead of tnm

Type	Size (GT)	2020 EEOI/AER	2030 EEOI/AER	2040 EEOI/AER	2050
Bulk carrier	0-9999	35.1 / 24.6	23.4 / 16.4	11.7 / 8.2	0
Bulk carrier	10000-34999	12.2 / 6.6	8.1 / 4.4	4.1 / 2.2	0
Bulk carrier	35000-59999	9.2 / 4.6	6.2 / 3.1	3.1 / 1.5	0
Bulk carrier	60000-99999	8.4 / 3.6	5.6 / 2.4	2.8 / 1.2	0
Bulk carrier	100000-199999	4.6 / 2.4	3.1 / 1.6	1.5 / 0.8	0
Bulk carrier	200000-+	4.1 / 2.3	2.7 / 1.5	1.4 / 0.8	0
Chemical tanker	0-4999	40.3 / 35.4	26.8 / 23.6	13.4 / 11.8	0

Type	Size (GT)	2020 EEOI/AER	2030 EEOI/AER	2040 EEOI/AER	2050
Chemical tanker	5000-9999	26.6 / 19	17.7 / 12.7	8.9 / 6.3	0
Chemical tanker	10000-19999	18.7 / 11.9	12.5 / 7.9	6.2 / 4	0
Chemical tanker	20000-+	12.3 / 6.5	8.2 / 4.3	4.1 / 2.2	0
Container	0-999	27.3 / 16.9	18.2 / 11.3	9.1 / 5.6	0
Container	1000-1999	24.9 / 14.8	16.6 / 9.9	8.3 / 4.9	0
Container	2000-2999	19.5 / 10	13 / 6.7	6.5 / 3.3	0
Container	3000-4999	16.8 / 8.3	11.2 / 5.5	5.6 / 2.8	0
Container	5000-7999	16.2 / 7.8	10.8 / 5.2	5.4 / 2.6	0
Container	8000-11999	14.1 / 6.7	9.4 / 4.5	4.7 / 2.2	0
Container	12000-14500	10.4 / 4.6	6.9 / 3.1	3.5 / 1.5	0
Container	14500-+	10.4 / 4.6	6.9 / 3.1	3.5 / 1.5	0
General cargo	0-4999	30.2 / 24.2	20.1 / 16.1	10.1 / 8.1	0
General cargo	5000-9999	27.2 / 16.7	18.2 / 11.1	9.1 / 5.6	0
General cargo	10000-+	24.2 / 13.1	16.2 / 8.8	8.1 / 4.4	0
Other liquid tanker	0-+	106.6/ 97.6	71.1 / 65.1	35.5 / 32.5	0
Ferry-pax only*	0-1999	1272135.8	848090.5	424045.3	0
Ferry-pax only*	2000-+	1740606.6	1160404.4	580202.2	0
Cruise*	0-1999	2044403.4	1362935.6	681467.8	0
Cruise*	2000-9999	1286641.3	857760.8	428880.4	0
Cruise*	10000-59999	1495064.7	996709.8	498354.9	0
Cruise*	60000-99999	1738613.6	1159075.7	579537.9	0
Cruise*	100000-+	1337274.9	891516.6	445758.3	0
Ferry-RoPax*	0-1999	822123.9	548082.6	274041.3	0
Ferry-	2000-+	1137003.8	758002.5	379001.3	0

Type	Size (GT)	2020 EEOI/AER	2030 EEOI/AER	2040 EEOI/AER	2050
RoPax*					
Refrigerated bulk	0-1999	72.8 / 48.7	48.5 / 32.5	24.3 / 16.2	0
Ro-Ro	0-4999	258.2 / 212.4	172.1 / 141.6	86.1 / 70.8	0
Ro-Ro	5000-+	63.9 / 45.9	42.6 / 30.6	21.3 / 15.3	0
Vehicle	0-3999	124.7 / 46	83.2 / 30.7	41.6 / 15.3	0
Vehicle	4000-+	58.1 / 13.8	38.7 / 9.2	19.4 / 4.6	0

Source: CBI (2020) The Shipping Criteria for the Climate Bonds Standard & Certification Scheme.

CBI Shipping Criteria developed an ambitious reduction trajectory with the aim to support the vessels that achieve zero emissions by 2050. One of the criticisms towards the CBI Shipping Criteria[128] expressed by shipping stakeholders is that it sets targets for vessels 30 years in advance based on their EEOI/AER. The shipping stakeholders argue that this linear approach excludes a significant share of the shipping industry from entering the transition. They also highlight that setting the technical criteria for the mid-term is challenging due to uncertainties regarding the technological pathways and reduction potential of the sector. The fear is that setting criteria to much in advance may either lead to too stringent or too lenient criteria, which may both have undesired impacts on the priorities of the operators both in the short term (i.e. not wanting to progress with green improvements because it is expected to become easier to meet criteria in the future) and in the long run (i.e. because projects or investments meet the criteria). At the same time, CBI proposes to continuously update the trajectories, to ensure that the parameters are updated with new developments and updated information.

5.3.3.5 Identification of the most energy efficient new vessels – design based criterion

Proposed criterion: Until 31 December 2030, the vessels have an attained Energy Efficiency Design Index (EEDI) value equal to or better than the 10% lowest EEDI scores of similar ships that entered the fleet in the three years prior to the time of the assessment; or

the vessels have an attained Energy Efficiency Existing Ship Index (EEXI) equal to or better than the 10% lowest EEXI scores of similar ships; or

the vessels have an attained EEDI or EEXI 10% below the EEDI/EEXI requirements applicable as from 1 January 2025, whichever value is lower (better).

One of the essential elements to consider is how to recognise best-in-class vessels beyond 2025. One of the main advantages for incentivising best-in-class is encouraging the most energy efficient vessels. If the best-in-class is recognised, it can follow in principle the same approach as for the criterion until 2025. Once the EEXI will become

[128] CBI (2020), Shipping. See: https://www.climatebonds.net/shipping

available for the remaining existing vessels, it can also be applied not only for new vessels.

A new element is inclusion of the consideration of 10% lowest EEDI scores of similar ships. This will compensate for the significant variation in the stringency of the thresholds for attained EEDI depending on the ship type. First part of the criterion requires that the vessels have an attained EEDI value 10% below the EEDI requirements applicable as from 1 January 2025. Second part uses a fixed percentage of the EEDI reference line that a vessel needs to be equal to or better than the 10% lowest EEDI scores of similar ships that entered the fleet in the three years prior to the time of the assessment. The objective of the combination is to ensure that indeed only the 10% best performing ships are included. Similar ships can be interpreted as ships that have a size, which is up to 10% smaller or larger. In case there are too few similar ships in the EEDI database (e.g. less than 10), the criterion could be applied that the attained EEDI needs to be at least 10% below the required EEDI. This approach would need a mechanism of annual updates of reference values to ensure universal application by financial institutions. It could become more practicable over the time as data availability in the IMO EEDI and EEXI databases improves.

The support for the most efficient fossil fuel vessels may negatively affect the demand for alternative fuels. For example, energy efficiency improvements in containerships are driven by the building of increasingly large containerships (megaships). Despite meeting the criteria set forth by the IMO, the size of vessels results in a disproportionally large contribution to committed CO_2 emissions, and studies show that in terms of committed emissions, new built best in class containerships are contributing to GHG emissions to a larger extent than existing, less efficient container ships.[129,130]

In addition, considering the long life-time of vessels, the criterion for new build best-in-class vessels has to ensure, in line with Article 10 of the Taxonomy Regulation, that there will be no lock-in effect into fossil fuel beyond 2050. In this regard, it should be considered whether it is technically possible by 2025 to introduce a requirement for the ships to be capable of being retrofitted to accommodate zero carbon fuels. Recognition of new best-in-class fossil-fuel based vessels should be discontinued as soon as low carbon technologies become scalable.

5.4 Do-No-Significant-Harm criteria

This section presents the DNSH criteria for the sea and coastal freight and passenger water transport. These criteria are not differentiated between until and beyond 2025. However, if stricter regulatory requirements for the remaining environmental objectives are introduced until 2025, those should also be considered for the DNSH criteria.

Despite the relatively low CO_2 emissions, freight and passenger shipping can have significant negative impacts on air (PM, NOX, SOX emissions), water, noise and vibrations, and marine ecosystems (introduction of invasive species). As such, DNSH criteria can ensure that no such harm is attributed to the activities that qualify under the climate mitigation criteria.

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[129] Bullock et al. (2020), Shipping and the Paris climate agreement: a focus on committed emissions. in BMC energy. See: https://bmcenergy.biomedcentral.com/articles/10.1186/s42500-020-00015-2

[130] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

In developing the DNSH-criteria, the following approach has been applied:

- For each of the environmental objectives, we have identified if and how the relevant economic activity contributes to these objectives[131];
- We have identified regulations at the global or EU-level that address the problem. If regulations exist, we have assumed that compliance with the regulations ensures that there is no significant harm;
- In cases where there is no regulation, we have analysed existing voluntary schemes. In the case of DNSH criteria, we have in particular analysed the criteria from Green Marine.[132] This is a multi-level voluntary scheme. The lower levels are entry levels and the higher levels are more ambitious levels, as such, it could be considered to use Green Marine level 4 and 5 as reference points.

5.4.1 Climate change adaptation

Ships used for sea and coastal freight and passenger water transport do not need to be modified or retrofitted to adapt to potential climate change. Ships do not cause a significant harm on climate adaptation. There is no evidence that potential increasing water levels will have an impact on the vessels or their operations.

However, freight and passenger operation should not be adversely affected by the adaptation efforts of others as well as all material risks to vessels operation should be reduced to the extent possible and on a best effort basis.

5.4.2 Sustainable use and protection of water and marine resources

Problem

The ships used for sea and coastal freight and passenger water transport have an impact on the use and protection of water and marine resources. The impact is dependent on the ship type, the ship design, the operational profile and the amount of people on board:

- Grey water, black water and bilge water which is discharged at sea may contain pollutants which can adversely affect the water quality.

Regulations

Discharges of black and grey water are regulated by Annex IV of the International Convention for the Prevention of Pollution from Ships (MARPOL)[133], Directive 2011/92/EU, Directive 2000/60/EC and Directive 2008/105/EC.

Voluntary scheme

Green Marine, a voluntary environmental certification program for the North American marine industry, has developed an environmental certification program for ship-own-

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131 Contribution is determined based on the activity's ability to demonstrate that additional value, according to the scope of the relevant criteria, is feasible through implementation of said activity. Furthermore, it is also considered a contribution, when mitigating changes are made to avert standard practice that impair any criteria, even if the mitigating change, in itself, does not contribute with additional value.

132 Green Marine (2020), Advancing environmental excellence. See: https://green-marine.org/

133 IMO (1992), International Convention for the Prevention of Pollution from Ships (MARPOL), Annex IV. See: https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx

ers to benchmark environmental performance. The Green Marine Environmental Program 2020 contains five levels for every environmental aspect. Level 1 contains basic criteria and level 5 contains the strictest criteria. Examples of criteria for oil discharges are presented in Text box 2.

Text box 2 Example: Green Marine Level 4 and Level 5 requirements for oily water discharge

The program provides the following requirements related to **oily discharge** on level 4 and level 5:

Level 4:
"For fleets with median vessel gross tonnage ≥ 400 GT
4.1. Adopt a modernization policy for oily water separators and all related control and verification equipment. Systematic application of this policy on all new buildings and all ships undergoing major modifications. Implementation on at least one vessel in the company's fleet
Vessels built after January 1st, 2011:
4.2. Implement an integrated bilge treatment system such as that defined in the IMO's revised guidelines (MEPC.1/Circ.511, 18 April 2006).
OR
Vessels built before 2011:"
Other requirements need to be developed for vessels which are built before 2011.

"For fleets with median vessel gross tonnage < 400 GT
4.4. Set reduction targets (for the fleet as a whole or by vessel category) for bilge water produced.
4.5. Implement effective measures to reduce the quantity of bilge water and sludge produced on 50 % of the company's vessels.
Examples: Separate drainage systems for water and oil drains, installation of drip trays or coamings under equipment, use less water for maintenance and cleaning, replacement and repair of stern tube seals, etc."

Level 5:
"For fleets with median vessel gross tonnage ≥ 400 GT
On the majority of the company's vessels:
Vessels built after January 1st, 2011:
5.1. Implement an integrated bilge treatment system such as that defined in the IMO's revised guidelines (MEPC.1/Circ.511, 18 April 2006).
OR
Vessels built before 2011:"
Other requirements need to be developed for vessels which are built before 2011.

"For fleets with median vessel gross tonnage < 400 GT
5.3. Implement effective measures to reduce the quantity of bilge water and sludge produced on 75 % of the company's vessels.
5.4. Demonstrate an annual reduction of the quantity of bilge water and/or sludge produced (intensity unit is to be determined by the company, e.g. tonnes/hour of operation)."

Source: Green Marine (2020), Performance indicator for ship owners. See: https://green-marine.org/wp-content/uploads/2020/03/2020_Summary_shipowners.pdf

5.4.3 Transition to a circular economy

Problem

Maintenance and end-of-life of ships can have a negative impact on human health, safety and the environment.

Regulation

Maintenance and end-of life management of vessels should be performed in compliance with EU and national legislation on hazardous waste generation, management and treatment, including:

- Regulation (EU) No 1257/2013 on ship recycling
    - Vessels sailing under Flag state of an EU member State can only be recycled at facilities included in that list
    - Facilities need to be approved by the Individual Member States (for yards within the EU) or the Commission (for yards in third states).
    - All vessels, irrespective of their flag, entering European ports will need to carry an Inventory of Hazardous Materials (IHM).
- Waste Framework Directive (2018/028) and MARPOL Annex V related to prevention of pollution by waste.
- Revised Port Reception Facility Directive (EU) 2019/883

Voluntary scheme

Green Marine provides examples of the specific requirements for ship-owners related to ship recycling on level 4 and level 5, see Text box 3.

Text box 3 Example: Green Marine Level 4 and Level 5 requirements for ship recycling

Level 4:
"ALL ship owners:
4.1. Develop Part 1 of an IHM for 50% of vessels. IHMs must meet the requirements set out in the Hong Kong International Convention for the Safe and Environmentally Sounds Recycling of Ships.
4.2. Implement the hazardous material removal plan adopted in level 3.
4.3. Make the ship recycling Policy publicly available; or make public the written/documented commitment (Procedures within management plans) demonstrates your company's ship recycling management practices and accountability.

Ship owners who sold a vessel for recycling during year of reporting only:
4.4. Require the ship recycling facility, through a contractual clause, to provide regular recycling progress reports, from the time of vessel arrival to the time of receiving a Certificate of Completion of Recycling."

Level 5:
"ALL ship owners:
5.1. Require all vessels to have completed Part 1 of an IHM.
5.2. Validate all IHM with accompanying statements of compliance and renew on a 5-year basis.
Ship owners who sold a vessel for recycling during year of reporting only:
5.3. Remove all hazardous materials not essential to the classification, certification or operation of vessel as part of pre-cleaning procedures prior to departure for the recycling facility.
5.4. Hire a third-party auditor to undertake announced and unannounced visits to the recycling facility during the dismantling. The frequency to be agreed between the participant and the recycling facility. The "Audit During Recycling" (ADR) will be undertaken on site involving the participant (or third-party auditor representing the participant) and the recycling facility

senior management team. Each ADR report will be shared with the participant and recycling facility."

Source: Green Marine (2020), Performance indicator for ship owners. See: https://green-marine.org/wp-content/uploads/2020/03/2020_Summary_shipowners.pdf.

5.4.4 Pollution prevention and control

Problem

The ships, which are necessary for sea and coastal freight and passenger water transport, emit air pollutants (NO_x, SO_x, PM and BC), which have an impact on the air quality. Ships also have an impact on the water quality because of water pollution due to:

- Hull coating
- Discharge water of open loop exhaust gas cleaning systems and bleed off from open loop exhaust gas cleaning systems.
- Discharge of grey water, black water and bilge water (also presented under the Sustainable use and protection of water objective)
- Exchange of ballast water which cause dispersion of invasive species

Regulation

For PM and SOx emissions: Ships must comply with MARPOL Annex VI Regulation 14 on the sulphur content of the fuel and the EU Sulphur Directive 2016/802. Sulphur in fuel content does not exceed 0.5 % in mass as of 1/1/2020 (the global sulphur limit) and 0.1 % in mass as of 1/1/2015 in the Emission Control Area (ECA) designated in the North and Baltic Seas, North America and US Caribbean Sea by the IMO. Ships can also opt for alternative means of compliance. They then need to for instance install an exhaust gas cleaning system (EGCS) that achieves at least the same reduction in SOx emissions as using compliant fuels. In that case, the EGCS needs to comply with the EGCS guidelines as developed by the IMO.[134]

For NOx emissions: Tier II NOx requirement applies to ships constructed after 2011. Only while operating in NOx Emission Control Areas (ECA) established under IMO rules, ships constructed after 1 January 2016 comply with stricter engine requirements (Tier III) reducing NOx emissions (in the Baltic and North Seas the requirement is applicable as of 2021).

Black Carbon (BC), tiny black particles found in ship exhaust, contributes to heart and lung disease and is a danger to the environment. BC accounts for 21% of the of CO_2 equivalent emissions from ships.[135] Currently, there are no national or international regulations regarding the limitations of BC emissions from ships. The EU legislation addresses BC in the Directive 2008/50/EC of the European Parliament and of the Council on ambient air quality and cleaner air for Europe.

Discharges of black and grey water are in accordance with Annex IV to the IMO MARPOL Convention.

For applied hull coatings, measures are in place to minimise toxicity in accordance with Regulation (EU) No 528/2012, which implements the International Convention on

[134] Resolution MEPC.259(68)

[135] ICCT (n.d.), Black Carbon from Ships. See: https://theicct.org/spotlight/black-carbon-ships

the Control of Harmful Anti-fouling Systems (AFS) on Ships. The IMO's International Convention on the Control of Harmful AFS on ships entered into force in 2008. This convention bans tributyltin (TBT) in ships' antifouling paints. To support the implementation, the IMO has adopted several sets of guidelines:[136]

- Guidelines for Survey and Certification of Anti-fouling Systems on ships (Resolution MEPC. 102(48)
- Guidelines for inspection of Antifouling systems on ships (Resolution MEPC. 105(49)
- Guidelines for brief sampling of anti-fouling systems on ships (Resolution MEPC. 104(49)
- Guidance on best management practices for removal of anti-fouling coatings from ships, including TBT hull paints (Circular AFS.3/Circ.3)

MARPOL Annex VI Regulation 4 allows the use of equivalent devices, including exhaust gas cleaning systems, in particular for the application of Regulation 14 reducing the sulphur content of marine fuels.

5.4.5 Protection and restoration of biodiversity and ecosystems

Problem

The ships, which are necessary for sea and coastal freight and passenger water transport, cause noise and vibrations due to the propulsion systems and other systems on board which can have impact on both humans and marine life. The exchange of ballast water causes dispersion of invasive species. Ships impact species safety and habitats, e.g. through collision with mammals and through anchoring, which may have a localised impact on certain habitats such as shallow reefs.

Regulations

IMO Regulation II-1/3-12 in the international Convention for the Safety of Life at Sea (SOLAS) provides international standards for protection against noise. The regulation is adopted by Resolution MSC. 337(91) and requires ships to be constructed to reduce on-board noise and to protect personnel from noise.

Noise and vibrations are in compliance with the IMO Guidelines for the Reduction of Underwater Noise and with the provisions set out under Directive 2008/56/EC in relation to its Descriptors 1 (biodiversity), 2 (non-indigenous species), 6 (seabed integrity), 8 (contaminants), 10 (marine litter), 11 (Noise/Energy) and Commission Decision (EU) 2017/848 in relation to the relevant criteria and methodological standards for those descriptors, as applicable.[137]

Invasive aquatic species present a threat to the marine ecosystems, while shipping has been identified as one of the main ways to introduce invasive species to new ecosystems.[138] To address this problem, the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM) is adopted in February

[136] EMSA (2009), Anti-Fouling systems. See: http://emsa.europa.eu/implementation-tasks/environment/anti-fouling-systems.html

[137] IMO (n.d.), Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life, (MEPC.1/Circ.833).

