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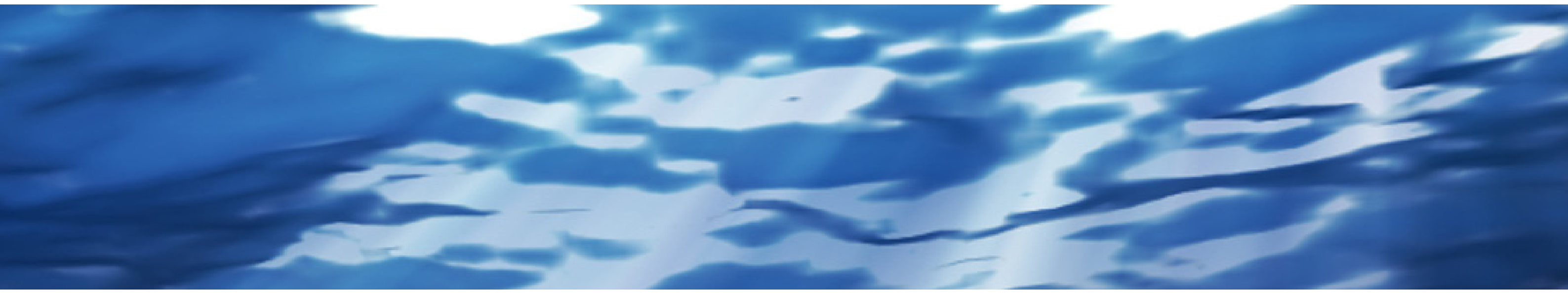

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Including maritime transport in the EU Emission Trading System – addressing design and impacts




En förstudie initierad av Lighthouse

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Including maritime transport in the EU Emission Trading System – addressing design and impacts

The aim of this project is to assess the overall design and consequences of including maritime transports in the EU emission trading system. The included aspects are geographical scope, allocation of allowances, time frame of implementation, as well as impacts on greenhouse gas emissions, economic impacts for the maritime sector as well as on early movers and modal split.

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Summary

This report summarizes the findings of the project "Including maritime transport in th EU Emission Trading System (EU ETS)". The aim of the project is to assess the overa design and consequences of including maritime transports in the EU ETS.

In the literature, there are several design proposals both on global and regional cap-and-trade systems to address the greenhouse gases (GHG) emitted by maritime transports, a few specifically addressing the EU ETS. To our knowledge no published literature on this topic, including the design and the consequences thereof, has based their assessments on the implemented monitoring, reporting and verification (MRV) regulation and the collected data for ships calling a port within the European Economic Area (EEA). At the time of writing of this report, there are no official proposals from the European Commission on the details of a system where shipping is included in the EU ETS. Hence, in this report we discuss and assess a variety of possible designs.

It seems likely that an inclusion of shipping in the EU ETS would be built upon the data and scope of the current MRV system, which is covering the legs of a ship's route before and after a port call to one of EEA's states (option 1). The time for an inclusion is according to our findings expected in 2026 at the earliest. Today the MRV system comprises only CO_2 emissions and an inclusion of other green-house gases, such as nitrous oxide (N_2O) and methane (CH_4), may cause further delays. The emissions of N_2O from ships is small and the CH_4 emissions are mainly associated with LNG-fueled ships, hence it's not likely to be included in an initial phase. The CO_2 emissions captured by MRV was 141 Mtonnes in 2018 and is estimated to grow to approximately 178 Mtonnes by 2026 if no abatement measures are taken. Alternatively, only including emissions from intra-EEA shipping would limit the emission scope, since this in 2018 represented 60 Mtonnes CO_2 which been estimated to reach approximately 75 Mtonnes in 2026 (option 4).

Table 1 Summary of assumptions and results from the impact assessment

Geographical scope		Option 1 (MRV scope)	Option 4 (Intra-EEA)
Time frame of implementation		2026	2026
Emission scope	2018	140 Mtonnes CO_2	60 Mtonnes CO_2
	2026	178 Mtonnes CO_2	75 Mtonnes CO_2
Allocation of allowances		5 % auctioned	5 % auctioned
		100 % auctioned	100 % auctioned
Price of allowances		EUR 25, 50 and 70	EUR 25, 50 and 70
Cost increase for the included shipping sector		0.2 - 12.5 billion Euro	0.09 - 5.2 billion Euro

The costs for the shipping sector will be determined mainly by 1) the price of allowances and 2) if allowances are given for free or if they are auctioned. A case with a price of allowances assumed at EUR 25 per tonne CO_2, and where only 5% of the allowances are auctioned, is estimated to result in an estimated cost increase of 0.2 billion Euro for the included shipping sector, i.e. our lower cost case assessed. The other case, where the price is assumed to be EUR 70, and 100% of allowances are auctioned, would generate an estimated cost increase of 12.5 billion Euro. Assuming the same price level as in the low case (EUR 25) but different levels of auctioned allowances gives a range of 0.2 - 4.4 billion Euro. To set these cost increases into a context, it generates a price increase of between 0.6% and 33% per tonne marine gas oil, assuming a price of EUR 630 per tonne fuel.

For aviation, included in the EU ETS since 2012, the distribution of free allowances is based on the produced transport work (in tonne-km). Since there is a high variation of emissions per unit transport work for different ship types and sizes, the economic impact will accordingly differ greatly if allowances are based on the same unit for the maritime sector. This means that the impact will likely be larger for e.g. RoRo compared to bulk vessels. Further, short sea shipping operating in competition with other modes, may not be able to pass on the additional costs in the same way as e.g. deep-sea shipping. Hence, the design of the system is very important for the actual impact.

How the maritime sector will respond to this price incentive is difficult to predict. Looking at the available data on abatement cost for the sector there are some measures with low or even negative costs, mainly operational, meanwhile technical measures in the shipping sector are estimated to cost more also in comparison to abatement measures in other sectors included in the EU ETS. This indicates that the inclusion of shipping in the EU ETS might not initially be enough to incentivise the implementation of significant abatement measures for the included shipping sector. However, the abatement costs are uncertain and will likely change in the future.

Further research is needed to assess the potential impacts of different design features in more detail.

Sammanfattning

Denna rapport sammanfattar resultaten av projektet "EU:s system för handel med utsläppsrätter och en inkludering av sjöfarten". Syftet med projektet är att utvärdera olika möjliga utformningar och konsekvenserna av dessa vid ett eventuellt införande av sjöfartstransporter i EU:s utsläppshandelssystem (EU ETS).

I litteraturundersökningen som genomförts återfinns ett antal designförslag både på regionala och globala s.k. *cap-and-trade* system för att minska sjöfartens utsläpp av klimatgaser, ett mindre antal fokuserar specifikt på EU ETS. Till vår kännedom är det dock ingen publicerad litteratur, som tar upp både olika utformningar och dess konsekvenser, som utgår ifrån det implementerade systemet för övervakning, rapportering och kontroll (MRV) på EU-nivå och den insamlade data över fartyg som anlöper en hamn i det Europeiska ekonomiska samarbetsområdet (EES). I skrivande stund finns inget officiellt förslag från EU-kommissionen om detaljerna i hur utformningen skulle kunna se ut för sjöfartens inkluderande i EU ETS. Därav, i denna rapport diskuteras och utvärderas ett antal möjliga utformningar.

Det verkar troligt att ett införande av sjöfarten i EU ETS skulle bygga på det nuvarande MRV-systemet, som innefattar den sista fartygsrutten till och den första rutten efter ett hamnanlöp i ett av länderna inom EES (alternativ 1). Tidshorisonten för ett inkluderande är enligt våra resultat tidigast att förväntas år 2026. MRV-systemet innefattar endast data för koldioxid (CO_2). En inkludering av andra växthusgaser, såsom dikväveoxid (N_2O) och metan (CH_4), skulle kunna innebära en fördröjning av införandet och bedöms därför inte som troligt. Dessutom är utsläppen av N_2O från fartyg små och CH_4-utsläppen är främst förknippade med fartyg som drivs på flytande naturgas (LNG). MRV-systemet omfattade 141 miljoner ton CO_2 från sjöfarten år 2018, vilket uppskattas växa till cirka 178 miljoner ton år 2026, om inga reningsåtgärder vidtas. Alternativet att endast inkludera utsläppen från sjöfart inom och mellan EES länderna skulle reducera omfånget av emissioner till att innefatta 60 miljoner ton CO_2 år 2018, och uppskattas att uppgå till cirka 75 miljoner ton år 2026 (alternativ 4).

Tabell 2 Sammanfattning av antaganden och resultat från konsekvensanalysen

Geografisk omfattning		Alternativ 1 (MRV:s omfattning)	Alternativ 4 (Inom EES)
Tid för implementering		2026	2026
Mängd utsläpp som inkluderas	2018	140 Mton CO_2	60 Mton CO_2
	2026	178 MTon CO_2	75 Mton CO_2
Andel auktionering av utsläppsrätter		5 %	5 %
		100 %	100 %
Pris på utsläppsrätter		25, 50 and 70 euro	25, 50 and 70 euro
Kostnadsökning för den inkl. sjöfartssektorn		0, 2 - 12,5 mdr euro	0,09 - 5,2 mdr euro

Kostnaderna för sjöfartssektorn kommer att bestämmas huvudsakligen av 1) priset på utsläppsrätterna och 2) om utsläppsrätter delas ut gratis eller om de auktioneras. Ett fall med ett utsläppspris på 25 euro per ton CO_2, där endast 5% av utsläppsrätterna auktioneras, uppskattas resultera i en kostnadsökning på 0,2 miljoner euro för den inkluderade sjöfartssektorn. I ett annat fall, där priset antas vara 70 euro, och 100% av utsläppsrätterna auktioneras, skulle detta generera en beräknad kostnadsökning på 12,5 miljarder euro. Vid antagande om samma prisnivå som i det lägre fallet (25 euro), men olika nivåer av antalet auktionerade utsläppsrätter erhålls ett intervall av 0, 2 - 4,4 miljarder euro. För att sätta dessa kostnadsökningar i ett sammanhang generera det en prisökning på mellan 0,6 % och 33% per ton marin gasolja, vid en prisnivå på 630 euro per ton bränsle.

För luftfarten, som ingår i EU:s system för utsläppsrätter sedan 2012, baseras fördelningen av fria kvoter av utsläppsrätter på det producerade transportarbetet (i ton-km). Eftersom det finns en stor variation i utsläppen per transportarbete för olika typer och storlekar av fartyg, kommer de ekonomiska konsekvenserna följaktligen att skilja sig åt mellan olika segment om ingen differentiering antas. Detta innebär att påverkan sannolikt blir större för exempelvis RoRo jämfört med bulkfartyg. Vidare kan inte närsjöfarten, som har en större konkurrensyta med andra transportslag, överföra merkostnaderna på samma sätt som t.ex. den transoceana sjöfarten. Därför är systemets utformning viktig för den faktiska påverkan.

Hur den maritima sektorn kommer att reagera på detta incitament är svårt att förutsäga. Om man tittar på tillgängliga uppgifter för kostnaderna att vidta olika åtgärder för att minska utsläppen för sjöfartssektorn, så framgår det att det finns åtgärder med låga eller till och med negativa kostnader, främst operativa medan tekniska åtgärder i sjöfartssektorn beräknas kosta mer, även i jämförelse med åtgärder inom andra sektorer som ingår i EU ETS. Detta tyder på att införandet av sjöfarten i EU ETS, i alla fall inte inledningsvis, skulle vara tillräckligt för att stimulera genomförandet av betydande minskningsåtgärder i den inkluderade sjöfartssektorn. Men kostnaderna för dessa åtgärder är osäkra och kommer sannolikt att förändras i framtiden.

