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Report from the Commission

2019 Annual Report on CO2 Emissions from Maritime Transport

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European Commission

2019 Annual Report

from the European Commission on

CO_2 Emissions from Maritime Transport

Climate Action

Contents

Executive Summary

Implementing the EU MRV system

2015: Adoption of Regulation (EU) 2015/757 on the monitoring, reporting and verification of CO_2 emissions from maritime transport.
2017: Preparation of monitoring plans.
2018: First reporting period.
2019: Collection and publication of information.

Tracking EU maritime CO_2 emissions

During the first reporting year, the system involved:

>11,600 ships

- Around two-thirds are non-EU flagged
- More than half are owned by entities based in the EU.

>2,000 companies

- Around half of these are European companies.

29 accredited verification companies

- Four verification companies have issued 62% of all documents of compliance. Three out of these originate from the EEA.

Maritime transport – a substantial CO_2 emitter

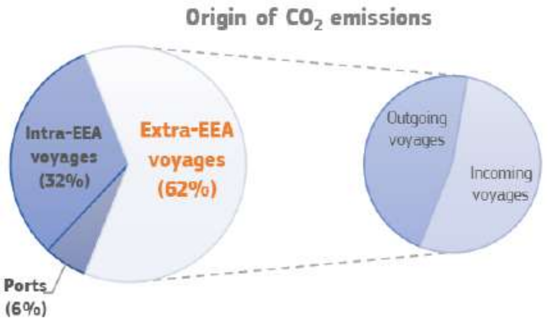
>138 million tonnes of CO_2 in 2018

- Over 3% of total EU CO_2 emissions
- Comparable to the CO_2 emissions of Belgium
- According to projections, CO_2 emissions from maritime transport are likely to grow in the future, reinforcing the need for CO_2 reduction efforts.

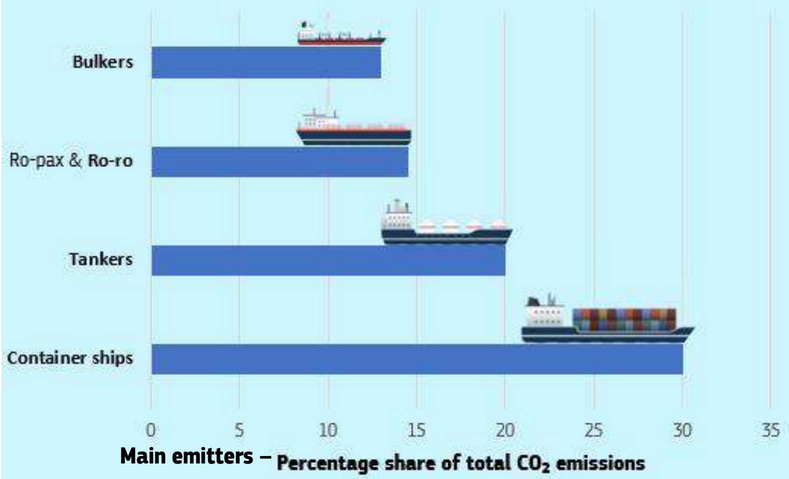
>44 million tonnes of fuels consumed

- 70% heavy fuel oils, which is a residual fuel and a heavy pollutant
- 20% marine gas oil and diesel
- 3% Liquefied Natural Gas (LNG)
- Represents around 90% of total marine fuel sales in EU ports.

Most CO_2 emissions come from voyages outside the European Economic Area



Container ships: the largest CO_2 emitters



Case studies:

Container ships

- **30% of total CO_2 emissions**
- 18% of the monitored fleet (DWT)
- Distance travelled: >70 million nm
- Average speed: 14 knots.

Bulkers

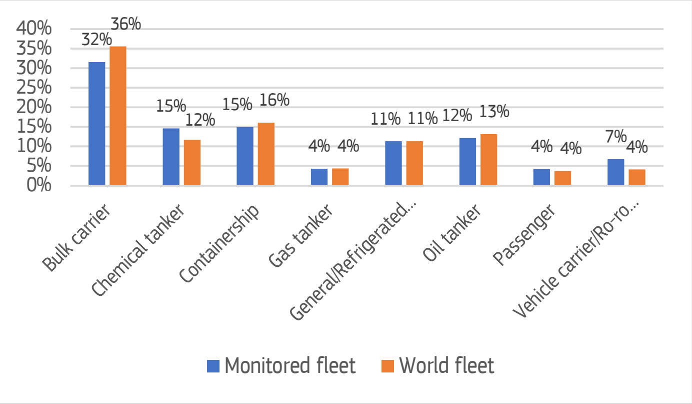
- **13% of total CO_2 emissions**
- 37% of the monitored fleet (DWT)
- Distance travelled: >55 million nm
- Average speed: 10.5 knots.

The EU maritime sector in a global perspective

- EU companies still own the largest single share of the world fleet and more than 50% of the monitored fleet (in terms of gross tonnage). However, more than two-thirds of the monitored fleet is non EU-flagged.
- CO_2 emissions reported in the EU MRV system represent 15% of the total CO_2 emissions from international and domestic shipping. At the same time, 17% of the world seaborne exports and 20% of the world seaborne imports took place in the EU.
- The European maritime technology sector produces around half of the world's marine equipment each year.
- The EU remains a global leader in the construction of sophisticated, higher added value-vessels.[1]

The monitored fleet compared to the world fleet

38% of the world merchant ships > 5,000 gross tonnage with a similar fleet structure



11 years old on average

- The monitored fleet is relatively young, although there are large age disparities between ship types. Bulkers are the youngest ships, while passenger ships and Ro-pax tend to be much older.
- Considering that ships can last 25 to 30 years, a large part of the monitored fleet is likely to still be operating in 2040.
- Since younger vessels tend to be more energy efficient, the age of ships in operation has an effect on fuel consumption and CO_2 emissions.

Energy efficiency of the monitored fleet

Technical energy efficiency

- The technical energy efficiency of the monitored fleet is generally comparable to that of the world fleet (except for small-size container ships).
- Most monitored ships built after 2015 already comply with energy efficiency standards applicable over the period 2020-2025 (EEDI phase 2).
- Younger ships from the monitored fleet tend to have lower installed power.
- Reported energy index values show similar trends as the EEDI reference lines, except for container ships.

Operational energy efficiency

- The vast majority of ships have reduced their speed compared to 2008 (with -15 to -20%). Cruising at lower speeds saves energy and fuel, and significantly reduces CO_2 emissions.
- The technical and operational energy efficiency levels in terms of the Annual Efficiency Ratio (AER) of bulkers and tankers are comparable, although smaller size segments tend to be less efficient.
- The operational energy efficiency (AER) of container ships is generally much better than their theoretical energy efficiency at reference design speed.

The EU MRV system

THETIS-MRV – the backbone of the MRV system

High coverage

By targeting ships above 5,000 gross tonnage, the EU MRV shipping Regulation covers around 90% of all CO_2 emissions, whilst only including around 55% of all ships calling into EEA ports.

Transparency, completeness and quality of data

- The data accounts for at least 94% of EEA port calls made by ships covered by the Regulation.
- The transparency of the system and the granularity of the reported data is key to addressing market barriers, and stimulating the uptake of energy efficient behaviours and technologies.
- Following some corrections completed after their initial publication, verified data from the MRV system is generally complete and sound, even though some inconsistencies and missing information was observed for this first reporting year.

A robust IT system

THETIS-MRV has demonstrated its ability to facilitate the collection of data and the transfer of information among all actors involved in the implementation of the Regulation.

Lessons learned

The first reporting year involved a learning curve for all actors. The lessons learned from this first year will inform improvements made to the MRV process.

1. Introduction

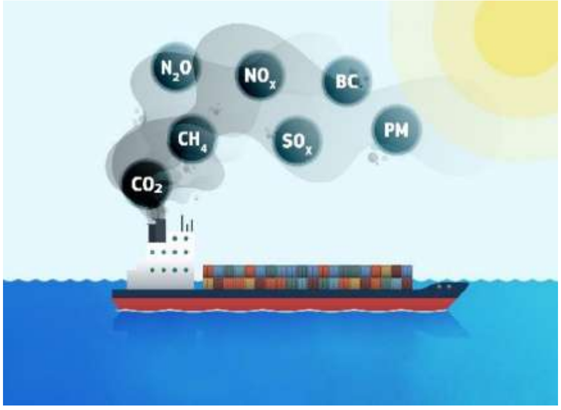
This report has been prepared using data from the implementation of the EU Regulation on the monitoring, reporting and verification of CO_2 emissions from maritime transport. All information was extracted on 23 September 2019. Data provided or updated after this date is not reflected in this report.

1.1 Shipping air emissions

This section briefly introduces the main types of emissions to air produced by maritime transport. It begins with CO_2 emissions, which is the main greenhouse gas produced by ships and the focus of this report.

It then introduces nitrogen oxides (NO_x), and sulphur oxides (SO_x), that are important pollutants.

Figure 1: Shipping air emissions



Significant and growing CO_2 emissions

CO_2 contributes to global warming by trapping heat in the atmosphere, and negatively affects marine ecosystems by increasing the acidity of seawater.

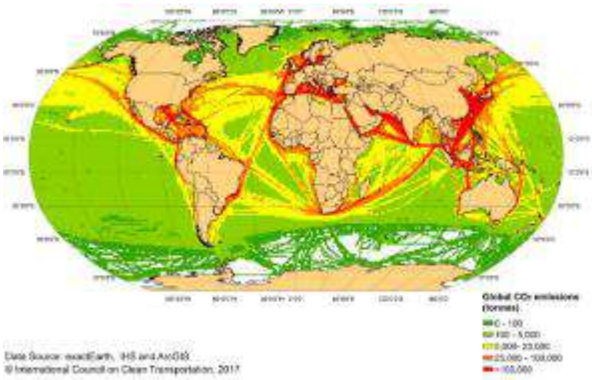
Currently, CO_2 emissions from international shipping amount to around 800 million tonnes of CO_2 per year[2], making the shipping sector a substantial contributor to climate change. These CO_2 emissions represent approximately 2-3% of total global CO_2 emissions and around 97% of all GHG emissions coming from international shipping.

If the shipping sector were a country, it would rank sixth in the world in terms of CO_2 emissions.

According to the third International Maritime Organization (IMO) GHG study from 2014, shipping emissions could increase by between 50% and 250% by 2050 (to be updated in the upcoming fourth IMO GHG study), depending on future economic and energy developments. The projected increase in international shipping emissions reflects the growth of world maritime trade in the context of a growing economy. Such a development would, without further action, offset the significant emission reduction expected from improvements in ships' energy efficiency.

The shipping sector has an equally considerable impact at the EU level. In 2017, shipping emissions from fuels sold (also including inland waterways) represented around 13% of all EU greenhouse gas emissions from the transport sector.[3]

Figure 2: CO_2 emissions from the world fleet



Source: ICCT (2017) Report: Global Shipping GHG Emissions 2013-15.[4]

These trends in terms of CO_2 emissions require determined action to limit the impact of the sector on climate change. This holds especially true at a time where significant emission reductions are urgently needed by all sectors to achieve the Paris Agreement objectives.

SO_x emissions

By emitting sulphur dioxides (SO_x), the shipping sector contributes to acid rain, which has a significant and negative impact on health.

While outside the scope of the EU Regulation on the monitoring, reporting and verification of CO_2 emissions from maritime transport (EU MRV Regulation), SO_x emissions are addressed by existing legislation. In practice, this is done by limiting the sulphur content in marine fuels, and by transposing legislation from the International Maritime Organization (IMO) into EU law, specifically the relevant provision of the Convention for the Prevention of Pollution from Ships (MARPOL, Annex VI).)

The IMO established the SO_x-Emission Control Areas (SO_x-ECA) in order to minimize airborne emissions from ships. In the EU, the Baltic, the North Sea and the English Channel were designated SO_x-ECAs by the IMO in 1997 and 2005.[5] As of 2015, EU Member States must ensure that ships use fuels with a sulphur content of no more than 0.10% in these areas.[6]

The successful implementation of the SO_x ECA limit in relevant EU waters led to a 20-60% decrease of SO_2 concentrations in the area since 2015, and showcase the feasibility of introducing ECAs in EU waters.[7]

As of 2020, the IMO global sulphur limit for marine fuels has entered into force, requiring all ships to use fuels with a sulphur content of no more than 0.50%. This landmark decision will significantly reduce the impact of shipping emissions on human health.[8]

NO_x emissions

Nitrogen oxides (NO_x) are gases that can cause the acidification and eutrophication of water and soil. By increasing the presence of nutrients in sea water, emissions of NO_x lead to the abnormal growth of algae. They also lead to the creation of particulate matters and ground-level ozone. In the coming decade, shipping is expected to become a bigger source of NO_x gases in the EU than all land-based sources.[10]

To reduce NO_x emissions, the IMO has strengthened engine standards for new ships sailing in NO_x Emission Control Areas (NO_x ECAs). These standards are intended to cut global NO_x emissions from new ships by 16-22% starting in 2011, and by 80% from 2016 or 2021, depending on the emission control areas, compared to 2000 levels.[11]

In Europe – at the request of riparian states affected by eutrophication – the IMO has designated the Baltic, the North Sea and the English Channel as NO_x Emission Control Areas (NO_x ECAs) as of 2021.

There is currently no EU legislation in place that specifically considers NO_x emissions from maritime transport, and they are not in the scope of the EU MRV Regulation. However, there is EU legislation addressing the negative effects of NO_x gases on air and water when produced by a wide range of sources and transport modes.

SHIPPING – A KEY EUROPEAN INDUSTRY[9]

International shipping is an essential part of European transport. It carries 75% of external EU trade, and 36% of intra-EU trade.

Shipping is an essential link in the global supply chain, and a **key part of the EU economy**. It is also one of the most **energy-efficient modes of transport** available.

The **EU shipping industry directly employs around 640,000 people** and up to **2.1 million when including the whole supply chain.** The industry **contributed nearly EUR 54 billion to the EU GDP in 2018.**

More than 400 million passengers embark or disembark each year at EU ports. Shipping contributes to coastal economies, and help bring Europeans closer together.

The European maritime technology sector produces **around half of the world's marine equipment** each year.

The EU remains a global leader in the construction of sophisticated, higher added value-vessels.

1.2 Reducing CO_2 emissions: a key priority at international and EU level

Multilateralism and broad cooperation is central to EU climate policy. The EU supports ambitious global cooperation and action to address climate change, complemented and supported by determined work at all levels, including at regional and national level. The EU is more than ever committed to lead the way in climate efforts. This commitment sees the EU engaging in action carried out on both the international and European level.

International action

At the international level, the Paris Agreement stresses the need to peak global greenhouse (GHG) emissions as soon as possible. It also stresses the need to reduce GHG emissions in all sectors of the economy in order to limit the global temperature increase to well below 2° C compared to pre-industrial levels, and pursuing efforts to limit global warming to 1.5° C. Achieving this goal will require a reduction of all anthropogenic sources of emissions, including from aviation and shipping.

In the international shipping sector, the International Maritime Organization (IMO) is committed to contribute to the global efforts to address climate change, and the EU is actively engaged in this cooperation at international level.

The IMO started to discuss climate action in 1997. In 2011, the Organization adopted the Energy Efficiency Design Index (EEDI) for new ships, which sets an internationally agreed energy efficiency standard for new vessels. That same year, it was decided that all ships would have to implement a Ship Energy Efficiency Management Plan (SEEMP). In 2016, one year after the adoption of the EU system for monitoring, reporting and verification of CO_2 emissions, the International Maritime Organization established a Data Collection System for fuel oil consumption of ships.

In 2018, the International Maritime Organization adopted an initial strategy to reduce greenhouse gas emissions from ships. Its objectives include reducing the carbon intensity of ships by at least 40% by 2030, peaking greenhouse gas emissions as soon as possible, and reducing these emissions by at least 50% by 2050 compared to 2008 levels. In parallel, it strives towards achieving full decarbonisation as soon as possible in this century.

This initial IMO strategy is a significant step forward in the global efforts to tackle climate change. For this initial strategy to succeed, it is now crucial that effective reduction measures are swiftly adopted and put in place before 2023. Preparations on longer term actions should also begin.

AN INTRODUCTION TO THE IMO

THE INTERNATIONAL MARITIME ORGANIZATION (IMO) is the United Nations (UN) specialised agency responsible for the **safety and security of shipping** and the **prevention of marine and atmospheric pollution** by ships.

The development and implementation of global standards for energy efficiency, new technology, and innovation underpin the IMO's commitment to a green and sustainable global maritime transportation system.

EU-level action

In 2014, the European Council endorsed a binding target of at least 40% domestic reduction in economy-wide greenhouse gas emissions by 2030 compared to 1990. In 2016, the EU ratified the Paris Agreement.

At present, only domestic navigation emissions and emissions from inland waterways are covered by mitigation measures at EU level (through the Effort Sharing Regulation). International shipping remains the only means of transportation not included in the European Union's commitment to reduce greenhouse gas emissions.

Improving the environmental performance of maritime transport has been on the EU agenda for a decade, starting with the 2009 Maritime Transport Strategy[12], the 2011 Transport White Paper[13], and more recently the 2016 strategy for low-emission mobility and the 2017 Valletta declaration. The European Parliament has also adopted resolutions calling for the EU to take more responsibility for shipping emissions.[14]

In 2013, the Commission set out a strategy for progressively integrating maritime emissions into EU climate policy, relying on three consecutive steps:

- Monitor, report and verify CO_2 emissions from maritime transport;
- Define Greenhouse gas reduction targets for the maritime transport sector;
- Develop further measures, including market-based measures, in the medium to long term.

As an initial step, the European Parliament and the Council adopted Regulation (EU) 2015/757 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport in April 2015. In February 2019 the Commission adopted a proposal to review the Regulation, taking into account, where appropriate, the IMO data collection system on fuel consumption implemented on a global level. The review is currently being discussed as part of the ordinary legislative procedure.

Several other EU legislative texts and policies support the sustainable transition of the maritime sector, including policies on energy efficiency, renewable energy sources, infrastructures and research and innovation.

In 2019, the Commission presented the European Green Deal – a roadmap that sets out how to make Europe the first climate-neutral continent by 2050, boosting the economy, improving people's health and quality of life, caring for nature, and leaving no one behind.

The European Green Deal covers all sectors of the economy, including waterborne transport. In this context, the European Commission will look into extending the Emissions Trading System to cover the maritime sector, along with other possible measures aimed at enhancing the sector's contribution to the fight against climate change.

1.3 Measures to reduce CO_2 emissions from shipping

Applying a basket of measures

Decarbonising the shipping sector will require the application of a basket of tools and measures.

In the short-term, emission reductions will need to come from the deployment of mature energy efficiency technologies and operational practices.

In the medium- and long- term, the shipping sector will have no choice but to shift from fossil-based marine fuels to alternative fuels, renewable energy sources, and hybrid technologies that are both environmentally sustainable and economically viable. This is the best way to decarbonise the sector in line with the objectives of the International Maritime Organization Strategy and the Paris Agreement.

The application and effectiveness of these measures will depend on a number of factors:

- their level of environmental and social sustainability;
- their costs and availability;
- their impact on the overall energy system and on bunkering infrastructures;
- their impact on ship safety and ship design;
- their maturity and reliability.

The deployment of these measures will require proper and timely regulatory incentives as well as non-regulatory incentives, both at global, regional and national level. Such incentives will need to be combined with an ambitious research and innovation agenda, and an investment-friendly environment.

Tapping into the potential for energy efficiency

A recent literature review found that emissions could be reduced by 33-77% compared to a 2050 baseline scenario based on current technologies, through a combination of policy measures.[15]

A wide range of measures have the potential to reduce emissions, including:

- improving ship design (e.g. hull design, power and propulsion optimisation, vessel size);
- improving ship operations (e.g. speed optimisation, weather routing, scheduling);
- using renewable energy sources (e.g. wind);
- using sustainable alternative fuels.

Addressing market barriers

Improving energy efficiency is key for shipping companies as energy costs account for 60-70% of overall operating costs. Despite this, studies have shown that companies are not sufficiently investing in cost-effective energy efficient measures.[16]

The lack of accurate and standardised information on energy efficiency achievements is one of the barriers to cost-effective emission reductions in the maritime sector.[17] This leads to flawed or inefficient decision-making, and makes it expensive for companies to seek out relevant information.

Market failures present another barrier, where the party investing in efficiency measures is not the one benefitting from the reductions in fuel consumption. This problem is particularly acute in the tramp shipping industry, where ship owners charter their ships to operators.

A lack of access to private finance is also hindering investment in energy efficiency when retrofitting existing ships, or purchasing new highly efficient ships.

1.4 EU Research and Innovation to pave the way towards zero-emissions ships

To support the decarbonisation of waterborne transport, the EU is actively funding a number of research and innovation projects. Every year, the Horizon 2020 programme provides a budget of around EUR 50 million to support waterborne research and innovation.

One successful example is the *Ellen E-ferry project,* which shows how a new and cost-effective approach to short-sea shipping can become reality with the support of EU funding.

The electric ferry *Ellen* is the result of a cooperation between a Swiss battery maker and a Danish mechanical firm. The ferry has an exceptional capacity of 4.3 MWh, which is seven times more than previously demonstrated.[18]

Ellen can carry 30 vehicles and 200 passengers, and completed her maiden voyage between the Danish island Ærø and the mainland in August 2019.[19] It is expected that the project, 'over one year, […] will prevent the release of 2,000 tonnes of CO_2, 42 tonnes of NO_x [Nitrogen Oxide], 2.5 tonnes of particulates and 1.4 tonnes of SO_2 [Sulphur Dioxide] into the atmosphere'.[20]

A pioneering project can pave the way for ambitious emissions reductions in the shipping sector.

With more than a hundred electrical ferries projected to be introduced by 2030 according to the project, the *Ellen E-Ferry* illustrates how pioneering activities can lead the way towards zero emissions ships.

Another example is the on-going EU-funded *RAMSSES project* that supports the widespread integration of components made from innovative, lightweight materials – from hulls, superstructures, decks and cabins, to rudders and propellers.

With 13 prototypes under development and one composite-fitted ship already in commercial use, RAMSSES will showcase how advanced materials not only match or surpass the resilience, strength and safety of steel, but can cut the weight of ships in half. This will enable ships to carry more passengers and cargo, while reducing fuel consumption and emissions.

In addition to the Horizon 2020 programme, the EU offers support for research on energy storage and fuels through the Innovation Fund, which aims at supporting the demonstration of innovative low-carbon technologies. The new Horizon Europe programme will also contribute to innovation in transport through the four 'Green Deal Missions'.

For the next programming period 2021-2027, the European Commission is considering a new Zero-emission waterborne transport partnership. Such a partnership could radically transform inland and maritime waterborne transport, develop knowledge, technologies and demonstrate solutions that will enable zero-emission shipping for all ship types and services. It would contribute to maintaining and further reinforcing Europe's global leadership in green shipping technologies. This partnership would support the demonstration of deployable zero-emission solutions suitable for all main ship types and services by 2030.

The development of zero-emission ships will require various research and innovation action, including on alternative fuels, power conversion and propulsion technologies, system integration and overall efficiency.

2. An EU system to monitor CO_2 emissions from maritime transport

2.1 EU MRV Regulation objectives

In 2015, the EU adopted new legislation to monitor, verify and report CO_2 emissions from maritime transport (Regulation (EU) 2015/757).

This legislation is the first step of a staged approach for the inclusion of maritime transport CO_2 emissions in EU Climate Policy. It has three key objectives:

- to collect **robust and verified CO_2 emission data**;
- to bring **transparency** and stimulate the uptake of energy efficiency investments and behaviours;
- to **support future policy discussions** and implementation of policy tools.

The legislation requires shipping companies to track and report key information about CO_2 emissions, fuel consumption and other relevant information. This data is then checked by independent verifiers accredited by national accreditation bodies. The Commission subsequently publishes the verified data and an annual report.

2.2 Scope and process

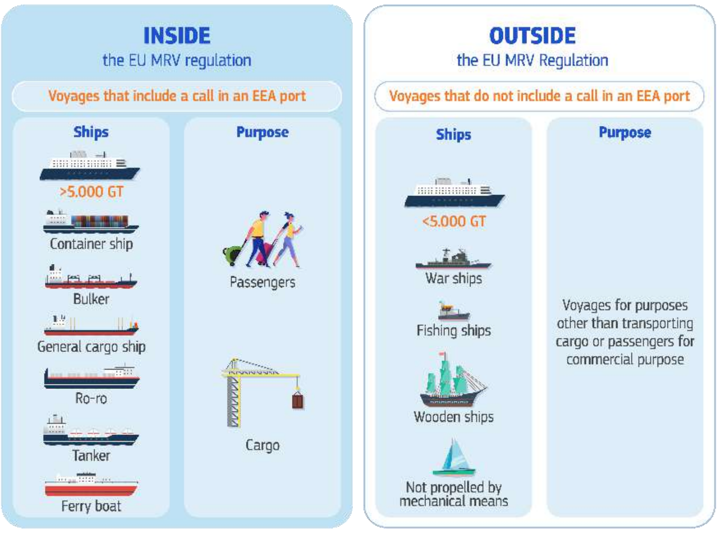
The Regulation covers all large ships over 5,000 gross tonnage (GT) loading or unloading cargo or passengers at ports in the European Economic Area (EEA). The Regulation is flag-blind, which means that ships have to monitor and report their emissions regardless of their flag.

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

The Regulation covers CO_2 emissions produced when a ship carries out a voyage from or to a port in the EEA when transporting goods or passengers for commercial purposes. For instance, it covers emissions from a ship that goes from Rotterdam to Shanghai. The Regulation also covers 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 (eg the port of Singapore) for cargo or passenger operations, only the emissions related to the last leg of the voyage (in this case Singapore-Rotterdam) will be reported in the system. Voyages that take place within the EEA are also covered, such as when a ship travels from Le Havre to Rotterdam, or from Ghent to Antwerp (domestic voyages). Emissions occurring when the ship is securely moored or anchored at a port (at berth) whilst loading, unloading or hoteling are also covered.

