EUROPEAN
COMMISSION

Brussels, 13.3.2023
SWD(2023) 54 final

COMMISSION STAFF WORKING DOCUMENT

Full-length report

Accompanying the document

Report from the Commission

Fourth Annual Report from the European Commission on CO_2 Emissions from Maritime Transport (period 2018-2021)

{C(2023) 1585 final}

EUROPEAN COMMISSION

Fourth Annual Report from the European Commission on CO_2 Emissions from Maritime Transport (period 2018-2021)

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Executive Summary

EU Regulation 2015/757 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, in the following referred to as 'EU Maritime MRV Regulation',[1] requires companies to monitor and report fuel consumption, CO_2 emissions and other key parameters for their ships when sailing to/from and between ports of the European Economic Area (EEA).

The European Commission makes the reported data, aggregated on a yearly basis, publicly available and also publishes an annual report, analysing the reported data. This report analyses the data for the period 2018-2021, with a particular focus on 2021 data corresponding to the fourth reporting period of the EU maritime MRV system.

The year 2021 was marked by two structural differences, which make direct comparison with the three previous reporting years a challenging exercise. First, the withdrawal of the United Kingdom from the EU brought a significant change in the geographical scope of the EU Maritime MRV Regulation, as voyages within the UK and between the UK and non-EEA countries are no longer reported under the system. Secondly, the long-lasting effects of the COVID-19 crisis kept affecting seaborne trade and maritime passenger transports, which only recorded a partial recovery from 2020, still below 2019 levels.

The monitored voyages (all trips to/from EEA ports) for the reporting year 2021 emitted 124.3 million tonnes of CO_2 into the atmosphere. Those emissions originated from a fleet of almost 11 800 ships. For comparison, 128.7 million tonnes of the CO_2 emissions were reported for the year 2020, and 147 million tonnes for the year 2019, which both included UK related emissions. Expressed in terms of fuel consumption, the monitored ships consumed 40 million tonnes of fuel in 2021.

The withdrawal of the United Kingdom from the EU caused a significant change in the distribution of the fleet's total CO_2 emissions over the different types of voyages. The share of emissions from intra-EEA voyages decreased from 33% in 2019 to 26% in 2021, and the contribution of extra-EEA voyages increased from 33% to 35% in the same years. For some ship types (ro-ro and ro-pax ships) there was also a clear shift of reported emissions between voyage types compared to 2020.

However, the share of the different ship types in the fleet CO_2 emissions remained stable across the four reporting periods. Container ships emitted the highest proportion in the fleet CO_2 emissions (2021: 33%) and together with the emissions of oil tankers and bulk carriers, emitted almost 60% of the 2021 total fleet CO_2 emissions. The share of fuel consumed at berth (6.4%) remained stable.

No major changes were recorded in the relative shares of the main fuel types consumed in 2021 compared to 2020. Among the main used fuels, LNG is the only fuel type for which consumption levels close to pre-COVID 2019 (-2%) were reported in 2021, with clear signs of an uptake in LNG consumption in some ship types (container ships, oil tankers, and passenger ships), beyond LNG carriers. The share of LNG carriers in total LNG consumption decreased from 88% in 2018 to 80% in 2021.

According to Eurostat data, following the overall decrease in extra-EU-27 trade flows recorded in 2020, the volume of traded goods for seven out of the fifteen main partners increased in 2021, yet in general below 2019 pre-COVID levels. The volume of waterborne transport

[1] Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC, OJ L 123, 19.5.2015, p. 55–76.

services in 2021 was particularly high on shipping routes between the EU and countries like Russia, the USA, the United Kingdom, Norway and Türkiye.

The data collected during the fourth reporting year showed that speed variation in the period 2018-2021 is negligible for most ship types. There are no signs of any ship type structurally slowing down over the period, with the notable exception of those still suffering from the economic effects of COVID-19 (e.g. passenger ships), which showed a decrease in speed in 2020 and only a partial recovery in 2021.

Both the average time at sea and the total time at sea increased in 2021 compared to 2020 for passenger ships and ro-pax ships, an indication that for such ship types the recovery from the COVID-19 crisis more than balanced the negative effects of the United Kingdom's withdrawal from the EU.

The graphical analysis of key technical and operational efficiency indicators shows that no significant changes took place over the period 2018-2021, as signalled by overlapping regression curves. Furthermore, the gradual increase of data correlation values stresses the completeness and correctness of the reported data and its improvement over the last four years.

The lower CO_2 emissions observed for 2021 compared to both 2020 and pre-COVID years, should not therefore be linked to a supposed overall improvement of the operational efficiency of the fleet but could instead be associated to the combined effect of two structural events of the year 2021: the long-lasting effects of the COVID economic crisis and the withdrawal of the UK from the EU.

An analysis of the implementation of the EU Maritime MRV Regulation shows that, by now, implementation actors are more familiar with the system, resulting in smoother internal procedures and improved data submission compared to the first EU Maritime MRV reporting years. This is reflected in the findings for the year 2021 on punctuality and quality of data submission.

1. Introduction

This report has been prepared using data from the implementation of the EU Regulation on the monitoring, reporting and verification of CO_2 emissions from maritime transport (Regulation (EU) 2015/757). All information was extracted on 30 September 2022[2]. Data provided or updated after this date is not reflected in this report.

1.1. The 2022 Annual Report: scope and objectives

This is the fourth report on CO_2 emissions data from ships entering and leaving EEA ports, collected under the monitoring, reporting and verification (MRV) system for CO_2 emissions from maritime transport adopted in 2015 (Regulation (EU) 2015/757), hereafter called the "EU Maritime MRV Regulation".

This legislation is the first step of a staged approach for the inclusion of maritime transport emissions in the EU's greenhouse gas (GHG) reductions commitments and the foundation for new policy initiatives that have been launched by the Commission mid-2021. The EU Maritime MRV Regulation has three key objectives:

1. To collect robust and verified CO_2 emission data;
2. To provide transparency and stimulate the uptake of energy efficiency investments and behaviours;
3. To support policy discussions and implementation of policy tools.

The legislation requires shipping companies to track and report key information about CO_2 emissions, fuel consumption and other relevant information. This data is then checked by independent verifiers accredited by national accreditation bodies. The Commission subsequently publishes the verified data and drafts an Annual Report on CO_2 emissions from maritime transport. A detailed description of the MRV process ("The MRV system – Steps of the MRV process") can be found in Annex 2.

Throughout the entire process, transparency is key. The currently available set of MRV data, is contributing to an enhanced understanding of the climate impact of the shipping sector regarding CO_2 emissions. The published raw data represents a valuable asset to universities and research organisations, public authorities and other market actors for analyses and studies on the maritime sector and its environmental performance.

The present report covers the four compliance cycles since the entry into force of the EU Maritime MRV Regulation, covering emissions from 2018 to 2021. It builds on the previous reports and allows for a comparison of data from these reporting years. The main objective of the present report is to examine trends in emissions and energy efficiency characteristics over the four available reporting cycles.

[2] For the three previously published annual reports, related to the reporting periods 2018, 2019, and 2020 the same principle, i.e. a cut-off date has been applied. For the purpose of this annual report, however, updated data as of 30 September 2022 has been used for these three previous periods. This means that the 2018, 2019, and 2020 figures presented in this report might slightly differ from those published in the first, second and third annual reports.

The scope of the EU Maritime MRV Regulation

The monitoring, reporting, and verification obligation applies to ships above 5 000 gross tonnage (GT) loading or unloading cargo or passengers at ports in the European Economic Area (EEA). The Regulation is flag-neutral, which means that ships must monitor and report their emissions regardless of their flag.

Despite limiting the monitoring requirements to large ships, the Regulation covers around 90% of all CO_2 emissions, whilst only including around 55% of all ships calling into EEA ports. For proportionality and subsidiarity reasons, military vessels, naval auxiliaries, fish-catching or fish-processing ships are excluded from the Regulation.

The Regulation covers CO_2 emissions produced when a ship carries out a voyage from or to a port in the EEA when transporting goods or passengers for commercial purposes. For instance, it covers emissions from a ship that goes from Rotterdam to Shanghai and the emissions produced when a ship sails from Shanghai to Rotterdam.

However, if a ship departs from Shanghai for Rotterdam and makes a stop at another port outside the EEA (e.g., port “A” which is nearer to the EEA) for cargo or passenger operations, only the emissions related to the last leg of the voyage (in this case port A to Rotterdam) will be reported in the system. International voyages that take place within the EEA are also covered, such as a ship travelling from Le Havre to Rotterdam, as well as domestic voyages, e.g., from Brest to Le Havre. Emissions occurring when the ship is within a port located in the EEA are also covered, including when the ship is moored or anchored at a port whilst loading, unloading or hotelling.

1.2. Context

1.2.1. 2021: a new geographical scope following the withdrawal of the United Kingdom from the EU combined with a partial post-COVID economic recovery

Two key factors marked the reporting year 2021 and should therefore be kept in mind when comparing 2021 data with previous years: 1. the (partial) recovery from the economic effects of the COVID crisis and; 2. the withdrawal of the United Kingdom (UK) from the European Union.

The global seaborne trade clearly recovered in 2021, following the remarkable decline registered in 2020 as a consequence of the COVID crisis. The levels for the year 2021 were still slightly below 2019 ones,[3] as trade was still affected, to some extent, by the longlasting effects of the pandemic, and a significant backlog in global logistics, due to a sudden increase in demand and shortages on the supply side, as confirmed by increasing port congestion (UNCTAD, 2022).

Eurostat data (Eurostat, 2022) confirms that Europe was in line with such global trends in seaborne traffic, further highlighting that the passengers sector is still well below pre-COVID levels.

[3] UNCTAD reports for international maritime trade a 3.8% decline worldwide for the year 2020 on 2019 and a 3.2% increase for the year 2021 on 2020.

The number of passengers embarking and disembarking in EU ports in 2021 increased by 16%, reaching 267.9 million passengers from 230 million in 2020. This was still considerably below the levels observed before the pandemic, -36% in 2021 compared with 2019, when EU ports registered 418 million passengers. The total gross weight of goods handled in EU ports in 2021 was estimated at 3.5 billion tonnes, a 4.1% increase on the previous year, after a 7.3% drop in 2020 on 2019, therefore still below (by 3.5%) the peak registered in pre-COVID 2019.

A second key factor to consider while analysing 2021 MRV data, is that, since 1 February 2020, the UK has withdrawn from the European Union.[4] Therefore, with the end of the transition period on 31 December 2020:

- voyages between the UK and an EEA country are, for the purpose of the EU Maritime MRV Regulation, no longer considered intra-EEA voyages but rather extra-EEA voyages and
- voyages between the UK and non-EEA countries which have previously been covered as extra-EEA voyages by the EU Maritime MRV Regulation are no longer under the scope of the Regulation.
- voyages within the UK, previously covered under intra-EEA voyages are no longer under the scope of the Regulation.

Meanwhile, a UK MRV System similar to the EU Maritime MRV System has been put in place. This means that domestic UK voyages as well as voyages between the UK and non-EEA countries are in principle covered by the UK MRV System but not anymore by the EU Maritime MRV system. Since the first reporting year of the newly established UK MRV system is 2022 (Maritime & Coastguard Agency, 2021), voyages within the UK, between the UK and EEA countries, and between the UK and non-EEA countries in 2021 are neither captured by the EU nor the UK MRV System.

1.2.2. The EU 'Fit for 55' package proposals

On 14 July 2021, the Commission proposed the 'Fit for 55 package', a set of legislative proposals aiming at delivering the EU's 2030 climate objectives. This corresponds to the concretization into policies of the strategy adopted in December 2019, the European Green Deal, aiming to transform the EU into a modern, resource-efficient and competitive economy, and to achieve climate neutrality by 2050. In the same year, the Commission also adopted the Communication on a new approach for a sustainable blue economy in the EU,[5] setting a detailed agenda for the sector to transition from "Blue Growth" to a "Sustainable Blue Economy", thus contributing to climate change mitigation, including by supporting the decarbonisation of maritime transport.

The 'Fit for 55 package' fully reflects the new EU intermediate climate objective to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels.The 'Fit for 55 package' represents a comprehensive set of climate proposals as it covers many different sectors and topics such as energy, taxation, forestry or transport. Regarding the latter, it notably aims at ensuring that maritime transport contributes to the increased EU climate effort

[4] For this Report it was not possible to recalculate historical data before 2021 so to exclude the emissions resulting from the full application of the EU Maritime MRV Regulation to the United Kingdom. This is because the legislation does not require shipping companies to report emissions at voyage level. Therefore, throughout the Report, the figures presented for the year 2021 are based on the data as reported excluding the Regulation full application to the United Kingdom (but only to EEA countries, including EU27), while for the three previous MRV reporting years the United Kingdom is accounted for as part of the EEA (EU28).

[5] Communication on a new approach for a sustainable blue economy in the EU Transforming the EU's Blue Economy for a Sustainable Future, Communication C(2021) 240 final.

and to the Paris Agreement commitments. This is of particular relevance as CO_2 emissions from waterborne transport represent 3-4% of total EU CO_2 emissions (European Commission, 2021c) and as the demand for waterborne transport services is expected to grow further in the future.

This is why in July 2021, the Commission proposed a series of measures to address the maritime transport's climate impact and foster the transition towards green shipping. The most relevant measures for the waterborne sector include:

1. A proposal to extend the European emissions trading system to maritime transport for the ships above 5 000 GT [6], thereby creating a CO_2 price signal, fostering the reduction of GHG emissions in a flexible and cost-effective manner, and generating revenues to tackle climate change and encourage innovation;
2. A proposal to boost demand for marine renewable and low-carbon fuels (the FuelEU Maritime Regulation)[7], by setting a maximum limit on the annual greenhouse gas intensity of energy used by ships calling at European ports, based on a technology-neutral approach and by encouraging zero-emission technology at berth;
3. A proposal to boost alternative fuel distribution (the Regulation on Alternative Fuels Infrastructure - AFIR)[8], which would set, among others, mandatory targets for shore-side electricity supply at maritime and inland waterway ports;
4. A proposal to accelerate the supply of renewables in the EU, through a revision of the Renewable Energy Directive (RED)[9] which increases the current EU-level target of 'at least 32%' of renewable energy sources in the overall energy mix to at least 40% by 2030, with a focus on sectors where progress has been slower to date – including (maritime) transport;
5. A proposal to revise the existing Energy Taxation Directive (ETD)[10] which aims at aligning the taxation of energy products with EU's climate objectives and removing outdated exemptions such as for the intra-EU maritime transport sector.

All these measures reflect the objective to reduce GHG emissions by addressing the various barriers to the decarbonisation of the sector (technological barriers, economic barriers, etc.), and through two complementary angles: first, the improvement of energy efficiency (i.e. using less fuel) and, second, increased use of renewable and low-carbon fuels (i.e. using cleaner fuels). These measures will allow the creation of a virtuous ecosystem for such cleaner fuels, as it boosts at the same time fuel demand, distribution, and supply. In addition, the Commission has launched some non-regulatory measures, which include amongst other a stronger, more targeted support to development, demonstration and deployment of clean innovative

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[6] Proposal for a Directive amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/757 (COM(2021) 551 final).

[7] Proposal for a Regulation on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC (COM/2021/562 final).

[8] Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council (COM/2021/559 final).

[9] Proposal for a Directive amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 (COM/2021/557 final).

[10] Proposal for a Council Directive restructuring the Union framework for the taxation of energy products and electricity (recast) (COM/2021/563 final).

technologies, enabling use of sustainable alternative fuels and other emission reducing solutions by ships. The Commission will continue supporting research and innovation towards the decarbonisation of maritime transport, in particular through Horizon Europe and the Innovation Fund. One of the initiatives supporting research and innovation in this area is the Horizon Europe Zero-Emission Waterborne Transport partnership, which underpins the objectives of the upcoming regulations.

The year 2022 saw significant legislative progress on the different files under the Fit for 55 Package, and, at the time of writing (November 2022), the European Parliament[11] and the Council[12] have adopted their positions with regards to most of the above-mentioned policy proposals and interinstitutional negotiations are ongoing.

In parallel, the Commission is committed to support ambitious progress at international level through the further implementation and revision of the IMO Strategy for GHG emission reductions.

1.2.3. Action at IMO level

In April 2018, IMO's Marine Environment Protection Committee (MEPC) adopted the 'Initial IMO Strategy on Reduction of GHG Emissions from Ships' (MEPC 72/17/Add.1, Annex 11).

The strategy aims to phase out GHG emissions from international shipping as soon as possible in this century. In addition, the initial strategy sets the ambitions to:

1. improve the carbon intensity of shipping by at least 40% by 2030, relative to 2008, and pursue efforts to improve it by 70% by 2050; and
2. reduce the GHG emissions of shipping by at least 50% by 2050, relative to 2008.

A revision of the initial strategy is scheduled for 2023 and the aim of the European Union is to revise it with the view to phase out GHG emissions from international shipping by 2050 at the latest following a pathway consistent with the goals of the Paris Agreement.

To achieve the levels of ambition, short-, medium- and long-term policy measures will be developed as part of the strategy.

Two specific short-term measures have been adopted by MEPC 76 in 2021:

1. A ship energy efficiency rating scheme based on the Carbon Intensity Indicator (CII) will be implemented starting 2023 for ships already subject to the IMO Data Collection System (DCS) requirements (5 000 GT and above). Ships that will rate D for three consecutive years or rate E, shall develop a plan of corrective actions to achieve the required annual CII and shall duly undertake the planned actions in accordance with the revised Ship Energy Efficiency Management Plan (SEEMP). In addition, administrations, port authorities, and other stakeholders are encouraged to provide incentives to ships rated as A or B. (Resolution MEPC.328(76), Regulation 28)
2. The Energy Efficiency Existing Ship Index (EEXI) will require all ships of 400 GT and above to meet technical standards comparable to the Energy Efficiency Design Index (EEDI) requirements that already apply for newbuild ships.

The amendments to MARPOL Annex VI required for the implementation of the two measures entered into force on 1 November 2022, with the requirements for EEXI and CII certification

[11] The European Parliament adopted its position on EU ETS on 22 June 2022, FuelEU Maritime on 19 October 2022.

[12] The Council agreed on its General approach to EU ETS on 29 June 2022, General approach to FuelEU Maritime on 2 June 2022.

coming into effect from 1 January 2023. The first annual reporting will be completed in 2023, with the first rating given in 2024 (IMO, 2021).

Medium- and long-term GHG reduction measures are currently under development.

The Work Plan for Development of Mid- and Long-Term Measures (MEPC 76/15/Add.2) consists of three main phases:

Phase I – Collation and initial consideration of proposals for measures;

Phase II – Assessment and selection of measure(s) to further develop; and

Phase III – Development of (a) measure(s) to be finalized within (an) agreed target date(s).

Five concrete proposals have advanced to Phase II of the work plan and will be further assessed. Among these proposal is the global GHG Fuel Standard (GFS) as proposed by the EU-27 countries together with Norway and the European Commission (ISWG-GHG 12/3/3) who also brought forward a combination of the GFS with a carbon pricing measure (ISWG-GHG 12/3/5).

1.3. Impact of maritime transport on global warming

The Intergovernmental Panel on Climate Change (IPCC) defines two broad categories of climate forcers: "long-lived GHGs, such as CO_2 and nitrous oxide (N_2O), whose warming impact depends primarily on the total cumulative amount emitted over the past century or the entire industrial epoch; and short-lived climate forcers (SLCFs), such as methane and black carbon, whose warming impact depends primarily on current and recent annual emission rates…. These different dependencies affect the emissions reductions required of individual forcers to limit warming to 1.5°C or any other level." (Allen et al., 2018). The different ways in which different types of climate forcers have to be taken into account when calculating aggregate emissions result from the different characteristics of the forcers. "Emissions of long-lived greenhouse gases such as CO_2 and N_2O have a very persistent impact on radiative forcing…, lasting from over a century (in the case of N_2O) to hundreds of thousands of years (for CO_2). The radiative forcing impact of short-lived climate forcers (SLCFs) such as methane (CH_4) and aerosols, in contrast, persist for at most about a decade (in the case of methane) down to only a few days." (Allen et al., 2018)

The IPCC's Special Report continues to explain that "whatever method is used to relate emissions of different greenhouse gases, scenarios achieving stable global mean surface temperature, added, well below 2°C require both near-zero net emissions of long-lived greenhouse gases and deep reductions in warming SLCFs…, in part to compensate for the reductions in cooling SLCFs that are expected to accompany reductions in CO_2 emissions…." (Allen et al., 2018).

Greenhouse gases (GHGs) coming from ships include for the most part CO_2 as the result of the combustion of mainly fossil fuels in the ship's combustion machinery (i.e., engines, auxiliary engines, boilers, etc.). Methane (CH_4) may be emitted to the atmosphere on ships using gas or dual fuel engines or from the cargo tanks in Liquified Natural Gas (LNG) carriers. Refrigerants are used for air conditioning and for cargo cooling processes and various gases are used including Hydro Fluorocarbons (HFCs, Perfluorocarbons (PFCs) and Sulphur Hexafluoride (SF6). Other air polluting emissions of ships include sulphur oxides (SOx), nitrogen oxides (NOx) and fine and ultrafine particulate matters including black carbon (BC). SOx and NOx are precursors of particulate matters responsible for the negative impacts on human health and polluting water when deposited. In the Arctic region, in particular, direct emissions of black carbon from shipping are also significant drivers of warming.

Emissions Inventory

In November 2020, MEPC 75 approved the Fourth IMO GHG Study. The study covers the historical emissions from shipping for the period 2012-2018. Overall, the GHG shipping emissions – including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), expressed in CO_2 equivalent (CO_2e) and including all shipping (international, domestic and fishing) have increased from 977 million tonnes in 2012 to 1,076 million tonnes in 2018, representing a 9.6% increase. The share of shipping emissions in global anthropogenic emissions also increased from 2.76% in 2012 to 2.89% in 2018.