Det behövs ytterligare forskning för att bedöma de potentiella effekterna i mer detalj.

Content

Glossary

Accountable activity: The activity used as a basis for calculating the regulated entity's (e.g. shipowner) liability to surrender allowances. This could e.g. be based on the performed transport work.

Accounting unit: Is the unit that the allowances are based on. In the case of this report and in the EU ETS, it is equal to 1 tonne of CO2-eq.

Allowance: Is an allowance to emit one tonne of CO_2 equivalent during a specified time period.

Carbon leakage: If GHG emissions increase in one jurisdiction as a result of climate policies in another jurisdiction, thereby leading to displacement of production, investment, or energy flows

EEA: The European Economic Area, which consists of the Member States of the EU and the three countries of the EFTA (see below).

EFTA: European Free Trade Association, which of Iceland, Liechtenstein and Norway are part of.

EUA: European Union Allowance (i.e. permit, certificate, unit). Once surrendered it allows to cover 1 tonne of CO2e

EUAA: EUA for Aviation. Same as EUAs but can only be used for compliance in the aviation sectors.

EU ETS: European Union Emissions Trading System

GHG: Greenhouse gas

Installation: An installation means a stationary technical unit where one or more activities listed in Annex I are carried out and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution. (EU 2015/757)

LRF: Linear Reduction Factor is the fixed amount by which the cap of the EU ETS is reduced every year. Will be 2.2% from 2021 onwards.

MSR: Market Stability Reserve is the supply mechanism that makes automatic adjustments to the annual volume of auctions in the EU ETS, depending on the number of allowances in circulation on the market

Operator: The legal entity operating installations or aircraft and who is able to make meaningful operational decisions.

Port of Call: "means the port where a ship stops to load or unload cargo or to embark or disembark passengers; consequently, stops for the sole purposes of refuelling, obtaining supplies, relieving the crew, going into dry-dock or making repairs to the ship and/or its equipment, stops in port because the ship is in need of assistance or in distress, ship-to-ship transfers carried out outside ports, and stops for the sole purpose of taking shelter from adverse weather or rendered necessary by search and rescue activities are excluded". (EU 2015/757, p. 60)

Regulated entity: The legal party responsible for submitting the allowances.

Shipping Company: With the term company the MRV regulations means the shipowner or any other organisation or person, such as the manager or the bareboat charterer, which has assumed the responsibility for the operation of the ship from the shipowner (EU 2015/757).

Stationary installation: Production facilities or part of production facilities such as a power plant, a blast furnace in steelmaking or a refinery. The EU ETS regulates the emissions of installations and sub-installations.

1 Introduction

According to both literature and representatives from the shipping sector, the preferable way to address emissions of greenhouse gases (GHG) from international shipping is to introduce a policy of a global scope[1]. On a global scale the initial IMO strategy is set to reduce annual GHG emissions by at least 50% by the year 2050 compared to 2008. Policy measures on a global scale could include different kinds of market-based instruments, e.g. a global tax on GHG or a global emission trading scheme. The implementation of such policy instruments is a complex issue and not likely to take place in the near future. According to the initial strategy by the IMO (2018), these belong to the long-term measures on the list of anticipated measures, assumed to be finalized and agreed upon by the Committee beyond 2030[2].

Therefore, regional and national policies are under discussion. One of these policies is a regional European emission trading scheme. This project focuses on the possible inclusion of maritime transport GHG emissions in the European Union's emission trading system (EU ETS), with the aim to address design features and estimate impacts of such an inclusion, both on emissions and on the shipping sector. The EU ETS is the main EU instrument for reducing GHG emissions. The need to address these emissions also for the maritime sector was stated in a directive by the EU (EU Directive 2018/410), claiming that action should start from 2023, either by EU or IMO. Also, the Transport and Environment (2019) has argued for an inclusion of maritime transport in the EU ETS to address the climate impact from this sector.

The European Commission with Ursula von der Leyen as the new president released the communication European Green Deal including a new growth strategy with the aim to *"transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy"* and, further, stating that EU will become climate neutral by 2050, i.e. no net emissions of GHG (European Commission 2019, p. 2). One of the specific measures that is proposed to achieve this is to extend the EU ETS to include the maritime sector, and that this will be coordinated with IMO at a global level. A review of EU ETS and the issue of including emissions from the maritime sector, is planned to June 2021 and is a part of a general review of the EU's 2030 climate and energy policy (European Commission 2019).

Further, the European Political Strategy Centre recently published a strategic note with a comment that the inclusion of maritime transport in EU ETS can send a strong signal to other global players, encouraging more ambitious actions within the IMO (EPSC 2019).

Hence, this suggests a high probability that the maritime sector will be included in this market-based instrument. There is therefore a need for more knowledge on how this could be done in practice and what the impacts may be. This project contributes with an initial analysis of how shipping can be included in EU ETS and the consequences thereof. This has been conducted through a literature review and an analysis of different

1 Today there is the Energy Efficiency Design Index (EEDI) on a global level, implemented via IMO (MARPOL) which set energy efficiency targets, however, only for new built ships (IMO 2020).

2 Dates of entry into force and when the measure can effectively start to reduce GHG emissions would be defined for each measure individually. (IMO 2018, p. 6 in Annex 11)

proposals as well as by personal communication to relevant stakeholders and policymakers.

2 Overview of the development of EU ETS

The EU ETS is described by the EU Commission as the cornerstone of the EU climate policy. Its objective is to promote greenhouse gas emissions reductions in a cost-effective and economically efficient manner (European Commission 2020a).

The EU ETS entered into force in 2005 and works as a "cap-and-trade" system, which is a market-based instrument aiming to reduce of GHG emissions in a cost-effective way by putting a price on CO_2 released and at the same time adding a cap of all emission from included sectors.

In the EU ETS, emissions are monitored, reported and verified as tonnes of CO_2-equivalent. For every tonne of CO_2-eq released, a certificate (i.e. allowance) needs to be surrendered (i.e. submitted) to the regulator[3]. The total number of allowances is capped and will be reduced annually by a fixed number. Allowances then need to be allocated to the companies that need them; this is done through a combination of auctioning and free allocation. The latter means that all allowances are distributed to the operators for free, based on e.g. some kind of benchmark or by historical production levels. In addition, companies (but also other actors who want to participate in the carbon market, e.g. investors or banks) can trade allowances. Companies therefore have a choice to acquire allowances and surrender them to account for their emissions, or to reduce emissions so that fewer allowances have to be acquired. Alternatively, reducing emissions also allows a company to sell previously acquired allowances at the current secondary market price, thereby raising revenues.

The EU ETS regulates the greenhouse gas emissions from about 12 000 stationary installations[4] for steel and other metals, cement and stone, pulp- and paper, energy, refineries and, from 2012, aircraft operators in the countries of the European Economic Area (the 27 EU member states, Norway, Iceland, Liechtenstein and until at least the end of 2020 the UK). In 2018, it covered about 40% of the total greenhouse gas emissions in the EU. This share is trending downwards (it was around 45% in 2008) as ETS sectors are required to reduce emissions at a faster pace than non-ETS sectors.

Further, the EU ETS has been divided into trading periods which are generally (though not as a rule) marked by an update of the scope and regulations concerning e.g. allocation. The first trading period took place between 2005 and 2007 and was a pilot phase to acquaint operators and regulators with the new policy instrument. This was a stand-alone phase with separate allocation rules based primarily on free allocation and no banking (i.e. it was not possible to transfer allowances from one trading phase to another, thus making it a separate phase) of allowances to subsequent trading periods. As a result of excess supply in the market and no banking, the ETS price dropped to zero in 2007. From 2008 onwards, allowances can be banked to following trading periods.

[3] In Sweden, it is the Environmental Protection Agency that issues permits, allocates allowances and is the authority to which Swedish participants report their emissions.
[4] An industrial production facility - industrial sites can have multiple of these installations and they are sometimes divided into smaller sub-installations.

The second trading period from 2008 to 2012 was aligned with the EU's compliance obligation under the Kyoto Protocol's first commitment period. The EU's commitment was to reduce greenhouse gas emissions by 8% below the 1990 levels. About 90% of all allowances were allocated for free. Allocation was decentralised to member states, who drafted their own national allocation plans. This decentralised allocation model resulted in an element of unintended incentives, since many member states, in an attempt to safeguard domestic competitiveness, were overly generous in allocating free allowances leading to the build-up of a surplus in the system.

The third trading phase (2013-2020) was in principle aligned with the second Kyoto Protocol commitment period although the entry into force of the Paris Agreement superseded this in political terms. Allocation rules were significantly adjusted: the power sector no longer received free allocation, with the aim of limiting 'windfall profits[5]', while the cap was also strengthened and set to decline by a fixed amount annually. The annual reduction of the cap is called the "linear reduction factor". It removes fixed percentage (1.74% between 2013 and 2020 and 2.2% from 2021 onwards) of the average cap between 2008-12 from the allowance supply. In practice, this amounts to an annual reduction of 38 million tonnes up to 2020 and 48 million tonnes from 2021 onwards, during phase 4.

Since the start of the EU ETS, emissions in the included sectors declined more rapidly than the cap. Between 2005 and 2018, EU ETS emissions declined by 29% while the target is 21% reduction by 2020. However, the fact that emissions declined does not necessarily imply that they declined *because* of the ETS price signal. In fact, other policies addressing introduction of renewables and energy efficiency or retirement of national coal-fired power generation may contribute to emissions reductions. Such policy interactions can however lead to demand and supply of allowances diverging more than expected.

The build-up of surplus allowances from 2008 onwards led to a fall in the carbon price from nearly 30 EUR per tonne CO_2-eq. in 2008 to less than EUR 5 per tonne five years later. This low price was sustained until the end of 2018[6]. This decline was also caused by the rigidity of the allocation system. Free allocation was based on higher historical production levels, but economic output was subject to severe volatility due to the economic crisis. This low price failed to provide sufficient incentives for innovation and deployment of low carbon technologies.

In response to this continued imbalance, some supply management interventions were passed by the EU legislators: 'backloading' in 2012 and the market stability reserve (MSR) in 2015. Both these supply-side measures result in changes to the auction volume, with the possibility of later returning (or invalidating) the allowances to the market. The MSR does so automatically based on pre-determined parameters (EU Decision 2015/1814 and Directive 2003/87/EC). With the Market Stability Reserve, a fixed number of allowances are withheld from auctions every year, as long as the surplus in the market exceeds a politically determined. Up to 2023, 24% of the surplus will be removed from auctions every year. After 2023, this will be reduced to 12%.

5 Windfall profits are profits that are substantial in size and unexpected due to unforeseen circumstances.
6 EUA prices can be tracked via EEX https://www.eex.com/en/market-data/environmental-markets/spot-market/european-emission-allowances

Seen in a historic perspective of the development of the EU ETS, the inclusion of aviation in 2012 is the most important comparison for the maritime sector. This since GHG emissions from aviation and maritime transports both continue to rise and, further, the international character of these transport modes has been one of the reasons for excluding them from climate policy before.

The European Commission proposed a Directive to include aviation on 20 Dec 2006 (COM(2006) 818 final). This Directive was adopted on 19 November 2008 as Directive 2008/101/EC. The co-decision process thus took just under two years, while the time from EC proposal to the inclusion of aviation in the ETS in 2012 was just over 5 years.

