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2023 Report from the European Commission on CO_2 Emissions from Maritime Transport

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European Commission

2023 Report from the European Commission on CO_2 Emissions from Maritime Transport

Climate Action

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Executive Summary

Since 2018, the 'EU Maritime MRV Regulation',[1] requires shipping companies to monitor and report their fuel consumption, greenhouse gas emissions [2] and other key parameters for their ships when sailing to/from and between ports of the European Economic Area (EEA).

Every year, the European Commission publishes the reported aggregated data and prepares an annual report to analyse changes over the years. This report is the fifth one. It analyses the data from the period 2018-2022, following the release of the data in 2023.

The monitored voyages for the 2022 reporting year emitted 135.5 million tonnes of CO_2 into the atmosphere. These emissions were 7.1% higher than those reported in 2021 and 7.9% lower than those reported pre-COVID-19 in 2019 (the 2019 figure did, however, include emissions related to the United Kingdom [3]). The emissions reported for 2022 originated from a fleet of almost 12 800 ships, the highest number registered so far for a single reporting period (6.5% higher than in 2021).

This total increase in CO_2 emissions for the period 2021-2022 hides significant disparities between the different ship types, which reflect the major economic trends that affected the year 2022, and notably the consequences of Russia's full-scale invasion of Ukraine. In 2022, 9 of the 15 ship types reported higher emissions than in 2021. By ship type group, passenger ships (+172%), liquified natural gas (LNG) carriers (+59%), and bulk carriers (+13%) recorded the highest increase in emissions compared to 2021, driven by the increasing number of reporting ships and higher activity levels. The increase in emissions from passenger ships reflects the sector's rebound (fully or partially) after the COVID-19 years, while the increase from LNG carriers reflects the record quantities of LNG imported into the EU in 2022. The activity of bulk carriers was notably affected by the impact of sanctions and geopolitical risks, which lead to changes in global shipping trends and increased distances travelled for many commodities, including energy products.

Conversely, the most significant reduction in CO_2 emissions was recorded by container ships, which emitted around 2.9 million tonnes of CO_2 less than in 2021 (-7.6%), following a decrease in activity in European container ship ports, a decrease in the average distance sailed (-3.9%), and a reduction of the average speed of active container ships (-4.7%). In 2022, CO_2 emissions from oil tankers were also at their lowest since 2018, notably affected by the impact of sanctions.

Most ship types' relative contribution to total reported emissions remained stable overall in 2018-2022, even in the first year of COVID-19 (2020) and in the years following the UK's withdrawal from the EU (2021 and 2022). Container ships, oil tankers, and bulk carriers were confirmed as the top emitters in 2022. They were responsible for around 55% of total reported emissions in 2022. Container ships alone were responsible for 28% of the total CO_2 emissions. Two ship types (passengers ships and LNG carriers) stand out because they have shown considerable yearly variations over the last three reporting periods.

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

[2] Following the entry into force of amendments to Regulation (EU) 2015/757 in June 2023, the Regulation is not limited to CO2 emissions anymore but also covers greenhouse gas emissions. The monitoring and reporting requirements are extended to non-CO2 gases only starting the reporting period 2024. The present report, which considers data reported over the period 2018-2022, therefore only covers CO2 emissions as reported within the EU MRV scope.

[3] It was not possible to recalculate historical data before 2021 so as to exclude the emissions resulting from the 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 this report, the figures presented for the reporting years after 2020 are based on the reported data, which excludes the Regulation's application to the United Kingdom (but only to EEA countries, including the EU-27). By contrast, the reported data for the reporting years 2018, 2019 and 2020 includes the Regulation's application to the United Kingdom, which is accounted for as part of the EEA (the EU-28).

The distribution of the fleet's total CO_2 emissions between the different types of voyages and at berth that was recorded in 2022 was almost the same as in 2021. Voyages starting or ending outside the EEA represented the bulk of the CO_2 emissions (around two thirds). Voyages between two ports in the EEA represented around a quarter of all CO_2 emissions, in line with the share observed in 2021 after the withdrawal of the United Kingdom from the EU. CO_2 emissions occurring when ships are at berth in EEA ports represented around 6% of total emissions. These shares are in line with the volume of inward and outward flows recorded by Eurostat data.

In terms of fuel consumption, the monitored ships consumed more than 43 million tonnes of fuel in 2022. Fuel consumption data for 2022 confirmed established trends for 2018-2021 – namely the shift towards light fuel oil, LNG, and diesel oil, which followed the introduction of the 2020 IMO limit on the sulphur content of fuel oil used onboard ships. The composition of the 2022 fuel mix, in comparison with 2021, highlights a decrease (from 26% to 22%) in the share of light fuel oil and an increase in the use of heavy fuel oil (from 48% to 50%). 2022 saw the highest recorded level of LNG consumed by the fleet (around +32% higher than in 2021), fuelled by an increase in the activity of LNG carriers combined with the accelerating uptake of LNG-use by container ships. The consumption of non-fossil bunker fuels remained negligible, as in all previous years.

According to Eurostat data, the total 2022 volume of inward trade flows increased by 2.5% and was nearly the same as in 2019. Compared with 2021, the inflow from the United States (East Coast), Egypt, Norway, China, the UK, Brazil, and Canada (East Coast) increased in 2022, while the inflows from Russia (Black Sea and Baltic Sea), Nigeria and Türkiye decreased. The total 2022 volume of outward flows decreased by 1.4% and was nearly the same as in 2019. It was primarily the outflows to China and the UK that decreased in 2022, but total outflows are still dominated by the outward flow to the UK.

MRV data for 2018-2022 highlights the fact that speed variation was minor for most ship types. However, it is to be noted that, following an increase in average speed in 2020 and 2021, container ships recorded in 2022 a 4.7% decrease in average speed in comparison with 2021. This was a major driver of the reduction in total emissions for this ship type in 2022 (-7.6% on 2021).

Between 2021 and 2022 the average time spent at sea decreased for 6 of the 15 ship types but increased for 8 ship types. Among the ship types that experienced a longer average time at sea in 2022, passenger ships, LNG carriers, and bulk carriers have spent the longest total time at sea since 2018. This indicates that there has been a recovery from the COVID-19 crisis and that the EU's efforts to diversify its energy imports have been at least partially successful.

The graphical analysis of key technical and operational efficiency indicators shows that no significant changes took place in 2018-2022. Furthermore, the completeness and correctness of the reported data, which improved over the period, is confirmed by increasing data correlation values between key technical and operational efficiency indicators [4] and the size of the ships reporting under the EU Maritime MRV Regulation.

Ships reported a better energy efficiency design index in 2022 when cumulated at fleet level (a 5.6% improvement on 2021) and their average size increased by 5.7% compared with 2018-2021.

In terms of implementation of the EU Maritime MRV Regulation, the 2022 results confirm the continuing improvement in the quality of data. However, punctuality in data submission decreased after considerable improvements in the first four reporting years.

[4] The Energy Efficiency Design Index (EEDI) and the Estimated Index Value (EIV) are assessed for the technical efficiency of ships. The Energy Efficiency Operational Indicator (EEOI) and the Annual Efficiency Ratio (AER) are assessed for their operational efficiency.

1. Introduction

This report has been prepared using data from the implementation of the EU Regulation on the monitoring, reporting and verification of greenhouse gas emissions from maritime transport (Regulation (EU) 2015/757), hereafter called the "EU Maritime MRV Regulation". All information was extracted on 19 September 2023[5]. Data provided or updated after this date is not reflected in this report.

1.1. The 2023 Annual Report: scope and objectives

This is the fifth report on CO_2 emissions from ships entering and leaving ports in the European Economic Area (EEA), collected under the EU Maritime MRV Regulation.

This legislation requires shipping companies to track and report on key indicators such as 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 analyses main trends in the form of an annual report[6].

Throughout the entire process, transparency is a prerequisite and a key principle. The currently available set of MRV data, is contributing to an enhanced understanding of the climate impact of CO_2 emissions from the shipping sector. 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. This data is important to support policy discussions and to track the effectiveness of climate policies. In addition, it constitutes an important input for the sector in order to take more effective and efficient climate measures.

The present report covers the five compliance cycles since the entry into force of the EU Maritime MRV Regulation, covering emissions from 2018 to 2022. It builds on the previous reports and allows for a comparison of data from these reporting years. The main objective of this report is to examine trends in emissions and energy efficiency characteristics over the five available reporting cycles, despite different disruptive events affecting the maritime sector over the period, such as the COVID-19 pandemic (from 2020 to 2022), the UK's withdrawal from the Union (from 2021), and the Russia's full-scale invasion of Ukraine (from 2021).

The scope of the EU Maritime MRV Regulation

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

Despite limiting monitoring requirements to large ships (above 5 000 GT), the Regulation covers around 90% of all CO_2 emissions in the EU maritime transport sector, whilst only including around 55% of all ships calling into EEA ports. For reasons of proportionality and

[5] For the four previously published annual reports, related to the reporting periods 2018, 2019, 2020, and 2021 the same principle, i.e. a cut-off date has been applied. For the purpose of this annual report, however, updated data as of 19 September 2023 has been used for these four previous periods. This means that the 2018, 2019, 2020, and 2021 figures presented in this report might slightly differ from those published in the first, second, third, and fourth annual report.

[6] A detailed description of the monitoring, reporting and verification process ("The MRV system – Steps of the MRV process") can be found in Annex 2 to the 2022 Annual Report from the European Commission on CO_2 Emissions from Maritime Transport, at https://climate.ec.europa.eu/system/files/2023-03/swd_2023_54_en.pdf

subsidiarity, 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 travels to or from an EEA port, while transporting goods or passengers for commercial purposes. For instance, it covers the emissions of a ship that travels from Rotterdam to Shanghai as well as 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, such as a ship travelling from Le Havre to Rotterdam, are also covered, as well as domestic voyages, e.g., from Brest to Le Havre. Emissions produced by a ship in an EEA port 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. 2022: Russia's full-scale invasion of Ukraine and the post-pandemic economic recovery

Throughout 2020 and 2021 the maritime shipping sector was heavily affected by the consequences of the COVID-19 pandemic, causing supply chain disruptions, travel restrictions and port congestions. Following clear recovery trends already visible in late 2021, 2022 was also heavily impacted by the consequences of Russia's full-scale invasion of Ukraine. The combined effect of border closures, trade restrictions and increased fuel costs, negatively affected consumer spending and demand for shipping containers. In turn, this impacted trade patterns and volumes especially in late 2022, thereby dampening the post-COVID-19 recovery of global trade (OECD, 2023)

As a result, global seaborne trade, expressed in traded volumes, declined marginally by 0.4% in 2022 and global containerized and dry bulk shipments declined by 3.7% and 2.9% respectively (UNCTAD, 2023). Eurostat data confirms a decrease in containerized cargo handled in European ports (-7%) but, on the contrary, shows an increase in the dry bulk goods (+4.7%) compared to 2021 (Eurostat, 2023). In line with these findings, the number of port calls by container ships in the EU in 2022 was the lowest in the period 2018 to 2022 – around 9% lower than in 2021. This is in contrast to the number of port calls made by bulk carriers, which were at their highest in the same year (+4.9% compared to 2021) [7].

Tourism (both domestically and internationally) was still affected by travel restrictions linked to the COVID-19 pandemic, especially in the first half of 2022 (OECD, 2022). In terms of number of port calls in the EU, the cruise sector seems to have almost fully recovered in 2022: after dropping to the lowest activity levels of the analysed period in 2020 (-66% in number of port calls compared to 2019) and a partial rebound in 2021 (-40% compared to 2019), 2022 port calls were only 3.9% lower than those in 2019 (and higher 2018 figures). The Ro-Pax sector, on the contrary, registered a full recovery in 2022, with a higher number of port calls than in 2019 (+2.5%).

In addition to the above, specific subsectors were particularly affected by sanctions implemented following Russia's full-scale invasion of Ukraine and by the overall security

[7] Port call data mentioned throughout this Report is sourced from MARINFO and covers ships above 5 000 GT calling at EEA ports. Port call data before 2021 are adjusted to exclude port calls in the United Kingdom.

challenges brought on by the war.[8] Dry bulk (grain [9]) and oil tanker shipments (crude oil and other refined products) were particularly affected (UNCTAD, 2023), leading to changes in global shipping trends and increasing the distances travelled for many commodities, as the Russian Federation sought new export markets for its goods and Europe looked for alternative energy suppliers. Growth in ton-miles exceeded growth in tons in 2022 (UNCTAD, 2023). Gas imports to Europe were also particularly hit: as the EU made efforts to diversify its imports away from Russian gas (General Secretariat of the Council, 2023) and new gas supplies (e.g. from the United States, Qatar or Nigeria) could not rely on pipeline connections, thus driving up liquified natural gas (LNG) seaborne imports – which increased by 69% compared to 2021 (IGU, 2023).

1.2.2. EU's continuous support to decarbonise maritime transport through the 'Fit for 55 package'

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 represents the concretisation of the the European Green Deal into policies. Adopted in December 2019, it aims to transform the EU into a modern, resource-efficient and competitive economy, and to achieve climate neutrality by 2050. Relevant measures proposed under the 'Fit for 55 Package' aim at ensuring that maritime transport contributes to the EU's increased climate ambition and to commitments under the Paris Agreement by addressing various barriers to the decarbonisation of the sector (technological, economic, legal 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 are expected to allow the creation of a virtuous ecosystem for such cleaner fuels, by looking at the entire value-chain and boosting fuel demand, distribution, and supply. In addition, the Commission will continue supporting research and innovation which supports the decarbonisation of maritime transport, in particular through Horizon Europe and the Innovation Fund.

The year 2023 saw significant progress in interinstitutional negotiations on the above mentioned proposals. At the time of writing (November 2023), the European Parliament and the Council have adopted most of the relevant measures affecting the maritime transport sector. The revision of the EU Emissions Trading System (ETS)[10] will extend the scope of the EU ETS to cover CO_2 emissions from large ships entering EU ports, starting from 1 January 2024 regardless of the flag they fly. The FuelEU Maritime Regulation[11] will ensure that the greenhouse gas intensity of energy used on-board ships gradually decreases over time, along with an obligation for passenger and container ships to use on-shore power supply while moored at the quayside in major EU ports as of 2030. Due to the Regulation on Alternative Fuels Infrastructure[12], maritime ports which welcome a minimum number of large passenger vessels, or container vessels, must provide shore-side electricity for such vessels by 2030.

[8] Also the composition of the 2022 MRV fleet that in 2022 was impacted by Russia's full-scale invasion of Ukraine, in particular since with Council Regulation (EU) 2022/576, into effect as of 8 April 2022, the EU has closed its ports to Russia's entire merchant fleet. The EU has further prohibited the maritime transport of Russian crude oil (from 5 December 2022) and petroleum products (from 5 February 2023) to third countries.

[9] Grain exports from Ukraine came to a halt with the Russian aggression and resumed only after mid-2022 following the Black Sea Initiative.

[10] Through Directive (EU) 2023/959, OJ L 130, 16.5.2023, p. 134, http://data.europa.eu/eli/dir/2023/959/oj.

[11] Regulation (EU) 2023/1805, OJ L 234, 22.9.2023, p. 48, http://data.europa.eu/eli/reg/2023/1805/oj.

[12] Regulation (EU) 2023/1804, OJ L 234, 22.9.2023, p. 1, http://data.europa.eu/eli/reg/2023/1804/oj.

The revision of the Renewables Energy Directive[13] will introduce more ambitious sector-specific targets in transport, including sub-targets for advanced biofuels and renewable fuels of non-biological origin.[14]

Horizon Europe [15] is supporting the successful implementation of the policy objectives of the above measures through research and innovation. In this context, the Zero-Emission Waterborne Transport partnership [16], with a budget of €3.8 bn, was set to demonstrate zero-emission solutions for all main ship types and services before 2030.

Compliance with the new obligations on shipping companies stemming from the extension of the EU ETS to maritime transport and the FuelEU Maritime Regulation will build on the monitoring, reporting, and verification system established by the EU MRV Regulation, which was also revised in May 2023[17]. Most notably, the revision affects the rules, to implement the extension of the EU ETS to the maritime sector and to account for the inclusion of non-CO_2 emissions (methane - CH_4 and nitrous oxide - N_2O) in the revised system. The new monitoring and reporting rules will apply from the 2024 reporting period.

1.2.3. Developments at the International Maritime Organization

Throughout 2022, the Commission maintained its support for ambitious progress at international level to reduce greenhouse gas emissions from shipping through effective global measures. In July 2023 the International Maritime Organisation (IMO) took a first step on this path by committing - through a revised strategy[18]- to new targets for GHG emission reductions and to develop and adopt a basket of measure(s) in 2025 aiming at delivering on these reduction targets.

In more detail, the revised strategy aims to:

1. reach net-zero GHG emissions from international shipping by or around, i.e. close to, 2050, with emissions peaking as soon as possible;
2. improve the carbon intensity of international shipping by reducing the CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, compared to 2008;
3. increase the uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources to represent at least 5%, and striving for 10%, of the energy used in international shipping by 2030; and
4. improve the carbon intensity of ships through further optimisation of the energy efficiency for new ships.

To ensure that net-zero GHG emissions are reached as envisioned, two indicative checkpoints have been scheduled:

1. by 2030, total annual GHG emissions from international shipping should be reduced by by at least 20%, and strive for 30%, compared to 2008; and

[13] Directive (EU) 2023/2413, OJ L 2023/2413, 31.10.2023, ELI: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413.

[14] The revision of the Directive on energy taxation, Council Directive 2003/96/EC of 27 October 2003, is still ongoing at the time of writing.

[15] Regulation (EU) 2021/695, OJ L 170, 12.5.2021, https://eur-lex.europa.eu/eli/reg/2021/695/oj.

[16] Commission Decision C(2021) 4113 of 14.6.2021 on the approval and signature of eleven Memoranda of Understanding for Co-programmed European Partnerships for Research and Innovation.

[17] Regulation (EU) 2023/957, OJ L 130, 16.5.2023, p. 105, http://data.europa.eu/eli/reg/2023/957/oj.

[18] The IMO's Marine Environment Protection Committee (MEPC) adopted the '2023 IMO Strategy on Reduction of GHG Emissions from Ships' (Resolution MEPC.377(80), MEPC 80/WP.12, Annex 1.

2. by 2040, total annual GHG emissions from international shipping should be reduced by by at least 70%, and strive for 80%, compared to 2008.

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

In this context, the 2023 GHG Strategy states that a basket of candidate measure(s), delivering on the aforementioned reduction targets, should be developed and finalized by 2025, comprising:

1. a technical element, namely a goal-based marine fuel standard regulating the phased reduction of the marine fuel's GHG intensity; and
2. an economic element, on the basis of a maritime GHG emissions pricing mechanism.

As part of the development of mid-term GHG reduction measures, a comprehensive impact assessment of short listed measure combinations will be carrid out.

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

2.1. The Fleet: emissions and number of ships

In 2022, emission reports for 12 744 ships were submitted by 1 762 companies for a total of CO_2 emissions from the EU MRV fleet of around 135.5 million tonnes (see Figure 1 and Figure 3).[19]

In terms of emissions, 2019 remains the year with the highest total CO_2 emissions on record. After a drop of 12.0% in total emissions in 2020 with respect to 2019, mainly due to the economic effects of COVID-19, emissions reached the lowest recorded level in the series in 2021 (126.5 million tonnes). The further reduction of 2.2% observed between 2020 and 2021 can largely be explained by reduced scope of the EU MRV after the UK's withdrawal from the EU, combined with only a partial recovery from the COVID-19 downturn. The year 2022 cleary shows there was a rebound in emissions levels linked to further recovery from the COVID-19 economic downturn. 135.5 million tonnes of CO_2 in 2022 implies an increase in total emissions of 7.1% compared to 2021. This is well above the levels registered in 2020 (the first year affected by COVID-19) and only 7.9% lower than in 2019 (the last year including the United Kingdom under full MRV scope).

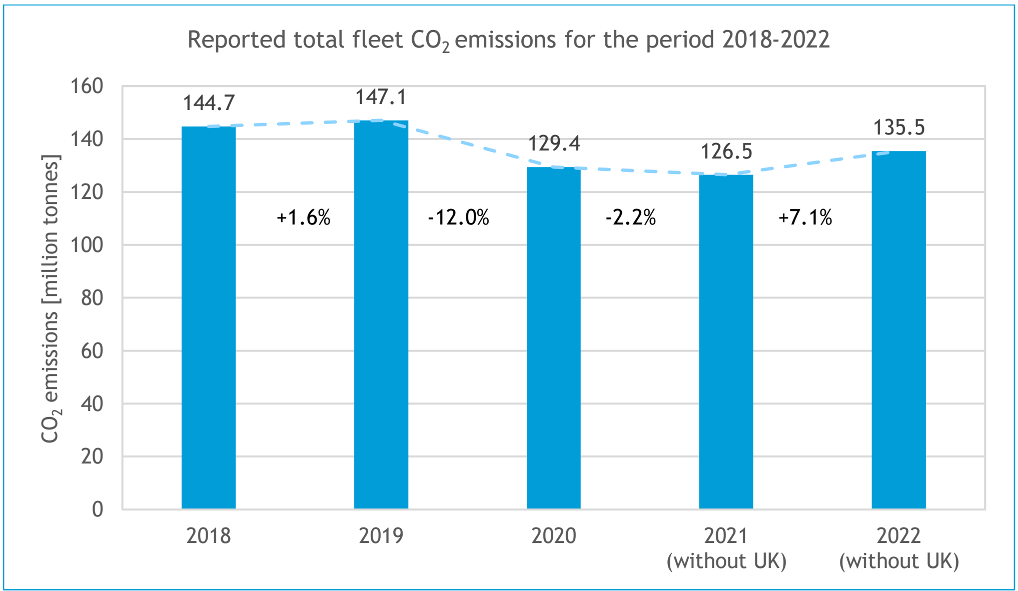


Figure 1: Reported total fleet CO_2 emissions; 2018-2022

The distribution of the fleet's total CO_2 emissions over the different types of voyages and at berth are almost the same in 2021 and 2022 (see Figure 2) and shows the impact of the UK's withdrawal from the EU from 2021 onwards, namely the decrease in emissions from intra-EEA voyages mirrored by an increase in emissions from extra-EEA voyages (both incoming and outcoming)[20]. Across the period 2018-2022, the share of emissions from intra-EEA voyages reached its lowest level in 2021 (25.5%, against its peak of nearly 32% in 2018-2019), while extra-EEA voyages, both incoming and outgoing, contributed the highest share of emissions

[19] In this Fifth annual report, just as in the 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. A decreasing number of ships has reported zero emissions over time: 638 in 2018 down to 211 in 2022. Only 21 ship have reported zero emissions in each of the five reporting periods.