It should be noted that any operation other than transporting cargo or passengers is excluded from the Regulation.

Figure 3: Scope of the EU MRV Regulation



The EU MRV process in practice

The following section introduces the six steps of the MRV process, and explains the implementation of these steps during the first EU MRV reporting period.

Figure 4: The steps of the EU MRV process

INTRODUCING THETIS-MRV

THE EUROPEAN COMMISSION AND THE EUROPEAN MARITIME SAFETY AGENCY (EMSA) established an IT tool called **THETIS-MRV** in order to facilitate the MRV process. This tool is the **backbone of the EU MRV system.**

The tool provides a single **portal for market actors** where they can report CO_2 emissions and other relevant information. It also gives access to all publicly available information.

THETIS-MRV **lessens the administrative burden** by facilitating the exchange of information between companies, verifiers, the European Commission, flag States and the public.

The THETIS-MRV portal is hosted by EMSA: https://mrv.emsa.europa.eu/#public/emission-report.

Step 1: Producing a Monitoring Plan

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

Ship owners are required to fill out a monitoring plan before engaging in monitoring and reporting. In this document, ship owners explain how they intend to monitor the relevant parameters required by the EU MRV Regulation. This monitoring plan must provide complete and transparent documentation of the monitoring method to be applied for each ship. It must follow the pre-defined template provided in the implementing legislation.[21]

Companies can choose between four methods to monitor CO_2 emissions:

- Bunker Fuel Delivery Note (BDN) and periodic stocktakes of fuel tanks;
- bunker fuel tank monitoring on board;
- flow meters for applicable combustion processes;
- direct CO_2 emissions measurements.[22]

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

All monitoring plans need to be assessed by an accredited verifier. If the verifier identifies any non-conformities, the company must revise its monitoring plan and submit the revised plan for a final assessment.[23] Monitoring plans can be created and assessed in THETIS-MRV on a voluntary basis.

Feedback from the first reporting exercise

During the first reporting period, companies relied on the first three monitoring methods to a similar degree but direct CO_2 emissions measurements were not used, possibly due to the complexity of such a measurement method.

The vast majority of companies used default values for the level of uncertainty associated with fuel monitoring, following the guidance and best practice document established by the European Sustainable Shipping Forum (ESSF).[24]

Around 50% of the monitoring plans were drafted in THETIS-MRV on a voluntary basis, which presumably provided shipping companies with a way to familiarise themselves with the template provided in the implementing regulation. All others were prepared outside the IT system.

Step 2: Monitoring and reporting

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

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

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

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

Feedback from the first reporting exercise

Around 10-15% of companies took the opportunity to voluntarily and separately report their CO_2 emissions related to on-laden voyages and ballast voyages.

Step 3: Providing an Emission Report

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

Feedback from the first reporting exercise

Close to 12,400 emission reports were created in the system as part of the first reporting period. Section 2.4 gives information about the quality and completeness of these emission reports.

Step 4: Verification of Emission Report

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

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

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

Feedback from the first reporting exercise

In total, 11,653 emission reports out of 12,400 were successfully verified and submitted to the Commission as of 23 September 2019. Around 400 were satisfactorily verified but not submitted by companies, suggesting that some of them did not fully understand the requirement to submit their emission report once approved by verifiers. In addition, around 300 other emission reports were in various drafting stages.

An analysis of THETIS-MRV conducted shortly after the April 2019 deadline showed that most companies fulfilled their obligation on time. Close to 80% of the emission reports were successfully verified and submitted before the deadline.

Step 5: Issuing a Document of Compliance

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

Feedback from the first reporting exercise

During the first reporting year, 11,589 documents of compliance were issued in the system. This means that almost 100% of all submitted emission reports resulted in the issuance of a document of compliance. At the time of this analysis, the remaining 64 missing documents can be traced back to a single verifier, who had not yet completed this final step.

Step 6: Publication of information and Annual Report

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

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

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

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

Feedback from the first reporting exercise

The first set of information was made publicly available on 1 July 2019 on the THETIS-MRV website. The Commission received a number of requests concerning the disclosure of data. These requests were rejected, as they did not meet the specific conditions and requirements laid out in the legislation.

Continuous enforcement activities throughout the EU MRV process

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

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

Feedback from the first reporting exercise

Due to the recent implementation of the EU MRV regulation, it is too soon to draw conclusions on enforcement. A first exchange of preliminary experience between Member States' competent authorities took place on 14 January 2020, which indicated that the large majority of inspected ships had a valid Document of Compliance on-board.

2.3 The actors involved

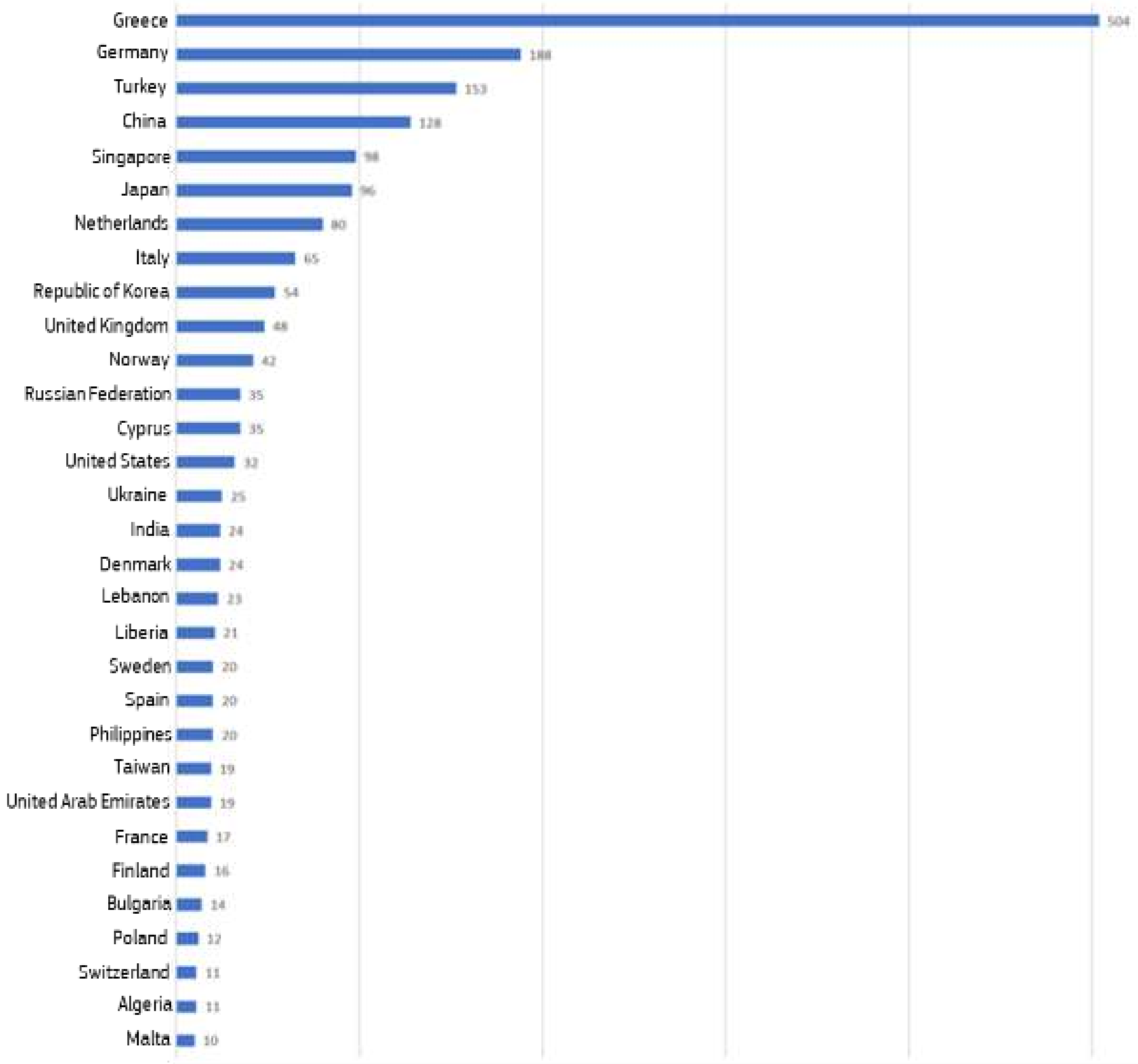
This section explains who the key players involved in the MRV process are. Starting with the shipping companies, this section goes on to discuss verifiers, national accreditation bodies, Member States (flag and port State control authorities), the European Maritime Safety Agency (EMSA), and the Commission.

2.3.1 Shipping companies

The EU MRV Regulation defines companies as the shipowner or any other organisation or person, which has assumed the responsibility for the operation of the ship from the shipowner.

Close to 2,000 shipping companies reported their CO_2 emissions during the first year of the EU MRV process. The figure below shows the origin of companies, which is different from the flag flown by individual ships. Around half of them are European with a quarter of the shipping companies coming from Greece and 10% from Germany. Around 20% of all shipping companies come from China, Singapore, Japan, and the Republic of Korea.

Figure 5: Origin of companies reporting under the EU MRV regulation



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).

2.3.2 Verifiers

Verifiers are legal entities carrying out verification activities (e.g. private companies). They need accreditation from a national accreditation body designated by an EU Member State. They must be independent from shipping companies, and act in the public interest.

Verifiers have to assess the reliability, credibility and accuracy of monitoring systems and the reported data. Their work is crucial in ensuring that companies provide correct and complete information. Verifiers also have a key administrative role, which includes communication with ship operators, and delivering the document of compliance. In practice, they verify the reported data through activities such as crosschecks with other sources (ship-tracking data), threshold comparisons, recalculations of reported data or site visits.

Most verifiers are well-established classification societies. The verification market is relatively concentrated, with four companies responsible for 62% of all documents of compliance (see Figure 6). Three out of these (DNV GL, VERIFAVIA, LR) originate from the EEA.

2.3.3 National Accreditation Bodies

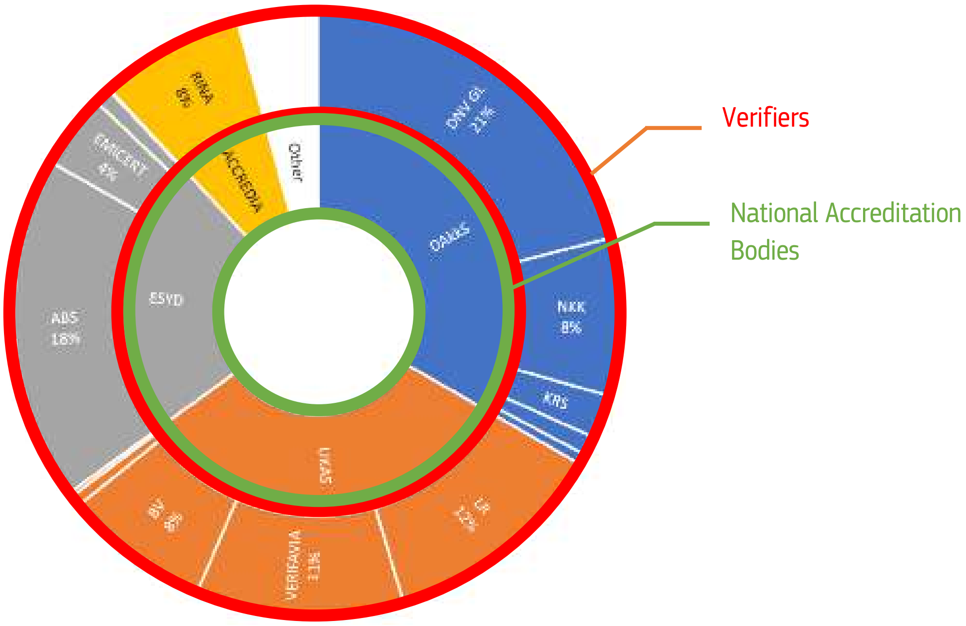
Accreditation is the confirmation by an officially recognised authority that a verifier and its personnel have the competence and the ability to perform the required verification activities. National accreditation bodies are the only ones allowed to provide such accreditation. They work independently of commercial activities, and exercise public authority.

The accreditation process must include a review of relevant documents, office visits, and audits. An accreditation certificate is valid for five years. National accreditation bodies also have to conduct annual surveillance of each verifier and decide whether to confirm, suspend or withdraw their accreditation.

National accreditation bodies are required to maintain a publicly available database of accredited verifiers. These can be accessed on the websites of national accreditation bodies.[25]

Figure 6 illustrates the key role played by a small number of national accreditation bodies. The national accreditation bodies from Germany (DAkks), the United Kingdom (UKAS), Greece (ESYD) and Italy (ACCREDIA) have accredited the verifiers responsible for 90% of all monitored ships.

Figure 6: Verifiers and related National Accreditation Bodies are behind 90% of all emission reports



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019). Notes on verifiers: RINA - Registro Italiano Navale (IT), EMICERT (EL), ABS – American Bureau of Shipping (US), BV – Bureau Veritas (FR), VERIFAVIA (FR), LR – Lloyds Register (UK), KRS – Korean Register of Shipping (KR), NKK - Nippon Kaiji Kyokai (JP), DNV GL - Det Norske Veritas and Germanischer Lloyd (NO). Notes on national accreditation bodies: ACCREDIA – L'ente Italiano de Accreditamento (IT), ESYD – Hellenic Accreditation System (EL), UKAS – United Kingdom Accreditation Service (UK), DAkks – Deutsche Akkreditierungsstelle (DE).

2.3.4 Member States

Member States are pivotal in the successful implementation and enforcement of the MRV process.

As flag State, Member States must take all the measures necessary to ensure compliance with the monitoring and reporting requirements for ships flying its flag. In addition, as port State Control Authority, Member States should ensure that any inspection of a foreign ship in a port under their jurisdiction includes checking that a valid document of compliance is carried on board.

Additionally, Member States must set up a system of effective, proportionate and dissuasive penalties for failure to comply with the monitoring and reporting obligations of the regulation, and must take all the measures necessary to ensure that those penalties are imposed.

Member States must also establish an effective exchange of information and effective cooperation between the national authorities responsible for ensuring compliance. This serves to ensure an effective enforcement mechanism.

2.3.5 European Maritime Safety Agency (EMSA)

The European Maritime Safety Agency is a decentralised EU agency based in Lisbon, Portugal. The Agency provides technical assistance and support to the Commission and Member States in the development and implementation of EU legislation on maritime safety, pollution by ships, and maritime security.

EMSA's mission is to ensure a high, uniform, and effective level of maritime safety, maritime security, prevention of – and response to – pollution caused by ships, as well as responding to marine pollution caused by oil and gas installations.

EMSA has also been given operational tasks in the field of oil pollution response, vessel monitoring, and in long-range identification and tracking of vessels. For the EU MRV Regulation, EMSA is in charge of the THETIS-MRV tool (design, administration, and helpdesk), and it supports the work of the Commission.

2.3.6 European Commission

The Commission is responsible for monitoring the implementation of the EU MRV Regulation. If an EU Member State does not fully implement the Regulation through its national law or fails to enforce it, the Commission may start formal infringement proceedings against the country in question. By convening and connecting key stakeholders involved in the process, the Commission also supports its implementation by encouraging the exchange of good practices.

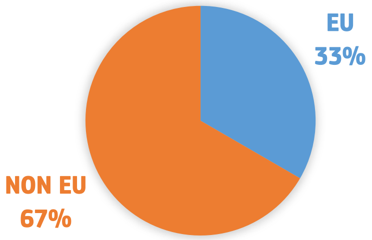
In addition, the Commission is responsible for making key information on CO_2 emissions publicly available and preparing an annual report to assess the maritime transport sector's overall impact on the global climate every two years.

2.3.7 Flag States

Flag State administrations (including those from outside the EU) can consult all emission reports and documents of compliance related to their ships.

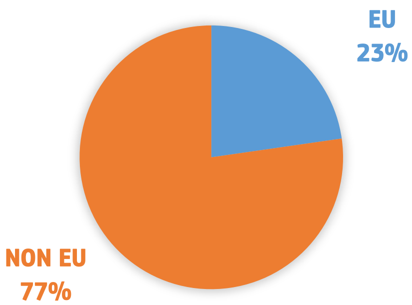
More than two-thirds of the monitored fleet (in GT) is non EU-flagged, with the Marshall Islands, Panama and Liberia covering more than 40% of all ships. Non-EU-flagged ships represent 77% of the world fleet, meaning that EU-flagged ships are generally better represented in the monitored fleet.

Figure 7: Distribution by flag State in the monitored fleet (in GT)



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).

Figure 8: Distribution by flag State in the world fleet (in GT)



Source: EMSA elaborations based on HIS MARKIT database.

More than half of the EU-flagged ships report their CO_2 emissions under the EU MRV system.

2.4 Quality and completeness of EU MRV data

Evolution of EU MRV data

In the context of this first reporting exercise, companies were given the opportunity to correct their emission report after the reporting deadline. For this reason, the dataset has been continuously updated since 1 July 2019. In total, 948 emission reports were added, and 476 were corrected between 1 July and 23 September 2019, the cut-off date for this analysis. These changes resulted in a fluctuation in the total amount of CO_2 emissions reported in THETIS-MRV shortly after the publication date, followed by a stabilisation phase.

In this context, it is important to recall that companies are the only ones able to make changes in the emission reports, and that all corrected data needs to be re-verified before it can be published.

Completeness and quality of the reported data

The EU MRV dataset extracted on 23 September 2019 is based on 11,653 emission reports submitted to the Commission, representing more than 1.5 million single data points. While the vast majority of this data appears correct and complete, the dataset contains some inconsistencies and missing information.

It should be noted that 630 emission reports out of the 11,653 in the database show 0 (zero) CO_2 emissions, because they concern ships that did not call at any EEA port during the reporting period. These emission reports are comparable to a nil declaration. Companies voluntarily seeking to obtain a document of compliance in order to facilitate possible future port State control inspections at EEA ports have drafted these reports. CO_2 emissions reported for these ships are rightly set at zero and should not be considered as missing information. With the exceptions of these specific cases, all emission reports include a range of information on CO_2 emissions, fuel consumption, distance travelled, and time spent a sea.

However, a common problem was incomplete information on addresses for ship owners (around 17% of all emission reports) and contact persons addresses (around 30% missing). On the other hand, almost all ships provided information such as email addresses and the telephone number of the contact person.

More importantly, information on the technical energy efficiency level (EEDI or EIV values) was missing for around 13% of the fleet. Confusion surrounding the mandatory nature of these indicators is likely to be the cause of these omissions.

Failure to report other types of missing information such as gross tonnage (1.3% of all ships) or the monitoring method (around 6.9% of the fleet) can be considered the result of negligence.

The data is generally sound. However, some irregularities were observed, including problems with the breakdown of CO_2 emissions in terms of patterns of voyages. This concerns emissions of CO_2 related to incoming voyages, outgoing voyages, intra-EEA voyages or emissions at berth. A number of encoding errors and the use of wrong units also resulted in some unrealistic values. Most of them were corrected in THETIS-MRV shortly after the first publication of data. Other quality issues concerned for instance the reporting of inconsistent time at sea or the reporting of unrealistic fuel measurement uncertainty levels (0.8% of all reported values).

Completeness of the ship coverage in THETIS-MRV

In order to identify possible ships missing in THETIS-MRV, a comparison was made with the port call information from the main THETIS system supporting port State control inspections.

This system provides information on all ships calling at ports in the EEA, but it does not contain information about the purpose of these calls.

The comparison found that 1323 ships made port calls in the EEA in 2018, but were missing in THETIS-MRV. In addition, 741 ships registered in THETIS-MRV called at a port in the EEA in 2018 but had not produced an emission report at the time of this analysis.

However, these ships might have called in at EEA ports for activities unrelated to the transport of goods and passengers. Such activities include repairs, ship maintenance and bunkering. In addition, it is worth noting that two-thirds of these ships have made less than five port calls in the EEA in 2018. In total, these ships only account for around 6.5% of the total number of port calls declared in the main THETIS system.

Lessons learned

Based on the first year of reporting, it is possible to provide a number of recommendations to improve the MRV system for the next reporting periods:

1. The level of coordination and cooperation between national accreditation bodies, verifiers, companies, port States, flag States and the Commission could be improved in order to facilitate the implementation of the Regulation;
2. The THETIS-MRV software could be updated to include warning and error messages when companies are entering seemingly incorrect or incomplete data;
3. The Frequently Asked Questions and the THETIS-MRV online tutorials could be updated to avoid misunderstanding and misreporting.

3. The monitored fleet at a glance

Introduction

More than 11,600 ships have taken part in this first monitoring exercise. These ships represent about 38% of the world merchant ships above 5,000 gross tonnage (GT).

This section looks at the characteristics of these ships. The primary purpose is to understand the key features that directly influence their CO_2 emissions, such as their type, size, age, fuel, and engines. The ship types are presented in line with the IHS *statcode5*, and this report works with the same level of aggregation as that used in the third IMO GHG Study. A second objective is to understand to which extent these ships compare to the world fleet (using a representative sample in terms of type and size).

Figure 9: Visualisation of the main ship types in the monitored fleet

3.1 Fleet structure

Distribution per ship type

The monitored fleet has a total carrying capacity of about 650 million deadweight tonnage (DWT). Five types of ship represent more than 80% of the fleet.

Bulk carriers designed to transport unpackaged dry bulk cargo, such as grains and cement, are the most common ship type within the monitored fleet. They represent 32% of all monitored ships, and 37% of the total fleet deadweight tonnage. For comparison, bulk carriers are even more predominant in the world fleet, representing 45% of the global fleet (over 5,000 GT) in DWT in 2018. Their importance in the EU MRV database reflects the high amount of bulk cargo handled in EEA ports. According to Eurostat, around 60% of seaborne freight in the EU consisted of liquid and dry bulk goods in 2017.[26] Their average capacity is around 69,000 DWT.

Oil tankers represent 12% of the monitored ships but 26% of the monitored fleet in terms of deadweight tonnage. The share of oil tankers in the EU MRV database is comparable to that observed at the global level. The high number of tankers involved in voyages in the EEA reflects the large volume of crude oil being transported by ships in Europe (e.g. to refineries). Oil tankers are also the ship type with the highest carrying capacity, with an average capacity over 122,000 DWT.

Container ships represent around 15% of the monitored ships and 18% of the monitored carrying capacity (DWT). This is more than in the world fleet, where container ships represent only 14% of the total world deadweight tonnage over 5,000 GT. The higher share of container ships in the EU MRV database can be explained by the high integration of the European Economic Area (EEA) into the existing global liner-shipping network, providing good accessibility to global trade. Container ships have an average carrying capacity of around 72,000 DWT.

Chemical tankers are adapted and used for the carriage of liquid chemicals in bulk. They represent an important part (15%) of the monitored fleet and 9% of monitored carrying capacity. This is more than in the world fleet, where chemical tankers represent only 6% of global fleet capacity (DWT).

General cargo ships are multipurpose vessels designed for flexibility. They can carry a large variety of cargo, and are usually outfitted with cranes. The use of general cargo ships has decreased over time. Nonetheless, these ships still constitute 10% of the monitored ships and around 4% of the monitored carrying capacity, which is comparable to their share in the global fleet.

Other ship types including vehicle carriers, LNG carriers, passenger ships, ro-ro (roll-on/roll-off ferries carrying cars and other wheeled cargo) and ro-pax ships (roll-on/roll-off passenger vessels), gas carriers and refrigerated cargo carriers represent around 16% of the monitored fleet.