The case of including aviation is also different from other scope extensions of the EU ETS, as a semi-parallel system applies to aviation. This means it has a separate class of allowances and different allocation methodology, based on transport work (tonne-km), see more in section 3.4. The separate class of allowances for aviation, so called European Aviation Allowances (EUAA), are used primarily for free allocation. In 2012 when aviation was first included in the ETS the plan was to allocate 82% of allowances for free, which would then be reduced in subsequent years. In 2018, about 32 million aviation allowances were allocated for free while 5.6 million were auctioned. As total aviation emissions were 67 million tonnes, just under 30 million regular allowances had to be bought by airlines (roughly equivalent to the emissions of the largest German power plant). While airlines can (and indeed must) use regular allowances (EUAs) for compliance the reverse is not possible: EUAAs are exclusively for use by airlines' ETS compliance.

Extension of the scope of the system has happened before, both in the case of sectors and countries. Since its launch in 2005, three member states have joined the EU and the ETS: Romania and Bulgaria in 2007, and Croatia in 2013. In these cases, the cap of the ETS was recalibrated to reflect the emissions from these countries. Pending the expiry of the Brexit transition phase, and in the absence of a new EU-UK agreement on emissions trading, the ETS cap will also be reduced at the end of 2020 to reflect the UK's withdrawal from the EU. Since 2008, the ETS also applies to Iceland, Liechtenstein, and Norway, i.e. the three countries of the European Free Trade Association (EFTA) that are not members of the EU. All the member states of the EU and the EFTA countries are part of the agreement on the European Economic Area (EEA).

In terms of sectors, from 2013 onwards certain energy-intensive industries were added to the EU's carbon market, including aluminium and petrochemical industries and various sectors emitting nitrous oxide.

3 Design options for including shipping in EU ETS

In the literature there are several proposals on how an emission trading scheme for maritime transports could be designed, including both international and regional schemes. Since our scope is the EU ETS, we focus on the regional alternatives and the pros and cons with these. Before going into the different design elements a description of the shipping EU MRV regulation (Monitoring, Reporting and Verification system) will be presented, since it has recently entered into force (first available data was released in July 2019) and is likely to be the basis for including shipping in the ETS according to European Commission (2020b). To our knowledge no published literature on assessing the impacts of an emission trading schemes for maritime transport has includes these data.

3.1 Monitoring, Reporting and Verification system

The Monitoring, Reporting and Verifying (MRV) system for shipping is an EU regulation (EU Regulation 2015/757). It requires shipowners and operators to annually monitor, report and verify CO_2 emissions from their ships. All ships larger than 5 000 GT sailing within or arriving at or departing from ports in EEA are included. All internal EEA voyages, all incoming voyages from the last non-EEA port to the first EEA port of call, and all outgoing voyages from an EEA port to the next non-EEA port of call, including ballast voyages, should be included in the reported data. CO_2 emissions in EU ports, including emissions from ships at berth or moving within a port, are also covered. The MRV regulation applies to all ships regardless of flag. However, dredging vessels, ice-breaking vessels, pipe laying or offshore installation activity vessels are not included. Vessels also exempted from the regulation are warships, naval auxiliaries, fish-catching or fish-processing ships, wooden ships of a primitive build, ships not propelled by mechanical means or government ships used for non-commercial purposes (EU regulation 2015/757). The ships above 5 000 GT account for about 90% of the emissions from maritime transport in the EU (EU regulation 2015/757).

The reporting includes data on each ship's CO_2 emission, fuel consumption and other parameters, such as distance, time spent at sea and cargo carried. These data are collected in order to determine the ships' average energy efficiency. The data are published by EMSA for each individual ship. The first data available are for the year 2018 and were published 2019-07-01.

The responsible entity for complying with the MRV regulation is the company, which is defined as follows:

"*'company' means the shipowner or any other organisation or person, such as the manager or the bareboat charterer, which has assumed the responsibility for the operation of the ship from the shipowner.*" (EU 2015/757, p. 3)

The content of the data is discussed further in section 3.3, and for an in-depth description of the MRV data see Fridell et al. (2018).

In addition to the MRV system, a parallel system on a global level is enforced, called the IMO Data Collection System (DCS). The DCS focus on fuel consumption on ships above 5 000 GT, and the data collection started on the 1st of January 2019. While the

MRV system is open access, the DCS will be kept confidential. The differences in reported data is presented in the Table 3 below.

Table 3 Reporting details in EU MRV vs IMO DCS

Data collecting system	MRV	DCS
Included ships	Ships > 5 000 GT calling any EEA ports	Ships ≥ 5 000 GT trading globally
Fuel consumption	Amount and *emission factor* for each type of fuel consumed in total	Amount of each type of fuel consumed in total
Emissions	Total CO_2 emitted and additionally differentiated to aggregated CO_2 emitted - Voyages to and from EEA ports - Voyages between EEA ports - At berth	-
Distance and transport work	Total transport work - Time at sea and in port - Cargo carried	Distance travelled Hours underway under own propulsion Dead weight tonnage (DWT) to be used as cargo proxy
Energy efficiency	Average energy efficiency	-

Reference: DNV GL (2020), and authors edits.

3.2 Geographical scope and regulated entity

In this section we give an overview of the different varieties of geographical scopes found in the literature review, as well as suggestions on whom should be the regulated entity, i.e. the one responsible for surrendering allowances and what to be the accountable activity, i.e. the activity used as a basis for calculating the shipowner's liability to surrender allowances.

Geographical scope

One of the issues in designing an emission trading scheme for maritime transport is the geographical coverage and the possibility to include emissions from international shipping in a regional scheme. Several different proposals have been suggested in the literature (e.g. Kågeson 2011; Faber et al. 2010; Kollamthodi et al. 2013; Heine et al. 2017; Dominioni et al. 2018; Gu et al. 2019), and by the time of writing there is no official proposal from the European Commission on how to include shipping in EU ETS[7]. We will elaborate on the following four different theoretical approaches presented in the literature:

1. To include the emissions released on all internal EEA voyages, all incoming voyages from the last non-EEA port to the first EEA port of call, and all outgoing voyages from an EEA port to the next non-EEA port of call (as in the

[7] Personal communication with representatives from European Parliament, stating that there is no specified policy instrument design for the shipping sector until the ongoing impact assessment of the Commission is finalised. 2020-02-07. As well as with representatives from the Swedish Transport Agency, stating the same (2020-04-02).

EU MRV system). In the literature sometimes referred to as emissions in first and last route. The shipowner is the regulated entity (or company as defined by the MRV regulations[8]).
2. To include the emissions released during a set time period. The shipowner is the regulated entity.
3. To include the released emissions from a whole route to an EEA port. The transport buyer is the regulated entity.
4. To only include emissions released within EEA's territorial waters. The shipowner is the regulated entity.

In option number 1, the geographical scope includes the emissions released during a ship's voyage from the last port of call to an EEA port of call, as well as from an EEA port of call to the next port of call. It also includes the emissions within the regulated port. The advantage with this is that it's in line with what the current MRV system is covering today, see section 3.1. Hence, it would facilitate the monitoring and reporting, and already reported data could constitute a base if a benchmark is to be set for allocation of allowances. Two cons with this approach, are that the scope of emissions covered is probably more limited than in the other options (however, it is a larger scope compared to option 4) and, that there are several potential avoidance strategies for shipowners (Heine et al. 2017; Dominioni et al. 2018; Gu et al. 2019). The avoidance strategies suggested are e.g.:

- To underreport sailed distance via transshipment or falsification of documents.
- Change the port of call during the route
- Reduce speed during the route covered by the scheme and compensate it by increasing the speed outside of the covered route.

However, the first two are addressed by the MRV system, at least concerning transshipment and the change of port. The first since the definition of a port of call in the shipping MRV regulation (p. 60) states that a *"'port of call' means the port where a ship stops to load or unload cargo or to embark or disembark passengers; consequently, stops for the sole purposes of refuelling, obtaining supplies, relieving the crew, going into dry-dock or making repairs to the ship and/or its equipment, stops in port because the ship is in need of assistance or in distress, ship-to-ship transfers carried out outside ports, and stops for the sole purpose of taking shelter from adverse weather or rendered necessary by search and rescue activities are excluded"*. The second since the reporting is based on annual basis and should be verified by an accredited verifier. Concerning the third bullet-point an operational change that outweigh the benefit of reducing the speed does not seem to have empirical evidence, at least not based on the experience from the previous introduction of Emission Control Areas for sulphur, according to Dominioni et al. (2018).

Option number 2 shows that, if instead emissions related to shipping during a set time period would be the selected design, it could open up for a larger coverage of shipping related emissions. This means that e.g. the emissions related to the ship's voyages during a certain time before and after the ship has called a port are included in the ETS. In the literature there are suggestion on time frames from a few days to several months, and the

[8] "'company' means the shipowner or any other organisation or person, such as the manager or the bareboat charterer, which has assumed the responsibility for the operation of the ship from the shipowner;" EU 2015/757, p. 60.

coverage of emissions would increase the longer the time period is set. However, the MRV system do not contain these data in its present form, and another system for data collection needs to be established.

Option number 3 suggests instead that the emissions released from the whole route to and from the port of call should be addressed in the scheme, independent of the time period and number of stops along the ship's route (option 3). The difference between this third option, and the first is that for different segments the number of stops along a whole route varies, e.g. there are more stops (port of calls) for container and general cargo vessels along the route compared to bulk vessels that often provide a service between just two ports. Hence, in the first option only the last/first voyage to/from an EEA port is included, meanwhile in this option all the stops along the whole route to/from an EEA (or EU) port is included.

This approach places the transport-buyer as the regulated entity. In e.g. Heine and Gäde (2018) and Dominioni et al. (2018) they argue that the cargo destined to or from the regulated port should be the accounting activity. This requires data on tonne-kilometre and a way of allocating the emissions per tonne-kilometre for each respective transport-buyer. Data on tonne-kilometres are covered by the MRV system for shipping, but not on the whole route as is needed in this approach. For data on the amount of cargo, this could be obtained via the bill of lading[9]. The need to complement the available MRV data would involve additional legal work, hence the legal compliance might be complex for this approach. Dominioni et al. (2018) argues that since the transport-buyer (or more specifically the consignor or consignee) would be the responsible entity and the cargo the accountable unit, this could facilitate the legal aspect since the importer or exporter to/from EU must be entities incorporated in the EU.

Option number 4, to only include emissions from shipping released within the territorial waters of EU member states would cover the least emissions (option 4). However, in the literature the geographical scope varies between including only territorial waters and including also the exclusive economic zone which would give a much greater coverage, 12 and 200 nautical miles from the baseline of a coastal state, respectively (Miola et al. 2011; Gu et al. 2019). A parallel can be drawn to aviation for which the initial intention was to include flights entering and leaving EEA airports, but in the end included only flights within the EEA. This was the result from a strong debate based on the competitive conditions for the industry. This option would be the most feasible from a legal perspective, since, according to the territoriality principle, a state's jurisdiction covers activities that take place within its territory (although the exclusive economic zone might be a more complex issue).