[20] This is because, 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.

(35.0% and 32.4% respectively). The share of emissions at berth compared to the total remained stable over the five reporting periods (around 6%).

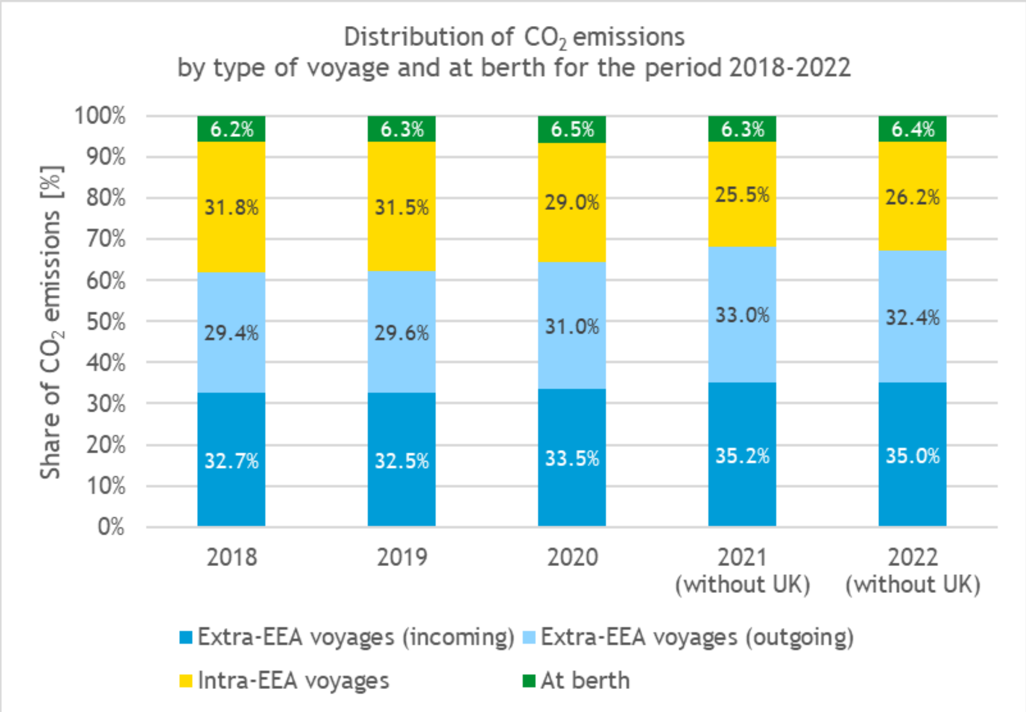


Figure 2: 2018 to 2022 share of fleet emissions per voyage type and at berth

The total number of ships submitting emission reports has remained relatively stable over the first four reporting years (around 12 000). In 2022 however, this number increased by 6.5% compared to 2021, reaching the highest level on record, despite the effect of the UK's withdrawal from the EU. The first year of implementation of the EU MRV system (2018), remains the period with the lowest number of submitted emissions reports.

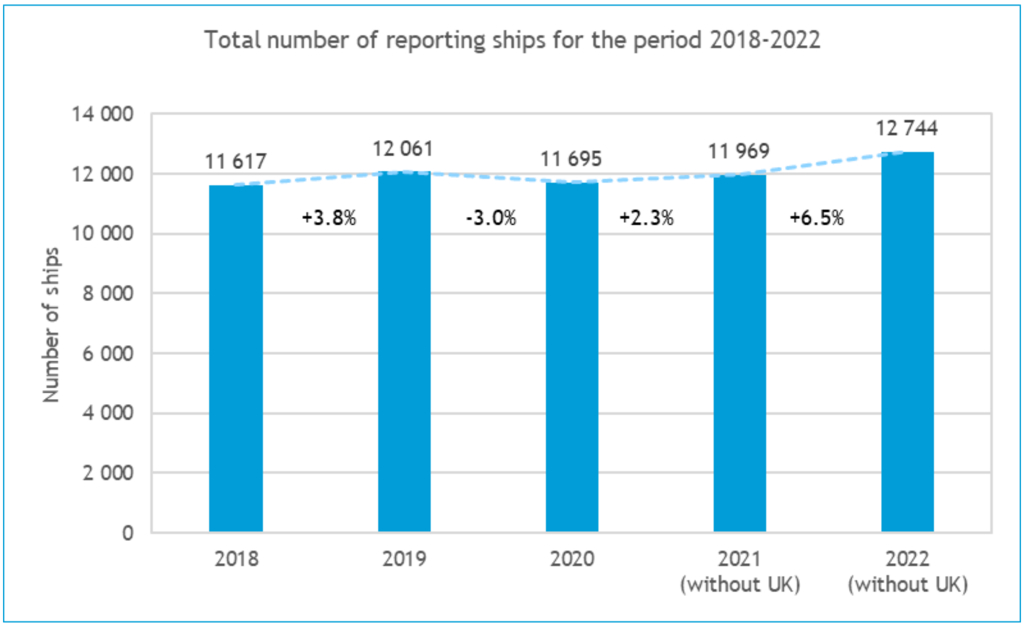


Figure 3: Total number of ships for which emissions report has been submitted; 2018-2022

2.2. Ship types: emissions and number of ships

Most of the 15 ship types reporting under the EU Maritime MRV Regulation recorded their highest emission levels in the years preceding COVID-19 and the UK's withdrawal from the EU, namely in 2018 (5 types) and 2019 (6 types) (see Figure 4). However, the year 2022 stands out for bulk carriers, LNG carriers and 'Other ship types' as they recorded their highest emissions over all reporting periods. Combination carriers remains the only ship type for which emissions peaked in 2020 (0.1 Mt).

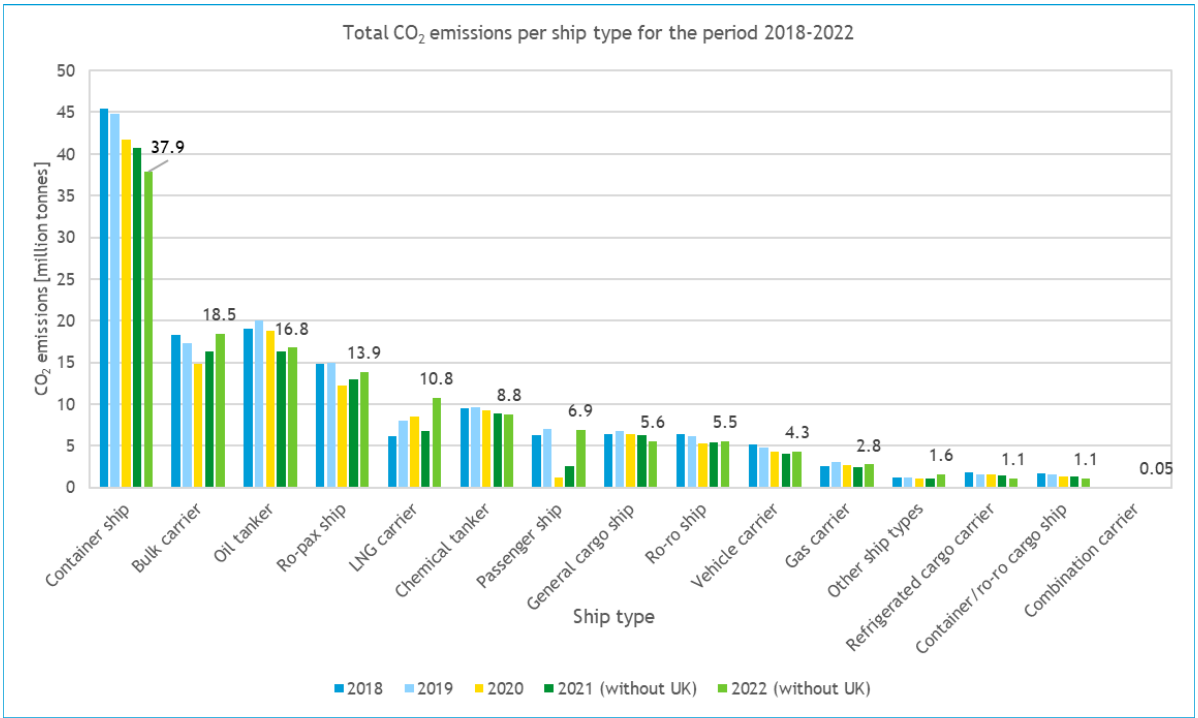


Figure 4: Total emissions per ship type; 2018 to 2022; descending 2022 order; levels given for 2022 (without UK)

For 9 of the 15 ship types, the year 2022 showed an increase in emissions compared to 2021 (Figure 5). In particular, CO_2 emissions from passenger ships and LNG carriers increased (by more than 4 Mt, +172% and +59% respectivaly on the previous year) and from bulk carriers (by more than 2 Mt, +13% on the previous year). Also noticeable is the reduction in CO_2 emissions from container ships, almost 3 Mt lower (-7%) compared to 2021.

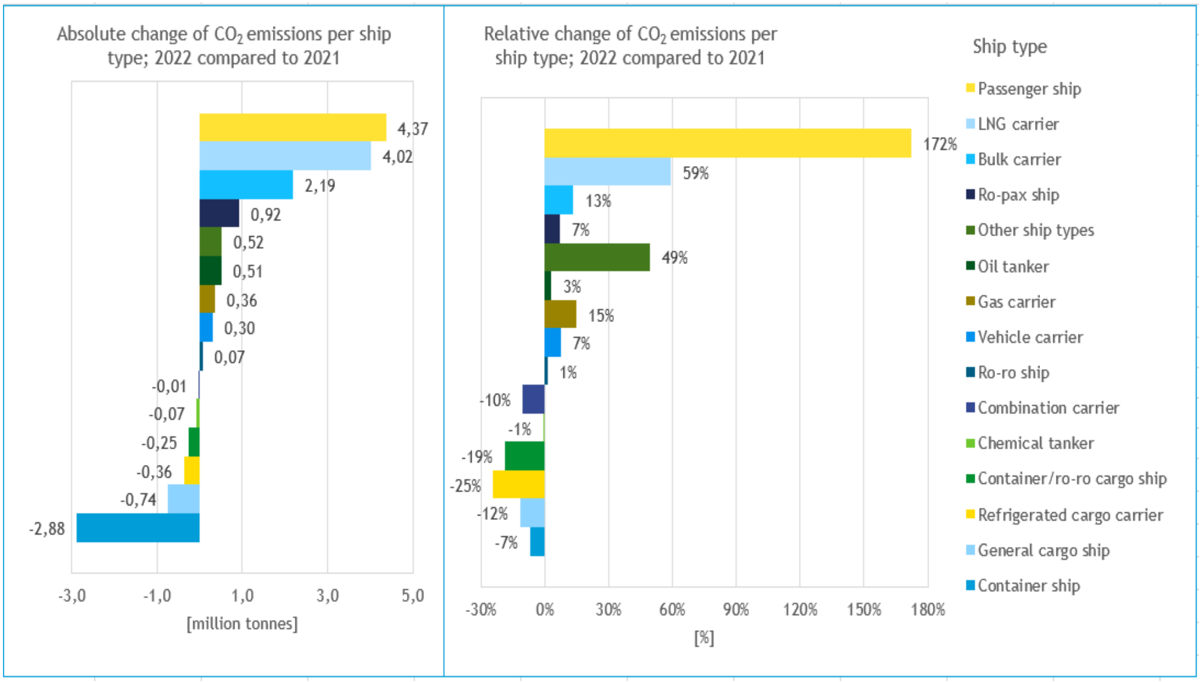


Figure 5: Change of emissions in 2022 compared to 2021 per ship type, in absolute and relative terms

Figure 6 allows to further analyse changes in total emissions reported, by ship and voyage type (including a differentiation between CO_2 emitted at sea and at berth), between 2021 and 2022.

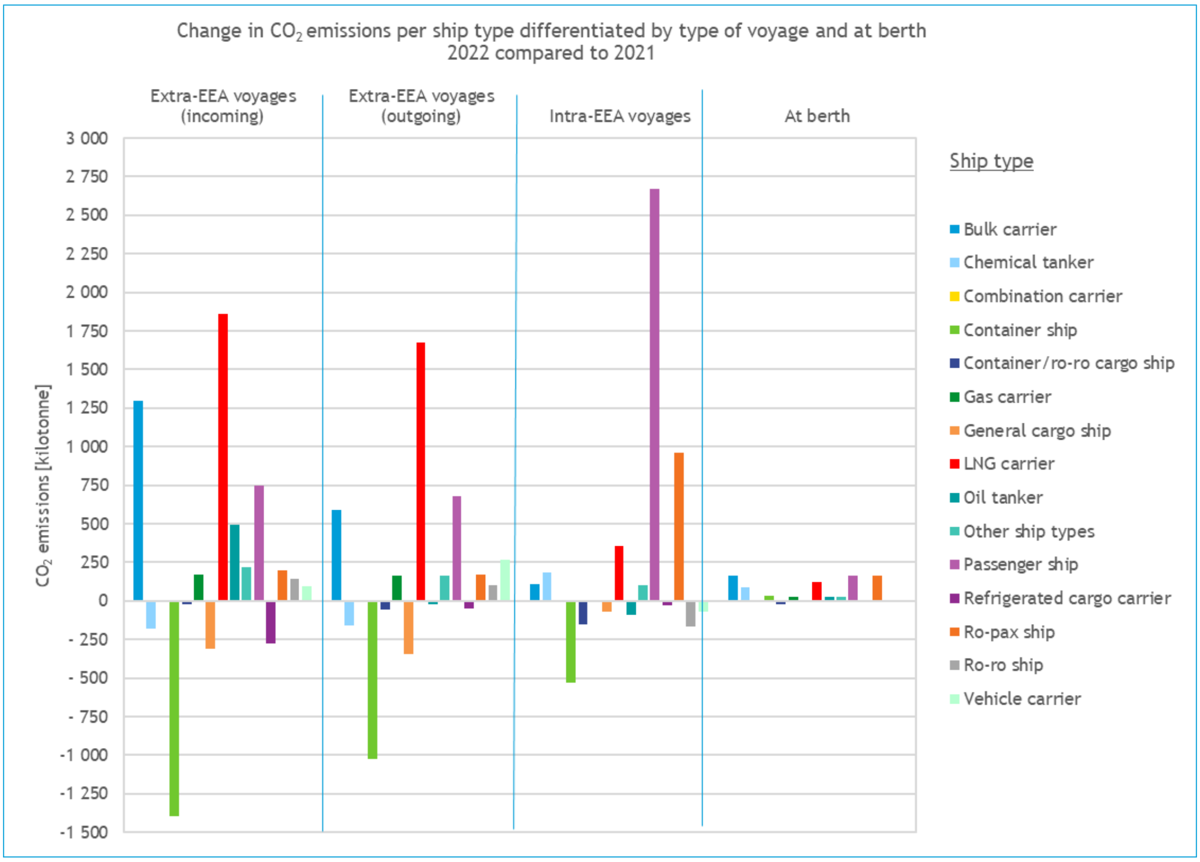


Figure 6: Change in emissions by ship type, differentiated by type of voyage; 2022 (without UK) on 2021 (without UK); ship types sorted by change of total emissions

Passenger ships show a relatively strong increase in emissions on intra-EEA voyages, which is an indication of further recovery from the COVID-19 crisis.

LNG carrier feature a relatively high increase in emissions on extra-EEA voyages (incoming & outgoing), fuelled by the increase in LNG imports to Europe, due to the EU diversifying away from Russian gas which had previously been mainly transported by pipelines.

Reported emissions from container ships have mainly decreased on extra-EEA voyages, but also on intra-EEA voyages, while bulk carriers show a relatively strong increase in emissions on incoming extra-EEA voyages and a smaller increase in emissions on outgoing extra-EEA voyages.

As illustrated by Figure 7 and 8, in 2022, container ships, even if decreasing from the previous year, maintained the highest proportion in the fleet CO_2 emissions (2022: 28%) and were, together with the emissions of oil tankers and bulk carriers, responsible for almost 55% of the 2022 fleet emissions.

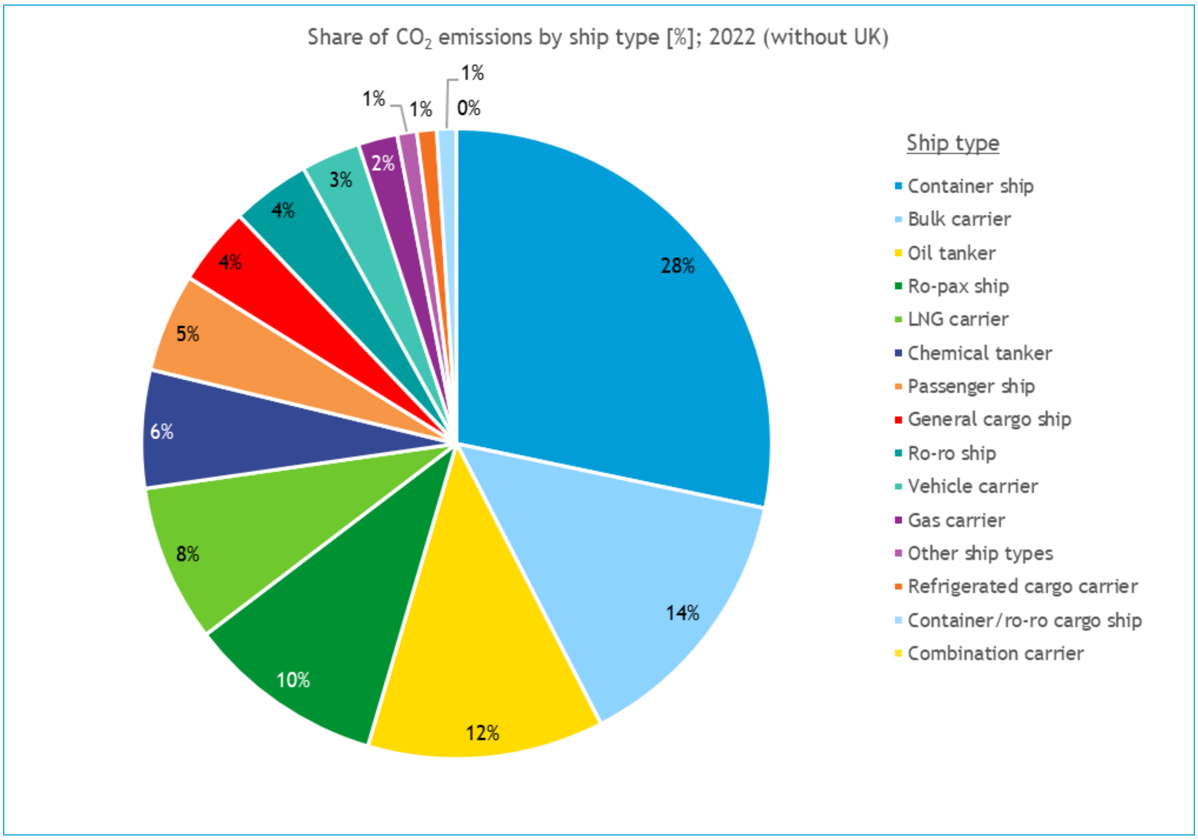


Figure 7: Share of overall fleet CO_2 emissions by ship type; 2022 (without UK), in %

For most ship types, their relative contribution to total reported emissions remained stable across the five years, even in the first year of COVID-19 (2020) and in the years following the UK's withdrawal from the EU (2021 and 2022). Two ship types (passengers ships and LNG carriers), on the contrary, showed considerable yearly variations in their contribution to total emissions reported by the MRV fleet, as a consequence of temporary disruptions brought on in the respective subsectors in the year 2020-2021 (for passanger ships) and in the last three reporting years (2020,2021,2022) for LNG carriers. In 2022, container ships and oil tankers stand out for reporting their lowest share of emissions out of the five reporting years, while bulk carriers and LNG carriers reported their highest share. For the first time in the period 2018-2022 bulk carriers surpassed oil tankers as the second largest emitter (see Figure 8).

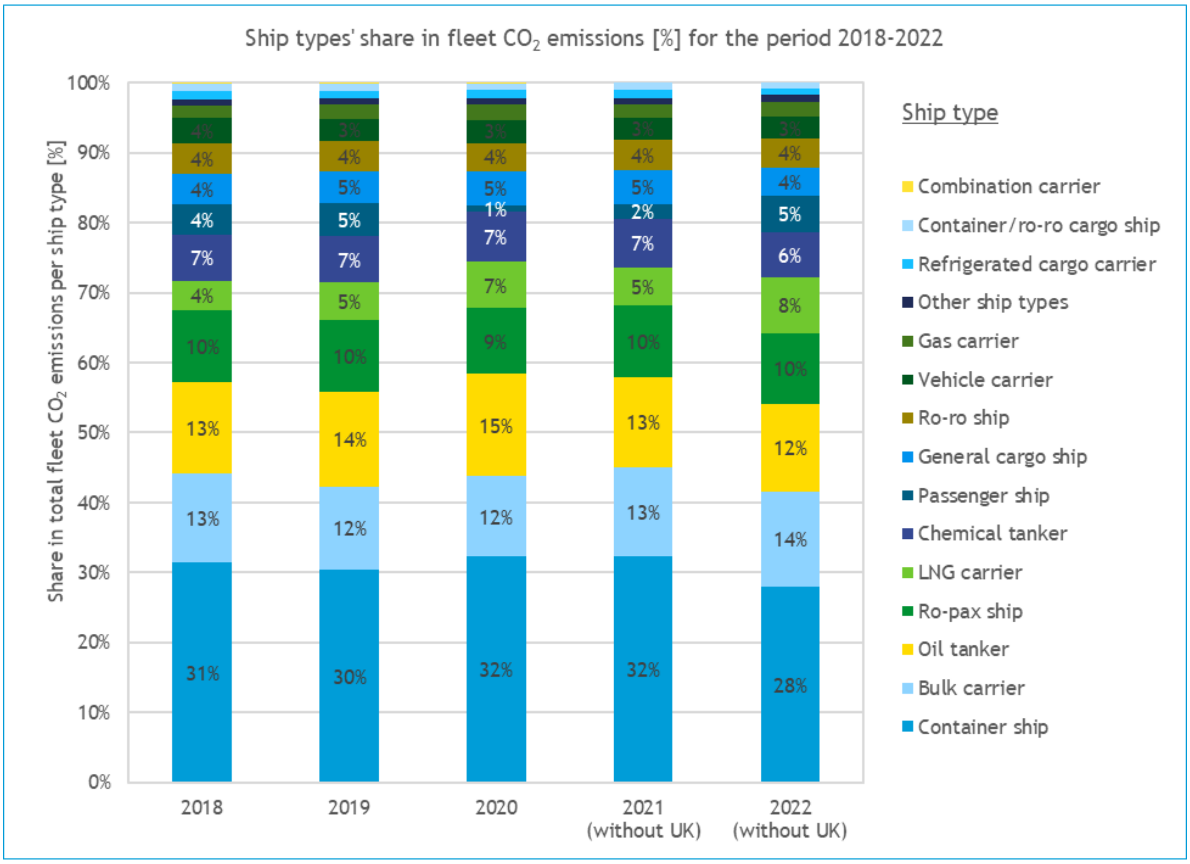


Figure 8: Ship types' share in fleet CO_2 emissions; 2018 - 2022

In terms of number of ships active in the MRV system, 5 ship types keep representing the lion's share: bulk carriers (31%), oil tankers (15%), container ships (14%), chemical tankers (11%) and general cargo ships (9%), account for 81.0 % of emissions reports submitted in 2022; this trend follows from the previous four years, where these 5 ship types also dominated emission figures (see Figure 9). This demonstrates an overall stability in the composition of the active fleet per ship type under the EU MRV system.