Figure 10: Distribution of number of ships by ship type in the monitored and world fleets (over 5,000 GT)

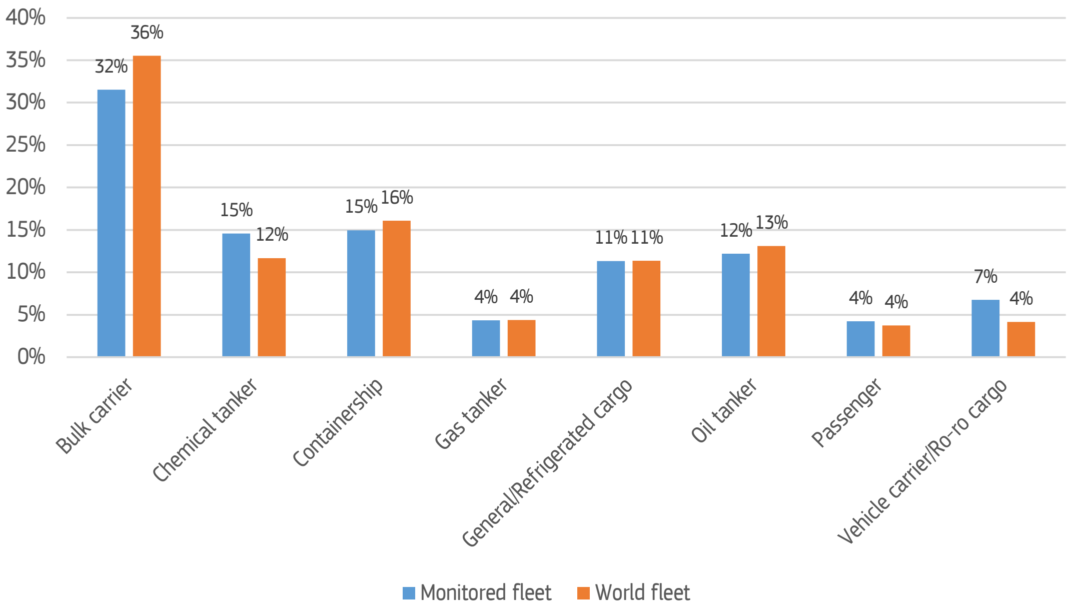


Figure 11: Distribution of carrying capacity (in DWT) by ship type in the monitored and world fleets (over 5,000 GT)

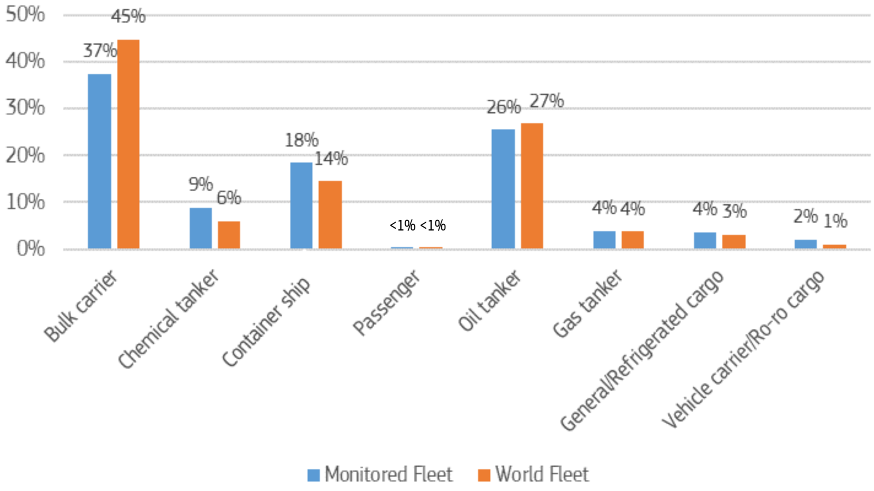
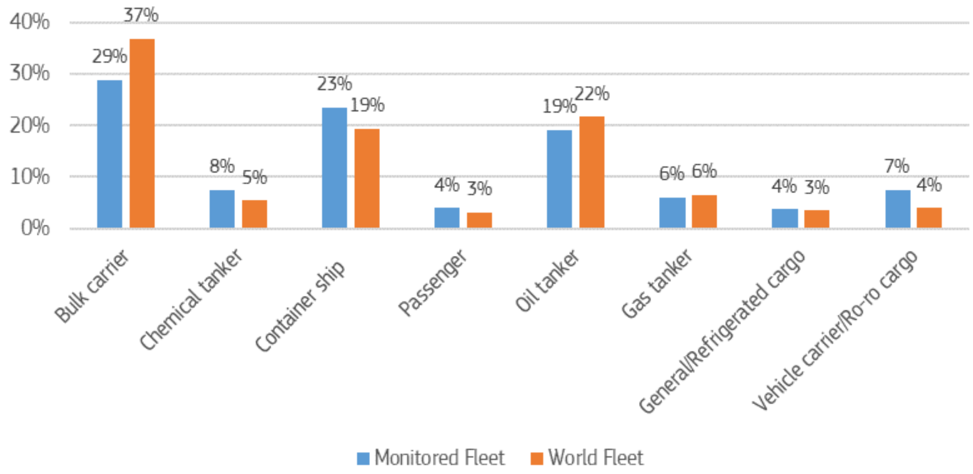


Figure 12: Gross tonnage distribution by ship type in the monitored and world fleets (over 5,000 GT)



Source: The figures above are based on EMSA elaborations using the THETIS-MRV database (Data extracted on 23 September 2019) and data from the MARINFO database (sourced by IHS Markit). Notes: 13 ships were not included in the statcode5 mapping used for this work.

Fleet ownership distribution

More than half of the monitored fleet (in terms of gross tonnage) is owned by entities based in the EU. These owners are not necessarily the MRV companies or the ones operating the ships. Greek companies own the largest share of the monitored fleet in terms of gross tonnage (20%), followed by companies from Japan (9%), Germany (8%) and Singapore (7%). Owners from Norway, Denmark and China each represent 5% of all monitored ships.

Looking at the two largest EU owners, Greek companies predominantly own bulk carriers (more than 50%) and oil tankers (around 25%). In contrast, German companies mostly own container ships and general cargo ships.

For comparison, EU companies own a significant smaller share of the world fleet with 39% of the total gross tonnage, while owners from countries such as China, Singapore or Japan have significant shares. However, EU companies still own the largest single share of the world fleet. Greek owners represent 16% of the world fleet, meaning that a significant share of their ships is not included in the monitored fleet.

Figure 13: Monitored fleet – Ownership distribution in terms of gross tonnage (GT)

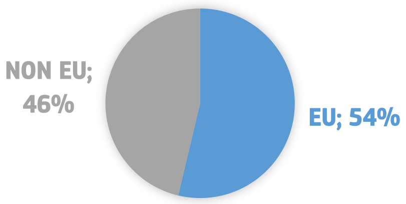
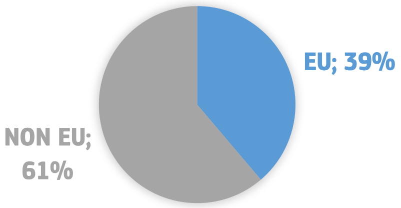
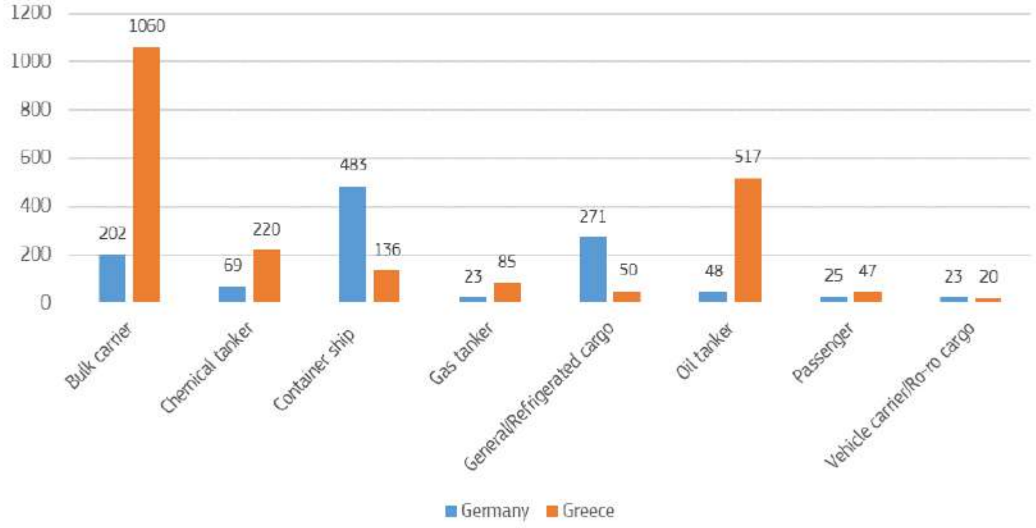


Figure 14: World fleet – Ownership distribution in terms of gross tonnage (GT)



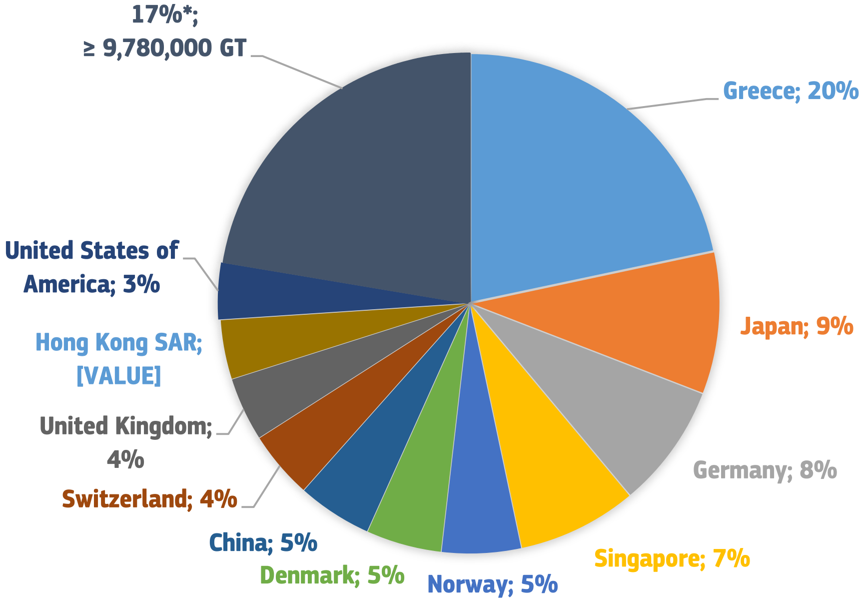
Source: EMSA elaborations based on IHS MARKIT database.

Figure 15: Number of ships owned* by German and Greek companies by ship type in the monitored fleet



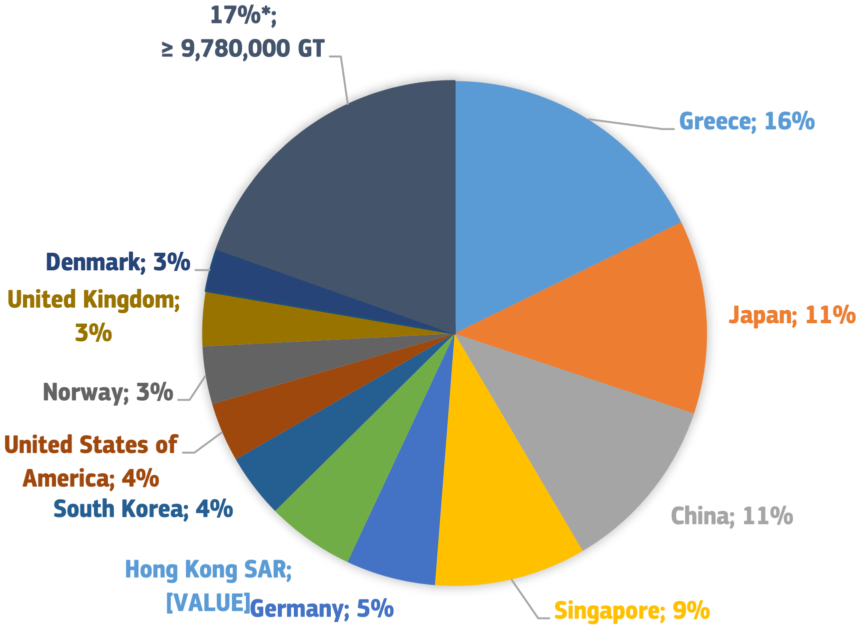
Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).
Notes: *Ownership refers to IHS Registered Owner.

Figure 16: Monitored fleet – Breakdown of ownership distribution in terms of gross tonnage



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).
Notes: *Includes (in order of magnitude): Italy (2%), United Arab Emirates (2%), South Korea (2%), Monaco (2%), the Netherlands (2%), France (2%), Turkey (2%), Belgium (1%), Cyprus (1%), Bermuda (1%), Canada (1%), Sweden (1%), Isle of Man (1%), Spain (1%).

Figure 17: World fleet – Breakdown of ownership distribution in terms of gross tonnage



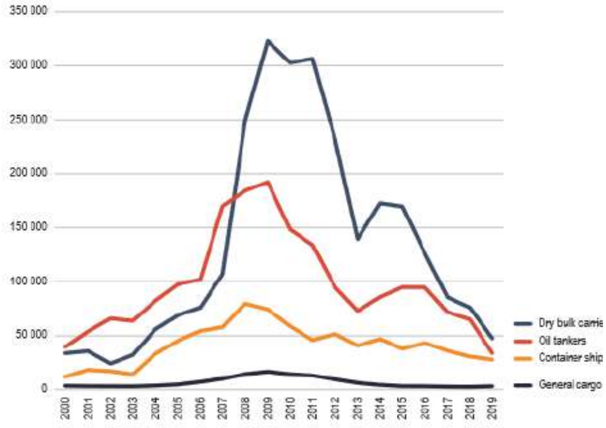
Source: EMSA elaborations based on IHS MARKIT database.
Notes: *Includes (in order of magnitude): Switzerland (2%), United Arab Emirates (2%), Belgium (1%), Monaco (1%), Italy (1%), Turkey (1%), Cyprus (1%), Bermuda (1%), Netherlands (1%), India (1%), Indonesia (1%), Canada (1%), Saudi Arabia (1%), Iran (1%), Malaysia (1%).

Fleet age distribution

The age of ships is an important factor, since younger vessels tend to be more energy efficient.

On average, ships in the monitored fleet are 11 years old. However, this figure conceals important disparities among ship types. While chemical tankers, oil tankers, LNG carriers, bulk carriers and gas carriers have an average age ranging between 8 and 10 years, other ship categories such as passenger ships and ro-pax are generally much older (average of 17 to 20 years old). Retrofitting programmes intended to prolong the service life of passenger ships could help explain their longevity. The high number of 8-10 year old bulk carriers and oil tankers reflects the many orders for new-builds placed in the period 2006-2013 at the world level (see Figure 18 below).

Figure 18: World tonnage on order 2000-2019 (in thousand deadweight tonnage and by year of manufacturing)



Source: UNCTAD secretariat calculations, based on data from Clarksons Research.
Notes: Propelled seagoing merchant vessels of 100 gross tons and above; beginning-of-year fgures.

Source: UNCTAD (2019). Review of Maritime Transport[27]

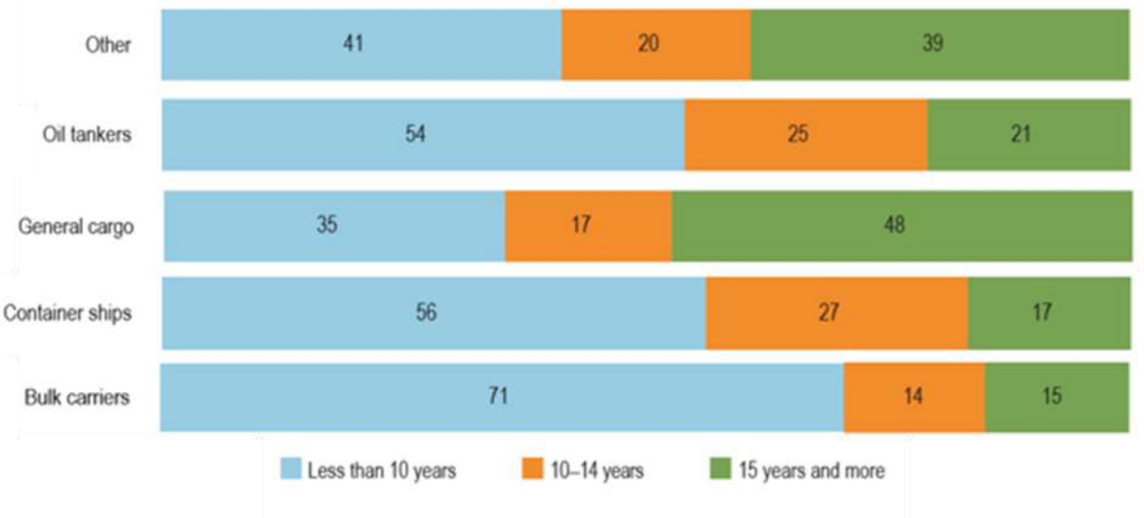
At the global level, the average age of merchant ships was 20.5 years in 2018. However, just as in the EU MRV database, the average age conceals large age differences between ship types. A high proportion of the carrying capacity of bulk carriers, container ships and oil tankers vessels are younger than 10 years of age. This is in line with the findings from the EU MRV database.

Figure 19 and Figure 20 illustrate the similarities and differences between the monitored fleet and the world fleet in terms of age.

Generally, 27% of both fleets consist of ships that are younger than five years.

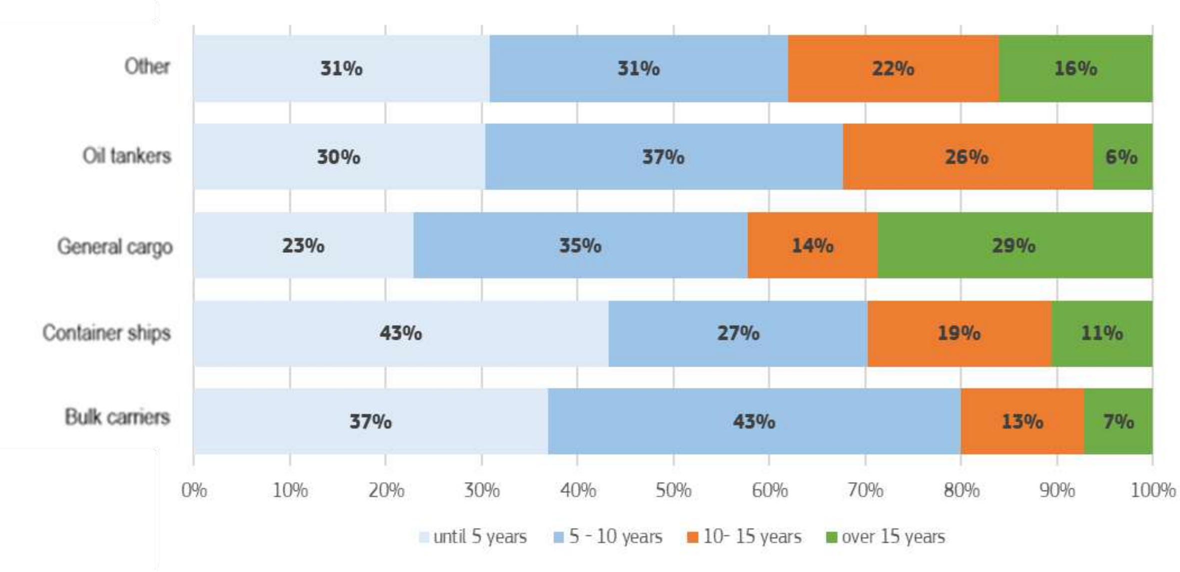
Similarly, the share of ships between 5-10 years old is largely the same for both fleets (35% of the monitored fleet, 33% of the world fleet). This means that the difference in average age can be explained by the larger share of ships older than 15 years in the world fleet. This share is especially significant for general cargo vessels and oil tankers in the world fleet.

Figure 19: World fleet – age distribution by ship type and age group



Source: UNCTAD secretariat calculations, based on data from Clarksons Research.

Figure 20: Monitored fleet – age distribution by ship type and age group



Source: EMSA elaborations based on THETIS-MRV and MARINFO database (sourced by IHS Markit & Trade) – data extracted on 23 September 2019.

Ice class

To ensure a level-playing field for ships operating in less favourable climate conditions, companies can voluntarily report the ice class of their ship under the EU MRV system. Around 16% of all ships in the monitored fleet have provided this information, in particular general cargo ships. More than half of these ships have ice class IA, which means that they are capable of navigating in difficult ice conditions, with the assistance of icebreakers when necessary.

3.2 Emission sources

Engines on board ships are amongst the largest types of engines in the world, and their size and characteristics directly influence fuel consumption and CO_2 emissions. Ships typically contain several engines for different purposes. The main engine turns the ship's propeller and move the ship through the water, whilst auxiliary engines aim at powering the ship's electrical systems, and a number of other machinery items providing additional essential services such as gas insertion, heat and steam production, and incineration.

In their emission reports, companies have reported more than 180,000 sources of emissions on board their ships, including:

- main engines (20%);
- auxiliary engines (50%);
- boilers (20%);
- insert gas generators (2%).

While CO_2 emissions are monitored for each type of fuel consumed, they are not reported per source of emissions.

Container ships have the highest average main engine rating power with 32,439 kW, followed by passenger and ro-pax (roll-on/roll-off passenger) ships. On the contrary, the main engines of oil tankers and bulk carriers are much smaller with an average power of 12,640 kW and 8,771 kW respectively.

The design and operation of container ships explains why they have, in general, more powerful engines compared to bulkers. For instance, they operate at much higher speeds (40% faster compared to bulkers) in line with the specific business model and standards associated with the container industry.

4. The monitored voyages at a glance

Introduction

This section relies on data from THETIS-MRV and IHS (Information Handling Services Markit) to better understand the characteristics of the voyages monitored under the EU MRV system. In addition, a preliminary analysis has been carried out based on Automatic Identification System (AIS) data provided by EMSA. The AIS system provides detailed positioning data on the geographical location of ships over time. Positioning data have been analysed for around 80% of the ships in the monitored fleet.

4.1 Number and types of voyages

Share of voyages covered in the EU MRV system

In 2018, the monitored fleet tracked with positioning data has performed more than 400,000 voyages, including 65% of EEA-related voyages (See Figure 21).

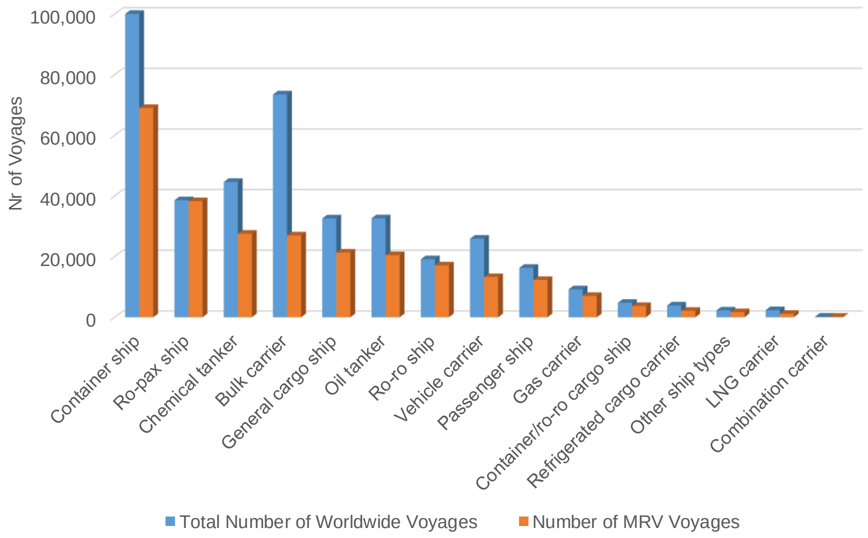
This preliminary AIS analysis shows that container ships carried out the highest number of voyages of all ship types. Around 100,000 MRV voyages were undertaken in 2018, of which two-thirds were reported under the EU MRV system.

Chemical tankers, oil tankers, and general cargo ships had a similar share of EEA related voyages during the first reporting period.

The EU MRV system covers the vast majority of voyages and emissions made by ro-pax (roll-on/roll-off passenger), ro-ro (roll-on/roll-off) and passenger ships, since these ship types often operate on fixed, short-distance itineraries within the EEA.

In contrast, bulk carriers saw most of their 2018 voyages falling outside the scope of the EU MRV system.

Figure 21: Monitored fleet – Total number of voyages vs voyages covered in the MRV (2018)



Source: RINA elaboration on the bases of THETIS-MRV and AIS database (Data extracted on September 23, 2019).
Notes: The figure is based on data from 9,924 ships, as voyages of ships in the THETIS-MRV database have been tracked, for the year 2018, on AIS database.

Distribution of number of EU MRV voyages

Based on the preliminary AIS analysis, Figure 22 illustrates the different types of voyages included in the EU MRV system. It only looks at the number of voyages, independently from their length or related emissions. The figure shows that three-quarters of the monitored voyages took place between ports in the European Economic Area (EEA) while the rest (25%) involved a port call outside the EEA. This means that a significant share of the monitoring and reporting activities required under the EU MRV Regulation originate from intra-EEA voyages.

The distribution of voyages varies between ship types.

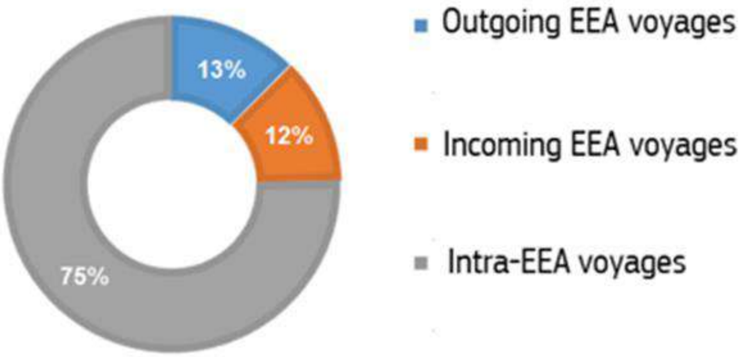
Average number of reported voyages per ship type

The subset of AIS data shows that on average, an emission report is made up of around 130 voyages. However, this number varies significantly between ship types. As expected, ro-pax (roll-on/roll-off passenger) ships undertake the highest number of voyages out of all ship types, performing more than 390 voyages per ship annually.

On the contrary, bulk carriers and oil tankers have monitored fewer voyages that fall within the scope of the EU MRV Regulation, undertaking an average of around 40 voyages annually.

Container ships have performed around 100 MRV voyages on average.

Figure 22: Distribution of number of voyages covered in the EU MRV system per type



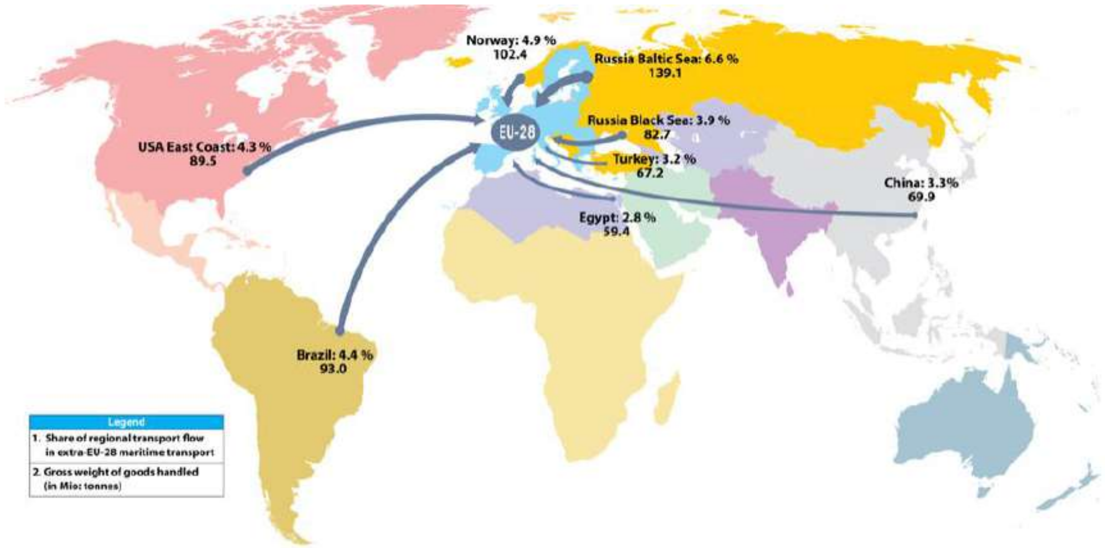
Source: RINA elaboration on the basis of THETIS-MRV and AIS database (Data extracted on September 23, 2019). Note: The figure is based on data from 9,924 ships, as voyages of ships in the THETIS-MRV database have been tracked, for the year 2018, on AIS database.