If activities occurring outside of the state's territory are to be regulated, like international shipping in this case, they can under general international law be based on the following principles:

"i) the nationality principle, which implies that states can prescribe laws regarding those of their nationals who are abroad; ii) the protective principle, which permits states to legislate on conduct that threatens their primary interests (e.g. security); iii) the

[9] A private commercial document over the cargo onboard the ship, as well as the date and place the cargo was shipped, often required by the customs authority to calculate e.g. import fees. (Faber et al. 2009)

universality principle, which allows actions aimed to counter extremely serious crimes such as genocide and war crimes; and iv) the effects principle, which poses that a state has jurisdiction over acts that take place outside its territory that have an impact within the state." (Dominioni et al. 2018, p. 6).

The literature review concerning the different ways of establishing jurisdiction of the shipping related emissions outside of the EU member states territory is inconclusive. Dominioni et al. (2018) states that all the options listed above are contested, but since jurisdiction can be based on the territoriality principle a coverage of EU territorial water would be of less controversy than addressing emissions on international or other countries' waters. And concerning the General Agreement on Tariffs and Trade (GATT)[10] principle on equal conditions of competition between imported and non-imported products, this principle does not seem to be an issue as long as the pricing scheme covers also the domestic transports. Further, Dominioni et al (2018) conclude that in a historical perspective actions on a regional level has been a driver for the expansion of individual states' jurisdiction under maritime law.

Regulated entity and accountable activity

Another design feature linked to the geographical scope is whom to be the regulated entity, meaning the one responsible for surrendering allowances (for instance the shipowner), as well as what should be the accountable activity, meaning the activity used as a basis for calculating the ship owner's liability to surrender allowances (for instance transport work). The accountable unit should be GHG emissions, and the emissions can be calculated based on an accountable activity multiplied with a benchmark, as for the aviation sector explained in section 3.4. These features are important for mitigating the risk of carbon leakage, i.e. that a business transfers its production or services to other countries or regions, to avoid additional costs related to climate policies. Due to this reason, e.g. Dominioni et al. (2018) argues that a fuel supplier should not be the regulated entity, since maritime fuel has a high cross-price elasticity, meaning there is a high risk of refuelling outside of the region if implementing a stricter climate policy such as EU ETS. Instead two other options are suggested: the shipowner or the transport-buyer (consignee/consignor). The most common suggestion in the literature is that that the shipowner (or operator) is the regulated entity, while the ship (e.g. vessel-kilometre) or a ship-related activity (such as fuel use or tonne-kilometre) should be the accountable activity (e.g. Kågeson 2011; Kachi et al. 2019; Gu et al. 2019). If instead the cargo would be the accountable activity, the transport-buyer would then be the regulated entity (Heine et al. 2017; Dominioni et al. 2018). One guiding principle can be to target the actor who has the power to make a change of the activity, and for administrative ease it would also be beneficial to use the same actor as in the MRV system, hence the shipowner or operator.

3.3 Emission scope

In this section we address the potential scope of emissions included from maritime transports. First, we address the different GHGs, and second the types of vessels to include.

10 General Agreement on Tariffs and Trade, one of the three main agreements of World Trade Organization (WTO)

Greenhouse gases to include

The EU ETS covers six greenhouse gases (see Annex II of the latest, consolidated version of the EU ETS Directive 2003/87/EC). Besides carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4), three fluorinated gases (HFC, PFC, and SF6) are included. The gases are included to the extent that they occur from the activities explicitly covered by the EU ETS Directive (see Annex I of the Directive). There are further rules on the measurement of greenhouse gases, including specific guidance on how to measure N_2O and fluorinated gases. Non-CO_2 greenhouse gases need to be reported in CO_2-equivalents, based on their global warming potential (GWP100) values[11].

For maritime transports, marine engines give rise to direct GHG emissions of carbon dioxide, nitrous oxide and methane, the latter mainly from the use of liquefied natural gas (LNG) as fuel. There are also emissions of black carbon (black particles found in smoke which contribute to climate change) from ship exhausts. However, black carbon is not included in the EU ETS. The global GHG emissions from shipping is presented in Table 4. The share of different GHGs from a 20 and 100-year GWP perspective is presented in Table 5. The total global shipping related CO_2 emissions amounted to 932 Mtonnes in 2015. Container ships represented 23%, bulk carriers 19 %, and oil tankers 13 % (Olmer et al., 2017). The total GHG emissions from shipping in 2015 is estimated to about 1 025 Mtonnes CO_2-eq (971 Mtonnes without black carbon) using GWP over a 100-year time scale and 1 222 Mtonnes CO_2-eq (954 Mtonnes without black carbon) using a 20-year time scale (Olmer et al., 2017). Thus, CO_2 emissions represent the major climate impact from shipping. In case of continued increased use of LNG, the methane emissions might increase.

Table 4 Estimates of global GHG emissions from maritime transports. In addition, ships emitted globally approximately 53-80 kton of black carbon in 2015 (Comer et al, 2017).

	Third IMO Greenhouse Gas Study 2014 (Smith et al., 2015) Year 2012	Greenhouse gas emissions from global shipping, 2013–2015. (Olmer et al., 2017) Year 2015
CO_2 emissions	942 Mtonnes of which • 805 Mtonnes from international shipping, • 86 Mtonnes from domestic shipping, and • 51 Mtonnes from fishing	932 Mtonnes of which • 812 Mtonnes from international shipping, • 78 Mtonnes from domestic shipping and • 42 Mtonnes from fishing
CH_4 emissions	Approximately 290 ktonnes	Approximately 363 ktonnes
N_2O emissions	Approximately 42 ktonnes	Approximately 46 ktonnes
Projected increase in CO_2 emissions	50-250% by 2050, depending on climate policy and economic development. *	-

11 See Commission Implementing Regulation (EU) 2018/2066. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.334.01.0001.01.ENG. GWP10 is based on the IPCC 4th Assessment report: https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf, Table 2.14, p. 212.

* Another report by CE Delft (2019) projects an increase by 20-50% by 2050 compared to 2008 levels, depending on economic developments. Thus, a narrower span compared to Smith et al (2015).

Table 5 The share of different GHGs of total GHG emissions in CO_2-eq in 2015 in a 20-year and 100-year GWP perspective.

	GWP 20	GWP 100
CO_2	76%	91%
N_2O	1%	1%
CH_4	2%	<1%
Black carbon	21%	7%

Reference: Olmer et al. 2017.

According to the MRV system the total CO_2 emissions from shipping reported were estimated at 141 Mtonnes CO_2 in 2018, of which 60 Mtonnes were from ships in EEA ports and between EEA ports (intra-EEA shipping). The CO_2 emissions from a specific ship depends on the size of the ship, load, propulsion system including fuel used and speed, and other operational measures.

Notably, no specific guidance is given for how to account for methane (CH_4) emissions in the EU ETS. This does not necessarily mean that they do not have to be accounted for, but rather that it is up to operators to determine CO_2-eq from methane. It can also be an indication that methane emissions from current ETS activities are rare. Indeed, in the EU ETS Handbook CO_2, N_2O and PFCs are covered for selected industry sectors, thereby leaving out methane (European Commission 2015). Nevertheless, the EU ETS legislation covers all six greenhouse gases. Therefore, should a sector be included that emits any of these greenhouse gases, allowances would need to be surrendered for them on the basis of their CO_2-eq if they are not exempted for any approved reason.

Although exceptions can be made to exclude non-CO_2 gases for a given sector, the starting point is that all the included GHG gases should be covered. Thus, the starting point for the maritime sector is therefore that all greenhouse gases from its activities would have to be accounted for and subject to surrendering allowances. An existing exception, mentioned previously, is emissions of black carbon that are not included in the EU ETS system as it is strictly speaking not a greenhouse 'gas'. In addition, neither the current EU MRV Regulation for the maritime sector nor the IMO's Data Collection System cover all greenhouse gases for now, instead both focus on CO_2 and fuel consumption. An inclusion of the maritime sector into the EU ETS may therefore require that MRV rules with regard to non-CO_2 greenhouse gases from shipping are developed. However, due to the current lack of collected emission data for methane, it is uncertain if these emissions will be included for shipping from the start.

As a frame of reference, it should be noted that even if all emissions from international and domestic shipping at about 890 million tonnes of CO_2 in 2015 (Omer et al., 2017) were included in the EU ETS, there are at current still larger ETS sectors (the power sector corresponds to about 900 million tonnes).

The total CO_2 emissions from shipping in the EEA area was 141 million tonnes in 2018 according to the MRV system. This equals approximately 8% of total EU ETS emissions in 2018. This would make it the 3rd largest individual ETS sector (as defined by NACE codes[12]), after power and steel sector, roughly comparable with the size of the oil refining sector. If comparing with the ETS emissions of member states, the maritime sector is larger than all but three member states; emissions are equal to Italy's ETS emissions in 2018, but below those of Poland and Germany, to give two examples.

Potential of measuring other GHGs that are included in the EU ETS directive

CH_4 and N_2O from shipping are not covered by the MRV database for maritime transport and these emissions are not reported today. In order to estimate these emissions, an emission factor needs to be used. In the current EU ETS there are no emissions factors for methane included but there are specific monitoring rules for different emissions for the activities covered including also N_2O (European Commission, 2018).

It would be possible to add CH_4 emissions by assigning emissions factors for methane related to fuel consumption for different fuel and engine type combinations. Since methane emissions is mainly an issue for engines using LNG, or corresponding biogas, restrictions are most relevant for LNG driven ships. Further, LNG engines of different types show distinctively different emissions (Sternersen and Thonstad 2017). Ship specific emission factors from measurements on individual engines can replace the default factors for ships. N_2O emissions are small from ship engines but if required the emissions could be included by applying emission factors related to the fuel consumed. Inclusion of other substances than CO_2 may cause delays to the inclusion of shipping in EU ETS.

Up-stream emissions

Up-stream emissions are not covered by the MRV system. In the EU ETS the direct emissions of each included stationary activity is covered, while the emissions from up-stream activities such as extraction, production and transport of fossil fuels used in the key stationary activities are not included as separate activities. For the activity combustion of natural gas this means that only tailpipe CO_2 emissions are considered, and not the substantial part emitted in extraction (Winebrake et al. 2019). However, due to the risk of carbon leakage, free allocation is given to e.g. the sectors “extraction of natural gas” and “extraction of crude petroleum" but as mentioned above, only for the direct emissions that take place within the sector due to the combustion of fuels. Methane leakage is not a direct result of fuel combustion when extracting either oil or natural gas and is therefore not included in the ETS (which is based on activities, not sectors as a whole). The free allocation is therefore limited and not taking methane into consideration.

Contribution to total emissions from up-stream emissions as well as the non-CO_2 GHG, CH_4 and N_2O for selected marine fuels are presented in Table 6, using data from Brynolf et al. (2014). The exact data will depend mainly on how the electricity that is used is produced. The example in Table 6 is based on European electric mix. Other factors that impact the upstream emissions are place of production and, raw material used, however, this gives an indication using the base case data in Brynolf et al. (2014). As can be seen,

12 NACE codes are part of a classification system used in the EU to classify different economic sectors and sub-sectors. See: https://ec.europa.eu/competition/mergers/cases/index/nace_all.html

when taking into account other GHGs this has a limited effect for CO_2-eq for conventional, fossil fuel oil but is significant for LNG and LBG.

Table 6 Impact of upstream emissions of CO_2 and other greenhouse gases. TtP = tank to propeller; WtT = well to tank. CO_2-eq includes carbon dioxide, methane and nitrous oxide.