[138] IMO (2014), International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM). See:https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Control-and-Management-of-Ships%27-Ballast-Water-and-Sediments-(BWM).aspx

2004 and entered into force in September 2017. This convention aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ship's BWM.[139]

The Marine Strategy Framework Directive aims to protect the marine environmental across Europe, focusing on understanding the impact of human activities on the sea and the implications for marine biodiversity, habitats and ecosystems. In line with the objectives of the Directive, Member States are introducing different measures such as technical solutions (less noisy ship engines), spatial planning/restrictions (licensing procedures), as well as awareness raising, governance actions and communication campaigns.[140] Furthermore, under the Marine Strategy Framework Directive obligations, Member States include initiatives taken in response to other relevant EU regulations, such as Water Framework Directive, Birds- and Habitats Directives, Common Fisheries Policy Regulation, Regional Sea Convention.[141] This EU regulation primarily covers coastal waters, and is less focused on the protection of biodiversity on open sea.

Voluntary scheme

Green Marine provides examples of specific requirements for ship-owners related to underwater noise on level 4 and level 5, see Text box 4.

[139] Regulation (EU) 1143/2014 on invasive alien species also touches on this issue. The regulation is aimed at control measures to be implemented by Member States and does not directly apply to the vessels or the operators.

[140] European Commission (n.d.), The Marine Strategy Framework Directive. See: https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

[141] European Commission (2018), Assessing Member States' programmes of measures under the Marine Strategy Framework Directive. See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0562&from=EN

Text box 4 Example: Green Marine Level 4 and Level 5 requirements for reduction of underwater noise

Level 4:
"4.1. Incorporate applicable vessel quieting technologies during retrofits and new vessel construction. Note: Refer to published documents like the IMO and the SNAME MVEP Guidelines, available in the Members section of the Green Marine website. This criterion is applicable only for ship owners ordering/designing new vessels (keel laid after Jan 2018) or conducting retrofits of propulsion systems or other equipment that contributes significantly to underwater noise.
AND, fulfil one of the following 3 criteria:
4.2. Work with ports to estimate relative ship noise levels for at least one vessel in their fleet.
OR
4.3. Estimate relative ship noise levels of at least one vessel in their fleet by using a dedicated hydrophone.
Note: Collaboration with a bio acoustician is essential to obtain reliable data.
OR
4.4. Support / collaborate on scientific research on underwater noise allowing the estimation of relative ship noise levels for at least one vessel in their fleet."

Level 5:
"5.1. Proceed to an in-depth analysis of vessel noise footprint on at least one ship in order to identify main noise sources. Solutions to be identified and implemented to reduce noise output.
Note: ANSI/ASA S12.64-2009 or ISO 17208-1:2016 underwater noise standard measurement methodology should be used where at all possible.
AND, fulfil one of the following 3 criteria:
5.2. Work with ports to estimate relative ship noise levels for 15% of the vessels in their fleet, with a minimum of 3 vessels measured.
OR
5.3. Estimate relative ship noise levels of 15% of the vessels in their fleet, with a minimum of 3 vessels measured, using a dedicated hydrophone.
Note: Collaboration with a bio acoustician is essential to obtain reliable data.
OR
5.4. Support / collaborate on scientific research on underwater noise allowing the estimation of relative ship noise levels for 15% of the vessels in their fleet with a minimum of 3 vessels measured."

Source: Green Marine (2020), Performance indicator for ship owners. See: https://green-marine.org/wp-content/uploads/2020/03/2020_Summary_shipowners.pdf

5.4.6 Summary of DNSH criteria

Table 11 summarises the DNSH criteria for sea and coastal freight and passenger water transport.

Table 11 Overview of DNSH for sea and coastal freight and passenger water transport as presented in Draft Delegated Act 2020

Sea and coastal freight water transport classified under NACE code H50.2.0 and 52.2.2 Sea and coastal passenger water transport classified under NACE Code H50.1.0	
Climate change adaptation	Operation of freight vessels does not lead to an increased adverse impact of the current and expected climate, on itself or for other people, nature and assets (Taxonomy Regulation, Art 12). The activity complies with the criteria set out in Appendix E of the Draft Delegated Act.
Sustainable use and protection of water and marine resources	Environmental degradation risks related to preserving water quality and avoiding water stress are identified and addressed, in accordance with a water use and protection management plan, developed in consultation with relevant stakeholders.
Transition to a circular economy	Measures are in place to manage waste, both in the use phase and in the end-of-life of the vessel, in accordance with the waste hierarchy in line with the Waste Framework Directive (2018/028). For ships above 500 gross tonnage, the activity complies with the requirements of Regulation (EU) No 1257/2013 of the European Parliament and of the Council relating to the control and management of hazardous materials on board of ships and the requirements applicable for their recycling. In particular, measures are in place to ensure that ships are recycled in facilities included on the European List of ship recycling facilities as laid down in Commission Implementing Decision 2016/2323459. The activity complies with Directive (EU) 2019/883 of the European Parliament and of the Council460 as regards the protection of the marine environment against the negative effects from discharges of waste from ships. The ship is operated in accordance with Annex V to the IMO International Convention for the Prevention of Pollution from Ships (IMO MARPOL). Scrubbers: Where exhaust gas cleaning systems (EGCS) are used, they are closed-loop systems.
Pollution prevention and control	*Air pollution:* For PM and SOx emissions: vessels comply with Directive (EU) 2016/802, and with Regulation 14 of Annex VI to the IMO MARPOL Convention. Sulphur in fuel content does not exceed 0,5 % in mass (the global sulphur limit) and 0,1 % in mass in emission control area (ECA) designated in the North and Baltic Seas by the IMO. For NOx emissions: vessels comply with Regulation 13 of Annex VI to IMO MARPOL Convention. Tier II NO_X requirement applies to ships constructed after 2011. Only while operating in NOx emission control areas established under IMO rules, ships constructed after 1 January 2016 comply with stricter engine requirements (Tier III) reducing NOx emissions. *Water pollution:* Black and grey water: discharges comply with Annex IV to the IMO MARPOL Convention.

	Hull coating: Measures are in place to minimise toxicity of anti-fouling paint and biocides as laid down in Regulation (EU) No 528/2012, which implements in Union law the International Convention on the Control of Harmful Anti-fouling Systems on Ships adopted on 5 October 2001.
Protection and restoration of biodiversity and ecosystems	Invasive species: the activity does not lead to releases of ballast water containing aquatic organisms as referred to in the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM). Noise and vibrations: comply with the IMO Guidelines for the Reduction of Underwater Noise and with the provisions set out under Directive 2008/56/EC in relation to its Descriptors 1 (biodiversity), 2 (non-indigenous species), 6 (seabed integrity), 8 (contaminants), 10 (marine litter), 11 (Noise/Energy) and Commission Decision (EU) 2017/848 in relation to the relevant criteria and methodological standards for those descriptors, as applicable.

5.5 Low carbon enabling infrastructure

In this section, the technical screening criteria for low carbon infrastructure is discussed in the light of the feedback from shipping stakeholders and the desk research. The focus is to examine whether the technical screening criteria put forth by the TEG (and the draft Delegated Act 2020) covers relevant activities that enable low carbon shipping.

Table 12 presents the technical screening criteria. The Low carbon enabling infrastructure for water transport includes inland waterway, inland ports and sea ports basic infrastructure. These waterway and ports are infrastructure for enabling modal shift to greener mode such as inland navigation, rail and shot sea shipping. As enabling factor, they should be included in the technical screening criteria as requested by several MS and stakeholders

Table 12 Infrastructure for water transport - Technical screening criteria

Substantial contribution to climate change mitigation	
1.	The activity complies with one or more of the following criteria:
1.1	the infrastructure is dedicated to the operation of vessels with zero direct (tailpipe) CO2 emissions: electricity charging, hydrogen-based refuelling;
1.2	the infrastructure is dedicated to the provision of shore-side electrical power to vessels at berth;
1.3	the infrastructure is dedicated to the performance of the port's own operations with zero direct (tailpipe) CO2 emissions;
1.4	the infrastructure and installations are dedicated to transhipping freight between the modes: terminal infrastructure and superstructures for loading, unloading and transhipment of goods.
2	The infrastructure is not dedicated to the transport of fossil fuels.

Source: Draft Delegated Act (2020).

The technical criteria cover the most highlighted aspects raised by the shipping stakeholders, namely infrastructure, which supports alternative fuels and electrification for charging batteries and for use during when vessels are berthed. In addition to this, shipping stakeholders highlight that the infrastructure will be more complex in the future as it will likely needs to accommodate the variety in a multi-fuel system. Shipping stakeholders also call for supporting R&D in infrastructure, which may be implied in the criteria, but is not mentioned. One shipping stakeholder finds that it may be relevant to overinvest in infrastructure related to alternative fuels to better gauge, which alternative fuels will be the feasible pathway fuels.

One of the challenges in relation to these criteria can be the interpretation of words 'infrastructure' and 'installations', i.e. whether a broader or stricter interpretation applies. For example, in the criterion 1.4, infrastructure may be interpreted as referring only to terminal infrastructure, which would exclude other related port infrastructure, for example, locks, access channels and breakwaters. As such, to avoid the exclusion of relevant types of infrastructure, the broader interpretation could be applied. However, it may require case by case assessment of whether this infrastructure is dedicated to the transhipment of freight between modes.

Several shipping stakeholders have pointed out that decarbonisation of the shipping sector is tied in large part to the overall development in the renewable energy sector. Examples they mention are carbon neutral alternative fuels and electricity, which are not sourced from renewable energy. In Transport & Environment's report on the shipping sector's road to decarbonisation, it is highlighted that the impact on the future EU renewable electricity production should not be underestimated.[142] Considerable additional investment will be required not only in the renewables sector, but also in electricity transmission grids, shore-side charging stations, hydrogen/ammonia production plants, new ship propulsion and energy storage designs and the widespread provision of new port bunkering infrastructure. They estimate that a full decarbonisation of EU-

[142] T&E (2018), 'Roadmap to decarbonising European Shipping'. See: https://www.transportenvironment.org/sites/te/files/publications/2018_11_Roadmap_decarbonising_European_shipping.pdf

related shipping by 2050 would require 11-53% additional renewable electricity generation across the EU28 (compared to 2015 levels).[142]

As regards technical screening criteria 2, which states that infrastructure should not be dedicated to the transport of fossil fuels, it excludes LNG (a fossil fuel) infrastructure. The Alternative Fuels Infrastructure Directive (AFID)[143] has as one of its objectives to create an LNG refuelling infrastructure in the main ports. The AFID is expected to be revised in 2021, which may have some implications on the development of the alternative fuels infrastructure for maritime shipping. Similarly, most shipping stakeholders considers LNG to be a transitional fuel, and it may be relevant to consider targeted or specific infrastructure related to LNG to support the transitional phase, especially as this infrastructure could be later adopted to biogas. However, Transport & Environment urges consideration in regard to the implications of commissioning additional LNG infrastructure.[144] While LNG infrastructure can possibly be used for synthetic methane bunkering, the NGO finds synthetic methane to be one of the least sustainable and enforceable technology pathways for shipping, as it emits GHG at vessel level and there is a potential for methane leakage. As such, it may be relevant to adequately consider LNG infrastructure with the aim to underpin synthetic methane uptake in the future.

In addition to the technical screening criteria, shipping stakeholders have pointed out an additional area of interest, which does not appear to be covered by the technical screening criteria as is: Port interface optimisation. In line with EU TEG methodology's mitigation criteria principle, port interface optimisation contributes to improving fleet efficiency.[145] Shipping stakeholders highlight undue waiting time in- and around ports, leading to congestion and emissions, which could have been averted. The findings from the desk research supports this view, and point to reduced waiting time as a 'low hanging fruit' GHG emission reduction measure. Reducing waiting time depends on optimised communication between ships and ports, business models, which do not incentivise fast sailing, but instead should incentivise just-in-time arrivals. Optimising port interfaces could also contribute to reduced waiting times. Operational measures, such as reduced waiting time, plays an important role in realising the short-term GHG emission reductions, but will also contribute to full decarbonisation.

5.6 Screening criteria for climate adaptation

An economic activity can be considered to substantially contribute to climate adaptation where that activity includes adaptation solutions that either substantially reduce the risk of the adverse impact or substantially reduces the adverse impact of the current and expected future climate; or where that economic activity provides adaptation solutions.[146]

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[143] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure, L 307/1, 28.10.2014

[144] T&E (2018), 'Roadmap to decarbonising European Shipping'. See: https://www.transportenvironment.org/sites/te/files/publications/2018_11_Roadmap_decarbonising_European_shipping.pdf

[145] European Commission (2020), EU TEG on Sustainable Finance. Taxonomy Report: Technical Annex. See: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy-annexes_en.pdf

[146] Regulation (EU) 2020/852 of the European parliament and of the council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation, Article 7

The maritime shipping activities have the largest potential at reducing the impact they have on climate mitigation objective, whereas climate adaptation is important to port infrastructure and other port activities.

As such, the activities that increase climate resilience of port infrastructure should be recognised in the EU Taxonomy. Some activities within the dredging industry can also support the coastal/flood and storm defences for ports, and those activities could be considered under the construction sector taxonomy.

The approach taken in the Draft Delegated Act 2020 applies the same generic climate adaptation technical screening criteria to all economic sectors and activities, focusing on "physical and non-physical adaptation solutions that reduce the most important physical climate risks that are material to that activity". The DNSH criteria are specific to each activity and reflect those applied to in case of technical criteria for climate mitigation.

Description of the scope of the activities is also specific and there the approach taken in the transport sector differs for operations and infrastructure (all modes). When for operations all activities are included, with the exception of those related to dedicated transport of fossil fuels, for infrastructure only activities complying already with climate mitigation criteria, qualify.

5.6.1.1 Infrastructure for water transport[147] – description of activity[148]

Draft Delegated Act 2020, annex II, section 6.16: Construction and operation of waterways, harbour and rivers works, pleasure ports, locks, dams and dykes and other as well as the dredging of waterways, including the provision of architectural services, engineering services, drafting services, building inspection services and surveying and mapping services and the like as well as the performance of physical, chemical and other analytical testing of all types of materials and products and excludes project management activities related to civil engineering works, where the infrastructure is not dedicated to the transport of fossil fuels and where it is one of the following:

(a) the infrastructure is dedicated to the operation of vessels with zero direct tailpipe CO2 emissions: electricity charging, hydrogen-based refuelling;
(b) the infrastructure is dedicated to the provision of shore-side electrical power to vessels at berth;
(c) the infrastructure is dedicated to the performance of the port's own operations with zero direct (tailpipe) CO2 emissions;
(d) the infrastructure and installations are dedicated to transhipping freight between the modes: terminal infrastructure and superstructures for loading, unloading and transhipment of goods.

The activity is classified under NACE code F42.9.1; F71.1 or F71.20 in accordance with the statistical classification of economic activities established by Regulation (EC) No 1893/2006.

This is a major limitation of the scope and implies that the activities most relevant for climate adaptation, such as works that would increase the climate resilience of the port infrastructure itself and protect it against e.g. rising sea levels and storms, are excluded. It would therefore seem appropriate to apply the same approach as for transport operations by deleting the limitations of the activities in points (a)-(d), while applying that only the infrastructure dedicated to fossil fuels would be excluded.

[147] Includes inland ports and waterways infrastructure.

[148] Draft Delegated Act 2020, section 6.16 of Annex II.

5.7 Screening criteria for to sustainable use and protection of water

The below recommendations should be considered as preliminary input to the work of the Platform on Sustainable Finance as actual thresholds or concrete screening criteria are not proposed at this stage for most activities, leaving this task to the Platform.

An economic activity can substantially contribute to sustainable use and protection of water and marine resources by contributing to achieving the good environmental status of marine waters, or to preventing their deterioration when they are already in good environmental state.[149] One of the areas where maritime shipping can support sustainable use of water is through further improving water management, by avoiding discharges of water pollutants and ensuring sustainable sewage treatment. One element should be highlighted here, the water management improvements should go beyond what is required by the relevant legislation (see Section 5.4 on DNSH to this criterion).

Improving water management

There are different technologies used on board of vessels that significantly improve water management and avoid discharges of water pollutants into marine environment. These technologies could be recognised under the EU Taxonomy.

MARPOL Annex I provide information about the required oil treatment equipment on board of ships. The maximum discharge limit according this Annex is 15 ppm. Systems such as a White Box System (WBS) can reduce this limit up to less than 5 ppm, which is above mandatory requirements. A WBS is a piece of equipment, which can be additionally used after treatment bilge/oil water by an oil water separator. The oil content of the pumping water is adjustable between 15 ppm and 5 ppm. The WBS is beyond the requirements set by MARPOL Annex I. The WBS is used by the Green Marine Label as a secondary monitoring unit to minimize the oily discharge. Green Marine Label has stricter requirements than MARPOL Annex I and can be used for inspiration for setting the screening criteria.

Sewage treatment

There are three different methods to store and treat sewage: a holding tank, a sewage comminuting and disinfecting system and a sewage treatment plant. All ships above 400 GT and all ships below 400 GT, which are certified to carry more than 15 persons need to comply with one of these three options where a holding tank is the minimum requirement. A sewage comminuting and disinfecting system and a sewage treatment plant are beyond the legal requirements. Rules regarding the discharge of sewage at sea depends on the geographical area, the installed systems on board and the type of ship, as the discharge from cruise ships in some area are more stringent. It is up to the shipping companies to determine, which systems they install on board of their ships, but in practice almost all ships have installed a sewage treatment plant due to the limit storage capacity on board. Sewage treatment systems, which are in compliant with the effluent standards of IMO Res. MEPC. 227(64) are the most environmentally friendly systems beyond requirements and could be used for setting the technical screening criteria.

[149] Regulation (EU) 2020/852 of the European parliament and of the council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation, Article 8

The table below presents the ideas for technical screening criteria (including DNSH) for the activities that could substantially contribute to sustainable use and protection of water.

Table 13 Technical screening criteria (including DNSH) for the activities that could substantially contribute to sustainable use and protection of water

Economic activity	Substantial contribution to sustainable use/ protection of water & marine resources	Do-No-Significant-Harm criteria				
		Climate mitigation	Climate adaptation	Transition to a circular economy	Pollution prevention and control	Protection of biodiversity & ecosystems
Technologies improving water management: e.g. installation of WBS, sewage treatment.	Demonstrates contribution to the protection of water, as relevant technologies can reduce damaging discharges further than required by regulation: - any oily mixture discharged into the sea after passing the filtering equipment has an oil content not exceeding 5 ppm - sewage treatment system in line with IMO Res. MEPC. 227(64)	NA	NA	Where feasible, ensure reuse of water	NA	If water is discharged to marine environment, ensure no significant harm

Source: COWI/CE Delft.

5.8 Screening criteria for circular economy

The below recommendations should be considered as preliminary input to the work of the Platform on Sustainable Finance as actual thresholds or concrete screening criteria are not proposed at this stage for most activities, leaving this task to the Platform.

The following activities can potentially contribute to circular economy objective: recycling of waste generated on board of vessels and introduction of circular economy practices; recycling of ships; and dredged sediment could be a valuable resource to reuse.