Main shipping routes

In general, the preliminary AIS analysis on sea routes tends to largely be in line with existing statistics. According to Eurostat (see Figure 23), the EU's top eight maritime flows of goods in 2017 consisted of inward flows coming from the Baltic Sea area of Russia (6.6% of total EU seaborne transport), Norway (4.9%), Brazil (4.4%), the East Coast of the USA (4.3%), the Black Sea area of Russia (3.9%), China (3.3%), Turkey (3.2%) and Egypt (2.8%).

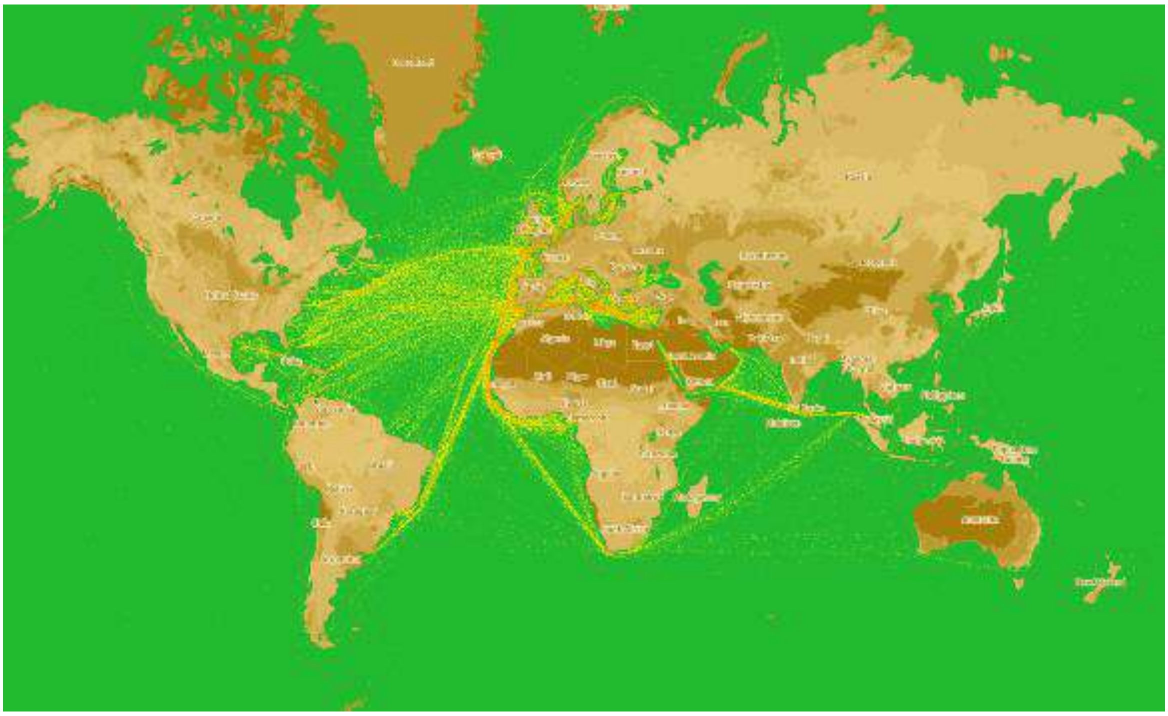
When looking at the most frequent departing ports outside the EEA included in MRV voyages, the preliminary AIS analysis highlights the importance of ports such as Tanger-Med in Morocco, the port of Singapore, and ports in Turkey, which are likely to represent intermediate port of calls. In general, transshipments and multiple voyage legs seem to be the main reason why Chinese or Russian ports are not more visible in this analysis.

Figure 23: Main extra-EU-28 maritime transport flows by gross weight of freight handled, 2017



Source: Eurostat (2019b) - Maritime transport - Goods (mar_go).[28]

Figure 24: Visualisation of routes used by the monitored fleet



Source: RINA elaboration on the basis of THETIS-MRV and AIS data covering 80% of the monitored fleet (Data extracted on 23 September 2019). Notes: Routes with a higher intensity in terms of voyages undertaken in 2018 are shown in orange.

4.2 Fleet speed

Speed is a key operational indicator, as it has a direct effect on the fuel consumption and CO_2 emissions. The relationship between speed and emissions is typically an exponential one. A speed reduction of 10% can lead to a reduction of CO_2 emission of around 20%.

Following this principle, a number of ship operators have adopted slow steaming approaches in the last decade in order to reduce their operational costs, increase their profit, and optimise the utilisation of their fleet. Research suggests that under certain conditions, speed reduction strategies can save energy and fuel across the fleet even when additional ships are needed to maintain service.

Speed is a parameter that is difficult to compare between different ship types as it reflects different ship designs and business models. However, speed evolution over time is an important indicator to explain variation in the operational energy efficiency of ships.

In that context, information on speed from THETIS-MRV (derived from distance travelled and time spent at sea) has been compared with observed speed data from 2008, as documented in the third International Maritime Organization greenhouse gas study (IMO 3rd GHG study).

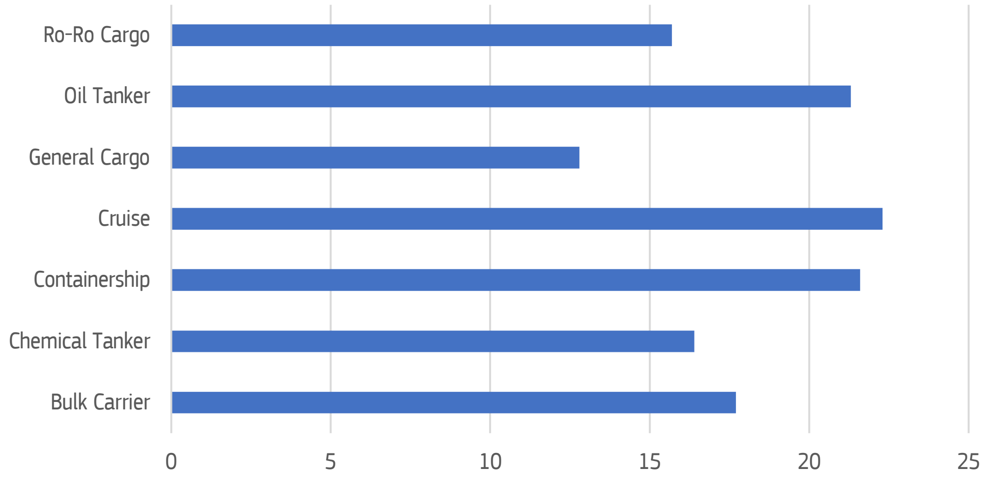
This comparison exercise shows that the monitored fleet has seen an average speed reduction of around 18% over the last decade (see Figure 25).

Container ships have experienced a significant reduction in speed, which is comparable to that of cruise ships. Notably, container ships saw a decrease in speed of over 20% for several ship sizes, except for the container ships above 12,000 GT that have reduced their speed by 14%.

Bulkers and oil tankers have also achieved high speed reduction rates in the last decade. While the most representative size of bulk carriers have reduced their speed by around 17%, a significant number of oil tankers have reduced their speed by around 27%.

Speed reduction is nevertheless less significant for general cargo, and speed is even increasing for refrigerated cargo in the period 2008-2018.

Figure 25: Weighted average speed reduction in the monitored fleet 2008-2018 (%)



Source: Elaborations based on THETIS-MRV (Data extracted on 23 September 2019) and the 3rd IMO GHG Study.
Notes: Averages are based on the speed reduction for each ship type, weighted for different size segments. Ship categories selected on basis of data availability.

4.3 Time spent at sea and distance travelled

Different ship types are at sea for varying amounts of time.

In total, bulk carriers spent the longest total time at sea with over five million hours during the first reporting year. However, bulk carriers have reported less than 2,000 hours on average, reflecting the high share of their total voyages that falls outside the scope of the Regulation.

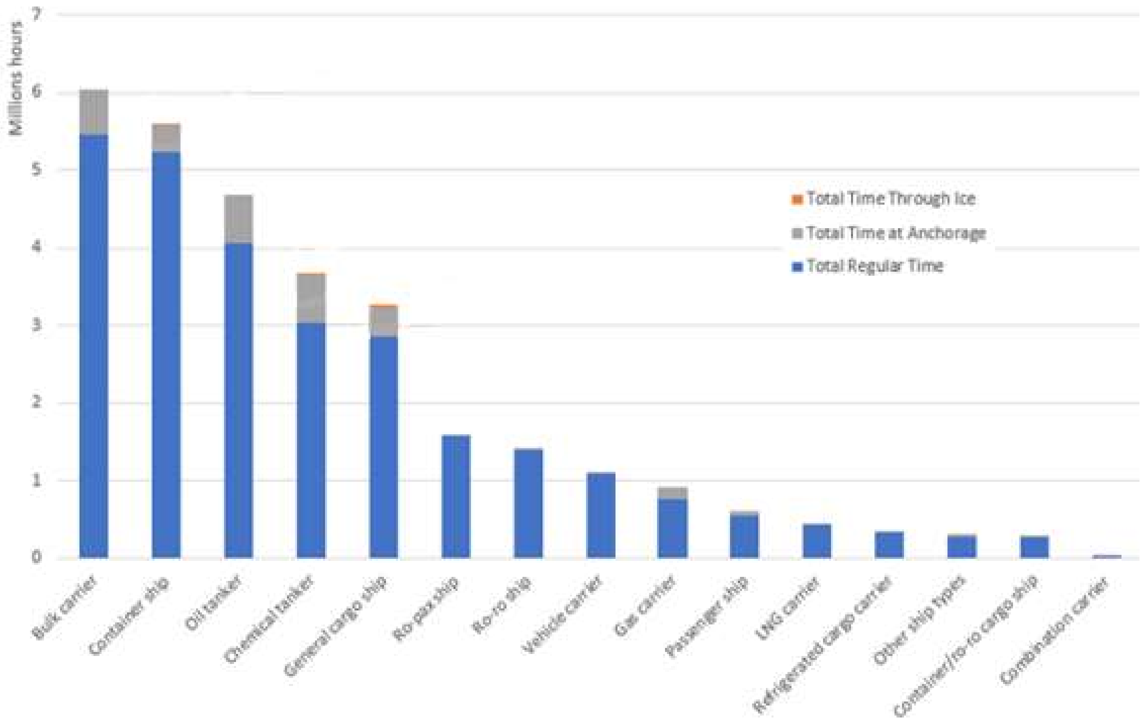
In comparison, ro-ro (roll-on/roll-off) ships spent a total of around 1.5 million hours at sea during the first reporting period, but reported the longest average time at sea per ship, at over 5,000 hours. This can be explained by the fact that most of their voyages take place within the EEA, and are therefore reported in the EU MRV system.

Out of the total time spent at sea, some ship types spent significant time at anchorage. Time at anchorage refers to the time when a ship is anchored in designated areas. It is reported on a voluntary basis.

Notably, bulk carriers spent over half a million hours at anchorage, as did oil tankers and chemical tankers. In contrast, ro-pax (roll-on/roll-off passenger), ro-ro and passenger ships have reported very little time at anchorage.

The figure below shows these trends.

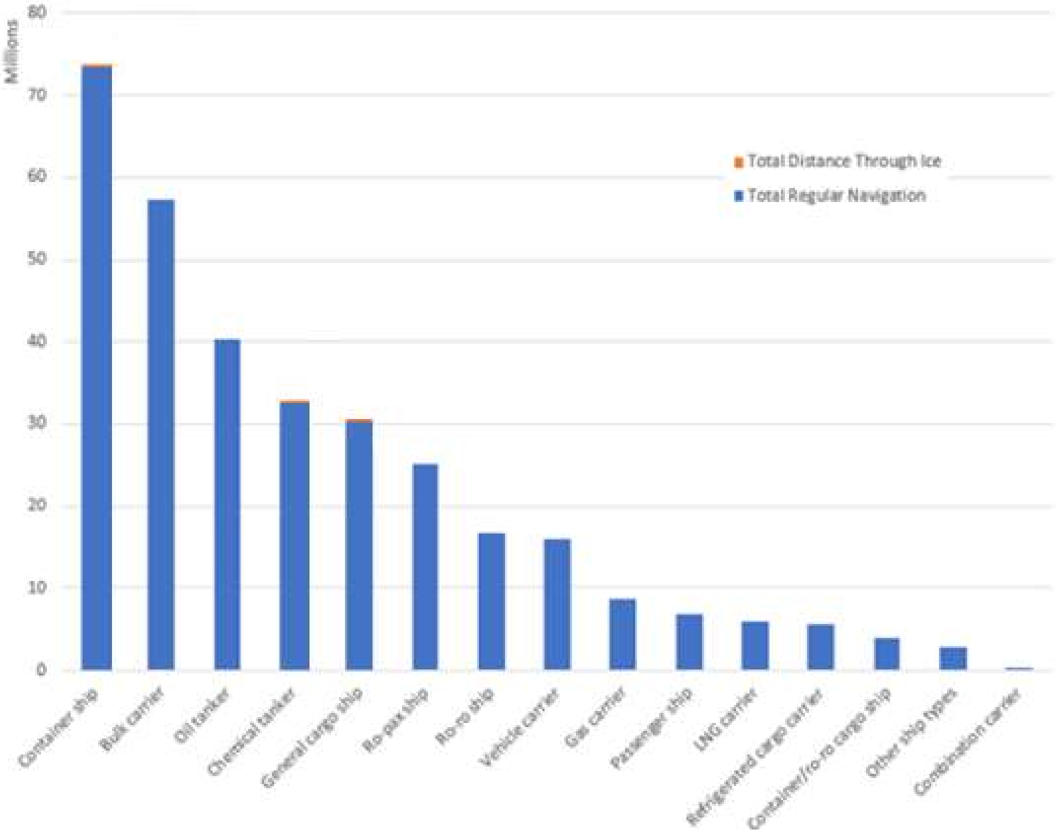
Figure 26: Total time spent at sea for EEA-related activities



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).

In terms of distance travelled, container ships have travelled the longest total distance with more than 70 million nautical miles reported in the EU MRV system. Due to their lower speed, bulk carriers have travelled a shorter distance (around 55 million nm) despite having spent more time at sea. Taken together, oil tankers, chemical tankers and general cargo ships have reported around a third of the total distance travelled reported in the EU MRV system.

Figure 27: Total distance travelled per ship type for EEA-related activities



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).

5. Fuel consumption and CO_2 emissions from the monitored fleet

5.1 Fuel consumption

A closer look at total fuel consumption

Fuel consumption is directly linked to CO_2 emissions and is one of the key indicators reported under the EU MRV regulation.

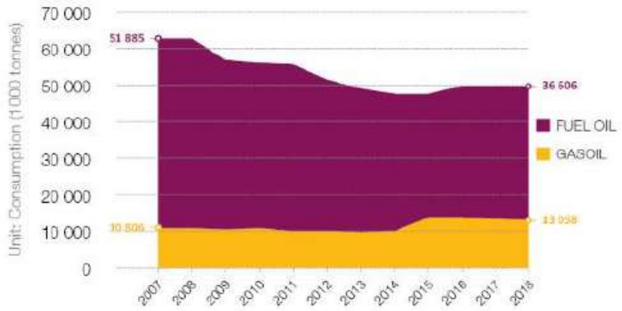
In total, the monitored fleet consumed more than 44 million tonnes of fuel in 2018. In comparison, the EU total oil demand amounted to 635.8 million tonnes in 2018.[29]

In absolute terms, container ships consumed the most fuel at 14 million tonnes, followed by bulkers and oil tankers at around 5.6 million tonnes each. Taken together, these three ship types represent close to 60% of all the fuel consumption reported in the EU MRV system.

Fuel consumption varies. It should be noted that container ships reported more than twice the fuel consumption than that declared by bulk carriers, despite having spent slightly less time at sea in total, and in spite of only travelling 28% greater distance. The design and operation of container ships explains this higher fuel consumption. Container ships generally have more powerful engines compared to bulkers (more than three times higher on average), and they operate at much higher speeds (40% faster compared to bulkers). The lower amount of fuel consumed by bulkers can mostly be explained by their low cruising speed.

The total amount of fuel consumption reported in THETIS-MRV represents around 90% of the marine fuel sold in the EU (see Figure 28). Although quite similar, these two quantities are difficult to compare since marine fuel sold in Europe might be used for voyages outside the scope of the EU MRV Regulation, and in the same way, fuel consumption reported in THETIS-MRV is likely to cover marine fuel purchased in another part of the world. Additionally, the fuel consumed by ships below 5,000 gross tonnage is not reported in THETIS-MRV. This has previously been estimated at around 10% of the consumption of larger ships.[30]

Figure 28: Marine fuel demand in the EU



Source: Wood Mackenzie.[31]

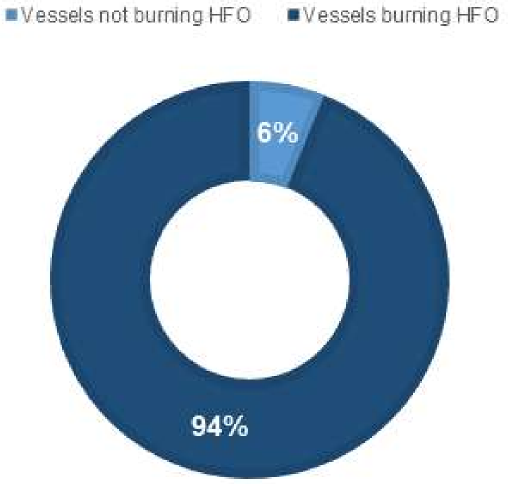
Use of different types of fuel

A little more than 70% of the fuel consumed by the monitored fleet in 2018 was heavy fuel oil (HFO). HFO is a category of fuel oil also known as bunker fuel or residual fuel oil. HFO is the result of, or remnant from, the distillation and cracking process of crude oil. This makes HFO a significant pollutant when compared to other fuel oils. HFO is predominantly used as a fuel source for marine vessel propulsion due to its relatively low cost. More than 90% of all monitored ships reported the use of HFO in 2018.

Gas oil accounted for only 10% of the total fuel consumed, such as light fuel oil and diesel oil taken together. These types of oil are generally used for auxiliary engines and boilers, or during the operation of a ship in Emission Control Areas (ECA).

The use of Liquefied Natural Gas (LNG) represented only 3% of the total amount of fuel consumed in 2018. It was mostly used by LNG and gas carriers. It should be noted that the use of LNG as a maritime fuel has been increasing over the past years notably due to stricter regulations on emissions. While the use of LNG significantly reduces emissions of SO_x and NO_x, its climate impact is negatively affected by the emissions of unburnt methane (e.g. “methane slip”).

Figure 29: Use of HFO by the monitored fleet



Source: RINA elaborations on the basis of the THETIS-MRV database (Data extracted on 23 September 2019).

5.2 Shipping CO_2 emissions

In total, the monitored fleet emitted more than 138 million tonnes of CO_2 emissions in 2018. These emissions originated from 11,653 ships that burned fossil fuels to perform over 400,000 voyages, travelled 323 million nautical miles (1,500 times the distance between the Earth and the Moon), and transported the vast majority of EU's external freight trade.

CO_2 emissions in the EU MRV system are estimated based on fuel consumption at individual ship level and based on specific emission factors defined for every fuel type. The monitoring of CO_2 emissions at such a level of detail is a first for the shipping sector.

138 million tonnes of CO_2 put into perspective

These CO_2 emissions represent over 3.7% of all CO_2 emissions reported by the European Union in 2017 (including international aviation).[32] In absolute terms, they are comparable to the CO_2 emissions from an EU Member State such as Belgium. In other words, if these emissions were emitted by a single EU Member State, it would be the eight largest emitter of carbon dioxide in Europe.

When compared to other modes of transport, 138 million tonnes of CO_2 corresponds to around 80% of the emissions generated by aviation (full-flight emissions of all flights departing from EU28 and EFTA airports)[33], or 16% of the CO_2 emissions released by road-transport.

At the global level, CO_2 emissions reported in the EU MRV system represent around 15% of the total CO_2 emissions emitted by international and domestic shipping, estimated at around 890 million tonnes of CO_2 in 2015.[34] At the same time, 17% of the world seaborne exports and 20% of the world seaborne imports took place in the EU.

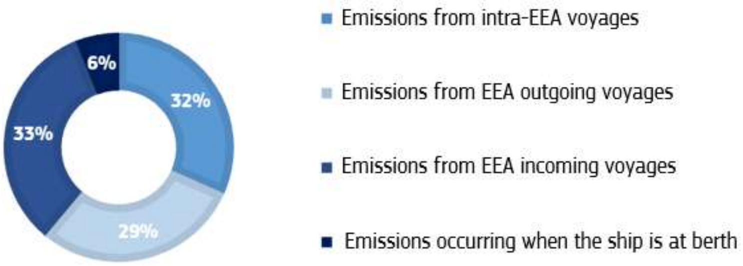
CO_2 emissions per type of voyage

Around two-thirds of the CO_2 emissions reported by the monitored fleet comes from voyages to or from a port outside the European Economic Area. These incoming or outgoing voyages are therefore responsible for the majority of CO_2 emissions. This is consistent with maritime port freight statistics, which indicate that most EU maritime freight transport (62% of goods) involves partners outside the EU.[35]

Looking in more detail, there are slightly more CO_2 emissions coming from incoming international voyages than emissions from outgoing voyages. This is in line with the pattern of the movement of goods in EU ports, where around 60% of goods are unloaded and 40% loaded. Liquid bulk goods, such as crude oil and oil products, make up a substantial proportion of the inward tonnage.

Voyages between ports in the EEA are responsible for around a third of the reported CO_2 emissions (32%), which equals around 44 million tonnes of CO_2 emissions. This is broadly consistent with the most recent port statistics (2017) where cross-border transport between EU ports represented 25% of all maritime transport activities and where voyages between national ports made up to 9% of the same total.

Figure 30: CO_2 emissions from different types of voyages



Source: RINA elaborations based on the THETIS-MRV database (Data extracted on 23 September 2019).
Note: CO_2 emissions at berth are those produced by vessels when moored in port.

Ships are also emitting CO_2 emissions when they are securely moored in port, as most ships produce their own electricity on-board to provide services for passengers and crew such as air conditioning, to refrigerate perishable goods, or to operate machinery to load or unload cargo. According to the EU MRV system, these emissions at ports represent around 6% of all reported CO_2 emissions, and around 8 million tonnes of CO_2 emissions in absolute terms, which is comparable to the CO_2 emissions from Cyprus.

CO_2 emissions per ship type

Ship types emitting the most CO_2 emissions are equally the biggest consumers of fuel.

As illustrated in Figure 31, container ships represented the largest share of total emissions in 2018, with over 30%. In absolute terms, these ships reported more than 44 million tonnes of CO_2, which is comparable to the CO_2 emissions of Ireland or Sweden. This pollution originated from only 1,742 ships that together reported over 5 million hours of time spent at sea.

Bulk carriers that represent 37% of the monitored fleet (in cargo carrying capacity) emitted approximately 13% of all reported CO_2 emissions (17.5 million tonnes).

Taken together, the CO_2 emissions from oil tankers and chemical tankers amount to around 20% of all CO_2 emissions, whereas they transport more than a third of the cargo handled in the main EU ports.

Ro-ro (roll-on/roll-off) and ro-pax (roll-on/roll-off passenger) reported around 20 million tonnes of CO_2. These emissions are primarily related to domestic or intra-EU ferry services concentrated in the Baltics, the North Sea and the Mediterranean. It is estimated that over 415 million passengers embark and disembark in EU ports every year.[36]

CO_2 emissions per ship age

About 74% of total CO_2 emissions are produced by vessels built before 2013. Out of the entire monitored fleet, 8,840 ships fall into this category. Older vessels have the highest average level of CO_2 emissions per vessel, while younger ships constructed after 2013 emit less on average.