Fuel	TtP CO_2 (fossil) (g/MJ)	TtP CO_{2eq} (g/MJ)	WtT CO_2 (fossil) (g/MJ)	WtT CO_{2eq} (g/MJ)
Heavy fuel oil (HFO)	77	78	6.7	8.6
Liquefied Natural gas (LNG)	54	72	8.3	9.2
Methanol (from natural gas)	69	69	20	20.4
Liquefied biogas (LBG)	0	20	27	32
Bio-methanol	0	0	17	18

References: Brynolf et al. (2014); Fridell et al. (2018)

Emission scope - types of vessels to include

Certain small emitters may be excluded from the EU ETS. The activity list of Annex I of the EU ETS Directive lists certain quantitative thresholds below which emitters and activities need not be included[13]. The main threshold for the common activity of combustion of fuels in stationary installations is that the rated thermal input should exceed 20 MW. Some of the industrial activities included also have output thresholds, e.g. paper production should exceed 20 tonnes a day. For aviation, some flights can be excluded based on the purpose or size. Some examples are in the case of official government travel, in the case of public service obligation flights, military and police flights, training flights, and flights related to search and rescue etc, or if the take-off mass is less than 5 700 kg.

In addition, any stationary combustion installation that emits less than 25 000 tonnes of CO_2-eq annually may be excluded by a member state[14]. Furthermore, any stationary installation emitting less than 2 500 tonnes of CO_2-eq per year may also be excluded by member states (Art 27a).

Hence, for maritime transport there will most likely be exceptions to the kinds of ships that are to be included in the EU ETS. Kågeson (2011) suggests a threshold including only ships larger than 400 GT, which is the size of vessels that need to comply with MARPOL. However, he states that for keeping transactions cost low, a limit of ships of

[13] See Annex I of Directive 2003/87/EC as consolidated

[14] Provided they notify the Commission (Art 27 ETS Directive) and apply equivalent measures.

5 000 GT might be more suitable. The latter is also in line with the ships included in the MRV database.

3.4 Allocation of allowances

The allocation principle of allowances for the maritime sector is uncertain and there are basically two main choices: auctioning and free allocation. In principle, auctioning is the main method of allocation in the EU ETS, with free allocation being intended as a transitional method and as a measure to decrease the risk of carbon leakage. However, before 2013, free allocation was applied to all sectors and based on historical emissions levels, so called grandfathering.

In the case of stationary installations, the main rule is that the power sector must acquire all their allowances through the market (i.e. from auctions or secondary trading). For aviation, the allocation is partly based on free allocation and partly based on auctioning. The free allocation is based on transport work benchmarks, described more below.

In order to prevent industrial production in the EU from moving outside the EU, so called carbon leakage, a share of the total number of allowances (currently 43%) are allocated for free to carbon intensive firms that are exposed to international competition. In practice, 94% of energy-intensive industrial (the power-sector exempted) ETS emissions are covered by this type of free allocation.

Free allocation to sectors at risk of carbon leakage is based on benchmarking. The allocation is based on an activity level (for instance tonnes of steel produced) times a benchmark (tonnes of CO_2 per tonnes of steel). This should ensure that installations with higher carbon-efficiency receive more free allowances than those that are less carbon-efficient. Besides efficiency benchmarks, historical production levels as well as the total quantity of free allowances available, determine the final amount of free allowances given to individual plants and operators. The benchmarks are set as the average of the 10% most efficient installations in the sector.

For aviation, free allocation is also based on a benchmark, but one that is defined by transport work measured as 'tonne-kilometres'. Tonne-kilometres are calculated from the combined total number of passengers and tonnes of freight, multiplied by the number of kilometres travelled. For every 1000 tonne-kilometres, 0.64 EUAA's are allocated. The total volume of free allocation to the aviation sector is determined by the legislator and then divided by the sum of tonne-kilometres to arrive at the benchmark value (see Art 3e(3) Directive 2003/87/EC).

For shipping, and to ensure that ships with a relatively high carbon-efficiency receives more free allocation, it seems reasonable that there are different benchmarks (potentially tonnes of CO_2 emissions per tonne-kilometre) for different ship types. As can be seen in Table 7, the emissions of CO_2 per transport work varies considerably between ship types.

Table 7 Emissions reported in the MRV for different shipping segments[15]

Ship type	Emissions total	Emissions within EEA	Emissions per distance (median)	Emissions per transport work (median)
	Mtonnes CO_2	Mtonnes CO_2	kg CO_2 / NM	g CO_2/tonne-NM
Bulk	18.1	2.93	290	8.48
Container	44.4	13.1	570	20.13
General Cargo	6.13	4.64	185	28.02
Oil Tanker	18.1	4.46	435	8.82
RoRo	6.06	4.51	338	91.03

3.5 Time frame

Extending the EU ETS to cover maritime emissions requires revising the EU ETS Directive. This needs to be done through the EU's ordinary legislative procedure (co-decision), where, as a first step, the European Commission presents a legislative proposal together with an impact assessment. It is then up to the Council of Ministers and the European Parliament – as co-legislators – to agree on a final legislation. This process generally takes around two years to complete, although it is possible to do this quicker if the scope of the legislative proposals is limited.

A proposal to include maritime emissions or in general extend the ETS to other sectors would probably be part of a larger reform of the EU ETS. This decreases the chance of a limited proposal that can be passed quickly. In the Annex to the European Green Deal, the Commission indicates a plan to propose revisions of the main elements of the 2030 climate and energy framework – including the EU ETS – by the summer of 2021. Should a maritime extension proposal indeed be combined with other climate policy and ETS issues, a more complicated negotiation including aspects of industrial competitiveness and carbon leakage risk, becomes likely.

One option if a rapid timeline for maritime inclusion is desired would be to include the sector from 2026 onwards. This would allow for a regular co-decision process to be completed, i.e. it requires consensus to be reached between the Council and the Parliament for legislation to be adopted, together with an implementation period to draft a sector-specific rulebook. It would then align with the second half of the 4th ETS trading phase, where a number of updated allocation rules for the stationary sectors will take effect.

Should more time be needed, the start of the 5th trading phase in 2031 would be an option. This would allow for more time to develop new implementing legislation and potentially for more alignment with IMO developments. It should be noted, however, that there is no legal impediment to other starting dates; this is up to the legislator. In the case of aviation, the sector was included from 2012 onwards, in the final year of the 2nd

15 There is also a large range of between vessels within the same categories. The differences are due to both real differences between e.g. vessel sizes but also poor data quality. The data quality will probably improve over time.

trading period. The high share of dedicated aviation allowances allocated for free may have facilitated this, i.e. being a semi-parallel system.

4 Impacts of including shipping in EU ETS

As described in the previous chapter there are several ways of including maritime transport in the current EU ETS. At the time of conducting this project, there is no official proposal on how this could be done, hence, to be able to make a rough assessment of potential impacts we need to make some assumptions. The main assumptions concerning the design are the following:

- Geographical scope is assumed to be based on the MRV system, i.e. including the ship movement from the last port of call, via the port within the EEA, to the next port of call. As a second option, a more limited geographical scope would be to only include ship movements within the EU (as the case of aviation today). These are described as options 1 and 4 in 3.2.
- Emission scope is set to only include CO_2 emissions. If the first/last route approach will be used and assuming the same limit for ship size as in the MRV system, i.e. ships above 5 000 GT, the system will cover about 141 Mtonnes CO_2 in 2018. This corresponds to approximately 15% of the total global CO_2 emissions from shipping. With an assumed growth of the maritime sector of 3.4 %, shipping would generate 178 Mtonnes by 2026, everything else equal. In a case including only the emissions from shipping in EEA ports and between EEA ports (intra-EEA shipping) the current CO_2 emissions amounts to 60 Mtonnes, growing to 74 tonnes in 2026 when using the same assumptions.
- Allocation is assumed using two options: either 5% of allowances are auctioned or 100% are auctioned. These two assumptions are motivated to generate a low and a high cost case. The reason for not assuming 100% free allocation in the low case is due to that the EU Commission in its Green Deal has indicated that it should be a reduced number of free allowances in the future in the EU ETS.
- Cap is assumed to be adjusted upward to reflect the inclusion of maritime emissions. An alternative is that a separate class of maritime allowances is created, as was done for aviation. In such a case, adjusting the cap could be avoided.
- Time frame for implementation: 2026.
- Regulated entity is assumed to be the shipowner or operator as of the MRV regulation. See further in 3.2.
- Price on allowances is subject to great uncertainties. We assume three different levels: EUR 25, 50 and 70. This is described further in 4.2.

4.1 Environmental impacts

In this section we assess the potential environmental impact, i.e. the mitigation of GHG, based on available data on abatement measures and their cost-effectiveness.

The actual impact on CO_2 emissions will depend on the specific design of the inclusion of shipping in EU ETS, and as described earlier a larger geographical coverage will potentially lead to larger total reduction in CO_2 emissions from shipping. The impact also depends on the level of the emission cap. If a separate system of allowances would be introduced for shipping, as for aviation, the cap will not be adjusted. However, if there isn't a separate class of allowances for shipping, adjusting the cap would most likely be needed. If the cap is adjusted, in principle both the supply and the demand for allowances will be higher. The cap will be increased to account for the additional emissions from shipping, which then would constitute the demand from the shipping sector. We assume that this will have a neutral impact on both the shipping sector itself as on other ETS sectors: i.e. the shipping sector will buy (or receive for free) the extra allowances made available. In reality, however, over time the sector could reduce emissions or grow, which would in turn have an impact on allowance demand and prices, and therefore the incentives to abate for all ETS sectors.

When assessing the impact, it is important to distinguish between the emission reductions in the shipping sector, and total emission reductions under the EU ETS due to the inclusion of shipping. Here, we focus on the first where the emission reduction depends on the price of an allowance in relation to the available abatement costs.

The literature on abatement costs for shipping as well as for other sectors relevant in EU ETS has, to our knowledge, not been updated in recent years which is important to bear in mind while reading the text below. Abatement costs are changing rapidly due to ongoing technological development.

In general, it is more costly to reduce CO_2 emissions in the transport sectors compared to the stationary sectors included in the EU ETS (OECD, 2016). According to McKinsey (2010) there are several abatement measures in the power sector in the range EUR 10-55 per tonne CO_2-eq in 2030, and several measures below EUR 50-55 per tonne CO_2-eq in several energy-intensive industries such as steel and cement production. The CO_2 abatement cost for road transport is indicated at about EUR 200 per tonne CO_2 in OECD (2016). However, the report by McKinsey (2010) indicates that there will be abatement measures with low or negative CO_2 abatement cost in the transport sector also in 2030. For shipping, there are also CO_2 abatement measures with relatively low or even negative CO_2 abatement costs, such as different operational measures (Eide et al., 2011).

The average marginal CO_2 reduction costs for a range of different measures for the shipping sector in 2030 are estimated in Eide et al. (2011), see Table 8, and reused in Wan et al. (2018). Cost-effective options having negative CO_2 reduction costs are mainly operational ones, for example slow steaming and weather routing (Wan et al., 2018). Concerning slow steaming, i.e. reducing the ship's speed, if an initial reduction of speed is performed, the economic benefits can be achieved. However, this relationship is rather complex, and with more reductions other effects which has impact on the total economic aspect for the shipowner/operator are realised. As an example, the most economic speed will vary over time with factors such as bunker price, supply and demand (which also will affect the freight rates). Over time, ships speed has varied widely and during the latest financial crisis large container vessels were operating at so called super slow steaming speeds. This practice included operations of large container vessels at as little as 10% of the main engine capacity lowering speed from over 20 knots to less than 15 and sometimes below 12 knots (Nottebom and Cariou 2013; Jivén et al. 2020).