Recycling of waste generated on board

The MARPOL Convention regulates, which waste fractions must be landed in ports, and which types of waste can be discharged into the sea. It is allowed to remove certain types of waste to the sea at a distance of 12 nautical miles (22.2 km) from the nearest land (tighter / looser restrictions apply depending on which sea). These include food waste, crushed and disinfected or untreated grey and black waters and bilge water under certain conditions.[150] Shipping stakeholders highlight waste recycling as an important activity that can further support the objectives of circular economy, as for

[150] VG-Shipping (2019), Meriaura Group aims to create a zero-waste fleet. See: https://vg-shipping.fi/en/meriaura-group-aims-to-create-a-zero-waste-fleet t

example, as seen in Meriaura Group's Waste Reduction Project "MERI". The project comprises four sub-areas, which include minimizing of waste at source, enhancing onboard process and operation to reduce waste, amplification of the recycling of waste materials and improvement of handling of residual waste products. Cruise ships are implementing waste management and recycling practices as well. Due to the efforts of highly trained waste management professionals onboard, some cruise ships repurpose 100 percent of the waste generated onboard - by reducing, reusing, donating, recycling and converting waste into energy. Cruise ship waste management professionals recycle 60 percent more waste per person than the average person recycles on shore each day.[151]

Green Marine Label, a voluntary environmental certification program, has been developed for ship-owners to benchmark their environmental performance, including within the waste management sector.[152] The program contains different levels with Level 1 containing the basic criteria and level 5 containing the strictest criteria. The objective of the certification is to reduce the waste generated and increase recycling in line with the waste hierarchy.

Text box 5 Example: Green Marine Label Waste Management Criteria (Level 4 & 5)

Level 4:
4.1. Develop and implement a garbage management strategy defining targets, tools and measures for reducing garbage generated, reducing discharge at sea and increasing recycling.
Level 5:
5.1. Demonstrate continual improvement by achieving targets defined in the garbage management strategy.

Source: Green Marine (2020), Performance indicator for ship owners. See: https://green-marine.org/wp-content/uploads/2020/03/2020_Summary_shipowners.pdf.

Green Marine Label and MERI Waste Reduction Project can serve as inspiration for setting the criteria for substantial contribution to circular economy.

Recycling of ships

Shipping stakeholders have developed an initiative that aims to supply more and better information on the recycling of ships in the belief that more information about different practices in the disposal of ships can eventually help harmonize conditions of competition.[153] The Ship Recycling Transparency Initiative (SRTI) uses transparency to drive progress on responsible ship recycling by way of a one-stop shop online platform to report information on policies and practices against a set of predefined disclosure

[151] Cruise line International Association (n.d.). Environmental management. See: https://cruising.org/en-gb/about-the-industry/policy-priorities/environmental-stewardshi

[152] Green Marine (2020), Performance indicator for ship owners. See: https://green-marine.org/wp-content/uploads/2020/03/2020_Summary_shipowners.pdf

[153] ECSA position paper Annex II

criteria.[154] Ship recycling is dependent on 'green' recycling yards, and the EC has established a list, which tracks approved yards complying with guidelines and technical requirement set forth by the EU.[155]

Dredged sediment

As a result of environmental standards, which have applied in recent decades, dredged sediment is now cleaner than it used to be and much of it no longer needs to be buried as new opportunity for usages are showing and improvements are elements of a general trend.[156] Potential usages include reuse in the creation of wildlife habitats (also contribution to the protection and restoration of biodiversity and ecosystems), and its reuse as a secondary raw material in e.g. concrete, roads, landscaped mound. Barriers for reuse are concerns relocation of sediment material and its quality – sediment commonly contain contaminants (such as highly persistent and bioaccumulative substances such as PCB, Tributyltin and heavy metals), organic matter (5%–30%), high water content (50%–200%), and is relatively small in particle size (Dmax ≤ 300 µm), calling for treatment technologies to be developed in order to ensure the durability of sediment-based structure and assess their environmental impact under prescribed conditions.[157] In 2012, the EU AGRIPORT project demonstrated the environmental and economic benefits of innovative phyto-treatment processes to recycle slightly polluted dredged sediments from ports into reusable soil. The project found that these processes had a high replication potential in the EU and the Mediterranean area as a sustainable alternative to other methods for treatment and disposal of dredged sediment.[158]

The table below presents the suggested technical screening criteria (including DNSH) for the activities that could substantially contribute to circular economy.

Table 14 Technical screening criteria (including DNSH) for the activities that could substantially contribute to circular economy

Economic activity	Substantial contribution to transition to a circular economy	Do-No-Significant-Harm criteria				
		Climate mitigation	Climate adaptation	Sustainable use/ protection of water & marine resources	Pollution prevention and control	Protection of biodiversity & ecosystems
Recycling of ships	Demonstrate contribution to	Recycling	NA	NA	Recycling of ships is com-	NA

[154] Ship Recycling Transparency Initiative (n.d.), Using transparency to drive progress on responsible ship recycling. See: https://www.shiprecyclingtransparency.org/

[155] European Commission (2020). Ship Recycling. See: https://ec.europa.eu/environment/waste/ships/list.htm Website

[156] Smithgroup (2019), Larger trends in beneficial reuse of dredged sediment: what this means for the great lakes. See: https://www.smithgroup.com/perspectives/2019/larger-trends-in-beneficial-reuse-of-dredged-sediment-what-this-means-for-the

[157] Amar, M. et al. (2020), 'From dredged sediment to supplementary cementitious material: characterization, treatment, and reuse', in International Journal of Sediment Research. See: https://www.sciencedirect.com/science/article/pii/S1001627920300664

[158] European Commission (2020), Agricultural Reuse of Polluted Dredged Sediments (AGRIPORT). See: https://ec.europa.eu/environment/eco-innovation/projects/en/projects/agriport

Economic activity	Substantial contribution to transition to a circular economy	Do-No-Significant-Harm criteria				
		Climate mitigation	Climate adaptation	Sustainable use/ protection of water & marine resources	Pollution prevention and control	Protection of biodiversity & ecosystems
	circular economy through efficient recycling and reuse of steel and other resources	produces secondary raw materials suitable for use instead of virgin materials			monly occurring in countries not adequately prepared, and relying on an under-educated workforce, raising concern for human and environmental pollution	
Recycling of waste generated on board	Demonstrate contribution to circular economy through market-based initiatives like Green Marine Label or achieving X % of recycling of waste	NA	NA	NA	NA	‘No waste overboard” policy (some exceptions can apply to food leftovers)
Reuse of dredged sediment	Demonstrate contribution to circular economy through multipurpose reuse of dredged sediment which previously would be buried / permanently stored elsewhere	NA	NA	If not adhering to the waste hierarchy (firstly; reduce), by excavating sediments for reuse which would not otherwise have been excavated, it can cause harm to marine resources	NA	NA

Source: COWI/CE Delft.

5.9 Screening criteria for pollution and prevention control

The below recommendations should be considered as preliminary input to the work of the Platform on Sustainable Finance as actual thresholds or concrete screening criteria are not proposed at this stage for most activities, leaving this task to the Platform.

The following activities can potentially contribute to pollution and prevention control: Low-sulphur fuels/ships running on fuels that have zero or very low NO_X, installation of abatement technologies such as exhaust gas cleaning systems (EGCS or scrubbers), and multipurpose safety islands (dry docking facility for tankers in distress), and decontamination of sea-beds. However, as regards scrubbers, recently a discussion on whether open-loop scrubbers are sustainable has stirred uncertainty on the topic.[159]

Safety islands

Oil spills can present serious local pollution problems, sometimes far reaching, depending on the extent of the spill. The number of oil spill has been falling steadily since the 1970's. However, they still raise concerns, and there is uncertainty surrounding the number of smaller spills (less than seven tonnes).[160] Shipping stakeholders state that establishing multi-purpose safety islands can help prevent such accidents by serving as dry docking facilities for crude carriers in distress.

Noise reduction measures

Noise pollution impairs humans (shore populations and vessel crews) and marine life, where studies show that underwater-radiated noise from commercial ships may have short and long-term negative consequences on marine life, especially marine mammals.[161] Accordingly, IMO has established guidelines for ship quieting technologies and operational measures, such as speed optimisation and noise reduction.[162] Additionally, international conventions such as the Convention on the Conservation of Migratory Species of Wild Animals and the Convention on Biological Diversity are recommending the use of Best Available Technology (BAT) and Best Environmental Practice (BEP). Practices such as slow steaming, and using onshore power instead of auxiliary engines is good environmental practice, which reduces noise pollution.

Exhaust gas cleaning systems

Ship exhaust emissions contain three main air pollutants: sulphur oxide (SOx), nitrogen oxide (NOx) and particulate matter. As elaborated in the policy context (see Section 3.1), the EU is seeking to reduce emissions of these pollutants through e.g. the Ambient Air Quality- and Sulphur Directives, zero pollution action plans, and Sustainable and Smart Mobility strategy.

As regards the prevention of SOx pollution, shipping stakeholders highlight that the EU is a frontrunner in EGCS (i.e. scrubbers). The use of scrubbers substantially contributes to pollution and prevention control. As of January 1[st,] 2020, the sulphur content in marine fuels (hence leading to SOx reduction) cap introduced by IMO in 2005 was tightened to 0.5% m/m (mass/mass) (Annex VI regulation). For some vessels of 400 GT and above this will likely require choices, such as installing scrubbers.[163] SOx are

[159] ICCT (2020), Scrubbers on ships: Time to close the open loop(hole). See: https://theicct.org/blog/staff/scrubbers-open-loophole-062020

[160] ITOPF (2020), Oil Tanker Spill Statistics 2019. See: https://www.itopf.org/fileadmin/data/Documents/Company_Lit/Oil_Spill_Stats_brochure_2020_for_web.pdf

[161] IMO (n.d.), Ship noise. See: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Noise.aspx

[162] IMO (2014), Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life. See: https://wwwcdn.imo.org/localresources/en/MediaCentre/HotTopics/Documents/833%20Guidance%20on%20reducing%20underwater%20noise%20from%20commercial%20shipping,.pdf

[163] Berger Maritiem (n.d.), EGCS. See: http://www.bergermaritiem.nl/scrubber_en#:~:text=What%20is%20an%20Exhaust%20Gas,and%20how%20does%20it%20work%3F&text=Herewith%20the%20funnel%20can%20be,the%20fuel%20oil%20sulphur%20limits.

known to be harmful to human health, causing respiratory symptoms and lung disease and in the atmosphere, SOx can lead to acid rain, which can harm crops, forests and aquatic species, and contributes to the acidification of the oceans. The tightened SOx cap and measures such as scrubbers will significantly reduce the amount of SOx emanating from ships and should have major health and environmental benefits for the world, particularly for populations living close to ports and coasts.[164]

While EGCS prevent/minimise the release of SOx emissions into the air, the negative effects are to some extent re-directed, as the scrubbers discharge waters into the sea. This is especially the case for open-loop scrubbers, and some countries have consequently chosen to ban the use of such scrubbers. The discussion of further bans on open-loop scrubbers at EU and IMO level is currently ongoing. Thus, notably open-loop scrubbers, are not aligned with the DNSH (however bleed off of the so-called closed loops may also present an issue of water pollution). This is aligned with the Draft Delegated Act 2020, which state that, in order to comply with the DNSH, scrubbers should be closed-loop systems.[165]

Low-sulphur fuels

Other measures to reduce SOx emissions include cylinder lubrication, which helps to neutralise the sulphur in fuel, and use of low-sulphur fuels. LNG has a SOx content well below the regulatory limit, and its clean burning properties make it an appealing choice (as detailed throughout Chapter 5, LNG requires extensive retrofits and its methane slip emissions could be considered as causing significant harm to climate mitigation, if not accounted for). Other new low-sulphur oils are also entering the market to meet the new requirements and these types of fuels are mostly neat distillates. However, they could also be hybrids – gas oil blended with residual oil. In general, these fuels work well with standard engine configurations, though they may require operational changes.[166] The low-sulphur fuels mentioned here are also fossil fuels. Thus, while they contribute to some aspects of pollution prevention and control, they can also do significant harm on the climate mitigation objective. As such, these types of fuels can at most be considered transitional fuels, as they have no place in a decarbonised shipping sector. As regards transitional qualities, there is ongoing discussion on LNG, and the relevance of considering conventional LNG worthwhile to pursue in the short-term, and later switch to bio LNG in the long term, see also Section 5.2.1 on transitional fuels. For a further discussion on the role of biofuel, please refer to Section 3.3.2 on alternative fuels.

As regards the DNSH criteria, it is worth noting that there are some possible conflicts between climate regulation and environmental regulation: CO_2 is regulated due to its contribution to climate warming, and NOx and SOx emissions are regulated due to their contribution to environmental pollution. However, substances such as black carbon and methane are not regulated, and these fuels can be used in order to meet the requirements of the NOx and SOx regulations despite their contribution to climate warming. Conflicting regulations such as this, can potentially pave the way for fuels such as LNG, which meet the current environmental regulations, despite contributing

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[164] IMO (n.d.), Sulphur 2020 – cutting sulphur oxide emissions. See: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx

[165] European Commission (2020), Sustainable finance – EU classification system for green investments. See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy#ISC_WORKFLOW

[166] Alfalaval (n.d.), Marine fuels in the low-sulphur era. See: https://www.alfalaval.com/industries/marine-transportation/marine/oil-treatment/fuel-line/marine-fuels-in-the-low-sulphur-era/

substantially to climate warming.[167] The purpose of DNSH criteria is to avoid such trade-offs.

Technology to reduce NOx emissions

As regards the prevention of NOx pollution, annex VI of MARPOL deals with restricting the amount of harmful emissions from ships' main propulsion system. IMO standards have become increasingly stringent within the four Emission Controlled Areas and shipping stakeholders are incentivised to make use of a range of technologies to reduce the amount of NOx from their ship's exhaust systems. Among the various emission control applications Selective Catalytic Reduction (SCR) system is considered efficient, effectively reducing ship's NOx emission by 90-95%.[168] By mixing a reagent (SCR 40 – 40% Marine Urea Solution) to the exhaust gas, NOx are converted to Nitrogen (N2), water and CO_2. Other technologies include: Exhaust Gas Re-circulation (EGR), Water Injection and Water emulsion, Humid Air Method, High Scavenge Pressure and Compression Ratio, Two Stage Turbocharger, and Engine Component Modification.

Onshore Power

The possibility to connect to onshore power enables auxiliary diesel engines to remain switched off while the vessels are in port. In ports, ships require electricity to support activities such as loading, unloading, heating and lighting and other activities, and the power is commonly generated by CO_2 emitting auxiliary engines that emit carbon dioxide. Substituting auxiliary engines with onshore power leads to significantly improved local air quality and reduces emission and noise pollution. Shipping stakeholders highlight that they are equipping vessels with the appropriate technologies, however they also highlight that not all ports are equipped to provide onshore power solutions,[169] which is being addressed by FuelEU Maritime Initiative.

The table below presents the ideas for technical screening criteria (including DNSH) for the activities that could substantially contribute to pollution prevention and control.

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[167] Bouman E.A. et al. (2017), State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. Transportation Research. See: http://www.smartmaritime.no/Customers/Mate/SmartMarin/Handlers/FileFeed.ashx?itemId=363&languageId=1&filename=Bouman%202017%20State%20of%20the%20art%20technologies-review.pdf

[168] Marine Insights (2019), 10 Technologies/Methods for Controlling NOx & SOx Emissions from Ships. See: https://www.marineinsight.com/tech/10-technologiesmethods-for-controlling-nox-sox-emissions-from-ships/

[169] EMSA (2020), Study on Electrical Energy Storage for Ships. See: http://www.emsa.europa.eu/publications/item/3895-study-on-electrical-energy-storage-for-ships.html

Table 15 Technical screening criteria (including DNSH) for the activities that could substantially contribute to pollution prevention and control

Economic activity	Substantial contribution to pollution prevention and control	Do-No-Significant-Harm criteria				
		Climate mitigation	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Protection of biodiversity & ecosystems
Safety islands	Demonstrate contribution to prevention control by enabling safe dry docking for ships in distress in order to avoid oil spills	NA	NA	Sustainable use of water during construction	Reuse parts and use recycled material during the construction	Construction of such island does not harm marine ecosystems
Noise reduction measures	Demonstrate contribution to pollution control by reducing noise pollution	NA	NA	NA	NA	NA
Technology to reduce NOx	Demonstrate contribution to pollution control by complying with NOx Tier III standards[170]	Depending on the type of technology, GHG emissions can be a side product of the treatment processes	NA	NA	NA	NA
Onshore power	Demonstrate contribution to pollution prevention by eliminating the need for auxiliary engines during berth	NA	NA	Sustainable use of water during construction	Reuse parts and use recycled material during the construction of infrastructure.	NA

Source: COWI/CE Delft.

[170] See Tier III requirements here: https://www.imo.org/en/OurWork/Environment/Pages/Nitrogen-oxides-(NOx)-%E2%80%93-Regulation-13.aspx

5.10 Screening criteria for protection and restoration of biodiversity and ecosystems

The below recommendations should be considered as preliminary input to the work of the Platform on Sustainable Finance as actual thresholds or concrete screening criteria are not proposed at this stage for most activities, leaving this task to the Platform.

The maritime shipping does not directly contribute to protection and restoration of biodiversity and ecosystems. However, some activities can contribute to better marine environment. Those activities include ballast water management systems and support to integrated ocean management.

The EU's biodiversity strategy

The EU's biodiversity strategy broadly covers EU biodiversity objectives across all sectors. However, it is also of relevance to the shipping sector; as part of the strategy, the national maritime spatial plans to be submitted in 2021 by the Member States shall aim to cover all maritime sectors and activities. An example of activity that could be aligned across the Taxonomy and the biodiversity strategy is the push for the European Maritime and Fisheries Fund to support the transition towards more selective and less damaging fishing techniques.[171]

Deterrents and other measures to protect biodiversity

Biodiversity is directly impacted by shipping through collision (also known as a vessel strike), wherein marine vessels collide with marine animals. Vessel strikes is the cause of premature death for several endangered marine mammals, such as the critically endangered North Atlantic Right whales, which led to the established of Seasonal Management Areas in 2008, mandating ships in select areas around the U.S. east coast to lower speed.[172] Slow steaming is an effective measure to reduce the likelihood of vessel strikes, but technical solutions such as deterrents can send warning signals, which alert marine life to coming vessels.[173] EU Member States report of spatial protection measures, whereby known habitats and breeding, feeding, and nesting sites are placed under spatial protection.[174] Spatial protection measures are also suited to address the problem of anchoring on sensitive habitats and reefs. Where such areas are identified, anchoring could be minimised/prohibited.

Integrated ocean management

The Waterborne Technology Platform envisions a 'fully integrated ocean' by 2030. Integrated ocean management is a monitoring system, covering short and deep sea and inland waterways. The system will provide a holistic view of the environmental impact of the shipping sector, and simultaneously enable the EU to implement large scale depollution operations. The shipping sector will contribute with technical support to col-

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[171] European Commission (2020), EU Biodiversity Strategy for 2030. See: https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF

[172] van der Hoop (2014), Vessel Strikes to Large Whales Before and After the 2008 Ship Strike Rule. See: https://conbio.onlinelibrary.wiley.com/doi/epdf/10.1111/conl.12105

[173] Hampton, L. (2016), Sound blasts could keep whales away from wind farm construction. See: https://www.newscientist.com/article/2107425-sound-blasts-could-keep-whales-away-from-wind-farm-construction/

[174] European Commission (2018), Assessing Member States' programmes of measures under the Marine Strategy Framework Directive. See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0562&from=EN

lection of observations, protection and sustainable exploitation promoting the development of blue technologies to strengthen the preservation of good environmental standards.