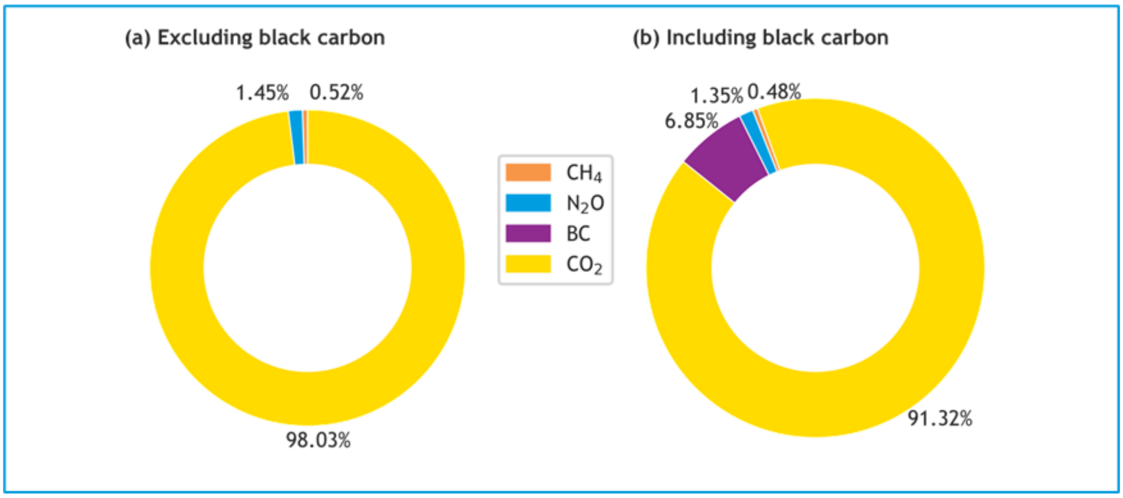

Figure 1: Contribution of different GHG emissions expressed in CO_2e to voyage-based international GHG emissions in 2018; Source: Fourth IMO GHG Study

Over the period studied 2012-2018, CO_2 emissions from international shipping increased by 5.6%. Methane emissions increased by 150%, far greater than the use of LNG as a marine fuel. Black Carbon emissions, which have a critical impact notably in Arctic waters, increased by 11.6% for total shipping (i.e. from 59 to 62 kilo tonnes).

The data reported under the IMO Data Collection System (DCS) gives an indication on the development of the CO_2 emissions after 2018, at least for the ships of 5 000 GT and above. According to the reported data, the CO_2 emissions of these ships amounted to 662 Mt in 2019. In 2020, these emissions decreased by 4.4%.

Emissions Projection

The Fourth IMO GHG Study projected global CO_2 emissions to increase from about 90% of 2008 emissions in 2018 to 90-130% of 2008 emissions by 2050 for a range of plausible long-term economic and energy scenarios.

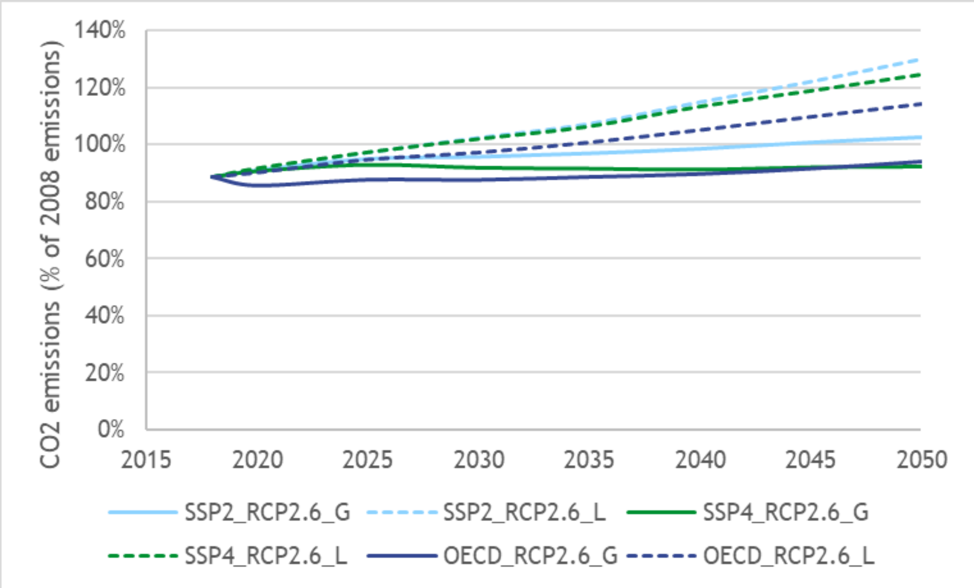

Figure 2: Projections of maritime ship emissions as a percentage of 2008 emissions; Source: Fourth IMO GHG Study

The differences in the BAU emission projections are caused by differences in transport-work projections which, in turn, are caused by differences in socio-economic projections and different methods to establish the relation between transport work and independent variables like per capita GDP, population and primary energy demand. The emissions are for total shipping.

Life Cycle GHG emissions

The inventory and the projection of the GHG emissions of maritime shipping that the IMO comissions on a regular basis, have, so far, focussed on the Tank-to-Wake emissions, i.e. the emissions that stem from the combustion of fuel on board ships. Meanwhile, the Well-to-Tank emissions that arise in the value chain of the energy carries used on board ships, up to the point where they are loaded on board ships, gain increasing interest. The proposed FuelEU Maritime Regulation which would set targets for the annual GHG intensity of the energy used on bord ships, would apply to CO_2, CH_4 and N_2O emissions considering both the Tank-to-Wake and the Well-to-Tank emissions.

At the IMO level, Guidelines for the Marine Fuel Life Cycle GHG Analysis are under development. A Correspondence Group under the coordination of China, Japan and the European Commission has been established which was instructed to further develop the draft guidelines on life cycle GHG intensity[13] with a view to finalizing the draft guidelines at MEPC 80 (July 2023). The Interim report of the Correspondence Group has been sumitted to MEPC 79 (MEPC 79/7/12).

[13] The Corresponding Group was instructed (see MEPC 79/7/12) to use annex 1 to document ISWG-GHG 11/2/3 as the basis and to also take into account relevant documents submitted to ISWG-GHG 11, documents MEPC 78/7/13 (Republic of Korea), MEPC 78/7/19 and MEPC 78/INF.25 (Solomon Islands et al.), and decisions and comments made at ISWG-GHG 11 and MEPC 78.

2. CO_2 emissions and related fuel consumption from the monitored fleet

Main findings

In 2021, 11 800 ships submitted an emissions report, accounting for 124.3 million tonnes of CO_2. While this represents a 3.5% decrease compared to 2020 emissions, the comparison with previous reporting years should be treated with caution since 2021 is the first year which accounts for the withdrawal of the United Kingdom from the European Union. In addition, 2021 data were marked by the partial recovery from the economic effects of the 2020 COVID crisis.

In more details, the analysis of 2021 data shows that:

- Container ships had the highest proportion in the fleet CO_2 emissions (2021: 33%) and were, together with the emissions of oil tankers and bulk carriers, responsible for almost 60% of the 2021 fleet emissions.
- An increase of emissions of passenger ships, bulk carriers, ro-ro ships and container/ro-ro cargo in 2021 compared to 2020 despite the effect of the UK withdrawal from the EU. However, their emissions were still lower than pre-COVID levels.
- Lower CO_2 emissions for some ship types (e.g. oil tankers, LNG carriers) compared to 2020, most likely since the UK, as a non-EEA country, now falls outside the scope of the Regulation.
- A shift of reported emissions between the different types of voyages, also due to the consequences of the withdrawal of the UK from the EU.
- No major changes were recorded in the relative shares of the main fuel types consumed in 2021 compared to 2020. Among the main used fuels, LNG is the only fuel type for which consumption levels close to pre-COVID 2019 (-2%) were reported in 2021, with clear signs of an uptake in LNG consumption in few ship types beyond LNG carriers (container ships, oil tankers, and passenger ships).
- The consumption of non-conventional (non-fossil) bunker fuels remained negligible.

2.1. Fleet: emissions and number of ships

In 2021, for almost 11 800 ships an emissions report has been submitted by 1 668 companies and the total CO_2 emissions of the EU MRV fleet amounted to around 124.3 million tonnes of CO_2 (see Figure 3: Total number of ships for which emissions report has been submitted; 2018-2021 and Figure 4: Reported total fleet CO2 emissions; 2018-2021).[14]

The total number of ships for which emissions have been reported has remained relatively stable over the four reporting years. In 2021, the total number of ships was 1.2% higher than

[14] In this Fourth annual report, emissions reports of ships declaring zero emissions and no fuel consumption under the MRV scope have been discarded. The relevant figures and analysis from previous reporting years have been adjusted accordingly.

in 2020, despite the effect of the UK's withdrawal from the EU, yet 2.1% lower than in pre-COVID 2019. The highest year on record in terms of reporting ships is 2019, the lowest 2018.

In terms of emissions, the year 2019 still reports the highest total CO_2 emissions on record. In 2020, CO2 emissions droped by 12.5%, mainly due to the economic effects of COVID and in 2021, emissions reached the lowest level of emissions in the series (124.3 million tonnes). The reduction of 3.5% that can be observed between 2020 and 2021 can mainly be explained by the change of scope due to the UK's withdrawal from the EU.

The number of companies that have submitted emissions reports reached its highest point in 2021: 1.5% higher than in 2019 and 6.2% higher than in 2018 (see Annex 3).

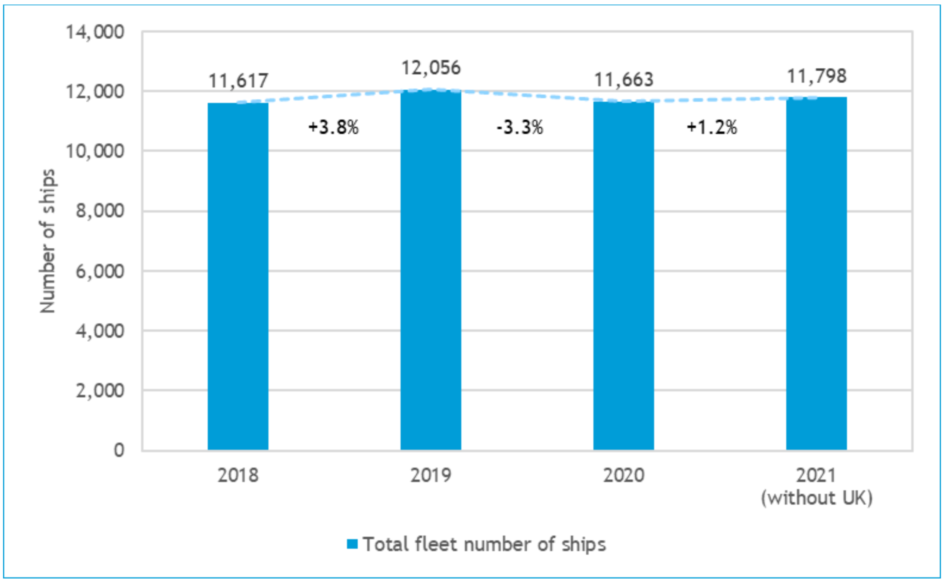

Figure 3: Total number of ships for which emissions report has been submitted; 2018-2021

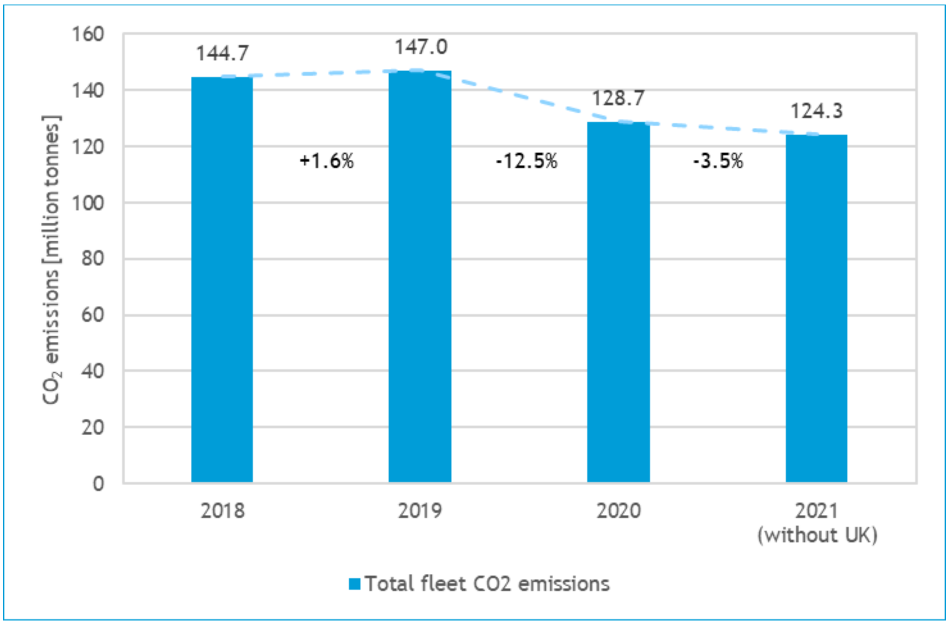

Figure 4: Reported total fleet CO_2 emissions; 2018-2021

The distribution of the fleet's total CO_2 emissions over the different types of voyages and at berth (see Figure 5) clearly shows the impact of the UK's withdrawal from the EU[15]: the share of emissions from intra-EEA voyages on total emissions has reached its lowest level (26%, against its peak of 33% in 2019), while extra-EEA voyages, both incoming and outgoing, now contribute for the highest share (35% and 33% respectively). The share of emissions at berth on the total has remained stable over the four years.

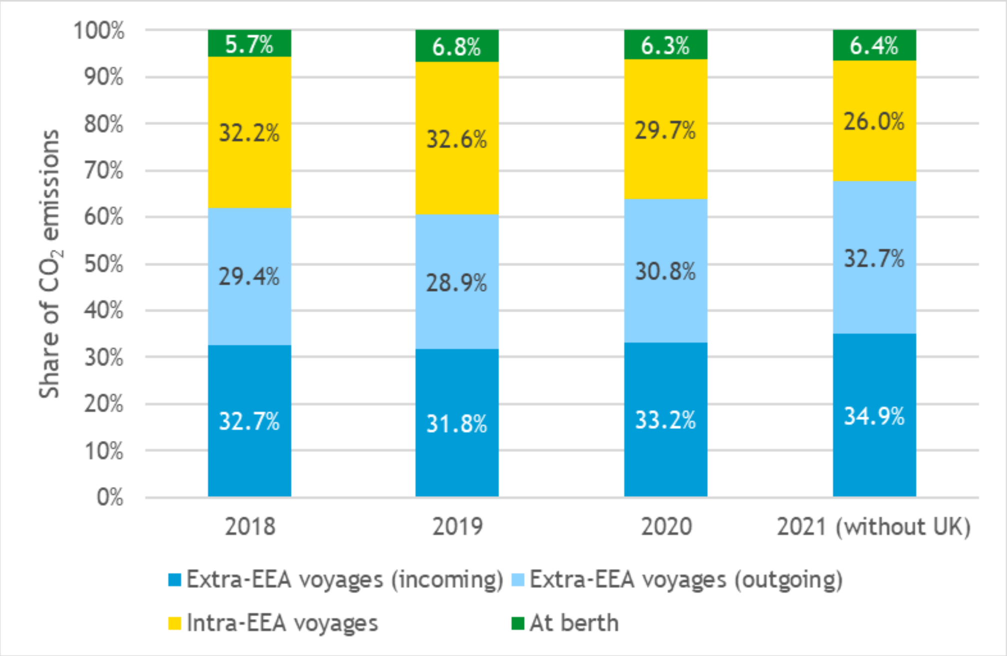

Figure 5: 2018 to 2021 share of fleet emissions per voyage type and at berth

2.2. Ship types: emissions and number of ships

Since the entry into force of the EU Maritime MRV Regulation seven out of a total of 15 ship types recorded their highest emissions levels in 2018 and six in 2019 (see Figure 6). Only LNG and combination carriers had the highest emissions in 2020. These were also the only ship types for which 2020 emissions were higher than 2019 emissions. In 2021, emissions of four ship types (passenger ships, bulk carriers, ro-ro ships, container/ro-ro cargo) increased compared to 2020, but remained below their pre-COVID levels. All other ship types reported less CO_2 emissions in 2021 compared to 2020 and with the exception of LNG carriers, no ship types attained higher emissions levels in 2021 than those of pre-COVID years (2019 or 2018). This decrease in emissions is mostly linked to the UK's withdrawal from the EU, which changed the scope of the EU MRV Regulation.

[15] As explained in section 1.2.1, as a consequence of the UK withdrawal from the EU, voyages between the UK and an EEA country are no longer considered intra-EEA voyages but rather extra-EEA voyages.

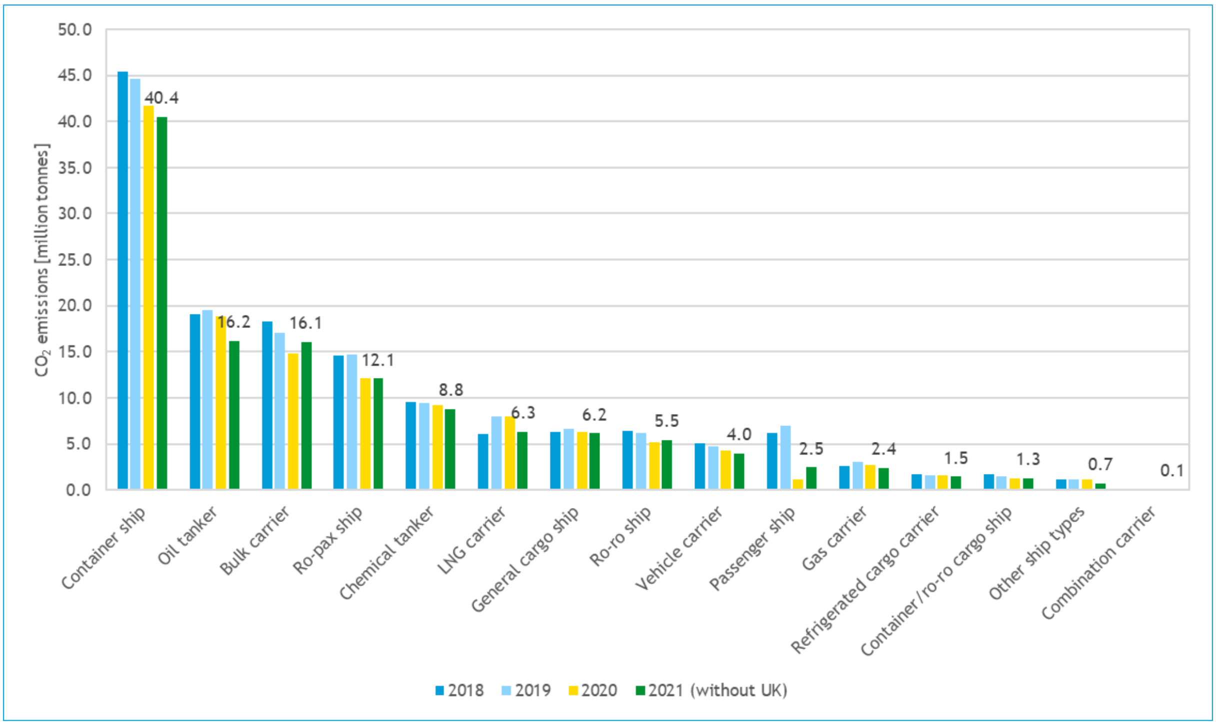

Figure 6: Total emissions per ship type; 2018 to 2021; descending 2021 order; levels given for 2021 (without UK)

As Figure 7 illustrates, compared to 2020, 2021 CO_2 emissions within the EU MRV scope have been lower for the majority of ship types, with the notable exception of passenger ships and, to a lesser extent, bulk carriers, ro-ro ships and container/ro-ro cargo ships.

The decrease of the CO_2 emissions within the scope has – in absolute terms – been relatively high for oil tankers, LNG carriers, and container ships.

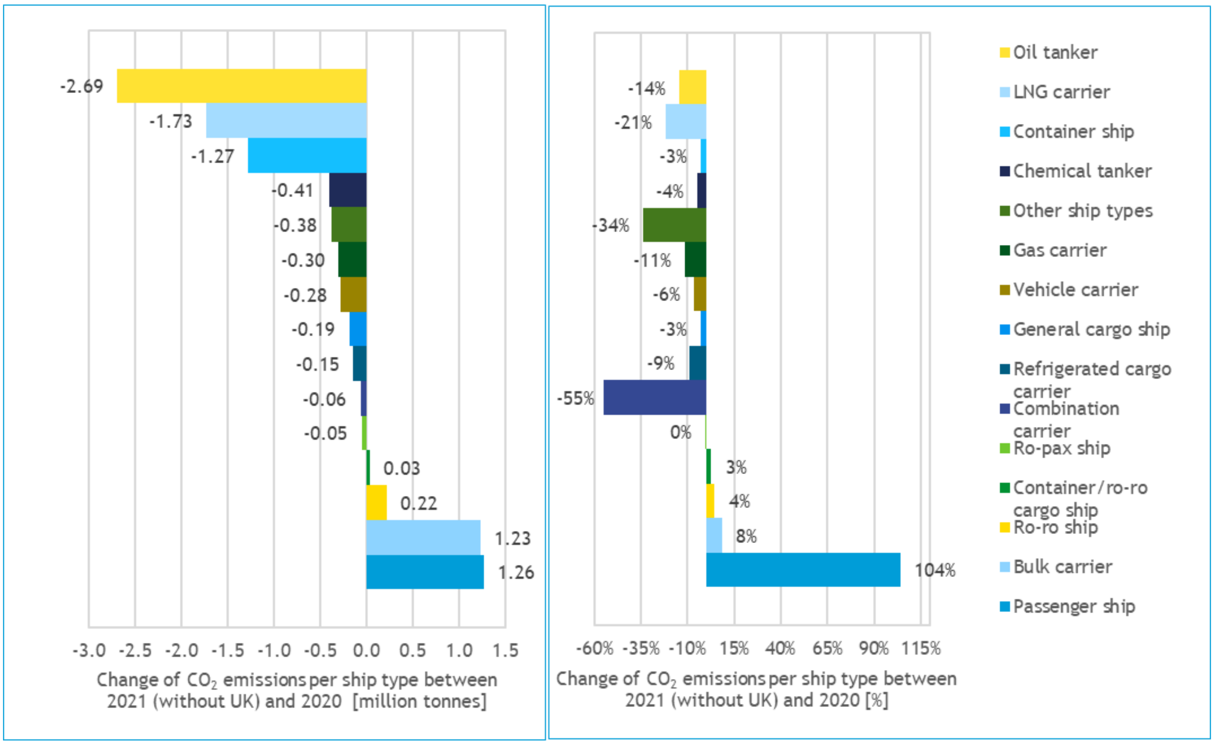

Figure 7: Change of emissions per ship type in absolute and relative terms; increasing 2021 order of absolute change

Figure 8 allows to further analyse the changes between 2021 and 2020 of the total emissions reported per ship type, by differentiating the emissions by type of voyage as well as the CO_2 emitted at berth.