Table 8 Average marginal abatement cost (USD/tonne and EUR/tonne assuming exchange rate at 0.9 Euro/USD) per measure for the shipping fleet in 2030.

Measure	Average abatement cost ($USD/tonne\ CO_2$)	Average abatement cost ($Euro/tonne\ CO_2$)
Voyage execution	-90	-81
Steam plant operation improvements		
Speed reduction due to port efficiency	-80	-72
Engine monitoring		
Reduced auxiliary power usage		
Trim/draft	-70 to -60	-63 to -54
Propulsion efficiency devices		
Frequency converters	-50 to -40	-45-to -36
Propeller condition		
Weather routing	-30- to -20	-27-to -18
Hull condition		
Air cavity lubrication		
Contra-rotating propeller		
Wind power: kite	Close to 0	Close to 0
Gas fuelled engines	20	18
Electronic engine control		
Fuel cells used as auxiliary engines	50-60	45-54
Energy efficient light system		
Speed reduction due to fleet increase	80-90	72-81
Wind power: fixed sails or wings	100	90
Waste heat recovery	150	135
Exhaust gas boilers on aux engines	190-200	171-180
Cold ironing		
Solar panels Wind generator	> 200	> 180

Reference: Eide et al. (2011).

For many of the included technical solutions (e.g., fixed sails/wings, fuel cells as auxiliary engines, waste heat recovery), the average CO_2 reduction cost is about EUR 50-180 per tonne or even higher (solar panels and wind generators). Yuan et al. (2016) confirm the cost-effectiveness of many operational shipping measures. Measures included in Yuan et al. (2016) are, presented from most negative to least negative value: propeller polishing, weather routing, autopilot adjustment, optimization waterflow of hull openings, air lubrication, propeller boss cap with fins, main engine tuning, speed control of pumps and fans, speed reduction and hull coating. Several of these measures have a fairly low CO_2 emissions reduction potential on a global scale - below 15 Mtonnes according to Yuan et al. (2016). Speed reduction is estimated to have the highest CO_2 reduction potential, about 220 Mtonnes, followed by air lubrication and propeller polishing (Yuan et al. 2016). However according to a report by IMO that includes estimates of maximum global abatement potential for selected operational measures in 2020, the average CO_2 reduction potential for speed reduction is approximately 100 Mtonnes. Further, they estimate reductions of 50 Mtonnes for propeller and propulsion upgrades, 45 Mtonnes for propeller maintenance, 40 Mtonnes for hull coating and maintenance, and 70 Mtonnes for other retrofit options while below 30 Mtonnes for the other included options (IMO 2009).

Other abatement measures for the shipping sector are, as indicated above, assumed to be more costly than operational measures. Chryssakis et al. (2017) assumes abatement costs for shipping in the range of EUR 150-200 per tonne CO_2 if using liquified biogas (LBG), methanol based on renewables, or biodiesel oil. In an assessment of seven "zero-emission options" including electricity, biofuels, hydrogen and ammonia solutions, the finding is that none of these options are competitive with conventional propulsion below approximately EUR 230 per tonne CO_2, at which the biofuel vessel is competitive. The ammonia and hydrogen fuel options become competitive at approximately EUR 460 per tonne or slightly higher (Lloyd's Register and UMAS, 2017). Ben Brahim et al. (2019) finds that a carbon price in the range of EUR 350-450 per tonne CO_2-eq would be required for a transition to renewable fuels in the Danish shipping sector.

The implementation of operational CO_2 abatement measures with estimated negative average abatement costs are counteracted by different barriers. This has been referred to as the energy-efficiency gap (Johnson and Andersson 2016). Causes for the gap can for example be lack of knowledge or that the fuel costs are covered by other parties than those making the investment decisions.

If shipping is included in the EU ETS, some of these operational measures will likely be implemented. According to Eide et al. (2011) the CO_2 reduction potential for abatement measures in shipping with negative abatement cost corresponds to up to 350 Mtonnes of CO_2 emissions per year globally. IMO (2009) report an estimated global CO_2 abatement potential for measures with negative cost of 135-365 Mtonnes, depending on scenario, and Yuan et al. (2016) report about 400 Mtonnes of CO_2[16]. No estimate for the corresponding reduction potential for these measures in the suggested geographical scopes within the EU has been found.

In order to reach more ambitious emission reductions than the ones possible to cover with abatement measures with negative costs, the price of the allowances must be higher. This since it seems that the abatement measures with a high mitigation potential in the shipping sector are relatively costly in comparison to available measures in other sectors in the EU ETS. Thus, the shift towards low carbon fuels in shipping will be more

[16] For a rough estimate of the potential for negative cost abatement measures in the EU, when assuming the same reduction potential for all parts of the global shipping sector, and using the share of 15% of the global CO_2 emissions covered by the MRV system results in an EU potential for negative cost abatement measures of 55-65 Mtonnes.

expensive (based on estimated cost for fuel switch) than implementing measures in stationary installations and likely more costly than the assumed cost of allowances (in our cases EUR 25, 50 and 70 per tonne). However, the abatement costs in shipping are uncertain and will likely change in the future.

4.2 Impact on the maritime sector

The impact on the maritime sector of extending the EU ETS to maritime transport depends on various design factors as described in Chapter 3. The assumptions on the design, which this assessment is based on, is summarised above. Apart from the design, also abatement costs and the price of allowances are important factors for the shipowners' decisions. The exact impact depends on complex relations of supply and demand factors for the EU ETS in general, including those external to the maritime sector itself, that are not included in this analysis. The inclusion of shipping into the EU ETS will increase marginal costs of maritime transport services, which ultimately will affect the freight rates. Increased freight rates could, in turn, have an impact on demand for shipping services, but the magnitude of this impact depends on the price elasticity of demand for shipping.

Hence, one crucial aspect for the impact on the maritime sector is the price incentive generated by an inclusion of shipping in the EU ETS. The price of emission allowance units has been between EUR 20 and 27 from 1 Jan 2019 until 1 March 2020 but dropped to 15 EUR on 23 March 2020 due to the covid-19 crisis. However, looking ahead, the allowance price is expected to increase as the cap - the amount of issued allowances - is reduced year by year. Assuming that the emissions in the EU and EU ETS will reach net zero before 2050, an upper limit for the allowance price in 2050 can be expected to be close to the cost of carbon capture and storage, somewhere between EUR 70 and 100 per tonne. In our impact assessment we have assumed three different price levels per allowance: EUR 25, 50 and 70 per tonne CO_2. Moreover, the allowance unit price for ship emissions will probably be at the same level as for the other industrial sectors.

In general, the greater the demand for allowances that need to be acquired through the market, the greater the potential impact from the price of allowances. Furthermore, the degree to which the cost of allowances can be passed on to transport buyers and end-consumers, in combination with the elasticity of demand for shipping, can further affect maritime emissions and demand for allowances.

According to the data published from the EU MRV system, emissions from shipping were estimated at 141 Mtonnes CO_2 in 2018, with the emissions from intra-European maritime transport accounting for 60 Mtonnes CO_2. According to the UNCTAD report (2019), international maritime trade is forecast to rise at an average annual growth rate of 3.4% in the next five years (2019-2024). In this case, the CO_2-emissions from shipping in Europe could also be assumed to increase in this period following the growth of maritime trade, arriving in 2026 at 178 Mtonnes, even though new vessels are usually larger and more energy efficient than those phased out. In case of a more limited scope, only including intra-EU shipping, which is 60 Mtonnes of CO_2 in 2018, and assuming the same growth rate, this will be approximately 75 Mtonnes in 2026. The assumption that the amount of CO_2-emissions increases with the estimated growth of shipping is also based on the fact that mainly fossil fuels are employed in the sector today. Hence, we do not take into account the fact that alternative and renewable fuels could be widely used for the propulsion of the vessels in the coming years. The assumptions are summaries in Table 9.

Table 9 Assumptions for the economic impact assessment

Geographical scope		Option 1 (MRV scope)	Option 4 (intra-EEA)
Time frame of implementation		2026	2026
Emission scope	2018	140 Mtonnes CO_2	60 Mtonnes CO_2
	2026	178 Mtonnes CO_2	75 Mtonnes CO_2
Allocation of allowances		5 % auctioned	5 % auctioned
		100 % auctioned	100 % auctioned
Price of allowances		EUR 25, 50 and 70	EUR 25, 50 and 70

To assess the overall potential economic impact on the maritime sector, we have conducted some illustrative calculations of the additional cost based on the assumed amount of allowances required. These are based on the above-mentioned emission data from 2018, and an expected growth until 2026 generating 178 Mtonnes of CO_2, assuming that no significant abatement measure will be taken due the lack of climate regulation targeting both old and new ships. In the first case, assuming that all allowances are auctioned, the total cost of allowances for the included shipping sector would range from around EUR 4.4 billion to 12.5 billion, see Table 10. In the option where only CO_2 emissions from intra-EEA shipping are included in the EU ETS, with all emissions auctioned, the total cost for the maritime sector would range from EUR 1.8 to 5.2 billion, with the assumption that intra-EEA shipping emissions increasing from 60 to 75 Mtonnes of CO_2.

Table 10 Cost increase for maritime sector assuming 100 % auctioning, expressed in MEUR

	Option 1 (MRV scope)		Option 4 (Intra-EEA)	
Emission allowance unit price	Year 2018 141 Mtonnes CO_2	Year 2026 178 Mtonnes CO_2	Year 2018 60 Mtonnes CO_2	Year 2026 75 Mtonnes CO_2
EUR 25	3 525	4 450	1 500	1 875
EUR 50	7 050	8 900	3 000	3 750
EUR 70	9 870	12 460	4 200	5 250

In the second case, we assume that 95% of these emissions will be allocated for free in the introduction phase based on a CO_2 emissions per tonne-km. Then, only allowances for the emissions released above this limit are needed to be purchased on the market at current price level. This indicates that emissions of approximately 9 Mtonnes in 2026 are needed to be purchased at the assumed prices: EUR 25, 50 or 70. The associated total cost of the maritime sector accounts for between 223 and 623 million EUR. In the option where only CO_2 emissions from intra-EEA shipping are included in the EU-ETS, with only 5% of these emissions auctioned, the total cost for the maritime sector would range from 93 to 259 million EUR. This is based on that allowances for approximately 4 Mtonnes of CO_2 would be auctioned for the shipping sector. See Table 11.

Table 11 Cost increase for maritime sector assuming 5 % auctioning, expressed in MEUR

	Option 1 (MRV scope)		Option 4 (Intra-EEA)	
Emission allowance unit price	**Year 2018** 7 Mtonnes CO_2	**Year 2026** 8.9 Mtonnes CO_2	**Year 2018** 3 Mtonnes CO_2	**Year 2026** 3.7 Mtonnes CO_2
EUR 25	175	223	75	93
EUR 50	350	445	150	185
EUR 70	490	623	210	259

In order to further understand the impact of these cost increases presented, we related them to current fuel prices. To calculate the increase in fuel price from the inclusion of CO_2 pricing, it is necessary to take into account the emission factor of the fuel as well as the emission allowance unit price. The emission factor of marine gas oil (MGO) fuel that is widely used in European waters after the international sulphur fuel limits imposed since January 2015 and January 2020 is about 3 tonnes CO_2 per tonne fuel. This means that, in case all emission allowances are being auctioned, the additional cost in MGO fuel price will vary between EUR 75 per tonne MGO, and EUR 210 per tonne, depending on the emission allowance unit price. Given that the current price of MGO is around EUR 630 per tonne, the MGO price could be 12% to 33% more expensive compared to the current price, incentivising investments in low-carbon technologies and operational measures.

