Regulatory measures to tackle climate changes

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Abstract. Until the Industrial Revolution, the concentration of greenhouse gases (GHG) (Carbon Dioxide, Methane, Nitrous Oxide, Ozone) in the atmosphere was quite constant; then human activities – such as burning of fossil fuels, industrial operations and deforestation – increased their concentrations, enhancing the natural greenhouse effect. According to the majority of the climate scientists, the warming observed since mid-20th century is mainly caused by human influence and there is a tight link between GHG pollution and global warming.
Recognizing the far-reaching and long-lasting consequences of the global warming for the planet, intense international debates at all levels take place to find possible responses to mitigate GHG emissions and reduce global warming effects.
The paper will present the high-level goals agreed at the UN Climate Changes Conferences (e.g. COP21 (Paris Agreement) and COP26) that boosted the discussion in important maritime fora and will critically review the new important and significant regulatory measures taken by the International Maritime Organization (IMO) and the European institutions and their impact on the maritime transport.
It will cover the IMO already adopted short-term measures (i.e. EEXI and CII) and the medium and long-term ones currently under discussion, such as carbon levy, life-cycle assessment and market-based measures.
A view on the very demanding climate targets in the EU for 2030 and 2050 (set by the European Climate Law adopted in June 2021) and the so-called "Fit for 55 Package" included in the legislative proposals to meet the 2030 objectives, will also complete the picture.

Keywords. GHG emissions, IMO Strategy, EEXI, CII, SEEMP, Fit for 55 Package

1. International ambitious targets set to tackle climate changes

Climate change and global warming are under everyone's eyes and it is undeniable that human activities – such as burning of fossil fuels, industrial operations and deforestation – are the main culprit of the global warming observed since mid-20th century.

Recognizing the far-reaching and long-lasting consequences for the planet, intense international debates at all levels have been opened to find possible responses to mitigate the effects taking into account the tight link between GHG pollution and global warming.

The 2015 United Nations Climate Change Conference (COP 21) in Paris agreed to keep the global temperature rise below 2° C above pre-industrial levels and to increase countries' ability to deal with climate change.

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In line with these ambitious goals, the International Maritime Organization (IMO) – strongly committed to address GHG emissions from ships since 1990 – adopted in April 2018 the "Initial Strategy on reduction of GHG emissions from ships" (Initial Strategy) [1], fixing ambitious goals for the shipping world:

- to reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008; and
- to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008.

To achieve the above-mentioned ambitious targets, the Initial Strategy contains a list of recommended short (2019-2023), mid (2023-2030) and long-term (beyond 2030) measures and is expected to be revised in 2023. In this regard and in line with the commitments taken at 26th UN Climate Change Conference of the Parties (COP26), proposals are already on the table to be discussed at IMO Marine Environmental Protection Committee (MEPC) in view of adopting a net zero target for 2050 or even an absolute-zero GHG target for 2050.

On the same path, the European Commission (EC) adopted the European Climate Law [2] on 9 July 2021 setting two very demanding objectives in the EU:

- the reduction of GHG emissions by at least 55% compared to 1990 by 2030;
- the climate neutrality, meaning 90% reduction of GHG emissions from the transport sector, by 2050.

2. IMO agreed short-term measures (2019-2023)

The IMO mandatory short-term measures have been introduced in MARPOL Annex VI and include technical and operational requirements based on a goal-based approach which will not limit the means of compliance and enable each shipowner to choose the most suitable option(s) for his specific ship and its trade. The measures include:

- the calculation and verification of a new Energy Efficiency Index for existing ships (EEXI);
- a strengthened Ship Energy Efficiency Management Plan (SEEMP); and
- a rating mechanism linked to a new operational Carbon Intensity Indicator (CII).

2.1. Energy Efficiency Index (EEXI)

Regulation 23 of MARPOL Annex VI [3] requires bulk carriers, combination carriers, containerships, cruise passenger ships having non-conventional propulsion, gas carriers, general cargo ships, refrigerated cargo carriers, LNG carriers, ro-ro cargo ships, ro-ro cargo ships (vehicle carrier), ro-ro passenger ships and tankers of 400 GT and above engaged in international voyages to calculate the Attained EEXI.