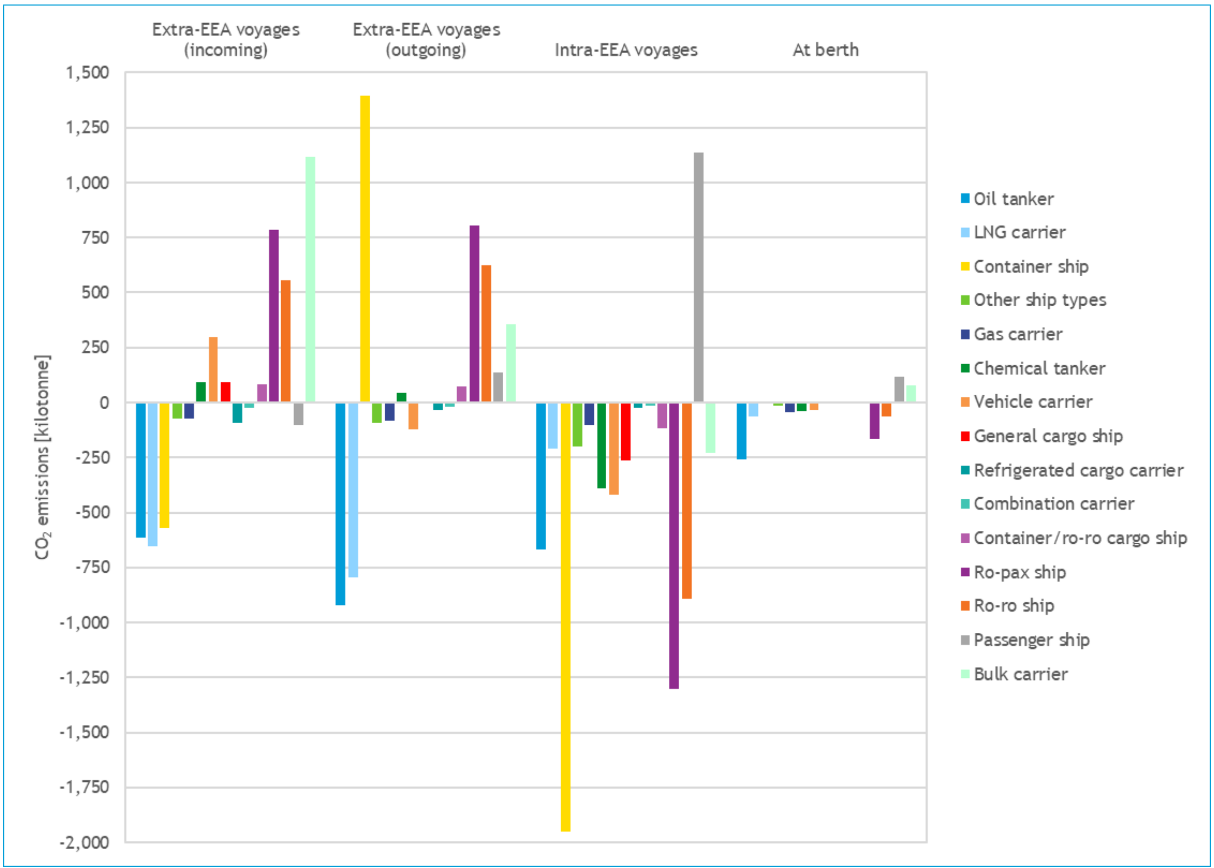

Figure 8: Change of emissions per ship type, differentiated by type of voyage; 2021 (without UK) versus 2020; ship types sorted by change of total emissions

Passenger ships show a relatively strong increase of emissions on intra-EEA voyages which indicates that the sector is recovering from the COVID-19 crisis.

Oil tanker and LNG carrier feature a relatively high drop of emissions on extra-EEA voyages (incoming & outgoing) which is probably related to the UK's withdrawal from the EU, since former extra-EEA voyages between non-EEA countries and the UK now fall outside the scope of the EU MRV system.[16]

The reported emissions of container ships are probably also impacted by the UK's withdrawal from the EU since we observe a general shift of CO_2 emissions from intra-EEA to outgoing extra-EEA voyages. We note however a decrease of CO_2 emissions related to incoming extra EEA voyages .

Ro-pax and Ro-Ro ships both feature a shift from intra-EEA voyages to extra-EEA voyages (incoming & outgoing) probably also related to the UK's withdrawal from the EU.

Bulk carriers show a relatively strong increase of emissions on extra-EEA incoming voyages with neither a strong increase of emissions on extra-EEA outgoing voyages nor a strong decrease of emissions on intra-EEA voyages. This is likely the result of an increased activity

[16] The UK has been Europe's third largest LNG importer after Spain and France in 2021 (IGU, 2022).

of bulk carriers within the EU MRV scope, coupled with possibly longer distances on incoming extra-EEA voyages compared to outgoing extra-EEA voyages.

As illustrated by Figure 9, in 2021, container ships had the highest proportion in the fleet CO_2 emissions (2021: 33%) and were, together with the emissions of oil tankers and bulk carriers, responsible for almost 60% of the 2021 fleet emissions. With CO_2 emissions above 10 million tonnes (see Figure 6), the contribution of Ro-pax ships has been relatively high too.

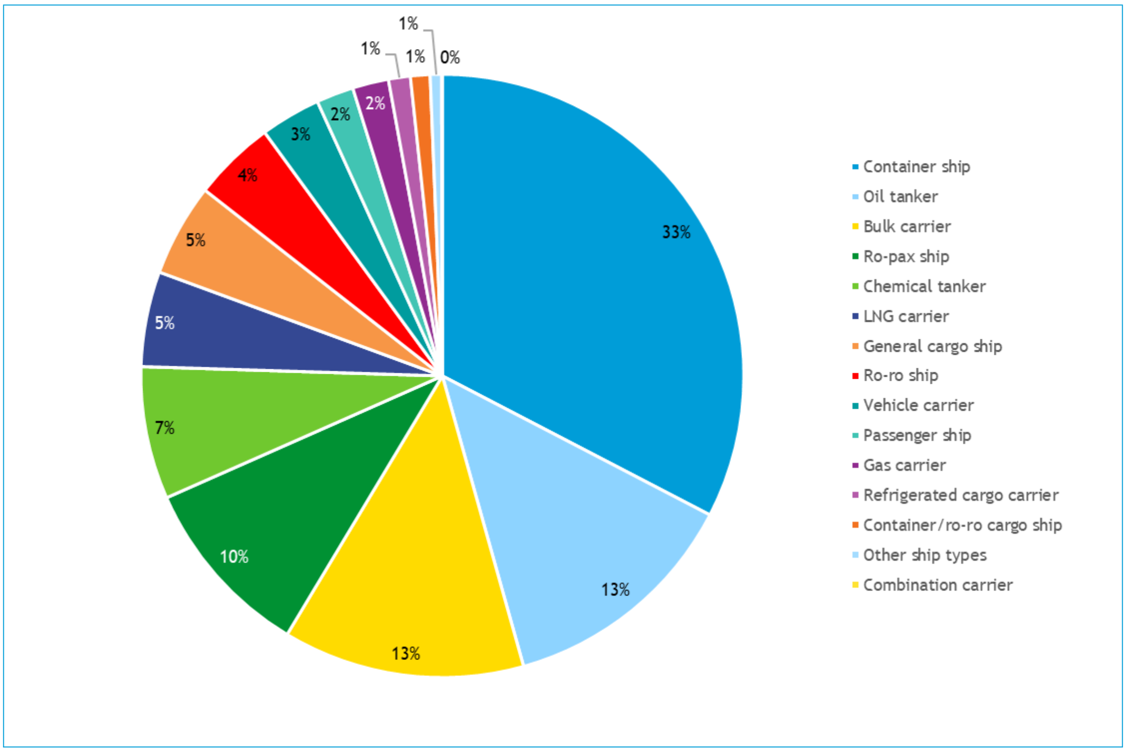

Figure 9: Ship types' share in fleet CO_2 emissions; 2021 (without UK)

The share of the different ship types in the fleet CO_2 emissions has been similar across the four reporting periods (see Figure 10). Only the share of passenger ships, with 1% and 2% in 2020 and 2021, remains much lower than in the pre-COVID-19 years (4% in 2018 and 5% in 2019).

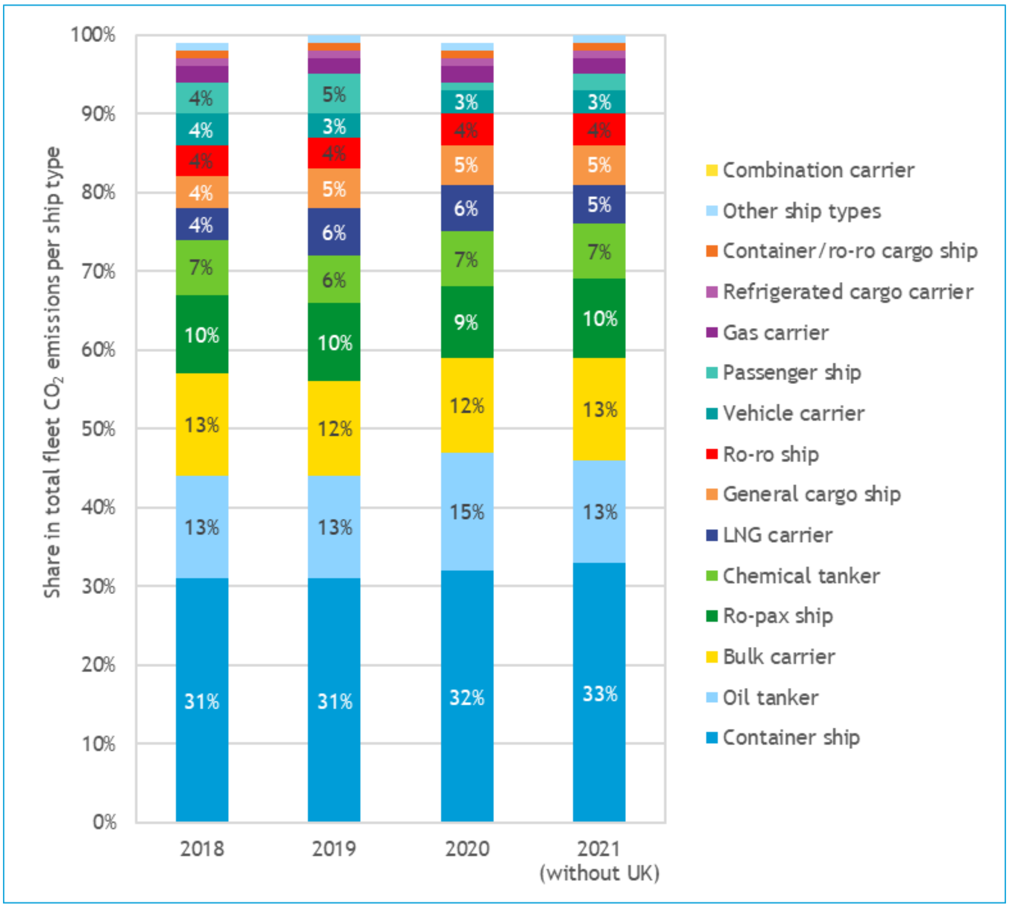

Figure 10: Ship types' share in fleet CO_2 emissions; 2018 - 2021

Five ships types keep representing the lion's share of total ships reporting under the EU Maritime MRV, as in the three previous years (see Figure 11): bulk carriers, oil tankers, container ships, chemical tankers and general cargo ships together account for 82.1 % of emissions reports submitted in 2021.

In absolute terms, the two ship types for which the greater change in the number of reporting ships was recorded in 2021 compared to 2020 were (see Figure 12) bulk carriers (+287 ships, +9%) and oil tankers (-96 ships, -5%). While in the case of bulk carriers this brought the levels in line with pre-COVID years (both 2018 and 2019), for oil tankers 2021 saw a -7.2% change on 2019.

Focusing on pre-COVID levels from 2019, two main trends stand out: the much lower number of passenger ships (-41%), and ro-ro ships (-19.9%) reporting, which signal the long-lasting effects of the COVID economic crisis still affecting 2019 for such market segments; and the sustained increase across the four reporting year in the number of LNG carriers (+35.7% on 2018).

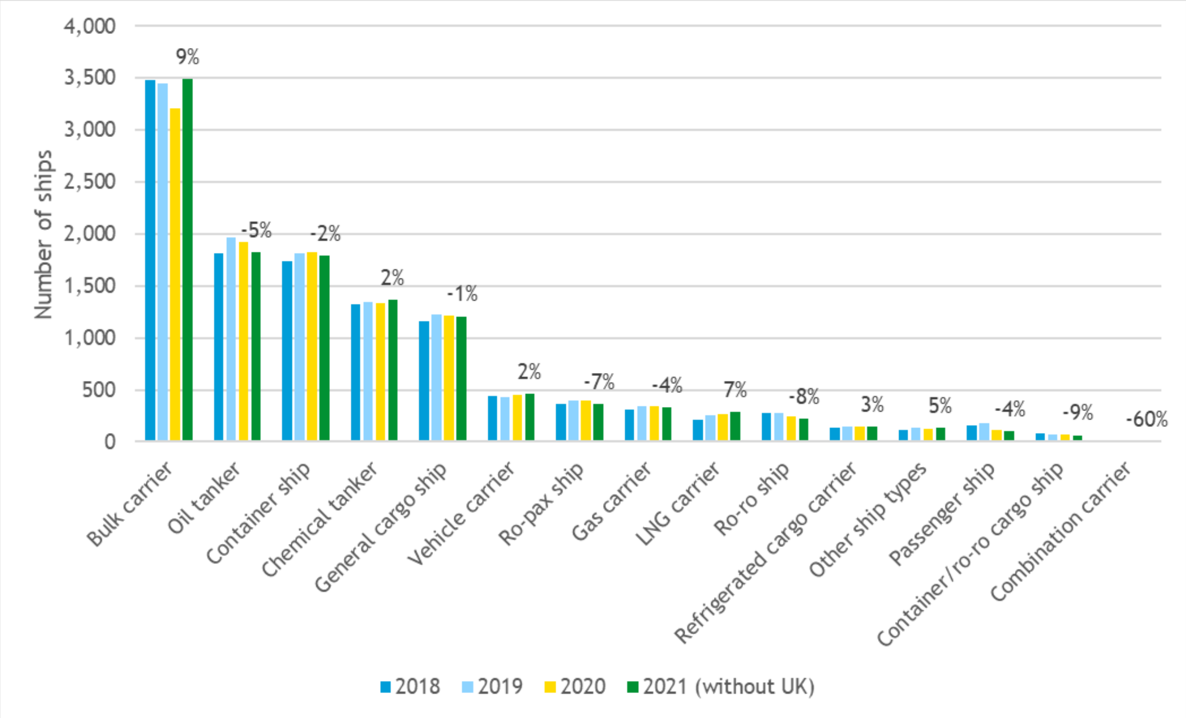

Figure 11: Number of ships per ship type; 2018 to 2021; descending 2021 order; percentage= 2021 compared to 2020;

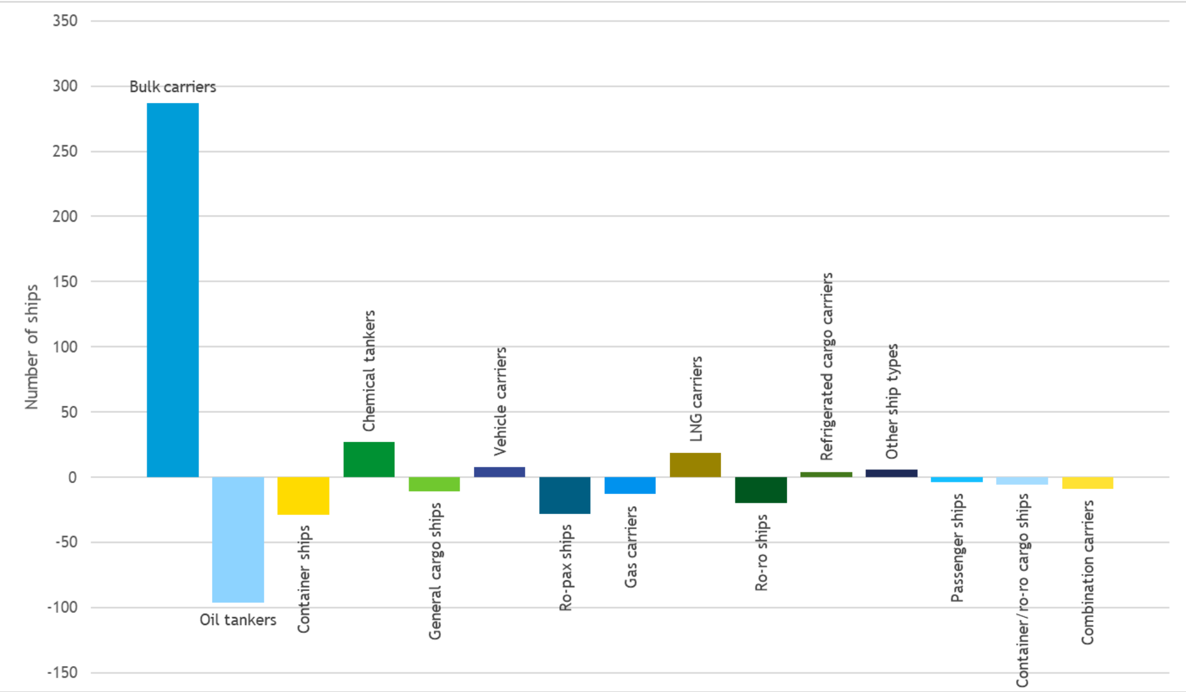

Figure 12: Change of number of ships per ship type; 2021 (without UK) versus 2020; order in line with Figure 11

The average emissions of almost all ship types dropped in 2020 and of most of the ship types they dropped even further in 2021. Only passenger ships, Ro-pax, Ro-ro, combination carriers and container/ro-ro cargo ships showed an increase of the 2021 average emissions. And only the 2021 average emissions of Ro-ro ships surpassed the 2019 level. This also points to only a partial recovery from the COVID-19 crisis for such ship types.

2.3. Further analysis of CO_2 emissions

In principle, the annual reported fleet CO_2 emissions can vary over time due to four main factors, the last three of which also have an impact on the average per ship emissions:

1. More/less ships have been active within the scope of the Regulation;
2. The ships active within the scope of the Regulation have been more/less used;
3. The ships active within the scope of the Regulation have been more/less energy efficient;
4. The ships active within the scope of the Regulation have used energy carriers that are more/less carbon intensive.

In addition to these four main factors, the year 2021 saw a change in the geographical scope of the Regulation due to the withdrawal of the UK from the EU.[17] Since both UK domestic voyages and voyages between a UK port and a third non-EEA country are no longer reported under the Regulation, all conditions being equal, less ships and voyages were monitored in 2021 in the system, less distance travelled and ultimately less reported emissions. On the other hand, the average energy efficiency and the average carbon intensity of the energy carriers used has not necessarily changed due to the adjusted scope of the system. Still, the average distance sailed for certain ship types monitored under the system may have changed if the length of voyages to/from the UK from/to non-EEA countries was above or below the average compared to previous years.

Below the changes in CO_2 emissions are further analysed for specific ship types. The reported data thereby allows to determine factors that mainly explain the observed changes, but does not allow to draw conclusions on the underlying factors, like the change of the scope of the EU Maritime MRV system. The analysis of the reported data over the period 2018-2021 shows that the first two of the above listed factors (number of reporting ships per ship type and activity levels as average distance sailed) are key to explain the development of the CO_2 emissions per ship type over the period. For some specific ship types, also the use of LNG (mainly LNG carriers and gas carriers) and the change in speed (mainly passenger ships) come into play.

The analysis of key emissions changes per ship type in the reporting year 2021 compared to the previous year focuses on those ship types featuring the highest decrease (see Table 1) and highest increase (see Table 2) in absolute CO_2 emissions.

Oil tankers, LNG carriers and container ships key indicators are shown below (see also Figure 7).

[17] Due to the UK's withdrawal from the EU, the geographical scope of the EU Maritime MRV Regulation has changed in the reporting period 2021: voyages within the UK and between the UK and other non-EEA countries now fall outside the scope of the system and voyages between the UK and EEA countries are no longer considered as intra-EEA voyages but incoming/outgoing extra EEA voyages.

Table 1 Analysis of 2021 CO_2 emissions decrease

Ship types featuring highest decrease of absolute CO_2 emissions compared to 2020

Ship type	Change of CO_2 emissions compared to 2020	Change of number of reporting ships compared to 2020	Change of average per ship emissions compared to 2020	Change of average distance sailed compared to 2020	Change of average emissions per nautical mile compared to 2020
Oil tankers	-14.3%	-5.0%	-9.8%	-5.1%	-5.0%
LNG carriers	-21.4%	+7 %	-26.7 %	-19.0%	-9.4%
Container ships	-3.1%	-2%	-1.5 %	-3.9%	+2.5%

Analysing this emissions decrease for these three ship types, it can be concluded that:

1. the decrease of the emissions of oil tankers and container ships cannot only be explained by the lower number of reporting ships; a decrease of the average per ship emissions plays a role too, especially for oil tankers. The average distance sailed has indeed decreased for both ship types and to a higher extend for oil tankers. In addition, for oil tankers a decrease of the average emissions per nautical mile can also be observed, whereas for container ships the average emissions per nautical was higher in 2021 compared to 2020.
2. the emissions of LNG carriers have decreased even though more ships have been active. This is due to a significant drop of average per ship emissions (-27%). The decrease of the average distance sailed (-19%) is an important factor in this context. It also indicates that the 2021 trade of LNG carriers in the scope of the EU Maritime MVR clearly followed a different pattern than in 2020. In addition, the average emissions per distance sailed was lower. A higher share of LNG consumption contributed to lower average per ship emissions.

Passenger ships, bulk carriers, and Ro-Ro ships showed, in absolute terms, the largest increase of the per ship type CO_2 emissions between 2020 and 2021 (see Figure 7).

Analysing this emissions increase for these three ship types (see also Table 2), it can be concluded that:

1. the emissions of passenger ships and Ro-ro ships have increased even though less ships have been active within the scope - the average emissions per ship and the average distance sailed increased significantly compared to 2020. This is especially evident for passenger ships and is an indication for the (partial) recovery of the sector. For passenger ships, the impact of the higher activity within the scope is partially offset by lower average emissions per nautical mile whereas for Ro-ro ships slightly higer average emissions per nautical mile reinforce the effect of the higher acitivity on the emissions.
2. The increase of the emissions of bulk carriers (+8.3%) is almost in line with the higher number (+8.7%) of ships that have been active within the scope, but the slight decrease of the average emissions per ship led to a slightly lower increase of the emissions. Bulker carriers sailed on average less within the scope of the EU Maritime MRV Regulation, but at the same time the emissions per nautical mile increased.