Ballast water treatment and management

Invasive species discharged through ballast water is a serious problem posed in the marine environment.[175] Since 2017, the International Convention for the Control and Management of Ships' BWM have regulated ships management of ballast water, and now ships must expel or render harmless the invasive organisms and pathogens before releasing water into new locations.[176] The ballast water treatment technologies can be port-based or ship-based and can be mechanical or chemical. Ballast water treatment technologies include: Filtration Systems (physical), chemical disinfection (oxidizing and non-oxidizing biocides), ultra-violet treatment, deoxygenation treatment, heat (thermal treatment), acoustic (cavitation treatment), electric pulse/pulse plasma systems, and magnetic field treatment. To ensure the ballast water meets IMO standards it is common practice that ships use more than one type of technology.[177]

Despite existing technologies and regulation, monitoring and testing ballast water is a complicated procedure and some shipping stakeholders find that a lack of enforcement and appropriate education results in sub-par ballast water being released.[178] The EU Taxonomy could possibly address lack of enforcement and incentivise adequate monitoring and testing. Furthermore, some shipping stakeholders state that not ports have the appropriate systems in place to take in ballast water.

The table below presents the ideas for technical screening criteria (including DNSH) for the activities that could substantially contribute to protection of biodiversity and ecosystems.

Table 16 Technical screening criteria (including DNSH) for the activities that could substantially contribute to protection of biodiversity and ecosystems

Economic activity	Substantial contribution to protection of biodiversity & ecosystems	Do-No-Significant-Harm criteria				
		Climate mitigation	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control
Deterrents and other	Demonstrates contribution to	NA	NA	NA	NA	Noise deterrents

[175] Tsolaki, E., Diamadopoulos, E. (2010), Technologies for ballast water treatment: a review, in Chemical Technology and Biotechnology. See: https://onlinelibrary.wiley.com/doi/epdf/10.1002/jctb.2276

[176] IMO (n.d.) Implementing the Ballast Water Management Convention. See: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Implementing-the-BWM-Convention.aspx

[177] Marine Insights (n.d.), How Ballast Water Treatment System Works? See: https://www.marineinsight.com/tech/how-ballast-water-treatment-system-works/#:~:text=The%20main%20types%20of%20ballast,oxidizing%20and%20non-oxidizing%20biocides)&text=Electric%20pulse%2Fpulse%20plasma%20systems

[178] Euroshore (n.d.) Ballast Water And Management Convention. See: https://euroshore.com/policy-statements/ballast-water

Economic activity	Substantial contribution to protection of biodiversity & ecosystems	Do-No-Significant-Harm criteria				
		Climate mitigation	Climate adaptation	Sustainable use/ protection of water & marine resources	Transition to a circular economy	Pollution prevention and control
measures to protect biodiversity	protection of marine wild life and the protection of selected vulnerable areas					may protect marine wildlife, but it may also contribute to noise pollution
Ballast water treatment and management	Demonstrates contribution to protection of biodiversity and ecosystems by preventing the spreading of invasive species beyond what is mandate by legislation	NA	NA	NA	NA	NA
Support to integrated ocean management	Demonstrates contribution to protection of biodiversity and ecosystems by establishing a strong knowledge base and integrated ocean management systems	Depending on the extent of extracurricular shipping activity, additional strain may be placed on climate mitigation	NA	NA	NA	Depending on the extent of extracurricular shipping activity, additional strain may be placed on pollution control and prevention

Source: COWI/CE Delft.

6 NECESSITY AND COST OF MONITORING

This chapter presents an analysis of the potential practices that can lead to greenwashing in the maritime shipping sector and examines measures needed for monitoring and transparency reporting.

6.1 Risk of greenwashing

The findings from the desk research and the stakeholder consultations are scarce on information on specific greenwashing activities. Some stakeholders point out that it is too early to assess the extent of greenwashing in shipping sector, as further 'greening' of the sector will need to happen first. For example, when the use of alternative fuels will be a more common practice. At this stage, three potential challenges related to greenwashing have been identified:

- the lack of common definitions / framework,
- the use of LNG without accounting for the methane slip,
- the use of EEDI without monitoring of the actual performance of ships.

Lack of common definitions / framework

There is no consensus on what defines 'green' shipping and stakeholders argue that this could lead to risk of greenwashing. The lack of a common understanding also enables the use of vague definitions of sustainability, which can be used to skew the perceptions of promotional material. For example, there are companies that claim to use biofuels, but it is not always indicated how much is used and whether it is 'green' or 'black' biofuel nor whether it is first-generation biofuels, which as mentioned in Chapter 3 is based on feed-stock.

Another important challenge mentioned by stakeholders is the temporal aspect of greenness, i.e. what is green today may not be considered green tomorrow. This aspect could lead to unintended risk of greenwashing, especially if the investment supported is a transitional activity. This is particularly relevant for the deep-sea shipping, where only very few (or none) low-carbon solutions are readily available.

LNG

The example above highlights the challenges and mixed viewpoints surrounding transitional activities and whether they can be deemed to be sustainable. Another example, which is still debated within the sector, is the degree to which LNG is sustainable, and in this context, whether it can be considered greenwashing to claim that LNG is a 'green' practice.

Since 2018, there were only a few cases of issuance of Green Bonds within the maritime shipping sector, see also Section 8.1 on state of play. Nippon Yusen Kaisha's (NYK)[179] labelled green bond from 2018 was the first shipping bond in the CBI's data-

[179] A Japanese shipping company and member of the Mitsubishi keiretsu. It is headquartered in Chiyoda, Tokyo, Japan and a fleet of about 800 ships, including container ships, tankers, bulk carriers, reefer vessels, LNG carriers and cruise ships, among others.

base. Although it finances LNG-powered assets, it was included because its GHG emissions targets are clear and the assets financed by NYK's bond are currently the lowest emission asset option for long-haul shipping.[180]

Findings from the interviews show that some stakeholders deem LNG to be a sustainable transitional activity, which can play a positive role in transitioning the sector to-towards long-term goals. Stakeholders with opposing views deem LNG to be an unsustainable activity as it is a fossil fuel, and they view the use of LNG in 'greening' material and under green bonds as greenwashing. This debate reflects the wider debate on transitional activities, and what is and what is not an activity that can help bring the sector on a pathway to carbon neutrality.

Further to the discussion of LNG as a transitional fuel, the research have examined whether labelling LNG as a transitional fuel may legitimise carbon-intensive natural gas development.[181] They conclude that applying terms such as "transition fuel" and "climate solution" to LNG does legitimise carbon-intensive gas development, and as such it may greenwash natural gas development.[182] Another important challenge of LNG is the existence of a methane slip, which is currently not accounted for. This significantly undermines the climate potential of LNG.

On the other hand, it can be argued that LNG can reduce sulphur emissions and can in this regard contribute to environmental objectives. Especially the contribution to pollution prevention and control on sulphur and nitrogen oxide is central in this debate, since LNG can lead to a substantial reduction regarding this environmental objective without increasing CO_2 emissions, as compared to conventional fossil fuels. However, methane emissions associated to the use of LNG need to be accounted to ensure that no significant harm is done on climate mitigation.

Finally, it is important to note that the EU Taxonomy requires technological neutrality, as such, no specific technology should be supported.

EEDI

EEDI is a theoretical design, which assumes that the ship sails at its design speed (full speed) and is fully loaded. These assumptions do not reflect the actual operating conditions of ships and can skew how well the ship is performing in terms of CO_2 emissions. At the same time, stakeholders agree that at the moment, the EEDI is the best tool for undertaking a theoretical evaluation of ships prior to their use (i.e. ex-ante). However, due to its theoretical nature, stakeholders point to the fact that the EEDI can lead to intentional and unintentional greenwashing. For example, use of a different load weight or varied speed may skew the result confirmed by the EEDI under the intended use of the ship. Consequently, a ship may be labelled as green according to the EEDI, but in practice it may not be meeting the requirements.

[180] CBI (2018), Bonds and Climate Change: The State of the Market 2018, p. 12.

[181] The research addresses the broad use of LNG and not in specific relation to shipping.

[182] Stephenson, E., Doukas, A., & Shawb K (2012), Greenwashing gas: Might a 'transition fuel' label legitimize carbon-intensive natural gas development, in Energy Policy Vol. 46.

However, it should be added that the issue on reliance on theoretical design performance is not specific to shipping – the same criticism could be made in relation to criteria for construction, vehicles and other sectors where design based ex ante criteria are used.

6.2 Countermeasures & transparency/reporting requirements

To avoid any potential risk of greenwashing and ensure a level playing field, transparent monitoring and reporting plays a key role.

Ex-ante reporting

Reporting can be performed on ex-ante and ex-post basis. An ex-ante assessment is performed when an investment is considered for eligibility as green. This assessment can be performed by external party, which would verify whether an investment can be considered aligned with the given sustainability criteria. Within the Green Bonds market, an external review and assurance has become a norm. The different review types are summarised in the following table.

Table 17 Types of external review for green bonds

Type of external review	Description	Service providers
Second Party Opinion[183]	An institution with environmental expertise that is independent from the issuer may issue a Second Party Opinion. The institution should be independent from the issuer's adviser for its Green Bond framework, or appropriate procedures, such as information barriers, will have been implemented within the institution to ensure the independence of the Second Party Opinion. It normally entails an assessment of the alignment with the Green Bond Principles. In particular, it can include an assessment of the issuer's overarching objectives, strategy, policy and/or processes relating to environmental sustainability, and an evaluation of the environmental features of the type of projects intended for the Use of Proceeds.	Scientific experts, e.g. CICERO, CECEP Consulting Business assurance / managing risk service providers, e.g. DNV GL Environmental, Social and Governance (ESG) service providers, e.g. Oekom, Sustainalytics, Vigeo)
Verification	An issuer can obtain independent verification against a designated set of criteria, typically pertaining to business processes and/or environmental criteria. Verification may focus on alignment with internal or external standards or claims made by the issuer. Also, evaluation of the environmentally sustainable features of underlying assets may be termed verification and may reference external criteria. Assurance or attestation regarding an issuer's internal tracking method for use of proceeds, allocation of funds from Green Bond proceeds, statement of environmental impact or alignment	Audit firms E.g. KPMG, Deloitte

[183] Earlier versions of the GBP used instead the category "Consultant Review", noting that "Second opinions" could fall into this category

	of reporting with the Green Bond Principles (GBP), may also be termed verification.	
Certification	An issuer can have its Green Bond or associated Green Bond framework or Use of Proceeds certified against a recognised external green standard or label. A standard or label defines specific criteria, and alignment with such criteria is normally tested by qualified, accredited third parties, which may verify consistency with the certification criteria.	CBI
Rating	An issuer can have its Green Bond, associated Green Bond framework or a key feature such as Use of Proceeds evaluated or assessed by qualified third parties, such as specialised research providers or rating agencies, according to an established scoring/rating methodology. The output may include a focus on environmental performance data, the process relative to the GBP, or another benchmark, such as a 2-degree climate change scenario. Such scoring/rating is distinct from credit ratings, which may nonetheless reflect material environmental risks.	Rating agencies, e.g. Moody's, RAM Holdings, R&I, S&P Global Ratings

Source: Based on a) ICMA (2018), Green Bond Principles 2018; and b) CBI webpage on External Review (https://www.climatebonds.net/market/second-opinion)

Although, the primary source of financing for the shipping sector stems from bank loans, alternative sources of finance is growing, such as private equity, leasing, and capital markets. Ex-ante reporting would need to be adjusted to the specific type of financing. For conventional bank loans, shipping finance stakeholders highlighted that green loans are tied to an agreed upon environmental thresholds, for example, a yearly energy efficiency reduction goal. These agreements are assessed ex-ante but requires ex-post monitoring to ensure the requirements are being met.

Reduction plans

A GHG reduction plan for vessels is a tool that can be used to compile and address information from the operational data. For example, IMO has developed a SEEMP, which uses EEOI as a monitoring tool for operators to measure fuel efficiency and to gauge the effect of any changes in operation/technical measures.[184] Another example is CBI's Managed Reduction Plan. The purpose of the Managed Reduction Plans is to show how the vessel plans to remain below the decarbonisation trajectory through future retrofits, changes to operational practices, or switching to alternative fuels. Furthermore, the planned measures must be shown to be financially feasible and that the vessel stays competitive.[185]

[184] IMO (n.d.), Energy Efficiency Measures. See: https://www.imo.org/en/OurWork/Environment/Pages/Technical-and-Operational-Measures.aspx

[185] CBI (2020), Shipping criteria. See: https://www.climatebonds.net/files/files/standards/Waterborne%20Transport%20%28Shipping%29/Broc%20CBI-Shipping%20Criteria%20Brochure%281%29.pdf

Reduction plans thus enable shipping companies to track the effect of the implemented measures and to see whether the outcome aligns with the anticipated effect. Furthermore, these plans outline the future planned measures for specific vessels to reduce energy consumption. How these plans are used in practice, depends on the purpose for which they are used. For example, the Managed Reduction Plans are intended to be used as the basis for CBI to issue green bonds to non-zero-emission vessels, where planned measures to reduce carbon intensity need to be established.

Ex-post monitoring

Once an investment is made, it should be monitored to ensure that it complies with the given criteria over time or performs as initially anticipated. Ex-post reporting is performed on annual basis to assess the impacts of the investments made. It is often linked to the requirements of the financial institutions. There are different initiatives developed by the market to harmonise the impact reporting and support comparability of the investments. For example, in April 2020, Harmonized Framework for Impact Reporting Handbook was developed by the Green Bond Principles and ICMA outlining the indicators proposed to capture environmental benefits of the 'clean transportation' projects.[186] Another important initiative within the shipping sector is Poseidon Principles, which is a commitment to transparent annual reporting of portfolio operational carbon intensity relative to an interpretation of the IMO's strategy.[187] The Poseidon principles are used to assess the climate alignment of financial institutions' shipping portfolios. To do so, the signatories of the Poseidon Principles pledge to use data types, sources, standards and service providers established by the IMO to measure their shipping portfolio's climate alignment. Similarly, the Sea Cargo Charter is another example of a market initiative to support assessment and disclosure of climate alignment of ship chartering activities.[188]

The EU Taxonomy could establish a requirement to monitor operational performance. A distinction could be made between design and operational criteria, whereby ex-post monitoring would be a mandatory obligation for green finance under the operational criteria, and encouraged under the design criteria. However, monitoring and reporting would be performed by the shipping companies and the financial institutions themselves. As such, the Taxonomy could encourage monitoring and reporting, while the financial institutions would be the ones requiring monitoring from the shipping companies.

Monitoring EEOI

One of the main challenges in terms of potential green washing raised by the stakeholders is the use of EEDI to predict performance of new ship. Even though the EEDI is currently the best available measure for new vessels (prior to their operation), some

[186] The Green Bonds Principles (2020), Harmonized Framework for Impact Reporting. See: https://www.ifc.org/wps/wcm/connect/3deee5d3-9073-4eff-99fb-b061d7137ff6/Handbook-Harmonized-Framework-for-Impact-Reporting-220420.pdf?MOD=AJPERES&CVID=n6IALH6

[187] Poseidon Principles (n.d.), A global framework for responsible ship finance. See: https://www.poseidonprinciples.org/#home

[188] Sea cargo charter (2020), Aligning global shipping with society's goals. See: https://www.seacargocharter.org/

stakeholders argue that it should not be used as standalone indicator and should be supported by the operational carbon intensity measure such as EEOI. EEOI measures all GHG emissions of ships in real operating conditions, which allows for comparison of the actual carbon intensity of different ships. The data on EEOI is already collected on annual basis for the ships above 5,000 GT calling a port in the European Economic Area under the MRV Regulation, as such, the requirement for EEOI data (or AER data) will not entail additional costs for shipping operators. For the other ships, AER could be calculated from the IMO’s Data Collection System, as proposed by the CBI Shipping criteria, see Section 5.3.3.

6.3 Assessment of the benefits & costs of additional (impact) reporting and verification

This section examines the costs and benefits associated with the increased reporting and transparency requirements. Regarding the costs, the data did not yield specific or quantifiable information related to costs, and the identified costs are therefore assessed qualitatively.

Reporting and monitoring related to operational performance, through for example EEOI, may require additional costs. Following EU MRV Regulation, EEOI is already in place, and one-off costs for implementing monitoring systems have been incurred. However, the compliance to EU MRV applies to vessels above 5,000 gross tonnage, which represent 90% of all CO2 emissions from maritime transport but approximately only 55% of the ships calling EEA ports.[189] There is still a large share of the fleet of smaller vessels, which stands to incur costs of setting up adequate ex-post reporting and monitoring systems.

The benefits from additional (impact) reporting processes and verification requirements to counter/avoid greenwashing include:

- The reduction in the reputational risk of issuers and associated (re)gained /increased investor trust and hence increased interest in green finance products and proceeds. Shipping financing stakeholders highlighted trustworthiness and reputational credibility as a core concern.

- Additional impact reporting is signalling to investors and customers that the shipping company is committed to the green transition. For investors, it showcases a strategic outlook and a company that adjusts to its environment. For customers, such a commitment can help contribute to positive branding.

- Collecting and analysing the operational data enables shipping companies to meticulously assess the performance of their ships. Knowing the ships performance in detail, makes it possible to measure the effect of retrofits, or changes to the way the ships is being sailed. Such information can contribute to development of a

[189] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

knowledge base of what green measures are most cost efficient, or which measures are likely to contribute most to fuel savings.

The reduction of uncertainty surrounding what constitutes 'green'. Several shipping financing- and shipping stakeholders stated that uncertainty of what is considered 'green' causes companies to hold back on pursuing green projects and green financing. Harmonised impact reporting would establish a common standard to measure against and reduce uncertainty on how to, for example, count and report GHG emissions.

Impact reporting is essential in the development of operational criteria. Without monitoring and reporting of operational data it is not possible to verify that vessels are meeting operational requirements.

Impact reporting enables verification of ex-ante assessments. For example, EEDI has by shipping stakeholders been identified as a possible route to greenwashing. However, impact reporting can be used to evaluate the validity of an EEDI assessment.

Shipping financing stakeholders all favoured harmonised impact reporting. However, it was also mentioned that harmonised reporting could benefit from some flexibility.

7 MARKET STUDY

This section presents the analysis of three scenarios of the technical screening criteria with different level of stringency. The scenarios are analysed based on their potential impact on supply and demand for green finance products and their attractiveness.

7.1 Scenarios

Based on the findings presented in Chapter 5, three scenarios are proposed with different level of greenness of newbuilds, retrofits and hybrid vessels. The other criteria proposed in Chapter 5, namely recognition of zero emissions vessels and modal shift, have a limited possibility for variations in stringency and affect only few vessels. The three scenarios outlined in the table below are in order of stringency of technical criteria, which puts increasing tighter requirements on green financing products to be labelled green (i.e. 'different shades of green'). The medium level scenario highly reflects the proposed approach in this study. However, it does not account for the carbon intensity based criteria (operational) presented as an optional criterion.

Table 18 Overview of three scenarios and eligible activities

Scenario	Eligibility
All maritime shipping activities should meet the soft criteria: Newbuilds: All vessels that have an attained EEDI value in line with the EEDI requirements applicable Retrofitting: activity reduces fuel consumption of the vessel by at least 5% (with slight tightening of the criteria overtime). Hybrid vessels: achieving at least 20% of GHG emissions reductions	All new vessels that meet EEDI requirement qualify Minor energy efficiency improvements (5%) qualify Majority of retrofitted vessels for hybrid and dual fuels would qualify, including LNG retrofitted vessels
All maritime shipping activities should meet the medium level criteria: Newbuilds: All vessels that have an attained EEDI value 10% below the EEDI requirements applicable (or EEXI requirements) Retrofitting: activity reduces fuel consumption of the vessel by at least 10% (with tightening of the criteria over time). Hybrid vessels: achieving at least 50% of zero tailpipe emission fuel mass or plug-in power for their normal operation	Energy Efficient new vessels that perform beyond the EEDI requirement qualify, best-in-class vessels Energy efficiency improvements (10%) qualify Only retrofitted vessels for hybrid and dual fuels that have at least 50% of zero tailpipe emission
All maritime shipping activities should meet the stringent criteria:	Only zero emissions newbuild vessels would qualify

Newbuilds: only zero emissions vessels are eligible Hybrid vessels: achieving at least 50% of zero tailpipe emission fuel mass or plug-in power for their normal operation Retrofitting: activity reduces fuel consumption of the vessel by at least 20%	Only retrofitted vessels for hybrid and dual fuels that have at least 50% of zero tailpipe emission would qualify Substantial energy efficiency improvements of more than 20%

Source: COWI/CE Delft.