Alternatively, in case 95% of these emissions are allocated for free in the introduction phase and only 5% are being auctioned, about 0.15 tonnes of CO_2 per tonne fuel of MGO would be included in the fuel price increase from the inclusion of CO_2 cost. The additional cost in MGO fuel price will vary between EUR 3.75 euros and 11.25 per tonne fuel depending on the emission allowance unit price. This would mean an increase of about 0.6% to 1.8% in the current price of MGO. The impact on MGO fuel price from the inclusion of CO_2 cost depends largely on the amount of emissions allowances that will be auctioned in the EU ETS. Further, who will pay for the additional cost depends on the possibility for the shipowner to pass them on, which is presented in the next section.

Who will bear the additional cost?

The inclusion of shipping in the EU ETS will have a direct impact on the actors that need to acquire and surrender allowances. As stated in the beginning of this chapter, we assume that it most likely will be the shipowners or ship operators that are the responsible entities for surrendering allowances and initially bear the CO_2 cost of shipping, because in most cases they have the most long-term interest in the operation of a ship.

The total costs for a shipping company for a given year varies among, and within, the different segments. The total cost depends on the amount of emissions before abatement, emissions after abatement, the price of the allowances, the average cost of abatement for reducing the emissions to a certain level and, finally, the amount of free allocation and the ability to pass on costs. Previously we presented impact assessment for assumed cases without abatement measures taken, we will in the following text focus on the ability to pass on cost.

The additional cost may be passed on to the shippers and from the shippers to the consumers depending on the market circumstances. When demand for maritime services is lower than supply of ships, freight rates are determined by marginal operational costs (i.e. costs for voyage and crew, repairs and maintenance, insurance and administration). Since emission allowance costs will consist of part of the voyage costs, they will increase the marginal operational costs and consequently the freight rates that the shippers will need to pay. Emission allowance costs will be borne by the shippers that will pass them on, in their turn, to the consumers (Stopford, 2009; Faber et al. 2010).

The additional cost from the inclusion of shipping in the EU ETS will have a small impact on the import prices of liquid bulk cargo and manufactured goods that the consumers will need to pay, as the value of these products is high and transport costs represent a minor part of their overall production cost. For dry bulk cargo, the impact from the increased import price will be higher, due to their low value and high-volume characteristics. Moreover, the increased import prices are likely to have a larger impact and a lower impact on demand on consumers in developed countries, as they are usually willing to pay higher prices for the products they buy compared to consumers in developing countries.

On the other hand, when demand for maritime services is higher than the supply of ships, freight rates are determined by shippers' marginal benefits, the price the shippers are willing to pay for the services provided increases. In this case, the additional emission allowance costs will not affect the – already high - freight rates and the CO_2 costs will be borne by the shipowner or operator reducing its profit margins (Faber et al. 2010). Shipowners and operators will rationally take measures to reduce emissions and additional CO_2 costs by increasing the energy efficiency of their fleet through technical and operational means.

What will be the impact on different maritime segments?

The impact from the inclusion of shipping in the EU ETS will differ substantially among the different types of ships. The different options for design of the system for including shipping in the EU ETS, will also influence different shipping segments in different ways depending on fuel consumption in relation to e.g. transport work, competition with other transport modes, and flexibility in scheduling.

In the case where no allowances are allocated for free, all ships would get increased costs in proportion to their fuel consumption and the fuel's carbon content within the ETS boundaries. For sectors competing with other transport modes, this will mean a specific disadvantage (see Section 4.3 below) unless the other modes are also subject to similar cost increases. In general, the costs for transport buyers can be expected to increase, but in shipping segments competing with land-based transport modes, shipping lines are likely to absorb the extra cost for routes where shipping does not have a geographical advantage. For example, the profit margins or competitiveness is likely to decrease for shipping lines offering the RoPax routes Gothenburg-Kiel and Nynäshamn-Gdansk with long distances in parallel with the Swedish coastline.

Segments with high fuel consumption in relation to transport work, such as RoRo and RoPax (see Table 5), are influenced to a higher degree. Further, smaller ships have in general higher fuel consumption in relation to transport work, compared with larger ships. This means that short sea shipping with e.g. feeders will be more influenced than deep sea shipping. Nevertheless, this is partly compensated by the fact that small feeder ships (up to 999 TEUs) on average sail at 12.4 knots, which is much slower than the larger vessels with an average of ca 16 knots (Smith et al. 2015).

In the case where allowances are allocated based on the transport work produced in the same way for all ships, there will be large differences between the segments. As mentioned in section 3.3 the emissions per tonne-km or vessel-km (or as denoted in the MRV system in nautical mile instead of km) for the vessel types bulk, container, general cargo and RoRo/RoPax vary significantly. Large dry bulk and wet bulk ships would then be given a large amount of allowances, especially in relation to their emissions, while e.g. RoRo vessels producing less transport work in relation to their fuel consumption, would be given less. Thus, such a system would result in a net flow from fuel intensive segments to fuel efficient segments. However, the system would also stimulate fuel efficiency by adopting various technical and operational measures for all sectors.

If allowances are calculated per segment and allocated per transport work produced, the situation would be quite different. Then efficient ships would have an advantage and larger ships would in general have an advantage over smaller ships. For segments with very heterogenous ships, such as RoPax, there will be a large spread in impacts depending on fuel consumption in relation to transport work as well as in relation to the distribution between passengers and freight. Particular attention must then be paid to the competitive situation, both between shipping lines and between maritime and land-based modes, route by route.

Since the IMO data collection system uses deadweight tonnage (DWT) as a proxy for cargo carried, it may also be possible to allocate allowances based on this quantity instead of tonne-km as reported in the EU MRV system. In that case the same amount of allowances would be allocated independent of actual cargo carried. In principle, the impact differences between the segments would be similar as outlined above, but with less incentive to increase the load factor since this is not captured in the DWT as it is in the reporting to the MRV system.

What happens to the early movers?

Both old and new vessels will be treated the same under the EU ETS as it is for the other sectors, including aviation, indicating that any ship with high fuel efficiency will benefit.

Shipowners and operators that have reduced the energy consumption of their vessels, either by investing in energy-efficient technical and operational measures or by using alternative or renewable fuels, will be able to sell the surplus allowances to companies that have not yet implemented the necessary abatement measures to reduce their emissions. Following the example of the aviation sector, emission allowances can be allocated on the basis of the transport work produced by the maritime sector, meaning that a benchmark will be set on the total transport work produced by the sector. In this way, frontrunners will be rewarded for their relatively good environmental performance and the adoption of energy efficiency measures will be incentivised by the potential profits generated from selling the allowances.

Shipowners and operators, as the responsible entities for surrendering allowances, will, at least in theory, rationally take measures to reduce emissions up to the point where the costs of these measures are equal to the allowance price. Policies that increase the costs of emissions, like emissions trading, are likely to reinforce the implementation of cost-effective measures, as shipowners and operators will take both the investment costs and the costs of the associated emissions into account. With the expected increased demand for efficient new ships, their supply will accordingly increase, reducing marginal costs for the shipyards. As marginal costs will fall, additional incentives will raise for the shipping companies to invest in new technologies. In this way, the inclusion of shipping in an ETS can stimulate investments in the maritime sector, and even if the ETS does not manage to reduce emissions, an inclusion will force other sectors to abate more as they are under the same cap.

4.3 Impact on modal split

The impact on modal split depends on the competition with other modes of transports and can be expressed as the elasticity of demand for a shipping service. The price elasticity of demand is defined as the percentage change in demand over the percentage change in the price/freight rate. This means that the less elastic the demand is for maritime services, the less sensitive shippers are to changes in freight rates.

The demand for deep sea shipping services is inelastic due to the lack of alternative transport modes, therefore the increased freight rates from the inclusion of shipping into the EU ETS will have only marginal impact on the demand for these services. For short sea services, though, the price elasticity of demand is larger due to competition with other transport modes, such as rail and road transport. According to Notteboom (2011), for short sea services, an increase of freight rates by a certain percentage leads to a decrease in demand of a similar percentage. Shifting to alternative transport modes is hence most likely to occur in unitised short sea shipping, e.g. RoRo and container shipping, as short sea bulk transport is dominated by high volume and low value cargos with economies of scale, resulting in low cost per unit of transport work. Substitution of short sea bulk transport by road transport would require a large number of trucks and trains, and, depending on geography, potentially increase overall transport work.

In the case of short sea shipping services where the elasticity of demand is relatively high, a potential increase in fuel price of up to 33% as presented in 4.2 due to obligation of submitting allowances to the price of EUR 70, will probably lead to changes in the modal split at the expense of these services. The impact on modal shift is not expected to lead to large traffic losses in the case that only 5% of emissions allowances will be initially auctioned in the EU ETS, which in comparing the impact with fuel prices indicates a range of 0.6% to 1.8% increase in fuel prices.

Apart from direct impacts, indirect impacts on the modal split might also occur. The shift to land-based transport modes and the loss of market share may result in reduced capacity utilisation levels, lower frequencies and certain services shutting down. This could lead to higher modal shifts at the expense of short sea shipping (SSS), which is against the targets of the European Union that promotes SSS for trading within the community.

Similar impacts on modal shift was expected from the broad introduction of marine gas oil (MGO) in 2015, which was a low sulphur option to heavy fuel oil (HFO) and became the primary fuel within the Emission Control Areas (Notteboom 2011). This was also identified by Zis (2017). However, marine transports were not negatively affected, instead companies improved their economic performance due to the extremely low fuel prices throughout 2015 that maintained freight rates at low levels. Shipowners were able to absorb the anticipated increased operating costs due to the more expensive MGO fuel and, secure their market share. The share of short sea shipping, though, would have increased if the new regulation was not in place. This indicates the importance of fuel prices, which are very volatile over time.

5 Discussion and conclusions

In this chapter we summarize our main findings on the design features of the inclusion of maritime transport in the EU ETS and its potential impacts, then we discuss some important aspects identified throughout this project and finally we present our conclusions and suggestions for further research.

Summary of our key findings

The aim of this project is to address design features and assess impacts of an inclusion of maritime transport in the EU ETS. Our results indicate that it is most likely that an inclusion would be based on the implemented EU's monitoring, reporting and verification (MRV) system, collecting data on CO_2 emissions from ships first respectively last leg to/from a port in one of the EEA states. In 2018, these emissions were 141 Mtonnes of CO_2, i.e. 15 % of global emissions from shipping. However, an inclusion can be expected to be realised earliest by 2026, to which emissions are assumed to increase to approximately 178 Mtonnes. The additional cost for the shipping sector will be determined mainly by the price of allowances and how large share of the allowances that will be auctioned. Our findings indicate that this could generate a total cost increase for the included shipping sector in the range of 0.17 up to 12.4 billion euro. This is based on the assumptions that 5 % of allowances would be auctioned to a price level 25 EUR in the lower case, and 100% auctioning and a price level of 70 EUR in the upper case. To set these cost increases into a context, it generates a price increase of between 0.6% and 33% per tonne marine gas oil at current fuel price (EUR 630).

5.1 Discussion

Our literature review shows that there are many suggestions on different designs of different cap-and-trade systems for shipping on global or regional levels. However less literature is focused on the EU ETS specifically, and to our knowledge no published literature has based their assessments on the implemented EU MRV system and the available data on emissions, apart from Transport and Environment (2019)[17].