The Attained EEXI is a technical efficiency indicator expressed in gCO_2/ton*nm, corresponding to the following:

$$Attained\ EEXI = \frac{CO_2\ emissions}{\text{transportation work}} \quad (1)$$

The CO_2 emissions are calculated considering the contributions from main engines, auxiliary engines, shaft generators, and any efficiency improvement deriving from the application of innovative technologies for reducing emissions.

The transportation work is a function of the capacity in fully loaded condition, of the reference speed (calculated at that capacity and at the 75% of the rated installed power, after having deducted any installed shaft generator, if present) and of any corrective factors introduced for specific ship types and designs.

The detailed formulation and all parameters are described in the 2021 IMO Guidelines on the method of calculation of the Attained EEXI [4].

Regulation 25 of MARPOL Annex VI requires the Attained EEXI to result equal or less than the Required EEXI, as follows:

$$Attained\ EEXI \leq Required\ EEXI = \left(1 - \frac{Y}{100}\right) \times EEDI\ ref\ line\ value \qquad (2)$$

The reduction factors Y and the reference line value to be used for calculating the Required EEXI can be found in MARPOL Annex VI and are specific for each ship type and dimension.

The verification of the ship's Attained EEXI shall take place at the first annual, intermediate or renewal survey of the IAPP Certificate or the initial survey of the IEEC Certificate, whichever is the first, on or after 1 January 2023.

Ships having the Attained EEXI greater than the Required EEXI shall implement suitable measures to comply with the requirement of Regulation 25 of MARPOL Annex VI, such as, for example, engine/shaft power limitation (EPL/ShaPoLi); re-assessment of the electric power table and introduction of energy efficient consumers; speed improvement by means hydrodynamic optimization or improvement of propeller efficiency; use of alternative fuels; application of innovative energy efficiency technologies (i.e. air lubrication systems, wind assisted propulsion systems, waste heat recovery system for generation of electricity, photovoltaic power generation systems).

However, it should be noted that the above-mentioned measures are ship-type sensitive and, for each ship, depend on the operability and trade. In fact, while the power limitation may be a solution for some ship types (e.g. cargo ships), it might result in a disadvantage for others, for instance ro-ro ships due to their operability and the fact that the power corrective factor $f_{jro\text{-}ro}$ decreases the effect of a power limitation. On the other hand, the re-assessment of the electric power table and introduction of energy efficient consumers is a measure applicable mainly to passenger ships (having the auxiliary engine power calculated on the basis of the electric load balance) and not effective for cargo ships (for which the electric power table is simply a function of the total installed power for propulsion).

A critical aspect of the EEXI measure is that, although being applicable to existing ships, it has been formulated in analogy to the Energy Efficiency Design Index (EEDI) for new ships. However, for new ships all the data needed to calculate EEDI are easily available by means of dedicated “EEDI tests”, while for existing ships it is very difficult to retrieve data at the EEDI conditions. One of the most significant case is the calculation of the reference speed. According to the EEDI framework, reference speed is to be calculated by means of model tank tests and sea trials in very specific conditions (i.e. at summer load line draught), usually not applied in pre-EEDI ship tests (normally at ballast and design draughts). The EEXI Guidelines [4] introduce the possibility to approximate

the reference speed from statistical mean of distribution of ship speed and engine power or to use numerical calculation to estimate it, but among these two opposite cases in terms of reliability, there are many already available intermediate cases (i.e. speed-power curve form tank tests and sea trials close to the requested conditions) that would be appropriate to further address.

Another hot topic is the application of power limitation, defined in EEXI guidelines as “overridable power limitation”. Also in this case, it would be appropriate to better define:

- how to manage all possible power limitation solutions, including permanent power limitation, in terms of contribution in the calculation, and
- issues such as maneuvering, minimum propulsion power, NO_x and barred speed range concerns and system layout.