7.2 Impacts of the scenarios

Findings from the interviews, desk research and workshop consultations, all highlight the importance of striking a balance between leniency and stringency, wherein as much of the sector as possible is incentivised to 'green' while ensuring that the green measures adequately matches the need to decarbonise. As regards the point of equilibrium in this balance, the maritime sector is not equally positioned. Generally, one group of stakeholders favours a more lenient approach in order to qualify a large share of the fleet for sustainable finance, whereas another group favours a more stringent approach in order to ensure adequate decarbonisation and avoid greenwashing.

As the sustainable finance market for shipping is in early stages of development and there is a scarcity of data, the study faces a challenge in terms of quantifying the impacts of the scenario. Consequently, the analysis below is qualitative and draws especially on interviews with shipping finance- and shipping stakeholders. Where possible, data, notable EU MRV data, is used to support the analysis and indicate the extent of the impacts. Moreover, the discussions on the proposed screening criteria in Chapter 5 include many complementary details as well as indications of how the current fleet would be subjected under a specific criterion.

7.2.1 Eligibility of investments under different scenarios

Soft scenario

For the soft scenario, a large share of the existing fleet will be able to qualify for green finance, however, concerns of greenwashing, lock-in effects in carbon intensive technologies, and insufficient 'greening' is also observed.

A large share of the fleet will be able to qualify, since it is likely they will be able to meet at least one of the criteria. Most notably, studies show that meeting the 5% retrofit criteria will require low investments (see Section 3.3.1 on energy efficiency measures), and in many cases, the shipping sector is already pursuing incremental improvements, as it also makes economic sense. Energy efficiency technologies such as rudder bulbs, hull coating, air lubrication, and post swirl fins require low investments, and can contribute to meeting the criteria. As such, the majority of vessels could be likely to qualify.

For the criterion on hybrid vessels that achieve at least 20% of GHG emissions reductions, hybrid/electrified vessels will qualify, but it is also possible that LNG vessels will qualify with 20% of GHG emissions reductions target. However, these vessels account for a smaller share of the fleet, for example, LNG vessels currently account for approximately 3% of the monitored EU MRV fleet.[190]

For the new builds criterion, it is likely that most new vessels will qualify 'automatically', as it is the IMO requirement. This will entail that all new fossil fuel based vessels will qualify as green, increasing the risk of greenwashing.

Medium scenario

For the medium scenario (aligned with the Draft Delegated Act 2020), a varying share of vessels may qualify, depending on criterion. The investment that will qualify under each criterion until 2025 are discussed in detail in Section 5.2.2. Concerns of lock-in mechanisms and insufficient 'greening' can be observed, especially if new best-in class vessel qualify beyond 2030.

While most of the same vessels may potentially qualify under the retrofitting criteria as for the soft scenario (an increase in reduction from 5% to 10%), it will require higher investments to reach a 10% reduction. For example, through technologies such as bow optimisation, wind power, ducted- and contra-rotating propellers, and wheels, or through a combination of cheaper technologies, as listed in above section on the soft scenario.

Between the soft and medium scenario, there is an increase from 20% to 50% of zero tailpipe emission fuel mass/plug-in power for the hybrid vessel criterion. Such an increase would mean that LNG fuelled vessels will no longer qualify, and only 'zero CO_2 tailpipe emissions vessels' will qualify. Furthermore, currently the most likely technology to qualify are hybrid/fully electrified vessels. As such, this criterion will be applicable to short-sea vessels which are frequently in ports, and is unlikely to apply for deep-sea vessels in the short-term. Shipping stakeholders, desk research and expert opinion all indicate that a very limited number of vessels will qualify. However, this criterion can also finance research and development projects on retrofitting the existing vessels to zero emissions fuels.

For the criterion on new builds a best-in-class component is added (10% lower than EEDI), which addresses the issue of vessels 'automatically' qualifying, as it has been the case for standard EEDI requirements. Approximately 12% of all EEDI ships (of the current fleet with attained EEDI) would be able to meet this criterion, however it varies across vessel types (see Section 5.2.2 for further elaboration). For example, 1% of the bulk carriers, 11% of the gas tankers, 23% of the tankers, 13% of the containers and 37% of the general cargo ships, which are ranked according the EEDI currently comply with this criterion. Since new builds take into account the increasingly strict EEDI requirements, it is possible that this share will increase in the coming years.

Strict scenario

For the strict scenario, it is likely that only a small pool of activities will qualify. While there are no issues raised concerning greenwashing, lock-in mechanisms, issue could

[190] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

be insufficient overall 'greening' because the pool of vessels that qualify is so narrow that there will not be enough projects to sustain the incentives provided by sustainable finance.

The retrofitting criteria of 20% would require substantial investments with a long ROI, and only few vessels would qualify. Likely, a combination of expensive measures are needed, such as combining wind power, bow optimisation, propulsion technologies, and operational measures such as slow-steaming.

The criterion for hybrid vessels is the same as for medium scenario. Accordingly, this criterion will be applicable to short-sea vessels which are frequently in ports, and is unlikely to apply for deep-sea vessels in the short-term.

For the new build vessels, only zero emissions vessels would qualify, which is currently only a few smaller ships such as electric ferries.

7.2.2 Attractiveness of green investment

Shipping finance- and shipping stakeholders commented on the limited amount of green bonds and green financing in the shipping sector (see also Section 8.1 on Green Bonds), despite an existing demand from investors. They pointed to the early-stage development of shipping decarbonisation technologies, as a key issue holding back the development of the green financing market in the sector. The early stage development of technologies, which are fit for use in a decarbonised sector, combined with the long lifespan of vessels, constitutes a key challenge in developing a sustainable finance market for the shipping sector.

Below, the analysis of the challenges and concerns, which have been identified in the data collection, are presented together with analysis on how the different scenarios impact/relate to these issues.

Reputational credibility

Findings from the interviews indicate that preserving reputational credibility is a core concern amongst issuers of sustainable finance products. Accordingly, in order not to incur reputational damages, issuers are showing reservations when determining what is considered sustainable. Despite a high demand from investors, issuers may withhold facilitating sustainable finance products. An example of this, is the shift in perspective regarding the sustainability of exhaust gas cleaning systems (scrubbers), see Section 5.9 for further elaboration). Scrubbers used to be perceived as a sustainable technology and was thus included in sustainable finance activities. However, recently a discussion on whether open-loop scrubbers are sustainable has stirred uncertainty on the topic.[191] Consequently, the stakeholder states that issuers that previously deemed scrubbers sustainable are opting to exclude scrubbers from their list of sustainable technologies to ensure that they do not incur reputational risks from supporting a questionable technology.

[191] ICCT (2020), Scrubbers on ships: Time to close the open loop(hole). See: https://theicct.org/blog/staff/scrubbers-open-loophole-062020

The same worries show in relation to green bonds. An interviewee mentioned that investors are approaching them with a view to issue green bonds. However, the lack of certainty around what constitutes 'green' blocks the issuance. Issuing a green bond, which may not be perceived as sufficiently green, or one that may not comply with the Taxonomy's criteria, places a risk on the issuers' credibility.

Thus, uncertainty on what constitutes 'green' may cause supply of green financing products to decrease. This relates to issues of greenwashing and is further elaborated below.

Decreasing demand for fossil fuel investments

For the soft scenario, a potential for greenwashing is raised as a point of concern. This is contrary to the purposes of the Taxonomy, which seeks to establish clear guidelines for what is 'green'. For example, the criterion for hybrid vessels in the soft scenario, is that they achieve at least 20% of GHG emissions reductions. This is likely to include LNG hybrid vessels.[192] However, there are opposing views as regards the sustainability of LNG vessels due to their methane slip.[193] While some shipping stakeholders perceive LNG as a transitional fuel of good value, other stakeholders urge the industry not to use LNG. The interviews with financing institutions indicate that such uncertainty may block the issuance.

Furthermore, as regards demand, fossil fuel divestment has been on the rise since the Paris Agreement, and, continuing with the example of LNG vessels, there is a risk that LNG may not be a desired investment.[194] In addition to the lack of uncertainty which blocks issuance, even if supply is available, it may be that a large supply of qualifying vessels, will not be matched by the demand, considering the trends in sustainable finance investment, which seeks to move away from fossil fuel.[195] Shipping financing stakeholders highlighted similar concerns in the interviews. For example, one interviewee mentioned that they are not comfortable selling green investments which are related to fossil fuels.

Thus, demand for fossil fuel is impacted by the uncertainty surrounding its legitimacy. Conversely, shipping financing stakeholders experience high demand for fossil fuel free solutions in the shipping sector. However, demand might increase, following the development of the Taxonomy, even for fossil fuel-based technologies, if those are legitimised by meeting the Taxonomy requirements.

For the medium scenario, there is a smaller margin for greenwashing, due to the stricter criteria for hybrid vessels (at least 50% of zero tailpipe emission fuel mass or

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[192] Sphera (2020), Life Cycle GHG Emission Study on the Use of LNG as Marine Fuel. See: https://sphera.com/research/life-cycle-ghg-emission-study-on-the-use-of-lng-as-marine-fuel/

[193] T&E (2019), LNG remains a dead end for decarbonising maritime transport. See: https://www.transportenvironment.org/newsroom/blog/lng-remains-deadend-decarbonising-maritime-transport

[194] IEEFA (2020), Financial giants leaving coal, oil, LNG, other fossil fuel platforms. See: https://ieefa.org/financial-giants-leaving-coal-oil-lng-other-fossil-fuel-platforms/

[195] Plantinga, A. Scholtens, B. (2020), The financial impact of fossil fuel divestment. In Climate Policy. See: https://www.tandfonline.com/doi/full/10.1080/14693062.2020.1806020

plug-in power for their normal operation) as well as energy efficiency criterion. This criterion may pave the way for investments away from fossil fuels, for which there is a demand. However, as several shipping stakeholders point out, there is currently a limited supply of projects, which meets this criterion.

For the strict scenario, preserving reputational credibility is not a major concern, as the requirements to qualify for sustainable finance is aligned with the EU's climate targets and the Paris Agreement. Thus, there will likely be a high demand amongst investors who have pledged themselves to pursue decarbonisation investments. However, the supply will likely be very low, as few projects will qualify.

Second-hand vessels

The second-hand market for vessels may also be impacted by the Taxonomy. In general, the EU fleet is younger than the global fleet. EU MRV data shows that the monitored fleet is 11 years on average. This is almost double in a global perspective, where the fleet is 20.5 years on average.[196] The average covers over a variance between vessels types. For example, for container ships, 56% of the EU fleet is under 10 years, while for the global fleet it is 70%.[197] This indicates that vessels have a longer lifespan outside EU, creating the possibility for EU vessels that do not meet the Taxonomy requirements to be sold as second hand vessels where it will continue operations.

From a decarbonisation perspective, moving vessels from the EU market to the global market does not support the transition away from fossil fuels, despite the potential improvement of meeting EU GHG emissions reductions targets. For the soft scenario, this is less likely to be case, as a larger share of the fleet would potentially qualify. However, some shipping stakeholders argued that under a strict scenario, shipping companies may opt to sell vessels that do not qualify and procure vessels that do meet the criteria. Ultimately, this will depend on the extent to which the Taxonomy is deemed feasible and, of course, financial considerations. For example, if the Taxonomy is so strict, that the shipping sector accepts that the majority of vessels will not qualify. It may as a result be that the consequences of not meeting the criteria are not frowned upon. For the medium scenario, it is more unsound to disregard the criteria, as they are more easily achievable, but here, there will still be vessels that will not qualify, increasing the incentive to sell off vessels to the global market, and perhaps more so than under a strict scenario.

[196] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

[197] European Commission (2020), 2019 Annual Report on CO2 Emissions from Maritime Transport. See: https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/swd_2020_82_en.pdf

7.2.3 Stage of development of decarbonisation technologies

Zero emission vessels

At the moment, there are little known technologies in place, which can sustain large investments and be guaranteed to be fit to function in a decarbonised sector. An example is zero-emission vessels: Zero-emission vessels (excluding vessels based solely on electricity), are dependent on the development of a viable alternative fuel, such as sustainable hydrogen, or hydrogen-based fuels (i.e. ammonia, methanol). A few vessels are currently based on methanol, however, the methanol, which is used, is 'black' methanol (i.e. not sustainable), and they are therefore not guaranteed to become sustainable.[198] Issuing green bonds typically requires less risky projects.

Thus, there is currently no supply of zero emission vessels (with the exemption of a small margin of fully electrified vessels which are charging from renewable energy grids). However, as the zero emission vessels foregoes fossil fuel, the demand is high.

Hybrid vessels

The medium- and strict scenario both includes a criterion for hybrid vessels that achieve at least 50% of zero tailpipe emission fuel mass or plug-in power for their normal operation. However, the emissions also take into account, the means of production of the fuel, and thus project such as the Stena Germanica ferry, does not qualify.[199] Generally, there is a limited supply of vessels/projects that able to meet this criteria, notably hybrid vessels with batteries such as ferries and high-speed ferries could reach above 50%.

It could be discussed whether it is relevant to discount the means of production of fuels in a short-term perspective (i.e. until 2025, or in the time period 2025-2030). This could potentially enable the commissioning of vessels, whereby the share of vessels, which are ready to transform to zero-emission vessels would already be growing in numbers, and by the time the production of alternative fuels have become feasible at scalable levels, there would be a share of vessels in existence readily in place to become zero-emission vessels. However, the drawback of this approach, would be to invest in vessels that run on alternative fuels, which do not become feasible to produce at scalable levels. This approach would carry a risk on investment and demand. However, it would address, to some extent, the issue of a limited project pipeline of 'green' projects and may thus spur a growth in supply.

Energy efficiency

For the soft scenario, the issue of insufficiently developed decarbonisation technologies is not a major concern, since a large share of the fleet/newbuilds may already

198 Wartsila (2020), Industry celebrates five-year anniversary of world’s first methanol-powered commercial vessel. See: https://www.wartsila.com/media/news/14-04-2020-industry-celebrates-five-year-anniversary-of-world-s-first-methanol-powered-commercial-vessel-2684363

199 Wartsila (2020), Industry celebrates five-year anniversary of world’s first methanol-powered commercial vessel. See: https://www.wartsila.com/media/news/14-04-2020-industry-celebrates-five-year-anniversary-of-world-s-first-methanol-powered-commercial-vessel-2684363

qualify under the criteria as a business-as-usual development. For example, the criterion on newbuilds, stating that all vessels that have an attained EEDI value in line with the EEDI requirements are applicable.

The second criterion on retrofitting includes activities that reduce fuel consumption of the vessel by at least 5% (with slight tightening of the criteria overtime). The shipping sector is continuously improving their energy performances over time, and several shipping companies reported on internal programmes to spur such incremental development, which they have successfully used, sometimes for decades. A 5% reduction may thus be possible with incremental improvements on existing and mature technologies, such as new propulsion technologies and other energy efficiency measures. For this criterion as well, there may already be a large share of the fleet, which qualifies.

The last criterion concerns hybrid vessels that achieve at least 20% of GHG emissions reductions, and as mentioned, this may include LNG vessels. Currently, EU MRV data shows that around 3% of the monitored fleet (LNG and gas carriers) use LNG fuel. However, due to the increasingly tight regulation on NOx and SOx emissions, the use of LNG has been growing over the years, indicating a growing supply of these vessels, which would qualify in the soft scenario.

In summary, for the soft scenario, a large share of the existing fleet would potentially qualify, and the supply of 'green' projects would thus likely be strong. Interviews with financing stakeholders and shipping stakeholders indicated that higher risk of greenwashing would not significantly influence the demand.

Business-as-usual

As elaborated above, a larger share of the existing vessels and newbuilds will qualify under the soft scenario. The argument for allowing a large share of existing vessels to qualify, is that it will facilitate a transition across the EU fleet. However, applying lenient criteria may support a business-as-usual approach to decarbonisation, which incentivises incremental (non-significant) improvements. As seen in the preceding paragraphs, the shipping sector is already undertaking measures to improve energy efficiency and reduce the fuel consumption. Consequently, the soft scenario may play into a business-as-usual approach, wherein focus on energy efficiency and emissions reductions are sustained in favour of alternative solutions. Decarbonisation under a business-as-usual approach is further exacerbated by the long lifespan of vessels, creating a need for significant cuts in GHG emissions at a later stage.

Expanding business-as-usual

As mentioned, the EU fleet is rather young (vessels are 11 years on average). Considering that ships can last 25 to 30 years, a large part of the monitored fleet is likely to still be operating in 2040. Accordingly, there is a case for incentivising the existing fleet to pursue greening measures. Regarding the balance between leniency and stringency, the medium scenario can be seen as creating incentives for the business-as-usual approach to pursue higher levels of greening. Shipping financing stakeholders have mentioned that, while it is not easily achievable, it is realistic to meet the criteria requirements under the medium scenario. The strict scenario is a full departure from a business-as-usual approach, as the criteria promotes substantial energy efficiency improvements and the development of alternative fuel technologies over fossil fuel solutions.

8 DEVELOPING OF GREEN FINANCE IN THE MARITIME SHIPPING SECTOR

This chapter presents the characteristics of shipping finance, the current state of green financing, including the green bonds market in the shipping sector. Based on this analysis, the chapter discusses green finance instruments and what measures are needed to further develop green financing in the maritime sector.

8.1 Current state of play

This section presents the current state of play in the finance of the maritime sector. The general characteristics of shipping finance are discussed, followed by an analysis of the state of play of green finance and green bonds.

8.1.1 Characteristics of shipping finance

The maritime sector is a highly capital-intensive industry, which is characterised by a large share of debt in the capital structures of shipping companies. Historically, debt financing from banks has provided most of the finance and it remains the primary source of finance. However, alternative forms of financing, for example, from capital markets and private equity are a growing source of finance in the sector.

In addition, the maritime sector is characterised by further risks related to the long lifespan of vessels, performance and engineering aspects of the projects, the financial viability of projects, a changing regulatory landscape, and uncertainty of future prevailing technologies.

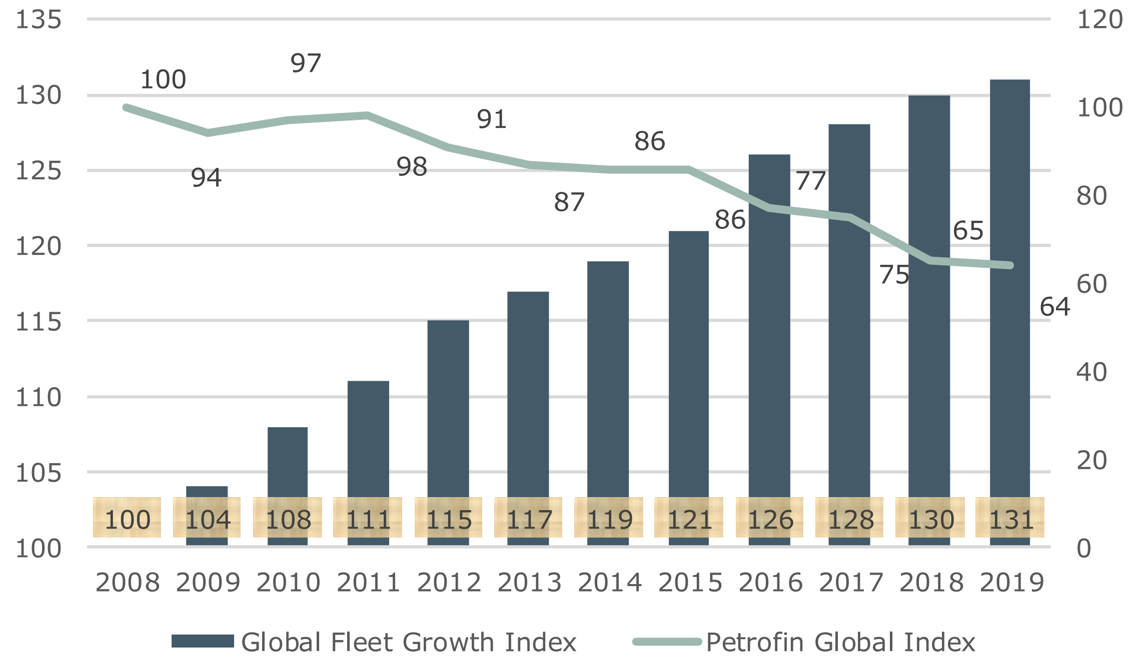
Recent developments in shipping finance

The financial crisis of 2007/2008 impacted traditional shipping finance by leading to a reduction in the availability of debt-based bank issued finance and an increase of sources of alternative finance.[200,201] Figure 4 shows that from 2008 to 2019 there has been a 36% decrease in shipping lending from the top 40 international banks that finance shipping.

