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Era of decarbonization, energy efficiency on existing ships (EEXI) and carbon intensity indicators (CII) implication on charter parties

Hildah Kerubo Omboga

WORLD MARITIME UNIVERSITY

Malmö, Sweden

ERA OF DECARBONIZATION, ENERGY EFFICIENCY ON EXISTING SHIPS (EEXI) AND CARBON INTENSITY INDICATOR (CII) IMPLICATION ON CHARTER PARTIES.

By

HILDAH KERUBO OMBOGA

Kenya

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.

(Signature): ……………………………………………

(Date): …… 20th September 2022. ……

Supervised by: …… Prof. Dr. Henning Jessen ……

Supervisor's affiliation: . …… Professor of Maritime Law and policy ……

Acknowledgement

God's grace and faithfulness illuminated my path daily. It's all a miraculous fluke.

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Abstract

Title of dissertation:	**The Era of Decarbonization, Energy Efficiency on Existing ships (EEXI) and Carbon intensity indicators (CII) implication on charter parties.**
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MARPOL Annex VI, an ex-ante intervention, prescribes regulations for the technical, design, and discharge of air pollution. It's not enough to build a ship as an "eco ship"; energy-saving techniques must be applied and maintained throughout its service life. The maritime industry is made up of long-lived assets, but decarbonization-related actions are predicted to cause significant disruptions this decade and next, making adaptation challenging. The global maritime industry will have a challenging decade in the years 2020s. The Marine Environment Protection Committee (MEPC76) revised Annex VI (MARPOL) to address existing ships' Energy Efficiency Index (EEXI) and operational Carbon Intensity (SEEMP/CII). Ship design and operation have technical and operational metrics. These measures are crucial to achieving the IMO's 2018 decarbonization objective of lowering shipping greenhouse gas emissions by 50% from 2008 by 2050.
EEXI circumvented grandfathering principles. The deadline of EEXI and CII implementation being January 1, 2023. These restrictions create legal and contractual lacuna that jeopardies the status quo in the maritime industry. Extra-contractual factors such as environmental preservation are rarely considered in traditional contract law. Transitioning to this new era of decarbonization necessitates redefining the contractual frameworks that support international maritime trade. While these contracts have been the bedrock of the international maritime commerce system for the past 150 years, their sufficiency for the decarbonization phase is debatable.

KEYWORDS: Charter parties, CII, Compliance, EEXI, IMO, Implementation, MARPOL, MEPC, SEEMP.

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List of abbreviation

BIMCO	The Baltic and International Maritime Council
CII	Carbon Intensity Indicator
CO_2	Carbon dioxide
DNV	Det Norske Veritas
DWT	Deadweight Tonnage
EBSCO	Elton B Stephens Company
EEDI	Energy Efficient Design Index
EEXI	Energy Efficiency on Existing Ships
EMSA	European Maritime Safety Agency
EPL	Energy Power Limitation
EU	European Union
GHG	Greenhouse Gas
GT	Gross Tonnage
ICAO	International Civil Aviation Organization
ISWG	Intersessional Working Group on Green House Gases
IMO	International Maritime Organization
IPCC	The Intergovernmental Panel on Climate and Change
ITF	International Transport Federation
KP	Kyoto Protocol
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MARPOL	The International Convention for the Prevention of Pollution from Ships
MASS	Maritime Autonomous Surface Ships
MBMs	Market Based Measures
MEPC	Marine Environment Protection Committee

MRV	Monitoring, Reporting Verification
NO_x,	Nitrogen Oxides
ODS	Ozone Depleting Substances
OECD	The Organization for Economic Cooperation and Development
ORC	Organic Rankine Cycle
SDG	Sustainable Development Goals
SEEMP	Ship Efficient Design Index
SO_x,	Sulfur Dioxide
SSY	Simpson Spence and Young
TCO	Total Cost of Ownership
UNCTAD	United Nation Conference on Trade and Development
UNFCCC	The United Nation Framework Conventions on Climate Change
UN	United Nations
VOC	Volatile Organic Compounds
WHRS	Waste Heat Recovery Systems
WP6	Working Party on ship build

1. INTRODUCTION

1.1 Background

Climate has already evolved beyond its natural variability, as human societies developed. Climate change is a complex policy subject. Climate change results in sea levels rising, storm waves is worsening, precipitation, snowfall patterns are shifting, and glaciers melting (Paskal, 2010). Threatening ecosystems, water, food, health, communities, and civilizations (IPCC, 2007). In 2018, 39 million persons were impacted by climate-related catastrophes such wildfires, hurricanes, droughts, floods, which can be traced back to the rising climate crisis fueled by GHG emissions (UN, 2020). 2019's carbon emissions were the highest in 2 million years (IPCC, 2021).

Anthropogenic activities have a direct impact on international politics. International shipping exacerbates environmental damage. Existing international regimes have left room for ambiguity in interpretation, posing significant risks to the sector and global trade; there is a lack of practicability, fairness, and equity, particularly the polluter pays principles to guide specific contracts such as time charters. Legislators must establish a legal framework and make it stricter by updating regulatory decisions since environmental issues arise before contracts are signed, and these principles are not reflected in any conventions (Eftest-Williamson, 2011). Contracts for sustainable transportation have potential to alter contractual norms in the maritime industry(Eftest-Williamson, 2011). Sustainable transport contracts potentially influence maritime industry contractual norms.

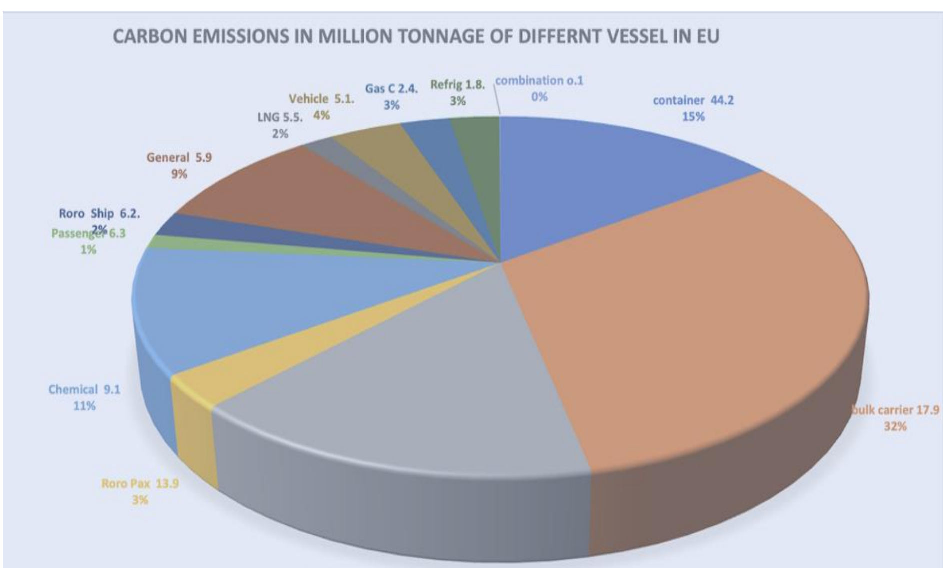
1.1.1. International commercial ships' carbon footprint

Shipping, a vital part of commerce provides 90% of worldwide tonnage transit, and the cheapest mode of transportation compared to others (Kaps, 2004). Diesel engines built the maritime sector, was based on century-old technology, they are reliable, efficient, cost-effective, and easy to maintain (Inal et al., 2022). Diesel engines ships dominated the maritime industry for decades owing to their ability to operate on heavy fuel oil and marine diesel oil (Corbett, 2004). These low-cost fuels contained dangerous compounds for the engine and the environment, such as GHG.

In 2012, shipping industry generated 977 million tons to the global total GHG emissions (IMO, 2020). Data from IMO (2020, as cited in De Beukelaer 2022), CO_2 emissions in 2018 rose by 9.6% to a total of 1,056 million metric tonnes, accounting for 2.89% of the overall anthropogenic carbon emissions of 36,573 million metric tonnes (IMO, 2020). Balcombe et al., (2019 as cited in De Oliveira, et al., 2022) inferences shipping the 6th largest emitter in the world, surpassing Brazil, and Germany. EMSA's THESIS MRV statistics 2019, maritime transport represented 3.3% of the EU's total CO_2 emissions, with container ships accounting for one-third and bulk carriers accounting for 13% represented in Figure 1.

Figure 1

CO2 emissions per transport work (gCO2/tonne-NM) from the shipping industry in 2019 in the EU for different ship types.

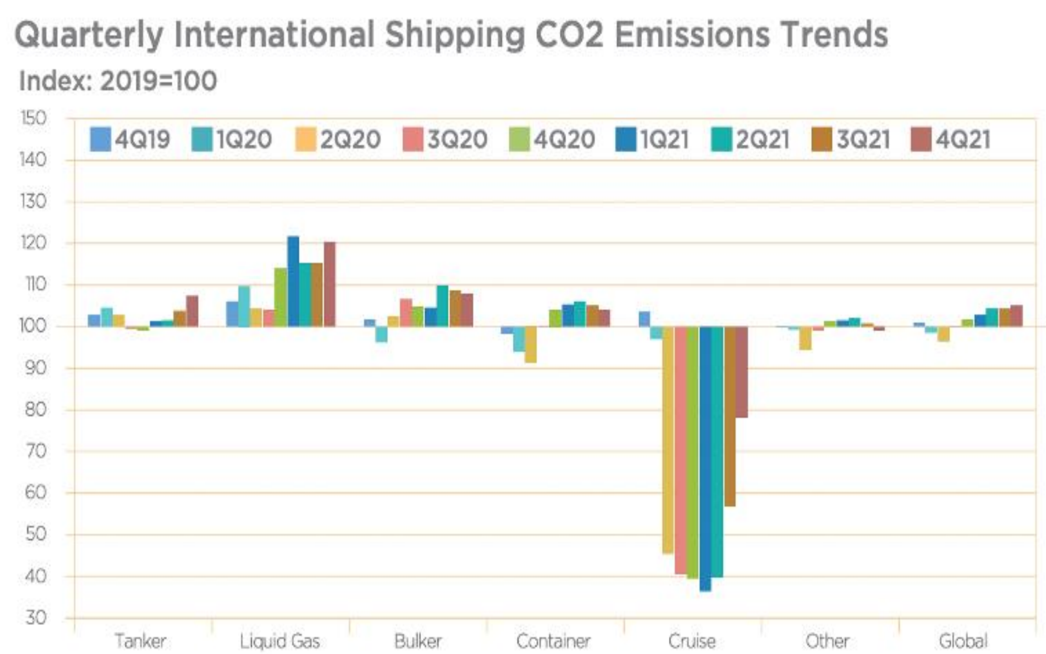


Note. Adapted from" EU MRV DATA", EMSA\THETIS MRV 2019. https://mrv.emsa.europa.eu/#public/emission-report

Data from Automatic Identification System, global shipping CO_2 emissions in 2020 was 800 million tonnes, rising to 833 million tonnes in 2021 (Marine Benchmark, 2022 as cited by SSY (2022), surpassing 2019 levels. *Figure 2 represents yearly, quarterly trend of carbon print(2019-2021)*, despite stricter regulation and reduction goals. The resurgence of global economy following Covid 2019 spurred the proliferation of consumer goods and services, port congestion, greater ton-mile trade, higher streaming speeds along some routes, and longer ton-mile commerce contributed to a spike in CO_2 emissions in 2021(SSY, 2022).