Our results are meant to give an overview of important design features of this market-based policy instrument, and what the potential overall impact could be on the shipping sector if different options are chosen. It has been beyond the scope of this study to

17 The report from Transport and Environment (2019) do not elaborate on the design features but on the motive for regulating the emissions from maritime transports.

conduct a deeper assessment of the impact on the shipping sector, and specific segments and commodities. We hence have made several simplifications in our impact assessment as stated, such as assuming no abatement measure to be taken until 2026 and simplifications of the cost structure the shipping companies would face of an introduction in the EU ETS. This is important to keep in mind when interpreting our results.

One aspect for discussion is the emission scope, in the sense of which GHG to include. Since the EU ETS directive covers six GHGs; carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) and three fluorinated gases (HFC, PFC, and SF6), and the current MRV system only covers CO_2 and this represents the major GHG for shipping, it is highly uncertain if CH_4 or N_2O emissions can be included initially. If CH_4 emissions would be included, this will impact mainly ships using LNG which according to the MRV data only constitutes 3% of total fuel consumed (DG MOVE 2020), and N_2O emissions from shipping are in general minor. It is potentially possible to create an exception if the legislators agree, and some possible options to cope with this are:

- Argue for an exception in EU ETS so that only CO_2 emissions from shipping are included and liable for compliance.
- Develop MRV rules for including also non-CO_2 GHGs and assess compatibility with IMO DCS.
- Focus on CO_2 and N_2O as there is existing experience with including these in the EU ET, which currently lacks for CH_4.

Applying the first option would allow shipping to be included in the ETS sooner than for the other options. The more complex the design will be, the more time is needed to implement it. Our finding is that it seems unlikely that an inclusion would occur before 2026.

Connected to the discussion on the emission scope, the quality of the data in the MRV system leaves room for improvement. The quality of the emission data will likely improve if shipping is included in the EU ETS. This since the availability and quality of data for the sectors already included in the ETS have improved over the years. This will facilitate monitoring and improve emissions statistics.

Another important feature is how allowances ought to be allocated. There are two main principles applied in the EU ETS: free allocation or auctioning. Auctioning follows the polluter pays principle and is the preferred method of allocation. However, free allocation is still common today due to carbon leakage risk, but is planned to be phased out, also for aviation. Hence, there are uncertainties how shipping will be treated. Some observers (e.g. Miola et al. 2011, Gu et al. 2019) advocates for full auctioning, since it would be the fairest from a distributional perspective and result in the strongest economic incentive to abate emissions, and not only to cap them and prevent an increase.

Free allocation calls for establishing a benchmark. Benchmark-based free allocation is seen as more complex for maritime transport compared to other sectors, among other things due to different ship types (used for different purposes and commodities) and sizes, but also due to volatility of freight rates, annual transport work and the dependence of volatile bunker prices that characterises the maritime transport market.

In the EU ETS the current benchmarks are set based on the utility each sector or activity produces. For aviation this is transport work produced, which could be relevant also for maritime transport. A benefit would then be that this data is already collected in the MRV system. A benchmark approach would result in that more efficient operators receiving a comparatively higher share of free allowances as compared to their released emissions. Hence, a benchmark approach generates an incentive to improve efficiency in the sector.

In comparison with shipping, aviation has a much more homogenous fleet so a benchmark approach for the whole maritime sector might not be suitable. We have identified the following potential ways of setting a benchmark based on transport work produced measured in tonne-kilometres for shipping:

- Equal for all ships no differentiation.
- Differentiation based on type of ship (within the MRV system there are 15 categories).
- Differentiation based on type of ship and size.

As stated above, the key benefit of auctioning is that it avoids having to design a sophisticated methodology to determine who gets what amount of allowances for free. The decision on how many allowances to acquire is then entirely up to operators who need to comply with the EU ETS.

With free allocation, there is a risk that allocated allowance volumes are either insufficient or too generous. The latter in particular can undermine efficiency as supply-demand imbalances can affect carbon prices, and therefore the decarbonisation incentives. Avoiding supply-demand imbalances is an important design consideration, especially in the context of economic volatility.

In the context of a highly volatile macroeconomic environment it is important that significant supply-demand imbalances do not arise, since this can impact carbon prices and thereby affect the incentives to reduce emissions. However, the cap is still preventing the emissions from increasing above the cap.

At the same time, there is some benefit to allowing carbon prices to fluctuate during times of economic distress as this creates an anti-cyclical effect. As an example, since the onset of the covid-19 crisis, the allowance price has dropped from EUR 25 to 15, thereby temporarily relieving carbon costs for distressed companies. The fact that allowances are an asset that holds value also means that their sale can generate income for companies. This will explain part of the decline in carbon prices during crisis situations. Therefore, during downturns the EU ETS is a relatively lighter burden for the actors while during economic growth periods it acts as a brake by increasing carbon costs.

The EU ETS policy design should balance this arguably desirable anticyclical effect with the need not to create large imbalances over time. If the maritime sector would be included in the EU ETS, the Market Stability Reserve (see Chapter 2) will help prevent such imbalances. However, it is still important that any potential free allocation method does not enhance imbalances. Should there be a separate trading system for the maritime sector, in the same way as aviation was introduced in the EU ETS, it would be important to have a similar mechanism to prevent market imbalances from arising.

The EU ETS has a two-folded way of regulating GHG emissions. First, to cap and prevent an increase of emissions. Second, to give an economic incentive to take abatement measures. Regarding expected abatement, several shipping-related operational measures are estimated to have relatively low or even negative CO_2 abatement costs. In an ideal world, shippers would seek to be cost-effective by implementing these measures, starting with the least costly ones. This assumes there are no non-economic barriers that hinder their uptake. However, experience shows that many measures that can be motivated from a pure economic perspective are still not effectuated due to e.g. lack of information, lack of capital or the existence of other investments that are more profitable.

On the other hand, many technical measures in the shipping sector are estimated to cost more than the assumed price for CO_2 allowances and are relatively high in comparison to CO_2 abatement measures in other sectors included in the EU ETS. This indicates that the inclusion of shipping in EU ETS might not initially be enough to incentivise the implementation of significant abatement measures in shipping. This reasoning is in line with Kågeson (2007) who concludes that if shipping is included in the EU ETS, the shipping industry can be expected to become a net-buyer of allowances from other sectors.

However, the abatement costs in shipping are uncertain and will likely change in the future, and the price incentive also affects different segments of the maritime sector in different ways. The latter depends mainly on two aspects. Firstly, due to the high variation of emissions per transport work for different ship types, as well as sizes, the economic impact on them will differ greatly. This means that the impact may be larger for e.g. RoRo vessels compared to bulk carriers, as the latter have better performance in terms of CO_2-emissions per tonne-kilometre. This holds true if no differentiation in the allocation of the allowances are made based on the differentiations. Secondly, increased freight rates are also expected to have a larger impact on demand for short sea shipping services, as their price elasticity is larger than for deep-sea shipping services due to the competition with land-based transport modes, such as rail and road transport.

Finally, it is also important to discuss this regional policy and its impact on global policymaking, i.e. at an IMO-level. If the EU ETS system would be integrated with a global system for maritime transport in the longer term, it is important to point out that in the IMO DCS there is no collection of data on transport work. In DCS information on dead weight tonnage (DWT), which indicates how much weight a ship can carry and not how much it is carrying, is used.

One potential approach on a global level could be to instead use traffic (in vessel-kilometre) as the accounting activity (instead of transport work in tonne-kilometre). According to the literature, there are both pros and cons with a region taking the lead, and the Secretary-General of the IMO has expressed his concerns for an inclusion in the EU ETS based on the argument that it could undermine efforts on a global level (see Gritsenko 2017; Dominioni et al. 2018).

On the other hand, in the literature review the conclusion is that pros seem to overcome the cons, since they generate ways to learn from practice how an ETS would work for shipping, including e.g. the implementation and enforcement phases. With the current lack of climate policy for maritime transport, apart from the IMO's energy efficiency design index (EEDI) addressing the energy-efficiency of new ships only, an inclusion of shipping in the EU ETS can generate an incentive for taking abatement measures by showing the way.

From the aviation sector, which is also of global nature, the introduction of aviation in the EU ETS arguably spurred the International Civil Aviation Organization (ICAO) to accelerate the development of the global market-based mechanism for aviation - Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

5.2 Conclusions

To our understanding it is feasible to include maritime transport in the EU ETS. It seems most likely that an inclusion will be built upon the data and scope of the current MRV system, that is covering the legs of a ship's route before and after a port call in one of the EEA states. The time for an inclusion is according to our findings expected to be during 2026 the earliest, this would also indicate to include only CO_2 emissions. The more complex the design of the inclusion will be, the more time is expected to be needed to implement it. If shipping is included in the EU ETS, we propose that the cap of the EU ETS is adjusted in order to balance supply and demand of allowances.

In the long term, allocation should be based on auctioning, which follows the polluter pays principle. In the short term, however, we suggest that if a portion of allowances are allocated for free, allocation should be based on produced transport work multiplied by benchmarks, specific to different ship categories.

The economic impact for shipowners and operators from the introduction of CO_2 costs depends largely on the amount of emission allowances that will be auctioned in the EU ETS. In our assessment the estimated cost increase has been set into to context by relating it to the current cost of marine gas oil, generating an increase in the range from 0.6% up to 33%. The lower case assumes that 5% of allowances are auctioned to a price of EUR 25, the high case assuming 100% auctioning and a price level of EUR 70. Due to a high variation of emissions per transport work for different ship types and ship sizes, the economic impact on them will differ. This means that the impact may be larger for e.g. RoRo vessels compared to bulk carriers.

Including shipping in the EU ETS leads to a cap on the emissions. However, the design choices are crucial for the financial impact on the maritime sector, and hence the incentive for the sector to take abatement measures. When prices of the allowances are too low to generate an incentive for abatement, the inclusion of shipping is still capping the emissions from growing. Abatement costs will be low or even negative as long as the maritime sector can apply operational energy-efficiency measures but increases when technical measures or switching to alternative fuels are needed.

Finally, including shipping will be an important step to curb emissions related to EEA-shipping and serve as an example for international action. Therefore, we would like to highlight the need for global action, and that it is important to keep in mind how this regional policy can support a potential future global system when designing the inclusion of maritime transport.

5.3 Further research

As can be seen from this project an inclusion of maritime transports generated several design features to decide upon, and at the time of writing there are no official proposals on the table. Hence, further research is needed to assess the potential impacts of these design features on a larger scale. In particular we would like to highlight the following topics for further research:

- Impact of different prices on different ship types and commodities.
- Impact of different allocation methods – how to set a benchmark for shipping?
- Impacts of including more GHGs than CO_2.
- How the policy design could offer flexibility in governance of allowances when a new sector is included, consider possibility to handle output shocks like in 2009 as well as this year due to covid-19.
- Estimations of the potential for negative and low-cost abatement measures in the shipping sector in the EEA and the potential for different ship types.
- One issue addressed in the literature, which has been out of the scope of this project, is how to redistribute the revenues from auctioning of allowances based on, partly, international emissions and how this can comply with the UNFCCC principle of Common But Differentiated Responsibilities and Respective Capabilities (CBDR-RC), i.e. the 'fairness' principle of international climate policy, with the IMO:s equal treatment. And how this could be an issue or not for EU ETS.

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