These uncertainties in the application of the IMO Guidelines for the calculation of EEXI [4] are currently under discussion with all stakeholders (i.e. IACS, industry associations and IMO) who are however concerned due to the imminent entry into force of the mandatory MARPOL requirements.

2.2. Ship Energy Efficiency Management Plan (SEEMP)

New Regulation 26 of MARPOL Annex VI require all ships of 5000 GT and above engaged in international voyages to which EEXI requirements apply with the addition of cruise having conventional propulsion, to include a new Part III in the SEEMP on or before 1 January 2023, detailing:

- the methodology that will be used to calculate the ship's Attained annual operational CII and the processes that will be used to report this value to the ship's flag Administration;
- Required annual operational CII for the next 3 years;
- an implementation plan to achieve the Required annual operational CII for the next 3 years; and
- a procedure for self-evaluation and improvement.

Confirmation of compliance shall be provided by the Administration or its recognized organization (RO) and retained onboard prior to 1 January 2023. The SEEMP of these ships shall be subject to verification and Company audits, taking into account the IMO Guidelines which are currently under finalization and will be published soon after the MEPC adoption.

The compilation of Part III does not present criticalities since the IMO Guidelines are sufficiently clear.

2.3. Operational Carbon Intensity Indicator (CII).

New Regulation 29 of MARPOL Annex VI requires ships - to which the new SEEMP requirements described in para. 2.2 above apply – to comply with a rating mechanism linked to a new operational Carbon Intensity Indicator, as follows:

- From 2023, after the end of each calendar year, the Attained annual operational CII is to be calculated over a 12-month period (1 January - 31 December) and electronically reported to the flag Administration/RO within March. The

Attained CII is calculated as the ratio of the total mass of CO_2 emitted to the total transport undertaken in a given calendar year, according to the 2021 IMO CII Guidelines G1 [5].

$$Attained\ CII = \left(\frac{Annual\ fuel\ consumption \times C_f}{\text{Annual distance travelled} \times Capacity}\right) \quad (3)$$

C_f represents the fuel mass to CO_2 mass conversion factor for fuel type.
The Capacity is the deadweight (DWT), for bulk carriers, tankers, container ships, gas carriers, LNG carriers, ro-ro cargo ships, general cargo ships, refrigerated cargo carrier and combination carriers; and the gross tonnage (GT), for cruise passenger ships, ro-ro cargo ships (vehicle carriers) and ro-ro passenger ships.
There is an on-going discussion to consider GT also for ro-ro cargo ships.
The formula for the CII calculation contains a number of corrections factors (factor in the CII formula to adjust the calculation of the attained CII for specific ship types and use cases) and voyage adjustments (deduction of fuel consumption and the associated distance travelled i.e. for sailing in ice conditions or scenarios which may endanger safe navigation of a ship) that have been finalized and will be published soon after MEPC adoption.

- The Required annual operational CII is to be calculated according to the 2021 IMO CII Reference Lines Guidelines G2 [6] and every year is to be reduced by a flat rate for all ship types (5% for 2023; 7% for 2024; 9% for 2025; 11% for 2026 and % still to be decided for 2027-2030).

The Administration/RO shall verify the Attained annual operational CII against the Required annual operational CII to determine carbon intensity rating A, B, C, D or E. A is the best rating, C is the minimum acceptable rating and the middle point of C is the value equivalent to the Required annual operational CII.

A ship rated D for 3 consecutive years or rated as E shall develop a corrective action plan to achieve the required annual operational CII. Such a plan shall be included in the SEEMP which shall be submitted to the Administration/RO for verification within 1 month after reporting the Attained annual operational CII

It is to be noted that the conversion factor C_f included in the formula for the calculation of the Attained CII is still based on a tank to well approach not considering the entire life cycle of the fuel. Therefore, biofuels, which are considered as one of the solutions to accelerate the decarbonization in shipping, are so far still accounted as a fossil fuel in term of carbon factor in CII calculation.