Table 2 Analysis of 2021 CO_2 emissions increase

Ship types featuring highest increase of absolute CO_2 emissions compared to 2020

Ship type	Change of CO_2 emissions compared to 2020	Change of number of reporting ships compared to 2020	Change of average per ship emissions compared to 2020	Change of average distance sailed compared to 2020	Change of average emissions per nautical mile compared to 2020
Passenger ships	+103.9%	-3.6 %	+111.7%	+167.0%	-21.7%
Bulk carriers	+8.3%	+8.7%	-0.6%	-5.7%	+5.4%
Ro-ro ships	+4.3%	-8.3%	+13.7%	+11.7%	+1.8%

2.4. Fuel consumption

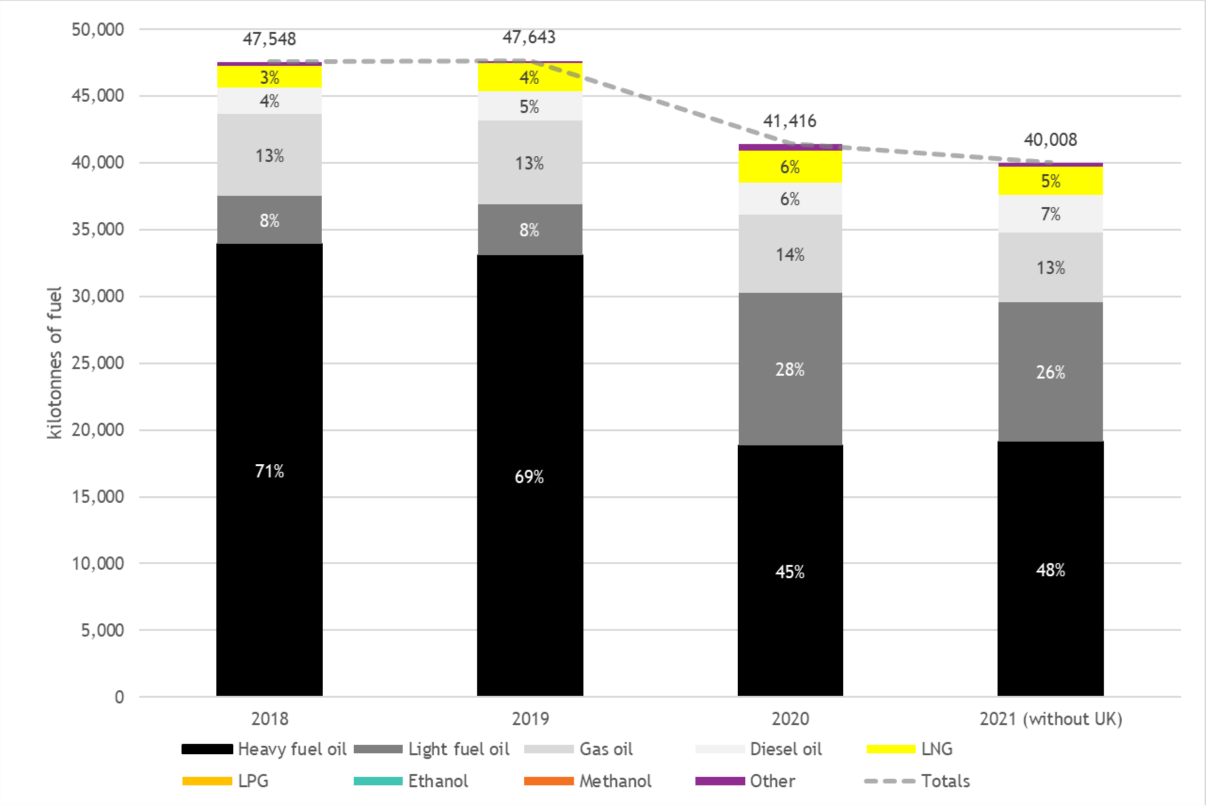

Figure 13: 2018 to 2021 total fuel consumption of EU MRV fleet and shares per fuel type

In 2021, as indicated by the length of the bar in Figure 13, the EU MRV fleet consumed in total around 40,000 kilotonnes (40 million tonnes) of fuel within the geographical scope of the Regulation, 3.4 % less than in 2020. In line with 2020, 5.5 % of the 2021 total fuel consumption was reported as fuel consumed at berth.

While the shares of the different fuel types in 2021 have hardly changed compared to 2020, we can observe as from 2020 a severe reduction of the use of Heavy Fuel Oil. This is the result of MARPOL Annex VI Regulation 14, which sets limits to the sulphur content of bunker fuel oils. Some of the requirements have became stricter at the beginning of 2020: outside Emission Control Areas, the maximum allowed sulphur content of the fuel has been reduced from 3.5% to 0.5% m/m. To comply with this sulphur limit, ships can either use energy carriers with a lower sulphur content (Very low sulphur fuel oil (VLSFO), low sulphur marine gas oil, LNG, LPG, methanol or ethanol) or can keep on using heavy fuel oil in combination with an exhaust gas cleaning system.

For most ship types, except LNG carriers, Other ship types and Combination carriers, Heavy fuel oil (HFO) is the fuel type with the highest share in the total 2021 fuel consumption. For Other ship types and Combination Carriers, the share of light oil is higher than that of HFO. LNG carriers' fuel consumption is highly dominated by LNG (75%) – these ships transport LNG and can also use LNG for propulsion purposes.

The share of LNG in the total fuel consumption had increased from 3.4% in 2018 to 5.8% in 2020. With 5.2% in 2021, LNG had a lower share in the total fuel consumption than in 2020, but a higher share compared to 2019.

Reported total LNG consumption increased in the period 2018 to 2020 and has decreased in 2021 by 14% to almost the same level (2% lower) as in 2019 (see Figure 14).

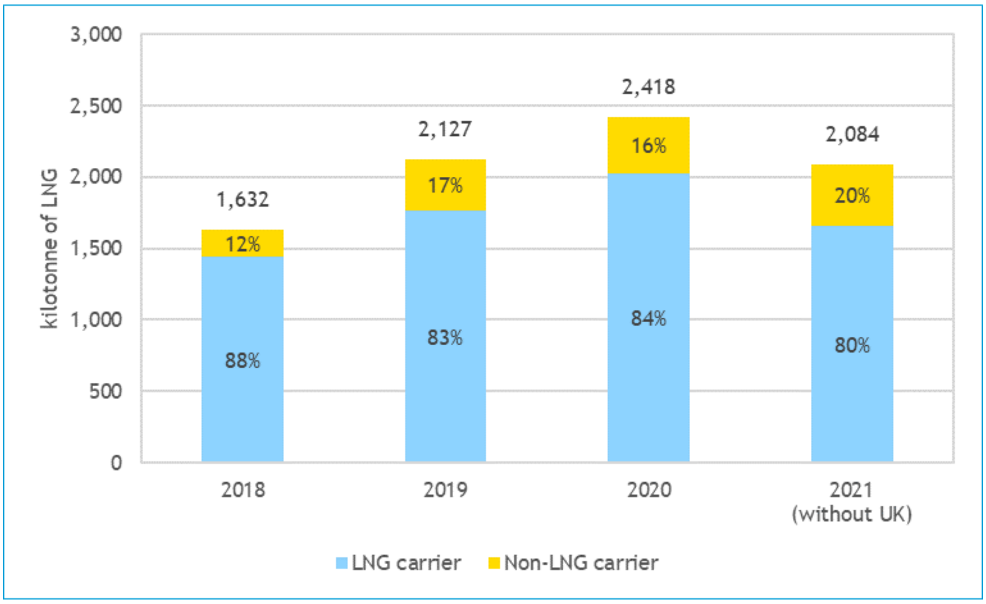

Figure 14: Total LNG consumption and distribution of the consumption over LNG and non-LNG carriers

The share of LNG carriers in the total LNG consumption has decreased from 88% in 2018 to 80% in 2021, but LNG carriers still account for the great majority of LNG consumption (see Figure 14). Total 2021 LNG consumption by LNG carriers within the scope of the EU MRV Regulation has decreased by 18% compared to 2020, relatively more than the overall fuel consumption of the fleet.

As Figure 14 illustrates, beyond LNG carriers, nine out of the fourteen other ship types used LNG. LNG consumption of non-LNG carriers almost doubled (+91%) between 2018 and 2019 and has gradually, but continously, increased thereafter. In 2021, non-LNG carriers consumed 424 kilotonnes of LNG which is around 8% more than in 2020.

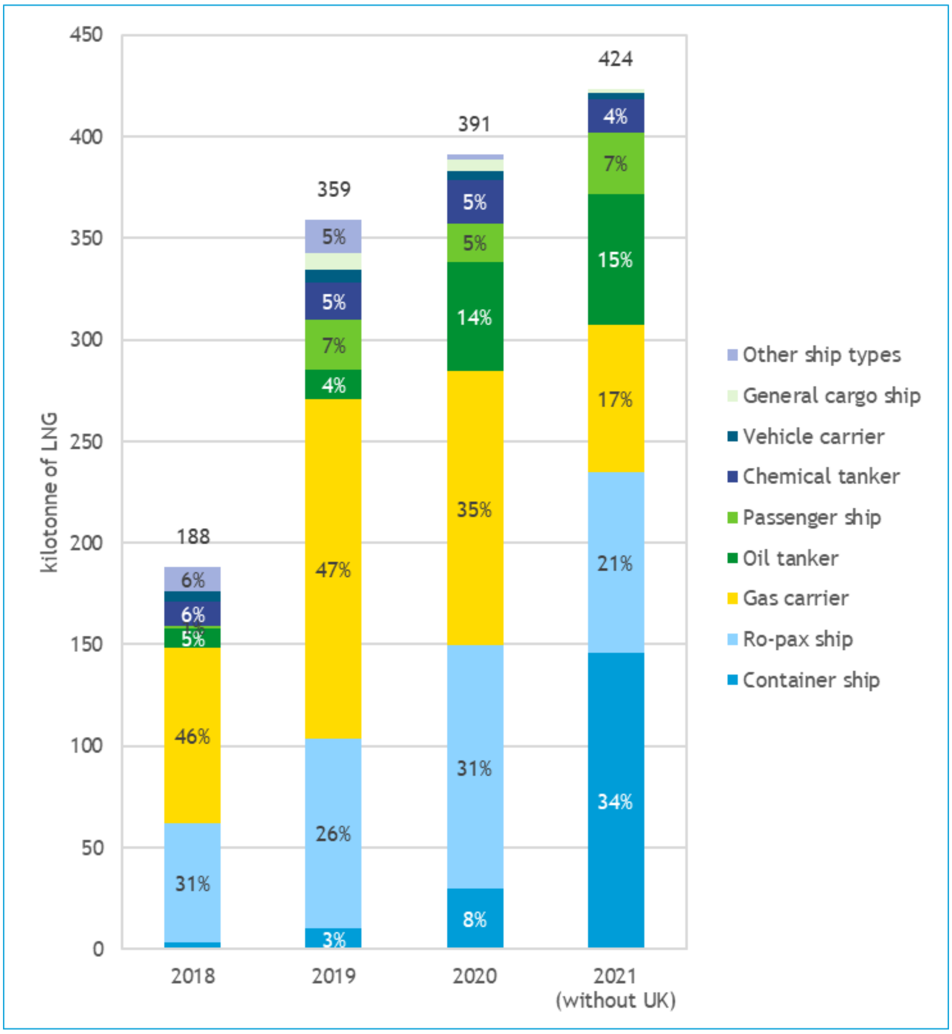

Figure 15: LNG consumed by ship types other than LNG carriers

Compared to 2020, only three of the nine ship types have consumed more LNG within the scope of the EU Maritime MRV in 2021: container ships, oil tankers, and passenger ships. Container ships and oil tankers have increased their consumption every year since the beginning of the EU Maritime MRV reporting, recording in 2021 a +4349% and a +576% increase on 2018 respectively. LNG consumption of passenger ships dropped in 2020, but increased relatively strongly in 2021, leading to a 2021 level of 30 kt which is 24% above the pre-COVID 2019 level.

The reported lower 2021 LNG consumption of some ship types is probably, at least partially, related to the UK's withdrawal from the EU. LNG carriers for example, which are currently the main user of LNG in the shipping sector, are no longer captured by the EU MRV system if they sail directly from a non-EEA country (e.g., a country in the Middle East) to the UK. In 2021, the UK has been Europe's third largest importer of LNG after Spain and France and the eighth largest wordwide (IGU, 2022).

The share of LPG (0.007%), ethanol (0%), methanol (0.0003%), and 'Other fuel types' (0.76%) in the fleet's overall fuel consumption remains neglible.

LPG use, either as butane or propane, within the EU Maritime MRV scope has more than doubled between 2020 and 2021, though the volume used remains negligible (2.9 kilotonnes in 2021). The sector only very recently (2020) started to use LPG as marine fuel. Currently

(June 2022), worldwide, 19 LPG-fueled ships are in service and another 57 on order (DNV, 2022).

The year 2021 recorded a drop in the use of methanol within the EU MRV scope (-96%) compared to 2020. Currently (June 2022), there are 11 methanol-fueled ships in service and 35 on order worldwide (DNV, 2022).

No ethanol consumption was reported in the year 2021: the only reporting year recording ethanol consumption in the EU Maritime MRV remains 2020 with 0.56 kilotonnes.

Under the category ‘Other fuel types’ ships report alternative fuel types not matching any of the other categories. Its highest volume (485 kilotonnes) was reported in 2020, and the year 2021 recorded a 37% decrease for this fuel group.

3. The monitored voyages at a glance: shipping routes, speed and time spent at sea

Main findings

Main shipping routes

- There was in 2021 a high demand of waterborne transport services between the EU and Russia, the USA, but also neighbouring non-EU countries such as the United Kingdom, Norway and Türkiye.
- While most of the main extra EU-27 flows decreased in 2020 compared to 2019, between 2020 and 2021 the different flows developed quite differently. Seven of the top 15 flows increased in 2021, but did not reach 2019 levels again. Only the outward flow from Türkiye shows a continuous growth in the period 2018 to 2021.

Fleet speed and time spent at sea

- Speed variation in the period 2018-2021 is negligible for most ship types. There are no signs of any ship type structurally slowing down over the period, with the notable exception of those still suffering from the economic effects of COVID-19 (e.g. passenger ships).
- Both the average time at sea and the total time at sea increased in 2021 compared to 2020 for passenger ships and ro-pax ships, a clear indication that for such ship types the recovery from the COVID-19 crisis has more than balanced the negative effects of the United Kingdom's withdrawal from the EU.

3.1. Main shipping routes

Similar to what was reported in the previous three annual emission reports, MRV voyages analysis continues to largely corroborate the data provided by Eurostat in terms of EU trade flows by gross weight of freight handled in main ports (see Figure 16). It shows a high demand of waterborne transport services between the EU and countries such as Russia, the USA and neighbouring non-EU countries such as the United Kingdom, Norway and Türkiye.

Table 7 in the Annex provides the main extra EU-27 flows by gross weight handled in main ports in the years 2018 to 2021 in million tonnes. Due to COVID-19 most inward and outward flows decreased in 2020 compared to 2019, with the exception of inward flows from the United Kingdom and Russia (Black Sea) and outward flows to China and Türkiye. Between 2020 and 2021, however, the different flows have developed quite differently. Flows from Egypt, Nigeria and the U.S.A (East Coast) dropped further, the inward flow from the UK and the outward flow China dropped in 2021 to levels above 2019 levels, the inward flows from Russia (Baltic Sea) and Türkiye and the outward flow from the UK increased to levels above 2019 levels and the remaining seven of the top 15 flows increased in 2021, but did not reach 2019 levels again. Only the outward flow from Türkiye shows a continuous growth in the period 2018 to 2021.

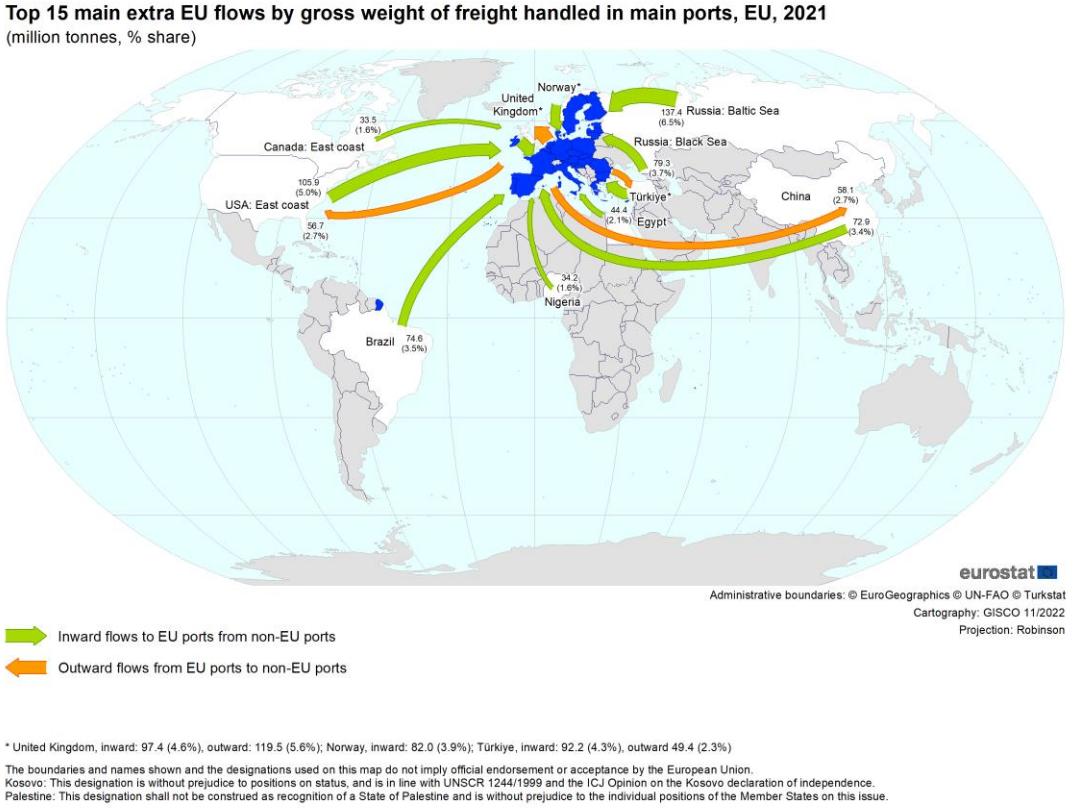

Figure 16: Main extra EU flows; Source: Eurostat (2022)

3.2. Fleet speed

3.2.1. Average speed by ship type

The speed at which ships sail is an important determinant of the ships' operational energy efficiency. By reducing their speed, ships can signficantly reduce the fuel consumption of their main engines. This leads, in many cases, to a net reduction of the ships' fuel consumption and therefore CO_2 emissions even if the ships' fuel consumption of the auxiliary engines may go up due to longer transit times and/or extra ship capacity has to be used to carry out the same amount of transport work.

Speed is a parameter which is difficult to compare between different ship types since their different ship designs and business models play an important role. However, speed variation over time is a relevant indicator to explain the evolution of the operational energy efficiency of ships.

In this context, the average speed by ship type has been calculated based on the monitored fleet reported figures (time spent at sea and distance travelled). Figure 17 provides an overview for the four reporting years whereas Figure 18 zooms in on 2021, illustrating the differences between the ship types, and gives the 2021 average speed per ship type.

Speed variation in the period 2018-2021 is negligible for most ship types. There are no signs of any ship type structurally slowing down over the period in the form of a clear sustained reduction pattern over time. In 2021, for most of the ship types, with the exception of oil tankers and LNG carriers, and combination carriers, the average speed seems to be the same as in 2020 or to have slightly increased. A notable exception is represented by passenger ships, for which the significant drop in average speed recorded in 2020 was not reverted in the year 2021. This can be for two reasons: the ships could deliberately be operated at lower speeds and/or the operational pattern of the ships still differs from the pattern in 2019 with a higher share of operations in ports and coastal areas where ships naturally sail at lower speeds.