In absolute terms, ship types which recorded the highest increase in the number of active ships between 2021 and 2022 were bulk carriers (+404 ships or +11%), oil tankers (+141 ships or +8%), LNG carriers (+91 or +31%), passenger ships (+74 or +66%). Only general cargo ships showed a relatively high decrease in the number of ships (-86 or - 7%) (see Figure 10). 9 out of the 15 ship types had the highest number of ships on record for that type in 2022. For the others, the highest number of ships on record were in the following years: general cargo ships and refrigerated cargo ships in 2021, container ships and combination carriers in 2020, and container/ro-ro cargo ships and Ro-ro ships in 2018 and 2019 respectively.

Despite lower CO_2 emissions, the number of container ships active in the system in 2022 is almost the same as in 2021 (+10 ships or +0.6%).

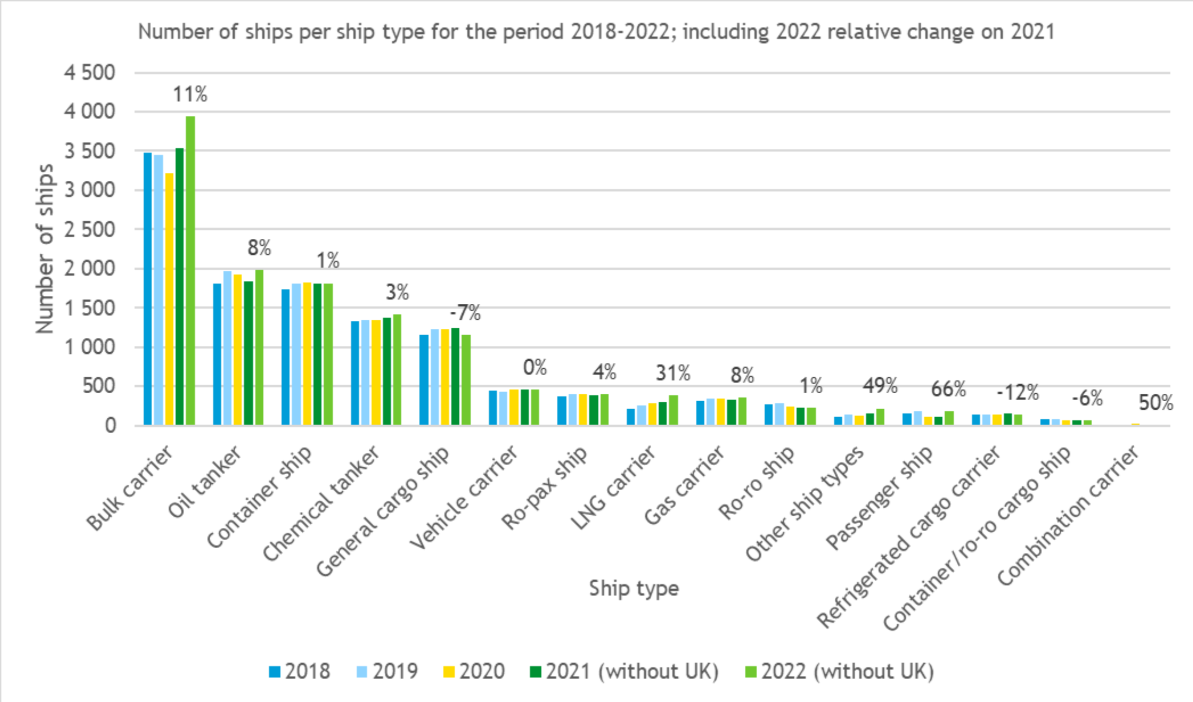


Figure 9: Number of ships per ship type; 2018 to 2022; descending 2022 order; percentage change in 2022 compared to 2021

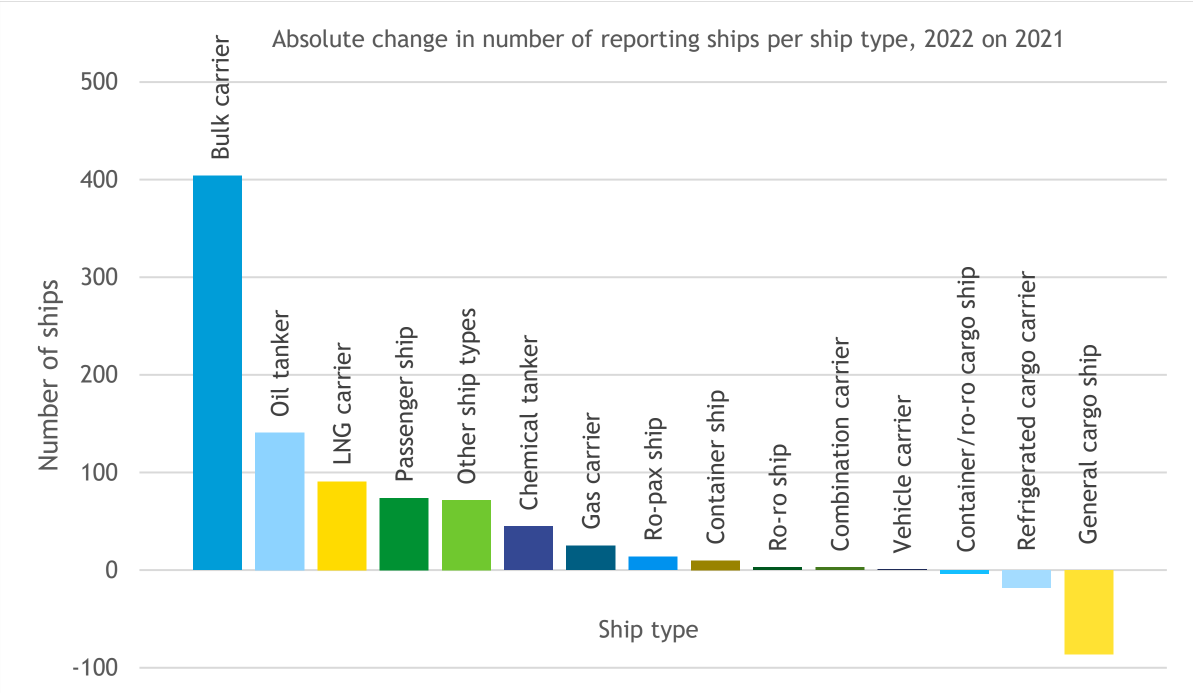


Figure 10: Change in number of ships per ship type; 2022 (without UK) on 2021 (without UK)

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 emissions per ship:

1. More/fewer ships active within the scope of the EU Maritime MRV Regulation;
2. Active ships within the scope of the Regulation are used to a different degree;

3. Active ships within the scope of the Regulation are more/less energy efficient;
4. Active ships within the scope of the Regulation use energy carriers that are more/less carbon intensive.

Below, changes in CO_2 emissions are further analysed for specific ship types, first focussing on the latest developments (2022 compared to 2021), followed by an analysis of identified trends in the first five reporting periods.

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 in the geographical scope of the EU Maritime MRV system (for the years 2021 and 2022 following the UK's withdrawal from the EU).

2.3.1. 2022 compared to 2021

The analysis of key changes in emissions per ship type in reporting year 2022 compared to 2021 focuses on those ship types featuring the highest decrease (see Table 1) and highest increase (see

Table ***2***) in absolute CO_2 emissions.

Container ships key indicators are shown below (see also Figure 5).

Table 1 Analysis of 2022 CO_2 emissions decrease

Ship types featuring highest decrease of absolute CO_2 emissions compared to 2021

Ship type	Change of CO_2 emissions compared to 2021	Change of number of reporting ships compared to 2021	Change of average per ship emissions compared to 2021	Change of average distance sailed compared to 2021	Change of average emissions per nautical mile compared to 2021
Container ships	-2.88 Mt (-7.6%)	+10 (+0.6%)	-1.7 kton/ship (-7.6%)	-1 497 Nm/Ship (-3.9%)	-0.02 tonne/Nm (-3.3%)

Analysing the emissions decrease of the container ship fleet in 2022, it can be concluded that:

1. The decrease in emissions of container ships cannot be explained by a change in the number of reporting ships, which is almost the same as in 2021 - the decrease in average emissions per ship is in line with the container fleet's overall decrease in emissions.
2. The decrease in average emissions per container ship is due to a combination of both a decrease in average distance travelled within the scope of the EU Maritime MRV and a decrease in average emissions per nautical mile.
3. According to Eurostat (2023), in 2022, 7% less containerised cargo (in tonnes) was handeld in EU-27 ports compared to 2021. This could possibly explain the decrease in average distance sailed by container ships.
4. The average speed of container ships was 4.7% lower than in 2021 (see 3.2.1), leading to higher fuel consumption savings, which contributed to the lower emissions per nautical mile.

In absolute terms (Mt), Passenger ships, LNG carriers, and bulk carriers had the largest increase in CO_2 emissions on a per ship type basis between 2021 and 2022 (see Figure 5).

Table 2 Analysis of 2022 CO_2 emissions increase

Ship types featuring highest increase of absolute CO_2 emissions compared to 2021

Ship type	Change of CO_2 emissions compared to 2021	Change of number of reporting ships compared to 2021	Change of average per ship emissions compared to 2021	Change of average distance sailed compared to 2021	Change of average emissions per nautical mile compared to 2021
Units	*Mt (% change)*	*Ships (% change)*	*Kton/Ship (% change)*	*nm/Ship (% change)*	*ton/nm (% change)*
Passenger ships	+4.4 (+172%)	+74 (+66%)	+14.5 (+64%)	+18 504 (+83%)	-0.12 (-12%)
LNG carriers	+4.0 (+59%)	+91 (+31%)	+5 (+22%)	+7 592 (+26%)	-0.02 (-2.3%)
Bulk carriers	+2.19 (+13%)	+404 (+11%)	+0.1 (+1.8%)	+234 (+1.5%)	-0.0001 (-0.02%)

Analysing the emissions increase for these three ship types, it can be concluded that:

1. The increase in emissions of the passenger ship fleet and the LNG carrier fleet can be explained by a combination of an increase in the number of ships that have been active within the scope of the EU Maritime MRV Regulation, as well as an increase of the average emissions per ship.
2. The average emissions per ship of the passenger ship fleet and the LNG carrier fleet have increased due to the higher average distance sailed. For passenger ships, this is probably related to further recovery from the COVID-19 crisis and for LNG carriers it is likely related to altered trade patterns, such as increased imports from the US.
3. The average passenger ship speed was cleary higher in 2022 than in 2021 (see 3.2.1). At the same time, 2022's average emissions per nautical mile were significantly lower than in 2021. This indicates that passenger ships with a higher technical energy efficiency or improved carbon intensity of energy consumption might have been active within the 2022 EU Maritime MRV.
4. The increase in emissions of the bulk carrier fleet can mainly be explained by an increase in the number of ships that were active within the scope of the EU Maritime MRV Regulation. The increased volume of dry bulk goods (+4.7%) handled in EU-27 ports in 2022 (Eurostat, 2023) seems therefore to have been met by a higher number of bulk carriers rather than by a more intensive use of the same bulk carriers. A small increase in the average emissions per ship also contributed to the increase in total emissions, which can mainly be explained by a higher average distance sailed by bulk carriers in 2022. Such trends in the EU MRV bulk carrier fleet are in line with those reported at the global level, where bulk carrier trade returned to pre-COVID-19 levels by the end of 2022 (UNCTAD, 2023).

2.3.2. Analysis over the period 2018-2022

2022 was the EU Maritime MRV system's fifth reporting period. An analysis of the data reported in the period 2018 to 2022 potentially allows to identify certain trends over time. An anlysis of trends is, however, limited due to two factors: first, the year 2021 saw a change in the geographical scope of the Regulation, due to the withdrawal of the UK from the EU[21] and, second, the composition of the active fleet within the scope of the EU Maritime MRV system changes annually. To date, only 5 213 ships have reported in each of the five reporting periods which corresponds to between 41% and 45% of the total number of ships for which a report has been submitted in a year. Due to these limitations, the following analysis focusses on potential trends of average per ship indicators.

An analysis of the average annual CO_2 emissions per ship type (see Figure 11) reveals a cluster of 9 ship types with similar average emissions of between 5 000 and 10 000 tonnes CO_2 per ship in 2022. The remaining 6 ship types feature much higher average annual CO_2 emissions, ranging from 17 600 tonnes CO_2 for container/ro-ro cargo ships to 37 100 tonnes for passenger ships in 2022. Out of these 6 ship types, only container ships show a continuously decreasing trend of the average annual CO_2 emissions (-20 % in the period 2018-2022), which is also matched by a reduction of the average distance travelled (see on this also section 2.3). Average annual CO_2 emissions of general cargo ships, LNG carriers and especially of passenger ships show strong fluctuations over time, an indication that the relevant market segments have been affected by disruptive trends in the period (such as COVID-19 economic downturn and the Russia's full-scale invasion of Ukraine). The average emissions of passenger ships were almost 4 times lower in the 2020 COVID-19-year compared to 2018, almost rebounding to 2018 levels by 2022. The average CO_2 emissions per ship within the scope of the EU Maritime MRV Regulation may vary over time for three, not mutually exclusive reasons: the activity of the ships (i.e. fuel consumption, which mainly depends on distance travelled), the energy efficiency of the ships, and the carbon intensity of the energy used onboard ships.

[21] 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.

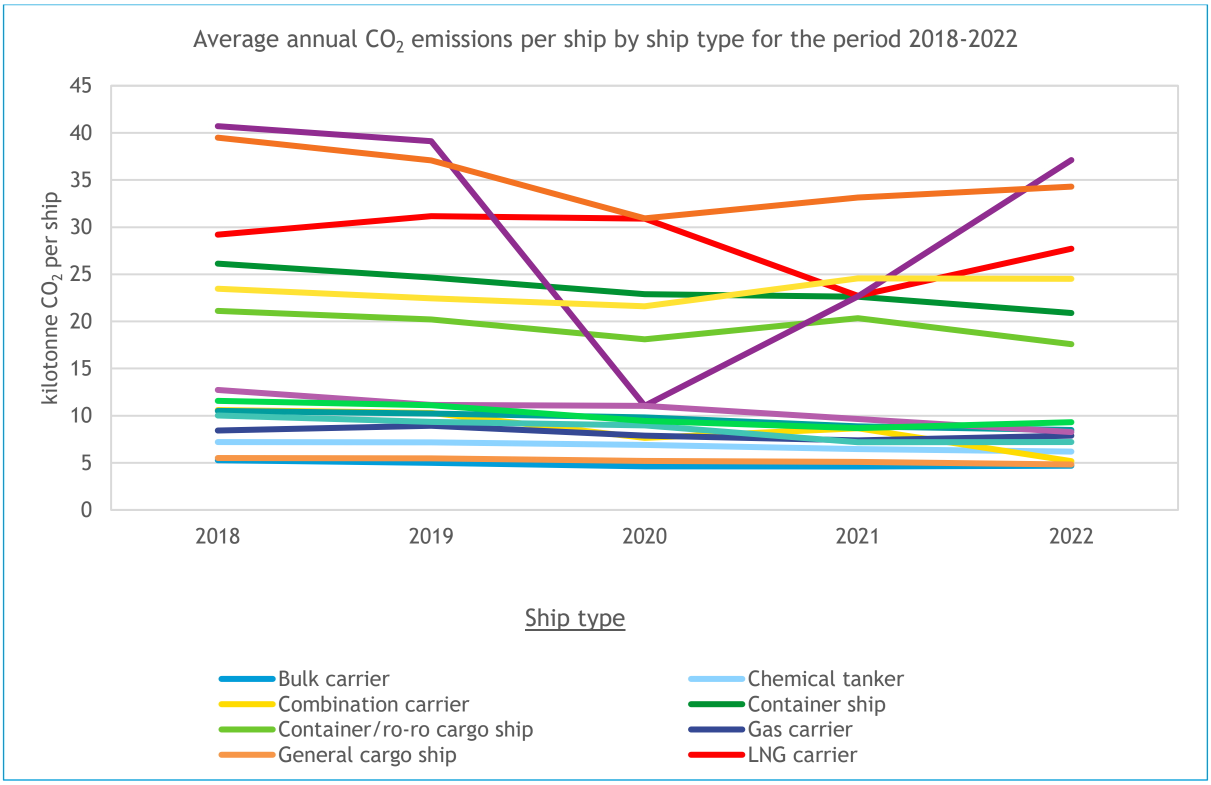


Figure 11: Average annual CO2 emissions per ship per ship type

Figure 12 presents the how the average age of ships (from built date) evolved over the analysed period, by ship type.

The analysis of the average age per ship shows that there are minimal changes (from built date) by ship type between 2018 and 2022 and confirms trends valid for the world shipping fleet (UNCTAD, 2023), both in terms of differences between ship types and increasing average age.

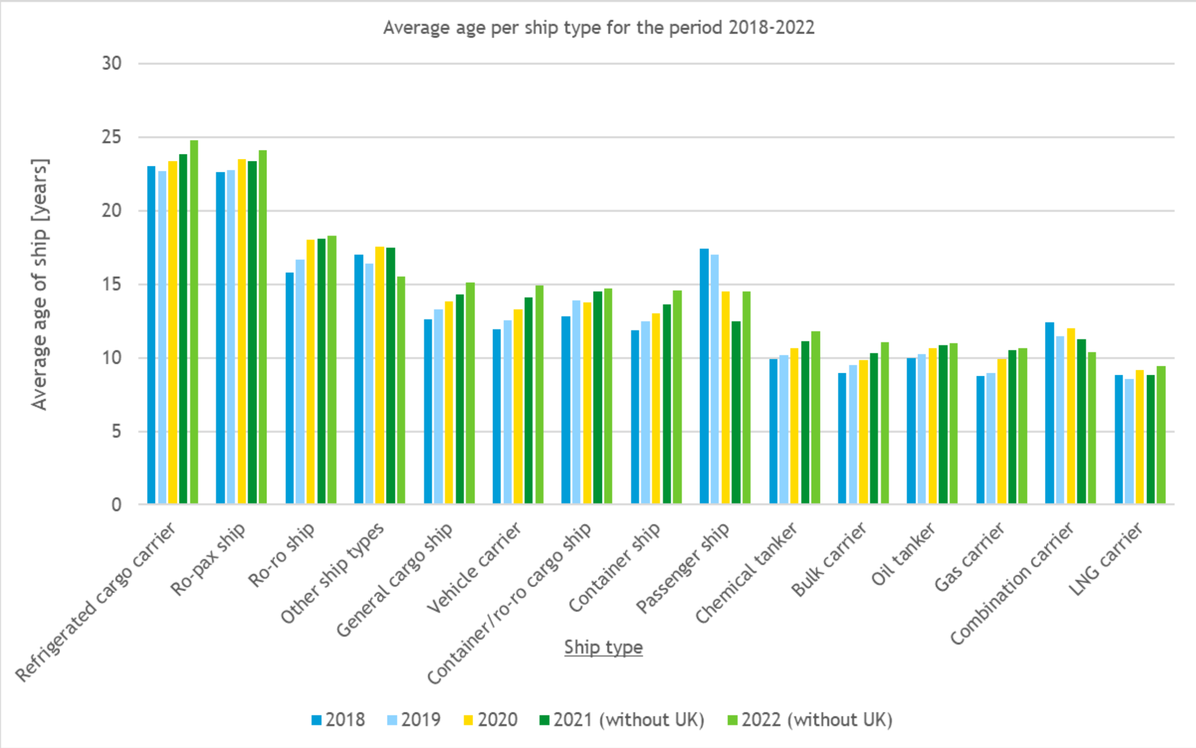


Figure 12: Average age (from built date) per ship type; descending 2022 order

12 ship types, representing 96% of 2022 reported emissions, have recorded a higher average age within the type in 2022 compared to what was reported in 2018 and for eight of these ship types, the age of active ships has been continuously increasing year after year over the period. Only 3 ship types (combination carriers, passenger ships, and other ship types) recorded a decreasing age compared to what was reported in 2018[22] . Chemical tankers, oil tankers, LNG carriers, bulk carriers, gas carriers and combination carriers are currently the types with the highest rate of newly built ships (average age ranging between 9 and 12 years), while refrigerated cargo ships, passenger ships, ro-pax and ro-ro ships are generally much older (18 to 24 years).

An analysis of the fleet size, in terms of tonnage (from dead weight tonnage or dwt), shows that the average size per ship for the entire MRV fleet has remained rather stable in the period 2018-2021 but registered an increase of +5.7% compared to the average value for the four preceeding years. At ship type level, 9 ship types, accounting for 81% of total reported emissions, recorded an increase of average size in 2022 compared to the average for the period 2018-2021. The 5 ship types (container ships, oil tankers, bulk carriers, ro-pax ships, and chemical tankers) responsible for the lion's share of reported emissions (72% in 2022) recorded an increase in the average size both compared to the average for the period 2018-2021 and compared to 2021 alone.