Moreover, there are practical cases showing distortions in the perception of what a “green ship” is, such as sister ships with a comparable distance travelled resulting in different Attained CII. This is due, for instance, to the fact that the transport work is expressed as travelled distance per “offered capacity” on not as actual carried cargo, resulting in a ship sailing in ballast condition with no cargo having a better rating than a sister ship sailing fully loaded with cargo. Furthermore, ships with prolonged periods without travelled distance (often for reasons outside the control of the ship’s operator) are strongly penalized by the current formulation (taking into account all the emissions - including waiting time at anchorage, stay in port, lay-up, etc. - instead of those during navigation with travelled miles only) even if they result with an absolute emission profile lower than other operating profiles.

3. IMO discussions on medium-term measures (2023-2030)

The IMO has started the discussion on medium-term measures and is evaluating the impacts of all the proposals on the table, in order to assess their feasibility and consider a possible basket of measures. These proposals include:

- establishment of a mandatory levy on all GHG emissions from international shipping and creation of an International Greenhouse Gas Levy Fund (GHGF) to collect and manage the levy;
- establishment of an emissions cap and trading system;
- development of lifecycle GHG and carbon intensity guidelines for maritime fuels (LCA Guidelines) [7]. The LCA Guidelines are expected to be finalized at the end of 2022 and will provide "Well-to-Wake" (WtW) and "Tank-to-Wake" (TtW) GHG emission factors for all fuels used for combustion and energy conversion (e.g. fuel cells) as well as electricity, for propulsion and operation on board a ship and a methodology to estimate such emission factors for all relevant fuels, fuel feedstock and production pathways. The GHGs included will be carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).
  The Guidelines will also define sustainability criteria for eligible marine fuels and contain provisions for applying a Fuel Lifecycle Label (FLL), which characterizes fuels per type, feedstock, production pathway, and relevant sustainability criteria. It is not clear at the moment whether the future LCA Guidelines will impact on the application of short-term measures (e.g. CII).

4. EU Fit for 55 Package

To deliver the 2030 climate target, the EC presented a basket of EU legislative proposals – the so-called Fit for 55 Package. The initiatives in the package concern all the sectors of EU economy, including measures for energy, climate, taxation, trade and transport, maritime included.

The most significant legislative proposals for the shipping are:

- the extension of the current EU Emission Trading System (ETS) to maritime transport; and
- the new FuelEU Maritime Regulation, aiming to increase the uptake of alternative low-carbon and zero-carbon fuels.

According to the EC proposal, both legislative measures will apply to ships of 5000 GT and above, irrespective of their flag, during their voyages either within the EU, or starting/ending outside the EU (counted at 50%) and during their stay at berth in EU ports. The emissions for the above-mentioned voyages are based on the data of MRV Regulation [8].

It is to be noted that the descriptions of the draft EU requirements are based on the EC Proposals which are still under discussion according to the EU trialogue procedure between the EU Council, the EU Parliament and the EC, therefore they are subject to changes before their entry into force.

4.1. Review of ETS Directive

From 2024 and by 31 March of each year, the Company shall submit to the responsible administering authority the verified aggregated emissions data at Company level that covers the emissions in the reporting period.

By 30 April of each year, the Company shall surrender a number of allowances equal to its total emissions except for the years falling in the "phase-in period" for which the Company shall surrender:

- 20 % of verified emissions reported for 2023
- 45 % of verified emissions reported for 2024
- 70 % of verified emissions reported for 2025
- 100 % of verified emissions reported for 2026 and after.

Where a Company fails to comply with its obligations, pecuniary sanctions will apply (i.e. 100 EUR for each tonne of carbon dioxide equivalent emitted for which allowances have not been surrendered by 30 April of each year) and, if the Company has failed for two or more consecutive years, the ship may be denied entry in EU ports.

The proposal is still a draft and during the debate the necessity to clarify certain aspects have been raised such as the need for clear contractual clause between the shipowner and the entity responsible for operating the ship, if different (e.g. charterer), in order to shift the obligations according to the polluter pays principle.