[200] Norton Rose Fulbright (2020), Trends in Ship Finance. See: https://www.nortonrosefulbright.com/en/knowledge/publications/b83d9cbc/trends-in-ship-finance

[201] Marine Money (2014), Shipping Finance in the Wake of Basel III. See: https://shippingfinance.files.wordpress.com/2016/07/2014-shipping-finance-in-the-wake-of-basel-iii.pdf

Figure 4 Lending from top 40 international banks for shipping finance compared to global fleet growth



Source: Petrofin (2020), Key Developments and Growth in Global Ship Finance.[202]

Some banks are opting to reduce their shipping portfolio or exit the market entirely, as in the case for RBS (UK)[203], NordLB (Germany),[204] and DVB (Germany). The latter previously being among the top 10 banks for shipping finance.[205] Notably, some banks are moving away from the shipping sector due to the risk profile of shipping companies. In the wake of the crisis, banks saw losses in their shipping portfolios, coupled with increased regulation and scrutiny, which further challenged financing in the shipping sector.

Notably, the Basel III and upcoming Basel IV (in 2023) regulations[206] enforced by the Basel Committee on Banking Supervision makes it harder to lend to the shipping sector .The regulations impose stricter liquidity requirements for bank lending, which is challenging for the shipping sector due to its high capital intensity and low-liquidity

[202] Petrofin (2020), Key Developments and Growth in Global Ship Finance. See: https://www.petrofin.gr/wp-content/uploads/2020/08/Petrofin-Global-Bank-Research-and-Petrofin-Index-of-Global-Ship-Finance-end2019.pdf

[203] Seatrade Maritime News (2017), RBS sells $600m in shipping loans: report. See: https://www.seatrade-maritime.com/europe/rbs-sells-600m-shipping-loans-report

[204] Lloyd's List (2019), NordLB to exit ship finance after 'painful' losses. See: https://lloydslist.maritimeintelligence.informa.com/LL1126937/NordLB-to-exit-ship-finance-after-painful-losses

[205] DVB Bank (n.d.), Shipping Finance. See: https://www.dvbbank.com/en/clients/shipping-finance

[206] BIS (n.d.), Basel III: international regulatory framework for banks. See: https://www.bis.org/bcbs/basel3.htm

debt structures. .Two key principles from the Basel III framework, the *Liquidity Coverage Ratio* and the *Net Stable Funding Ratio*, set standards to ensure banks avoid short-term liquidity[207] pressure and draw away from funding profiles with higher risks.[208] Consequently, the liquidity requirements are likely to have longer lasting effects in the availability and terms of shipping finance from banks.

While some banks are downsizing their shipping portfolios, there are also reports of other banks continuing their activities in the shipping sector, typically lending to strong and large shipping companies and shipping segments that have a higher liquidity than the overall shipping sector.[209] Further to this, other western banks, such as BNP Paribas and KfW, are absorbing the shipping portfolios from DVB and NordLB, indicating a stabilisation in the decline of available bank financing.[210]

As the 2007/2008 financial and COVID-19 crisis will subside, lingering effects, such as increased oversight in the banking sector will remain. Banks that remain active in shipping are likely to lend to shipping companies that display strong corporate cultures and those that align their business with Basel III and upcoming Basel IV regulation, as well as other measures such as the Poseidon Principles (see Text box 6).

[207] Liquidity can be defined as the ease of converting assets into cash without affecting its market price.

[208] BIS (n.d.), Basel III: international regulatory framework for banks. See: https://www.bis.org/bcbs/basel3.htm

[209] Norton Rose Fulbright (2020), Trends in Ship Finance. See: https://www.nortonrosefulbright.com/en/knowledge/publications/b83d9cbc/trends-in-ship-finance

[210] Petrofin (2020), Key Developments and Growth in Global Ship Finance. See: https://www.petrofin.gr/wp-content/uploads/2020/08/Petrofin-Global-Bank-Research-and-Petrofin-Index-of-Global-Ship-Finance-end2019.pdf

Text box 6 Poseidon Principles

The Poseidon Principles launched in the summer of 2019 and aims at aligning ship finance with the IMO strategy to reduce GHG emissions by at least 50% by 2050 based on 2008 levels. There are four principles:

1) Assessment of climate alignment

- On annual basis, signatories will measure carbon intensity of shipping portfolio
- On annual basis, signatories will assess climate alignment (carbon intensity relative to established decarbonisation trajectories) of their shipping portfolios

2) Accountability

- Signatories will rely exclusively on the data types, data sources, and service providers identified in the Technical Guidance

3) Enforcement

- Signatories will agree to work with clients and partners to covenant the provision of necessary information to calculate carbon intensity and climate alignment

4) Transparency

- Signatories will publicly acknowledge that it is a signatory of the Poseidon Principles
- On annual basis, signatories will report on the overall climate alignment to the secretariat of the Poseidon Principles and in a publicly available report.

Currently, 20 banks are signatories and in December 2020, 15 banks disclosed the climate alignment of their shipping portfolios.

Source: Poseidon Principles (n.d.), A global framework for responsible ship finance. See: https://www.poseidonprinciples.org/#home

The impact of COVID-19

COVID-19 continues to negatively impact some part of the shipping sector. Particularly, the European shipbuilding and maritime equipment industry and its passenger segments are struggling due to uncertain recovery prospects and halted passenger transport.[211,212]

Due to the impact of COVID-19 and the ensuing uncertainty of future developments, the first half year of 2020 had the lowest half-yearly order volume for global shipbuilding in more than 25 years. Furthermore, the impact of COVID-19 on global supply chains is challenging the shipbuilding industry, as the lengthy production time of ships (2-3 years) is heavily dependent on well-functioning and established supply chains.[213] Consequently, the "forward cover" (i.e. the average number of years work in store for shipyards), is hitting record lows, and the European shipbuilding sector is facing great

[211] EMSA (2021), COVID-19 – impact on shipping. February 2021. See: http://www.emsa.europa.eu/newsroom/covid19-impact/item/4324-february-2021-covid-19-impact-on-shipping-report.html

[212] UNCTAD (2020), COVID-19 and maritime transport: Impact and responses. See: https://unctad.org/system/files/official-document/dtltlbinf2020d1_en.pdf

[213] Safety4Sea (2020), European shipbuilding sector calls for urgent support due to COVID-19 crisis. See: https://safety4sea.com/european-shipbuilding-sector-calls-for-urgent-support-due-to-covid-19-crisis/

challenges to maintain its normal operation. A recent example saw the German shipyard Meyer Werft halt its productions for six weeks in July/August 2020. The shutdown was due to a cancellation and extensions of orders on cruise liners.[214]

The pandemic's impact on the industry has cast a light on underlying challenges and regional differences in the shipbuilding industry. With global tourism to a standstill, unfavourable market conditions and very low-priced offers from shipbuilders in Asia, there has been a concentration of global orders in the Asian market. As such, approximately half of the global orders were placed in China, which further cements it global leading position in some segments of the shipbuilding industry.[215] While Chinese shipyards have with governmental support managed the crisis fairly well, European yards are facing severe challenges, with a drop in new orders by 77% in value, compared to 2019.[216]

Alternative financing

Alternative financing refers to forms of financing that are not conventional bank loans, such as finance from the capital markets, private equity, leasing and (high yield) bonds. While conventional debt-based bank finance is decreasing, alternative financing is covering the gap, as capital markets are seeking new opportunities and other financing solutions. Further to this, the global fleet and trade is expanding, albeit at a slower pace than earlier (a downturn in growth is observed since 2007), meaning that future alternative financing is likely to further increase.[217] Apart from a need for further financing to support replacement vessels and newbuilds under a future growth scenario, additional capital is needed to finance the green transition of existing vessels and new builds. Unlocking additional finance is needed to cover the cost of retrofits and highly energy efficient/ zero emission vessels. This is especially the case for technologies that are not yet fully cost-effective.

The benefit of a higher variety of financing mechanisms is that more possibilities emerge. For example, the capital market is more flexible than conventional bank loans, as it can provide longer maturities and fixed interests.[218] As banks tend to favour large companies, alternative financing enables small and medium sized shipping companies to procure the required capital – and for this part of the sector, alternative financing is becoming the primary source of capital.[219, 220] Private equity can support

[214] DW (2020), Pandemic forces German cruise ship-builder into temporary shutdown. See: https://www.dw.com/en/pandemic-forces-german-cruise-ship-builder-into-temporary-shutdown/a-54233075

[215] SEA Europe (2020), Shipbuilding market monitoring report no. 50 (1H 2020)

[216] SEA Europe (2020), Shipbuilding market monitoring report no. 50 (1H 2020)

[217] UNCTAD (2020), Review of Maritime Transport 2020. See: https://unctad.org/system/files/official-document/rmt2020_en.pdf

[218] KPMG (2015), Shipping industry seeking alternative financing. See: https://assets.kpmg/content/dam/kpmg/pdf/2015/09/kpmg-shipping-insights-briefing-2015.pdf

[219] Norton Rose Fulbright (2020), Trends in Ship Finance. See: https://www.nortonrosefulbright.com/en/knowledge/publications/b83d9cbc/trends-in-ship-finance

[220] Direct Ship Finance (2020), Alternative lending to shipping turns mainstream. See: https://www.directshipfinance.com/latest/alternative-lendng-in-shiping

opportunistic investment options, for example by targeting distressed asset sales by banks. Private equity can support these assets by providing flexibility and extended lines of credit, thus enabling financing of riskier projects.[221]

However, alternative financing may also come with a higher price tag than conventional bank debt. While various financing avenues are available to SMEs, not all options are feasible options as the cost of debt can be high.[222] The UN Conference on Trade and Development highlights continuous consolidation in the shipping sector overall, with the share of the top 10 container shipping line companies increasing from 68% in 2014 to 90% in 2019 of container shipping.[223] The current financial landscape is incentivising a continued trend of consolidation. For green finance, there is thus a need to incorporate the financial requirements of SMEs in the maritime sector.

Incentives for change

The shipping sector is highly diverse and characterised by a multitude of different types of business models and contractual agreements. For the uptake of green measures, diversity in the sector brings about a range of different incentives, which in turn promotes different financial agreements and the pursuit of different green measures. CBI have identified two core grouping as shipowners/shipping investors and ship operators/charterers.[224]

For shipowners/shipping investors, CBI finds that companies will differentiate themselves through a focus on asset value, through maximising operational profitability, or somewhere in between.[225] Companies that opt for an asset value approach typically apply a short-term perspective (3-5 years) and rely on positive cashflows as well as aim to reduce operational risk. Conversely, companies that opt for maximising operational profitability are more likely to apply a long-term perspective.[226] Varying perspectives such as these may impact the incentive for change. For example, retrofits of existing vessels with +5 years return on investment may not be relevant to a company focused on short term value.

For ship operators/charterers, CBI finds that companies will distinguish themselves through a focus on above-market performance, through value-added services, or somewhere in between.[227] The nature of the contractual agreements between the owner of the vessel and operator shapes different incentives for change. For example, under a time-charter agreement, a cargo owner will lease a ship for a specified period.

[221] KPMG (2015), Shipping industry seeking alternative financing. See: https://assets.kpmg/content/dam/kpmg/pdf/2015/09/kpmg-shipping-insights-briefing-2015.pdf

[222] Maritime Executive (2019), Ship Finance Update: Many Choices, Few Options. See: https://www.maritime-executive.com/editorials/ship-finance-update-many-choices-few-options

[223] UNCTAD (2020), Review of Maritime Transport 2019. See: https://unctad.org/system/files/official-document/rmt2019_en.pdf

[224] CBI (2020), CBI Shipping Criteria – Background Paper. See: https://www.climatebonds.net/files/files/CBI%20Certification%20-

[225] Ibid.

[226] Ibid.

[227] Ibid.

Under such a contract, the cargo owner covers fuel costs, while the shipowner covers maintenance and installation of new technologies. In such a case, the cargo owner is incentivised to optimise use of fuel, for example, through slow steaming, while the ship owner is less incentivised to pursue fuel optimisation investments as they are not the one reaping the benefits of fuel savings.

8.1.2 State-of-play of green finance in shipping

Prior to the development of the EU Sustainable Finance framework, in absence of clear definitions, the financial market actors began developing their own standards on what can be considered green. This led to the emergence of a self-regulated market to meet the high demand for green investments. Stakeholders and finance market actors such the EIB, external reviewers such as the CBI and CICERO, and finance associations developed guidelines and definitions for what should be considered 'green'.[228,229,230] The speed with which sustainable finance products were purchased, underlined the strength of the demand and the market is growing rapidly.[231]

Green bond market development

Green bonds is one of these financial products. Green bonds use their proceeds to finance green assets in line with ICMA's Green Bond Principles. Since their emergence in 2007, the green bond market has seen rapid growth, attracting different types of bond issuers and investors. Initially, the market was dominated by Multilateral Development Banks (MDBs) (including the EIB and EBRD). This allowed the MDBs and other actors to raise awareness in the market as well as develop frameworks for transparent reporting on the use of proceeds.

The green bond market has since diversified in terms of geographical coverage and types of issuers, bonds and projects financed, driven by increased corporate and municipal issuance. Global green bonds and green loan[232] issuance reached a record USD 258 bn in 2019, up 51% from the 2018 figure. USD 10 bn (4%) of the total issuance were green loans.[233] The wider European market was the main driver behind the substantial increase in 2019 volumes, accounting for 45% of global issuances in 2019.

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[228] EIB (n.d.), Climate Awareness Bonds. See: https://www.eib.org/en/investor_relations/cab/index.htm

[229] CBI (2020), Climate Bonds Taxonomy. See: https://www.climatebonds.net/standard/taxonomy

[230] CICERO (n.d.), Our approach – Research-based, independent and relevant. See: https://www.cicero.green/our-approach

[231] Bloomberg (2020), Why Bonds Good for the Earth Now Carry a 'Greenium'. See: https://www.bloomberg.com/news/articles/2020-10-30/why-bonds-good-for-the-earth-now-carry-a-greenium-quicktake

[232] Green loans are any type of loan instrument made available exclusively to finance or refinance, in whole or in part, new and/or existing eligible green projects. Unlike green bonds, the returns on investments in a green loan may be directly dependent on the borrower's ability to benefit the environment.

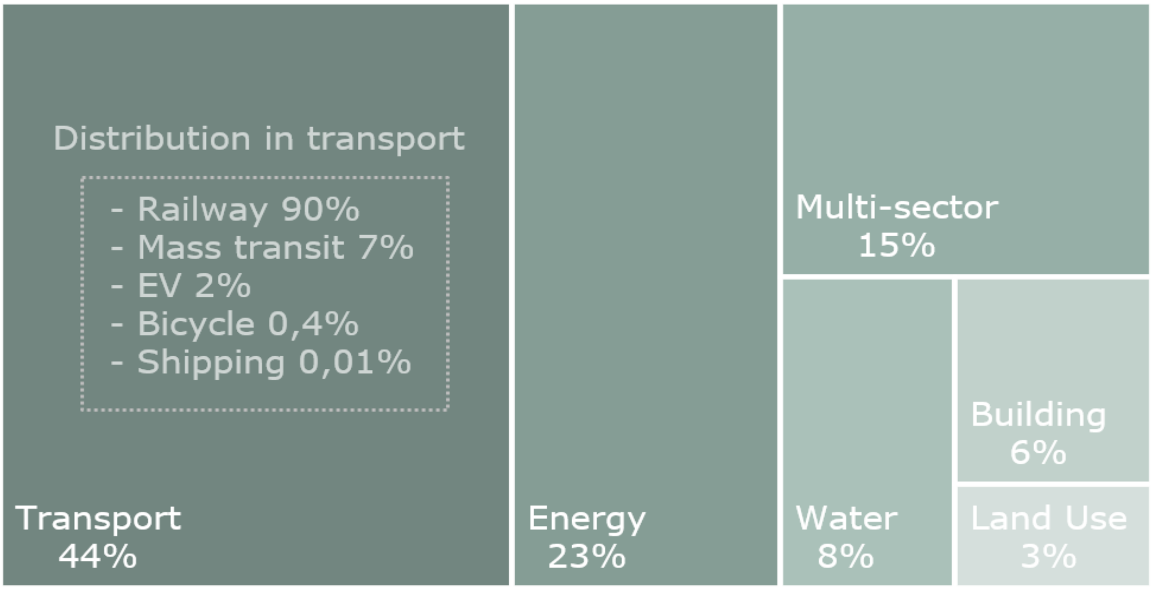
[233] CBI (2020), Green Bond Highlights 2019: Behind the Headline Numbers: Climate Bonds Market Analysis of a record year, https://www.climatebonds.net/2020/02/green-bond-highlights-2019-behind-headline-numbers-climate-bonds-market-analysis-record-year

The total amount of green bonds issued in Europe was up 74% from 2018, reaching a total of USD 117 bn.[234]

Green bonds in transport

In 2019, 20% of global green proceeds allocations went to transport.[235] In terms of climate-aligned bonds[236], the transport sector made up 44%, with USD 532 bn outstanding, see Figure 5.[237] However, maritime shipping accounted for less than 1% of climate-aligned financing.

Figure 5 Distribution of climate-aligned bonds by sector and within the transport sector in 2018



Source: CBI (2018), Bonds and climate change. The state of the market 2018.

Looking specifically at the shipping sector, despite its significant share of global GHG emissions, and large untapped potential to reduce emissions, issuers struggle to attract green investments. This is illustrated by the fact that the first green bond from shipping was only issued in May 2018[238], more than 10 years after the EIB issued the first green bond ever.

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[234] CBI (February 2020), 2019 Green Bond Market Summary, https://www.climatebonds.net/files/reports/2019_annual_highlights-final.pdf

[235] CBI (2019), Annual Highlights 2019. See : https://www.climatebonds.net/files/reports/2019_annual_highlights-final.pdf

[236] Climate-aligned bonds are bonds that are both labelled and unlabelled bonds, which finance projects that contribute to low-carbon economy. This term is broader than green bonds.

[237] CBI (2018), Bonds and climate change. The state of the market 2018. See: https://www.climatebonds.net/files/reports/cbi_sotm_2018_final_01k-web.pdf

[238] CBI (2019), Climate Bonds Launches Expert Groups to Develop Shipping Criteria: Low Carbon Baselines for Shipping Sector Issuers. See: https://www.climatebonds.net/2019/04/climate-bonds-launches-expert-groups-develop-shipping-criteria-low-carbon-baselines-shipping

Shipping green bonds

Since 2018, there were only a few cases of issuance of Green Bonds within the maritime shipping sector. Out of the four identified green bonds, three emanated from the Asian market (Japan and Taiwan) and one from Norway. The Norwegian bond issued by Teekay Corporation, specialised in oil and gas transportation has received a lot of controversy since their primary operations are fossil fuel based.