Figure 2

Quarterly Trends in Shipping CO2 Emissions.

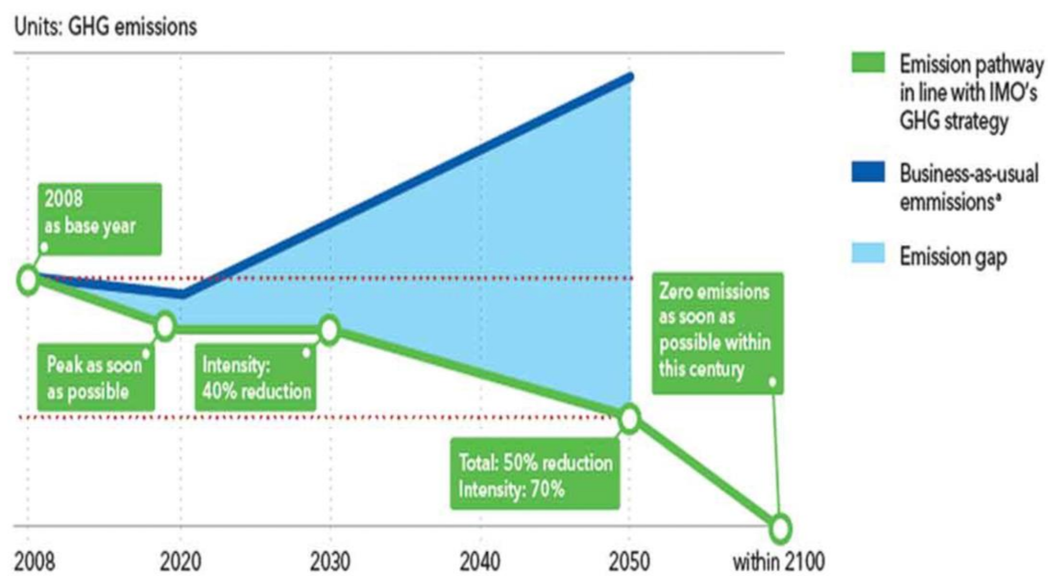


Note. From "outlook 2022", Simpson Spence Young Outlook, SSY 2022, p. 44 (https://www.ssyonline.com › ssy-2022-outlook-final)

Shipping industry CO_2 emissions are expected to surge from 1,000 Mt in 2018 to 1,500 Mt in 2050 if no action is taken to curb its production, presenting 0–50% growth compared to 2018 and 90–130 % increase contrast to 2008 levels (IMO, 2020) illustrated in Figure 3. Maritime CO2 emissions continue rising due to a growing population, more resource consumption, globalization, global civilization (Kaps, 2004), technical developments, increased maritime traffic, and the rise of modernity.

Figure 3

IMO GHG strategy vs. BAU emissions



Note. From "Potential decarbonization strategies for a new LNG carrier design" DNV, 2022. https://www.dnv.com/expert-story/maritime-impact/Potential-decarbonization-strategies-for-a-new-LNG-carrier-design.html.

1.1.2. IMO, Maritime carbon emission reduction framework for the maritime industry.

Kyoto Protocol 1997, required industrialized nations to investigate lowering marine bunker fuel GHG emissions by internationally negotiated quantifiable emission limits and establishment of multiple market-based mechanisms to achieve their targets (Kyoto

Protocol, 1997). Shipping emissions were exempt from the KP's mandatory emission reduction targets because maritime transport lacks a nationality (Gritsenko, 2017) and states disagreements over country-by-country emission allocation (Oberthür and Ott, 1999).

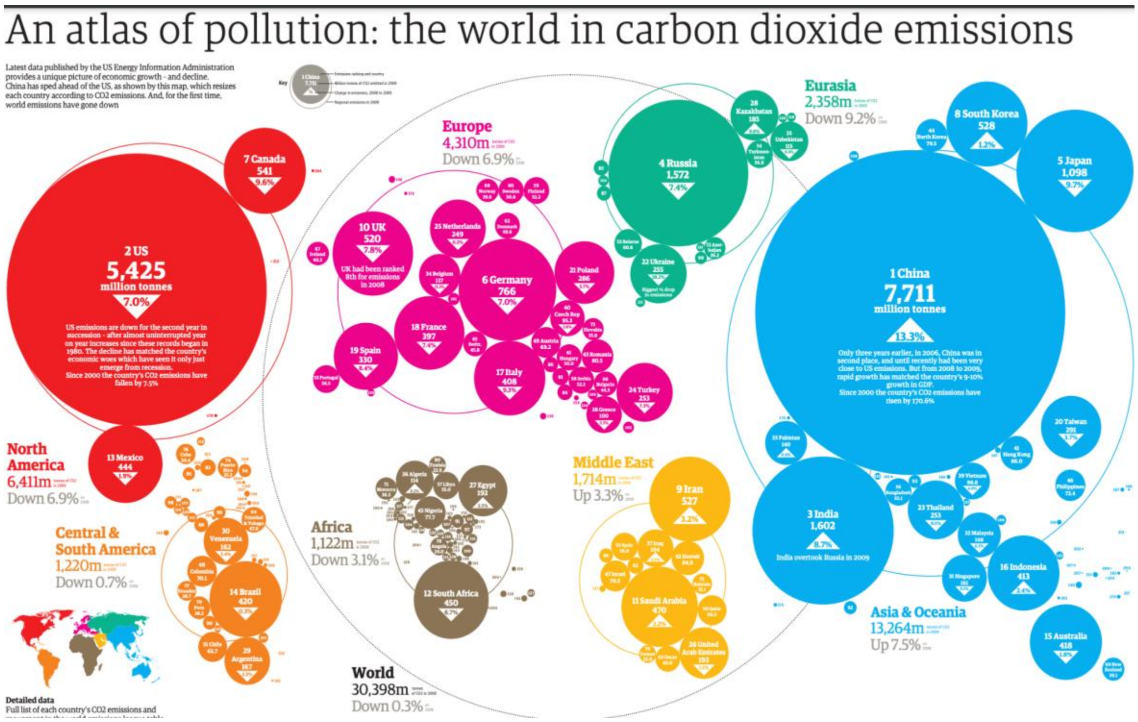
Kyoto Protocol,[1] endorsed IMO jurisdiction to regulate international Commercial shipping, conforms with UNSDG 13, that mandates swift response to mitigate climate change and all sectors cooperation to limit the average global temperature rise below 1.5^0C for climate change initiatives to succeed.

The Paris Agreement expanded on the Copenhagen Accord of 2009 as well as the Cancun Agreements of 2010, endeavoring to prevent global warming "*far below 2 ° C above pre-industrial levels*" shipping emissions were not considered(Sirimanne et al., 2019). National emission targets were pursued (Sirimanne et al., 2019), as part of the bottom-up ideology of the Paris architecture, each country offered its "nationally decided contributions" describing strategies to reduce its carbon footprint (Bodansky, 2016) shown in *Figure. 4* IMO targets to halve shipping's 2008 carbon footprint by 2050, under the component of Paris Accord, ratified in 2015 and effective in 2018(IMO, 2018).

[1] *Article 2.2. Kyoto Protocol*

Figure 4

National emissions of Co2

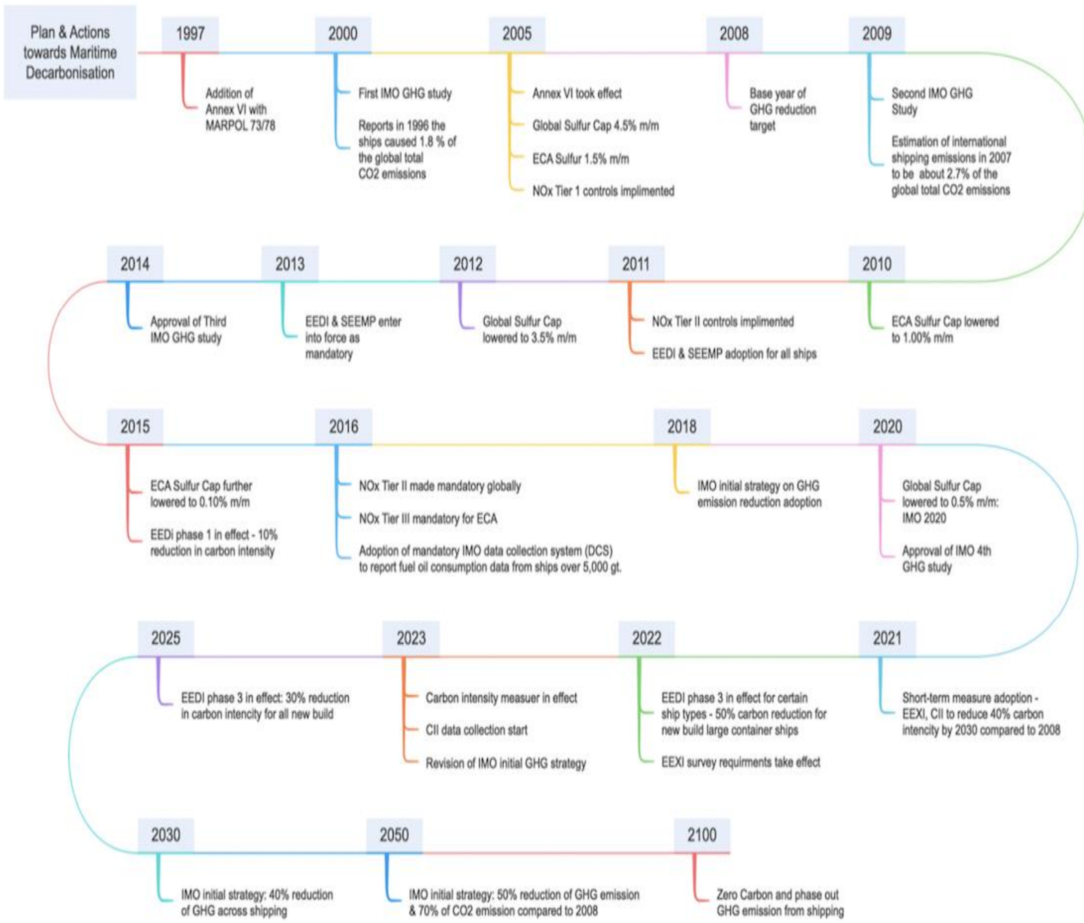


Note. From "An Atlas of Pollution: The World in Carbon Dioxide Emissions" Guardian, 2011, https://www.theguardian.com/environment/2011/jan/31/pollution-carbon-emissions.

The MARPOL Convention was revised with the 1997 Protocol, Air pollution from ships was addressed by adopting Annex VI[2](IMO, 1998). MARPOL annexes have transmogrified IMO's environmental protection rules in the last 20 years, Figure *5 illustrates international shipping decarbonization timetables from 1997 to 2100.*

Figure 5

Decarbonization timescales for international shipping.