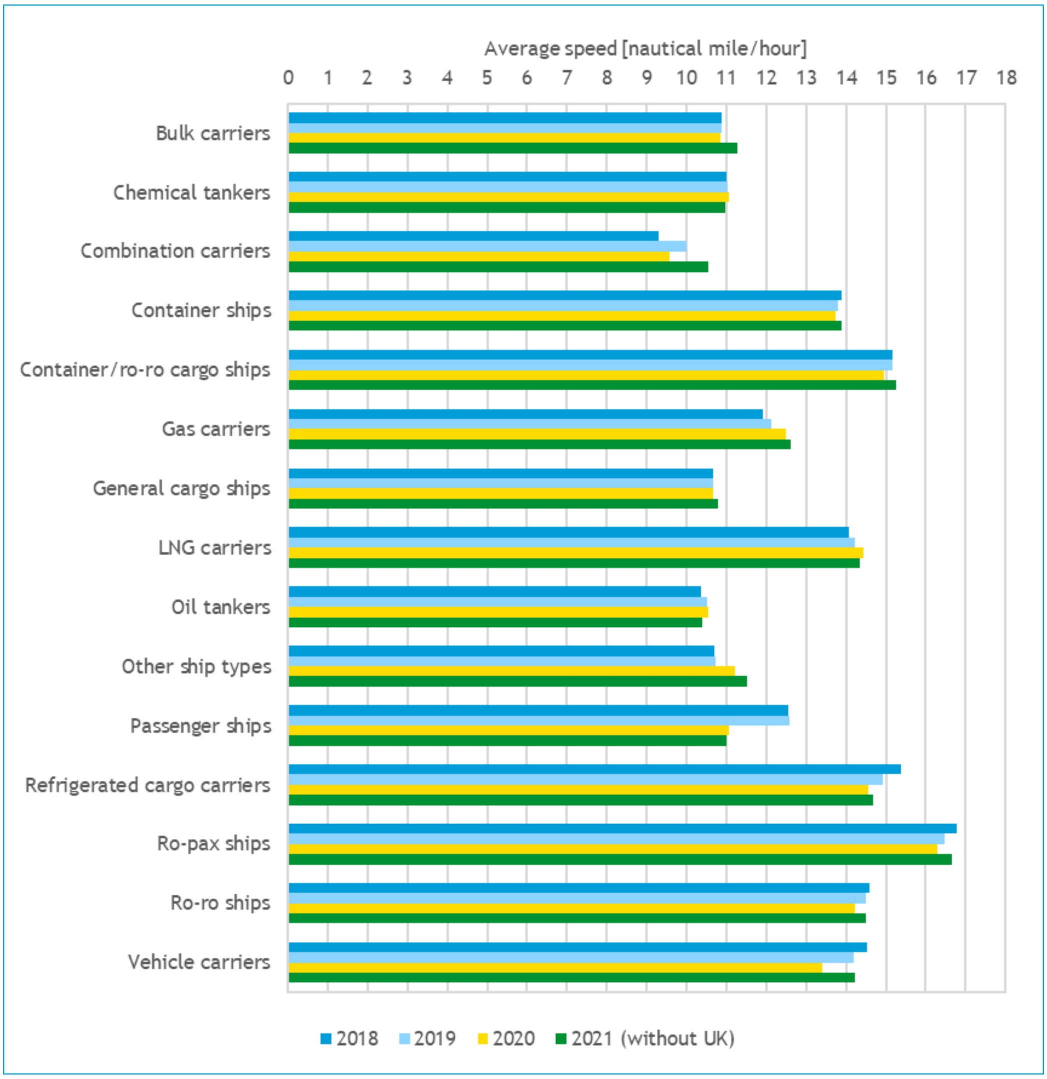

Figure 17: Average speed by ship type; 2018-2021; alphabetical order

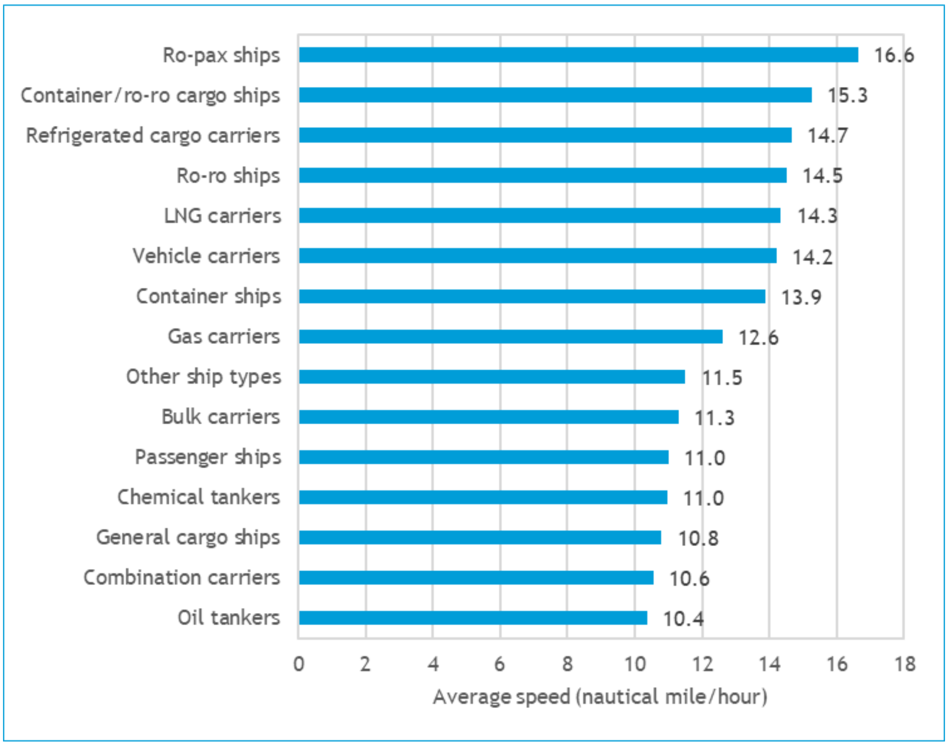

Figure 18: Average speed by ship type; 2021 (without UK); sorted by average speed

3.3. Time spent at sea

3.3.1. Time at sea by ship type

The time that the ships are active within the scope of the EU MRV during a reporting period can be expected to differ between the ship types due to their different operational profiles. This pattern clearly shows if you compare the average time at sea of the different ship types for 2021 (see Figure 19). Changes in the average time at sea for the different ship types across the reporting years could be due to different factors: the amount of idle time[18], shifts of trade patterns within the scope (e.g. trade on shorter intra-EEA routes), and/or shifts of the activity outside of the scope of the system. Such shifts can be related to the UK's withdrawal from the EU and/or shifts in the economic activities between regions (e.g. loss of market share of EU seaborne exports to a non-EEA country to the benefit of another region).

Between 2020 and 2021 the average time spent at sea within the EU MRV scope decreased for ten out of the fifteen ship types, while for five ship types (Ro-ro, Ro-pax, container/ro-ro cargo, passenger ships as well as combination carriers) it increased. For passenger ships and ro-pax ships not only the average time at sea but also the total time at sea increased between 2020 and 2021 (see Figure 20), an indication that for those two ship types, the effect of the recovery from the COVID-19 crisis exceeded the effect of the UK's withdrawal from the EU.

[18] Time at anchorage is not part of the time at sea.

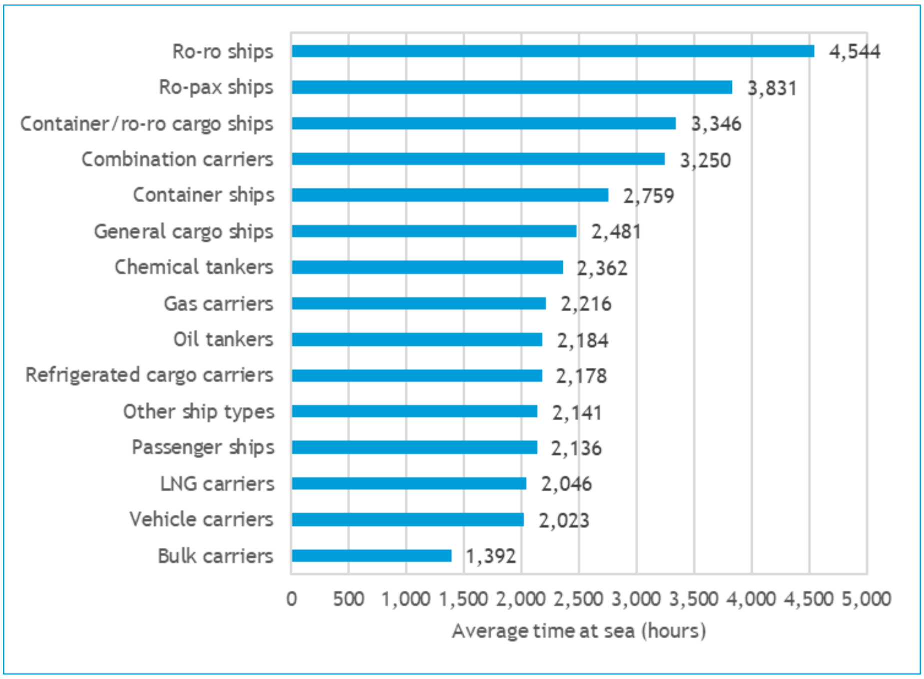

Figure 19: Average time at sea by ship type; 2021 (without UK); sorted by average time at sea

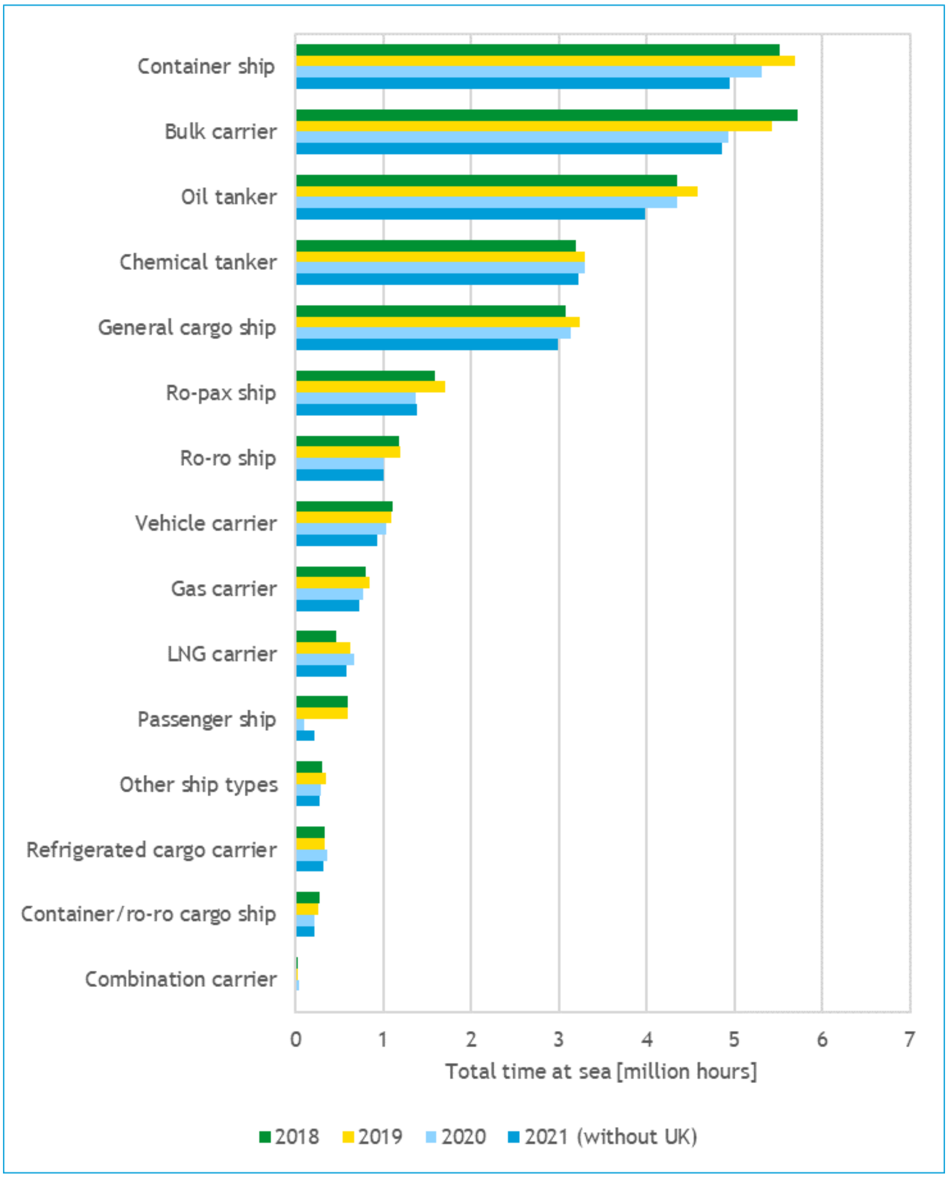

Figure 20: Total time at sea by ship type; sorted by 2019 total time at sea

4. Technical and operational efficiency of the monitored fleet

Main findings

The data collected under the EU MRV system, in its fourth reporting year, allows now for an assessment of the evolution of the technical and operational efficiency of the monitored fleet as well as of the robustness of the reported data since 2018. The graphical analysis of key technical and operational efficiency indicators shows that no significant changes took place over the period 2018-2021, as signalled by overlapping regression curves. Furthermore, the gradual increase of data correlation values stresses the completeness and correctness of the reported data and its improvement over the last four years.

Technical efficiency of the monitored fleet

The analysis of the 2021 MRV data shows consistency and no significant changes in the technical efficiency of the most representative ship types of the monitored fleet. Overall high correlation values between EEDI/EIV and the carrying capacity are shown, generally improving over the 2018-2021 period.

In 2021, in total, 3 545 ships have reported their EEDI, which is more than in the previous year (+13.5%) and 7 775 ships their EIV. The year 2021 registered a slight improvement (1%) in the EEDI, as average reported value at fleet level.

Operational efficiency of the monitored fleet

The analysis highlights that, also in 2021, the operational efficiency trends did not significantly change, as shown by the different reporting periods' regression curves overlap, resulting from the currently established technological and commercial status-quo of the maritime sector.

The absolute emissions reduction observed for 2021, both on 2020 and on pre-COVID 2019, should not therefore be linked to a supposed overall improvement of the operational efficiency of the fleet but could instead be associated to the combined effect of two structural events of the year 2021: the long-lasting effects of the COVID economic crisis and the withdrawal of the UK from the EU.

The energy/carbon efficiency of ships can be measured in terms of technical or operational efficiency and by means of various indicators. Technical efficiency indicators aim at measuring the energy consumption/the emissions of a ship, depending on its design, whereas operational efficiency indicators also account for how a ship is operated. For any of the indicators in this section, the lower the value, the higher the efficiency of the ship.

The year 2021 representing the fourth reporting year of the EU MRV system, a substantial amount of data on the reporting ships has become available, allowing for an assessment of the evolution of the technical and operational efficiency of the monitored fleet and also the robusteness of the reported data.

As in previous years, such an analysis has been carried out by means of a graphical analysis, plotting the relevant indicators per ship type against the cargo carrying capacity. On the basis of this years analysis, whose most representative results are shown in Annex 5, two main findings are worth highligthing: 1. The completeness and correctness of the reported data, which has been clearly improving over time, confirmed by the subsequent data correlation values' gradual increase, particularly when comparing the initial 2018 with a steadier and more robust 2021; 2. as in previous years, technical and operational efficiency trends did not significantly change, as shown by the different reporting periods' regression curves overlap, resulting from the currently established technological and commercial status-quo of the maritime trade.

Combining the above observations, it can be concluded that the 2021 MRV reporting year confirms the consistency of the reported data, and therefore the increasing robustness of the monitoring, reporting and verification framework for maritime transport.

4.1. Technical efficiency

4.1.1. Overview

According to the EU Maritime MRV Regulation, ships have to report their technical efficiency. This can be done through two indicators, which are mutually exclusive and apply depending on the year of build of the ship: the Energy Efficiency Design Index (EEDI) or the Estimated Index Value (EIV). A third possibility is to report the entry 'not applicable', an exemption foreseen only for a minority of ship types (see below for details).

The EEDI is an energy efficiency measure implemented at the IMO level with the aim to improve the technical energy efficiency of newbuild ships. Newbuild ships of certain types and size segments need to meet EEDI requirements in terms of CO_2 per capacity nautical mile if they have been built after 1 January 2013 or 1 January 2015, depending on the ship type and size. The EEDI requirements become more stringent over time, also depending on ship type and size (see Table 8 in the Annex for an overview of the EEDI requirements).

The EIV is a simplified version of the EEDI, used to calculate the energy efficiency reference lines for ships pre-dating the application of the EEDI.

The specific EU MRV reporting requirements regarding the technical carbon efficiency of ships are as follows (European Commission, 2017):

- The attained EEDI has to be reported where required by and in accordance with MARPOL Annex VI, Regulations 19 and 20.'[19] (European Commission, 2017).
- Ships that do not fall under these MARPOL Annex VI Regulations (for example due to the year of build or the ship size), but that are ship types that in principle are covered by these MARPOL Annex VI Regulations, have to report the EIV. They are also encouraged to report the EEDI instead of the EIV on a voluntary basis.
- Ships of ship types not covered by the MARPOL Annex VI Regulations are not required to report their technical efficiency (European Commission, 2017), which explains why for some ships the 'not applicable' value was entered in the technical efficiency section.

In 2021, in total, 3 545 ships have reported their EEDI and 7 775 ships their EIV (with 149 'not applicable'). The majority of reporting vessels report their EIV, yet their share has been always decreasing since 2019 (from 74% to 68% in 2021), while the share of those reporting their

[19] Regulation 19 (Application) and Regulation 20 (Attained EEDI) are part of Chapter 4 (Regulations on energy efficiency for ships) of Annex VI of the IMO MARPOL Convention.

EEDI has increased (from 23 to 31% in 2021). This is a direct consequence of the fleet renewal under the MRV scope, as new ships with higher EEDI standards progressively replaced older vessels reporting EIV (see Table 9 in Annex 5).

As in 2020, gas carrier are the ship types reporting the higher shares of EEDI (up to 45% in 2021 from 39% in 2020), followed by oil tankers (38%), chemical tankers (38%) and bulk carriers (37%). This reflects a relatively high number of young ships built in 2013[20] or later and also the fact that for these ship types, the EEDI requirements came into force at an earlier stage, i.e. 2013 instead of 2015.

The average EEDI values reported in 2021 per ship type highlight that oil tankers, combination carriers, and bulk carriers reported the lowest average EEDI values, while ro-pax ships, refrigerated cargo carriers and vehicle carriers the highest ones.

In 2021 the fleet average EEDI recorded a further improvement (1%), confirming the positive trend of 2020 (1.6% on 2019). This however does not necessarily mean that individual ships' technical efficiency has improved as the value represents an average at fleet level and the composition of the fleet differs between the different years.

In terms of average EEDI per ship type, for nine out of fifteen vessel groups, the year 2021 saw either an improvement or the same average EEDI values being recorded.

4.1.2. Evolution of the Technical Efficiency of the monitored fleet

The technical efficiency (EEDI or EIV) of the monitored fleet was further analysed by mean of a graphical analysis, by plotting EEDI and EIV values against its capacity (DWT or Gross Tonnage). Regression curves with R2-values have then been calculated. Similar to previous years, the technical efficiency trends did not significantly change, as shown by the different reporting periods' regression curves shown in Annex, which overlap for the most representative ship types of the monitored fleet, for which a high correlation between the EEDI/EIV and the carrying capacity has been recorded. In addition, an improvement in correlation values is visible for the overall period 2018-2021 across different ship types. Such findings result from the present technogical and commercial status quo of the maritime trade, and confirm the quality and consistency of the data reported under the EU MRV system.

As a representative example, the graph below shows the EIV graphical analysis for bulk carriers. The 12 graphs produced for a total of nine ship types, for which robust R2 correlation values have been detected (above 0.6), are presented in Annex 5. These represent 93% of total emissions reported in 2021.

[20] The first newbuild ships to which Phase 0 applied where ships with a building contract placed on or after 1 January 2013 / ships the delivery of which was on or after 1 July 2015

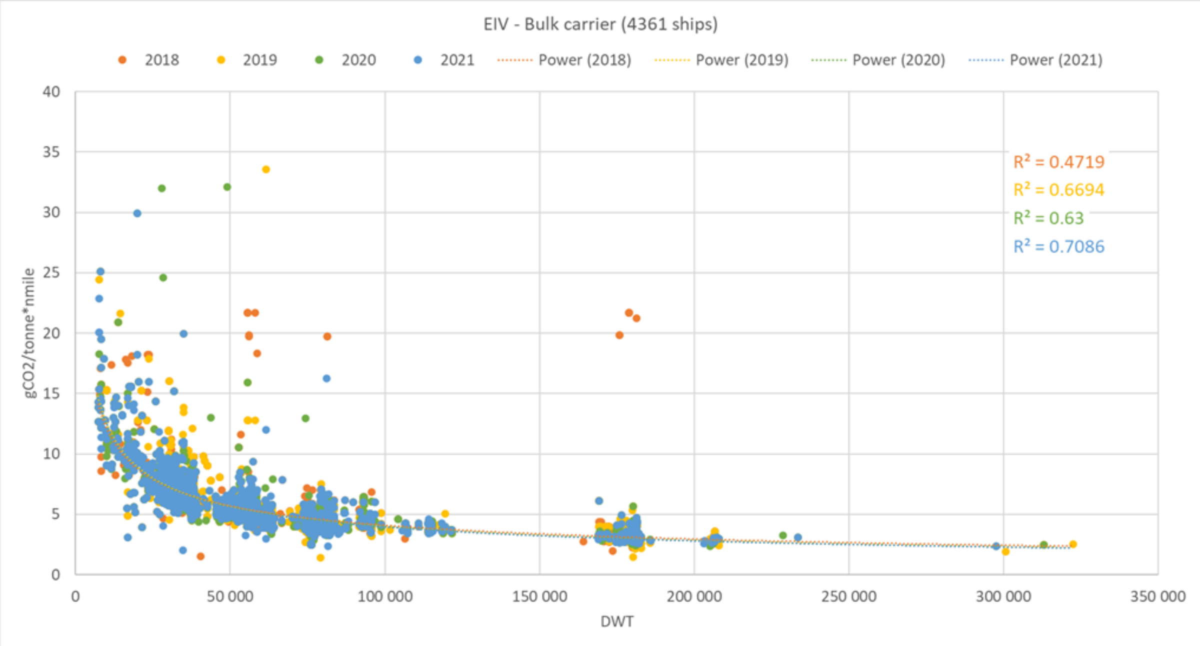

Figure 21: Plot of attained EIV values of bulk carriers over the four reporting years and according trendlines

4.2. Operational efficiency

4.2.1. Overview: EEOI and AER

According to the EU Maritime MRV Regulation (see Annex II, B. of the Regulation), ships have to monitor their average operational energy efficiency by using at least four indicators:

1. Fuel consumption per distance;
2. Fuel consumption per transport work;
3. CO_2 emissions per distance;
4. CO_2 emissions per transport work (also referred to as Energy Efficiency Operational Indicator (EEOI)).

which have to be calculated as follows:

- Fuel consumption per distance = total annual fuel consumption/total distance travelled;
- Fuel consumption per transport work = total annual fuel consumption/total transport work;
- CO_2 emissions per distance = total annual CO_2 emissions/total distance travelled;
- CO_2 emissions per transport work = total annual CO_2 emissions/total transport work.

The metric for the transport work can thereby differ, depending on the ship type (see Implementing Regulation 2016/1927), e.g. depending on whether cargo or passengers or both are transported. The majority of the ships (have to) apply a metric which uses the mass of the cargo transported, measuring their transport work in tonne nautical miles. (see Table 10 in the Annex for more details about the indicators reported per ship type).

The Energy Efficiency Operational Indicator (EEOI) is defined, in its most simple form, as the ratio of mass of CO_2 emitted per unit of transport work. As it varies according to the actual cargo carried, this indicator reflects the carbon intensity of the transport service rendered by each individual ship. Thus, it is highly influenced by the actual loading of vessels (including ballast voyages). Keeping everything else equal, ships with higher payload utilisation will therefore tend to have a lower EEOI, which makes them appear more energy efficient.

The principal challenge with regards to the operational efficiency of ships lies in the fact that there are various factors that have an impact on the operational efficiency of a ship. Some of these factors, such as the speed of a ship, can be determined by the operator, while others, like voyage conditions (wind, waves etc.), cannot. Analysing operational efficiency at ship type level and on an annual basis allows to average out factors such as voyage conditions and for ships, like liner ships or ferries, which operate on the same/comparable routes in the different years, a change of the ships' operational efficiency between the years will likely be mainly linked to a change in the operation of the ship, like a speed reduction.

Based on the data reported by the companies, an additional operational efficiency indicator, the AER (Annual Efficiency Ratio) can be determined. This indicator works with a proxy for the ships' transport work, i.e. the deadweight tonnage, resulting in the following metric: g CO_2 / (dwt n miles). Comparing the different indicators, the AER features comparably less variation, since the proxy for the ships' transport work, i.e. the deadweight tonnage, is constant.

4.2.2. Evolution of the operational efficiency of the monitored fleet

The evolution of the operational efficiency of the fleet was analysed by means of a graphical analysis, applied to both EEOI and AER indicators. To this end, the AER and EEOI per ship type have been plotted against the cargo carrying capacity (in DWT, GT or both). Regression curves with R2-values have then been calculated.