Moreover, it is expected that future revision of the Directive will enlarge the scope of application to other ships (i.e. ships of 400 GT and above) and other emissions will be counted such black carbon.

4.2. FuelEU Maritime Regulation

By 31 August 2024, the Company shall submit to the verifier a monitoring plan for each of its ships to monitor and report the amount, type and emission factor of energy used on-board and other relevant information.

From 1 January 2030, containerships and passenger ships (i.e. ships carrying more than 12 passengers, including cruise ships, high speed passenger crafts, and ships with facilities to enable road or rail vehicles to roll on and roll off the vessel) at berth in EU ports shall connect to on-shore power supply - OPS - and use it for all energy needs unless they are at berth less than 2 hours; or use a zero-emission technology; or are unable to connect to OPS due to unavailable/incompatible connection points in the port.

From 2025, the yearly average GHG intensity of the energy used on-board by each ship during a reporting period (previous calendar year) shall not exceed the reference value (still unknow and to be calculate by the EC on the basis of MRV data) reduced by an ever increasing % (i.e. by 2% in 2025 up to 75% in 2050). The calculation of the yearly GHG intensity of the energy used on-board follows a "well-to-wake" approach, assessing the entire GHG performance of fuels, taking into account the impacts of energy production, transport, distribution and use on-board.

To facilitate the compliance, the regulation foresees the possibility of banking and borrowing of ship's over-compliance (surplus) between reporting periods and pooling of compliance between two or more ships, even of different Companies but with the same verifier.

In case of compliance, by 30 June of each year, the FuelEU Certificate of Compliance shall be issued and taken onboard.

The Regulation includes penalties to be paid in case the ship has a compliance deficit and for each non-compliant port call (applicable from 2030 to containerships and passenger ships when do not connect to OPS while at berth).

5. Conclusions

Tackle climate changes is one of the greatest challenges of our century and involve all human activities and economic sectors, shipping included.

The imminent entry into force of the IMO short-term measures (1 January 2023) and the fast-tracked discussion within the EU has already shown how high the level of attention on these issues is and regulatory discussions are accelerated.

IMO short-term measures introduced indexes measuring the ship's design energy efficiency of existing ships (i.e. EEXI) and ship's operational efficiency (i.e. CII) with the purpose of pushing ships to continually improve their energy efficiency, thus reducing its emissions.

Therefore, it is expected that the green challenge will get technologically more and more difficult in future as the 2050 targets are approaching.

While clean energy technologies may be technically available as alternatives to the fossil fuels, they should become affordable and globally utilizable. This is another problem to be addressed due to the interdependencies between supply, distribution and demand of fuels and the long-life span of vessels and bunkering infrastructure.

Moreover, uncertainties on the regulatory framework, the combined application of the IMO and EU requirements which are not fully consistent and the unpredictability of alternative fuels availability and infrastructure may impair the choices of early movers and make others to waste valuable time in order to understand what the right move is.

References

[1] IMO Res. MEPC.304(72) - Initial IMO Strategy on Reduction of GHG Emissions from Ships

[2] EU Reg. 2021/1119 - European Climate Law

[3] IMO Res. MEPC.328(76) – Revised MARPOL Annex VI

[4] IMO Res. MEPC.333(76) - 2021 Guidelines on the method of calculation of the Attained Energy Efficiency Existing ship index (EEXI)

[5] IMO Res. MEPC.336(76) - 2021 Guidelines on operational Carbon Intensity Indicators and the calculation methods (CII Guidelines, G1)

[6] IMO Res. MEPC.337(76) – 2021 Guidelines on the reference lines for use with operational carbon intensity indicators (CII Reference Lines Guidelines, G2)

[7] IMO ISWG-GHG 11-2-3 - Updated draft Lifecycle GHG and Carbon Intensity Guidelines for marine fuels (EU Member States, Japan, Norway, EC and ICS)

[8] Regulation (EU) 2015/757 of the EU Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC