Learnings from EC THETIS 2018 Report

Maritime transport plays an essential role in the EU economy. It transports 75% of EU's external trade, 36% of intra-EU trade flows and more than 400 million passengers each year at EU ports. By targeting ships above 5,000 gross tonnage, the EU MRV shipping Regulation covers around 90% of all CO2 emissions, whilst only including around 55% of all ships calling into EEA ports.

The first reporting period took place in 2018 representing the first set of reported CO_2 emissions come from more than 11,600 ships, showing 38% of the world merchant fleet (above 5,000 gross tonnage).Considering that ships can be used for 25 to 30 years, a large part of the monitored fleet is likely to still be operating in 2040, which underlines the need to address emissions from existing ships as well as new ships. Data collected from the EU MRV system confirmed that CO_2 emissions from maritime transport are substantial, with over 138 million tons of CO2 released into the atmosphere in 2018. This represents over 3.7% of total EU CO2 emissions.

Currently, CO_2 emissions from international shipping amount to around 800 million tonnes of CO2 per year, making the shipping sector a substantial contributor to climate change. These CO2 emissions represent approximately 2-3% of total global CO_2 emissions and around 97% of all GHG emissions coming from international shipping. According to the *3rd 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.

4th IMO GHG study reveals that total GHG emissions rose by 9.6% between 2012 and 2018, while international shipping GHG emissions increased by 5.6 % over the same period. The introduction of new voyage based emissions allocation, based on AIS data and tested against EU MRV data, has permitted revisions in the proportion of emission allocated to national as opposed to international voyages . As a result this has increased form 15% in the 3rd GHG study's vessel based methodology to 30 %. The implications of this change for the regulation of short sea shipping by flag states with aggressive national CO2 reduction targets remains to be seen.

Reducing CO2 emissions: A Must

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 decarbonization as soon as possible in this century. it is now crucial that effective reduction measures are swiftly adopted and put in place before 2023.

At EU Level 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.

Measures to reduce CO_2 emissions from shipping

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

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

Barriers discouraging emission reduction

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.

The lack of accurate and standardized information on energy efficiency achievements is one of the barriers to cost-effective emission reductions in the maritime sector. 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.

Monitoring Fleet Emissions

The key features that directly influence fleet emissions are such as their type, size, age, fuel, Speed and engines. Around 75% of the monitored voyages took place between ports in the European Economic Area (EEA).The monitored fleet has a total carrying capacity of about 650 million deadweight tonnage (DWT). Five types of ship(Bulk carriers 32 % ,Oil tankers 12% ,container 15%, Chemical tankers 15 % and General Cargo ship with 10%) represent more than 80% of the fleet while 16% represents 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.

-**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. 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).About 74% of total CO_2 emissions are produced by vessels built before 2013. Older vessels have the highest average level of CO_2 emissions per vessel, while younger ships constructed after 2013 emit less on average.

-**Engines** onboard ships their size and characteristics directly influence fuel consumption and CO_2 emissions. 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%).

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.

-**Speed** is a key operational indicator, as it has a direct effect on the fuel consumption and CO2 emissions. According to as study, A speed reduction of 10% can lead to a reduction of CO2 emission of around 20%.

Vessel speed is one of the key variables that directly influence CO2 emissions and varies significantly among ship types. For instance, container ships operate at much higher speeds compared to bulkers, in line with their specific business model and standards. When comparing the CO2 emissions among different ship types, containerships represented the largest share of total emissions while representing 15 % of the monitored fleet, with over 30% of total emissions around more than 44 million tonnes of CO2 at cruising speed of 14 knots for distance travled more than 77 nautical miles. In comparison, bulk carriers emitted approximately 13% of all reported CO2 emissions for a distance travelled of around 55 million nautical miles at a speed of 10.5 knots representing 32 % of monitored fleet.

Comparison made with 2008 data documented in Third IMO GHG study shows that the monitored fleet has seen an average speed reduction of around 18% over the last decade. Containers operating on high speeds approx. 40 % faster than bulkers due to specific business model and industrial standard associated, have reduced their speed up to 20 %. likewise Bulkers and Oil tankers practices the reduction of 17 % and 27% respectively on contray for Refrigerated Cargo ships increment in speed have been observed over the period 2008 -2018.

-**Fuel** Consumption is directly linked to CO2 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.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. The lower amount of fuel consumed by bulkers can mostly be explained by their low cruising speed. The use of LNG as a maritime fuel has been increasing over the past years as it significantly reduces emissions of SOx and NOx, its climate impact is negatively affected by the emissions of unburnt methane (e.g. “methane slip”).

Energy efficiency of the monitored fleet

Most monitored ships built after 2015 already comply with global energy efficiency standards applicable over the period 2020-2025 (EEDI phase 2), confirming the need to revise the reduction factors in the EEDI legislation to ensure that new ships have a higher technical energy efficiency than ships built in previous phases.