The issued Green Bonds are predominantly financing LNG fuelled ships and bunkering as well as support various abatement technologies such as ballast water treatment equipment, SOx scrubbers and VOC reduction plant. The Teekay Corporation Green Bond also supports battery powered hybrid technology for fuel savings.

Table 19 Overview of green bonds issued in the shipping sector

Name of the organisation	Country/ Market	Size of the bond	Type of the projects financed	Second opinion
NKY Group, Japanese shipping company and member of the Mitsubishi keiretsu.	Japan	EUR 84 million (JPY 10bn)	The bond was issued as part of the companies' Roadmap for Environmentally Friendly Vessel Technologies' to finance investments toward mainly new, but also existing (refinancing) projects such as (1) LNG-fuelled ships, (2) LNG bunkering vessels, (3) ballast water treatment equipment, and (4) SOx scrubber systems	Vigeo Eiris has defined the proceeds likely to contribute to air and water pollution prevention, and marine biodiversity protection objectives, without significantly contributing to energy transition and climate change mitigation objectives.
Mitsui O.S.K. Lines (MOL)	Japan	USD 45 million (JPY 5bn)	The net proceeds are used to finance and refinance, in whole or in part, the following projects: (1) Ballast Water Management Systems, (2) SO_X Scrubber Systems, (3) LNG Bunkering Vessels, (4) LNG-fuelled Vessels, (5) Upgraded Propeller Boss Cap Fins, (6) Wind Challenger Project.	Vigeo Eiris has considered MOL's first Green Bond to be coherent with the company's main sustainability strategic priorities and sector issues and to contribute to achieving its sustainability commitments. The objectives associated with the Ballast Water Management Systems, SOx Scrubber Systems and Wind Challenger Project categories were defined, relevant, measurable and precise. The objectives associated with LNG related Projects and Upgraded Propeller Boss Cap Fins were defined, measurable, precise but partially relevant as regard to environmental objectives.

Name of the organisation	Country/ Market	Size of the bond	Type of the projects financed	Second opinion
Teekay Corporation	Norway	USD 125 million	Net proceeds are used for the financing or refinancing of E-Shuttle, in whole or in part. For example to be used in (1) Battery powered hybrid technology for fuel savings, peak load shaving, and added overall system redundancy, (2) LNG as fuel instead of marine gas oil and heavy fuel oil, (3) Volatile Organic Compound (VOC, crude oil vapours) reduction plant - condensation type, (4) Gas turbines for reducing non condensable VOCs (including methane), (5) Possibility to mix condensed VOCs with LNG – turning VOC emissions into usable fuel for the generators.	CICERO Shades of Green declared that Teekay provides a short-term solution for important efficiency improvements and supports accelerating lower emission shipping through innovation but does not provide a long-term solution to a low-carbon and climate resilient future.
Evergreen Marine Corp	Taiwan	USD 65.7 million	The Taiwanese shipping company issued the bonds with the aim to purchase and install eco-friendly fuel equipment (scrubbers) in ships.	Not available

Sources: NYK (2018), Green Finance: Green Bonds; Vigeo Eiris (2018), Second Party Opinion On The Sustainability of NYK's Green Bond; CBI (2018), Green Bond Fact Sheet; Vigeo Eiris (2018), Second Party Opinion On The Sustainability of MOL's Green Bond; Teekay (2019), Green Bond Framework; Cicero, Shades of Green (2019), Why we need all sectors to contribute to a global transition to green.

8.1.3 Global shipbuilding

Industrial policy considerations

The global structure of the shipbuilding industry has evolved so that certain ship types are mainly built in certain geographical areas. In the far East (China, Japan and South Korea) shipbuilding is specialized mainly in tankers, bulkers, and containers ships, while European shipbuilding activity is mainly concentrated on passenger ships (cruise/ferries) and complex special ships (such as dredgers, cable layers, research, special bunker ships for alternative fuels, etc.).

In the past decade, the evolution of the Asian shipbuilding sector has undergone rapid transformation, and the impact is felt in the European shipbuilding sector. In 2004, there was a balanced orderbook with many ship types being built in Europe. However, aggressive pricing policies supported by government subsidies of the Asian competitors had the effect that close to 90% of the EU's shipbuilding industry is now dedicated to the construction of passenger ships, while hardly any containerships, cargo ships, bulk carriers or tankers are now being produced in Europe. Consequently, the European shipbuilding industry is left greatly exposed to shifts in demand for passenger shipping, such as it has been the case under the ongoing COVID-19 pandemic.

The level of ambition in terms of overall emissions reductions (at least in the mid and long term) calls for radical technological developments that will have profound impact on the entire maritime value chain. This could provide the European shipbuilding industry a window of opportunity to diversify.

Retrofitting projects with green technologies may spark some activity. However, it is also likely that those projects will be mostly focused on incremental technologies, rather than on cutting-edge ones.

Strategically more valuable could be to focus on large-scale projects, with first-of-a-kind demonstration and deployment challenges. Evaluation of the impact of certain technologies and the viability of the underlining business model, involves always larger groups of stakeholders, across the maritime and energy value chains and creates conditions for high level European value added. In this respect, the role of large shipyards integrators as innovation-hubs should not be underestimated.

However, the risk remains of financing (with European instruments) the development of green technologies in Asian countries, especially if certain ship types are considered as eligible in the financing schemes, without any geographical content consideration.

The following trade rule compatible risk mitigation measures could be considered:

- Prioritise green projects for which the maritime value chain is fully developed in Europe (i.e. passenger and special ships). This ensures that all relevant European stakeholders are involved, from SMEs to large shipyard integrators, allowing for a consistent technological growth for the entire sector;

- Prioritise green projects with an on-shore element (such as facilities for bunkering, cold-ironing) in connection with green technologies on board of the vessels, clearly linking the ship to on-shore infrastructure developed on European soil, e.g. a large fuel cell installation on board combined with its bunkering facility on land.

- Prioritise support to the deployment of new green technologies patented in Europe and with a European value chain.

Asian markets

A comprehensive European approach is the more important given that the Asian markets, and particularly the Chinese market, are strengthening their international positions in global supply chains and are growing increasingly dominant in the global shipping sector. For example, China controls the second-largest fleet and in 2019 they built more than 1/3 of all new vessels.[239,240]

As mentioned in Section 8.1.1, the impact of COVID-19 has brought underlying challenges to light and highlighted the power of China in the global shipping sector. While European shipyards are struggling to maintain operations and keep up their forward orders, Chinese shipyards are not facing challenges to the same extent. This is largely due to the shipbuilding segments that China dominates (container and bulk) and an extensive and complicated system of formal and informal state support. In a recent report, the Center for Strategic and International Studies developed an overview of the various streams of direct and indirect state support the China offers its shipping sector. This overview is presented in Table 20.

[239] Hellenic Shipping News (2018), China-owned fleet becomes world’s second largest. See: https://www.hellenicshippingnews.com/chinaowned-fleet-becomes-worlds-second-largest

[240] UNCTAD (2020), Review of Maritime Transport 2019. See: https://unctad.org/en/PublicationsLibrary/rmt2019_en.pdf;

Table 20 China's state support scheme for the shipping sector

China's state support scheme	
Direct state support	
Direct subsidies	China provides a wide variety of cash payments and rebates to its enterprises to offset costs, boost revenue, encourage the adoption of new technology, and aid ailing firms. Examples include subsidies for exports, insurance, research and development, employment, and loan interest, as well as value-added tax rebates, income tax exemptions, and reduced port fees.
State financing	China’s state banks have taken a dominant role in the shipping sector through lending and leasing to both domestic and international firms. This funnels new orders to Chinese shipbuilders and expands China’s ownership of the world’s merchant fleet.
Indirect state support	
State fundraising	The Chinese government directs SOEs to support each other through a variety of means, including low-interest loans with preferential terms, debt forgiveness, government-mandated equity infusions, and low-interest bond issuance.
Indirect subsidies	China provides subsidies and non-monetary support to adjacent industries (e.g., steel, oil, electricity, and real estate) that translate into reduced costs for shipping and shipbuilding companies.
Barriers for foreign firms	China deters foreign firms from competing with or supplying Chinese shipping and shipbuilding companies through domestic input requirements, import substitution, and export restrictions.
Consolidation policies	China consolidates its SOEs to promote global dominance in strategic industries. In 2015, for example, the government approved a merger to give it the largest shipping and logistics company in the world.
Forced tech transfer and IP theft	Foreign firms are required to transfer technology in order to secure market access, while state-sponsored hacking and commercial espionage have targeted foreign intellectual property (IP), including maritime technology.

Source: Center for Strategic and International Studies (2020), Hidden harbors – China's State-backed Shipping Industry. See: https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/207008_Blanchette_Hidden%20Harbors_Brief_WEB%20FINAL.pdf

8.2 Conditions and requirements for developing green finance for the maritime sector

Based on insight from the preceding section and interviews conducted with shipping finance stakeholders, this section discusses the conditions and requirements for developing green finance in the shipping sector. Firstly, conditions and requirements for Green Bonds are analysed, followed by an analysis of conditions and requirements for other green finance instruments.

8.2.1 Green Bonds Standards for the maritime sector

Tapping into existing bond market

The use of regular bonds has been increasing in the shipping sector.[241, 242] Green bonds could potentially tap into this growing market and support financing the green transition as they provide long-term maturities and a low-risk profile.[243] As financing is likely to continue to be in low supply, and as the sector is increasingly consolidating, bonds are becoming an increasingly viable means of finance in the sector. As noted in the above analysis, an issuance of green bond in the shipping sector is currently a rarity, however, as the bonds market is growing, there is an opportunity for green bonds to capture a larger market share. Such an expansion is contingent on the sector developing established conditions and requirements for green bonds. There is especially a need to mitigate the risk profile of green transition initiatives, if green bonds are to grow.

Challenges in defining green

One of the main challenges in further increasing green bonds issuance in the shipping sector is the lack of commonly agreed definitions on what constitutes green. This also leads to further uncertainties and hesitations from different market participants. For example, the second opinion providers are cautious about giving 'green' reviews and investors are less likely to invest is something that may or may not be perceived as green. Investments related to LNG and scrubbers are present in all of the issued green bonds. However, both LNG and (open loop) scrubbers are controversial from a climate and environmental standpoint. As such, to avoid reputational risk, investors may be reluctant to invest in such technologies. These issues related to lack of definitions further highlight the importance of the EU Taxonomy as a means of building consensus and providing certainty to the market participants.

Lack of low carbon technologies

The challenge of defining green is also linked to the lack of scalable low carbon technologies. This issue was highlighted by the shipping stakeholders as one of the reasons why there are so few green bonds issuances in the sector. More specifically, in the absence of clear definitions, shipping companies and investors are cautious about which projects can be labelled as green to avoid potential reputational risk and greenwashing claims.

Financial risks/low credit ratings

In Europe, there is a growing market for green bonds within the transport sector, primarily related to the rail sector, as also shown in Figure 5. Rail projects are typically issued by government entities of government backed bodies, leading to bonds with an A or above rating. For the shipping sector, bonds are typically issued by shipping com-

[241] Offshore Energy (2017), Shipping Bonds Issuance Momentum Explained. See: https://www.offshore-energy.biz/shipping-bonds-issuance-momentum-explained/

[242] Global Trade (2017), Shipping Bonds Issues Momentum Continues. See: https://www.globaltrademag.com/shipping-bonds-issues-momentum-continues/

[243] CBI (2020), CBI Shipping Criteria – Background Paper. See: https://www.climatebonds.net/files/files/CBI%20Certification%20-

panies, i.e. not backed by the public sector. One shipping finance interviewee highlights that the credit ratings for shipping companies are typically very low, leading to low rated bonds, or non-rated bonds, which carries a larger risk than what is conventionally associated with bonds. Consequently, credit enhancement may be needed to make it more attractive to issue a bond. Another possibility is to promote Public-Private Partnerships. These partnerships enable the public sector to support climate objectives and enable the shipping sector to de-risk their projects and issue higher rated bonds.

Transitional bonds

As there are very few (or none) low-carbon solutions readily available for the shipping industry, activities that incentivise the transition to a climate-neutral economy are important. To support these industries, so called transitional bonds were created. A transitional bond is a financial instrument created by the French multinational insurance firm AXA to bridge the gap between already green projects and industries that require more time to implement transition. The EU Taxonomy also includes transitional activities, and within the framework of the Taxonomy the specified transitional activities are green, by way of inclusion in the framework. However, in this context, transitional bonds are not inherently green, rather they are a bridge the gap between regular and green bonds. The transition bonds issued by AXA are financing three areas: electric transportation, marine transport, and industrial resource efficiency. In the shipping sector, the bonds will mainly focus on helping shipping companies to switch from heavy marine diesel oil to LNG propulsion. As for green bonds, the issuers are to use indicators, either to demonstrate the environmental impact of transition bond-funded projects for the use-of-proceeds, or the strategic shift to low carbon model of the company for climate key performance indicator (KPI)-linked bonds.[244]

For transitional bonds, the lack of guidelines and common consensus is thus likely to be difficult to assess, due to controversy and a continues development of what is agreed to be sustainable. For example, another shipping finance interviewee highlighted open loop scrubbers as a technology, which was previously considered sustainable across most groups of actors. However, in recent years the perspective has shifted, and financial institutions are removing open loop scrubbers from their list of sustainable technologies.

Blue bonds

Blue bonds can also play a role in the shipping sector as they cover all projects around marine and ocean-based projects. The bonds are still considered green and follow all the ICMA principles. At the end of 2017, Fiji issued a sovereign blue bond worth $50 million USD aimed at both climate mitigation and adaptation with some use of proceeds having a positive impact on the blue natural capital of Fiji.[245] Blue bonds are not usually focused on shipping but can incorporate targets of cleaner transportation and

[244] AXA (2019), Forming a bond supporting the energy transition. See: https://www.axa.com/en/magazine/forming-a-bond-supporting-the-energy-transition

[245] BNCFF (2019), Blue Bonds Financing Resilience of Coastal Ecosystems. See: https://www.4climate.com/dev/wp-content/uploads/2019/04/Blue-Bonds_final.pdf

tend to fund maritime infrastructure in a sustainable manner. The Fiji bond's main focus, for example, was on sustainable development of natural resources, renewable energy, clean transport, water and energy efficiency, wastewater management and sustainable agriculture to reduce fertilizer run-off into the ocean, avoiding damage to coastal ecosystems.

8.2.2 Other green finance instruments

Green loans

In addition to the green bonds, there are other instruments that could be incentivised such as green or sustainability-linked loans. Green loans functions as regular loans that are tied to environmental criteria. Despite conventional bank finance decreasing in the shipping sector in recent years, it remains the primary source of finance, especially in the European market. Green loans is thus a means to tap into existing financial flows and established structures. Financial stakeholders in the shipping sector also mention green loans as either a current practice, albeit at a low scale, or a practice they intend to pursue.

Consequently, green loans is a financial instrument that is, and can be further developed, to play an important role in scaling green finance in the maritime shipping. Green loans are set up by banking institutions for companies to lend money specifically for a "green" investment. Criteria for being "green" have, for example, been set by the Green Loans Principles with the aim to promote the development and integrity of the green loan product. [246] For example, NYK benefited from JPY 2 billion (EUR 15.8 million) in 2019 from a green loan credited by Taiyo Life Insurance Company and certified by Japan Credit Rating Agency Ltd. The company will use the loan to build a new methanol-fuelled chemical tanker. The methanol-based engine will reduce SOx by approximately 99% compared with those based on heavy oil. [247]

To establish a sound basis for green loans, banks rely on sound evaluation of risks and require transparency and monitoring. Banks opt for shipping companies that display strong corporate cultures and those that align their business with relevant banking regulation and initiatives such as the Green Loans Principles or the Poseidon Principles. For example, a shipping finance stakeholder mentions that investors are considering the long-term plans and may be more inclined to finance transitional activities if the shipping companies can present long-term strategic plans for phasing out fossil fuel related activities.

The framework offered by the Taxonomy for the maritime sector is highlighted by shipping finance stakeholders as a good basis for establishing shared definitions. The stakeholders also highlight the need for a sound monitoring and reporting framework

[246] LMA (2018), Green Loan Principles, Supporting environmentally sustainable economic activity. See: https://www.lma.eu.com/application/files/9115/4452/5458/741_LM_Green_Loan_Principles_Booklet_V8.pdf

[247] NYK (2018), NYK to Build its First Methanol-fuelled Chemical Tanker with Green Loan. See: https://www.nyk.com/english/news/2018/20181227_01.html#:~:text=NYK%20will%20receive%202%20billion,of%20funding%20environment%2Dfriendly%20projects.

to ensure transparency. Ideally, the monitoring and reporting should be harmonised. However, stakeholders also found that monitoring and reporting should be flexible enough to account for differences in companies and practices. Under Green Loan Principles, the investors ask borrowers to collect information on the use of proceeds and on annual basis to update this information. Information on the impacts is also collected through recommended quantitative indicators, such as GHG emissions reduced.

Shared savings

The business models in the shipping sector are highly varied. This report has previously examined the varying degrees of incentives between vessels owners and vessel charters as well as a general business set up, which promotes ships to arrive in port ahead of schedule, only to loiter outside ports before they can be received. Financial measures related to a shared savings concept, such as pay-as-you-save and fuzzy-pay-off approaches, are beneficial as they can contribute to bridging the divide across different incentives from collaborating actors and financiers and the maritime sector. These financial concepts are relevant tools as they specifically target green behaviour and/or technologies.

These approaches enable comparison between the risk profiles of different technologies by indicating the real value and spread of assumed impact of the investments.[248] This is valuable as shipping companies may sometimes opt for replacing vessels with newbuilds that meet the current green standards, rather than pursuing retrofits that may or may not bring a vessel up to standards.

Accessing alternative finance

Some financial institutions are likely to involve themselves in the shipping sector to a further extent than banks. For example, private equity firms may impose different requirements, such as bringing in a more institutionalised approach in the management of the companies, and some investors may finance shipping companies by pursing strategic partnerships.

Linking financial and environmental performance

Alignment of bank lending with the EU climate objectives requires a robust quantitative understanding of the links between financial and environmental performance. Establishing a quantitative relationship (or correlation) between green measures, technical screening criteria, credit risk and asset value can provide an important case for lenders and supervisors to consider energy efficiency of assets in the capital requirements for credit risk. Since credit risk is typically the largest risk of a bank, and capital requirements are the limiting factor to loan origination, this would be a particularly effective tool for aligning bank lending and climate goals in the shipping sector.

[248] Metzger, D. & Schinas, O. (2019), Fuzzy real options and shared savings: Investment appraisal for green shipping technologies, in Transportation Research Part D: Transport and Environment, Vol 77. See: https://www.sciencedirect.com/science/article/abs/pii/S1361920919309289

Renewal and retrofitting support schemes

Since advanced zero-emission vessels and GHG-emission free fuels are still in early stages of development, and due to the long lifespan of vessels, there is need to focus on greening of the existing fleet through retrofits. Depending on the extent and nature of the retrofits, the financing requirements can be substantial. Current examples of green retrofitting support schemes include EIB's Green Shipping Guarantee Program[249] and Green Shipping Programme Loan[250], which set out to accelerate the implementation of investments in greener technologies by European shipping companies, and to finance small shipbuilding projects that promote sustainable transport and environmental protection. Such initiatives in many cases lead to successful energy efficiency improvements and significant GHG emissions savings.[251] The other programmes supporting retrofits include the DNV GL's newbuilding and retrofit support[252] and KfW IPEX-bank's Fleet Retrofit - Financing for the Maritime Industries[253].