The analysis highlights that, also in 2021, the operational efficiency trends did not significantly change, as shown by the different reporting periods' regression curves overlap, resulting from the currently established technological and commercial status-quo of the maritime trade.

As a representative example, the graph below shows the EEOI graphical analysis for oil tankers. The other graphs, for a total of ten ship tpyes, for which robust R2 correlation values have been detected (above 0.6), are grouped in Annex 5.

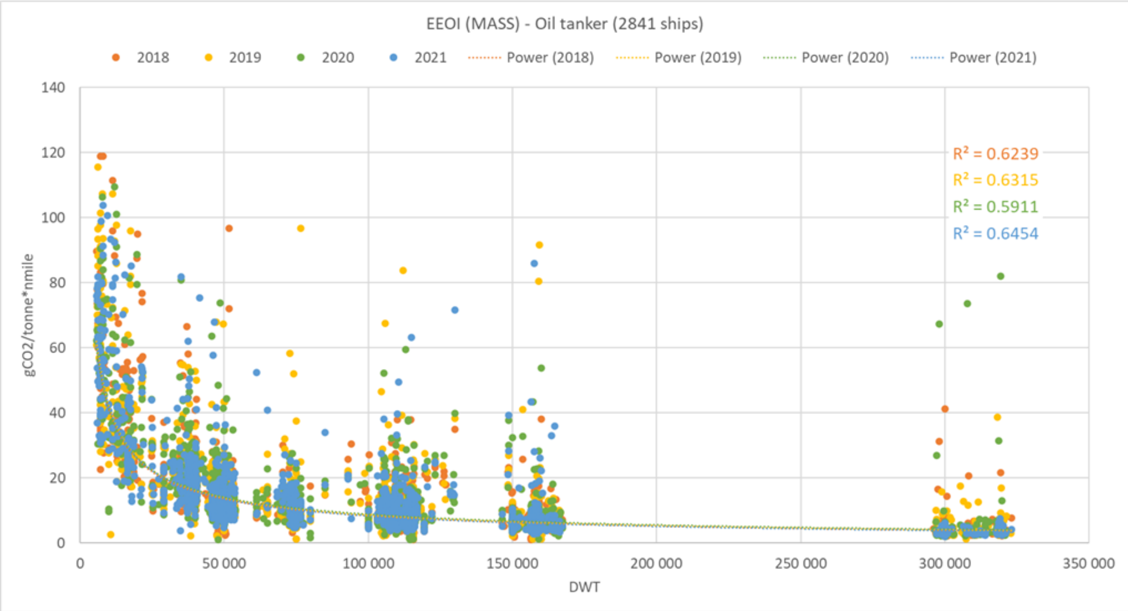

Figure 22: Plot of attained EEOI values of oil tankers over the four reporting years and according trendlines

5. Assessing the implementation of the EU Maritime MRV Regulation

Main findings

- The main advantage of the EU Maritime MRV Regulation is the insights gained in the environmental performance of the largest vessels entering or leaving EEA ports. This enables shipping companies, but also other stakeholders, like Member State authorities, to identify trends in the overall performance of individual vessels and/or the entire fleet. It also enables them to use this information to develop further policies options.
- Many start-up issues that stakeholders encountered at the beginning of the implementation of the EU Maritime MRV Regulation seem to be resolved - stakeholders seem to have familiarised themselves with the system, resulting in smoother internal procedures and better quality of the submitted data. This is reflected in improving trends across the available reporting years for all key indicators on the punctuality, quality and completeness of the submitted data.

5.1. Key indicators on the MRV process in 2020

5.1.1. Punctuality

According to article 11 of the EU Maritime MRV Regulation, by 30 April in the year after the reporting period, shipping companies have to submit the verified emissions report to the Commission and the flag State. The share of all emissions reports that have been submitted to the European Commission (including resubmitted reports that required a revision) until May has been relatively stable for the reporting year 2018 and 2019: with 55%, it has been relatively low. With a share of 66%, the reporting period 2020 shows some improvement, which was maintained in 2021 (65%).

A timely submission of the verified emissions report to the Commission highly depends on a timely submission of the emissions report by the company to the verifier. The share of the emissions reports that have been submitted to the verifier (including those that had to be revised and thus had to be submitted twice) by 30 April have been improving in the last years. After a robust year-on-year increase from 71% to 77% in the reporting year 2020, in the year 2021 the share slighlty increased to 78%.

5.1.2. Non-compliant emission reports and revisions

With the exception of the first reporting year, for which 149 cases were recorded, the number of initially non-compliant emission reports, as a transitory status at the moment of transmission, remains extremely low: 6 cases were recorded in 2021, compared to 4 cases in the reporting year 2020 and 10 in 2019.

The share of the emissions reports that have been verified as satisfactory without any additional revision has increased from 35% for the 2018 reporting period to 71% for the 2021 reporting period.

5.2. Quality and completeness of EU MRV data

5.2.1. Outliers

There are some cases of misstatements in verified emissions reports. Some of the verified emissions reports indeed include few outliers, i.e. relatively easily identifiable, obvious mistakes.[21] The number of emissions reports with outliers has continuosly decreased over the years, down to 83 reports in 2021 compared to 365 reports in the 2018 reporting period. In the reporting year 2021, only 0.7% of all emissions reports contained one or more outliers. Also the impact of these misstatements on the total fleet CO_2 emissions has been decreasing over the period 2018-2021, recording its lowest level in 2021 (the emissions reports containing outliers represent 1.1% of all emissions).

5.2.2. Verifiers

For the majority of the verifiers (17 out of 20), the number of emissions reports containing outliers has decreased in 2021 compared to the previous year. The number of emissions reports that contain outliers is not evenly distributed over the different verifiers. For the 2021 reporting period, three verifiers stand out with between 13 to 15 emissions reports featuring outliers, which corresponds to a share of between 0.7% and 1.7% of the respective verified reports.

With the aim of continuous improvement in the implementation of the EU maritime MRV Regulation, the Commission holds periodic meetings over the year with the relevant stakeholders, namely verifiers and National Accreditation Bodies, to further improve the punctuality, quality, and completeness of the reported data.

[21] Across the whole present report, in view of ensuring the accuracy of data, clear outliers identified during the analytical process have been discarded, as in previous years.

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Annex 1 Abbreviations and definitions

Table 3 Abbreviations and definitions

Abbreviation	Meaning
AER	Annual Efficiency Ratio
AFIR	Regulation on Alternative Fuels Infrastructure
BDN	Bunker Delivery Note
CII	Carbon Intensity Indicator
DoC	Document of Compliance
dwt	Deadweight tonnage
EC	European Commission
EEA	European Economic Area (EU-27 + Norway, Iceland, Liechtenstein)
EEDI	Energy Efficiency Design Indicator
EEOI	Energy Efficiency Operational Indicator
EEXI	Energy Efficiency Existing Ship Index
EIV	Estimated Index Value
EMSA	European Maritime Safety Agency
ETD	Energy Taxation Directive
ER	Emissions report
EU	European Union
GHG	Greenhouse gas emissions
GT	Gross tonnage
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
LNG	Liquefied Natural Gas

LPG	Liquefied Petroleum Gas
LRIT	Long Range Identification and Tracking
MARINFO	EMSA's internal database fed by information bought from commercial providers
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environmental Protection Committee
m/m	Mass per mass
MP	Monitoring plan
MRV	Monitoring, Reporting, Verification
MS	Member State
NAB	National Accreditation Body
n miles	Nautical miles
Pax	passenger
RED	Renewable Energy Directive
Ro-ro ship	Roll-on/roll -off ship
Ro-pax ship	Roll-on/roll-off passenger ship (vessel built for freight vehicle transport along with passenger accommodation)
TEN-T	Trans-European Transport Network
THETIS-MRV	EMSA web-based application established for the implementation of the EU Maritime MRV Regulation (e.g. to be used by companies to generate emissions reports).
VLSFO	Very Low Sulphur Fuel Oil

Annex 2 The EU MRV system: Steps of the process

Figure 23 illustrates the different steps of the EU MRV system.

Figure 23: Steps of the EU MRV process

Step 1: Producing a Monitoring Plan

The first step of the MRV process consists of the drafting of the so-called **monitoring plan**.

Ship owners are required to fill out a monitoring plan before engaging in monitoring and reporting. In this document, ship owners explain how they intend to monitor the relevant parameters required by the EU Maritime MRV Regulation. This monitoring plan must provide complete and transparent documentation of the monitoring method that will be applied for each ship. It must follow the pre-defined template provided in the implementing legislation.

Companies can choose between four methods for monitoring CO_2 emissions:

1. Bunker Fuel Delivery Note (BDN) and periodic stocktakes of fuel tanks;
2. bunker fuel tank monitoring on board;
3. flow meters for applicable combustion processes;
4. direct CO_2 emissions measurements.

For each method, companies have to indicate the corresponding level of uncertainty.

All monitoring plans need to be assessed by an accredited verifier. If the verifier identifies any non-conformities, the company must revise its monitoring plan and submit the revised plan for a final assessment.

Step 2: Monitoring and reporting

Once the monitoring plan has been assessed by an accredited verifier, ship owners can proceed to the second step of the MRV process, which consists of the monitoring and reporting of the relevant parameters. The data produced by this ongoing monitoring activity is reported on an annual basis. The monitoring requirements in the Regulation are based on information already available on-board ships. This maximises the effectiveness of the Regulation, and minimises the administrative burden placed on companies.

Monitoring and reporting of CO_2 emissions and other mandatory information has to occur while the ship is at sea as well as at berth.

In addition, companies can report voluntary information to ease the interpretation of their CO_2 emissions and energy efficiency indicators. For instance, companies can voluntarily distinguish ballast voyages (without cargo) from laden voyages (with cargo), and, for relevant ship types, single out fuel consumption and CO_2 emissions related to cargo heating, and dynamic positioning.

Shipping companies are ultimately responsible for the accuracy and completeness of the monitored and reported data. Accordingly, they must record, compile, analyse and document monitoring data, including assumptions, references, emission factors and activity data. This must be done in a transparent manner that allows for reproduction of the determination of CO_2 emissions by the verifier.

Step 3: Monitoring and reporting

In the third step of the MRV process, companies must prepare an **emission report** in THETIS-MRV based on their monitoring activities.

Step 4: Verification of Emission Report

In the fourth step of the MRV process, independent accredited verifiers have to corroborate the emission reports submitted by companies. The design of this verification mechanism is in part modelled on other emission monitoring systems.

Verifiers should assess the reliability, credibility, and accuracy of the reported data and information in line with the procedures defined in the legislation. If an emission report is without omissions and errors – and if it fulfils the requirements under the legislation – verifiers issue a **verification report** classifying the emission report as satisfactory.

Starting in 2019, companies must have their emission report verified as satisfactory in THETIS-MRV by 30 April of each year and submit it to the Commission and to their flag State.

Step 5: Issuing a Document of Compliance

When an emission report has been satisfactorily verified, the verifier drafts the verification report, issues a **document of compliance**, and informs the Commission and the flag State. This document confirms a ship's compliance with the requirements of the Regulation for a specific reporting period. It has to be carried on board no later than 30 June. The document of compliance is generated using THETIS-MRV and is valid for a period of 18 months.

Step 6: Publication of information and Annual Report

According to the legislation, the Commission has to make information on CO_2 emissions and other relevant information publicly available by 30 June each year. The information is available at individual ship level, aggregated on an annual basis.

This data is accessible on the public section of the THETIS-MRV website in the form of a searchable database or a downloadable data sheet. Making the information publicly available and easily accessible ensures a high level of transparency. Such transparency is key to addressing market barriers related to the lack of information, and stimulates the uptake of energy efficient behaviours and technologies.

Under specific circumstances, companies can make a request to the Commission to disclose less details of information unrelated to CO_2 emissions. Such requests can only be justified in exceptional cases, where disclosure would undermine the protection of commercial interests, thereby overriding the public interest in granular information.

The Regulation also requires the Commission to publish an annual report in order to inform the public and allow for an assessment of CO_2 emissions and the energy efficiency of maritime transport.

Continuous enforcement activities throughout the EU MRV process

Member States implement and enforce the EU MRV process by inspecting ships that enter ports under their jurisdiction and by taking all the necessary measures to ensure that ships flying their flag are compliant with the regulation.

Non-compliance should result in the application of penalties fixed by Member States. Those penalties should be effective, proportionate, and dissuasive. Expulsion is a last resort measure when a ship is non-compliant for two or more consecutive reporting periods

Annex 3 Outcomes of the fourth compliance cycle

A.3.1 Fuel/emissions monitoring methods

As explained in Annex 2, the companies can apply four different fuel/emission monitoring methods: Bunker Fuel Delivery Note (BDN) and period stock takes of fuel tanks (Method A), bunker fuel tank monitoring on-board (Method B), flow meters for applicable combustion processes (Method C) and direct CO_2 emissions measuring (Method D).

The data for the four reporting years shows strong consistency in the methods reported by ships under the EU Maritime MRV, without any significant changes on the previous year nor on pre-COVID.

Table 4 Fuel monitoring methods

Share of ships that have applied a method; 2018 to 2021

	Method A	Method B	Method C	Method D
2018	44.8%	33.2%	33.3%	0%
2019	48.5%	32.2%	32.3%	0.02%
2020	49.1%	32.6%	33.9%	0.02%
2021	49.9%	31.1%	34.0%	0.02%

The vast majority of reporting ships applied only one of the monitoring methods (86% in 2021) while a smaller share of ships applied two of the methods (13.6% in 2021). Only 0.7% of reporting ships in 2021 applied three monitoring methods. In the 2021 reporting period, Method D has, just like in the previous reporting periods, been hardly applied: only for two ships Method D has been reported to be applied, in both cases in combination with method A and C.

A.3.2 Shipping companies

1 668 companies have submitted emission reports for the reporting period 2021; 4.1% more companies than for the reporting period 2020 and 1.5% more companies than for the reporting period 2019. The number of companies has been highest in the reporting period 2021.

As the following figure illustrates, in the reporting period 2021, 53.1% of these companies are registered in an EU country, 44.6% in a non-EEA country and 2.3% in an EEA-non-EU country. These shares slightly deviate from the shares in the previous reporting periods due the UK's withdrawal from the EU. In 2021 36 companies where registered in the UK, a number in line with those for the reporting year 2020 (38 companies) and 2018/2019 (37 companies).

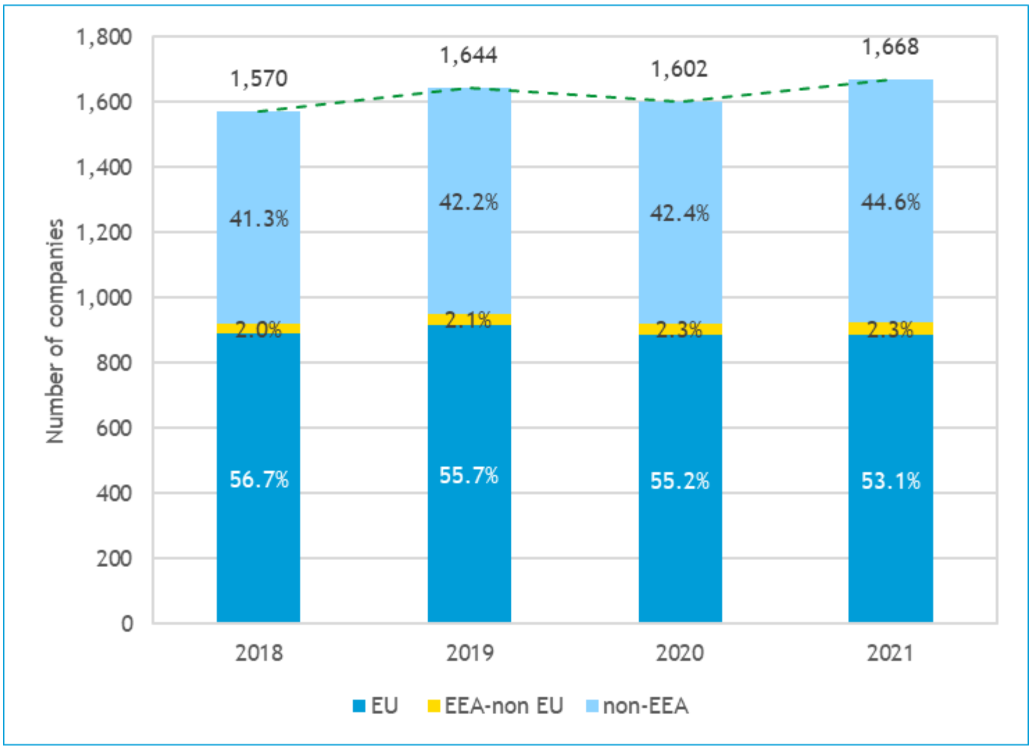

Figure 24: Number of companies and distribution over region of registration; 2018 to 2021

A.3.3 Verifiers and National Accreditation Bodies

In the reporting period 2021, 20 different accredited verifiers have been called in for verification activities required for the shipping companies' compliance with the EU Maritime MRV Regulation. The five largest of the verifiers have covered around 70% of the ships for which an emission report has been submitted in 2021. Five of the 20 verifiers are not located in an EEA country. Ten different national accreditation bodies (NABs) have accredited the 20 verifiers active in the 2021 reporting period. Four of these NABs have accredited more than one verifier.

Table 5 Number of verifiers accredited per National Accreditation Body

Number of verifiers accredited per National Accreditation Body in 2018 to 2021*

	National Accreditation Body	2018	2019	2020	2021
1	ACCREDIA	1	1	1	1
2	COFRAC	2	2	2	2
3	Croatian Accreditation Agency	1	1	1	1
4	German Accreditation Body (DAkkS)	5	5	5	5
5	The Danish Accreditation Fund (DANAK)	1	1	1	2

6	Dutch Accreditation Council (RvA)	1	1	1	1
7	Hellenic Accreditation System (ESYD)	6	5	5	5
8	Polish Centre for Accreditation (PCA)	1	1	1	1
9	Portuguese Institute for Accreditation (IPAC)	1	1	1	1
10	Swedish Board for Accreditation and Conformity Assessment (Swedac)	1	1	1	1
11	The United Kingdom Accreditation Service (UKAS)	3	2	0	0
	Total	**23**	**21**	**19**	**20**

*Verifiers with the same accreditation number are considered as one verifier.

Table 6 Number of verifiers

Number of verifiers per country in 2018 to 2021

	Country	2018	2019	2020	2021
1	Croatia	1	1	1	1
2	France	2	2	2	2
3	Germany	3	3	3	3
4	Greece	6	5	5	5
5	Italy	1	1	1	1
6	Poland	1	1	1	1
7	Portugal	1	1	1	1
8	Sweden	1	1	1	1
9	United Kingdom	4	2	0	0
10	China	1	1	1	1
11	India	1	1	1	1
12	Japan	1	1	1	1
13	Republic of Korea	1	1	1	1
14	Russian Federation	0	0	0	1
	Total	**24**	**21**	**19**	**20**

Annex 4 Main extra-EU flows

Table 7 provides the main extra EU-27 flows by gross weight handled in main ports in the years 2018 to 2021 in million tonnes. Except for the flow to Brazil and to/from the United Kingdom, all inward and outward flows increased between 2018 and 2019. Due to COVID-19 most inward and outward flows decreased in 2020 compared to 2019, with the exception of inward flows from the United Kingdom and Russia (Black Sea) and outward flows to China and Türkiye. Between 2020 and 2021, however, the different flows developed quite. Flows from Egypt, Nigeria and the U.S.A (East Coast) dropped further, the inward flow from the UK and the outward flow China dropped in 2021 to levels above 2019 levels, the inward flows from Russia (Baltic Sea) and Türkiye and the outward flow from the UK increased to levels above 2019 levels and the remaining seven of the top 15 flows increased in 2021 but did not reach 2019 levels again. Only the outward flow from Türkiye shows a continuous growth in the period 2018 to 2021.

Table 7 Main extra EU-27 flows by gross weight handled in main ports

Inward and outward flows from/to EU-27 ports (million tonnes)

	2018	2019	2020	2021
Inward flows to EU ports from non-EU ports				
Russia (Baltic Sea)	129	131.5	120.7	137.4
U.S.A. (East Coast)	91.3	106.5	100.0	105.9
United Kingdom	105.0	104.8	105.7	97.4
Türkiye	73.2	82.2	81.3	92.2
Norway	86.0	90.0	80.8	82.0
Russia (Black Sea)	78.6	81.3	83.2	79.3
Brazil	86.5	76.2	68.2	74.6
China	61.6	65.9	62.4	72.9
Egypt	50.0	54.2	47.5	44.4
Nigeria	35.0	46.2	39.2	34.2
Canada (East Coast)	34.4	34.8	32.6	33.5
Outward flows from EU ports to non-EU ports				
United Kingdom	114.0	108.3	99.8	119.5
China	42.0	51.2	61.4	58.1

U.S.A. (East Coast)	52.6	53.3	47.3	56.7
Türkiye	46.1	48.0	49.0	49.4

Source: Eurostat (2022)

Annex 5 Technical and operational efficiency of the monitored fleet

A.5.1 Technical efficiency (related to Section 4.1.1.)

Table 8 gives an overview of the EEDI requirements (=percentage reduction factor to be applied to reference value) that hold for the different ship types as specified in the first column, differentiated by ship size and Phase. To give an example: In 2013 and 2014 (i.e. in Phase 0) new bulk carriers of 20 000 dwt and above had to attain an EEDI value that was equal to the reference value (i.e. a reduction factor of zero applied), while in 2015 to 2019 (i.e. in Phase 1) new bulk carriers of 20 000 dwt and above had to attain an EEDI value that was 10% below the reference value (i.e. a reduction factor of ten applied).