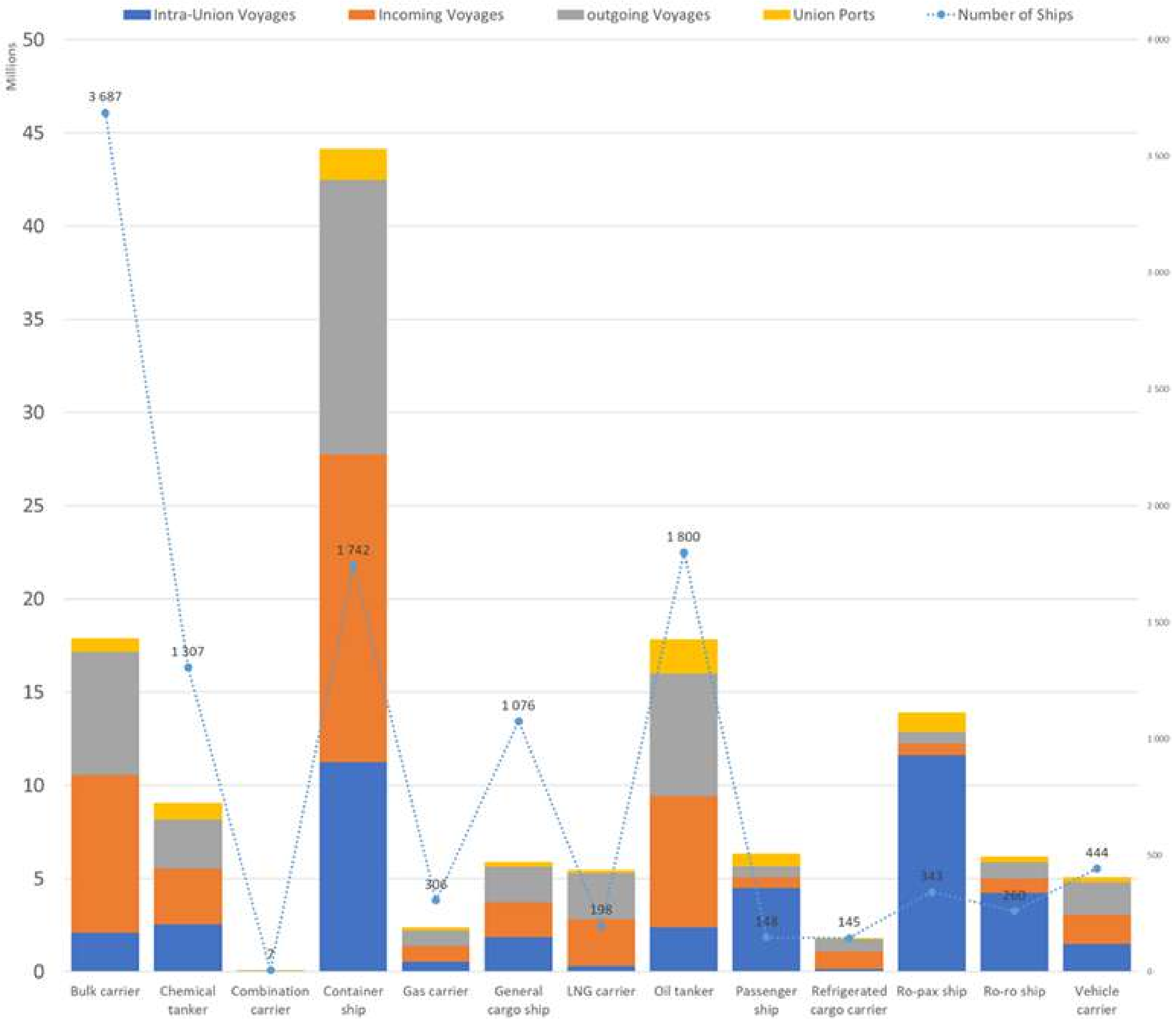
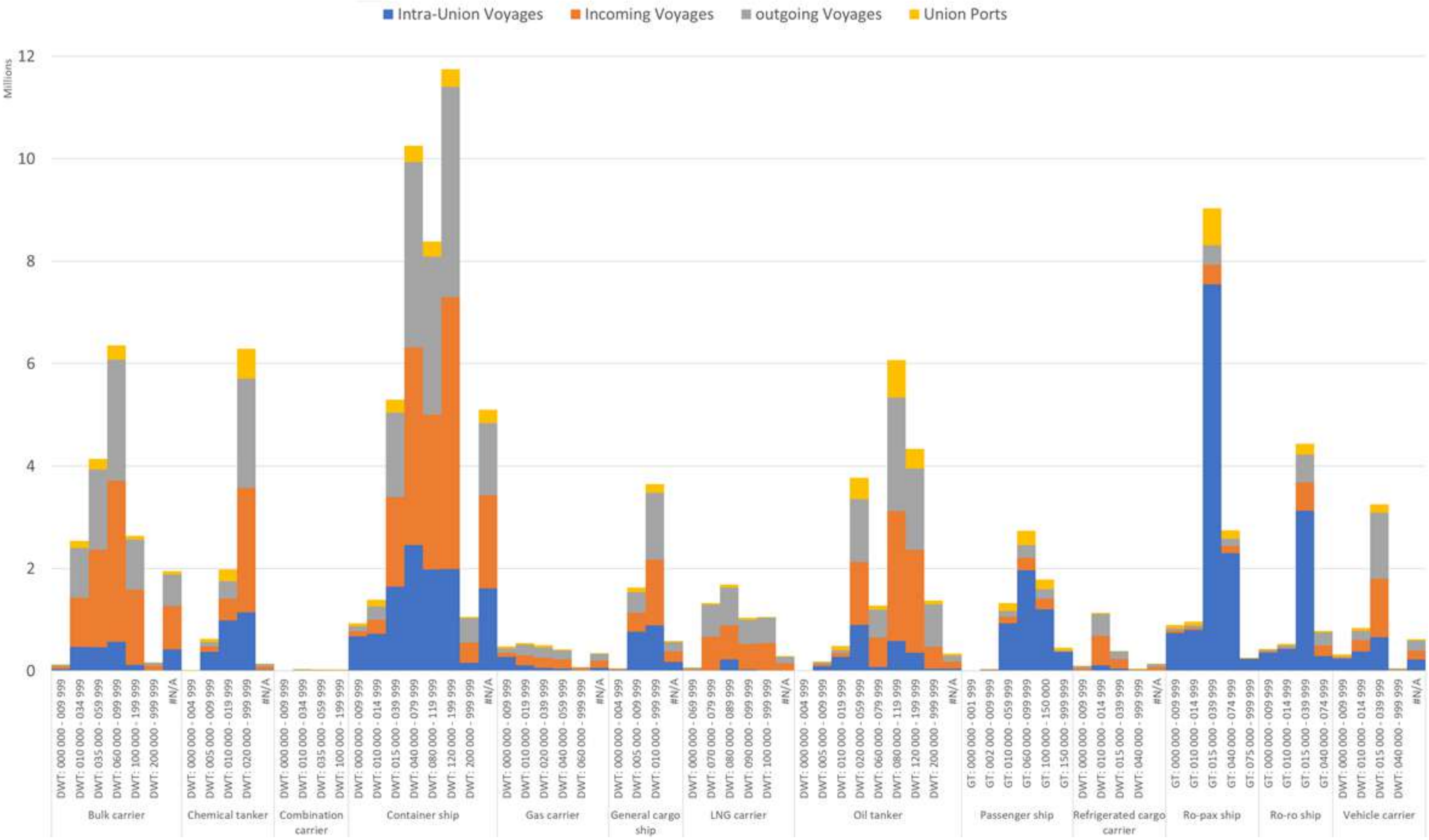


Figure 31: Total CO_2 emissions from different ship types and number of ships

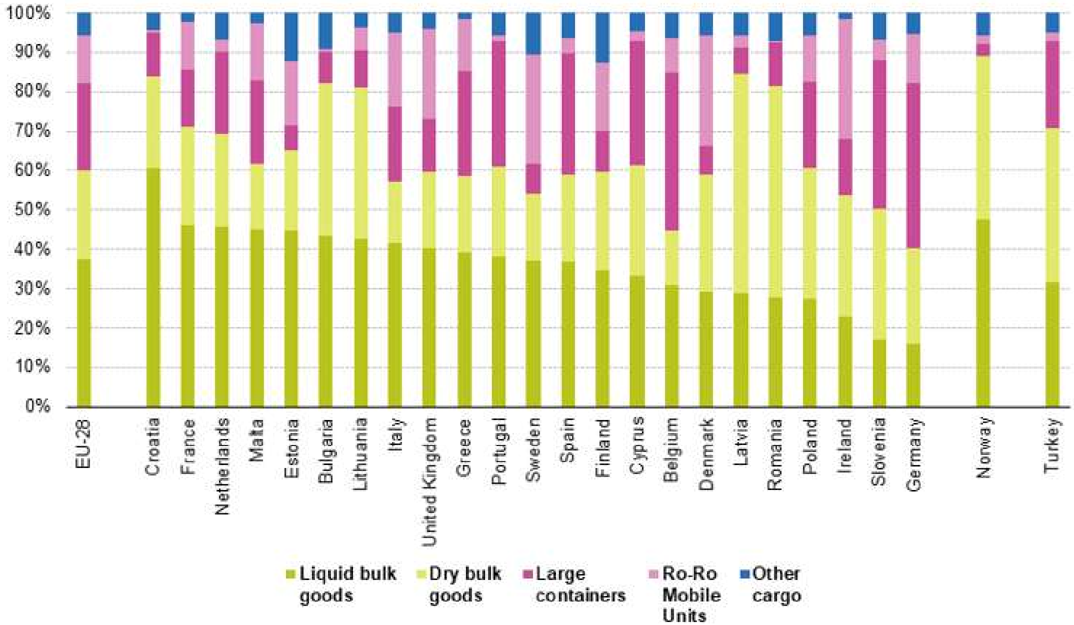
Source: Based on EMSA elaborations on data from THETIS-MRV (Data extracted on 23 September 2019).

Figure 32: CO$_2$ emissions per ship type and type of voyage



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019 without one outlier). Notes: Due to unavailability of information on sizes for ships of the types "Other ship types" and "Container/ro-ro cargo ship", Emission reports for these ships were not included. (189 ERs, 1.6 % of all the 2018 ERs). Due to missing reporting on deadweight values, some emission reports were aggregated as N/A. (933 ERs, 8.0 % of all the 2018 ERs).

Figure 33: Gross weight of seaborne freight handled in main ports by type of cargo, 2017



Source: Eurostat. Online data code: mar_mg_aa_ohwd, Notes: Percentage share based on tonnes.[37].

6. The technical and operational energy efficiency of the monitored fleet

6.1 Technical energy efficiency of the monitored fleet

Monitoring the technical energy efficiency of ships (EEDI & EIV)

In 2011, the International Maritime Organization adopted the Energy Efficiency Design Index (EEDI) in order to set an energy efficiency standard for new ships of different ship types and size segments.

The EEDI sets the amount of CO_2 emissions permitted when carrying a unit of transport work (i.e. gCO_2 per tonne-mile). The lower the EEDI value, the better the technical energy efficiency of the ship.

$$EEDI = \frac{CO_2\ emission}{transport\ work}$$

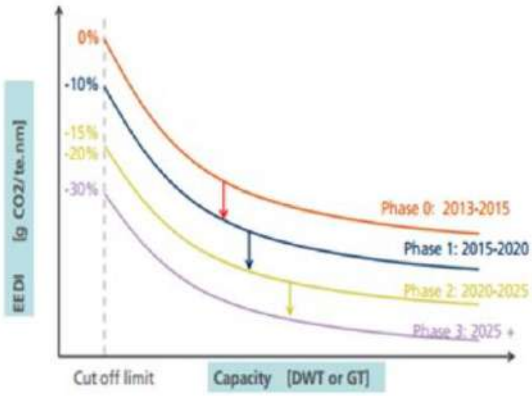
The EEDI threshold varies for different ship types and sizes. The EEDI attained value is a certified value that represents the design energy efficiency sea-going condition of a ship. The ships covered under the EEDI framework are responsible for approximately 85% of the CO_2 emissions from international shipping.

The main objective of the IMO regulation is to encourage ship designers and builders to invest in innovation, and to support the introduction and deployment of more energy efficient design, equipment, and engines.

As shown in Figure 34, the EEDI legislation is implemented in phases. In phase 0 (2013-2015), new ships were required to have a design efficiency at least equal to the average performance of ships built between 1999 and 2009 (called the reference line). In phase 1 (2015-2020), new ships had to be 10% more energy efficient compared to that reference line. In phase 2 (2021- 2025), the reduction factor compared to the baseline is increased to 20%, and in phase 3 (after 2025), it reaches 30%.

The Energy Efficiency Design Index (EEDI) sets energy efficiency standard for ships built after 2013.

Figure 34: Energy efficiency Design Index (EEDI) (IMO)[38]



For ships built before 2013, the technical energy efficiency values are based on a simplified version of the EEDI called the Estimated Index Value (EIV). This value can be calculated based on publicly available information.

Comparing the EEDI values of the monitored fleet with IMO EEDI values

A statistical analysis has been undertaken to assess the technical energy efficiency of the monitored fleet. This analysis was performed on the most representative ship categories (type & size), covering bulkers, tankers, container ships and gas carriers.

As a first step, the EEDI attained values reported in THETIS-MRV (around 2,100) were compared with the values reported in the IMO EEDI database (around 5,000), which contains anonymised data provided by companies on a voluntary basis.[39] The purpose of this exercise was to compare the technical efficiency of the monitored ships with the one from the world-wide fleet as reported in the IMO EEDI database. A secondary objective was to better understand the representativeness of the voluntary IMO database.

To ease the comparison between the EU MRV and the IMO database, the single EEDI values were converted to regression lines, following the methodology used by IMO to establish the EEDI reference lines.

Figure 35: Energy efficiency (EEDI) of world fleet (IMO) vs energy efficiency (EEDI) of monitored fleet

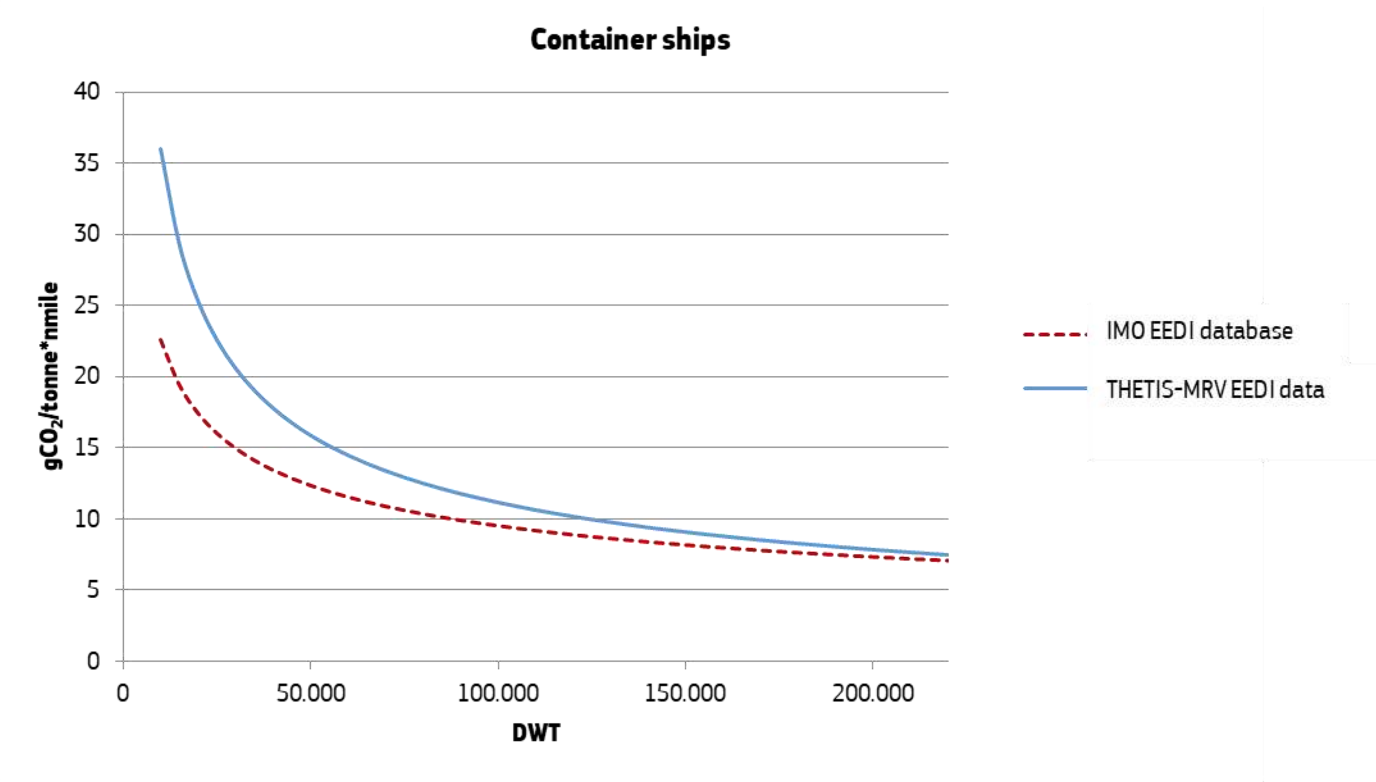


Figure 36: Energy efficiency (EEDI) of world fleet (IMO) vs energy efficiency (EEDI) of monitored fleet

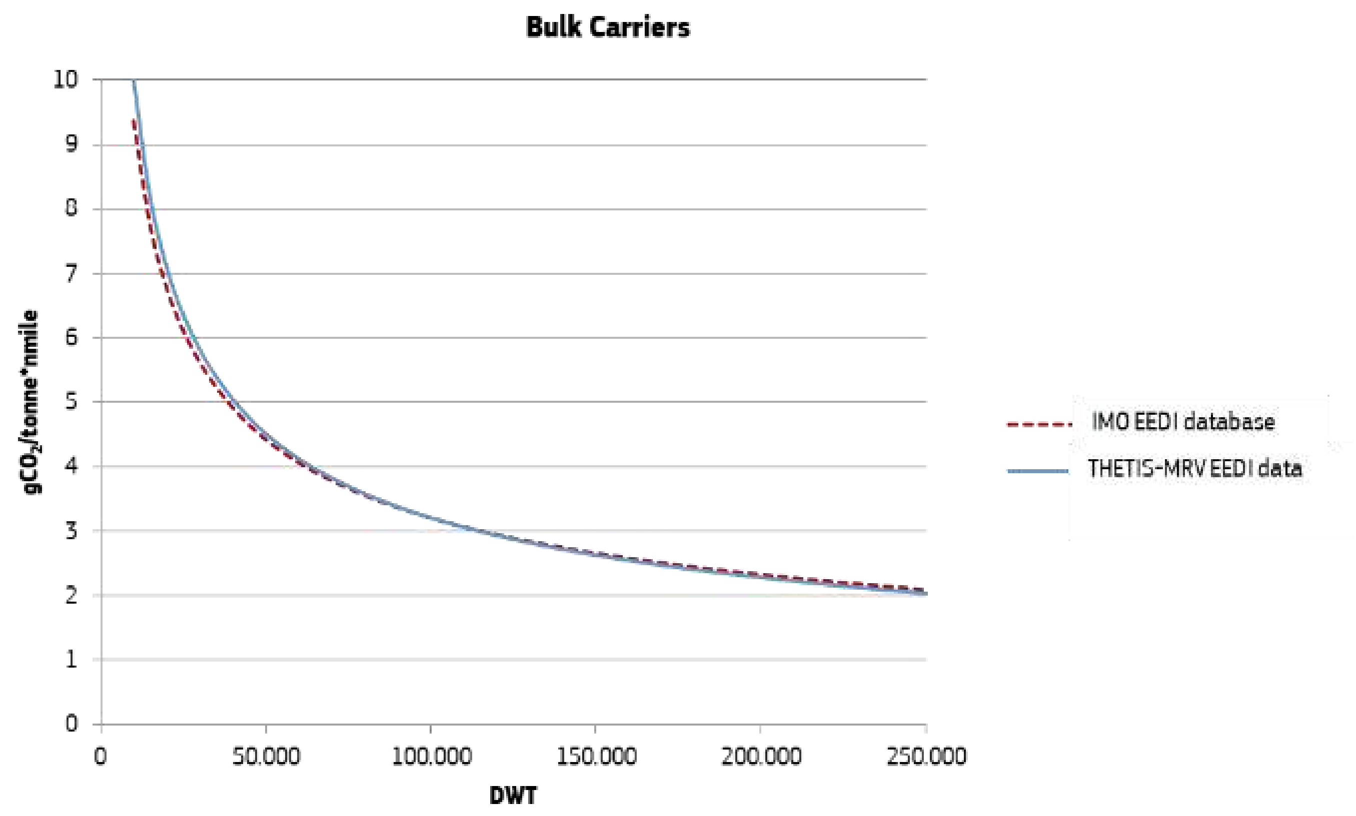


Figure 37: Energy efficiency (EEDI) of world fleet (IMO) vs energy efficiency (EEDI) of monitored fleet

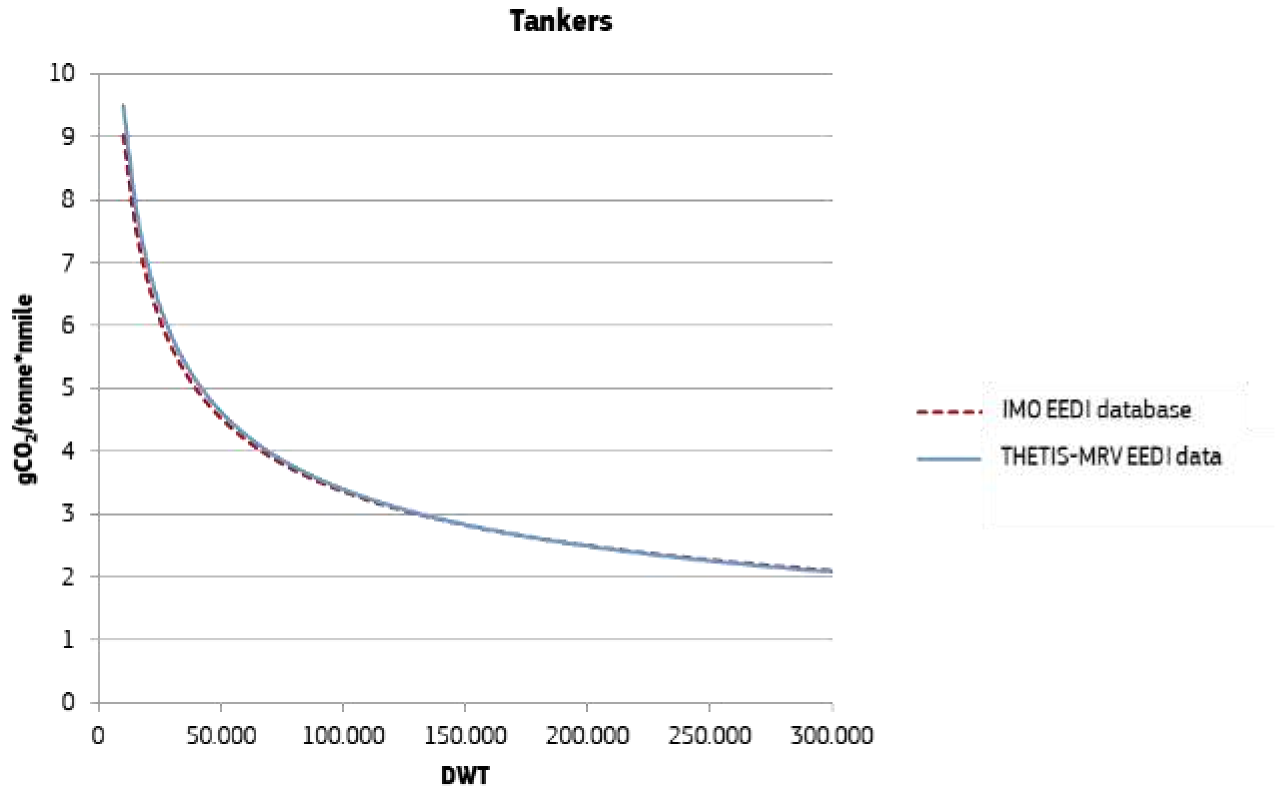
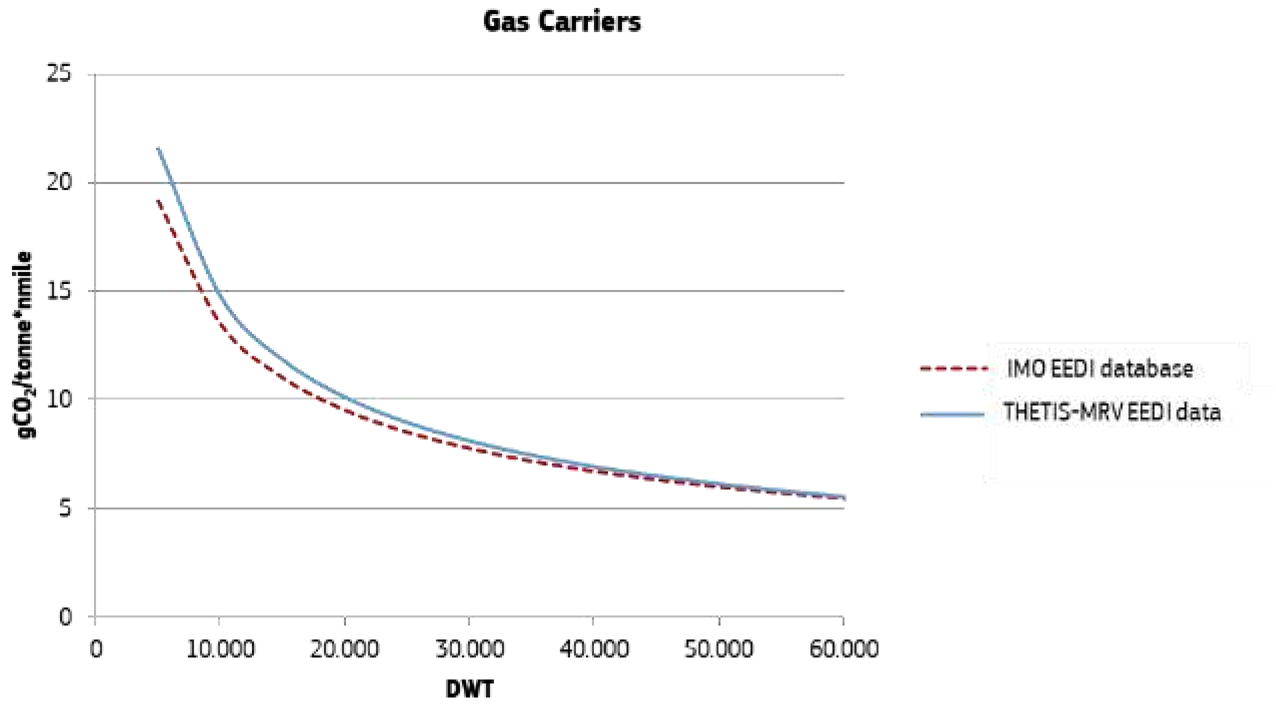


Figure 38: Energy efficiency (EEDI) of world fleet (IMO) vs energy efficiency (EEDI) of monitored fleet



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019). Notes: The estimations of the curves based on the EU MRV database have been performed using the same DWT and EEDI ranges of IMO database.

Initial analysis indicates that bulkers, tankers and gas carriers follow similar trends in terms of attained EEDI values in both the IMO EEDI database and THETIS-MRV. This means that, on average, bulkers, tankers and gas carriers built after 2013 and involved in EEA voyages have a comparable design efficiency to similar ships cruising in other parts of the world. It also confirms the representativeness of the voluntary IMO EEDI database. However, in relation to container ships, one can observe that the EEDI of the monitored fleet is showing lower levels of energy-efficiency compared to the IMO EEDI fleet. This is particularly notable for ships below 100,000 DWT.