The Energy Efficiency Operational Indicator (EEOI) has a high degree of sensitivity when it comes to cargo variations, it makes difficult to compare with the Energy Efficiency Design Index (EEDI) based on ships’ carrying capacity to the Annual Efficiency Ratio (AER).

A . Technical Energy Efficiency (EEDI & EIV)

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***.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.

Analysis for categories of ships

There are indications that bulkers, tankers and Gas carriers follow similar trends in terms of attained EEDI values in both the IMO EEDI database and THETIS-MRV. On an 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.
For container ships, it is observed that the EEDI of the monitored fleet is showing lower levels of energy-efficiency compared to the IMO EEDI fleet for ships below 100,000 DWT. From the lower size-segments (below 15,000 DWT) in THETIS-MRV, ships appeared to be significantly high powered and moving at high average speed while container ships in the low intermediate size segments.

It is clear that ships trading in the EU have generally high installed engine powers (over 30%) and high design speeds (over 7%). This explains why these ships have higher attained EEDIs compared to those represented in the world fleet.

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.

Comparison between EEDI values and future EEDI standards

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 tech. energy efficiency

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). 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%).

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, 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.

Comparing EIV with EEDI reference lines.

The EIV values reported in THETIS-MRV (around 6,200) comparing with the EEDI reference lines basis, it is observed 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 different trends were observed.

B. Operational Energy Efficiency (EEOI, AER & ISPI)

In contrast to technical energy efficiency, 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).

-The Energy Efficiency Operational Indicator (EEOI) – CO2 emissions per transport work

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 CO2 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.*

- Individual Ship Performance Indicator (ISPI) – CO2 emissions per distance travelled

The EU MRV indicator that considers CO2 emissions per distance travelled (deriving from fuel consumption per nautical mile) is comparable to parameter namely “Individual Ship Performance Indicator” (ISPI). Compared to the EEOI, this indicator is considered a proxy for carbon intensity.

-Annual Efficiency Ratio (AER) – Based on CO2 emissions, DWT, and distance travelled

This operational energy efficiency indicator “Annual Efficiency Ratio” (AER),captures the ratio between CO2 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 CO2 emissions per transported tonne-mile than a ship with a higher value for AER.

Operational energy efficiency indicator (EEOI/ AER / ISPI) analysis:

The operational energy efficiency of ships (bulkers, container ships and oil tankers) being considered as the most representative ship categories of monitored fleet in terms of type and size have been assessed based on three indicators (EEOI, ISPI, and AER) that have varying degrees of sensitivity level when it comes to cargo variations and conclusions are as follows :

- 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.

- The AER values, which appear to follow similar trends as for EEOI. However, the CO2 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.

- the ISPI indicator, which considers CO2 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. Although there is no linear correlation between fuel consumption per distance, and the size of vessels.

Technical vs 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 CO2 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 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.

EIV and attained EEDI compared to AER

A comparison made between the technical and operational energy efficiency of the most representative ship categories (bulkers, tankers and container ships). AER values compared with EIV values for pre-EEDI ships. Such comparison is possible as both indicators are based on deadweight tonnage. For ships built after 2013, a similar comparison done but using the attained EEDI values reported in THETIS-MRV, instead of EIV values.

- For bulk carriers, it is observed 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 maneuvering profile, which negatively affects their average fuel consumption.

-On the other hand 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.

- 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, different trends realized for ships built before the 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.

EEOI vs AER vs EEDI

For container ships only it is of great interest to compare operational efficiency in terms of EEOI, with EIV/EEDI values. This comparison is not feasible for other ship types, as the EEOI is entirely dependent over the capacity utilization of vessels and ballast voyages.

EIV/EEDI values for container ships are calculated based on 70% of DWT, which is more comparable to real operational conditions. EEOI values are generally higher than AER values, in particular for small-to medium-size container ships. However, for larger container 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 behavior throughout the size segment.*

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.

Quality and completeness of EU MRV data : inconsistency observed for 2018

In total, 948 emission reports were added, and 476 were corrected between 1 July and 23 September 2019.The EU MRV dataset based on 11,653 emission reports submitted to the Commission. The dataset contains some inconsistencies and missing information.

a. a common problem was incomplete information on addresses for ship owners (around 17% of all emission reports) and contact persons addresses (around 30% missing).

b. More importantly, information on the technical energy efficiency level (EEDI or EIV values) was missing for around 13% of the fleet.

c. 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.

d. some irregularities were observed, including problems with the breakdown of CO2 emissions in terms of patterns of voyages. This concerns emissions of CO2 related to incoming voyages, outgoing voyages, intra-EEA voyages or emissions at berth.

e. 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).

Lessons learned from first reporting period

a. The level of coordination and cooperation between national accreditation bodies, verifiers, companies, port States, flag States and the Commission to be further improve to facilitate the implementation of the Regulation.

b. The THETIS-MRV software to be updated to include warning and error messages when companies are entering seemingly incorrect or incomplete data.

c. The Frequently Asked Questions and the THETIS-MRV online tutorials to be updated to avoid misunderstanding and misreporting