Note. From, "Alternative Marine Fuel Research Advances and Future Trends: A Bibliometric Knowledge Mapping Approach", Moshiul et. al., 2022, *Sustainability*, *14(9), 4947*. *https://doi.org/10.3390/su14094947*

IMO passed Resolution A.963 (23) on December 5, 2003, MEPC was advised to investigate and devise measures to restrict GHG emissions (Wan et al., 2018, IMO, 2003). Preventing Air Pollution from Ships in MARPOL Annex VI aimed to reduce pollutants transmitted by ships:- NOx, ODS, shipboard incineration, SOx, VOC, leds to increased CO2 emission with no regulations to curb them (Bouman, et al., 2017). MEPC 55 approved a work plan in 2006 focusing on technical design, operational, and market-based measures.

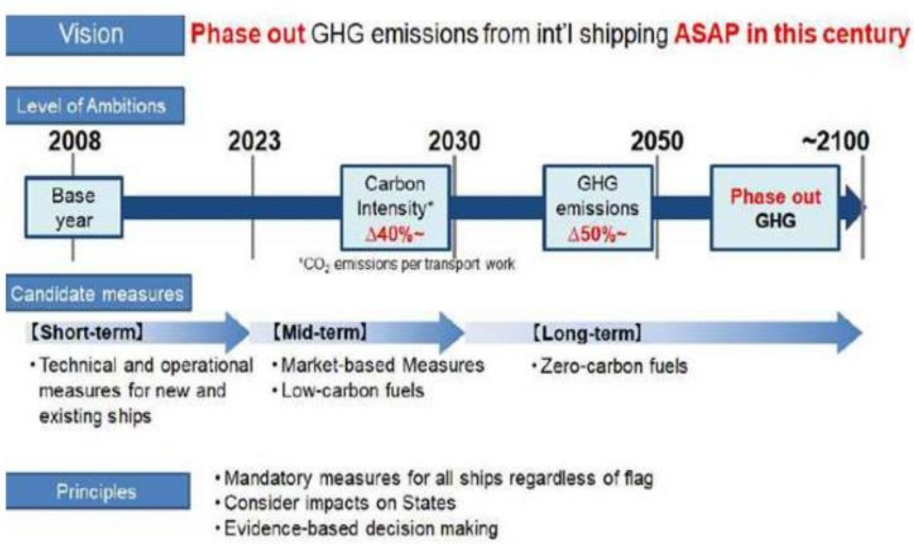
The preeminent Programme components led to voluntary measures in 2009:- intermediate recommendations on computing and confirming Energy Efficiency Design Index(EEDI) for new ships (UNFCCC, 2009), guidance on developing a Ship Energy Efficiency Management Plan(SEEMP) for new and existing ships that finest integrate practices for use of Fuel Efficiently on Ships operation, and recommendation for unilateral use of the Ship Energy Efficiency Operational Indicator(EEOI) for new and older vessels (UNFCCC, 2009) allowing operators to examine vessel fuel efficiency (UNFCCC, 2009).

IMO's first commitment to the global mandated GHG reduction regime for ships was established in July 2011(Psaraftis & Kontovas, 2020) at the 62nd MEPC meeting, adding MARPOL Annex Chapter VI, on energy efficiency, establishing EEDI and SEEMP mandatory for new ships, must be constructed and envisaged to be more energy efficient than that of the baseline, and for all other ships, the requirements are based on the mandatory SEEMP. SEEMP mandates operators to implement ship-specific energy-saving methods. This law applied to 400 GT ships as of January 1, 2013, aimed to lower carbon emissions from international commerce ships. Since adopting these amendments, the MARPOL parties have adopted detailed guidelines for EEDI and SEEMP, as well as guidelines for the unilateral use of Energy Efficiency operational indicators (EEOI), which measure fuel efficiency and serve as a streamlined auditing indicator and metric for monitoring operating effectiveness (IMO, 2014, Bodansky, 2018).

IMO began debating market-based mechanisms (MBMs) to reduce ship GHG emissions (Psaraftis & Kontovas, 2020), but the roadmap was adopted in 2016, MEPC 70 adopted a proposal to build a road map for the overall IMO strategy for reducing GHG emissions from ships, and it created short-, mid-, and long-term measures to implement the strategy by 2023. In 2018, the IMO approved its initial strategy to reduce greenhouse gas emissions from ships. The strategy aims to decrease the carbon intensity of shipping (Emissions of co2 per transport work) by a baseline of 40% in 2030, 70% by 2050, and also to peak international shipping greenhouse gas emissions (GHG) with at least a 50% reduction of aggregate GHG emissions in 2050, relative to 2008 levels. (IMO, 2018). The inaugural IMO GHG policy sets varying goals for decreasing carbon emissions in international shipping. The 73rd MEPC June 2018 (IMO, 2018a) negotiated an authorized roadmap outlining the IMO strategy for GHG emission reductions through 2050, as well as following initiatives, with the plan's completion date set for 2023 (Psaraftis & Kontovas, 2020) The Strategy divides emission reduction efforts into:- short-term goals by 2023, with a focus on speed reduction and operational optimization, medium-term market-based actions anticipated for 2023-2030 long-term initiatives for 2030-2050 for alternative fuels shown in Figure 6

Figure 6

IMO GHG initial strategy priorities and measurements.

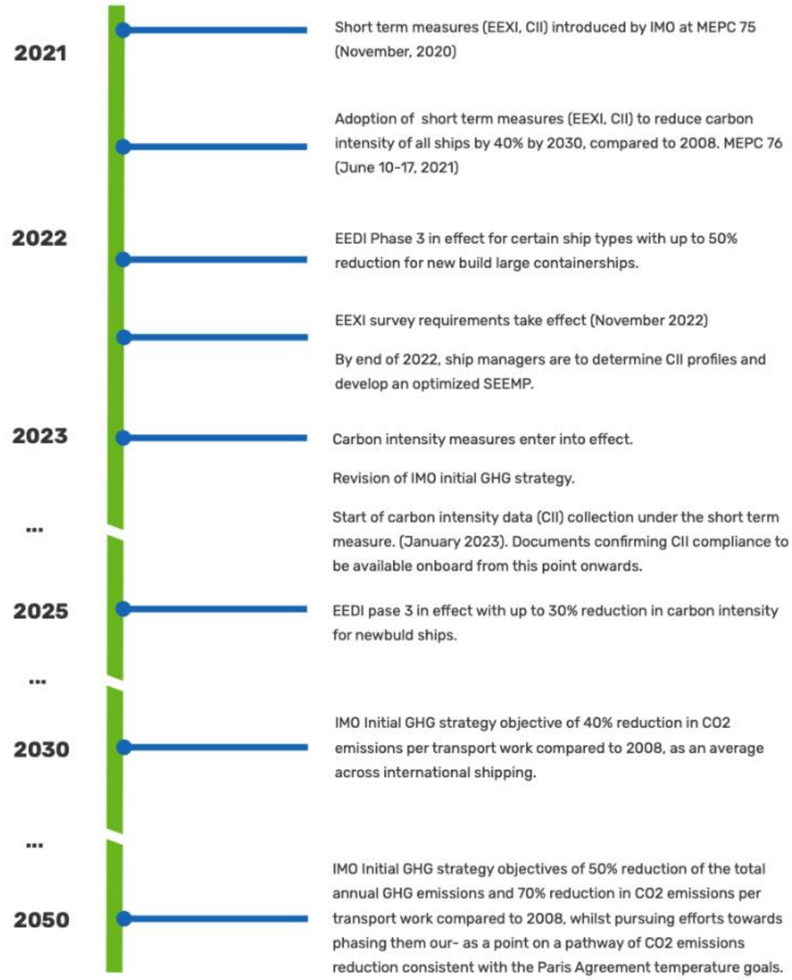


Note. From "Roadmap to Zero Emission from International Shipping (Special Feature Articles on Reduction of GHG Emissions)", NISHIMURO, M. 2020, Classnk Technical Journal, 2020(1), 13-20.

The IMO drafted revisions to Annex VI in November 2020, and MEPC 76 adopted new Annex VI (MARPOL) standards in June 2021, with a target on vessels for decarbonization, energy efficiency broadening from newly constructed vessels to existing vessels (Kim, 2021), and the mechanism of reduction shifting from the vessel's design and technical features EEDI and EEXI operational aspects and in CII (IMO, 2021). MARPOL Annex VI amendments and EEXI and CII accreditation deadlines are November 1, 2022, and January 1, 2023. In 2023, the first report and rating are due. Shipowners must follow these guidelines. New ship requirements are based on the EEDI, which means they must be more energy efficient than the baseline. Existing ship requirements are based on the SEEMP. SEEMP mandates operators to implement ship-specific energy efficiency methods (IMO, 2021). *Figure 7 depicts CII, EEXI, and IMO actions after 2021*

Figure 7

CII, EEXI, and IMO actions after 2021

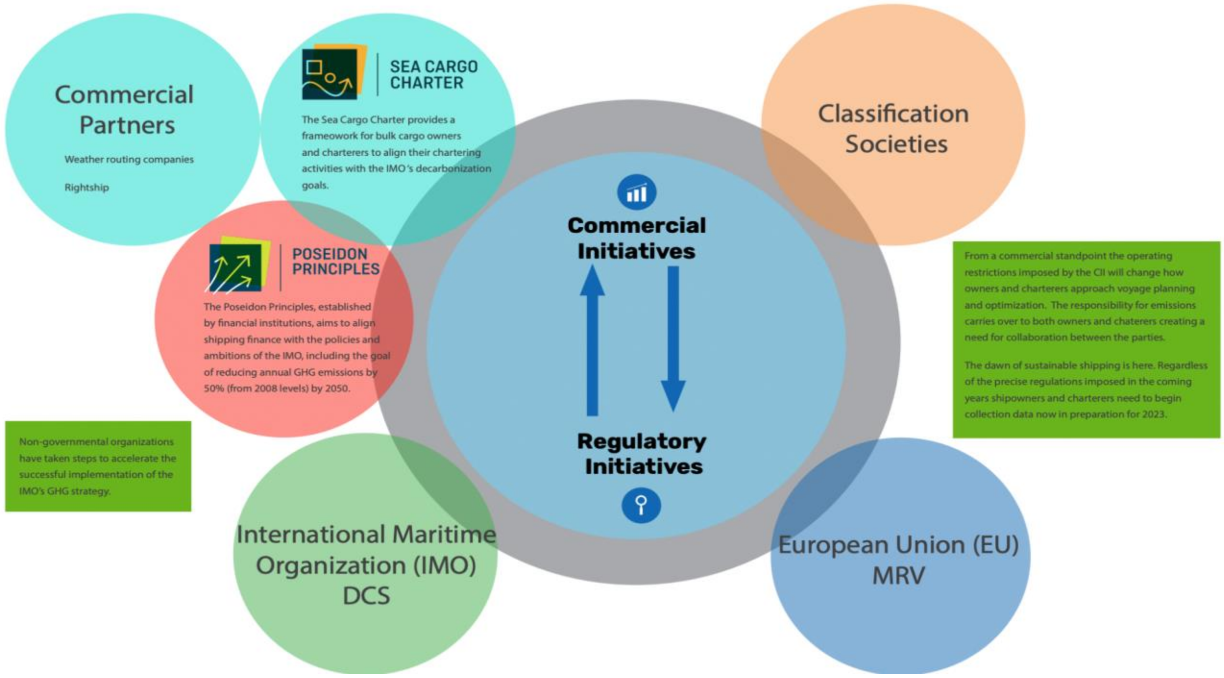


Note. Maritime Decarbonization, a regulatory explainer", true north marine 2022 https://tnmservices.com/whitepapers/Emissions_White_Paper.pdf

Shipping is a worldwide industry with various participants operating explicitly and implicitly as shown in Figure 8 and how they impact energy-efficiency measures in a broad range of situations.

Figure 8

Different stakeholders and enforcement regime



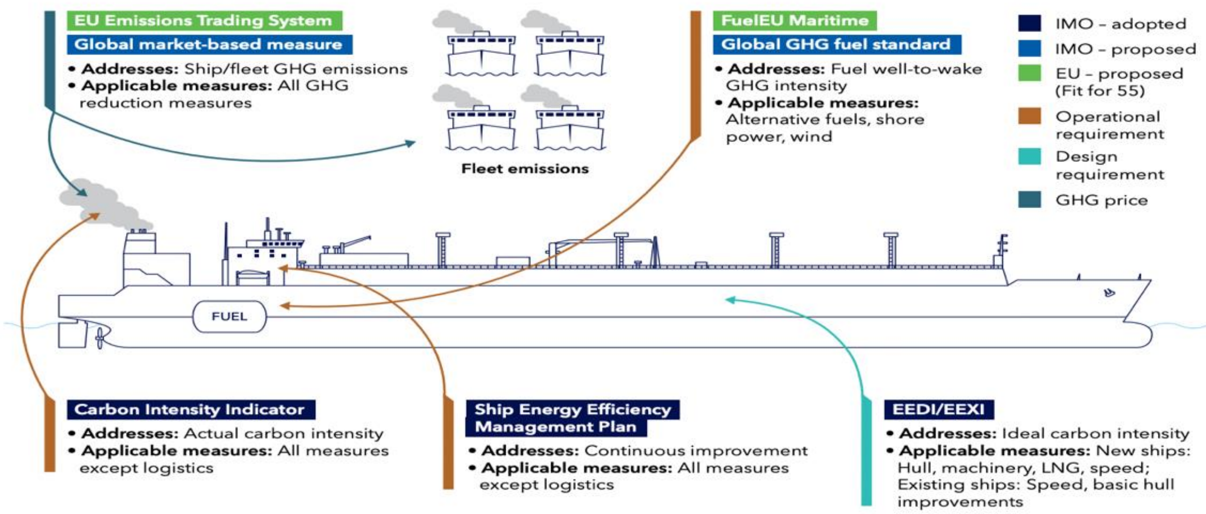
Note. From "Maritime Decarbonization, a regulatory explainer", true north marine 2022 https://tnmservices.com/whitepapers/Emissions_White_Paper.pdf

The shipping sector advocated for IMO carbon emission regulations at COP26 so it could decarbonize fully. UNFCCC and other UN climate bodies must work closely with maritime value chain participants. Given the irreversibility of biodiversity loss and rising carbon emissions, the sooner we limit carbon emissions, the better for the international shipping industry. Future generations require a global behavioral revolution. Growing support exists for more dramatic legislation reforms. Clean Shipping Coalition and Pacific Environment presented a new regulatory proposal to the IMO in March 2020(Chou et al., 2021) to cut CO2 emissions in half by 2030, up from 40% in April 2018. The same proposal recommended assessing carbon intensity for every journey to make charterers more accountable for their operational actions

The environmental regulation portfolio benefits from IMO and regional efforts. The European Commission proposed "Fit for 55 packages" on July 14, 2021, by 2030, the EU's GHG emissions will be cut by 55% (European Commission, 2021). The EU may decarbonize by 2050 (Schlacke et al., 2022). New and tougher EU shipping laws include the European Trading System Directive, the Fuel EU Maritime Regulation, and the Energy Taxation Directives. EU Shipping regulations (European Commission, 2021) could hamper efforts to minimize carbon emissions. Shipowners and operators will need to comply. Violators risk fines and banishment from EU waters. Figure 9 illustrate the EU and the IMO regulatory framework towards decarbonization.

Figure 9

EU and IMO regulatory framework for GHG



Note: From, "Maritime forecast to 2050, Energy Transition Outlook 2022, DNV, 2022, https://eto.dnv.com/2021/maritime-forecast-2050/about

1.1.3. Rationalizing commercial decisions

a) Maritime economics

Watson et al. (2021, citing Watson 2019), argued that a shipping entity, like any other, generates capital. It alters the form of capital from one form to another (Watson et al., 2020), particularly by increasing the value of export products and economic capital by getting them closer to the end consumers. This is a centuries-old trade that has thrived along the Euphrates and Tigris rivers for thousands of years. The capital model remains the same, but it is now substantially more capital, energy, and information-intensive (Lind et al., 2021).

Shipping markets are platforms whereby economists can observe and analyze the classic pig cycle to precision since not only the supply and demand sides, but also market outcomes (the freight rate) were relatively well recorded (Lemper, & Tasto, 2015). The requirement for freight transportation is designed to reflect the demand side, while the ships that deliver the products are believed to depict the supply side; these entities interact in the freight market (Lemper & Tasto, 2015), where the service is ordinarily traded for US dollars (Lemper & Tasto, 2015). Energy-saving solutions, according to shipowners, should swiftly pay for themselves in terms of economic return, and external costs will be absorbed. Fuel price fluctuations, coupled with volatility in the maritime domain, heighten investment risk. Considering this risk, a short-term investment strategy in energy efficiency solutions is required (Kaya & Erginer, 2021). Energy efficiency measures with the highest performance values and certification status are operational, not retrofit, measures (Kaya & Erigner, 2021). This means that shipowners go to great lengths to prevent risks. Shipowners are wary of investing in innovations that require intensive planning, procurement, and installation, as well as large expenditures and shipyard oversight (Kaya & Erigner, 2021). The total cost of the EEXI modification and CII will be reflected in higher freight pricing.

b) Management systems

Shipping firms must cut energy use to comply with SEEMP, EEOI, and EEDI. ISO 50001 worldwide standards (Johnson et al., 2013). ISO 50002[3](Von Knorring, 2019, Krmek,

[3] Energy Audit

2021), ISO 50003[4](Fedoskina, 2016),ISO 50004[5] (Krmek, 2021). ISO 14001 can increase SEEMP implementation (IMO, 2012, IMO, 2022) by incorporating operational environment efficiency into a company's management system (Yülek, 2018).

Implementation, maintenance, and enhancement of energy management systems (Fedoskina, 2016), are used to demonstrate consumption reduction to third parties. Requirements with usage guidelines and allied standards are catalysts for implementing ship operating energy efficiency as illustrated in Figure 10. Energy is substituted with "emission."

Figure 7

Emission management principles following ISO 50001[6]

Note. From, "*Abatement of GHG Emissions Onboard Mobile Offshore Units.*" *Ng, C., Li, J., Mishra, R., & Fagan, C. 2022, Abatement Of GHG Emissions Onboard Mobile Offshore Units. Journal Of Physics: Conference Series, 2311 Doi:10.1088/1742-6596/2311/1/012036*.

c) Charters

[4] Requirements with guidance for use Energy management systems,

[5] Requirements for bodies providing audit and certification of energy management systems, Energy management systems - Requirements for audit and certification

[6] Energy management systems - Requirements with guidance for use.

Charterers can drive change instead of a ship owner (Rehmatulla et a., 2017), a charterer may win the "first, not second" race. Cargill, Huntsman, and UNIPEC UK declared in October 2012 that they will no longer charter the fleet's least efficient ships using Right Ship and the Carbon War Room's A to G GHG Emissions Rating (Rehmatulla et al., 2017). As a result, many of these corporations are not shipping their cargoes on F or G rated vessels (the least efficient in the fleet). Improving fuel efficiency is now imperative to remaining competitive (Stulgis et al., 2014)

Corporate Social Responsibility (CSR) initiatives at large firms, notably those with a public profile on stock exchanges, encompass declarations that vessels chartered by the company to transport its cargo complies with sustainability rules and procedures (Armstrong & Banks, 2015). This decision comes as customers prioritize energy efficiency and low-carbon supply chains in the face of mounting climate change concerns.

d) Enforcement of MARPOL Annex VI

MARPOL Annex VI is enforced under port state jurisdiction [7] and the nondiscriminatory concept applies to both MARPOL parties and non-parties[8]. Coastal governments may also conduct enforcement actions against vessels in nearby waters[9] and may extend to the economic exclusive zone[10].

The current regulations do have the potential to destabilize the shipping industry and may rewrite commercial shipping terms of the contract. What constitutes a seaworthiness obligation, scope of warrant is expanding, and failure to comply with any international, national, state, or local government entity laws, regulations, and policies, including MARPOL 1973/1978, will impede a vessel's ability to earn a profit from its commercial

[7] Article 5(2), MARPOL
[8] Article 5(4), MARPOL
[9] Article 4(2) MARPOL
[10] UNCLOS, Art 211(4), Art 211(2).

activities. Owners and charterers will negotiate who pays for and meets EEXI and CII criteria.

Technical as well as contractual initiatives, should improve shipping energy efficiency. The adoption of sustainable transportation contracts may result in a shift in maritime contractual requirements. Demurrage, laycan, utmost dispatch, speed guarantees, ballast cruises, and off-hire have evolved in marine contracts to share the cost of operational inefficiencies between ship owners and charterers (or buyers or sellers of cargo). As cited by Johnson & Andersson (2016); Psarros (2017); Psarros & Mestl (2015) deduced that the scontractual framework of charter party agreements must accommodate the capability to tackle energy efficiency comprehensively in to fully reap the rewards of a global shipping community's endeavors for greener performance.

1.3. Aim and objectives

Considering the IMO's compliance requirements for reaching the short-term goal on the technical and operational aspects of Existing Ships, which is a retrospective factor, this research reviews prior work on EEXI, CII, and charter parties; the obstacles faced by the shipowner towards compliance; and the parties whose obligation it is to ensure compliance.

This research explored and synthesized EEXI and CII compliance literature to map what is known about charter party compliance, who will pay the costs, and what needs to be investigated further. This review looks at any published risk, including its topic, nature, study technique, and theoretical context. Locations, sample sizes, and situations are considered.

This evaluation considers private law and the enforcement of environmental regulations. The similarities in the effects and approaches of literature are explained.

This study reconciles discordant research findings. The issues raised in the review are then used to provide a list of areas that require further investigation, and the vessel's energy efficiency specification could be included in any alterations or amendments to the applicable charter party contract provisions.