Currently, retrofitting support schemes are largely focused on facilitating the vessels to meet the IMO standards. As such, support is extended to the installation of scrubbers, LNG related activities, and low-sulphur emission fuel related activities. Consequently, there is need to align these schemes (or newly created schemes) with the EU Taxonomy and the overall EU climate objectives.

Overcapacity is a recurring issue in the maritime sector.[254] Overcapacity can render vessels unused or underused for shorter or longer periods of time, which negatively impacts the shipping companies forced to letting their assets idle. Periods of overcapacity could be seen as an opportunity to commence retrofits, much like the COVID-19 pandemic could be seen as a similar opportunity.[255] However, overcapacity may conversely keep shipping companies from undertaking expensive retrofits, if the vessels are not likely to re-enter the market. Such a scenario is likely in times of high uncertainty due to the pandemic and unresolved technology pathways, as it is currently the case. Therefore, it is important that certainty will be provided by global and EU regulators on future requirements, so that this period of overcapacity can be used for retrofitting of vessels which would then re-enter the market as more energy efficient and

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[249] EIB (2016), Green shipping guarantee programme. See: https://www.eib.org/en/projects/pipelines/all/20150334

[250] EIB (2016), Green shipping programme loan. See: https://www.eib.org/en/projects/pipelines/all/20150742

[251] Henderson, C. (2018), The Financing of Green Shipping. See: https://www.assetfinanceinbrief.com/2018/10/financing-green-shipping/

[252] DNV GL (n.d.), Newbuilding and retrofit support. See: https://www.dnvgl.com/services/newbuilding-and-retrofit-support-4975

[253] KfW IPEX (2018), Green Shipping: Fleet Retrofit - Financihttps://www.dnvgl.com/services/newbuilding-and-retrofit-support-4975ng for the Maritime Industries. See: https://www.marinemoney.com/system/files/media/2018-11/1510%20KFW.pdf

[254] UNCTAD (2020), Review of Maritime Transport 2020. See: https://unctad.org/system/files/official-document/rmt2020_en.pdf

[255] Bucher, A. (2020), Shipowners should use pandemic downtime to retrofit. See: https://www.wartsila.com/insights/article/shipowners-should-use-pandemic-downtime-to-retrofit

competitive. Green finance, based on a common EU policy aligned Taxonomy, could play a role in supporting retrofits in the periods of overcapacity.

Access to green finance for SMEs

When setting the conditions and requirements for developing green finance in the maritime sector, it will be crucial to consider how to facilitate the access to financing for SMEs. SMEs play a central role in the green transition ensuring value creation, innovation, and social cohesion,[256] and as seen in Section 8.1.1, SME's are facing greater challenges in obtaining financing than large shipping companies. Recently, the EC issued a new SME strategy for a sustainable and digital Europe[257], wherein one of the three core pillars is improved access to financing.

One possible financing solution is leasing. Leasing in the shipping sector has been growing in recent years, most notably in China,[258] but European banks and financial institutions are also offering leasing solutions to shipping companies, for example, Societe Generale.[259] In short, leasing circumvents the need for substantial upfront capital investments, which is a common feature of conventional ship finance. With leasing, SMEs can instead make a small down payment and/or a series of payments for the use of assets. At the end of the lease, SMEs can, but do not have to, purchase the asset in its entirety for a buyout payment.[260] For SME's leasing can therefore help improve liquidity and cash management, diversify funding and mitigate risk related to technological advances. For leasing companies, the risk profile of leasing is also attractive and can lead to higher financial leverage in debt markets and drive higher return on investments. However, for the lessors, there is a need to establish sound risk management approaches to mitigate credit- and asset risks.[261]

There are several ways to structure leasing agreements and establish price levels that benefits both parties. There is therefore a need to further analysis how leasing options in shipping can be structured to include SMEs.

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[256] UNEP (2015), Green SMEs and access to finance. See: http://unepinquiry.org/wp-content/uploads/2015/10/2ii_banking_diversity_v0.pdf

[257] European Commission (2020), An SME Strategy for a sustainable and digital Europe. See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0103&from=EN

[258] Deloitte (2017), EU Shipping Competitiveness Study. See: https://www.ecsa.eu/sites/default/files/publications/2017-02-23-Deloitte-Benchmark-Study-FULL---FINAL.pdf

[259] Societe Generale (n.d.), Global Shipping & Offshore Finance – Capital Markets, Financing, Advisory. See: https://cib.societegenerale.com/fileadmin/user_upload/SGCIB/Global_Shipping_Finance_Brochure.PDF

[260] World Bank Group (2018), Improving access to finance for SMEs, opportunities through credit reporting, secured lending, and insolvency practices. See: https://www.doingbusiness.org/content/dam/doingBusiness/media/Special-Reports/improving-access-to-finance-for-SMEs.pdf

[261] Clausius, P. (2015), Ship Leasing, in HSBA Handbook on Ship Finance. See: https://www.researchgate.net/publication/304116225_Ship_Leasing

Apart from leasing, there are other pathways to obtain finance, and EU policies are in place to promote SME access to, and SME awareness of, other types of finance.[262] Table 21 presents an overview of sources of financing for SMEs, as well as briefly outlines the potential and challenges related to obtaining the respective sources of finance for SMEs in the shipping sector. Access to finance for SMEs is an established topic and has been the subject of much research and policies are generally in place to promote access to finance at different levels of governance.

While SMEs in the shipping sector can benefit from existing knowledge, there is a need to carry out further analysis on how they specifically can improve access to the different sources of financing.

Table 21 Sources of financing for SMEs

Sources of financing for SMEs	
Public financing	Public financing programmes can be used, e.g. Recovery and Resilience Facility, InvestEU, ETS, European Investment Fund, Future Mobility Facility, Innovation Fund, CEF Transport Blending Facility, EIB standalone operations.
Bank Loans	SMEs are generally challenged when trying to obtain standard bank loans, and especially the shipping sector due to substantial upfront investments needs.
	Guarantees provided by public and private institutions can enhance the creditworthiness of SMEs in the shipping sector
Venture capital (private equity)	Private equity firms entered the shipping sector in large numbers in 2010-2015, however since then, given the lack of measurable success and a swift return on investment, interested has stifled.[263]
	The challenges to overcome rests on agreements between the private equity partners and the SMEs, wherein in the shipping industry long-term investment plans are prioritised, rather than short-term investment plans commonly pursued by private equity. Additionally, private equity funding typically includes a commitment for the beneficiaries to release a share of their control over the company, which is not often welcomed by smaller businesses.
Debt markets	In particular, green bonds can be a way to provide access to debt markers for SMEs.
	As seen in section 8.1.2, there is a very small amount of green bonds being issued in the shipping sector, and furthermore, these are typically issued by large shipping companies. SME's are not in position to issue their own green bonds, and there is therefore a

[262] European Commission (n.d.), Access to finance for SMEs. See: https://ec.europa.eu/growth/access-to-finance_en

[263] IHS Markit Maritime & Trade Expert (2017), Private equity pursues more targeted shipping approach. See: https://ihsmarkit.com/research-analysis/private-equity-pursues-more-targeted-shipping-approach.html

	potential for green bonds that are issued by banks, or financial institutions, that finance a range of SMEs in the shipping sector.
Fintech	Financial technology (fintech), such as blockchain, cryptocurrency, regulatory technology (regtech), and crowdfunding, offers great potential for innovation for SMEs, by creating access, reducing complexity and prices of financial transactions.
	For shipping companies, fintech can help innovate and attract green finance for sustainable companies. For example, crowdfunding can help support highly sustainable and innovative ideas, and regulatory technology can help reduce complexity related to financial and other regulation, which SMEs are less likely to manage on their own. The potential of fintech is still developing, and it is not yet as well-developed traditional sources of financing.

Source: COWI/CE Delft based on EC (n.d.), Access to finance for SMEs. See: https://ec.europa.eu/growth/access-to-finance_en, UNEP (2017), Mobilizing sustainable finance for small and medium sized enterprises. See: https://www.cbd.int/financial/2017docs/unep-smefinance2017.pdf.

Next steps

On the basis of economic activities and technical screening criteria for the maritime sector, this chapter has analysed the financial state-of-play in shipping finance and provided recommendations to support development of green finance in the maritime sector.

The current landscape of green finance in the European maritime sector is underdeveloped, due in part to the nature of the shipping sector's global interconnectedness, uncertainty about technology pathways, and capital-intensive investment needs. European shipping companies, financial institutions, and other stakeholders welcome the inclusion of the maritime sector in the EU Taxonomy as an opportunity to stimulate and expand the development of existing green financing practices.

In summary, there are different green finance instruments available for the shipping sector such as green bonds, transitional bonds, blue bonds, green / sustainability-linked loans, shared savings, leasing and others. To support the scaling up of green finance, the challenges that the shipping companies face need to be tackled. The challenges related to financial risks and low credit ratings could be mitigated through credit enhancement measures. The technological uncertainty of climate transition in the sector needs to be minimised, to avoid companies investing in assets that in few years could become stranded. This could be supported through further R&D and demonstration projects on promising technologies and fuels.

The continuing fall-out of the COVID-19 pandemic is causing great stress for the maritime sector, and particularly for the European shipyards, where production of passenger- and special purpose vessels are brought to a halt. Considering that notably passenger- and offshore ships, as well as other special ships, are strong industries with full value chains within Europe, ensuring they have access to green finance contributes to strengthening the EU's maritime sector, as well as the recuperation of the sector following the pandemic.

The EU Taxonomy will play a pivotal role by providing more clarity to the market participants on what can be considered green.

9 CONCLUSIONS

This study has examined the development of the technical screening criteria for the maritime shipping activities and projects. The study has assessed which economic activities and under which conditions could be considered environmentally sustainable in line with the Taxonomy Regulation. The focus on this study was on substantial contribution of the shipping operations to the climate mitigation objective and do no significant harm on other environmental objectives. In addition, the technical screening criteria for low carbon waterborne infrastructure were considered. The substantial contribution to other environmental objectives was also examined but to a lesser extent.

Screening criteria for substantial contribution to climate mitigation until 2025

The proposed technical screening criteria until 2025 focus on greening of shipping operations and facilitating carbon neutral shipping. The key considerations when developing the screening criteria included compatibility with the IMO framework, ability to capture diversity of vessels and business models, support for zero emissions vessels, enabling R&D on alternative fuels and infrastructure while distinguishing retrofitting and newbuilding.

The criteria proposed for shipping activities for the period up to 31 December 2025 are the same as in the Draft Delegated Regulation (published for public feedback on 20/11/2020), as the study provided parallel input to the Commission services on these criteria. The criteria are presented in the text box below.

Sea and coastal freight and passenger water transport:

- *Zero emissions vessels: The vessels have zero direct (tailpipe) CO_2 emissions;*
- *Hybrid vessels that achieve significant GHG emissions reductions: Until 31 December 2025, hybrid vessels use at least 50 % of zero direct (tailpipe) CO_2 emission fuel mass or plug-in power for their normal operation.*
- *Enabling modal shift of freight: Until 31 December 2025, and only where it can be proved that the vessels are used exclusively for provision of coastal services designed to enable modal shift of freight currently transported by land to sea, the vessels have direct (tailpipe) CO_2 emissions, calculated using the International Maritime Organization (IMO) Energy Efficiency Design Index (EEDI), 50 % lower than the average reference CO2 emissions value defined for heavy duty vehicles (vehicle sub group 5-LH) in accordance with Article 11 of Regulation 2019/1242;*
- *Supporting the best in class new vessels: Until 31 December 2025, the vessels have an attained Energy Efficiency Design Index (EEDI) value 10 % below the EEDI requirements applicable on 1 April 2022.*
- *Retrofitting of vessels to improve energy efficiency: Until 31 December 2025, the retrofitting activity reduces fuel consumption of the vessel by at least 10 % expressed in grams of fuel per deadweight tons per nautical mile, proven by computational fluid dynamics (CFD), tank tests or similar engineering calculations.*
- *For any categories above, vessels are not dedicated to the transport of fossil fuels.*

Under the two first criteria, only few projects will qualify, e.g. smaller battery powered ships and some ongoing R&D projects on the use of hydrogen. Despite of that, the two criteria encourage further innovations in new propulsion technologies and alternative fuels, which is crucial for achieving climate neutrality.

The criterion enabling modal shift follows the TEG proposal to set similar thresholds across modes, with an aim to promote modal shift as a greater proportion of fleets in lower carbon modes are Taxonomy eligible. To avoid greenwashing, this criterion can be used only to finance the operation with a proved potential of modal shift.

The 'Best in class' criterion is benchmarked to the IMO Energy Efficiency Design Index EEDI and is aimed at supporting the best performing vessels in their respective categories. Based on the EEDI values attained for vessels (2013-2019), and reported in the IMO EEDI database, around 12% of all EEDI ships have an attained EEDI value 10% below the EEDI requirements.

Given the long lifespan of vessels, it is important that taxonomy continues to incentivise the greening of the existing fleet. In particular, older more polluting ships could have a great energy saving potential, in best cases more than 20%. These developments are encouraged via the retrofitting criterion.

Green transition requires also low carbon enabling infrastructure. The technical criteria considered in the study cover infrastructure which supports alternative fuels and electrification for charging batteries and for use during when vessels are berthed.

Following the TEG approach, the transportation of fossil fuels should not be eligible under the EU Taxonomy. However, this criterion could be difficult to apply to shipping. The same dry bulk carrier can as an example, carry coal, ore, wood chips, fertiliser or grain. To avoid penalising best-in-class and zero emissions tankers and bulk carriers, which can carry versatile cargo including renewable fuels, it can be relevant to consider how to operationalise the definition of 'dedicated'.

Screening criteria for substantial contribution to climate mitigation beyond 2025

Compared to the criteria until 2025, it is expected that the criteria are tightened over time as new technologies are developed and currently innovative technologies become standard. The criteria should also reflect the latest developments at EU and IMO levels, as well as support continuous energy efficiency improvements, incentivise renewable and low carbon fuels and vessels, and dual fuel vessels.

It is recommended that after 2025, the modal shift criterion is discontinued and the new best-in-class criterion is carefully considered to avoid lock-in effect to high carbon solutions until 2030. As soon as commercially scalable zero emission solutions become available, shipping should no longer be considered a transitional activity and the best-in-class criterion should be discontinued. Furthermore, it is also recommended that an operational criterion is introduced to incentivise operational efficiency for additional GHG emissions reductions.

Taking these into account, the study proposed the following criteria:

Sea and coastal freight and passenger water transport:

- *Zero emissions vessels: The vessels have zero direct (tailpipe) CO_2 emissions;*
- *Hybrid and dual fuel propulsions vessels that achieve significant GHG emissions reductions: Until 31 December 2030, hybrid vessels deriving at least 50% of*

their energy from zero tailpipe CO_2 emission fuels or plug-in power for their normal operation; OR Until 31 December 2030, hybrid and dual fuel vessels using at least 60% of their energy from non-fossil origin or electricity for their normal operation;

- *Retrofitting of vessels to improve energy efficiency: Until 31 December 2030, the retrofitting activity reduces fuel consumption of the vessel by at least 10 % expressed in grams of fuel per deadweight tons per nautical mile, proven by computational fluid dynamics (CFD), tank tests or similar engineering calculations.*

The following two best-in-class criteria focus on different elements, the first one – on the operational performance of vessels, the second – on design of vessels.

- *Decreasing carbon intensity of the fleet – operational criterion: Until 31 December 2030, vessels that have achieved carbon intensity expressed in Energy Efficiency Operational Index (EEOI) /Carbon Intensity Indicator (CII) below certain thresholds*
- *Identification of the most energy efficient new vessels – design based criterion: Until 31 December 2030, the vessels have an attained Energy Efficiency Design Index (EEDI) value equal to or better than the 10% lowest EEDI scores of similar ships that entered the fleet in the three years prior to the time of the assessment; or the vessels have an attained Energy Efficiency Existing Ship Index (EEXI) equal to or better than the 10% lowest EEXI scores of similar ships; or the vessels have an attained EEDI or EEXI 10% below the EEDI/EEXI requirements applicable as from 1 January 2025, whichever value is lower (better).*

Similarly to the criteria for until 2025, the first two criteria are aimed at encouraging further innovations in new propulsion technologies and alternative fuels, while the third criterion supports the improvement of the energy efficiency of the existing fleet.

The latter two 'Best-in-class' criteria focus on different elements: operational performance versus design of vessels. The design criterion is linked to the EEDI or EEXI values, whereas the operation criterion is linked to carbon intensity measure (EEOI or CII). Each of the criteria has its own benefits and drawbacks in terms of its use. The benefits of design criteria are that they allow ships' green properties to be assessed prior to their construction. It is thus a theoretical exercise, which enables to estimate ex-ante whether a vessel complies with a green threshold based on the estimated effects of used and new technologies. The benefits of operational criteria are that they focus on real emissions and enable ship performance to be accurately evaluated. However, it is challenging to implement in practice as the shipping sector and vessel types are highly diverse, and the operational efficiency can significantly vary from year to year.

The proposed criteria should be carefully re-evaluated at the time of setting the post 2025 criteria to ensure that new developments in the shipping sector are accounted for.

Screening criteria for other environmental objectives

In addition to climate mitigation criteria, this study has examined, which economic activities within the sector can also contribute to other environmental objectives. The initial assessment of the screening criteria for other environmental objectives identified the activities that can be considered in the EU Taxonomy, see the table below.

Substantial contribution to:	Relevant economic activities
Climate adaptation	Not relevant directly to ship operations but very important to port infrastructure by increasing their climate resilience
Sustainable use/ protection of water & marine resources	Technologies improving water management: e.g. installation of white box system, and sewage treatment
Transition to a circular economy	Recycling of ships; Recycling of waste generated on board; Reuse of dredged sediment
Pollution prevention and control	Safety islands; Noise reduction measures; Technology to reduce NO_X, SOx, PM; Onshore power
Protection of biodiversity & ecosystems	Deterrents and other measures to protect biodiversity; Ballast water treatment and management; Support to integrated ocean management

Need for monitoring

The study examined the practices that can potentially lead to greenwashing. To avoid any potential risk of greenwashing and ensure a level playing field, transparent monitoring and reporting is needed. Reporting can be performed on ex-ante and ex-post basis. An ex-ante assessment is performed when an investment is considered for eligibility as green. Once an investment has been made, it should be monitored (ex-post) to ensure that it complies with the given criteria over time and performs as initially anticipated.

Scaling up green finance

Despite overall high demand for green investment opportunities in financial markets, the current landscape of green finance in the European maritime sector is limited. There are only few green products (green bonds/loans) used by the shipping sector. To support the scaling up of green finance, the challenges related to the lack of definitions of what can be considered 'green', financial risks, low credit ratings and technological uncertainty need to be tackled. The challenges related to financial risks and low credit ratings could be mitigated through credit enhancement measures. The technological uncertainty of climate transition in the sector needs to be minimised, to avoid companies investing in assets that in few years could become stranded. This could be supported through further R&D and demonstration projects on promising technologies and fuels. It is also expected that the EU Taxonomy will provide further clarity on which investments can be considered 'green' to the market participants.

Considering that notably passenger- and offshore ships, as well as other special ships (such as dredgers, cable layers, research vessels), are strong industries with full value chains within Europe, ensuring their access to green finance contributes to strengthening the EU's maritime sector. A comprehensive European approach is more important given that the Asian markets, and particularly the Chinese market, are strengthening their international positions in global supply chains and are growing increasingly dominant in the global shipping sector.

The development of the EU Taxonomy and the corresponding technical screening criteria is an ongoing process. At the time of finalizing this study, the Draft Delegated Act 2020 on climate mitigation and adaptation criteria were being revised based on the feedback received from stakeholders. The EU Taxonomy will be revised on continuous basis through delegated acts to account for new market and technological developments. Criteria for transitional activities are, according to the Taxonomy Regulation, revised at least every three years.

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