2.4 Fuel consumption

In 2022, inflation rates increased significantly in some regions and bunker fuel prices, both for traditional marine fossil fuels and LNG, reached a peak by mid-2022. The impact of such fuel prices changes on the fuel consumption is, however, not straightforward, since choices on fuel

[22] In the case of passenger ships it is worth stressing that the fleet composition greatly changed in the years most affected by COVID-19 (2020 and 2021), when many ships reporting in previous years remained inactive.

consumptions are impacted by various factors amongst which the relative price increase, the flexibility of the ships' propulsion systems, the ability to pass on the costs.

In 2022, the EU MRV fleet consumed in total around 43 700 kilotonnes (43.7 million tonnes) of fuel within the geographical scope of the Regulation, 7.2 % more than in 2021 (Figure 13).

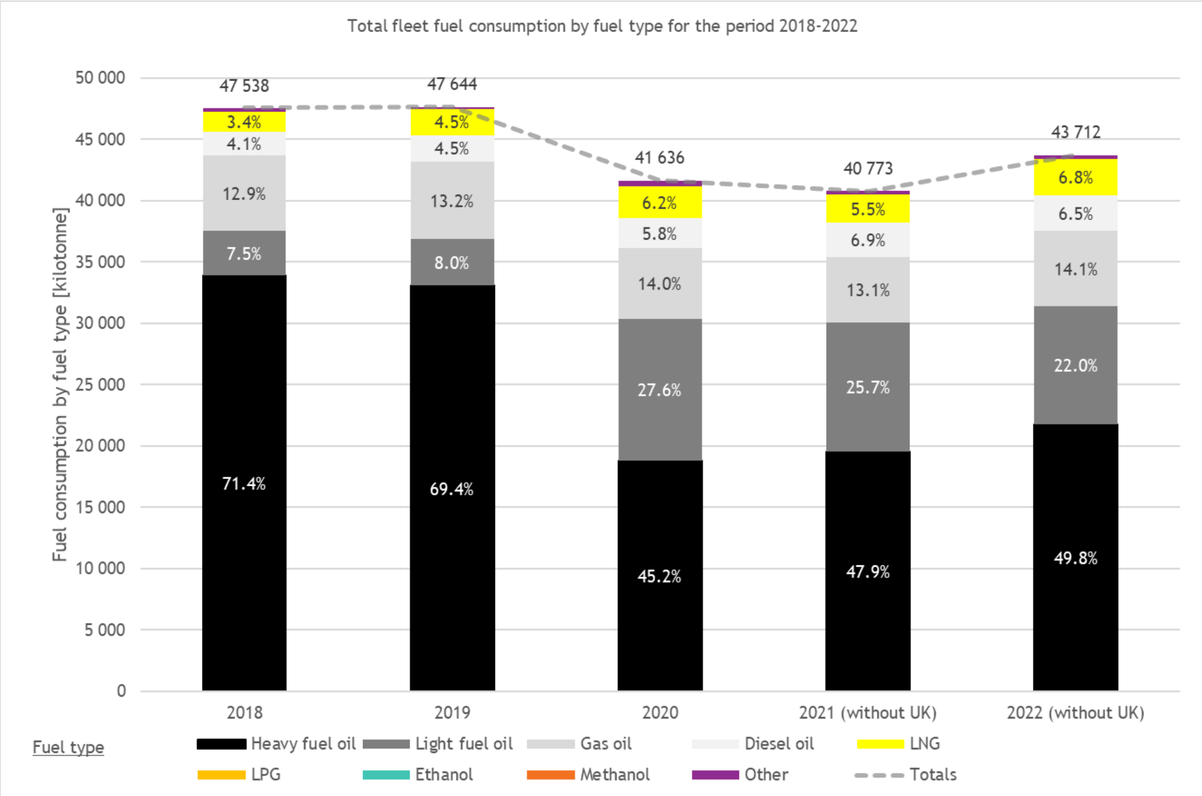


Figure 13: 2018 to 2022 total fuel consumption of EU MRV fleet and shares per fuel type

While the shares of different fuel types were quite similar in 2020 and 2021, there was a noticeable decrease in the share of light fuel oil in 2022, accompanied by an increase in the share of heavy fuel oil, gas oil and LNG. The year 2020 is marked by the application of MARPOL Annex VI Regulation 14, which sets limits on the sulphur content of bunker fuel oils and in particular of some of its requirements becoming stricter at the beginning of 2020[23], leading to a large reduction in the use of Heavy Fuel Oil (HFO) and a significant increase in the use of Light Fuel Oil (LFO), which persisted in the years after 2020.

For all ship types, except LNG carriers, Heavy Fuel Oil (HFO) is the fuel type with the highest share of total 2022 fuel consumption.

The share of LNG in the fuel consumption of the entire fleet increased every year over the period 2018-2022, with the exception of 2021, because of the reduction of LNG consumed by LNG carriers, in line with the decrease of seaborne LNG imports to Europe, in that year (IGU, 2022). As a result, the amount of LNG consumed by the fleet over the period 2018-2022 increased by 82.6% and its relative share of the total went from 3.4% (2018) to 6.8% (2022).

In 2022 the fuel consumption of LNG carriers, which transport LNG and can also use LNG for propulsion purposes, remained highly dominated by LNG (69% of total fuel consumption in tonnes). This is in line with the previous years, where the LNG consumption share of LNG carriers ranged from 61% in 2019 to up to 76% in 2021. The share of LNG carriers in the total

[23] 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.

LNG consumption is comparable to the 2018 share, with LNG carriers accounting for the great majority of LNG consumption (see Figure 14). Total 2022 LNG consumption by LNG carriers within the scope of the EU MRV Maritime Regulation has increased by 43% compared to 2021, which is a significanlty higher growth rate compared to the overall fuel consumption of the fleet. In 2022, the number of LNG carriers that reported to have consumed LNG increased from 283 to 360. 73 of these extra 77 ships reported LNG consumption for the first time in 2022 and the majority of these ships (68) also reported for the very first time under the EU Maritime MRV. We can therefore assume that such ships have been active due to the unprecedented increased LNG demand in Europe met by seaborne imports as a consequence to Russia's full-scale invasion of Ukraine (see on this section 1.2.1).

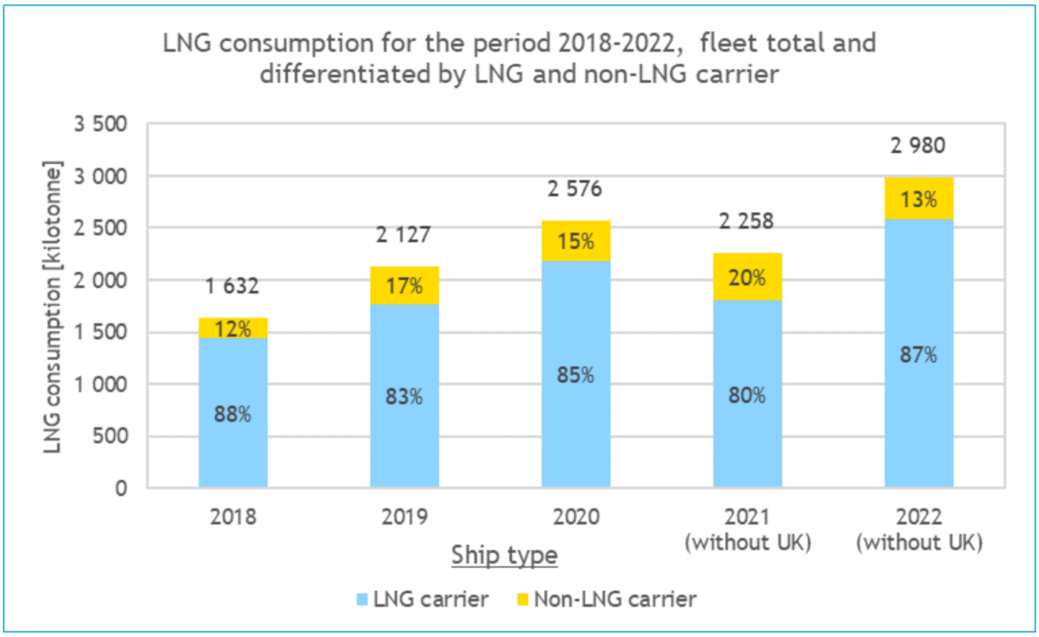


Figure 14: Total LNG consumption and distribution of the consumption over LNG and non-LNG carriers

As Figure 15 illustrates, beyond LNG carriers, ten out of the fourteen other ship types used LNG. The LNG consumption of non-LNG carriers almost doubled (+91%) between 2018 and 2019, which was followed by a gradual increase in 2020 and 2021 and a decrease in 2022, reaching a level comparable to 2020.

The share of container ships in the LNG consumption of non-LNG carriers is significantly higher than in the previous reporting periods. While in 2020, only eight container ships used LNG within the scope of the EU Maritime MRV Regulation, this number inreased to 25 in 2021 and 30 in 2022. This is in line with the deployment of LNG-fuelled container ships in the world fleet, which has significantly increased in the last three years. As of July 2023, 196 LNG-fuelled container ship were on order, representing 24% of total LNG-fuelled ships on order in the world (DNV, 2023).

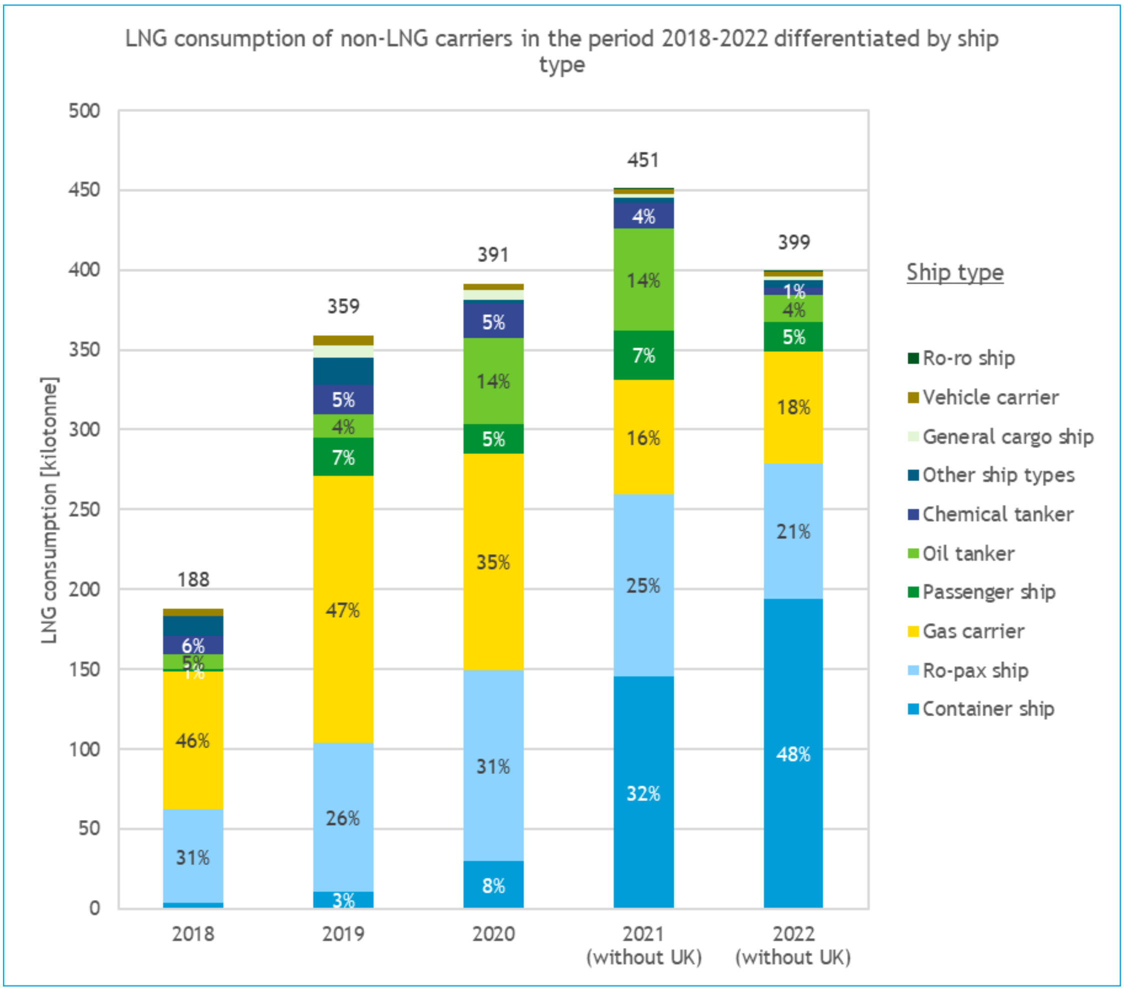


Figure 15: LNG consumed by ship types other than LNG carriers

The share of LPG (0.04%), ethanol (0.00%), methanol (0.02%), and 'Other fuel types' (0.66%) in the fleet's overall fuel consumption for the year 2022 remains neglible.

Though the volume used remains negligible (18.2 kilotonnes in 2022), LPG use, either as butane or propane, within the EU Maritime MRV scope has more than doubled between 2020 and 2021 and increased by a factor 6 between 2021 and 2022. The sector only very recently (2020) started to use LPG as a marine fuel. As of July 2023, worldwide, 91 LPG-fueled ships were in service and another 96 on order, most of them LPG carriers. (DNV, 2023)

After the EU MRV fleet reported a methanol consumption close to zero in 2021 (0.1 kilotonnes), the year 2022 recorded a new peak, with 6.8 kilotonne being reported (+82% compared to 2018). As of July 2023, there were 27 ships in service worldwide that can be methanol fuelled[24], 23 of which are methanol carriers, and 151 more methanol fuelled ships were on order worldwide, many of them container vessels (DNV, 2023).

No ethanol consumption was reported in the year 2022: the only reporting year which recorded ethanol consumption in the EU Maritime MRV remains 2020 with 0.56 kilotonnes.

Under the category 'Other fuel types' ships report alternative fuel types which do not match any of the other categories. Its highest volume (485 kilotonnes) was reported in 2020, while a relative low level (288 kilotonnes) was recorded for this fuel type in 2022, comparable to levels recorded in 2018 (274 kilotonnes).

[24] Ships that can be methanol fuelled do not necessarily use methanol as the dual fuel engine which is required can also be powered by other fossil fuels (such as HFO or LFO).

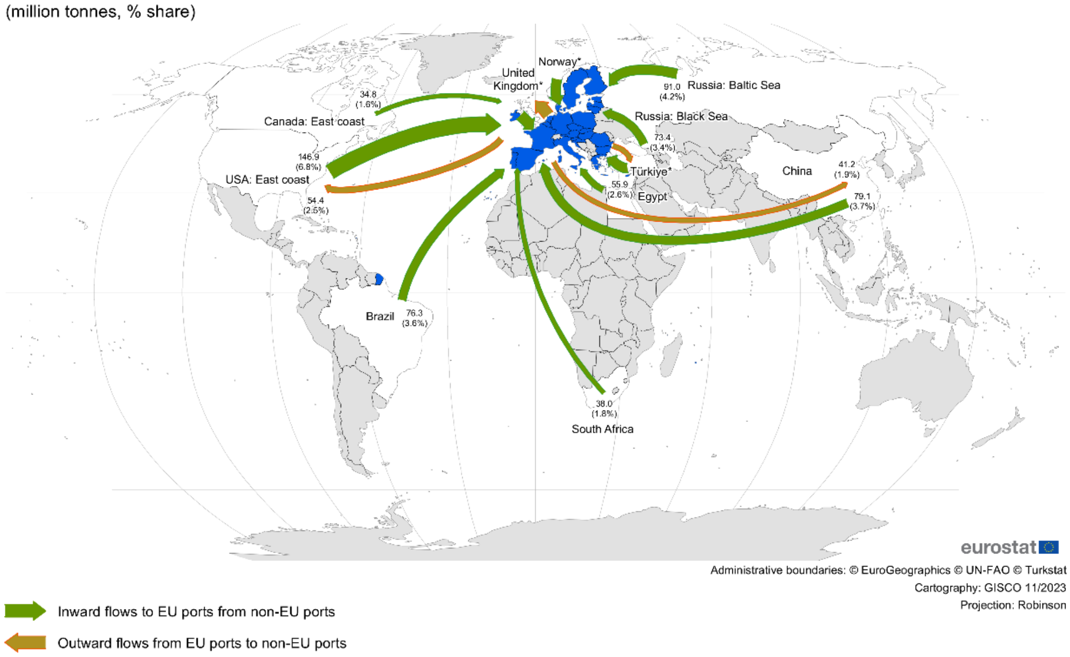
3. The monitored voyages at a glance: shipping routes, speed and time spent at sea

3.1. Main shipping routes

Similar to what was reported in the previous four 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 for waterborne transport services between the EU and countries such as Russia, the United States and neighbouring non-EU countries such as the United Kingdom, Norway and Türkiye.

Table 7 in Annex 3 provides the 15 main extra EU-27 flows by gross weight handled (in millions of tonnes) in main ports in the years 2018 to 2022. Eleven of the flows are inward flows, while four are outward flows.

Top 15 main extra EU flows by gross weight of freight handled in main ports, EU, 2022
(million tonnes, % share)



* United Kingdom, inward: 106.6 (5.0%), outward: 113.1 (5.3%); Norway, inward: 89.7 (4.2%); Türkiye, inward: 90.8 (4.2%), outward 46.1 (2.1%)

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the European Union.
Kosovo: This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.
Palestine: This designation shall not be construed as recognition of a State of Palestine and is without prejudice to the individual positions of the Member States on this issue.

Figure 16: Main extra EU flows; Source: Eurostat (2023)

The total 2022 volume of inward flows increased by 2.4% and is nearly the same as in 2019 (0.4% higher than in 2019). The 15 countries related to these flows remained stable over the last five years, though their position in terms of the annual volume of the flow varies over time. Compared to 2021, 2022 inflows from the United States (East Coast), Egypt, China, Norway, the UK, Canada (East Coast), and Brazil increased, while the inflows from Russia (Black Sea, Baltic Sea), Türkiye, and Nigeria decreased. As a consequence, inflows from the United States (East Coast) and the UK surpassed the inflow from Russia (Black Sea) for the first time in 2022.

The total 2022 volume of outward flows decreased by 1.4% and is nearly the same as in 2019. The main outflows to decrease in 2022 were to China and the UK, but total EU outflows are still dominated by the outward flow to the UK.

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 fuel consumption of the ships' auxiliary engines may increase 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 different ship designs and business models play an important role. Ro-pax ships and refrigerated cargo ships are, for example, known to sail fast compared to tankers or bulk carriers (see Figure 17), serving very different markets.

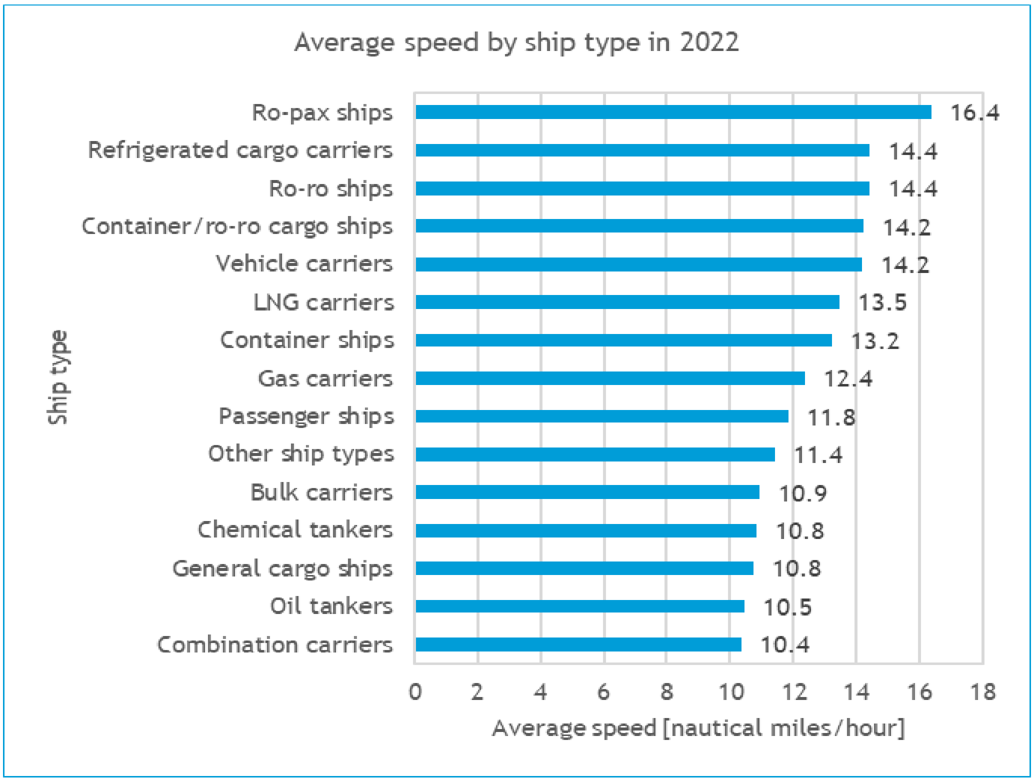


Figure 17: Average speed by ship type; 2022 (without UK); sorted by average speed

Speed variation over time is a relevant indicator to help explain the evolution of operational energy efficiencyover the analysed period. In this context, the average speed by ship type was calculated based on figures reported by the monitored fleet (time spent at sea and distance travelled).

Figure 18 provides an overview for the five reporting years whereas Figure 17 zooms in on 2022, illustrating the differences between the ship types and giving the 2022 average speed per ship type.

Variations in the average speed over the period 2018-2022 differ between ship types:

- The largest difference between the highest and lowest average speeds over the period was observed for gas carriers and combination carriers (more than 2 knots);

- The smallest difference between the highest and lowest average speeds over the period was observed for Ro-ro ships and refrigerated cargo carriers (less than 0.5 knots).

For most of the ship types, the highest average speed was recorded in 2021; only passenger ships, Ro-pax ships, vehicle carriers and chemical and oil tankers showed the highest average speed before 2021; none of the ship types recorded their highest average speed in 2022. None of the ship types showed a continuously decreasing trend for their average speed over the period 2018 to 2022.

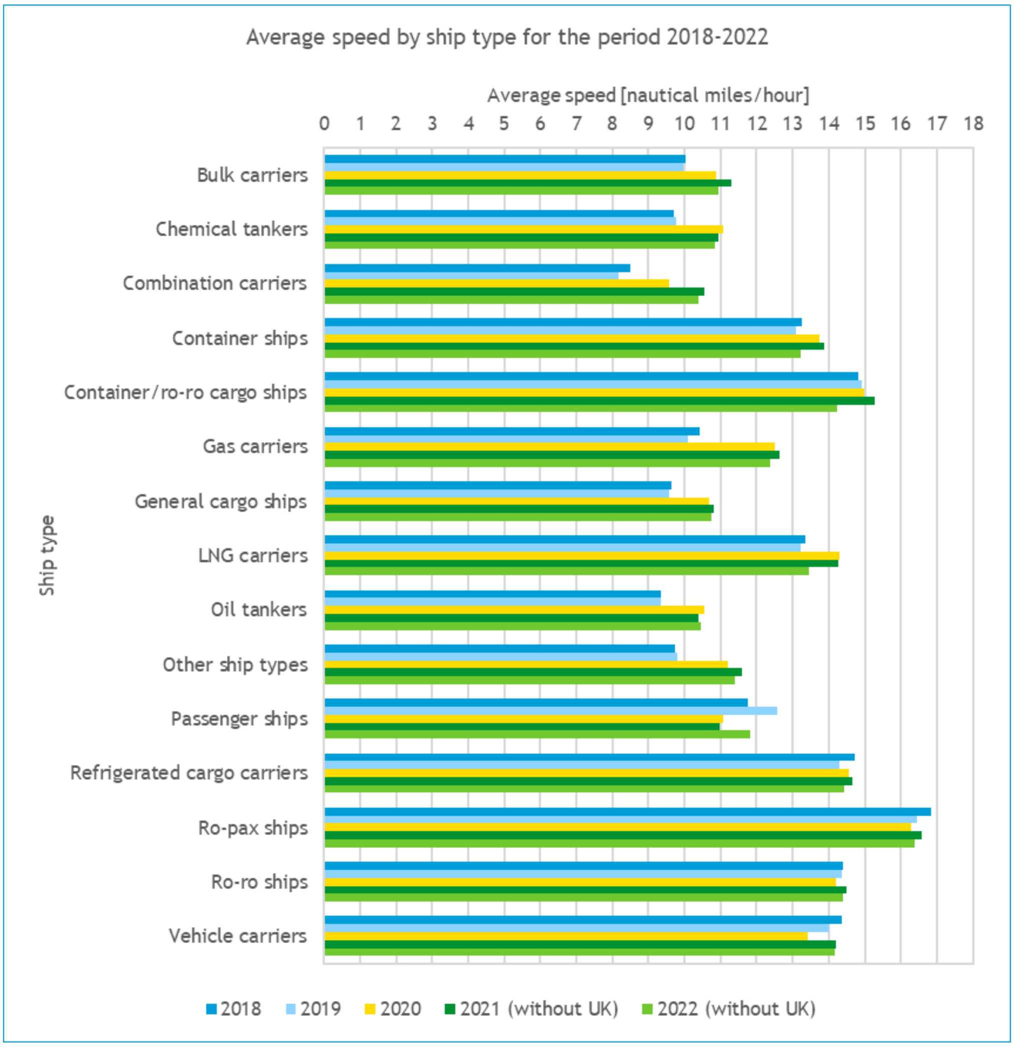


Figure 18: Average speed by ship type; 2018-2022; alphabetical order

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 Maritime MRV Regulation during a reporting period can be expected to differ between 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 (see Figure 19): ship types that often sail according to a regular schedule (liner ships, ferries) show a higher average time at sea, while ships which engaged in tramp trade spend a lower average time at sea. Goods shipped by dry bulkers are often traded on the spot market, leading to a high fluctuation in the number of individual bulk carriers that are used for trade to/from Europe. As a result, individual bulk carriers have the lowest average time at sea within the scope of the EU MRV, although the total time at sea of the entire bulk carrier fleet is the highest of all ship types (see Figure 20).

Changes in the average time at sea for the different ship types across the reporting years can be related to different factors: the amount of idle time[25], shifts in trade patterns within the scope of the EU MRV (e.g. trade on shorter intra-EEA routes), and/or shifts in activity outside of the EU MRV. Such shifts can be linked 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 but also changes in trade patterns due to security hazards, such as war).

Between 2021 and 2022 the average time spent at sea, within the scope of the EU MRV, decreased for 6 out of the 15 ship types, while it increased for eight ship; and remained stable for container ships. The increase in average time at sea was especially high for passenger ships and LNG carriers. The former probably being related to the further recovery of the sector, while the latter probably due to modified trade patterns (e.g. increased imports from the US).

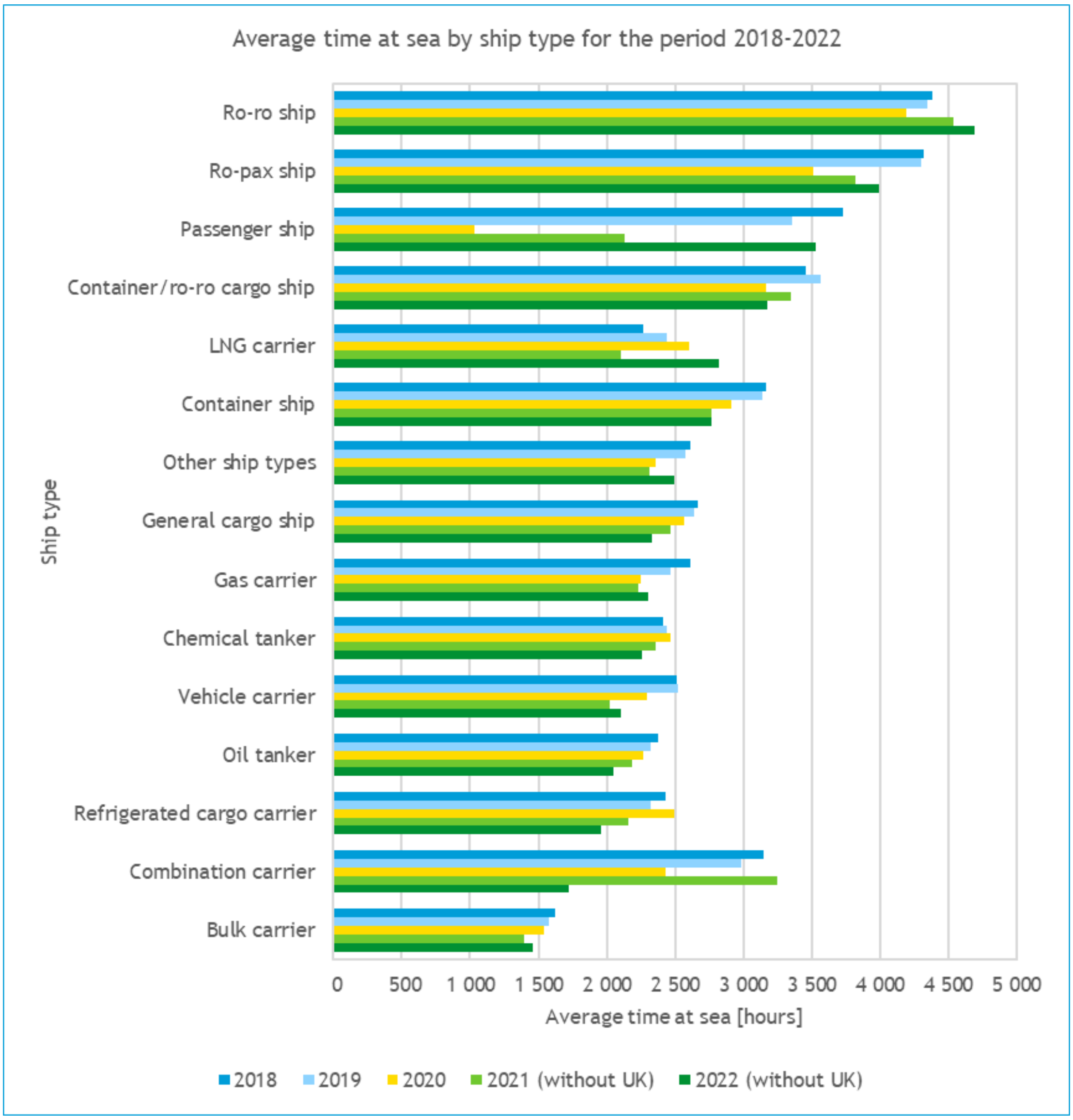


Figure 19: Average time at sea by ship type; 2018-2022; sorted by 2022 average time at sea

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

Regarding the total time the ship types spent at sea (total time for the entire fleet over the year) within the EU Maritime MRV (see Figure 20), passenger ships and LNG carriers also stand out. These two ship types, along with bulk carriers, reported the highest total time at sea in 2022, out of the first five reporting periods.

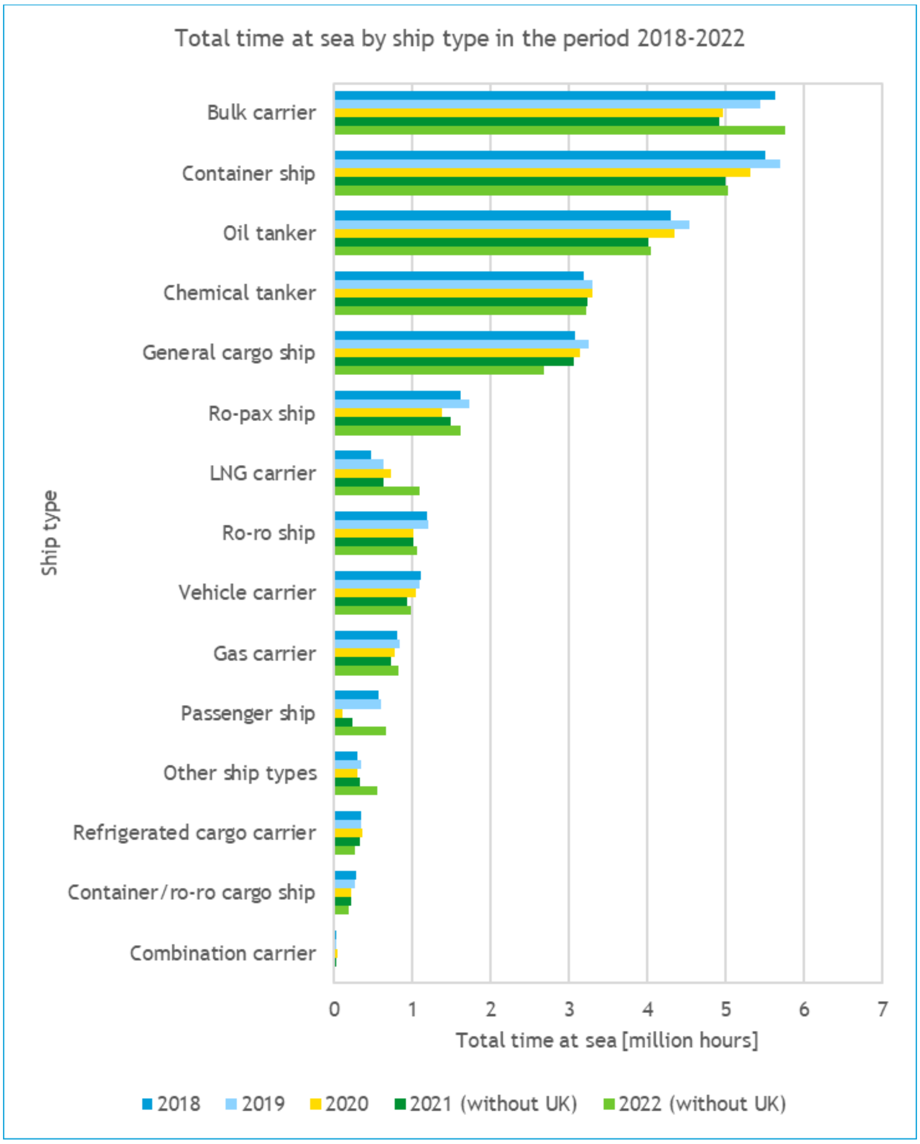


Figure 20: Total time at sea by ship type; sorted by 2022 total time at sea

4. Technical and operational efficiency of the monitored fleet

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 all the indicators in this section, the lower the value, the higher the efficiency of the ship.

The year 2022 represents the fifth reporting year of the EU MRV system, a substantial amount of data on reporting ships has become available, allowing for an assessment of the evolution of both the technical and operational efficiency of the monitored fleet, and also the robustness of the reported data.

As in previous years, such an analysis was carried out by means of a graphical analysis, plotting the relevant indicators per ship type against the cargo carrying capacity. This year's analysis, the most representative results of which are shown in Annex 4, further corroborates two key findings which were highlighted in the fourth annual report: (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 2022; (2) as in previous years, technical and operational efficiency trends did not significantly change, as shown by the different reporting periods' regression curves overlap (as shown in Annex 4).

Combining the above observations, it can be concluded that the fifth MRV reporting year confirms the consistency of 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 also available as an exemption: to report the entry 'not applicable', but that is 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 built after 1 January 2013 or 1 January 2015[26] need to meet EEDI requirements in terms of CO_2 per capacity nautical mile (CO_2/t*nm). 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.

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

[26] Depending on the ship type and size.

- The attained EEDI has to be reported where required by and in accordance with MARPOL Annex VI, Regulations 19 and 20.[27] (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 2022, a total of 4 232 ships reported their EEDI while 8 423 ships reported their EIV (with an additional 300 'not applicable' reports). The majority of reporting vessels report their EIV, however their share of total reports has been steadily decreasing since 2019 (from 74% to 65% in 2022), while the share of ships reporting their EEDI has increased (from 23% in 2019 to 33% in 2022). This is a direct consequence of fleet renewal under the scope of the MRV, as new ships with higher EEDI standards progressively replace older vessels which were required to report EIV (see Table 9 in Annex 4).

In 2022, for 8 of the 15 ship types, more than a third of the ships within their ship type reported their EEDI; these ships are combination carriers (56%) and gas carriers (48%), followed by oil tankers (43%), chemical tankers (41%), LNG carriers (38%), bulk carriers (37%), and container ship (32%).

This reflects the fact that the fleet is composed of a relatively high number of young ships, built in 2013[28] or later, and also the fact that for most of 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 2022 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. This is in line with what was reported in 2021.

In 2022, the fleet average EEDI reached its lowest level so far – an improvement of 7.7% compared to 2019 and of 5.6% compared to 2021. 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 in 2022, 8 out of 15 ship types reported their lowest level recorded so far, however, only for general cargo ships the average 2022 EEDI level was significantly lower than the lowest annual average EEDI recorded in the period 2018 to 2022. Comparing the average 2018 to 2022 EEDI per ship type, with the average 2022 EEDI per ship type, not only general cargo carriers stand out, but also Ro-pax ships, Ro-ro cargo ships, and refrigerated cargo carriers which all show an improvement of more than 5%.

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 means of a graphical analysis, by plotting EEDI and EIV values against a ship's capacity (DWT or Gross Tonnage). Regression curves with R2-values have then been calculated. Similarly to previous years, technical efficiency trends did not significantly change, as shown by the different reporting periods' regression curves shown in Annex 4. These overlap for the most

[27] 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.

[28] 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

representative ship types in the monitored fleet, for which a high correlation between the EEDI/EIV and the carrying capacity was recorded. In addition, an improvement in correlation values is visible for the overall period 2018-2022, across different ship types. Such findings result from the current technological 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's graphical analysis for bulk carriers. Robust R2 correlation values were calculated (above 0.6) for a total of 11 ship types, representing 82% of total emissions reported in 2022. 14 graphs produced for this analysis, showing the most significant values, are presented in Annex 4.

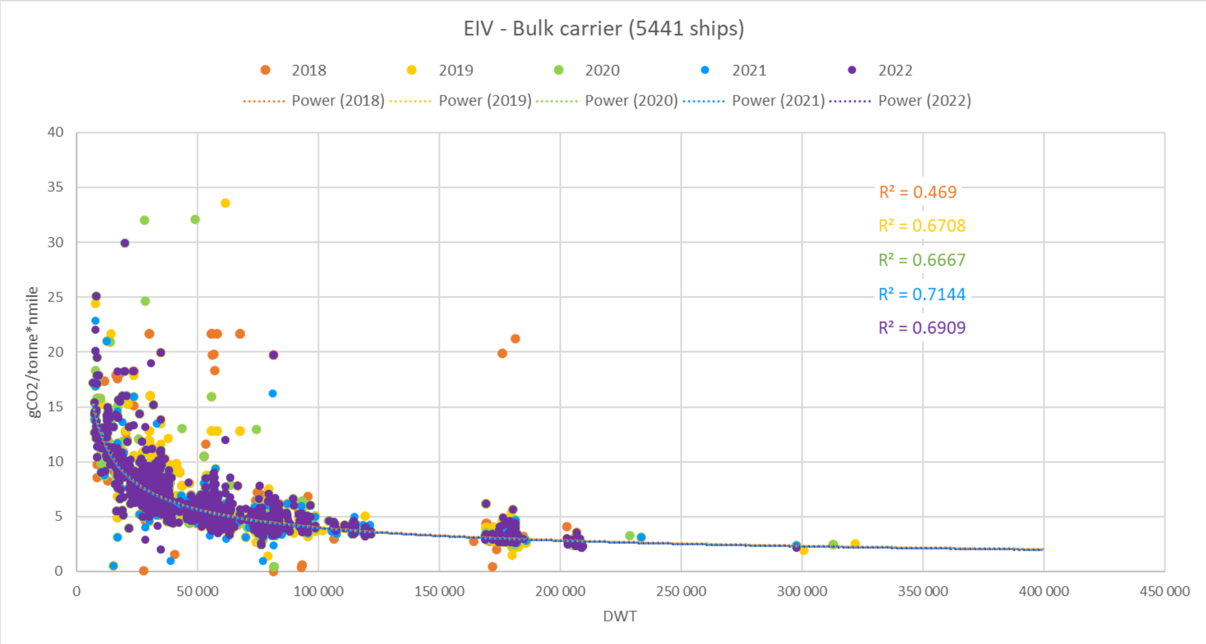


Figure 21: Plot of attained EIV values for bulk carriers over the five reporting years and associated trendlines

4.2. Operational efficiency

4.2.1. Overview: EEOI and AER

According to the EU Maritime MRV 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 [29];
3. CO_2 emissions per distance;
4. CO_2 emissions per transport work (also referred to as Energy Efficiency Operational Indicator (EEOI)).

which are calculated as follows:

[29] Transport work expresses the product of distance travelled per the amount of cargo carried over the period. For an overview of the metrics applied under the EU MRV to the different ship types, see Table 10 in Annex 4.

1. $$\text{Fuel consumption per distance} = \frac{\text{Total annual fuel consumption}}{\text{Total distance travelled}}$$

2. $$\text{Fuel consumption per transport work} = \frac{\text{Total annual fuel consumption}}{\text{Total transport work}}$$

3. $$CO_2 \text{ emissions per distance} = \frac{\text{Total annual } CO_2 \text{ emissions}}{\text{Total distance travelled}}$$

4. $$CO_2 \text{ emissions per transport work} = \frac{\text{Total annual } CO_2 \text{ emissions}}{\text{Total transport work}}$$

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*nautical 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 2022, 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 gas carriers. 21 graphs have shown robust R2 correlation values (above 0.6) for a total of 11 ship types, representing 79% of total reported emissions in 2022. The most significant ones are grouped in Annex 4.

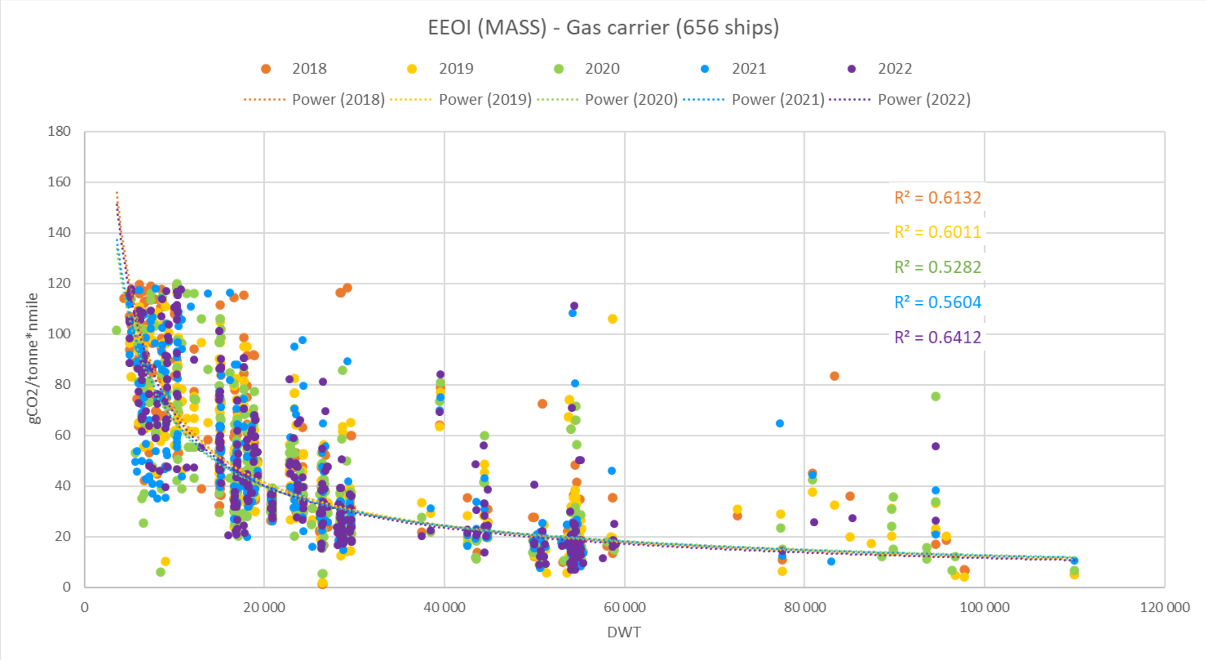


Figure 22: Plot of attained EEOI values of gas carriers over the five reporting years and associated trendlines

5. Assessing the implementation of the EU Maritime MRV Regulation

5.1. Key indicators on the MRV process in 2022

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 their 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) before May has improved remarkably over the first four reporting period, increasing from 54.7% in 2018 to 67.3% in 2021. The year 2022, however, recorded a worsening of this indicator, down to 55.8%.

A timely submission of the verified emissions report to the Commission highly depends on a timely verification by the verifiers, which is possible once companies finalise transmission of the emissions report to their verifier. The share of the emissions reports that have been verified as satisfactory by 30 April, while increasing in the years 2020 and 2021 (reaching a peak of 75.7%), decreased in 2022, for which only 64.9% of total emissions report were verified as satisfactory by the verifier.

The data over the period 2018-2022 confirms that the submission of a large amount of verified emissions reports is finalised after April, so that companies can obtain a valid document of compliance by 30 June, deadline of expiration of the one from the previous compliance cycle. The share of emissions reports submitted by this latter date reached its peak (92%) in 2022.

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, a transitory status at the moment of transmission, remains extremely low: only 5 cases were recorded in 2022, similar levels to those recorded in the period 2019-2021. The share of emissions reports that have been verified as satisfactory without any additional revision has continuously increased year after year over the period, from 34% in 2018 to 76% in 2022.

5.2. Quality and completeness of EU MRV data

5.2.1. Outliers

Some of the verified emissions reports include a few outliers, i.e. relatively easily identifiable, obvious mistakes.[30] However, the number of emissions reports with outliers has continuously decreased over the years, down to 91 reports in 2022 compared to 354 reports in the 2018 reporting period. In the reporting year 2022, 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 2018-2022, recording its lowest level in 2022 (the emissions reports containing outliers represent 0.9% of all emissions).

[30] 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.

5.2.2. Verifiers

The majority of active verifiers verifed emissions reports with fewer or the same number of outliers compared to 2021. Only 5 out of 19 active verifiers [31] verified emissions reports containing more outliers than in 2021. The number of emissions reports that contain outliers is not evenly distributed over the different verifiers. For the 2022 reporting period, three verifiers stand out with between 11 to 20 emissions reports featuring outliers, which corresponds to a share of between 0.6% and 4.2% 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.

[31] This notably excludes a twentieth verifier which was active in the system for the first time during reporting period 2022.

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Annex 1 Abbreviations and definitions

Table 3 Abbreviations and definitions

Abbreviation	Meaning
AER	Annual Efficiency Ratio
AFIR	Alternative Fuels Infrastructure Regulation
BDN	Bunker Delivery Note
CII	Carbon Intensity Indicator
DCS	Data Collection System
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
GT	Gross tonnage
HFO	Heavy Fuel Oil
IGU	International Gas Union
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
PSC	Port State Control
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)
SEEMP	Ship Energy Efficiency Management Plan
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).
UNCTAD	United Nations Conference on Trade and Development
VLSFO	Very Low Sulphur Fuel Oil

Annex 2 Outcomes of the fourth compliance cycle

A.2.1 Fuel/emissions monitoring methods

Under the EU MRV Regulation, 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 vast majority of reporting ships applied only one of the monitoring methods (86.5% in 2022) while a smaller share of ships applied two of the methods (12.7% in 2022). Only 0.8% of reporting ships in 2022 applied three monitoring methods. In the 2022 reporting period, Method D was not applied by any reporting ships.

The data for the five reporting years shows hardly any variation in the share of ships that apply methods C and D. In contrast, the share of ships applying method A increased over time, while the share of ships applying method B decreased.

Table 4 Fuel monitoring methods

Share of ships that have applied a method; 2018 to 2022

	Method A	Method B	Method C	Method D
2018	47.0%	35.0%	34.9%	0.0%
2019	49.8%	32.9%	32.8%	0.0%
2020	49.2%	32.7%	33.2%	0.0%
2021	50.4%	31.2%	32.5%	0.0%
2022	52.2%	29.7%	32.4%	0.0%

A.2.2 Shipping companies

1 759 shipping companies have submitted emission reports for the reporting period 2022: 3.5% more companies than for the reporting period 2021 and 6.7% more companies than for the reporting period 2019.

As the following figure illustrates, 51.9% of companies in the 2022 reporting period were registered in an EU country, 45.7% in a non-EEA country and 2.4% in an EEA-non-EU country. These shares are almost the same as in 2021 and slightly deviate from the shares in the period 2018 to 2020, before the UK's withdrawal from the EU.

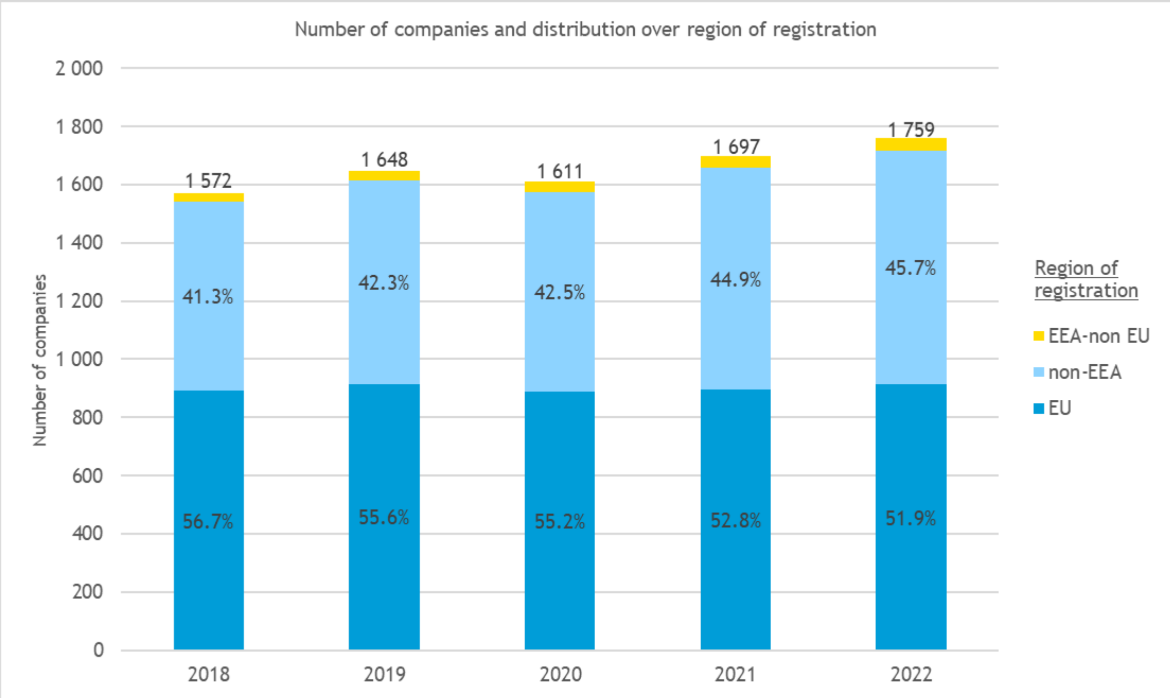

Figure 23: Number of companies and distribution over region of registration; 2018 to 2022

A.2.3 Verifiers and National Accreditation Bodies

In the reporting period 2022, 19 different accredited verifiers were called in for verification activities required for the shipping companies' compliance with the EU Maritime MRV Regulation. The five largest of the verifiers covered around 65% of the emissions reports that were submitted in 2022. Eight different national accreditation bodies (NABs) have accredited the 19 verifiers active in the 2022 reporting period. Three of these NABs have accredited more than one verifier.

4 of the 19 verifiers are not located in an EEA country (see Table 6) and the highest number of verifiers is located in Greece (6 out of the 19).

Table 5 Number of verifiers accredited per National Accreditation Body

Number of verifiers accredited per National Accreditation Body in 2018 to 2022*

	National Accreditation Body	2018	2019	2020	2021	2022
1	ACCREDIA – IT	1	1	1	1	1
2	COFRAC - FR	3	2	2	3	2
3	Croatian Accreditation Agency – HR	1	1	1	1	0
4	German Accreditation Body (DAkkS) – DE	5	5	5	5	5
5	The Danish Accreditation Fund (DANAK) – DK	0	0	0	1	0
6	Dutch Accreditation Council (RvA) - NL	1	1	1	1	1

7	Hellenic Accreditation System (ESYD) – EL	6	5	5	5	6
8	Polish Centre for Accreditation (PCA) – PL	1	1	1	1	1
9	Portuguese Institute for Accreditation (IPAC) – PT	1	1	1	1	1
10	Swedish Board for Accreditation and Conformity Assessment (Swedac) - SE	1	1	1	1	1
11	The United Kingdom Accreditation Service (UKAS) - UK	1	1	1	1	1
	Total	24	21	19	21	19

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

Table 6 Number of verifiers

Number of verifiers per country in 2018 to 2022

	Country	2018	2019	2020	2021	2022
1	Croatia	1	1	1	1	0
2	France	2	2	2	2	2
3	Germany	3	3	3	3	3
4	Greece	6	5	5	5	6
5	Italy	1	1	1	1	1
6	Poland	1	1	1	1	1
7	Portugal	1	1	1	1	1
8	Sweden	1	1	1	1	1
9	United Kingdom	4	2	0	0	0
10	China	1	1	1	1	1
11	India	1	1	1	1	1
12	Japan	1	1	1	1	1
13	Republic of Korea	1	1	1	1	1
14	Russian Federation	0	0	0	1	0
	Total	**24**	**21**	**19**	**20**	**19**

A.2.4 Port State Control inspections

According to Article 19(2) of the EU MRV Regulation (2015/757) each Member State shall ensure that any inspection of a ship in a port under its jurisdiction carried out following Directive 2009/16/EC includes checking that a valid MRV Document of Compliance (DoC) is carried on board. Figure 24 and Figure 25 provide an overview of the number and the outcome of the inspections of the MRV DoC during Port State Control (PSC) inspections in EEA Member States for the period 2019-2023 [32], which refers to the five compliance years associated to the reporting years 2018-2022.

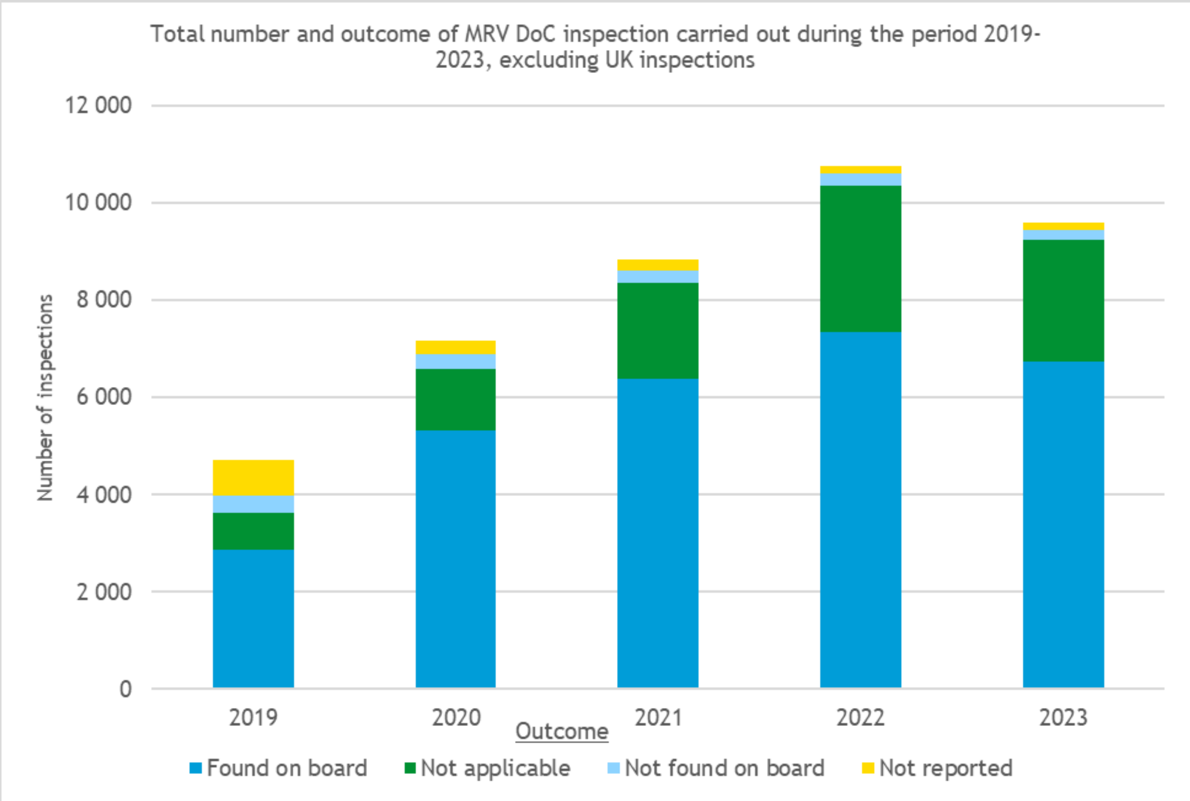

Figure 24: Total number and outcome of MRV DoC inspection as part of PSC inspection over the period 2019-2023

During the compliance checks carried out the first five reporting years, up to November 2023, 41 037 ships were inspected to confirm the presence of valid MRV DoC on board the ship. 70% of these ships were able to present a valid DoC, while 23% of the ships were not required to carry a valid MRV DoC onboard. Over the five compliance cycle only 3% of the inspected ships could not produce a valid DoC, a share which has considerably decreased after the first two compliance years, during which much higher values were registered (of 7% and 4% respectively).[33]

[32] The date includes the dataset available at the time of writing, thus referring to inspections carried out from January 2019 to early November 2023.

[33] The value 'not reported' refers to cases where the PSC inspector did not declare the outcome of the inspection with respect to the MRV DoC. Those accounted for 5% of inspected ships over the period.

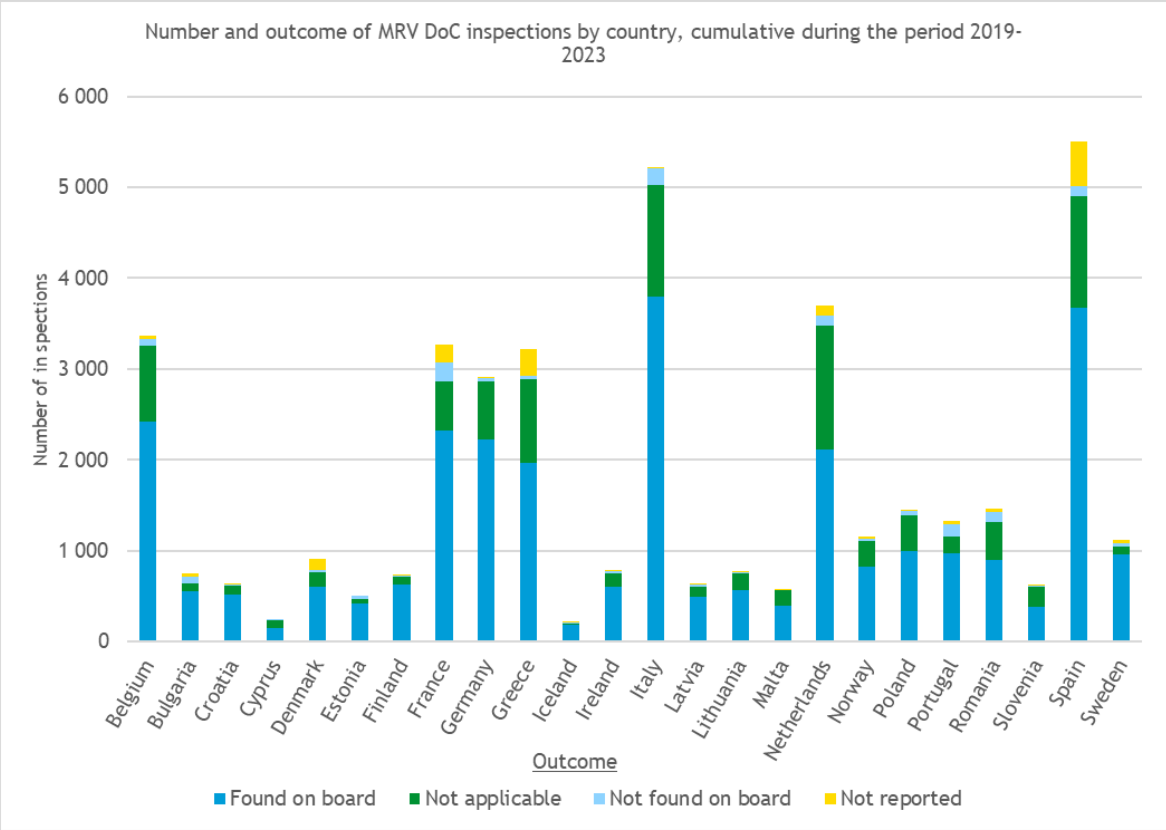

Figure 25: Number and outcome of MRV DoC inspections by country, cumulative during the period 2019 - 2023

Annex 3 Main extra-EU flows

Table 7 provides the top 15 extra EU-27 flows by gross weight handled in main ports over the years 2018 to 2022, in millions of tonnes. Eleven of the flows are inward flows, while four are outward flows.

The total 2022 volume of inward flows increased by 2.4% in 2022 and is nearly the same as in 2019 (0.4% higher than in 2019). The fifteen countries related to these flows remained stable over the last five years, though their position in terms of the annual volume of the flow varies over time. Compared to 2021, inflows from the United States (East Coast), Egypt, China, Norway, the UK, Canada (East Coast), and Brazil increased in 2022, while inflows from Russia (Black Sea, Baltic Sea), Türkiye, and Nigeria decreased. As a consequence, the inflows from the United States (East Coast) and the UK surpassed the inflow from Russia (Black Sea).

Table 7 Top 15 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	2022
Inward flows to EU ports from non-EU ports					
United States (East Coast)	91.3	106.5	100.0	106.0	146.9
United Kingdom	105.0	104.8	105.7	101.1	106.6
Russia (Baltic Sea)	129	131.5	120.7	137.4	91.0
Türkiye	73.2	82.2	81.3	92.2	90.8
Norway	86.0	90.0	80.8	81.8	89.7
Brazil	86.5	76.2	68.2	74.6	76.3
China	61.6	65.9	62.4	72.1	79.1
Russia (Black Sea)	78.6	81.3	83.2	79.4	73.4
Egypt	50.0	54.2	47.5	44.4	55.9
Nigeria	35.0	46.2	39.2	34.4	32.7
Canada (East Coast)	34.4	34.8	32.6	33.5	34.8
Outward flows from EU ports to non-EU ports					
United Kingdom	114.0	108.3	99.8	120.8	113.1
United States (East Coast)	52.6	53.3	47.3	57.1	54.4
China	42.0	51.2	61.4	53.7	41.2

Türkiye	46.1	48.0	49.0	49.2	46.1

Source: Eurostat (2023)

Annex 4 Technical and operational efficiency of the monitored fleet

A.4.1 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)

"

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 reported their EEDI, EIV or 'not applicable' in 2022

Technical efficiency indicators reported per ship type

Ship type	# of ships which reported their EEDI in 2022	# of ships which reported their EIV in 2022	# of ships that reported 'Not applicable' in 2022
Bulk carrier	1 478	2 516	55
Chemical tanker	591	810	24
Combination carrier	5	4	0
Container ship	588	1 224	22
Container/Ro-ro cargo ship	8	52	0
Gas carrier	170	178	5
General cargo ship	175	1004	8
LNG carrier	147	237	5
Oil tanker	850	1 117	20
Other ship types	6	131	108
Passenger ship	63	98	25
Refrigerated cargo carrier	19	115	1
Ro-pax ship	22	358	26
Ro-ro ship	38	188	0
Vehicle carrier	72	391	1
Total	**4 232**	**8 423**	**300**

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 five reporting years (2018 to 2022) 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 2022 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 eleven out of the fifteen ship unique types reporting under the EU MRV system, representing, in emissions terms, 82% of total reported emissions in 2022.

The correlation values are generally increasing over the years, with all ship types showing a higher correlation value in 2022 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.

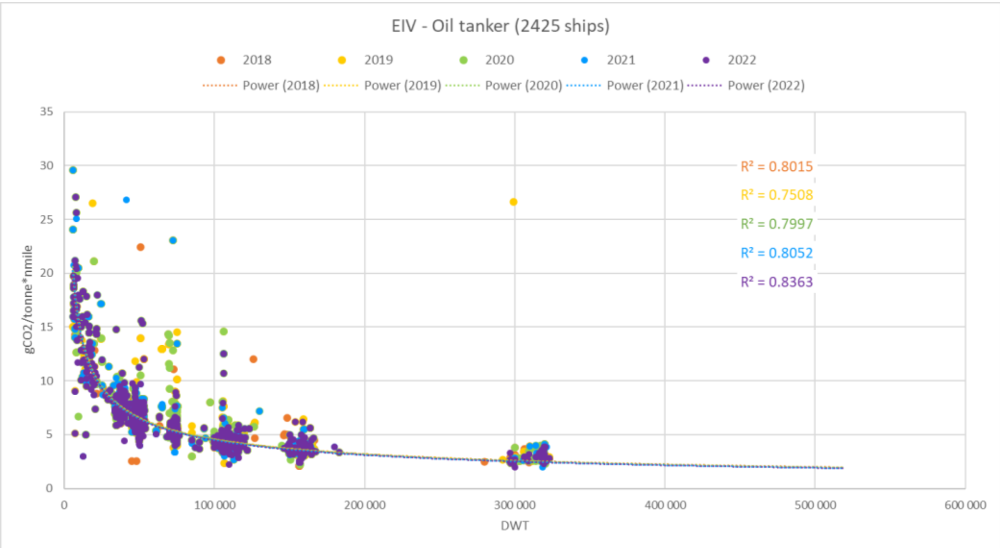

Figure 26: Plot of attained EIV values of bulk carriers over the five reporting years and associated trendlines

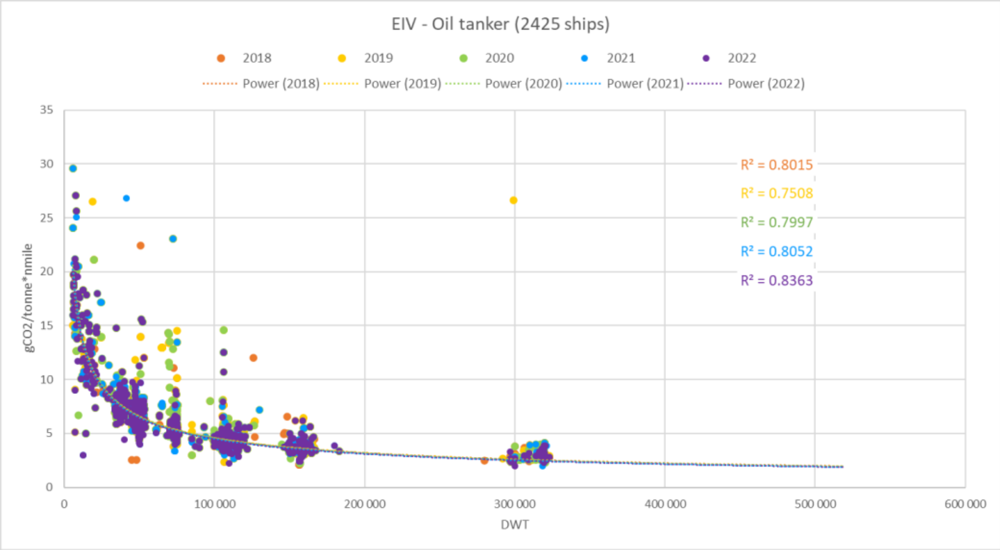

Figure 27: Plot of attained EIV values of oil tankers over the five reporting years and associated trendlines

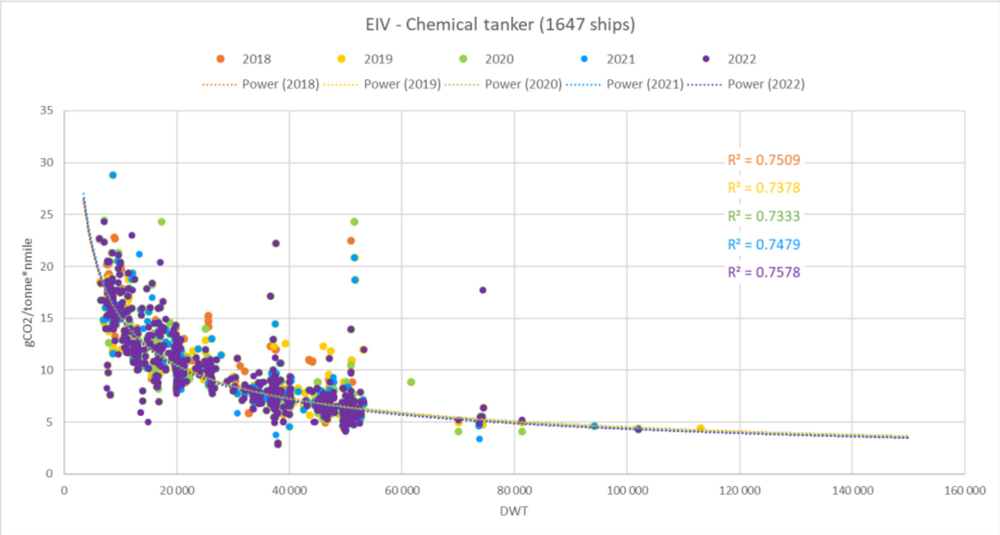

Figure 28: Plot of attained EIV values of chemical tankers over the five reporting years and associated trendlines

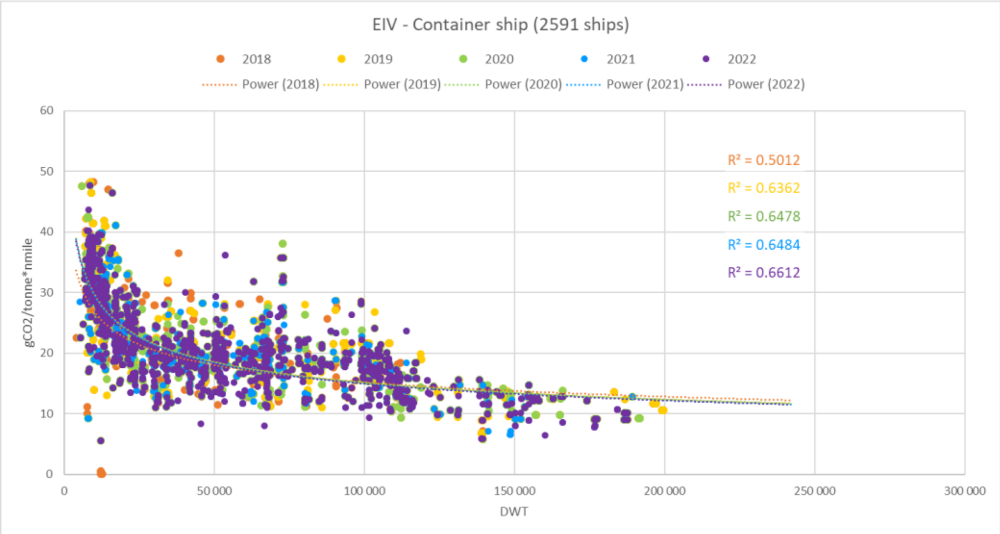

Figure 29: Plot of attained EIV values of container ships over the five reporting years and associated trendlines

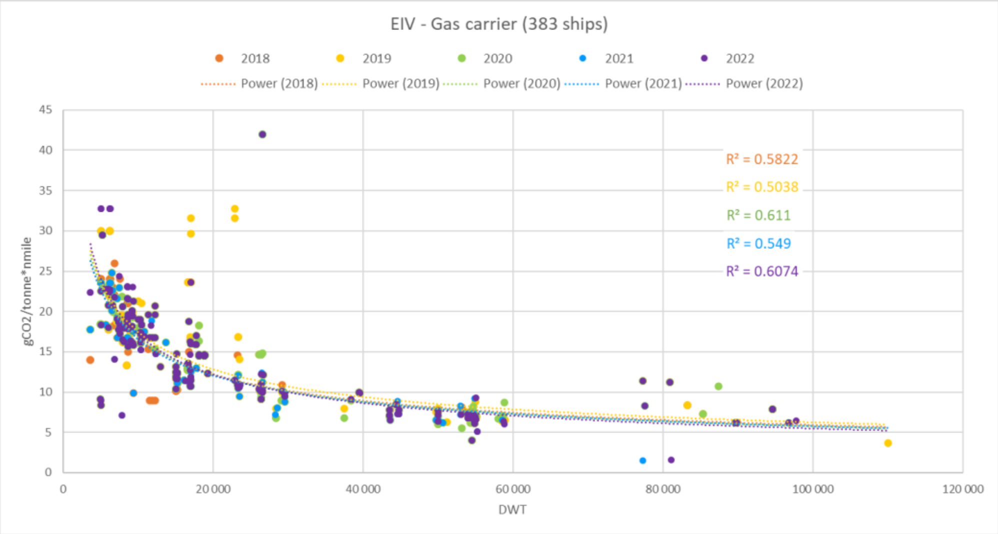

Figure 31: Plot of attained EIV values of gas carrier ships over the five reporting years and associated trendlines

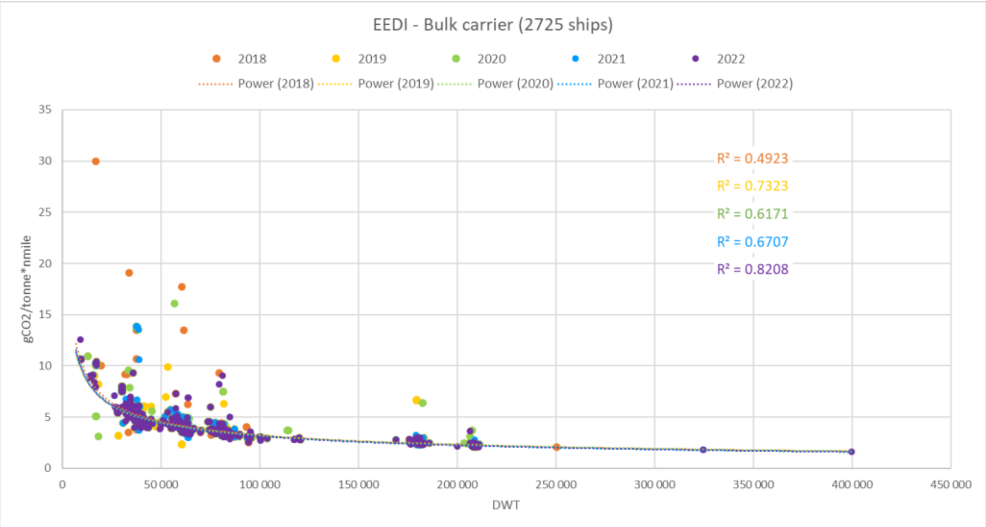

Figure 32: Plot of attained EEDI values of bulk carriers over the five reporting years and associated trendlines

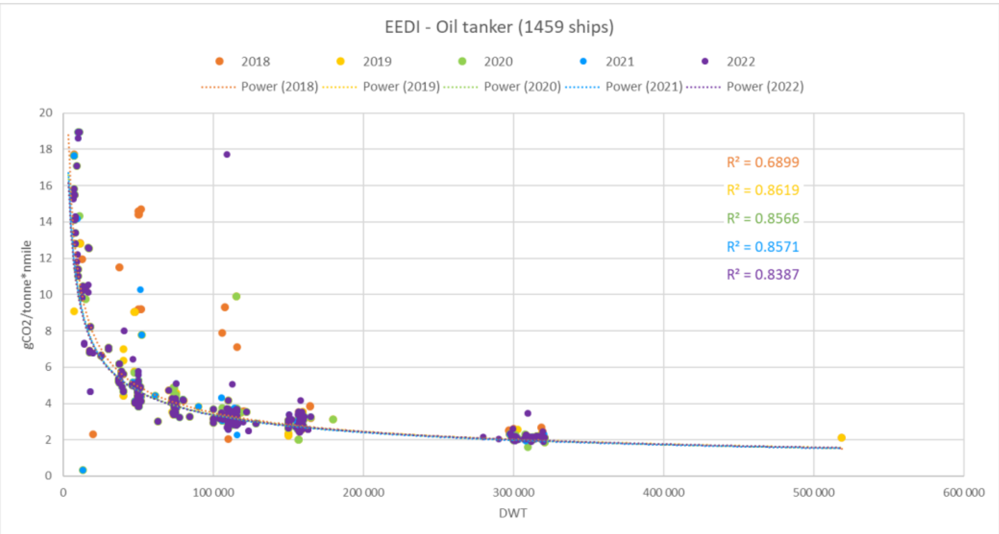

Figure 33: Plot of attained EEDI values of oil tankers over the five reporting years and associated trendlines

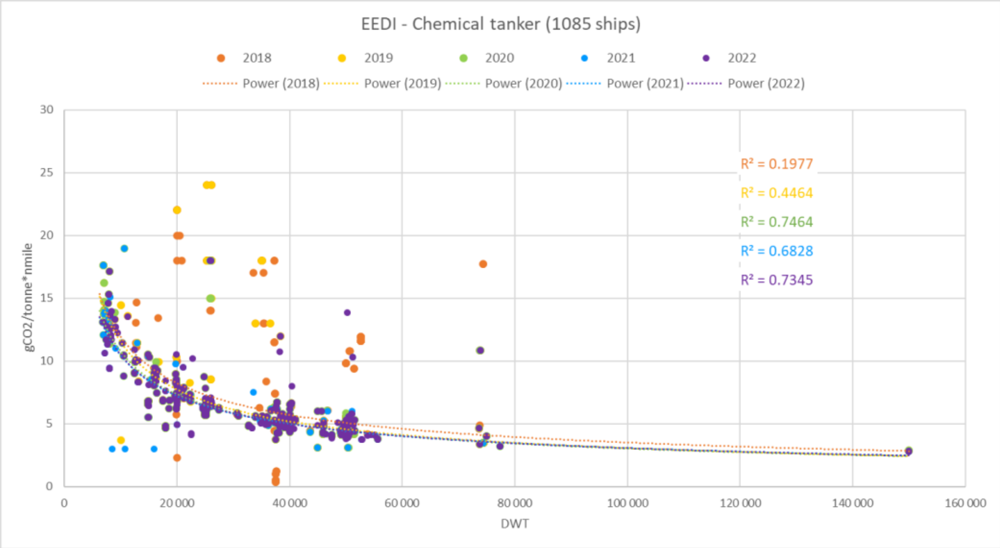

Figure 34: Plot of attained EEDI values of chemical tankers over the five reporting years and associated trendlines

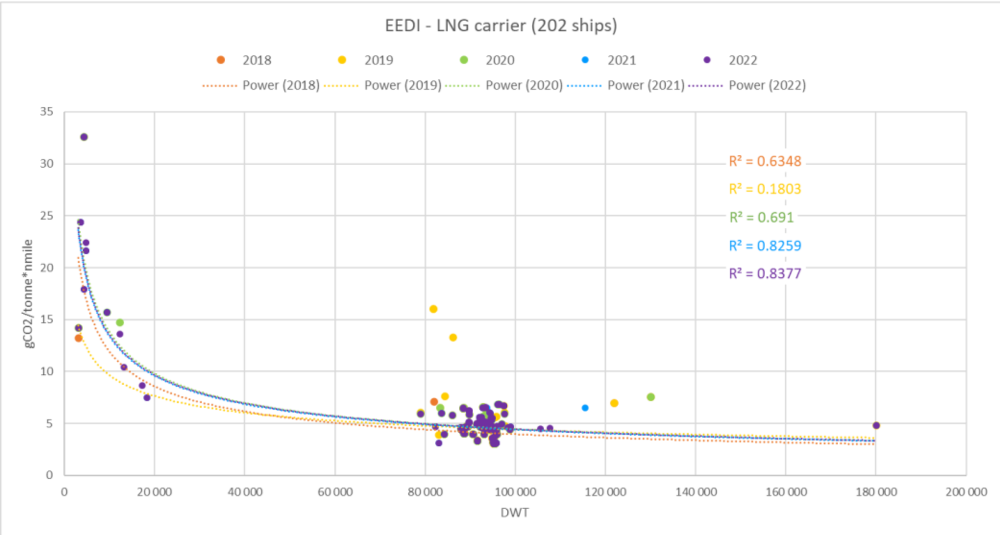

Figure 35: Plot of attained EEDI values of LNG carriers over the five reporting years and associated trendlines

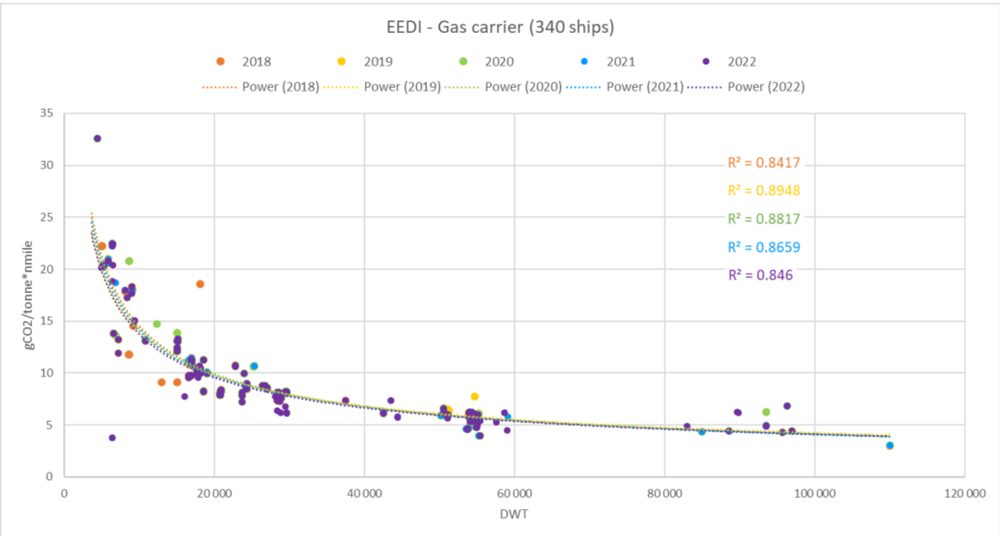

Figure 36: Plot of attained EEDI values of gas carriers over the five reporting years and associated trendlines

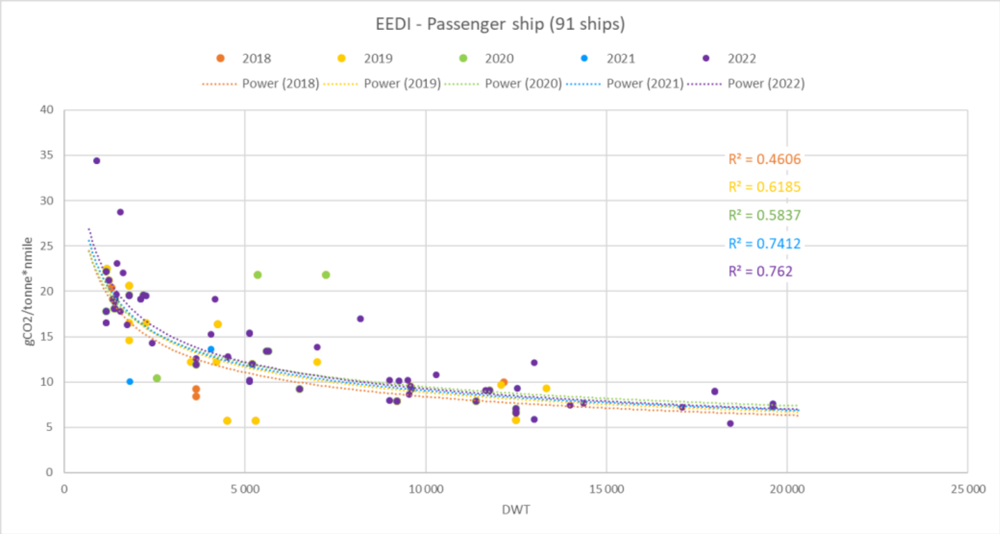

Figure 37: Plot of attained EEDI values of passenger ships over the five reporting years and associated trendlines

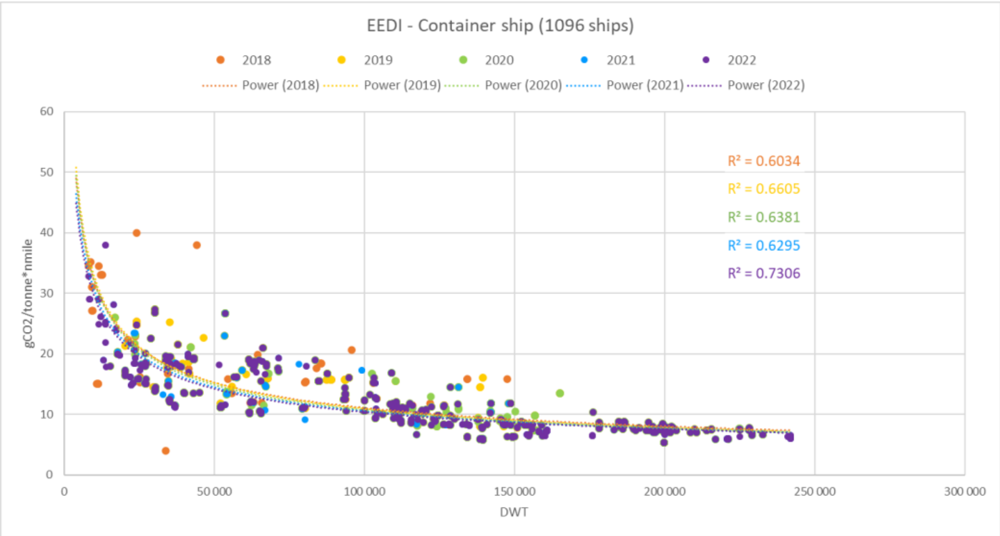

Figure 38: Plot of attained EEDI values of container ships over the five reporting years and associated trendlines

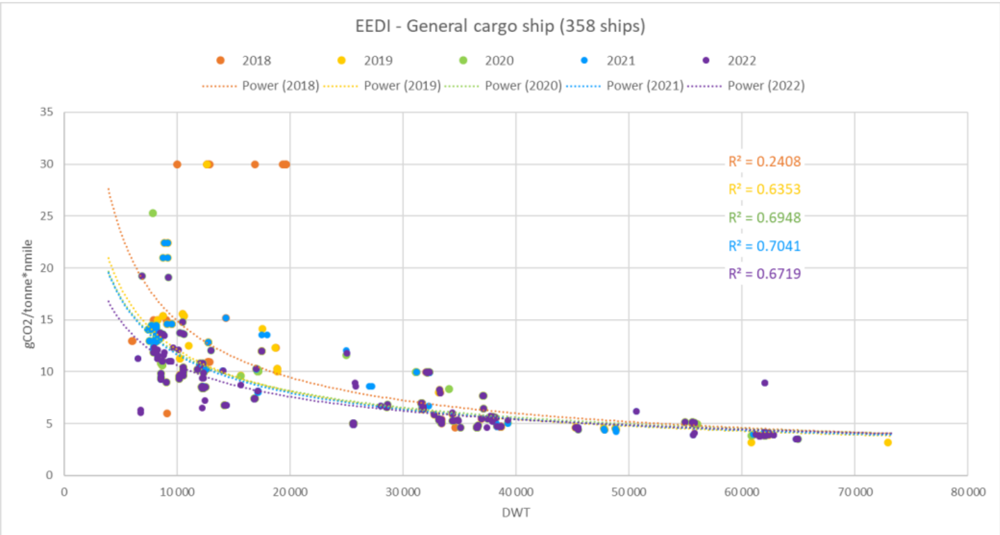

Figure 39: Plot of attained EEDI values of general cargo ships over the five reporting years and associated trendlines

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

Operational efficiency 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 carriers 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'[34].

Table 10 gives an overview of the different operational efficiency indicators and metrics that were reported in 2022. The table hereunder only shows the CO_2 efficiency indicators. The corresponding energy efficiency indicators are not presented in the table, but the same 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	Indicator Units	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

[34] 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 values for the Energy Efficency Operational Indicator (EEOI) and the Annual Efficiency Ratio (AER) for eleven ship types in the five reporting years (2018 to 2022), 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 a 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 2022 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 eleven out of the fifteen unique ship types reporting under the EU MRV system, representing 74% of total reported emissions in 2022.

The correlation values are generally increasing over the years, with all ship types showing a higher correlation value in 2022 than in 2018 (with the exception of chemical tankers for which the correlation value is the same).

The ship types for which the sample is too small (<25 occurrences), or the regression line is not reliable enough to draw conclusions (e.g. due to high variability/scatter), have not been shown [35].

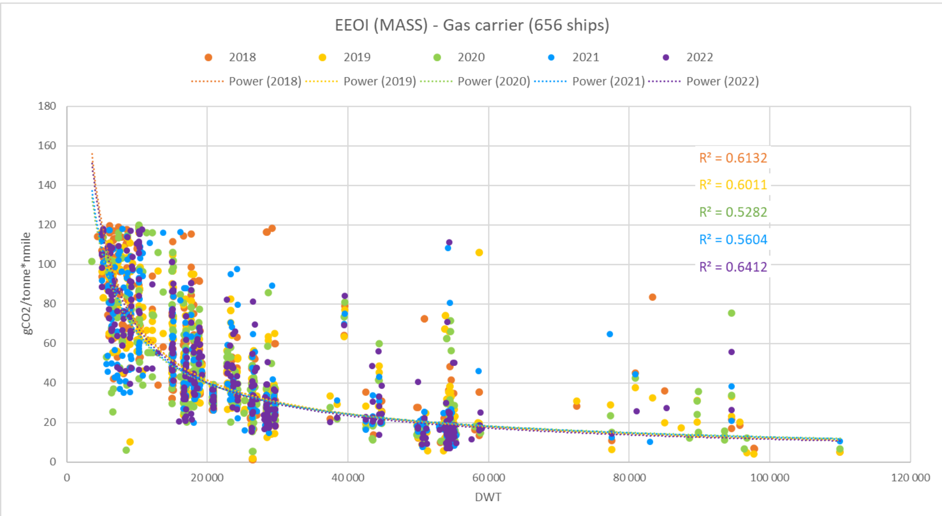

Figure 40: Plot of attained EEOI values of gas carriers over the five reporting years and associated trendlines

[35] 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 impacting the period 2020-2022 resulted in higher and more fluctuant EEOI and AER values for these types of vessels, limiting therefore the interest of applying a regression analysis.

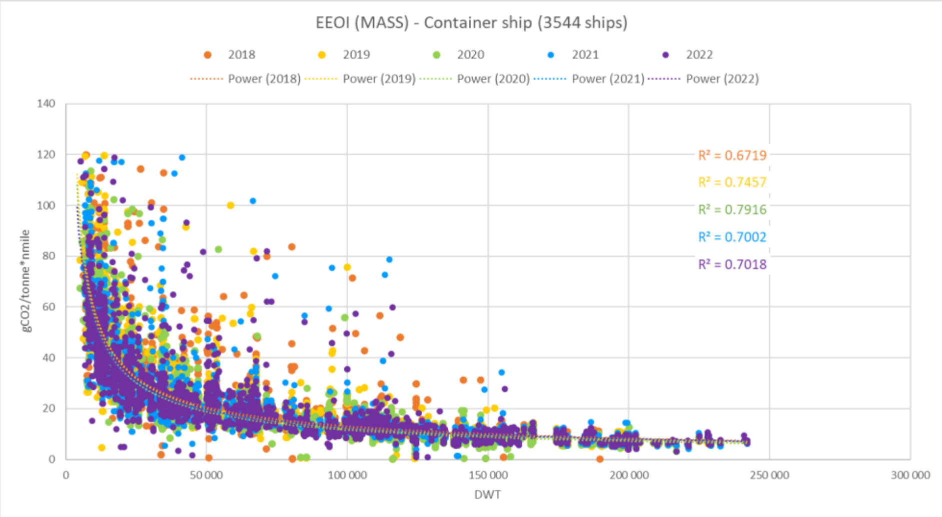

Figure 41: Plot of attained EEOI values of container ships over the five reporting years and associated trendlines

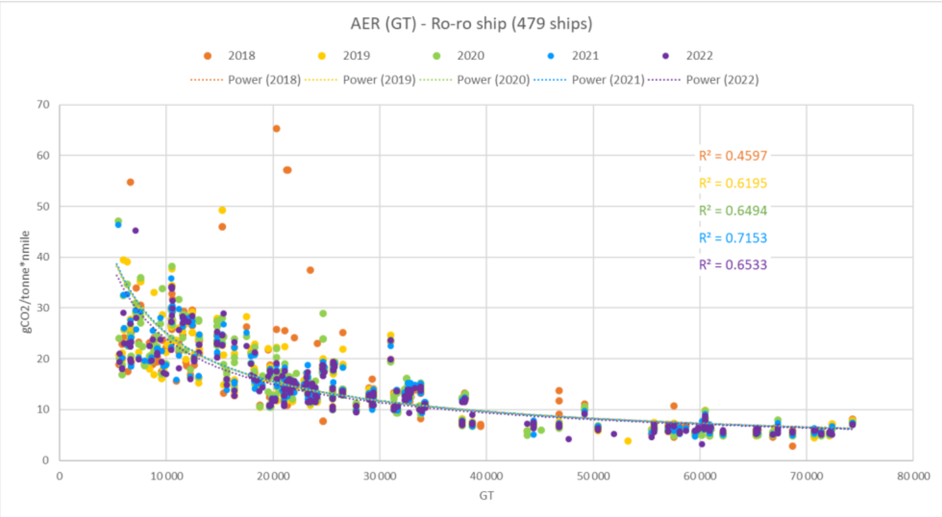

Figure 42: Plot of attained AER values of ro-ro ships over the five reporting years and associated trendlines

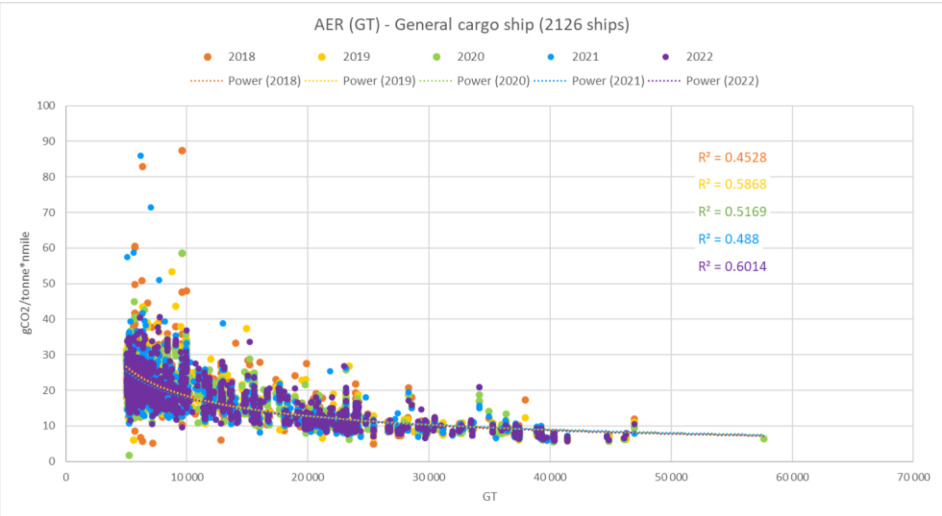

Figure 43: Plot of attained AER values of general cargo ships over the five reporting years and associated trendlines

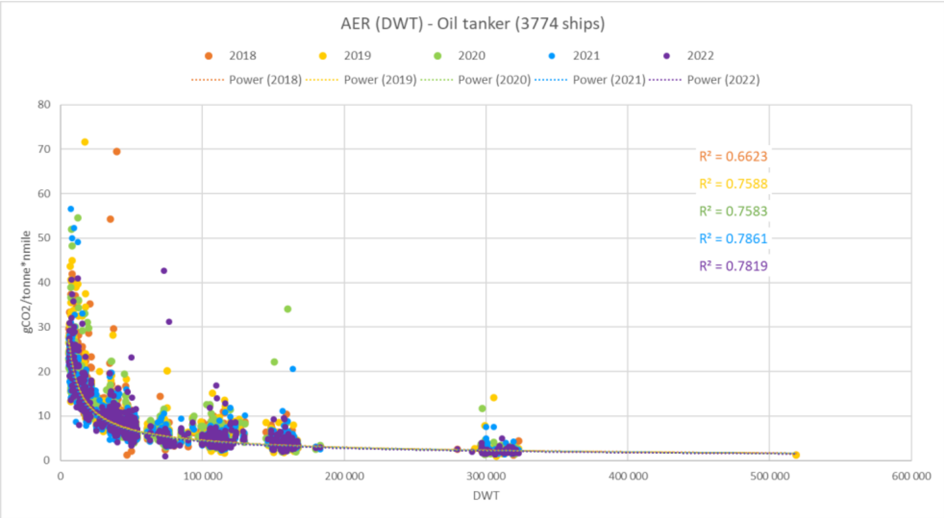

Figure 44: Plot of attained AER values of oil tankers over the five reporting years and associated trendlines

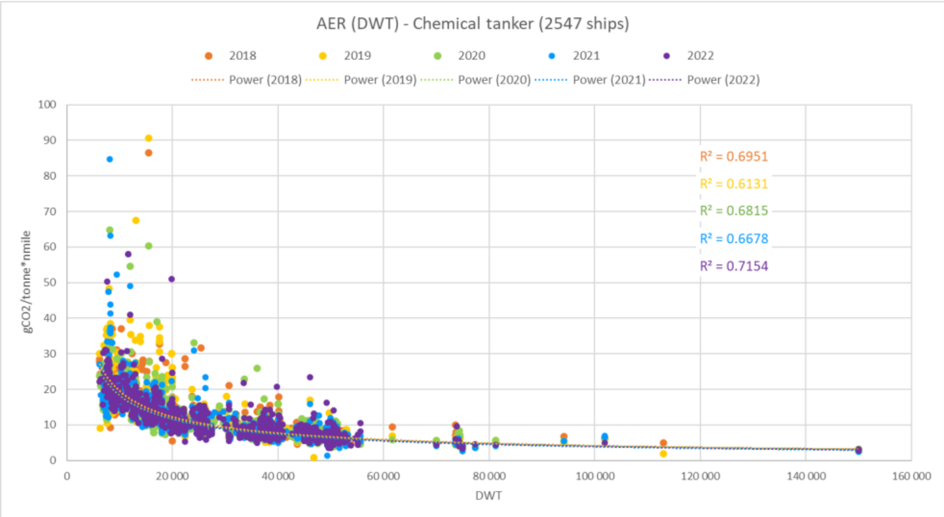

Figure 45: Plot of attained AER values of chemical tankers over the five reporting years and associated trendlines

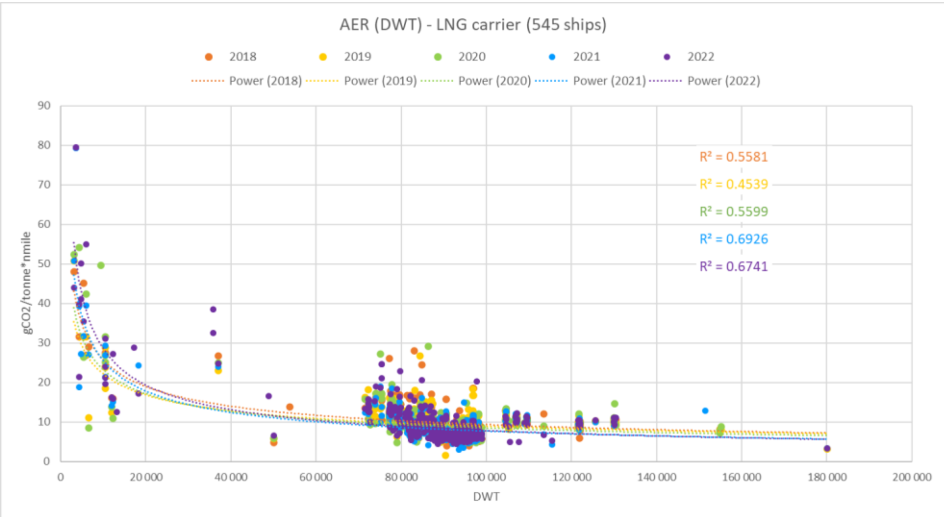

Figure 46: Plot of attained AER values of LNG carriers over the five reporting years and associated trendlines

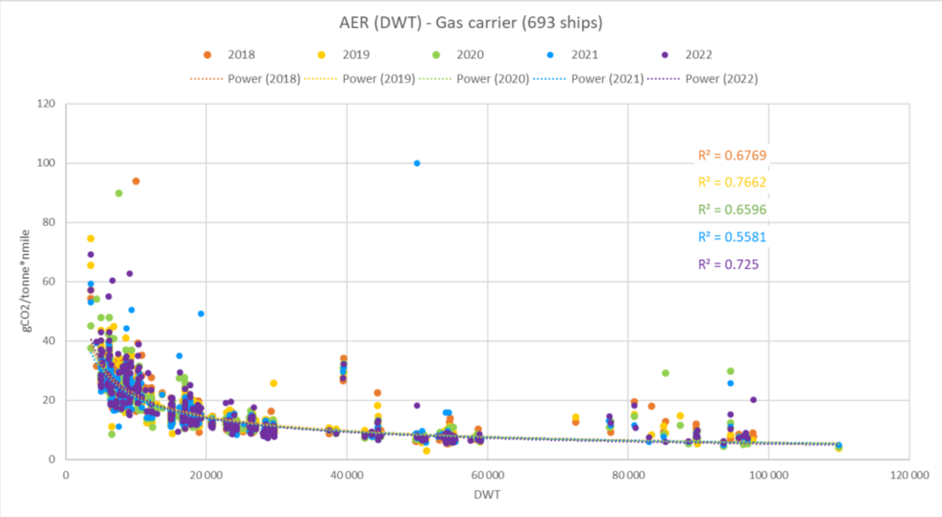

Figure 47: Plot of attained AER values of gas carriers over the five reporting years and associated trendlines

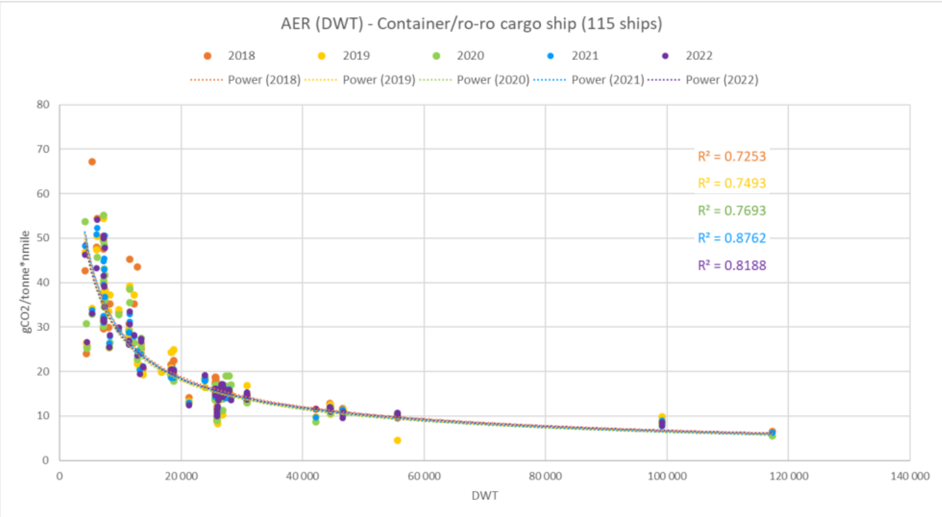

Figure 48: Plot of attained AER values of container/ro-ro cargo ships over the five reporting years and associated trendlines

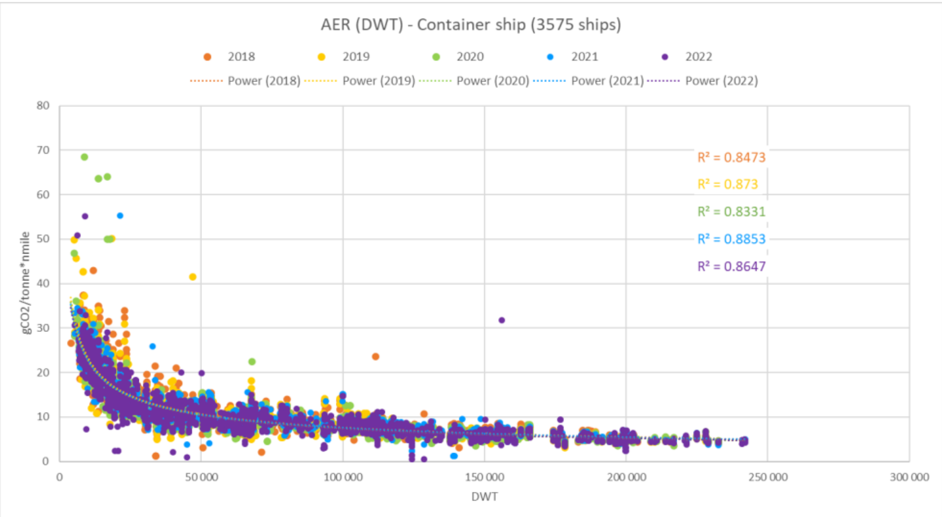

Figure 49: Plot of attained AER values of container ships over the five reporting years and associated trendlines

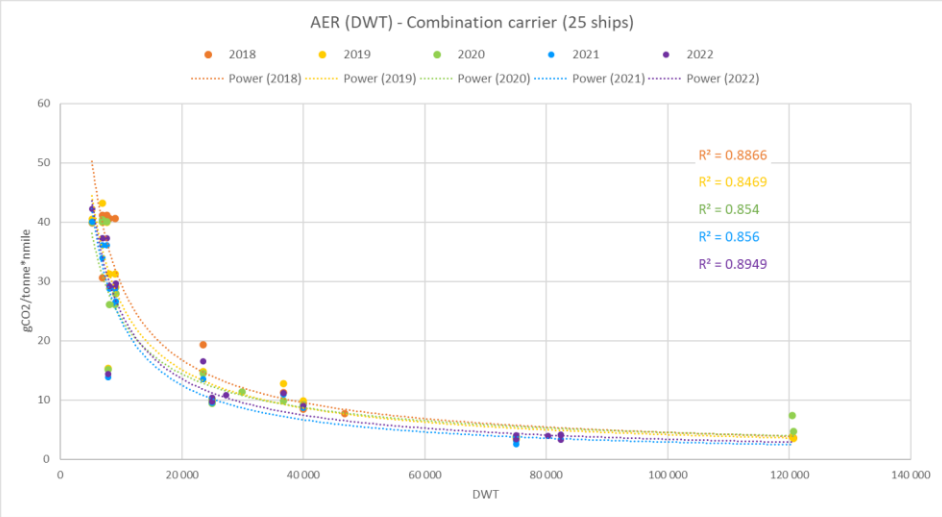

Figure 50: Plot of attained AER values of combination carrier ships over the five reporting years and associated trendlines

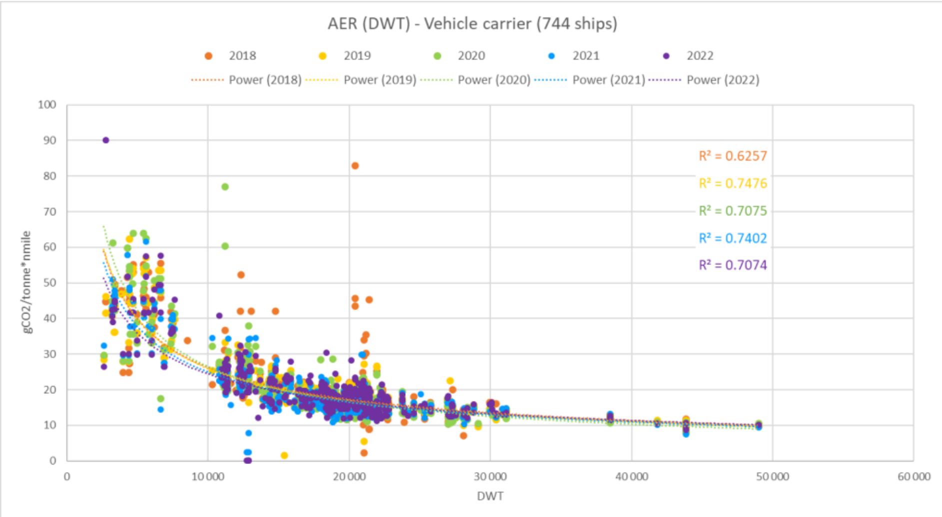

Figure 51: Plot of attained AER values of vehicle carrier ships over the five reporting years and associated trendlines

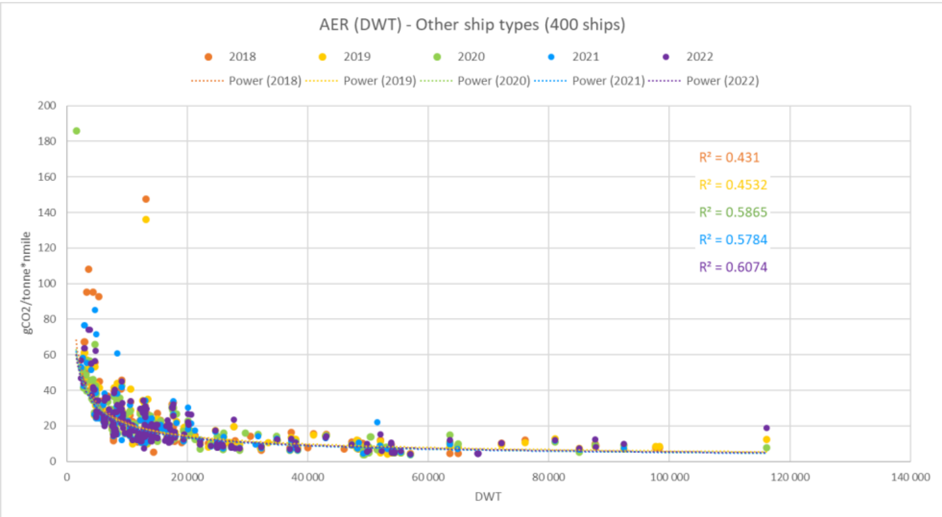

Figure 52: Plot of attained AER values of other ship types over the five reporting years and associated trendlines