1.4 Research questions

This study is aimed to provide answers to the following questions:

1. What precisely are EEXI and CII Regulations?
2. What are the proposed measures for implementing the EEXI and CII into operation?
3. What technical and operational efforts are being made to implement the IMO 2023?
4. What obligations and clauses are affected by EEXI and CII implementation?
5. What contractual solutions are recommended for ship owners to include in their contracts in terms of ship efficiency and GHG emissions?

1.5 Research Methodology

Research methodology is "a systematic algorithm for solving a research topic" (Kothari, 2004:). This encompasses all a researcher's actions performed to answer a research topic, as well as the underlying philosophy and methods or strategies employed.

This section discusses the study's research strategy, data collection methods, and data analysis methodologies. This study employed a qualitative approach as well as a systematic examination of the literature and legal research technique.

1.5.1 Qualitative research

Qualitative research methodology emerged as a suitable method for the collection and analysis of data. The hallmarks of qualitative research design are the ability to find information, interpret it, and comprehend it (Yilmaz, 2013). The ability to uncover information, interpret it, and comprehend it are hallmarks of qualitative research design (Yilmaz, 2013). The study intends to openly investigate the problems surrounding the implementation of EEXI and CII in the shipping industry, both before and after, which makes the qualitative approach acceptable due to its ability to reveal nuances in private contractual occurrences. The approach's ability to handle enormous quantities of text.

1.5.2 Systematic literature review

Pickering and Byrne (2014), a review can be conducted using a variety of known and emerging methodologies, which can be broadly classified as meta-analysis, classic narrative review, and systematic literature review. A systematic literature review was selected as the methodology in this study because of the significance of obtaining a complete picture of the topic and it can guarantee that all relevant literature in a particular research stream is included. A systematic review is a review of a clearly defined subject that uses systematic and explicit procedures to identify, select, and critically appraise relevant research, as well as collect and analyze data from included studies. Statistical approaches (meta-analysis) may or may not be used to appraise and summarize the findings of the included research. Meta-analysis refers to the use of statistical tools in a systematic review to combine the findings of included studies (Moher, 2009). This study's systematic review process was adopted from Petticrew and Roberts (2006) and Pickering and Byrne (2014). This methodology incorporated several ideas offered for the extensive survey conducted. When doing this review, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards were followed.

This is a novel title, and few scholars are focusing on a systematic and cross-disciplinary studies to establish the effects of EEXI and CII application on charters, obligations, liabilities, and implications for the maritime industry.

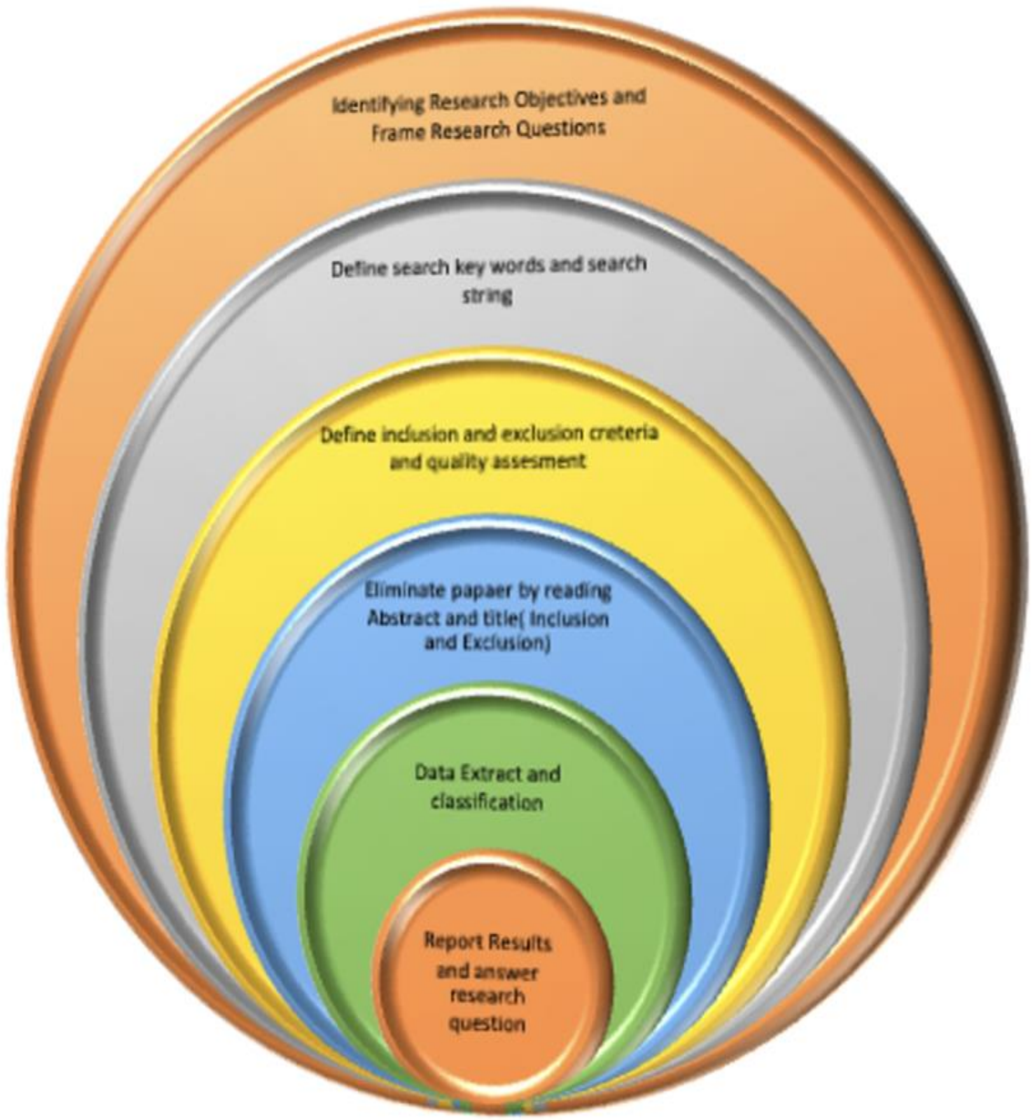
1.5.3 Survey methodology

A meta-study of systematic review publications in, technical, operational, and energy efficiency, and charter parties was done to investigate how scholars in this area conducted and reported systematic quantitative literature reviews. This systematic review was carried out by formulating the research questions, discussing information sources, collectioning criteria, quality assurance, and drawing findings. *The process flow chart is shown in*

Figure 11. The resulting search strings included only relevant keyword combinations from a given domain. Finally, inclusion and exclusion criteria were developed to include only relevant research publications.

Figure 8

Survey methodology



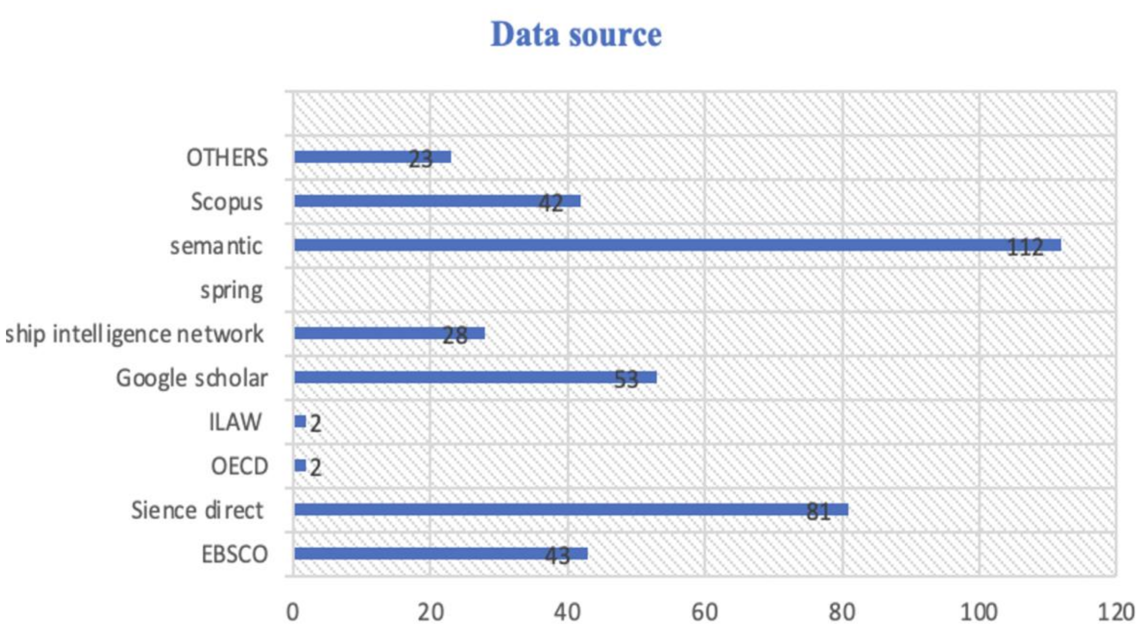
Note. By author

1.6 Source of information

This study gathered more relevant EEXI, CII, Charter Parties, operational, technical measures, design energy improvement, and energy efficiency publications through rounds of data collecting. Scopus, Semantic Scholar, EBSCO host, Science Direct, Hein online, I law, IMO Vega, OECD Energy, library, Clarkson Research service, ship intelligence network, and Google Scholar were used in the initial search to identify all relevant papers and data depicted since they are database that offers, credible, evidence of a claim, case studies of scholarly, scientific, academic, technical and professional resource shown in *Figure 12.*

Figure 9

Source of data



Note. By Author

The research criteria for extracting the data were constructed using search keywords. First, we combined the phrases "EEXI, CII, Energy Efficiency," "Operational and Technical

Measures for Vessels," and "Charter Parties," "Contract Law," and "Private Law" and "Responsibility to Implement," to generate keywords like "EEXI, CII, responsibility," "EEXI, CII, Compliance," "EEXI, CII, cost bearing," and "Energy Efficiency, charter parties, Energy efficiency, contract law in shipping ." Keywords were identified in three sections: the title, abstract, and keywords. The researchers did not designate a start date and collected articles published from 2011 for some energy efficiency until July 2022, and some from 2021 until July 2022. This study's systematic review process was adopted by Petticrew &Roberts (2006) and Pickering &Byrne (2014).

Secondary data sources were heavily used in this research to explore this complex topic with an elusive population. Primary texts and videos, mostly from the EU website and the International Maritime Organization (IMO), as well as preliminary decisions, position statements, and final agreements, were utilized. Secondary data sources included journal publications, websites such as the UN, IPCC, and IMO, governments and international papers from international databases, newsletters, press releases, media stories, and conference participant reports. Sources included speeches and interviews, conference reports and declarations, and reports from Governmental and Intergovernmental Organizations. The majority of data was acquired via search engines such as Google Search Scopus, Semantic Scholar, EBSCO host, Science Direct, Hein online, I law, OECD Energy library, Clarkson Research service, IMO Vega and, ship intelligence network.

1.7 Ethical issues / Budget

There was no ethical clearance submitted to the World Maritime University Research Ethics Board for an assessment study that relied on secondary sources of data.
However, all other types of ethical considerations were adhered to in terms of writing the study.

1.8 Key assumptions/Potential limitation

The goal of achieving zero net carbon emissions in the year 2050 can be attained using technical and market-based strategies. Energy efficiency may be enhanced using private contracts that incorporate operational, technical design, and contractual changes.

1.9. Summary and organization of reminder of the study

There are five (5) chapters comprising the research. The research is introduced in chapter one (1), summarizing the background of the study, providing the problem statement, and defining the questions that will be answered in the study based on the problem statement and questions, the study's objective and, justification are formulated. In this chapter,we also examine the rationale behind our findings and the methodology used to arrive at them. The study's literature review is presented in Chapter 2. The study is described within a structure that discusses its context. The existing literature landscape pertinent to this research was explored, with a focus on two primary themes: uncertainties, hazards, and limitations with regards to EEXI and CII in vessels, and the theories and concepts underlying them. The structure systematically addresses the known and unknown, with a focus on how the data influences decisions about vessel selection, measures for operational and technical efficiency, and the resultant charter parties and other affreightment contracts between ship owners and charterers. This chapter surveys the existing state-of-the-art literature in shipping on a bid to identify knowledge gaps that the rest of the thesis will endeavor to address. Examining the EEXI, CII, and SEEMP procedures described in Chapter Three. Case law is reviewed considering the charter party obligations and warranties in Chapter 4, while the Conclusion and Recommendations are presented in Chapter 5.

2. LITERATURE REVIEW

2.0. Introduction

This Chapter provides a thorough and fair review of the existing literature on EEXI, CII implementation, and charter party ramifications. The study identifies themes, trends, hypotheses, and conflicts on the issue. It covers an assessment of the overall methodological strengths and weaknesses in the use of EEXI, CII, regulatory policy framework, and economic variables, as well as a synthesis of previous material. This study analyses past studies quantitatively and qualitatively to determine the most relevant solutions for compliance, effective design, and operational energy efficiency, as well as the effects of EEXI and CII compliance on cargo transit, commercial, and legal difficulties. Couple of studies incorporate the effects of evidence-based remedies on operational measures in charter parties.

This study intends to give an informed discussion of the maritime industry's short-term goals, with an emphasis on the EEXI and CII developments, as well as the measures required for compliance and how these measures will be implemented in charter contracts between ship owners and charterers. For 150 years, charter parties have served as the backbone of international sea commerce, but it is questionable if they will be sufficient to enable decarbonization. When ships perform well, everyone gains, but articulating and agreeing on how to split those earnings can be tough. There will be costs connected with implementing rigorous limits to reduce shipping's carbon footprint. The maritime industry will construct jurisprudence in commercial contracts as it seeks to strike an acceptable balance between trade liberalization goals and environmental goals on a global, regional, and national scale.

This chapter will be divided into four sections: a) compliance options available, ship-related aspects on the option provided, about design and operation aspect, b) risks associated with compliance, main discourse will be on financial risk, c) port-related aspects, d) other aspects that will enable reduction of decarbonization, and finally a conclusion.

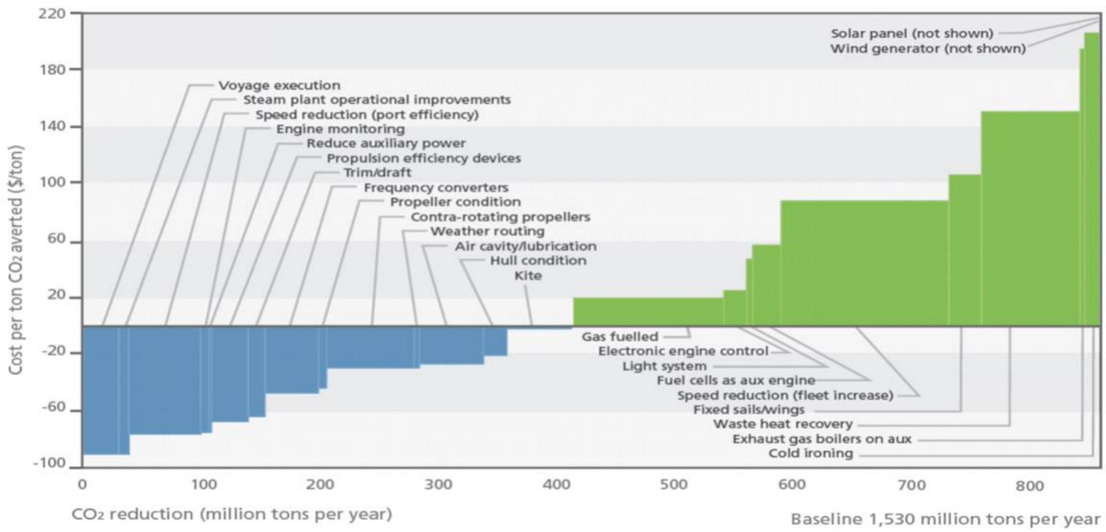
2.1. Evidence-based studies

2.1.1. Alternatives for Implementing Regulations in Ship Design and Operation

Psarros 2017 questioned how to reverse engineer and study a vessel's operating energy efficiency to determine if it performed well or poorly, given short-term goals are more focused on the ship's operation and design. IMO environmental requirements have spurred ship owners to employ operational measures like decreasing engine speed, cleaning the hull and propeller, rerouting around inclement weather, and deploying technologies to reduce design or operating inefficiencies (Bouman et al., 2017), including air lubrication, a bulbous bow, (Psarros, 2017) heat recovery, hull optimization, propeller nozzles, diesel-electric motors, and counter-rotating propellers (Psarros, 2017) as presented in Figure 13

Figure 10

Potential strategies by which a ship's carbon footprint can be reduced (Solutions applicable to ships)



Note. From, "*Future Cost Scenarios For Reduction Of Ship CO2 Emissions"* Eide et al.2011 *: Maritime Policy & Management: The flagship journal of international shipping and port research, 1464-5254, Vol. 38, Issue 1; p. 11–37. https://doi.org/10.1080/03088839.2010.533711* .

Key engine de-rating and energy-saving technologies are the main technological measures to comply with EEXI (Ritari et al., 2021), since it excludes shipbuilding, the EEXI could benefit new ships (Ahn et al., 2021; Wang 2021). These initiatives have increased focus on ship performance at sea. There is no standardized technique to evaluate a ship's performance throughout operations, as opposed to sea trials (Kuroda & Sugimoto, 2022). It's vital to compare theoretical estimates of the EEXI's efficacy with empirical assessments made in the real world (Rutherford et al., 2020). No specific conclusions of the required cost of compliance measures per ship segment have been publicly revealed, despite their relevance. Psaraftis was able to undertake a qualitative assessment in Denmark in 2021 by answering questions about the probable negative impact on operational/logistic and technical levels. A quantitative assessment of the impact was not possible due to a lack of data and a strict IMO timeline. Besides concerns of data dependability and uncertainties with emission rate estimates, various concepts such as reference lines (Masodzadeh et al., 2022), necessary and attained CII, required and obtained reduction factors, and rating mechanisms may be complicated for ship operators in the case of CII (Masodzadeh et al.,2022) . Ship operators may find CII notions such as reference lines (Masodzadeh et al., 2022), necessary and accomplished CII, required and gained reduction factors, and rating methods confusing (Masodzadeh et al., 2022). BIMCO warned that CII may increase carbon emissions (Osler, 2021) under the paradox of transport management on shipping emissions. Further sophisticated models, paired with real data, simulations can and should be designed to figure out the proportion of ships whose carbon emissions will rise, the average rise for these ships, and the average fall for the remaining ships for each CII option (Wang et al., 2021).

a) Design related aspects.

Turkish shipowners prioritized operational measures for EEXI compliance, according to a study conducted by Kaya & Erginer, (2021). The study was justified by ship owners' reluctance to take risks and to retrofit aging vessels. Spot market ship owners invested more on energy efficiency than time charter owners. The study by Clarkson Research 2021, revealed that reducing CO2 emissions on existing ships will not improve energy efficiency, Only 30% of vessels (25,000+ dwt) are currently in conformity with the EEXI's design efficiency criteria, whereas 40% of tankers and 25% of bulkers will be if they undergo "engine power limiting" (EPL). Seven out of ten bulk carriers are 'non-eco' (EEXI), meaning they must be modified, or the fleet will be scrapped. From 2023-30, many ships will need to reduce emissions to meet a new Carbon Intensity Indicator (CII), which will require an 11% improvement in fleet-wide operational efficiency by 2026 (from 2019 fleet average levels) (Shipping Review and Outlook, Sale & Purchase, 2021). Certain EEXI solutions may incur large retrofitting costs or have an impact on operations or engine performance disrupting voyage schedules.

b) Operational aspects using various models

Speed requirements in charter agreements substantially impact commercial vessels' performance, speed is a warrant in a charter party. Warranties consider efficiency, energy consumption, and voyage conditions. Speed determines a voyage span. Carbon emissions affect sailing speed decisions due to its correlation to a ship's speed (Wang et. al., 2019). Sailing times for operations and logistics may increase if vessels slow speed to meet the carbon intensity objective. Charter arrangements limit ships' speeds (Aßmann et al., 2015). Speed affects charter rates, which affects cargo shipping if ships are delivered below design speeds. Economics can anticipate the supply curve. If there is perfect competition in the shipping industry. When freight rates are high, it's profitable to steam at full speed; in a low-freight-rate market, it may be more economical to steam at a slower pace because fuel savings will more than compensate for income lost (Stopford , 2008). Daniel et al., 2022), monitoring the OECD Council Working Party 6 on Shipbuilding (WP6) market, expected the average transit speed to decrease in 2023 due to EEXI and CII requirements. Legally, speed reduction agreements are iffy. Slow steaming clauses may conflict with the "due dispatch" requirements. A bill of lading bearer can hold the carrier accountable for late delivery. Slow steaming should be included in a bill of lading, nevertheless, the legitimacy of this depends on the bill of lading regulatory framework, which must weigh the opportunity costs and rewards.

i. Real time ship energy optimization model.

Real-time ship energy efficiency optimization model (Wang et al., 2016) is the most effective approach in choosing the optimal engine speed for maximum energy efficiency (Wang et al., 2016) under forecasted operating conditions. Reduce the velocity and installed power of the primary engine to satisfy EEDI (Kim et al., 2019). This strategy improves ship energy efficiency by slowing the ship. Slow steaming is a key operational parameter for reducing CO2 emissions, according to Halim et al.,(2018).

ii. Systematic Assessment of vehicle emission (SAVE)

Based on research by Rutherford et al. (2020), EEXI would only contribute 0.8% to 1.6% less CO_2 from the 2030 fleet compared to a baseline without EEXI using the Systematic Assessment of Vehicle Emissions (SAVE) model developed by the International Council on Clean Transportation (ICCT) (UNCTAD, 2020, Rutherford et al. (2020). This is attributed to most ships still using slow steam at engine loads (Rutherford et al., 2020), which is unregulated by the EEXI's technical efficiency criterion (Rutherford et. al, 2020). Unless the EEXI reduces engine power below what ships utilize, neither ship speed nor carbon dioxide emissions can be reduced. The key benefit that the EEXI is expected to deliver is publicizing the positive impacts of slow steaming on operational efficiency.

iii. ORC integrated Waste Recovery systems

Future ship EEXI and EEDI upgrades should aim to meet the fuel savings and emission reduction potential presented by the ORC integrated Waste Heat Recovery System WHRS design described by Konur et al. (2022). Ships with high energy requirements can install waste heat recovery systems to improve energy efficiency (Ghimire et al., 2021) and lower fuel consumption. The energy from the ship's low-grade waste heat (Ng et al., 2022) could be utilized with the help of ORC technology (IMO, 2012;IMO, 2020).

iv. Carbon capture

Carbon capture on ships during maritime operations is a technically and economically possible method of reducing CO_2 emissions in a carbon-intensive industry (Damartzis et al., 2022). A qualitative analysis was recommended due to the absence of real-time expertise with onboard solvent membrane CO_2 capture. On June 6, 2022, at IMO MEPC 78, Hyundai Glovis, HHI, G-Marine Service, ABS, and the Marshall Islands Registry signed a Joint Development Project Agreement to develop a 74,000 cu.m. Transporter of CO_2. In 2021, HHI plans to construct a 40,000-cubic-meter CO_2 transporter.

Diverse viewpoints were expressed at MEPC 78; carbon capture on board should not be addressed by EEXI and EEDI, which are design-related, but by operational CO_2 capture solutions; discussions are set to continue in MEPC 79(IMO, 2022).

c) Port related options

Seyhan et al. (2022), ports are critical in mitigating global warming emissions. When calculating a ship's CO_2 output, its maneuvering and berthing operations are considered (Dawangi& Budiyanto, 2021). Seyhan and Daniel analyzed the effect of innovation on the EEXI and CII in 2022 to explore how ports may minimize greenhouse gas emissions and enhance ship efficiency. Masodzabeh et al.(2022) advocated that port speed limits replace or supplement EEXI/EPL for any boats built before 2013. When port infrastructure is present, a ship may slow down to berth (Kim, et al., 2016). According to Bazari and Longva's 2011 report to the IMO, the speed decrease due to improved port efficiency attributed for approximately half of the overall influence of the SEEMP (Johnson & Styhre, 2015). Curbing idle port time boosts fleet efficiency and SEEMP (Johnson & Styhre, 2015).

Shore power can reduce port pollution and provide ship owners more operational flexibility. Daniel et al.(2021) used a 34,564 DWT bulk carrier FEDRIC Balitic with six cargo holds, four 35t cranes on four decks, one main engine, and three diesel generators as a case study for EEXI, EEDI, and CII indexes. The EEXI did not account for shore power while calculating the CII. EEXI and CII are affected by shore electricity. It raises CII ratings.

d) other options

i. Alternative fuels

New ships will employ alternative fuels like LNG and LPG to meet with new rules, speed reductions, and biofuel mixes for current ships (Cullinane & Haralambides, 2021, UNCTAD 2021).

ii. The O-KPI and hybrid MBM

The O-KPI and hybrid MBM (Masodzadeh et al., 2022) that could be used to augment or replace EEXI. It was created as a substitute for CII, but it is also compatible with SEEMP. Operational variables such as loading factor, (Masodzadeh et al., 2022) fuel quality, navigation circumstances, weather condition, contractual responsibilities, sailing speed, hull roughness, and whether or not ballast legs are included all have an impact on carbon intensity (Masodzadeh, 2018). A plethora of these issues can not be fixed by the operator. While the estimated emission rates with operational uncertainties can be useful for research and commercial assessment, they are not an appropriate criterion for evaluating operational efficacy. Keeping tabs on how much fuel a ship consumes is no longer sufficient; instead, attention must also be paid to the measures taken to improve fuel efficiency.

iii. Reshape scenario

Combating climate change requires the initiative of government and private industry alike to act to lower carbon emissions (Richstein & Neuhoff, 2022). Striking a balance between environmental externalities and economic considerations, governments must enact laws and policies to guarantee a source of revenue for low-carbon activities (Stern & Stern, 2007). ITF Transport Outlook, 2021 created the Reshape scenario, a paradigm shift in which governments decarbonize transportation post-pandemic. These policies impact transportation users' behavior, stimulate sustainable energy and vehicle technologies (ITF, 2020), and digitalization to boost transportation efficiency, and encourage infrastructure investment to fulfill environmental and social development goals (ITF 2021).

2.3. Risks associated with compliance

Implementation is hampered by financial, technical, and external concerns. Financial risks are associated with investment repayment, which poses a serious hurdle, as are difficulties in financing old ship refits, and the degree of contribution (or responsibility) oto perceived negative (and disproportionately unfavorable) implications of the goal-based measure (Psaraftis & Zis, 2021) cannot be determined precisely. (Daniel et al., 2021). Technical risks include the dependability and performance of established measures (such as economic trends, fuel prices, legislation, and regulations). Upgrading existing ships with energy-saving technologies or alternative fuels, or investing in new ships that use them, may incur technical costs. The most difficult compliance component is external risk. There have been no comprehensive evaluations of compliance costs by ship segment made public (Daniel et al., 2022). Life-cycle costs make ship changes and retrofits more expensive than new designs (Fridell & Styhre, 2013). Concerns of operational costs, tonnage efficiency, the availability of low-carbon fuels, the opportunity cost and ramifications of speed reduction, split-incentives and other financial constraints, transportation demand growth, and fleet renewal/scrapping rates under the EEXI/CII regulations (OECD 2021), Many shipping companies are taking a "wait and see" attitude to investing.

2.3.1 Financial assessment

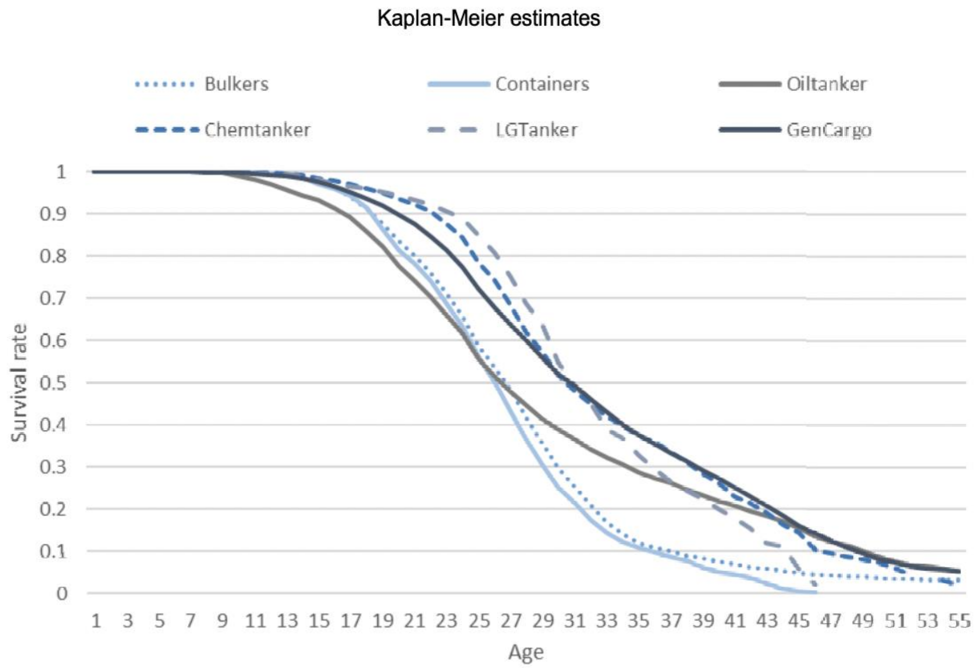
Schinas & Bergmann (2021) developed a financial model for the maritime industry from 2021 to 2026 using a bottom-up approach. The model computes the financial consequences of vessel types, age categories, and individual vessels. Decarbonizing the world fleet through 2026 would cost USD 317 billion based on base case characteristics. These figures demonstrate a yearly demand of USD 63 billion to construct new ships and upgrade existing ones, excluding demolition sales (Schinas & Bergmann (2021). Given current loan-to-value ratios, this would imply annual debt commitments of 36-45 billion USD.

Ovcina (2021) Martin Stopford forecasts presently to 2050, the merchant fleet will need to be upgraded at a cost of $3.4 trillion, with $2.2 trillion going toward ensuring that tonnage is green enough to meet regulatory criteria and $1.2 trillion going toward increasing global trade.

CE Delft assessed the annual total cost of ownership (TCO) impact of labeling ships to CII rating scale threshold C and revenue loss for existing ships due to speed reduction. The cost of upgrading D-rated ships to C or above was determined for several ship segments.: - Small bulk carriers' TCO was assessed at 55,724 USD/year, whereas large bulk carriers was 135,502 USD/year (Faber et al., 2020). These ship segments are estimated to lose between $172,000 and $324,000 per year (IMO, 2021).
The OECD developed a fleet survival model used to calculate the implications of environmental legislation and regulation on vessel value and seaborne trade, noting that compliance costs reduce a vessel's net present value, affecting its fleet survival chances. Ship owners assess the vessel's net present worth, that encompasses future revenue from transportation services, existing backlog, age, and other attributes, against its current scrap value before considering whether to keep the ship operational or scrap it (OECD, 2019) Figure 14 depicts vessel survival under the new regulation. If the cost of compliance measures for each ship is known, it is simple to predict how many more ships will be demolished because their value is less than the cost of demolition. The specialized fleet may be scrapped to save money.

Figure 11

Vessel survival under the new regulation.



Note. From "*Shipbuilding Market Developments, First Semester 2022: Monitoring Developments in Ship Supply, Demand, Prices and Costs", Daniel et al., 2022 OECD Science, Technology and Industry Policy Papers, No. 132, OECD Publishing, Paris, Https://Doi.Org/10.1787/E511558d-En.*

2.4 Conclusion

Since days of sail, the operational model for cargo ships has not changed much: every vessel sails at its own optimum speed in the direction it must go (often the service speed that suits that of every other vessel in the same category (Sung et al., 2022), with no regard for the other ships or the conditions at the destination (Sung et al., 2022). Precise research of powering performance in real-world sea conditions (Shin et. al., 2020) and speed-power analysis of running ships are critical to ensuring ship operators' competitiveness for GHG reduction and fuel savings in the ship. Only by pinpointing a precise resistance propulsion performance can ship operators prove the efficiency of initiatives taken to improve the efficiency of their current fleet of ships.