To better understand this discrepancy, an analysis has been performed to compare the technical characteristics of the container ships in THETIS-MRV (those that have reported EEDI) with the technical characteristics of similar container ships in the world wide fleet (built after 1 January 2013), but operating outside the scope of the EU MRV Regulation.

Since technical energy efficiency (EEDI) is directly influenced by the maximum installed power and design speed, these two variables were used in the analysis to characterise the two fleets. The IHS database served as the source of information. It captures average maximum installed power, and average service speed (taken at 85% Maximum Continuous Rating). In addition, the analysis uses the usual thresholds for ship size (in DWT) to infer the technical efficiency performance within each size segment. This serves to highlight the differences between ship types operating in short-sea and deep-sea conditions from each other (e.g. feeders and liners respectively).

According to this analysis (see Table 6 in Appendix 2), container ships from the lower size-segments (below 15,000 DWT) in THETIS-MRV appear to be significantly higher powered, and moving at a higher average speed. However, this observation is only based on four ships, and might therefore not reflect a market trend. One could also question the impact of these few ships on the overall attained EEDI regression line for container ships. To provide increased certainty, a new regression line has been calculated without those ships, which shows the same result. This means that the trend of higher attained EEDI in THETIS-MRV persists.

When looking at container ships in the low-intermediate size segments, it is clear that container ships trading in the EU have generally higher installed engine powers (over 30%) and higher design speeds (over 7%). This explains why these ships have higher attained EEDIs compared to those represented in the world fleet. The reason for these different design approaches could be explained by the high demand for quick ‘feeder trade’ in the EU. This trade is carried out between big container terminals hubs such as Rotterdam, to smaller EEA ports such as Lisbon.

For the larger size segments of container ships, the EEDI attained values start to converge. This could be explained by the similarity between the large deep-sea liners trading within the scope of the MRV system, and those active in other parts of the world. The differences in design speed and maximum installed power between the two fleets is much less prominent than for other size segments.

Comparison between EEDI values and future EEDI standards

A second analysis was undertaken to compare the EEDI values reported in THETIS-MRV and the future minimum EEDI standards that new ships will have to abide by starting in 2020 (EEDI phase 2), and 2025 (EEDI phase 3). This analysis showed that most of the monitored bulkers built after 2015 were already on track to achieve EEDI Phase 2 and showed a positive trend toward EEDI Phase 3, in particular for vessels with a capacity lower than 100,000 DWT.

For container ships, the analysis shows that most of the ships built after 2015 have already overtaken EEDI Phase 3. Today, oil tankers have achieved EEDI Phase 2, and vessels built after 2015 with a capacity of around 100,000 DWT have already achieved EEDI Phase 3. These findings confirm the need to revise the reduction factors in the EEDI legislation in order to ensure that new ships have a higher technical energy efficiency than ships built in previous EEDI phases.

The impact of age on energy efficiency

A third analysis was undertaken to understand if younger container ships, bulkers and oil tankers (up to 10 years old) from the monitored fleet tend to be more energy efficient than older ones from a design point of view (relating to EEDI).

For simplicity, energy efficiency is defined as the ability of a ship to transport the same amount of cargo at the same speed but with less installed power and inherently less fuel consumption and CO_2 emissions.

This analysis considered ships built five years before and after EEDI entered into force (1 January 2013). The number of ships in the monitored fleet that fit this description included: 2842 bulk carriers (77% of all ships of this ship type), 870 container ships (50%), and 876 oil tankers (49%).

The IHS database was used to get the average maximum installed power and average service speed (85% MCR). The traditional size thresholds (in terms of DWT & Twenty-foot equivalent units) were used to infer the technical efficiency performance within each size segments. This mainly served to highlight the differences between short-sea (feeders) and deep-sea shipping (liners), but was also used to calculate the weighted average of each ship type.

Table 1 shows that younger ships that are between 0-5 years old, have reduced their power the most in comparison to older ships that are between 5-10 years old (of all three considered ship types: bulk carriers, container ships and oil tankers). Newly constructed container ships have reduced their maximum installed power by around 25% compared to older ships. Bulk carriers and oil tankers constructed less than five years ago have reduced their power by around 15% each.

In terms of lowered average service speed, container ships have reduced their speed the most (9%) out of the three ship types, although in accordance with the propeller law ($Power \approx Speed^3$), indicative speed reductions of 10% correspond roughly to 20-25% power reductions. On the other hand, bulk carriers have notably seen close to no difference in average service speed.

As a result of these trends in installed power and service speed, it seems that bulk carriers have undergone some tangible energy efficiency improvements as they succeeded in lowering their installed power without a significant change in average speed.

Table 1: Split of speed and power reduction in the monitored fleet based on ship type and age

Ship type & size	Number of ships in a specific age category		Average max installed power MCR (kW)		Average service speed - 85% MCR (knot)		Power reduction trends [0-5 years vs 5-10 years] (in %)	Speed reduction trends [0-5 years vs 5-10 years] (%)
Years	0-5	5-10	0-5	5-10	0-5	5-10		
Bulk carrier (DWT)	**1297**	**1545**	**8863**	**9947**	**14.4**	**14.2**	***15.2%***	***-0.3%***
0 - 9999	1	16	3,000	2,690	13.0	11.8	-11.5%	-10.0%
10000 - 34999	77	350	6,388	6,643	14.1	14.0	3.8%	-0.8%
35000 - 59999	393	563	6,868	8,668	14.2	14.3	20.8%	0.6%
60000 - 99999	697	393	8,927	10,775	14.4	14.4	17.2%	-0.5%
100000 - 199999	95	218	15,910	17,385	14.5	14.5	8.5%	-0.4%
>=200000	34	5	16,720	19,182	14.6	14.3	12.8%	-1.8%
Container ships (TEU)	**395**	**475**	**46,284**	**41,380**	**21.3**	**22.6**	***24.7%***	***9.0%***
0 - 999	1	25	9,000	8,438	18.3	17.8	-6.7%	-2.7%
1000 - 1999	16	92	11,319	11,759	18.3	19.1	3.7%	4.4%
2000 - 2999	20	38	13,981	22,645	19.4	21.9	38.3%	11.2%
3000 - 4999	31	94	24,167	36,070	21.4	23.5	33.0%	9.1%
5000 - 7999	12	68	29,566	53,196	22.0	24.2	44.4%	9.3%
8000 - 11999	114	78	46,866	61,646	22.2	24.4	24.0%	9.0%
12000 - 14500	67	76	52,283	70,868	23.3	24.3	26.2%	4.0%
>14500	134	4	58,676	74,959	20.0	24.7	21.7%	19.1%
Oil tanker (DWT)	**380**	**496**	**14,054**	**15,841**	**14.5**	**15.1**	***13.8%***	***4.2%***
0 - 4999	1	-	2,000	-	11.5	-	-	-
5000 - 9999	11	14	3,001	3,102	11.8	12.8	3.3%	8.1%
10000 - 19999	10	1	4,398	4,500	13.7	13.6	2.3%	-0.8%
20000 - 59999	8	48	7,610	9,286	13.5	14.9	18.1%	9.6%
60000 - 79999	28	72	10,219	12,512	14.3	15.0	18.3%	4.9%
80000 - 119999	174	164	12,010	13,979	14.5	15.0	14.1%	3.0%
120000 - 199999	99	143	15,922	18,399	14.7	15.4	13.5%	4.8%
>=200000	49	54	25,517	28,506	15.2	15.7	10.5%	2.9%
Grand total	**3212**	**4073**	**-**	**-**	**-**	**-**	**-**	**-**

Source: EMSA elaborations based on THETIS-MRV and IHS data (Data extracted on 23 September 2019).
Notes: MCR stands for Maximum Continuous Rating, which is the maximum output that can be produced by an engine continuously without causing the failure of the propulsion machinery.

Comparing EIV Values with EEDI reference lines

The EIV values reported in THETIS-MRV (around 6,200) were compared with the EEDI reference lines, as shown in Figure 39-Figure 42. Based on this analysis, bulkers, tankers and gas carriers have EIV regression lines based on THETIS-MRV data that are very similar to the EEDI reference lines.

However, for container ships, the two curves show different trends. This can be explained by the fact that 110 large container ships (pre-EEDI ships) – with a cargo carrying capacity above 120.000 DWT – reported their EIV values in THETIS-MRV, whilst only 3 ships of the same age and size were taken into account when preparing the EEDI reference line. Considering that the EEDI reference line for container ships is based on EIV values from 1999 to 2009, it is clear that it does not reflect the new reality for the construction of this ship type. The lack of such data meant a more modest energy efficiency reference line, which is de facto accentuating the increase in energy-efficiency of all the newbuild ships in this size segment.

Figure 39: Average energy efficiency (EIV) performance of the monitored fleet vs EEDI reference lines

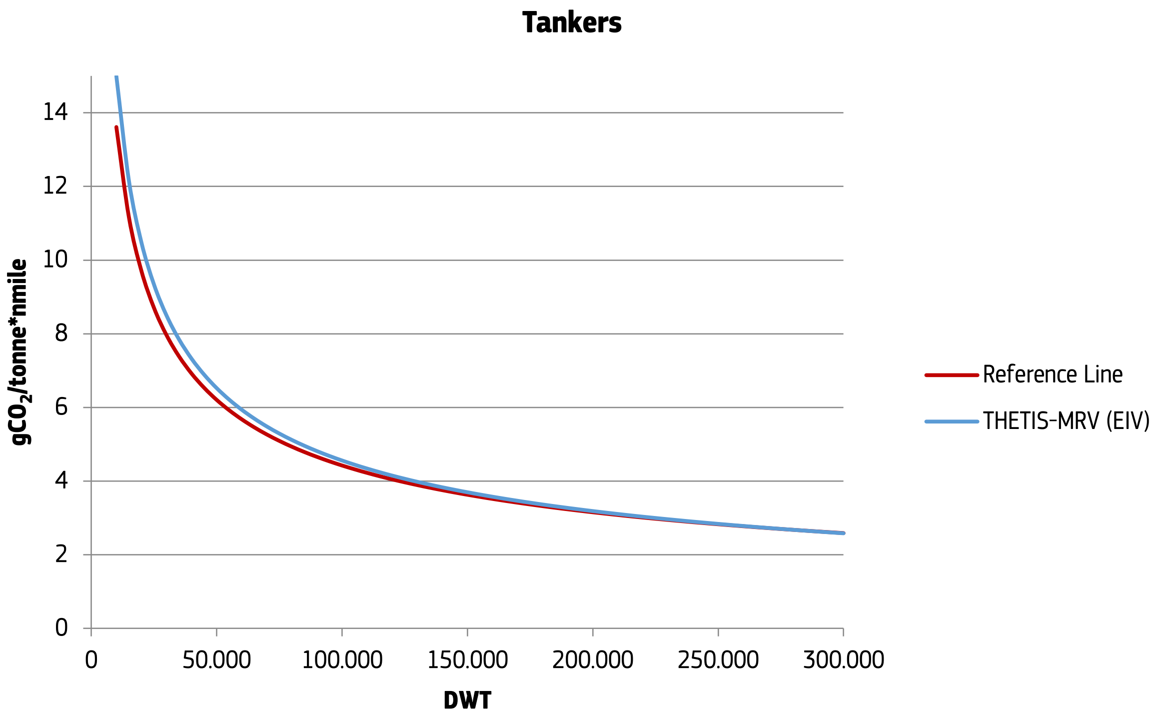


Figure 40: Average energy efficiency (EIV) performance of the monitored fleet vs EEDI reference lines

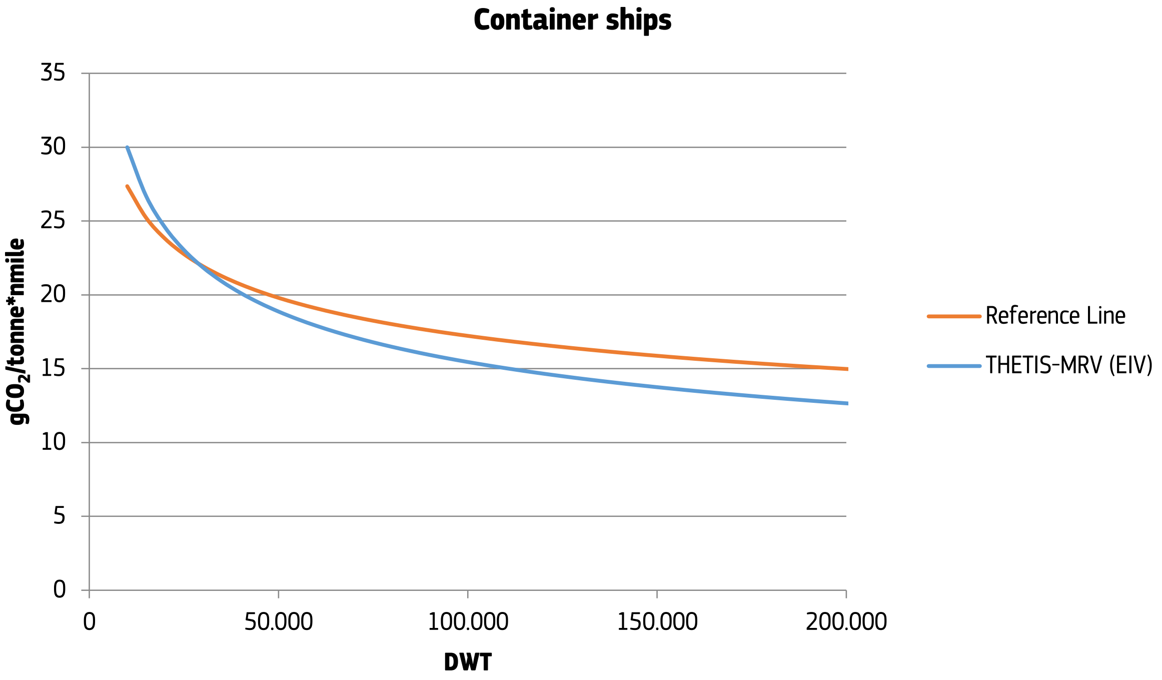


Figure 41: Average energy efficiency (EIV) performance of the monitored fleet vs EEDI reference lines

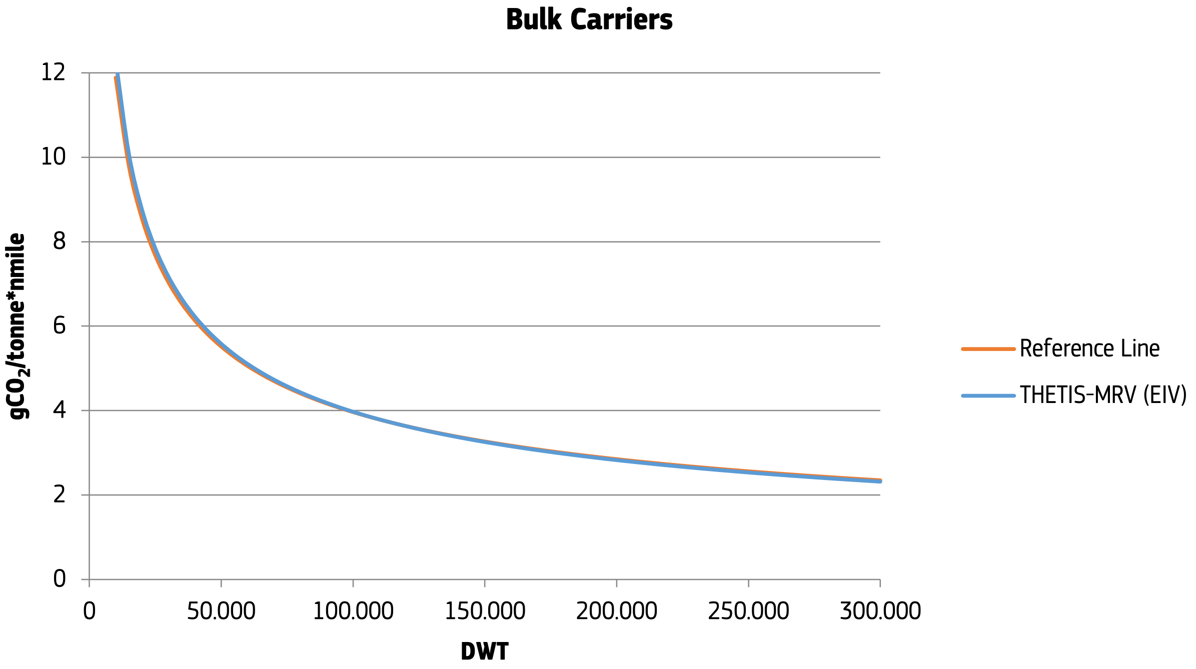
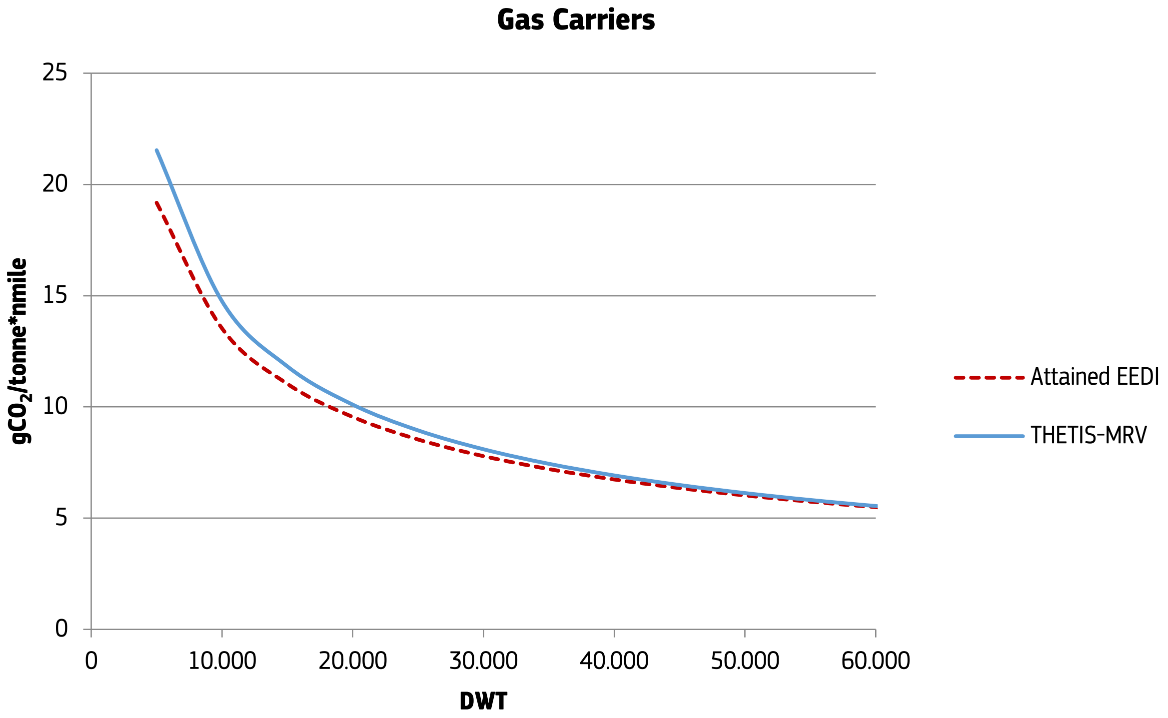


Figure 42: Average energy efficiency (EIV) performance of the monitored fleet vs EEDI reference lines



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).
Notes: The estimation of the curve on MRV database have been performed using the DWT range applied in the IMO database for the respective ship types.

6.2 Operational energy efficiency of the monitored fleet

Monitoring the operational energy efficiency of ships

The main objective of operational energy efficiency indicators is to monitor the performance of a ship when operating in real conditions. In contrast to technical energy efficiency indices, operational indicators are influenced by factors that vary over time and often diverge from the ship design conditions, including:

- distance travelled and time spent at sea
- average cruising speed
- amount of cargo transported
- loading condition, including ballast
- displacement (related to loaded draft)
- oceanographic and weather conditions
- energy requirements at berth

Operational energy efficiency indicators are key to tracking the actual operational performance of ships, and are essential to the implementation of any Environmental Management System (ISO 14001).

Operational Energy Efficiency Indicators reflect the ship's performance in real conditions.

In the EU MRV system, companies have to use several indicators to monitor their operational energy efficiency:

- CO_2 emissions/ fuel consumption per distance
- CO_2 emissions/ fuel consumption per transport work

Transport work represents the actual maritime transport service determined by multiplying the distance travelled with the amount of cargo carried. Depending on ship type, cargo carried may be expressed in several units such as metric tonnes of cargo, number of passengers, TEUs, volume of cargo, number of cargo units or occupied surface, and so on.[40]

While CO_2 emitted, fuel consumption, cargo carried and transport work have to be monitored for each voyage, companies report their operational energy efficiency indicators in the form of an annual average.

Operational energy efficiency indicators are fundamentally different from one another, making it important to understand what they actually represent when interpreting them.

To facilitate their interpretation, the EU MRV Regulation allows companies to report additional information on a voluntary basis, which serves to explain and contextualise the indicators. For instance, shipping companies can provide information relating to navigation through ice, or report their performance in laden i.e. loaded condition only.

The Energy Efficiency Operational Indicator (EEOI) – CO_2 emissions per transport work

One of the indicators required under the EU MRV Regulation is aligned with the "Energy Efficiency Operational Indicator" (EEOI). This indicator was introduced by the IMO as one of the monitoring tools that companies can use when implementing their Ship Energy Efficiency Management Plan (SEEMP). In its most simple form, the EEOI is defined as the ratio of mass of CO_2 emitted per unit of transport work.

As it varies according to actual cargo carried, this indicator reflects the carbon intensity of the transport service rendered by each individual ship. As a result – keeping everything else equal – ships with higher payload utilisation tend to have a lower EEOI, making them appear more energy efficient. This illustrates the high influence of the capacity utilisation of vessels (including ballast voyages) on this indicator.

Individual Ship Performance Indicator (ISPI) – CO_2 emissions per distance travelled

The EU MRV indicator that considers CO_2 emissions per distance travelled (deriving from fuel consumption per nautical mile) is comparable to the so-called "Individual Ship Performance Indicator" (ISPI). Compared to the EEOI, this indicator is considered a proxy for carbon intensity.

Annual Efficiency Ratio (AER) – Based on CO_2 emissions, DWT, and distance travelled

The THETIS-MRV data reported by the monitored fleet makes it possible to estimate another operational energy efficiency indicator called the "Annual Efficiency Ratio" (AER). This indicator is commonly used by the shipping industry, and captures the ratio between CO_2 emission and the maximum transport work i.e. cargo carrying capacity (DWT or GT as applicable).

This key indicator relies on a proxy for transport work which assumes that ships are fully loaded on every voyage. By using this approximation, the AER reduces the variability related to actual cargo carried and ballast voyages and it allows comparison of the operational performance of ships with their technical energy efficiency. However, the assumption that ships always sail fully loaded leads to a situation where a ship with a lower AER might produce in fact more CO_2 emissions per transported tonne-mile than a ship with a higher value for AER (assuming that the difference in the fuel consumed does not compensate for the non-utilised cargo capacity).

It should also be noted that AER can be further corrected with an average utilisation factor per ship type (derived for example from UNCTAD annual data) to obtain a more accurate estimate of overall carbon intensity.

An analysis of operational energy efficiency indicators

A statistical analysis has been carried out to assess the operational energy efficiency of bulkers, container ships and oil tankers. These are the most representative ship categories of the monitored fleet in terms of type and size. The operational energy efficiency of these ships have been assessed based on three indicators (EEOI, ISPI, and AER) that have varying degrees of sensitivity level when it comes to cargo variations.

This analysis covers 3,000 bulk carriers, 1,450 container ships, and 1,650 oil tankers. Regression curves with R^2-values have been calculated using the explained approach provided by the International Maritime Organization.[41] Figure 43-Figure 45 show the average EEOI values reported in each ship category. These graphs capture the high correlation between the EEOI values and the carrying capacity of ships (DWT). The larger the ship, the lower the fuel consumption per unit of cargo transported, and the lower the emissions per transport work.

Figure 43: EEOI for container ships per ship size

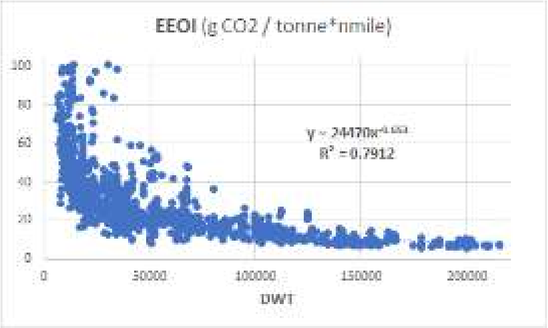


Figure 44: EEOI for bulkers per ship size

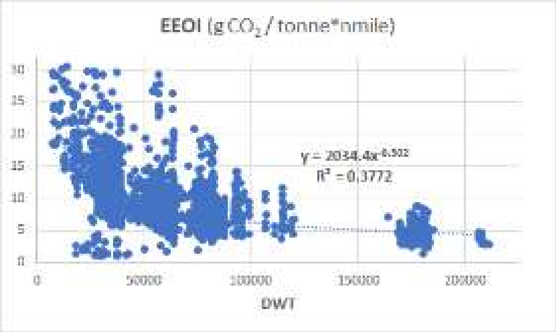
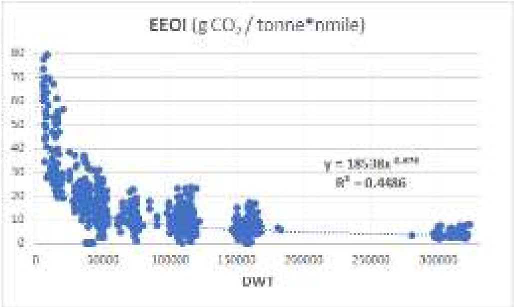


Figure 45: EEOI for oil tankers per ship size



Source: The figures above are based on EMSA elaborations relying on THETIS-MRV data (Data extracted on 23 September 2019).