Table 8 EEDI requirements depending on ship type and size and phase as published in Resolution MEPC.324(75)

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Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Mar 2022	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Apr 2022 and onwards	Phase 3 1 Jan 2025 and onwards
Bulk carrier	20,000 DWT and above	0	10		20		30
	10,000 and above but less than 20,000 DWT	n/a	0-10*		0-20*		0-30*
Gas carrier	15,000 DWT and above	0	10	20		30	
	10,000 and above but less than 15,000 DWT	0	10		20		30
	2,000 and above but less than 10,000 DWT	n/a	0-10*		0-20*		0-30*
Tanker	20,000 DWT and above	0	10		20		30
	4,000 and above but less than 20,000 DWT	n/a	0-10*		0-20*		0-30*
Containership	200,000 DWT and above	0	10	20		50	
	120,000 and above but less than 200,000 DWT	0	10	20		45	
	80,000 and above but less than 120,000 DWT	0	10	20		40	
	40,000 and above but less than 80,000 DWT	0	10	20		35	
	15,000 and above but less than 40,000 DWT	0	10	20		30	

Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Mar 2022	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Apr 2022 and onwards	Phase 3 1 Jan 2025 and onwards
	10,000 and above but less than 15,000 DWT	n/a	0-10*	0-20*		15-30*	
General Cargo ships	15,000 DWT and above	0	10	15		30	
	3,000 and above but less than 15,000 DWT	n/a	0-10*	0-15*		0-30*	
Refrigerated cargo carrier	5,000 DWT and above	0	10		15		30
	3,000 and above but less than 5,000 DWT	n/a	0-10*		0-15*		0-30*
Combination carrier	20,000 DWT and above	0	10		20		30
	4,000 and above but less than 20,000 DWT	n/a	0-10*		0-20*		0-30*
LNG carrier***	10,000 DWT and above	n/a	10**	20		30	
Ro-ro cargo ship (vehicle carrier)***	10,000 DWT and above	n/a	5**		15		30
Ro-ro cargo ship***	2,000 DWT and above	n/a	5**		20		30
	1,000 and above but less than 2,000 DWT	n/a	0-5*,**		0-20*		0-30*
Ro-ro passenger ship***	1,000 DWT and above	n/a	5**		20		30
	250 and above but less than 1,000 DWT	n/a	0-5*,**		0-20*		0-30*
Cruise passenger ship*** having non-conventional propulsion	85,000 GT and above	n/a	5**	20		30	
	25,000 and above but less than 85,000 GT	n/a	0-5*,**	0-20*		0-30*	

* Reduction factor to be linearly interpolated between the two values dependent upon ship size. The lower value of the reduction factor is to be applied to the smaller ship size.

** Phase 1 commences for those ships on 1 September 2015.

*** Reduction factor applies to those ships delivered on or after 1 September 2019, as defined in paragraph 43 of regulation 2.

Note: n/a means that no required EEDI applies."

Table 9 gives an overview of the number of ships that, per ship type, have reported, the EEDI, the EIV or 'not applicable' as technical efficiency indicator.

Table 9 Number of ships which have reported their EEDI, EIV or 'not applicable' in 2021

Technical efficiency indicators reported per ship type

Ship type	# of ships which have reported their EEDI in 2021	# of ships which have reported their EIV in 2021	# of ships that have reported 'Not applicable' in 2021
Bulk carrier	1,212	2,068	22
Chemical tanker	519	830	19
Combination carrier	2	6	0
Container ship	560	1,194	26
Container/Ro-ro cargo ship	7	62	0
Gas carrier	148	184	0
General cargo ship	154	1,037	11
LNG carrier	87	183	2
Oil tanker	663	1,073	15
Other ship types	14	69	21
Passenger ship	35	54	11
Refrigerated cargo carrier	26	118	1
Ro-pax ship	17	326	20
Ro-ro ship	35	204	1
Vehicle carrier	66	367	0
Total	**3,545**	**7,775**	**149**

Evolution of the Technical Efficiency of the monitored fleet – graphical analysis

The figures below plot the Estimated Index Value (EIV) and Energy Efficiency Design Index (EEDI) values for twelve ship groups in the four reporting years (2018 to 2021) against the size of the relevant ships measured in deadweight tonnage (see dots with a different colour per year). As in previous annual reports, only graphs with robust R2-indicator (>0.6) for the correlation between EEDI/EIV and the respective cargo carrying capacity have been included in this report.

The EIV/EEDI trendlines for 2018 to 2021 for the following ship types clearly overlap, which indicates that the technical efficiency of these subsegments of the fleet has not significantly changed. The ship types included in this graphical analysis cover nine out of the fifteen ship unique types reporting under the EU MRV system, representing, in emissions terms, 93% of total reported emissions in 2021.

The correlation values are generally increasing over the years, with all ship types showing a much higher correlation value in 2021 than in 2018.

The ship types for which the sample is too small (below 25 occurrences) or the regression line not reliable enough to draw conclusions (e.g. due to high variability/scatter) have not been shown.

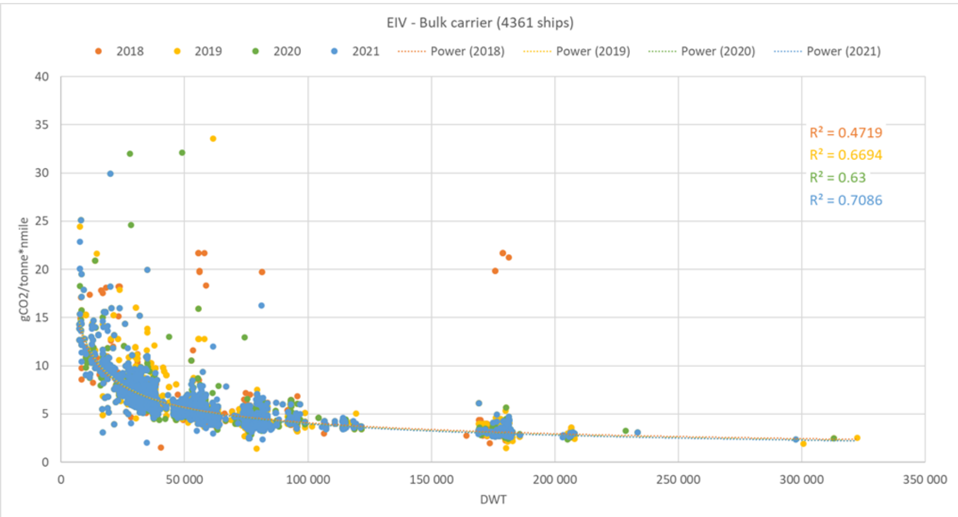

Figure 25: Plot of attained EIV values of bulk carriers over the four reporting years and according trendlines

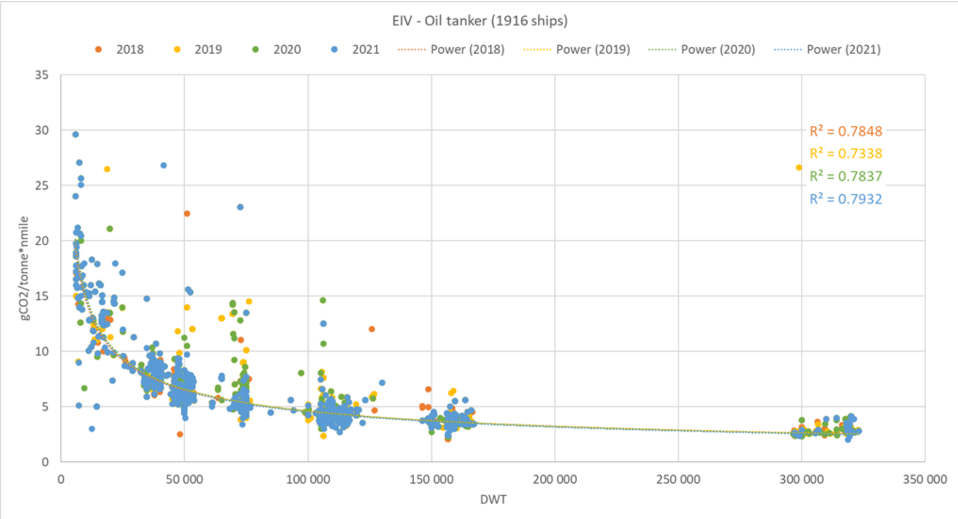

Figure 26: Plot of attained EIV values of oil tankers over the four reporting years and according trendlines

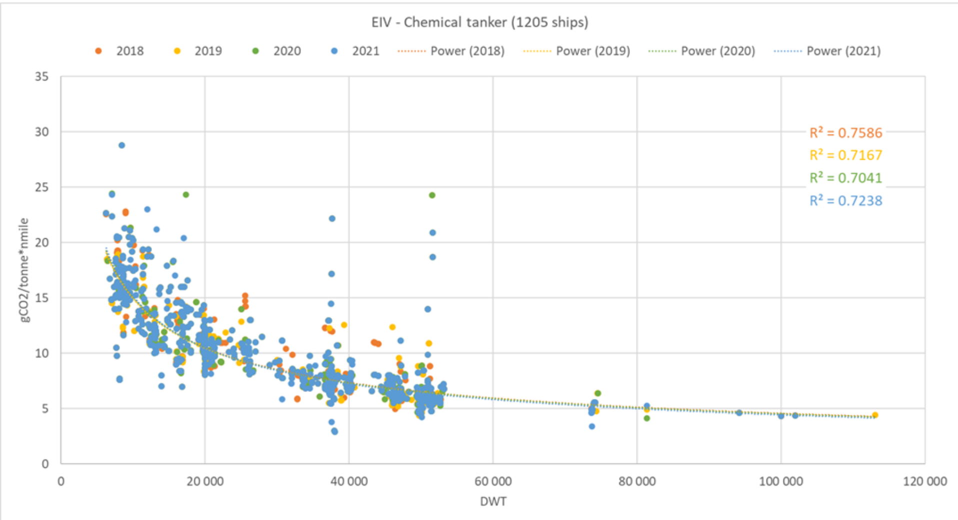

Figure 27: Plot of attained EIV values of chemical tankers over the four reporting years and according trendlines

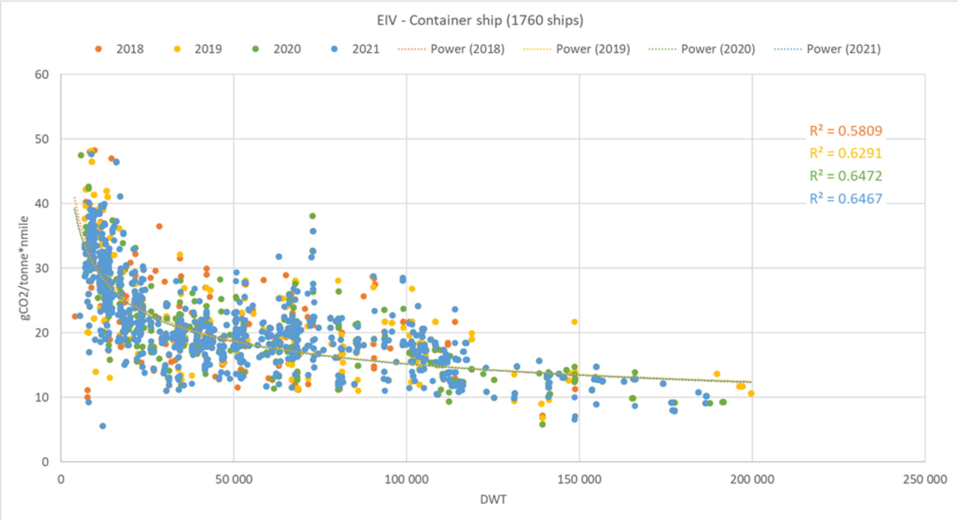

Figure 28: Plot of attained EIV values of container ships over the four reporting years and according trendlines

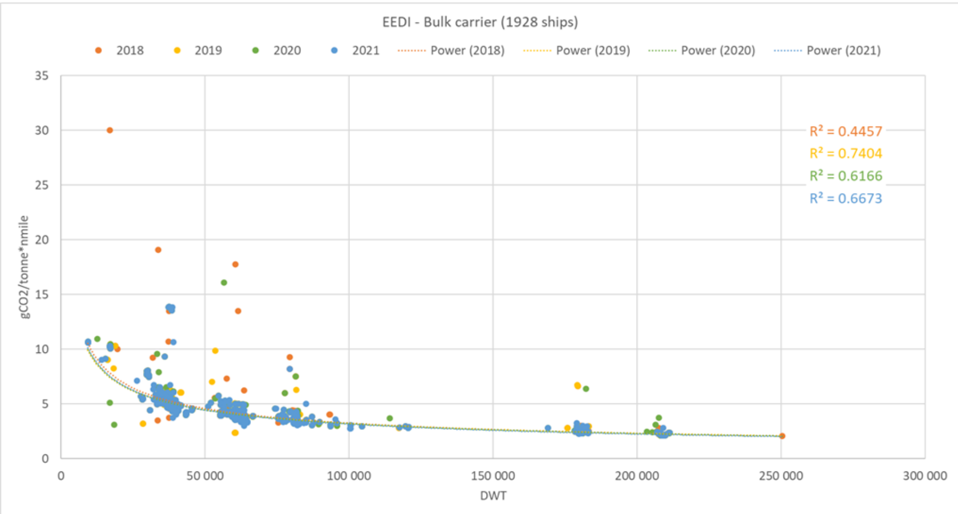

Figure 29: Plot of attained EEDI values of bulk carriers over the four reporting years and according trendlines

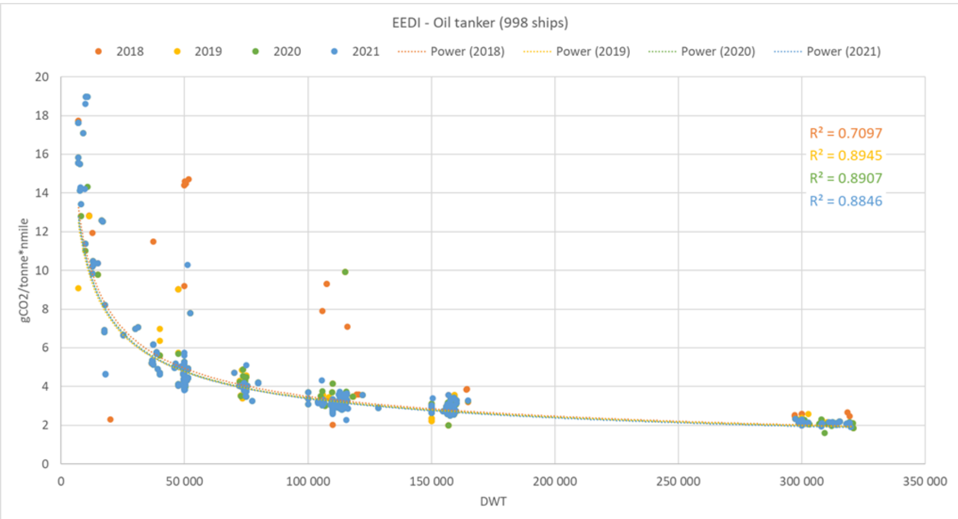

Figure 30: Plot of attained EEDI values of oil tankers over the four reporting years and according trendlines

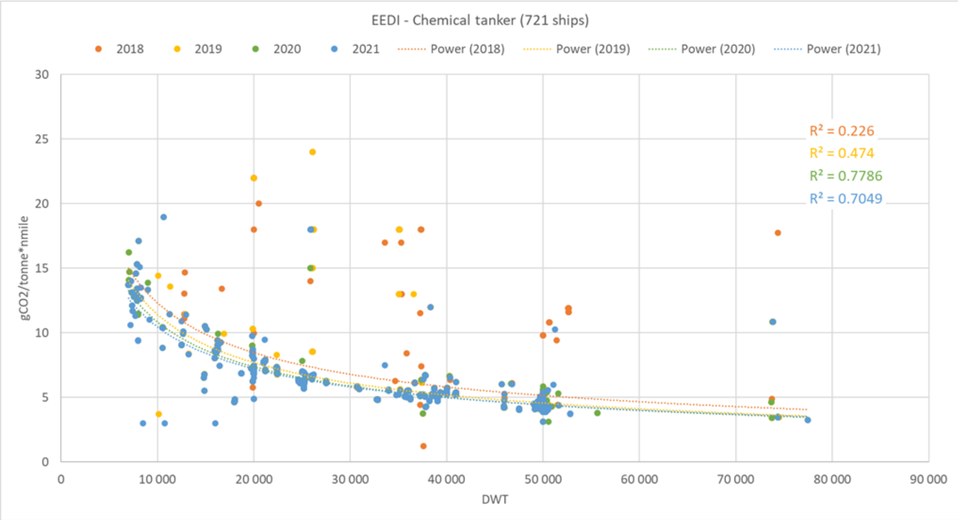

Figure 31: Plot of attained EEDI values of chemical tankers over the four reporting years and according trendlines

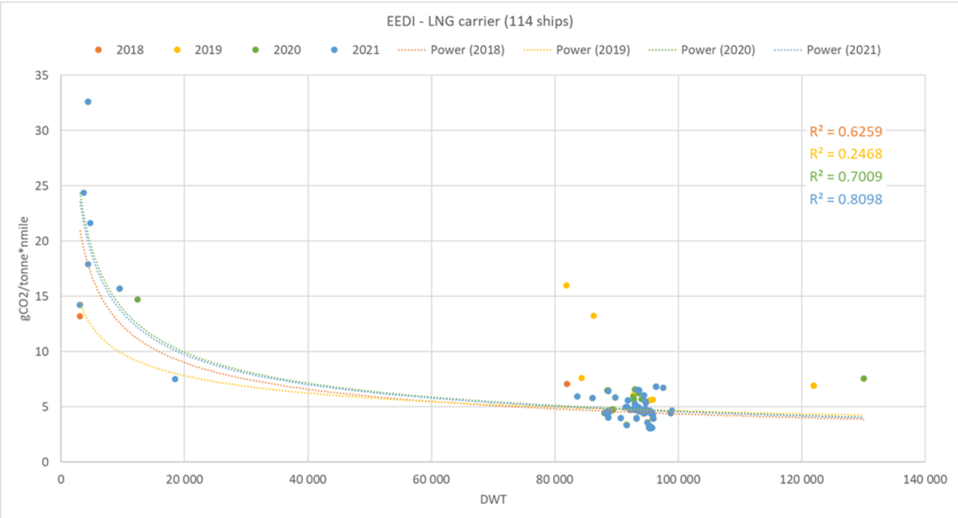

Figure 32: Plot of attained EEDI values of LNG carriers over the four reporting years and according trendlines

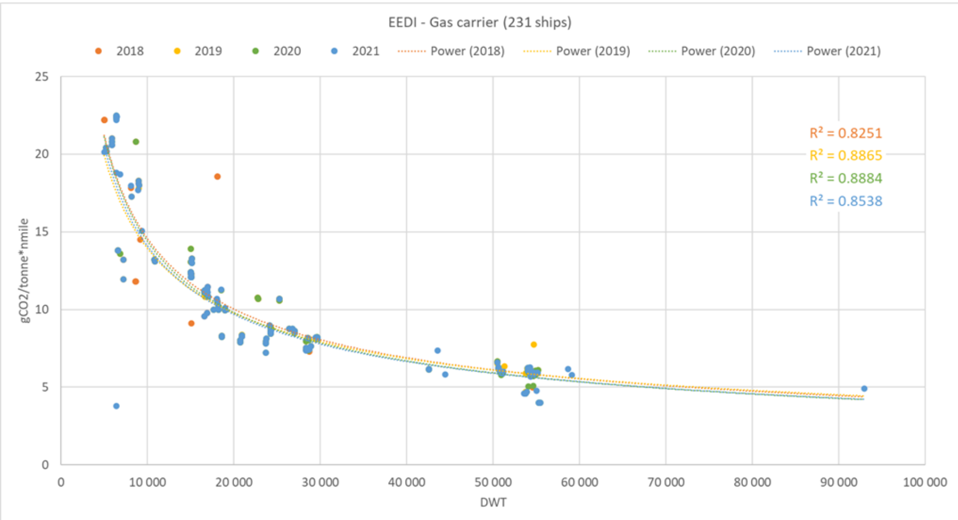

Figure 33: Plot of attained EEDI values of gas carriers over the four reporting years and according trendlines

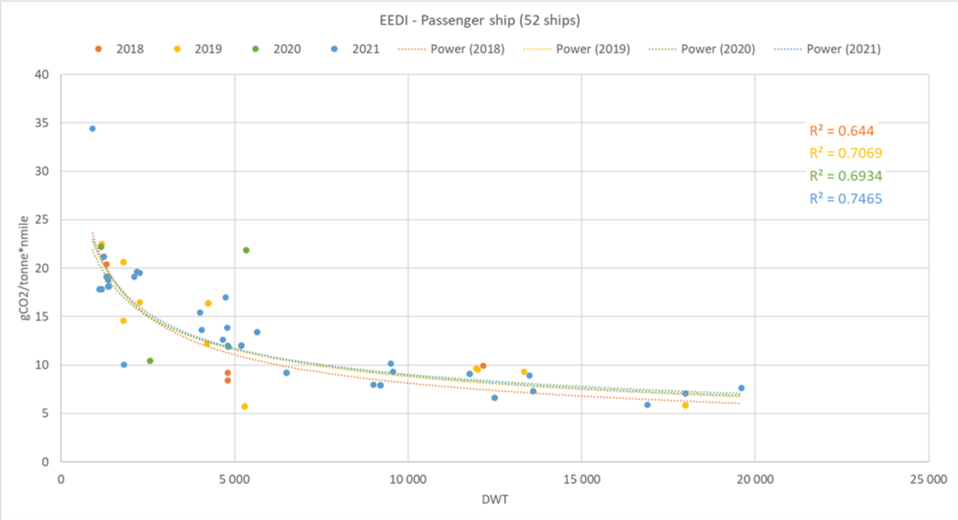

Figure 34: Plot of attained EEDI values of passenger ships over the four reporting years and according trendlines

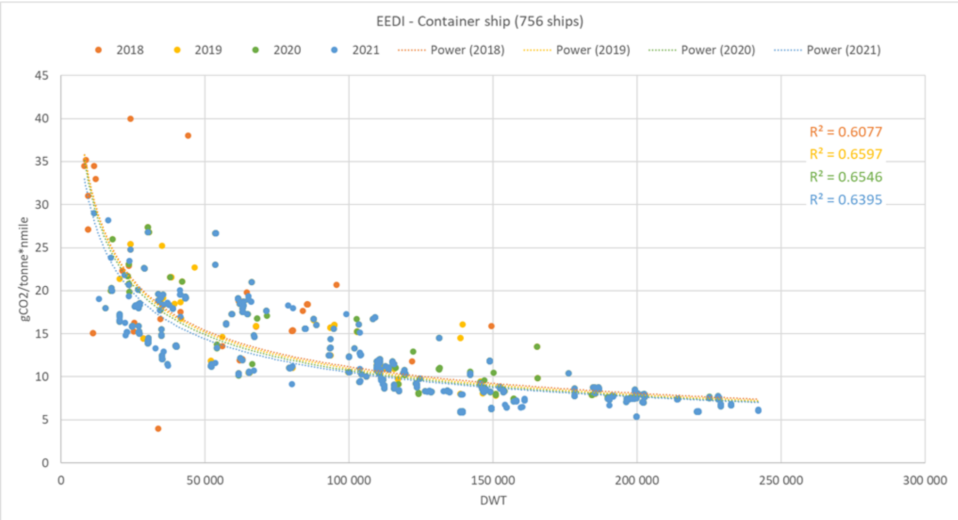

Figure 35: Plot of attained EEDI values of container ships over the four reporting years and according trendlines

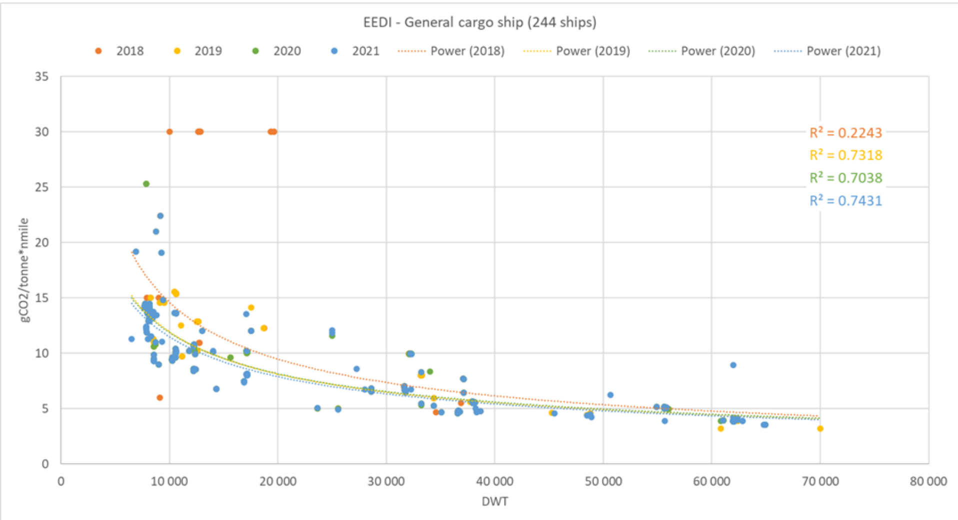

Figure 36: Plot of attained EEDI values of general cargo ships over the four reporting years and according trendlines

A.5.2 Operational efficiency (related to Section 4.2.)

Operational effiicency indicators

The majority of the ships (have to) apply a metric which uses the mass of the cargo transported, measuring their transport work in tonne nautical miles. In contrast, container/Ro-ro cargo ships and LNG carrier apply a metric which uses the volume of the cargo transported, measuring their transport work in cubic metre nautical miles. Passenger ships naturally determine their transport work in terms of passenger nautical miles. Ro-pax ships, which transport cargo and passengers, report two indicators, one in terms of passenger nautical miles and the other in terms of tonne nautical miles for the freight transported. Three categories of ship types (general cargo ships, vehicle carriers, other ship types) can, instead of mass of the cargo transported, alternatively determine their transport work by means of 'deadweight carried'[22].

Table 10 gives an overview of the different operational efficiency indicators and metrices thereof that have been reported in 2021. The table thereby only shows the CO_2 efficiency indicators. The corresponding energy efficiency indicators are not presented in the table, but the same according metrics hold (kg fuel/n miles instead of kg CO_2 / n mile etc.) and have been reported by the same ship types.

Table 10 Operational efficiency indicators

Indicators reported by ship type

Operational efficiency indicator	Metric of indicator	Indicator reported by…
Annual average CO_2 emissions per distance	[kg CO_2 / n mile]	All ship types
Annual average CO_2 emissions per transport work (mass distance)	[g CO_2 / (m tonnes · n miles)]	All ship types except • Container/Ro-ro cargo ship, • LNG carrier, • Passenger ships, • Ro-pax ships
Annual average CO_2 emissions per transport work (volume)	[g CO_2 / (m^3 · n miles)]	Container/Ro-ro cargo ship LNG carrier
Annual average CO_2 emissions per transport work (dwt carried)	[g CO_2 / (dwt carried · n miles)]	Mainly General cargo ships and Other ship types; very few ships of other types.
Annual average CO_2 emissions per transport work (pax)	[g CO_2 / (pax · n miles)]	Passenger ships Ro-pax ships
Annual average CO_2 emissions per transport work (freight)	[g CO_2 / (m tonnes · n miles)]	Ro-pax ships

[22] According to Implementing Regulation 2016/1928, deadweight carried (in metric tonnes) is the volume displacement multiplied with the water density, with the mass of fuel and lightweight subtracted.

Evolution of operational efficiency – a graphical analysis

The figures below plot the Energy Effificency Operational Indicator (EEOI) and Annual Efficiency Ratio (AER) values for ten ship groups in the four reporting years (2018 to 2021) against the size of the relevant ships measured in deadweight tonnage or gross tonnage (see dots with a different colour per year).

As in previous annual reports, only graphs with robust R2-indicator (>0.6) for the correlation between EEOI/AER and the respective cargo carrying capacity have been included in this report.

The EEOI/AER trendlines for 2018 to 2021 for most ship types clearly overlap, which indicates that the operational efficiency of these subsegments of the fleet has not significantly changed. The ship types included in this graphical analysis cover six out of the fifteen ship unique types reporting under the EU MRV system, representing, in emissions terms, 79% of total reported emissions in 2021.

The correlation values are generally increasing over the years, with all ship types showing a higher correlation value in 2021 than in 2018 (with the exception of chemical tankers for which the correlation value is the same).

The graphical analysis confirms that the fleet operational efficiency does not seem to have changed or to have only slightly changed in the period 2018 to 2021 for the following ship types (regression lines overlap/almost overlap): Oil tankers, Container ships, Ro-ro ships, Container/Ro-ro cargo ships, Bulk carriers, Chemical tankers, Vehicle carriers, General cargo ships.

For passenger ships (cruise liners) and ro-pax vessels no EEOI/AER regression curve is presented since the long-lasting effects of the COVID-19 pandemic resulted in higher and more fluctuant EEOI and AER values for these types of vessels, limiting therefore the interest of applying a regression analysis.

The ship types for which the sample is too small (below 25 occurrences) or the regression line not reliable enough to draw conclusions (e.g. due to high variability/scatter) have not been shown.

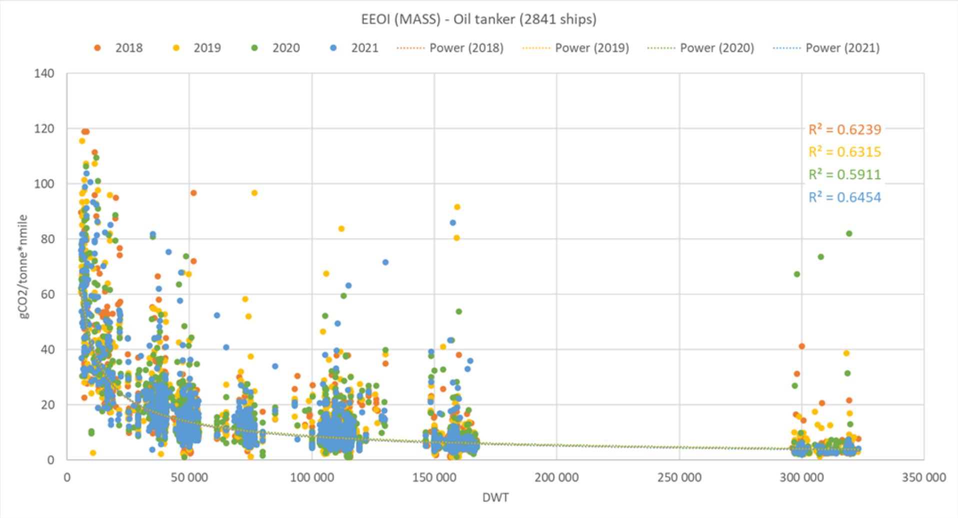

Figure 37: Plot of attained EEOI values of oil tankers over the four reporting years and according trendlines

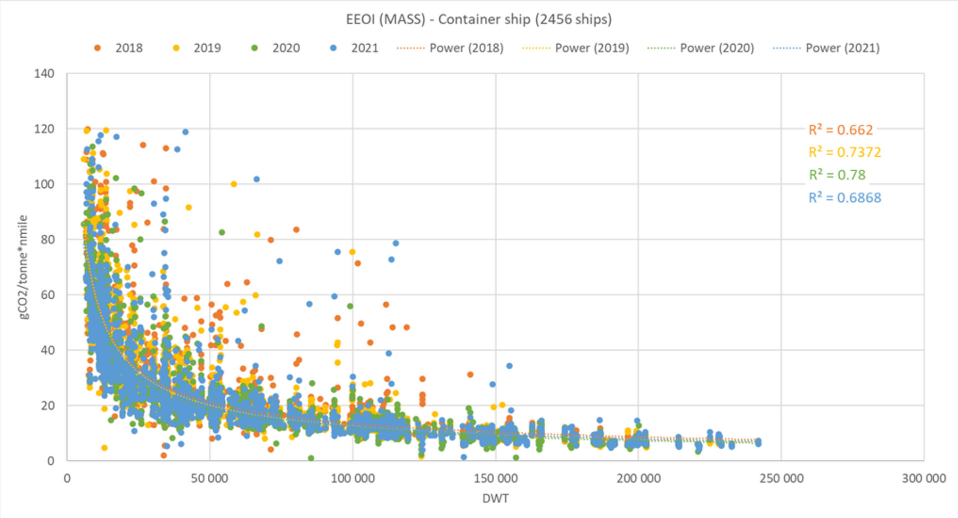

Figure 38: Plot of attained EEOI values of container ships over the four reporting years and according trendlines

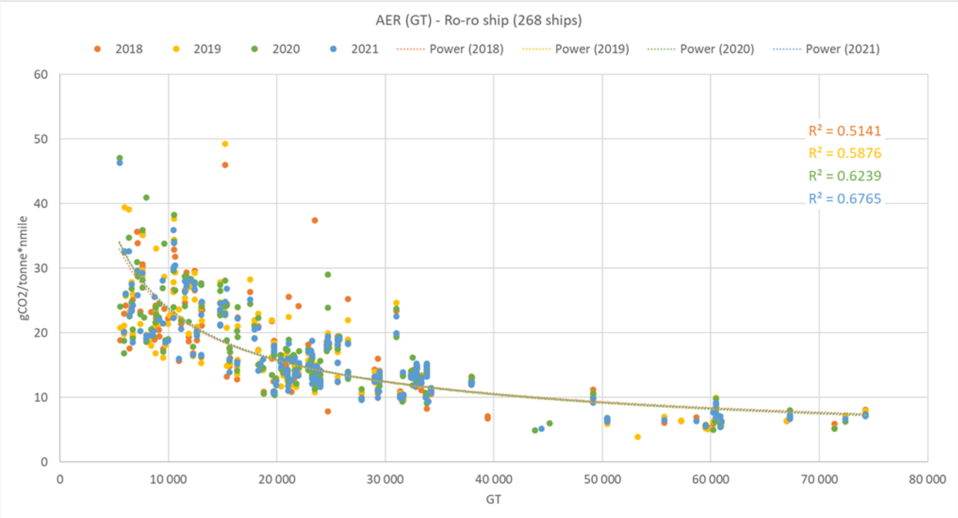

Figure 39: Plot of attained AER values of ro-ro ships over the four reporting years and according trendlines

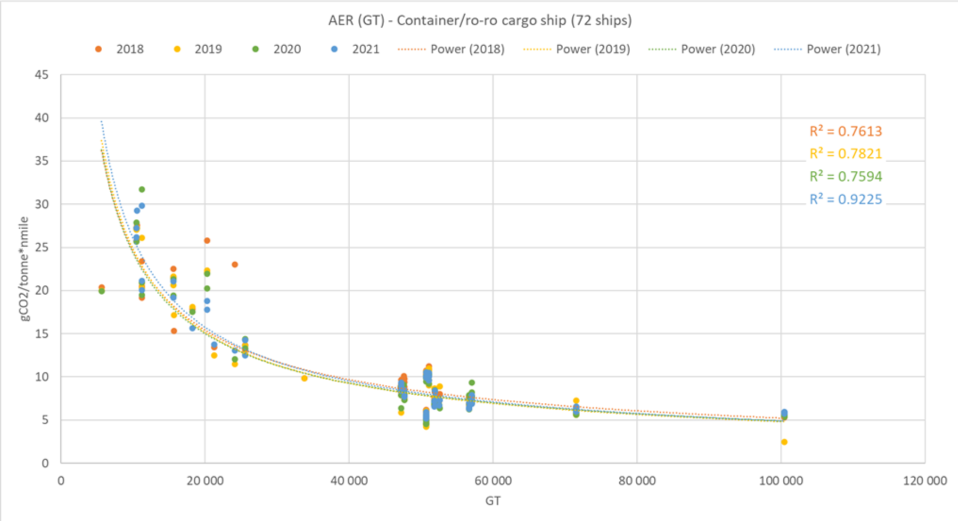

Figure 40: Plot of attained AER values of container/ro-ro cargo ships over the four reporting years and according trendlines

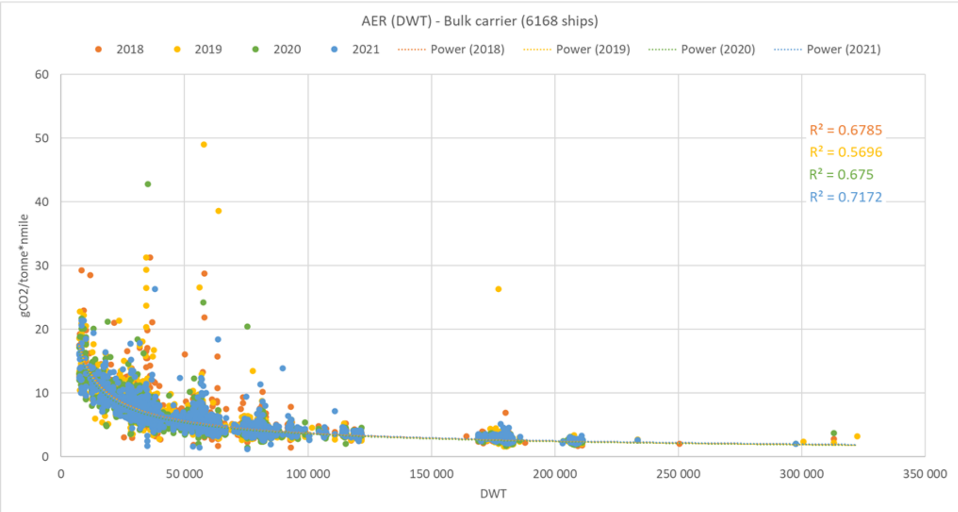

Figure 41: Plot of attained AER values of bulk carriers over the four reporting years and according trendlines

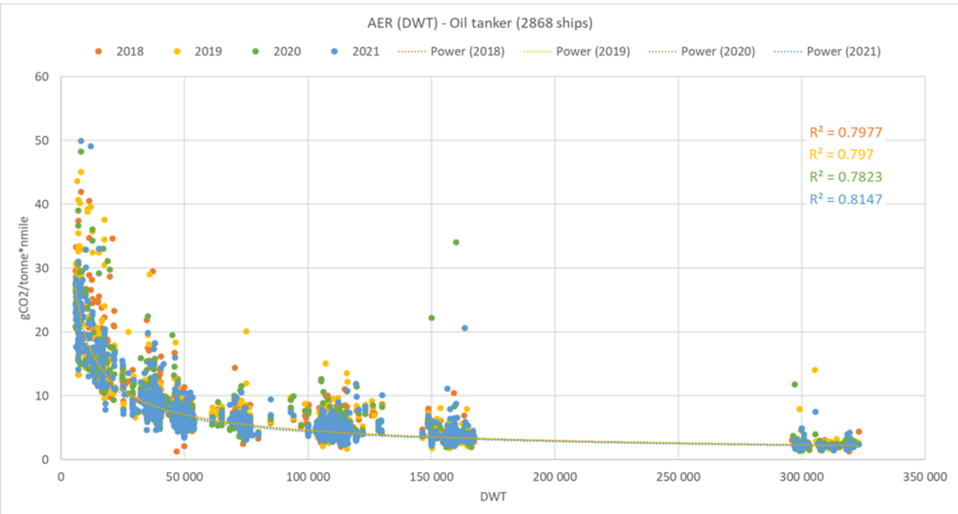

Figure 42: Plot of attained AER values of oil tankers over the four reporting years and according trendlines

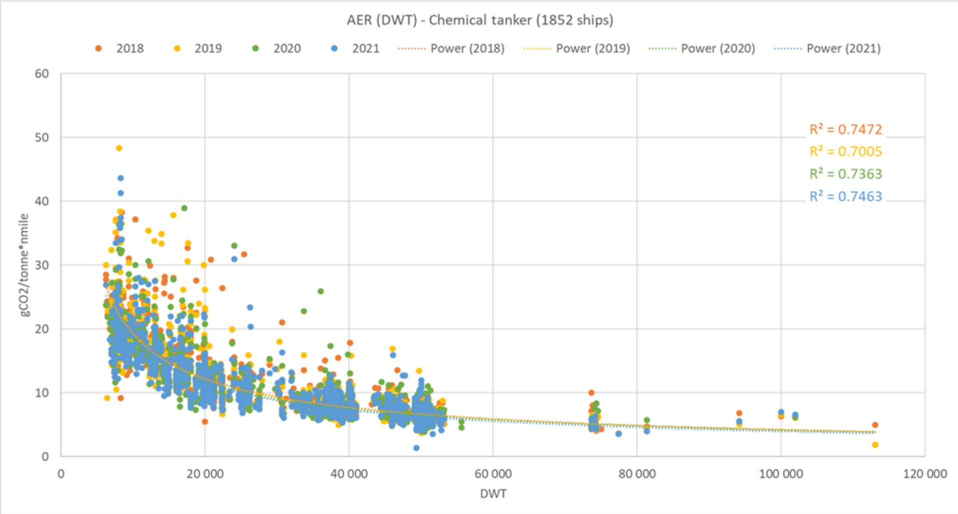

Figure 43: Plot of attained AER values of chemical tankers over the four reporting years and according trendlines

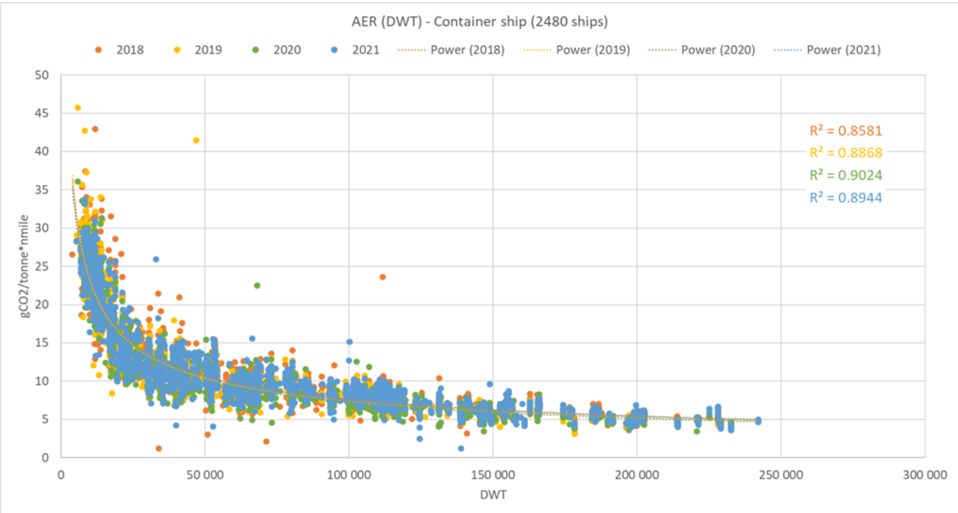

Figure 44: Plot of attained AER values of container ships over the four reporting years and according trendlines

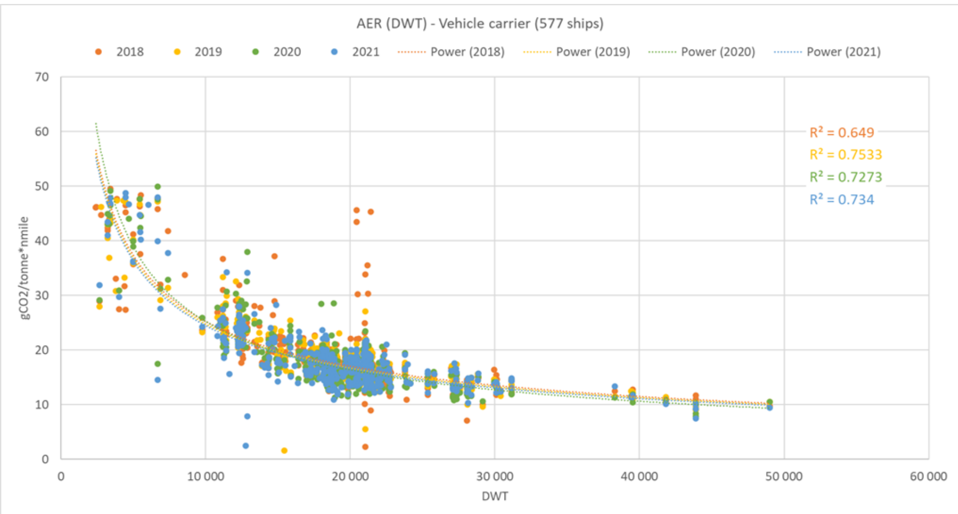

Figure 45: Plot of attained AER values of vehicle carriers over the four reporting years and according trendlines

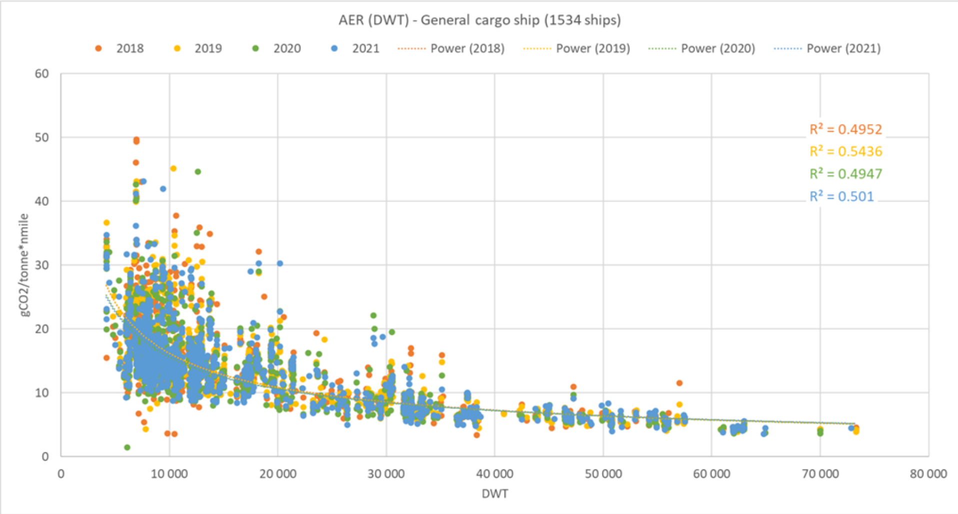

Figure 46: Plot of attained AER values of general cargo ships over the four reporting years and according trendlines