A general observation is that the EEOI of container ships is generally much higher than the values for bulkers and oil tankers. This reflects that container ships travel at higher speeds than these two ship types, but additionally that container ships generally transport a lower density of cargo. Accordingly, the mass of cargo transported is an important factor that directly influences the EEOI. This is also why ship types such as gas carriers have a much higher EEOI than dry and liquid bulkers. According to previous studies, 60% of the variation in EEOI values observed for identical ships is related to speed, total amount of cargo carried, and the share of laden voyages.[42]

The figures also show that the variability in EEOI is generally higher for bulkers and tankers than for container ships. This trend is partly the result of ballast voyages and varying capacity utilisation affecting EEOI values, in particular for bulkers and tankers. Ballast legs increase CO_2 emissions, but have no impact on transport work. A ship doing less ballast voyages will therefore appear as being more energy efficient. Another explanation is the age of the ship, as the newer ships (built after 2015) tend to have lower EEOI values than others.

Figure 46-Figure 48 show the AER values, which appear to follow similar trends as those discussed for EEOI. However, the CO_2 emissions per tonne nautical mile are much lower (at around half the EEOI values), and the data appears less scattered. All three ship types follow a very clear statistical trend, and have high correlation values.

Figure 46: AER for container ships per ship size

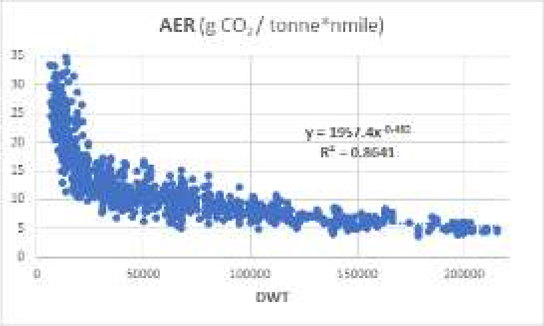


Figure 47: AER for bulkers per ship size

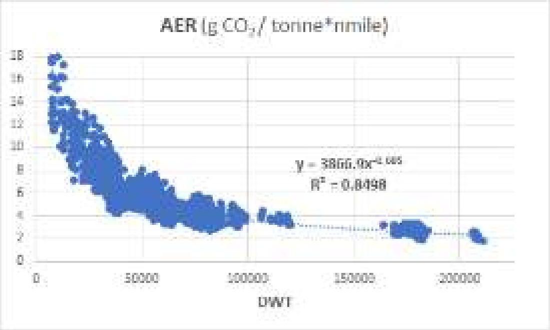
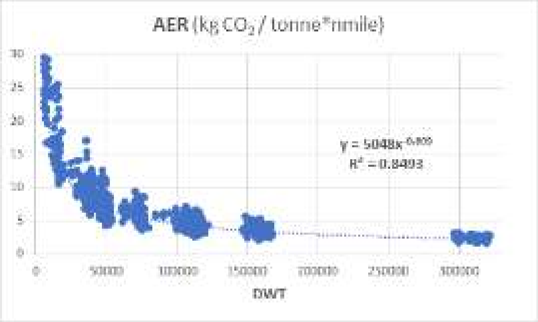


Figure 48: AER for bulkers per ship size



Source: The figures above are based on EMSA elaborations using THETIS-MRV (Data extracted on 23 September 2019).

These findings are related to the definition of AER, where transport work only relies on the distance travelled and on the ship's carrying capacity. This facilitates the comparison between ships, but it also underestimates the carbon intensity of the maritime transport service unless corrected with an average utilisation factor per ship type. However, it should be noted that EEOI and AER are not easily comparable, taking into account the different behaviour throughout the size segment of ships.

Finally, Figure 49-Figure 51 look at the ISPI indicator, which considers CO_2 emissions per distance. As observed with AER values, ISPI values are, in general, highly correlated with DWT. Larger vessels tend to consume more fuel per distance than smaller ones. This observation has been found across all ship types (see Figure 52), although there is no linear correlation between fuel consumption per distance, and the size of vessels.

Figure 49: ISPI for container ships per ship size

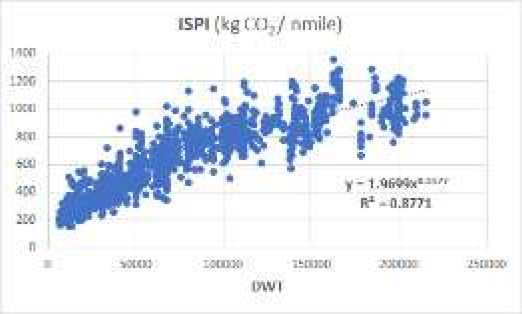


Figure 50: ISPI for bulkers per ship size

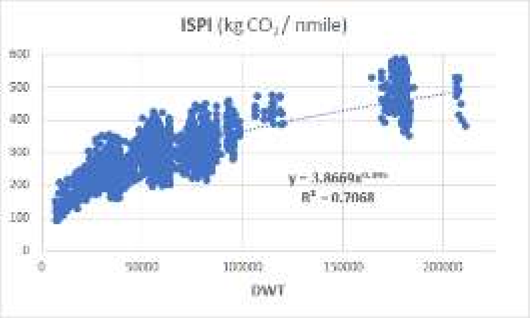
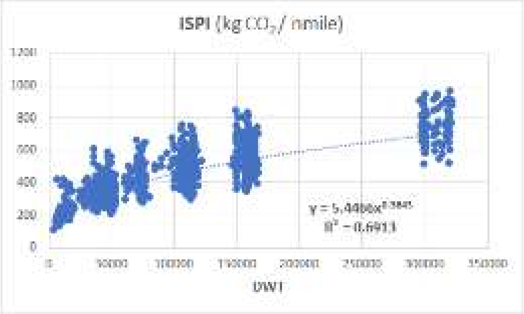
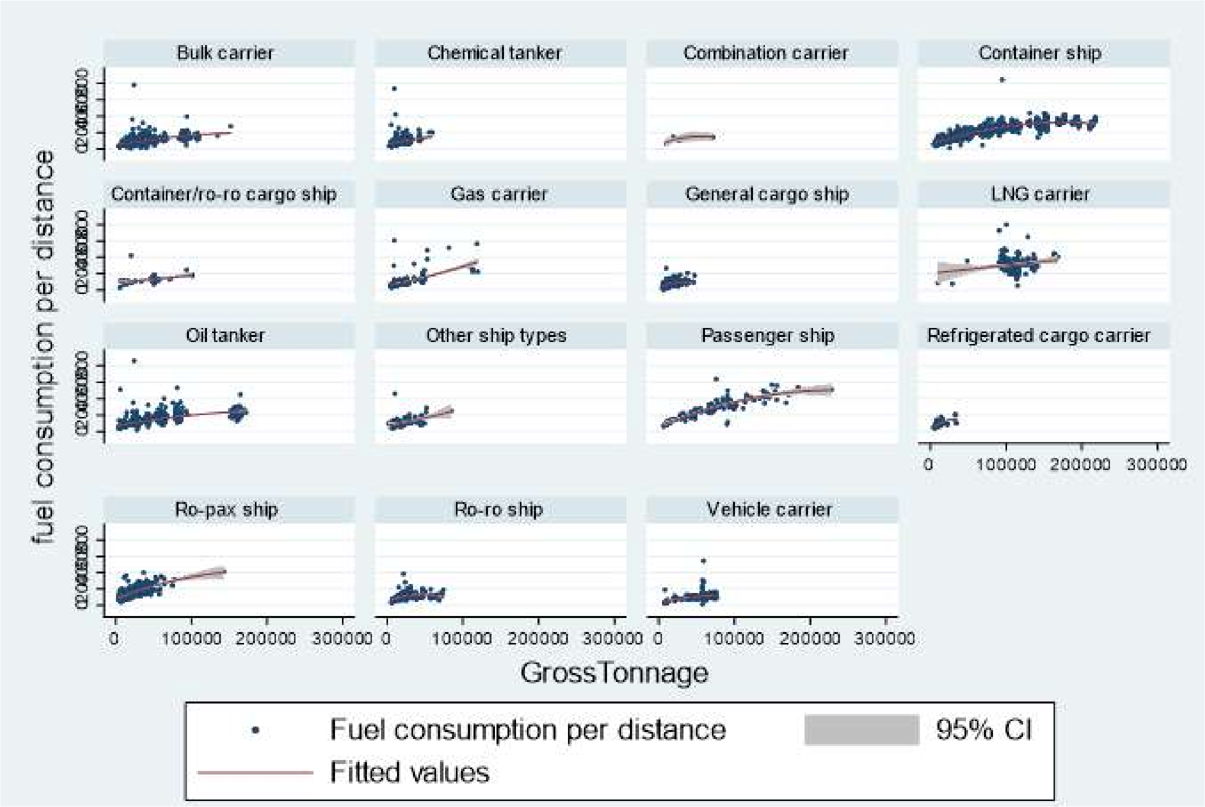


Figure 51: ISPI for oil tankers per ship size



Source: The figures above are based on EMSA elaborations relying on THETIS-MRV data (Data extracted on 23 September 2019).

Figure 52: ISPI related analysis - Relationship between fuel consumption per distance and ship's GT by ship type



Source: RINA elaborations based on the EU MRV database accessed through THETIS-MRV (Data extracted on the 23 September 2019).

Table 2 summarises the correlation between the ship's carrying capacity and the three indicators. The table shows that AER had the highest level of correlation for all ship types. EEOI had the lowest level of correlation for bulk carriers and oil tankers, whereas relatively high levels of correlation were obtained for all indicators when it comes to container ships.

Table 2: Explanatory power of operational average energy efficiency indicators related to DWT

R^2	Bulk carriers	Container ships	Oil tankers
ISPI	0.70	0.88	0.69
AER	0.85	0.86	0.85
EEOI	0.38	0.79	0.45

Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).

6.3 Assessing Technical vs Operational Energy Efficiency

EIV and attained EEDI vs AER

A comparison was made between the technical and operational energy efficiency of the most representative ship categories (bulkers, tankers and container ships).

To this end, AER values were compared with EIV values for pre-EEDI ships. Such a comparison is possible as both indicators are based on deadweight tonnage. For ships built after 2013, a similar comparison was done but using the attained EEDI values reported in THETIS-MRV, instead of EIV values.

For bulk carriers, the figures below show that their technical (EIV or EEDI) and operational energy efficiency level (AER) are relatively comparable. However, for small ship size segments, the operational performance tend to be slightly worse than the technical energy efficiency (up to 20%). The poorer performance of smaller vessels might be explained by their short-sea restricted high manoeuvring profile, which negatively affects their average fuel consumption. In addition, it should be noted that operational energy efficiency indicators are influenced by weather conditions, contrary to design performance based on calm water conditions.

On the contrary, larger bulkers tend to have a better operational performance compared to their technical efficiency (up to around 10%). This difference reflects the fact that bulkers cruise at lower operational speed in comparison to their design reference speed.

Similar to bulkers, the AER values for small- to medium-size oil tankers are generally somewhat higher than corresponding EEDI or EIV values. This difference is particularly notable for small and medium vessels, whereas no difference is observed for the large ones.

In relation to container ships, the graphs show different trends for ships built before the introduction of EEDI and those built after. For pre-EEDI ships, their observed operational energy efficiency is much better than their technical energy efficiency at design reference speed. This significant difference is due to the speed reduction within the sector. In 2018, container ships cruised on average at around 60% of their design reference speed. For the newer ships (post-EEDI), the operational energy efficiency is much closer to the reported EEDI values because they are operating closer to their design reference speed.

Figure 53: Comparison between EIV and AER for pre-EEDI bulk carriers

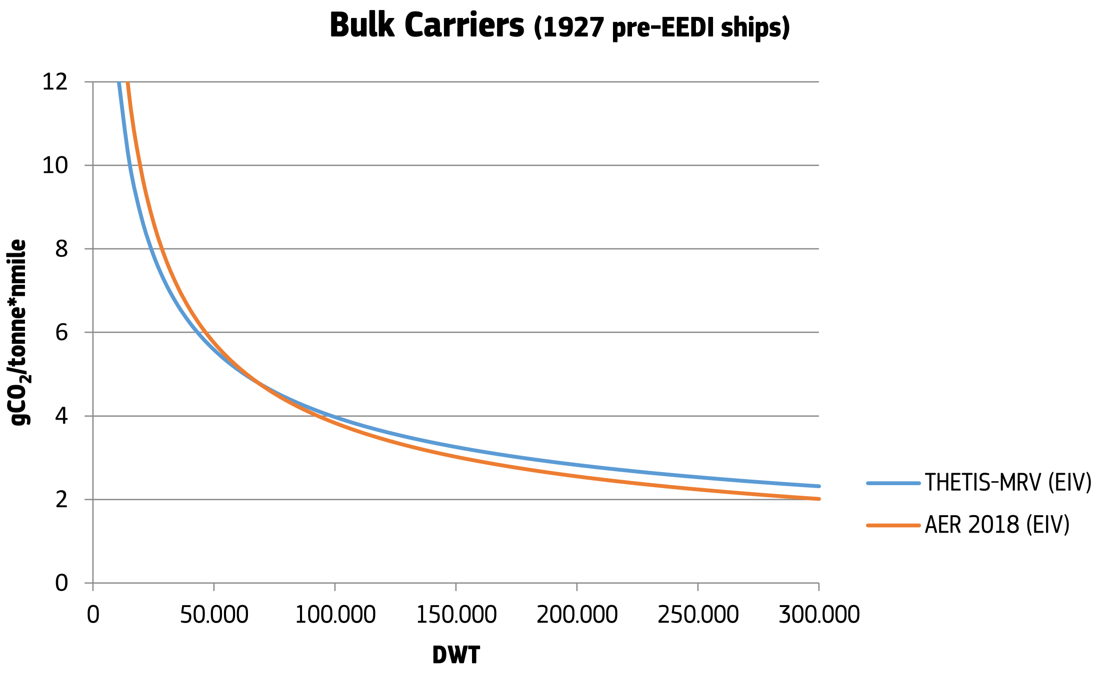


Figure 54: Comparison between attained EEDI and AER for EEDI bulk carriers

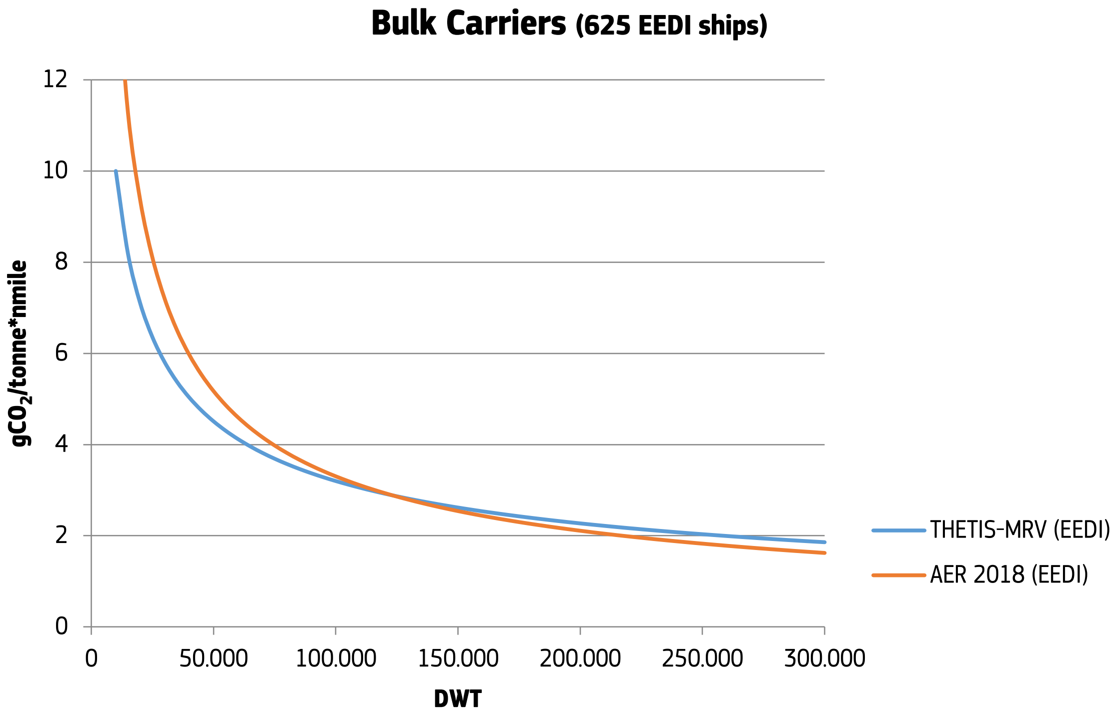


Figure 55: Comparison between EIV and AER for pre-EEDI oil tankers

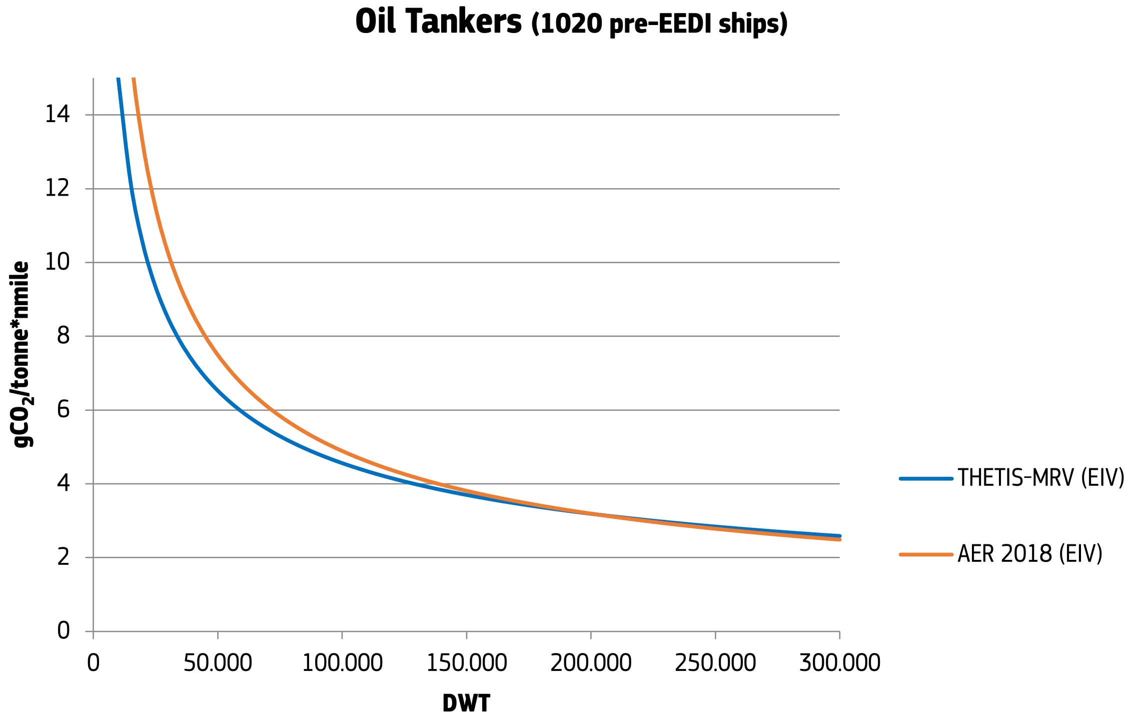


Figure 56: Comparison between attained EEDI and AER for EEDI oil tankers

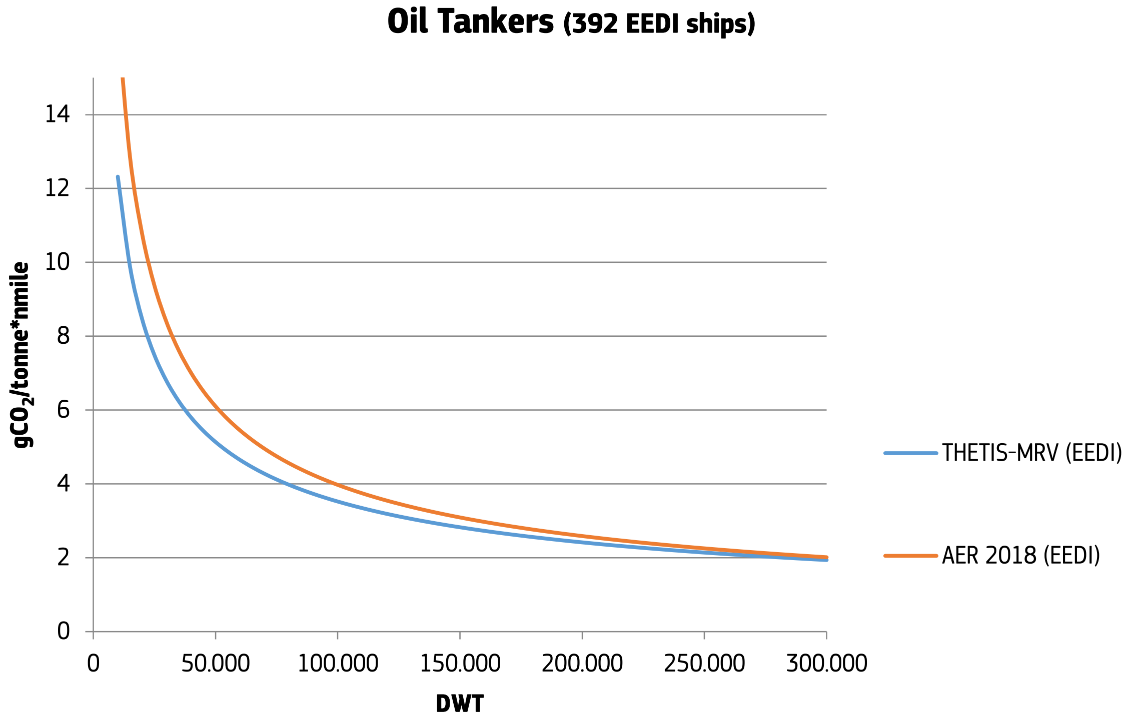


Figure 57: Comparison between EIV and AER for pre-EEDI container ships

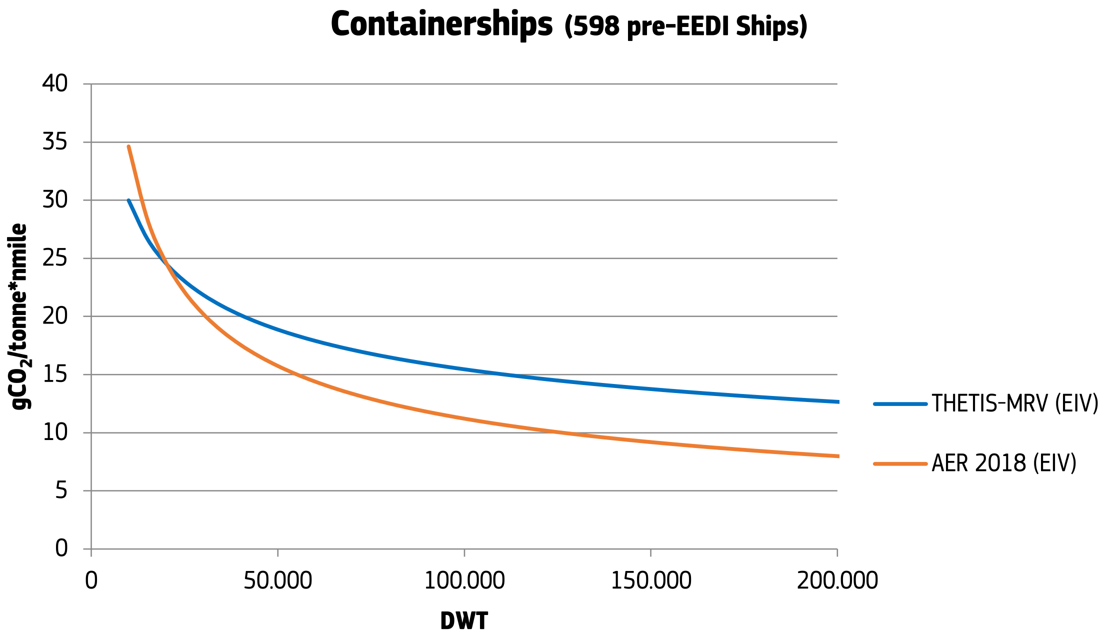
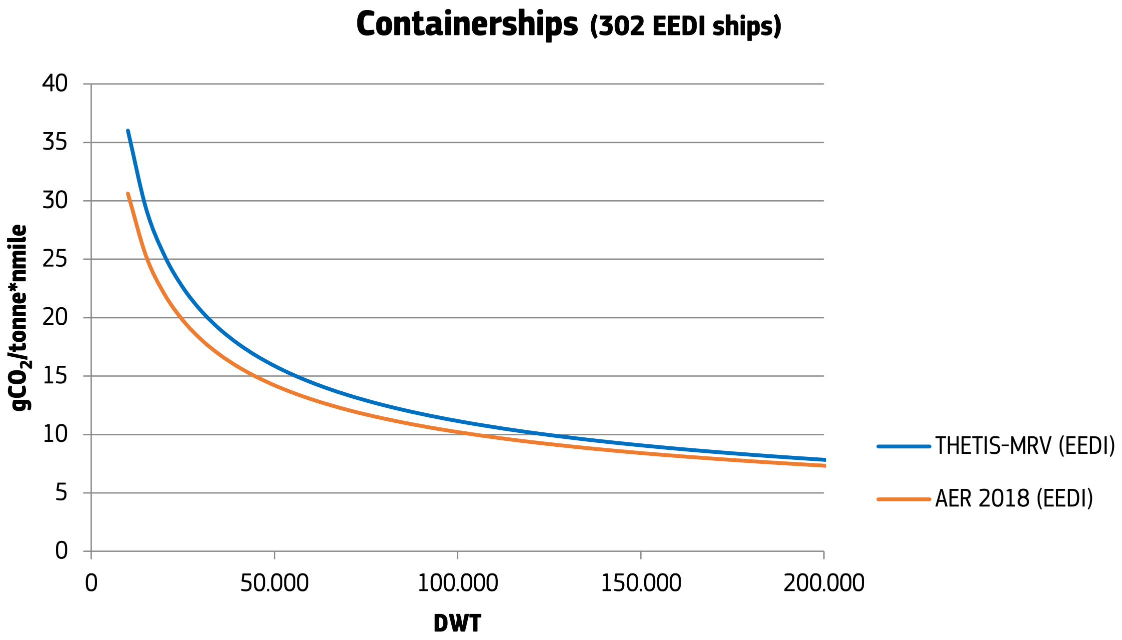


Figure 58: Comparison between attained EEDI and AER for EEDI container ships



Source: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).
Notes: The estimation of the curve on MRV database have been performed using the same DWT range of IMO database for container ships.

EEOI vs AER vs EEDI

For container ships it is of interest to compare operational efficiency in terms of EEOI, with EIV/EEDI values. This comparison cannot be made for other ship types, as the EEOI is overly influenced by the capacity utilisation of vessels and ballast voyages. It should also be noted that EIV/EEDI values for container ships are calculated based on

70% of DWT, which is more comparable to real operational conditions.

As shown in the figure below, EEOI values are generally higher than AER values, in particular for small-to medium-size ships. However, for larger ships, these two indicators converge.

This difference could be attributed to the variation in capacity utilisation of ships, meaning that larger container ships use more of their available capacity. This also means that EEOI and AER are not easily comparable, taking into account the different behaviour throughout the size segment.

It should also be noted that contrary to AER values, EEOI trends show that the operational energy efficiency of container ships based on real cargo carried is generally worse than their technical efficiency. This is particularly true for small- to medium-size container ships.

Figure 59: EEOI, EEDI and AER comparison for container ships

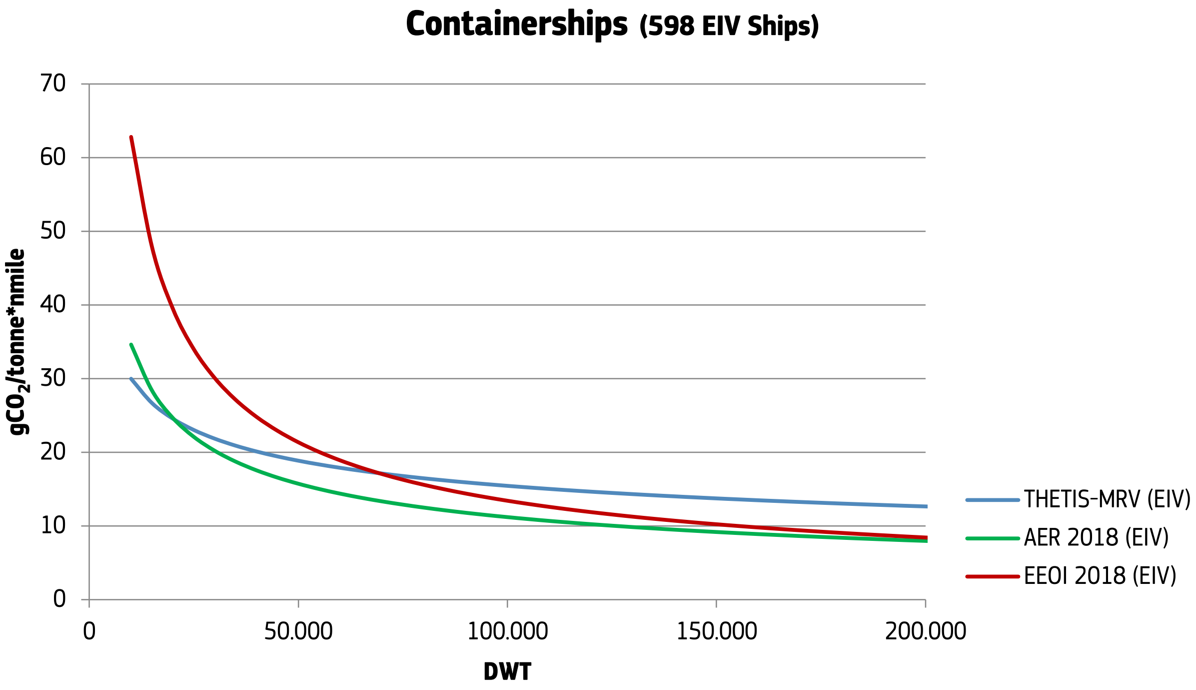
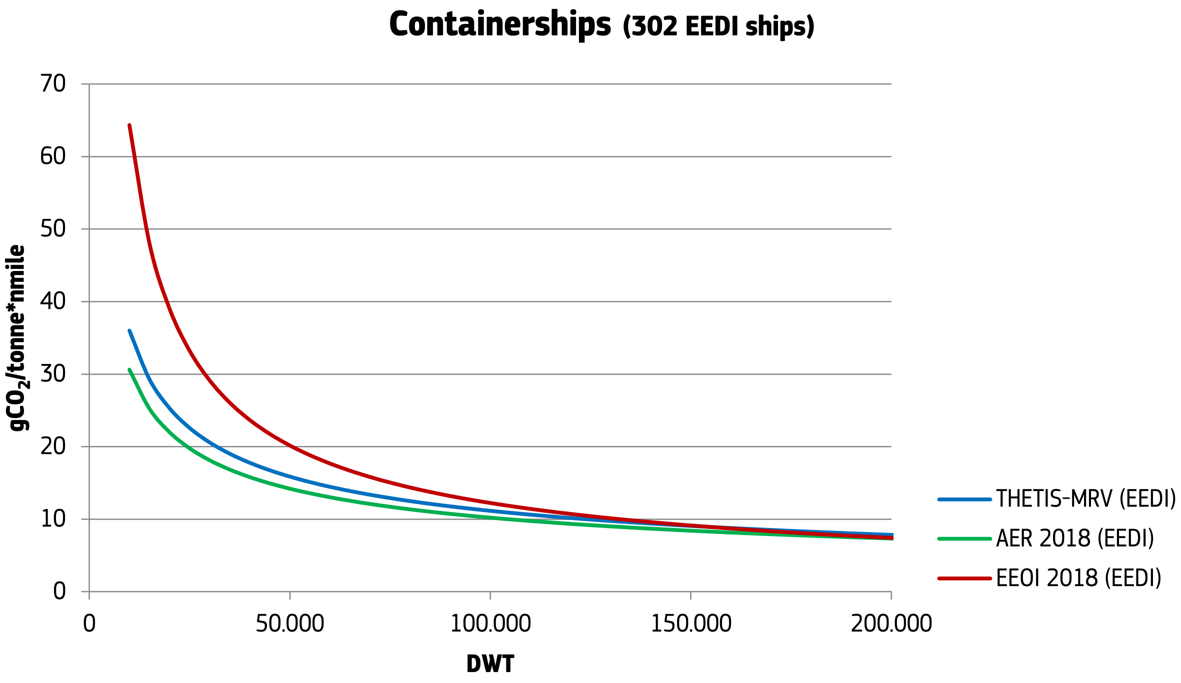


Figure 60: EEOI, EEDI and AER comparison for container ships



Sources: EMSA elaborations based on THETIS-MRV (Data extracted on 23 September 2019).
Notes: The estimation of the curve on MRV database have been performed using the same DWT range of IMO database for container ships.

Appendices

Appendix 1: Abbreviations & Definitions

AER: Annual Efficiency Ratio

BDN: Bunker Fuel Delivery Note

CO_2: Carbon Dioxide

DoC: Document of Compliance

DWT: Dead Weight Tonnage

EEA: European Economic Area

EEDI: Energy Efficiency Design Index

EEOI: Energy Efficiency Operational Indicator

EIV: Efficiency Indicator Values

EMSA: European Maritime Safety Agency

ER: Emission Report

ESSF: European Sustainable Shipping Forum

EU: European Union

EUR: Euro (€)

GHG: Greenhouse Gases

GISIS: Global Integrated Shipping Information System

GT: Gross Tonnage

HFO: Heavy Fuel Oil

ICS: International Chamber of Shipping

IMO: International Maritime Organization

ISPI: Individual Ship Performance Indicator

kW: Kilowatt

LNG: Liquefied Natural Gas

LPG: Liquefied Petroleum Gas

MCR: Maximum Continuous Rating – The maximum output that can be produced by an engine continuously without causing failure to the propulsion machinery.

MRV: Monitoring, Reporting, and Verification

NAB: National Accreditation Body

NM: Nautical Miles

NO_X: Nitrogen Oxides

Ro-pax: Roll-On/Roll-Off Passenger Vessel

Ro-ro: Roll-On/Roll-Off Ship

R^2: Coefficient of determination

SEEMP: Ship Energy Efficiency Management Plans

SO_X: Sulphur Oxides

TEU: Twenty-Foot Equivalent Unit – a measurement of a ship's carrying capacity, where the dimensions of one TEU corresponds to one standard shipping container (20 ft by 8ft).

T-nm: Thousand nautical miles

UN: United Nations

Appendix 2: Tables

Table 3: Average speed of ships per voyage, by ship type

Ship Type & Size	Number Ships	Service Speed IHS 85% MCR (knot)	Average Max Power Output IHS MCR (kW)	Total Distance MRV (nm)	Total Time at Sea MRV (hr)	Average Speed MRV (knot)	Average (AIS) Observed Speed 2008 (knot)	Average Speed Reduction MRV 2008-2018 (%)
Bulk Carrier	**3675**	**14.3**	**9312.97**	**17323.16**	**1653.63**	**10.5**	**-**	**-**
0 - 9999	32	12.1	2867.09	25859.87	2810.31	9.2	10.3	10.7
10000 - 34999	675	14.0	6350.38	18153.09	1754.10	10.3	12.2	15.2
35000 - 59999	1229	14.3	8047.91	15025.65	1423.06	10.6	12.7	16.9
60000 - 99999	1301	14.4	9634.26	18680.86	1731.70	10.8	13.1	17.7
100000 - 199999	397	14.5	16927.45	17776.84	1842.93	9.6	13.2	26.9
>=200000	41	14.5	17113.54	15059.18	1378.89	10.9	12.5	12.6
Chemical Tanker	**1700**	**14.4**	**7699.12**	**25722.89**	**2410.43**	**10.7**	**-**	**-**
0 - 4999	1	13.0	1850.00	42126.70	4474.35	9.4	10.5	10.3
5000 - 9999	100	13.5	3840.85	36432.23	3449.02	10.6	11.8	10.5
10000 - 19999	370	14.0	5550.48	28114.88	2662.76	10.6	12.8	17.5
>=20000	1229	14.6	8664.68	24094.45	2245.97	10.7	13.6	21.1
Container ships	**1744**	**21.8**	**37134.95**	**43933.89**	**3147.79**	**14.0**	**-**	**-**
0 - 999	168	17.9	8007.17	50796.03	4178.20	12.2	13.2	7.9
1000 - 1999	302	19.3	12660.15	40558.25	3462.78	11.7	15.2	22.9
2000 - 2999	222	21.3	21420.37	44345.32	3303.59	13.4	16.7	19.6
3000 - 4999	265	23.2	36022.73	49575.18	3411.35	14.5	18.1	19.7
5000 - 7999	233	24.6	53756.62	41595.85	2760.60	15.1	19.7	23.5
8000 - 11999	266	23.6	56968.99	36505.66	2367.60	15.4	20.3	24.0
12000 - 14500	143	23.8	62160.20	37429.13	2353.15	15.9	19.2	17.2
>14500	145	20.3	60175.72	55837.15	3375.56	16.5	-	-
Cruise	**152**	**20.3**	**39524.80**	**47377.80**	**3852.25**	**12.3**	**-**	**-**
2000 - 9999	7	14.9	4800.29	29887.08	2799.75	10.7	11.4	6.4
10000 - 59999	60	19.0	19047.37	40602.91	3718.05	10.9	14.8	26.2
60000 - 99999	52	22.1	49264.08	52940.74	3963.83	13.4	16.3	18.1
>=100000	33	21.2	68775.58	55069.53	4161.78	13.2	17.1	22.6
General Cargo	**1184**	**14.4**	**6227.91**	**28039.74**	**2636.42**	**10.6**	**-**	**-**
0 - 4999	13	12.9	3673.38	38247.69	3201.13	11.9	9.2	-
5000 - 9999	407	13.6	3838.31	31812.61	3177.69	10.0	11.3	11.4
>=10000	764	14.8	7544.38	25806.67	2331.82	11.1	12.9	14.2
Liquefied Gas Tanker	**505**	**17.1**	**18200.83**	**29899.41**	**2456.55**	**12.2**	**-**	**-**
0 - 4999	11	13.9	3565.91	37416.56	4035.65	9.3	-	-
5000 - 9999	77	15.1	4910.06	35787.11	3581.59	10.0	-	-
10000 - 19999	78	15.9	7319.01	29611.93	2516.13	11.8	-	-
20000 - 59999	138	16.2	10917.09	26255.18	2159.15	12.2	-	-
60000 - 79999	37	19.7	26714.22	38872.13	2822.50	13.8	-	-
80000 - 119999	143	18.9	34664.92	28205.61	2010.06	14.0	-	-
120000 - 199999	21	19.2	35769.86	25576.97	1830.13	14.0	-	-

Oil Tanker	**1410**	**14.9**	**14534.16**	**23072.10**	**2332.54**	**9.9**	**-**	**-**
0 - 4999	1	11.5	2000.00	20126.90	3594.80	5.6	9.6	-
5000 - 9999	37	12.6	3255.59	28308.35	4050.77	7.0	10.1	30.8
10000 - 19999	19	13.9	5300.00	29336.46	2762.37	10.6	10.8	1.7
20000 - 59999	160	14.8	9044.89	26008.85	2583.97	10.1	12.7	20.7
60000 - 79999	198	14.9	12021.44	16239.17	1514.58	10.7	13.4	20.0
80000 - 119999	508	14.8	13228.63	25707.94	2661.46	9.7	13.2	26.8
120000 - 199999	366	15.2	17600.68	22538.33	2243.29	10.0	13.6	26.1
>=200000	121	15.5	27112.30	18295.28	1620.47	11.3	14.6	22.7
Refrigerated Cargo	**135**	**19.8**	**10630.39**	**38992.61**	**2354.10**	**16.6**	**-**	**-**
all refrigerated cargo	135	19.8	10630.39	38992.61	2354.10	16.6	13.7	-20.9
Ro-Pax	**339**	**22.5**	**25106.56**	**73517.66**	**4597.66**	**16.0**	**-**	**-**
>=2000	339	22.5	25106.56	73517.66	4597.66	16.0	17.2	7.0
Ro-Ro Cargo	**252**	**18.9**	**14871.81**	**67817.11**	**5585.75**	**12.1**	**-**	**-**
>=5000	252	18.9	14871.81	67817.11	5585.75	12.1	14.4	15.7
Vehicle Carrier	**534**	**19.7**	**13744.30**	**38387.39**	**2629.99**	**14.6**	**-**	**-**
all Vehicle carrier	534	19.7	13744.30	38387.39	2629.99	14.6	15.9	8.4
Other Liquids Tanker	**10**	**17.3**	**13334.10**	**48493.56**	**3437.00**	**14.1**	**-**	**-**
all other liquids tanker	10	17.3	13334.10	48493.56	3437.00	14.1	-	-
(blank)	**12**	**12.2**	**11125.33**	**21535.76**	**2457.87**	**8.8**	**-**	**-**
(blank)	12	12.2	11125.33	21535.76	2457.87	8.8	-	-
Total	**11652**	**16.4**	**15142.76**	**29567.10**	**2481.39**	**11.9**	**-**	**-**

Source: EMSA elaboration on the basis of THETIS-MRV and AIS database.

Table 4: Overview of the monitored fleet

THETIS MRV Monitored Fleet				
Ship Type	**Size**	**Size Unit**	**Number of ER in the Fleet**	**%**
Bulk Carriers	0-9,999	DWT	30	0.26
	10,000-34,999		659	5.66
	35,000-59,999		1,111	9.53
	60,000-99,999		1,157	9.93
	100,000-199,999		334	2.87
	200,000-+		396	3.40
	TOTAL-Bulk Carriers		3,687	31.6
Chemical Tankers	0-4,999	DWT	2	0.02
	5,000-9,999		99	0.85
	10,000-19,999		321	2.75
	20,000-+		885	7.59
	TOTAL-Chemical Tankers		1,307	11.2
Container Ships	0-999	TEU	172	1.48
	1,000-1,999		297	2.55
	2,000-2,999		222	1.91
	3,000-4999		265	2.27
	5000-7,999		233	2.0
	8,000-11,999		265	2.27
	12,000-14,500		143	1.23
	14,500-+		145	1.24
	TOTAL-Container Ships		1,742	15.0
General Cargo Ships	0-4,999	DWT	7	0.06
	5,000-9,999		353	3.03
	10,000-+		717	6.15
	TOTAL-General Cargo Ships		1,077	9.24
Oil Tankers	0-4,999	DWT	2	0.02
	5,000-9,999		39	0.33
	10,000-19,999		63	0.54
	20,000-59,999		491	4.21
	60,000-79,999		200	1.72
	80,000-119,999		496	4.26
	120,000-199,999		348	2.99
	200,000-+		161	1.38
	TOTAL- Oil Tankers		1,800	15.4
Combination carriers	*TOTAL-Combination carriers*		*7*	*0.06*
Gas carriers	*TOTAL-Gas carriers*		*306*	*2.63*
LNG carriers	*TOTAL-LNG carriers*		*198*	*1.70*
Other ship types	*TOTAL-Other ship types*		*112*	*0.96*
Passenger ships	*TOTAL-Passenger ships*		*148*	*1.27*
Refrigerated cargo carriers	*TOTAL-Refrigerated cargo carriers*		*145*	*1.24*
Ro-pax ships	*TOTAL-Ro-pax ships*		*343*	*2.94*
Ro-ro ships	*TOTAL-Ro-ro ships*		*260*	*2.23*
Vehicle carriers	*TOTAL-Vehicle carriers*		*444*	*3.81*
Container/ro-ro cargo ships	*TOTAL-Container/ro-ro cargo ships*		*77*	*0.66*
Total Monitored Fleet			**11,653**	**100**

Table 5: Total CO_2 emissions and total fuel consumption by ship type and size

THETIS-MRV Monitored Fleet			
Ship Type	**Size**	**Total fuel consumption**	**Total CO_2 emissions**
Bulk Carrier	0-9,999	40,824.0	128,363.4
	10,000-34,999	813,961.6	2,578,653.0
	35,000-59,999	1,329,335.0	4,163,485.0
	60,000-99,999	2,014,142.0	6,311,194.0
	100,000-199,999	830,556.8	2,597,302.0
	200,000-+	660,318.2	2,083,026.0
	TOTAL-Bulk Carrier	**5,689,137.6**	**17,862,023.4**
Chemical Tanker	0-4,999	3,510.4	16,462.1
	5,000-9,999	199,780.2	629,824.9
	10,000-19,999	634,321.9	2,001,398.0
	20,000-+	2,065,855.0	6,490,979.0
	TOTAL-Chemical Tanker	**2,903,467.5**	**9,138,664.0**
Container Ship	0-999	680,105.4	2,136,168.0
	1,000-1,999	1,151,877.0	3,608,449.0
	2,000-2,999	1,298,367.0	4,059,368.0
	3,000-4999	2,147,890.0	6,717,513.0
	5000-7,999	2,057,990.0	6,431,235.0
	8,000-11,999	2,615,801.0	8,167,536.0
	12,000-14,500	1,604,265.0	5,005,027.0
	14,500-+	2,550,929.0	7,964,795.0
	TOTAL-Container Ship	**14,107,224.4**	**44,090,091.0**
General Cargo Ship	0-4,999	13,525.6	42,485.5
	5,000-9,999	518,369.8	1,631,338.0
	10,000-+	1,350,320.0	4,233,271.0
	TOTAL-General Cargo Ship	**1,882,215.4**	**5,907,094.5**
Oil Tanker	0-4,999	1,432.1	4,480.0
	5,000-9,999	57,523.3	181,154.1
	10,000-19,999	152,121.7	480,557.7
	20,000-59,999	1,207,190.0	3,813,617.0
	60,000-79,999	411,355.8	1,289,710.0
	80,000-119,999	1,921,769.0	6,063,986.0
	120,000-199,999	1,353,724.0	4,236,768.0
	200,000-+	547,230.0	1,711,760.0
	TOTAL- Oil Tanker	**5,652,346.0**	**17,782,032.8**
Combination carrier	**TOTAL - Combination carrier**	**26,892.0**	**84,088.0**
Gas carrier	**TOTAL - Gas carrier**	**792,534.6**	**2,452,061.0**
LNG carrier	**TOTAL - LNG carrier**	**1,903,895.0**	**5,467,346.0**
Other ship types	**TOTAL - Other ship types**	**329,854.7**	**1,033,029.0**
Passenger ship	**TOTAL - Passenger ship**	**2,026,514.0**	**6,367,662.0**
Refrigerated cargo carrier	**TOTAL - Refrigerated cargo carrier**	**570,700.0**	**1,782,187.0**
Ro-pax ship	**TOTAL - Ro-pax ship**	**4,344,727.0**	**13,600,000.0**
Ro-ro ship	**TOTAL - Ro-ro ship**	**1,916,224.0**	**6,046,936.0**
Vehicle carrier	**TOTAL - Vehicle carrier**	**1,608,581.0**	**5,041,300.0**
Container/ro-ro cargo ship	**TOTAL - Container/ro-ro cargo ship**	**514,422.2**	**1,611,117.0**
TOTAL Monitored Fleet		**44,268,735.2**	**138,265,631.8**

Source: RINA elaborations based on online EU MRV database accessed through THETIS-MRV (Data extracted on 23 September 2019).

Table 6: Comparing the speed and power of container ships in the monitored and world fleet

THETIS-MRV container ships with an attained EEDI value				World tanker fleet (excluding ships in the monitored fleet)				Differences %	
DWT_Range	**Number of ships**	**IHS Average Max Installed Power (kW)**	**IHS Average Service Speed (85% MRC) (knot)**	**DWT_Range**	**Number of ships**	**IHS Average Max Installed Power (kW)**	**IHS Average Service Speed (85% MRC) (knot)**	**Power**	**Speed**
0 - 9999	2	7.500	17,5	0 - 9999	34	3.072	11,8	**144,1**	**48,9**
10000 - 14999	2	8.900	18,3	10000 - 14999	100	7.025	17,1	**26,7**	**6,5**
15000 - 39999	65	17.817	20,2	15000 - 39999	278	13.652	18,8	**30,5**	**7,5**
40000 - 79999	50	37.338	22,5	40000 - 79999	166	24.176	20,2	**54,4**	**11,3**
80000 - 119999	93	51.187	23,3	80000 - 119999	186	48.355	22,9	**5,9**	**2,0**
120000 - 199999	111	54.688	20,5	120000 - 199999	212	52.723	22,5	**3,7**	**-8,8**
>=200000	9	59.628	20,0	>=200000	18	66.316	18,8	**-10,1**	**6,2**
TOTAL SHIPS	**332**			**TOTAL SHIPS**	**994**				

Source: EMSA elaborations based on THETIS-MRV and IHS data (Data extracted on 23 September 2019).

Table 7: Comparing the speed and power of bulkers in the monitored and world fleet

THETIS-MRV bulker ships with an attained EEDI value				World bulker fleet (excluding ships in the monitored fleet)				Differences %	
DWT_Range	**Number of ships**	**IHS Average Max Installed Power (kW)**	**IHS Average Service Speed (85% MRC) (knot)**	**DWT_Range**	**Number of ships**	**IHS Average Max Installed Power (kW)**	**IHS Average Service Speed (85% MRC) (knot)**	**Power**	**Speed**
10000 - 34999	78	6.388	14,1	10000 - 34999	240	5.771	13,7	**10,7**	**2,5**
35000 - 59999	196	6.741	14,2	35000 - 59999	797	7.230	14,3	**-6,8**	**-0,4**
60000 - 99999	377	8.781	14,5	60000 - 99999	1.364	9.096	14,4	**-3,5**	**0,0**
100000 - 199999	54	15.772	14,4	100000 - 199999	229	15.526	14,5	**1,6**	**-0,6**
>=200000	15	16.706	14,5	>=200000	273	19.213	14,6	**-13,0**	**-0,7**
TOTAL SHIPS	**720**			**TOTAL SHIPS**	**2903**				

Source: EMSA elaborations based on THETIS-MRV and IHS data (Data extracted on 23 September 2019).

Table 8: Comparing the speed and power of tankers in the monitored and world fleet

THETIS MRV tanker ships with an attained EEDI value				World tanker fleet (excluding ships in the monitored fleet)				Differences %	
DWT_Range	**Number of ships**	**IHS Average Max Installed Power (kW)**	**IHS Average Service Speed (85% MRC) (knot)**	DWT_Range	**Number of ships**	**IHS Average Max Installed Power (kW)**	**IHS Average Service Speed (85% MRC) (knot)**	**Power**	**Speed**
5000 - 9999	7	3.615	12,6	5000 - 9999	164	2.897	12,2	**24,8**	**3,0**
10000 - 19999	74	4.984	14,0	10000 - 19999	198	4.383	13,4	**13,7**	**4,5**
20000 - 59999	359	7.596	14,4	20000 - 59999	491	8.138	14,4	**-6,7**	**-0,2**
60000 - 79999	34	10.466	14,3	60000 - 79999	51	10.624	14,6	**-1,5**	**-2,5**
80000 - 119999	156	12.031	14,5	80000 - 119999	134	12.416	14,3	**-3,1**	**1,4**
120000 - 199999	96	16.078	14,7	120000 - 199999	119	15.995	14,8	**0,5**	**-0,4**
>=200000	37	25.147	15,2	>=200000	232	26.094	15,1	**-3,6**	**0,8**
TOTAL SHIPS	**763**			**TOTAL SHIPS**	**1389**				

Source: EMSA elaborations based on THETIS-MRV and IHS data (Data extracted on 23 September 2019).

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