Ship owners cannot guarantee increased efficiency because they do not transport their personal cargoes. Conflicting incentives between the ship owner (who invests) and the charterer (who gains from energy savings) prevent widespread adoption of energy-saving techniques in countries where ship owners do not manage their vessel operations (Faber et al., 2020). Ship Owners must examine their vessel's top speed and fuel economy if power reduction is employed to comply with EEXI. IMO holds ship owners accountable for CII ratings, but charterers control day-to-day decisions. Considering the uncertainty, the market should incorporate an agreement that splits costs and benefits between owners and charterers, albeit this is not currently the norm. Shipowners require intervention in securing green contracts. It is reasonable to assume that carbon costs will be negotiated given that the shipowner is accountable for compliance but does not have a financial stake in the cargo (Lagouvardos & Psaraftis, 2022). Charter agreements must better align tasks and operational decisions to avoid the "patsy" scenario. These terms may be drafted collaboratively by shipping companies. In light of growing interest in environmentally friendly transport, maritime contracts may need to be revised to avoid legal issues. BIMCO has created provisions for future charter agreements that take EEXI into account. Once EEXI comes into force in 2023, suggested clauses would compel shipowners and charterers to acknowledge that a vessel must conform, which may entail alterations.

Time and tide wait for no man. This is an important truth in the shipping industry: Decarbonizations, like the tides, ebbs, flood, and are inescapable thanks to Newton's law of gravity, which is why this is such a crucial truth in the shipping business. Those in the maritime sector who opt to ignore the force and rhythm of the tides in order to advance the industry's development do so at their own peril. Monitoring trends and changes in decarbonization.

The IMO prioritizes environmental protection concerns; such changes indicate approval of environmental restrictions that impede international trade under certain circumstances.

The first is concerned with norms, while the second is concerned with institutions. Environmental considerations are likely to be used to justify commercial agreements, particularly charter parties (Sands et al., 2012).

Charterparties and commodities sale contracts will be reconsidered and rebuilt in preparation for decarbonization. The present two-poled world navigational safety and commerce will be replaced by navigational safety, business reality, and pollution reduction. To respond adequately, one must reject regulatory compliance's tight constraints and allow shipping to do what it has always done: adapt to a changing world through commercial contracts.

3. IMPLEMENTATION OF EEXI AND CII

Shipping will continue to be impacted by regulations, the majority of which pertain to environmental concerns (Lloyd et al., 2015). March 1989, the oil tanker "EXXON Valdez" ran aground off the coast of Alaska (Davidson, 1990), spewing more than 11 million gallons of crude oil (Galiano, 2003). The next year, the US approved OPA 90, which phased out single-hulled oil tankers in the region. Ten years later, the single-hulled tanker 'Erika' caused major oil contamination along the French coast, causing the EU to consider banning single-hulled ships from EU waters. After the sinking of the single-hulled tanker 'Prestige' in November 2010, the EU has moved up the timetable for phasing out these vessels. IMO modified the phase-out schedule of Annex 1 MARPOL for all single-hulled tankers worldwide. As a result, single-hulled tanker feet declined rapidly. Despite a 30% increase in the world tanker fleet since 2005, the number of single-hulled oil tankers declined from 103.4 million DWT to 15.2 million DWT (UNCTAD, 2006, 2005) .

The changing regulatory landscape currently affecting the industry is decarbonization, characterized by the timeline for introducing zero-carbon ship propulsion systems, and the timeline for digital technology in ships, companies, and logistics (Stopford, 2020). These are economic and regulatory frameworks within which the marine industries will operate in the next decade.

Decarbonization, in contrast to other areas of regulation, is a journey whose road is murky and the ultimate goal, whether a percentage reduction or net zero, remains undefined. Ship energy efficiency is related to the quantity of fuel energy consumed in relation to the amount of transport work performed. Energy Efficiency Design Index (EEDI), Ship Energy Efficiency Management Plan (SEEMP), Energy Efficiency Operational Index (EEOI), (Nuchturee et al., 2020), and International Energy Efficiency Certificate are the acronyms used to define ship energy efficiency.

CO_2 is a significant component to anthropogenic GHG emissions and has a correlation to fuel consumption (Nuchturee et al., 2020), the lesser the volume of fuel used to accomplish the given output, the greater the energy efficiency (Ghimire et. al., 2021; Zheng et al., 2013). CO_2 emissions indices evaluate a ship's energy efficiency based on CO_2 emissions (Nuchtree et al., 2020). IMO introduced an Energy Efficiency Design Index for Existing Ships (EEXI) during MEPC 75 in November 2020. Subsequently, in June 2021, IMO while focusing in energy efficiency(Perčić et al., 2022) and emission goals at the MEPC 76 adopted the short-term measures a combined EEXI/SEEMP/CII which provide a technical standard represented by EEXI to improve the energy efficiency requirements on existing ships (Perčić, et al., 2022) and a rating scheme based around the operational CII (Schroer, et al., 2021) with the aim to reduce ships CO_2 carbon intensity at least 11% in 2026 compared to 2019, by 40% within the next decade is 2030 as presented in MEPC(76)/WP.4 (IMO, 2021).

EEXI and CII are command and control measures. Prior understanding of EEDI is needed to understand EEXI, which aligns with IMO's 2050 goal. IMO established EEDI for all newly built ships in 2010. The index is defined as the number of grams of CO_2 released per mile traveled by the ship (IMO 2009). The IMO established the EEDI to provide a fair basis for comparison and to encourage the development of novel, energy-efficient vessels (Ančić, et. al., 2018; IMO 2011). EEDI is a useful metric to measure CO_2 emissions; a lower EEDI indicates greater efficiency. EEXI, uses the EEDI as its foundation, with certain tweaks made to make it applicable to ships that are already in operation (Vidas et al., 2021). Emissions per cargo ton and mile are the metric in use from 2023(Rutherford et. al., 2021) onward for boats with a gross tonnage of 400 GT or more. Newly built ships' EEDI and older ships' EEXI are measures of efficiency and emissions respectively.

Design and operational measures are opening up opportunities for designers who are prepared and adding a huge risk for those who are prepared and adding huge risks for those who are not

3.1 EEXI

EEXI is an IMO vessel design efficiency metric that will be obligatory for many fleet ships in 2023, however it is a one-time assessment of a ship's energy efficiency, with the next IMO review slated for 2026. Given the limited access to design data for existing vessels, EEXI will expand for present ships of the new building based EEDI (DNV GL, 2021).

EEXI relies solely on the design of the ship itself, it does not rely on any substantial quantifiable values from prior years, it does not require any measurements to be conducted while the ship is in operation. The ship design process is extensive and multifaceted, including many aspects and individuals, with the goal of creating a vessel that fits the owner's operational or functional requirements while conforming to regulatory standards norms (thus rule-based design) (Soares, 2009; Vassalos et al., 2006) A ship is constructed for specialized commercial and noncommercial services, with specific functionality, characteristics, hull form and powering, space, and weight distribution, and technological and economic performance (Papanikolaou, 2014). A successfully designed ship is the product of close effective coordination between the designer, the customer, the yard, and the equipment supplier (Vossen et al., 2013).The sequential and iterative stages of ship design, include conceptual design, preliminary design, contract design, and detailed design, are frequently represented by a spiral diagram(Gale, 2003).

According to Psarro & Mestl (2015), a ship's operational performance is determined by a variety of elements, including conventional design measures, outfitting measures, and hull form optimization for least powering(Papanikolaou, 2014), fuel consumption, enhanced diesel combustion, improved fuels, and so on. Historically, the hull design of a ship was selected by shipyard designers who considered the contract design values for speed and fuel use at design draught. A comparable set of ballast draught values could be used in conjunction with these for some designs.

EEXI are design indicators that analyze the ship in ideal sea conditions (Daniel et al., 2022), which are based on the ship sailing at the planned speed in deep water with a summer cargo draught, the weather being calm with no wind or waves. A ship's performance in the high seas can be forecasted in three ways: calm water, seaway speed loss due to wind, waves, swell, and current, and steering speed loss forecasts (Insel et al., 2018). Ships that are relatively new may profit considerably from the EEXI because it disregards the time of construction of the vessel.

3.1.1 EEXI calculation

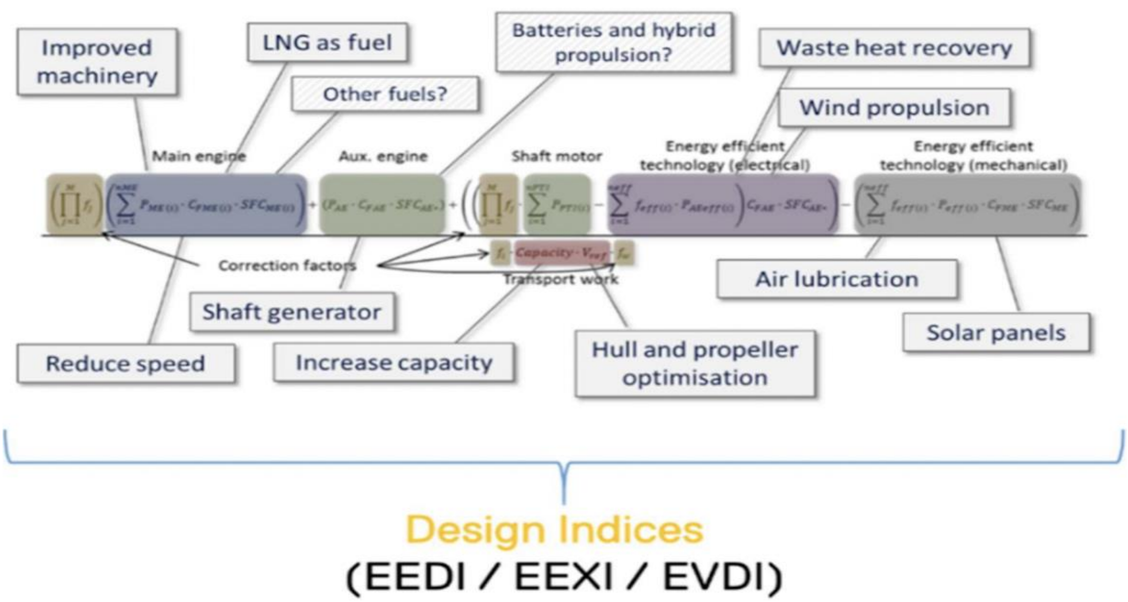
The EEXI employs the same methodology as the Energy Efficiency Design Index (EEDI) for new vessels, published in MEPC 203(62)(IMO, 2011) and MEPC(76)/WP.4. The calculation guidelines are based on identical EEDI guidelines for new construction, with some major adjustments for existing vessels (IMO, 2021) that were not designed in accordance with EEDI Phase 2 or Phase 3 criteria due to limited access to design data. The efficiency metric for ships is CO2 emissions per ton of capacity times distance traveled

The EEXI standardizes CO2 emissions based on installed engine power, transit capacity, and ship speed. three things are needed to calculate CO2 output: how much fuel oil was consumed, how much power was installed in the main engine, and a conversion factor (IMO 2022). Attained EEXI is the final EEXI score. The methodology used to calculate the required EEXI is governed by Regulation 23 of MARPOL Annex VI (Resolution MEPC.333(76), (EEXI Calculation Guidelines) as depicted in Figure 15 The EEXI would limit carbon dioxide emissions not in terms of transportation output but rather supply (measured in deadweight ton-nautical miles, for instance)..

$$EEXI = [gCO_2/tonne \times nautical\ mile]$$

Figure 12

EEXI calculation formula



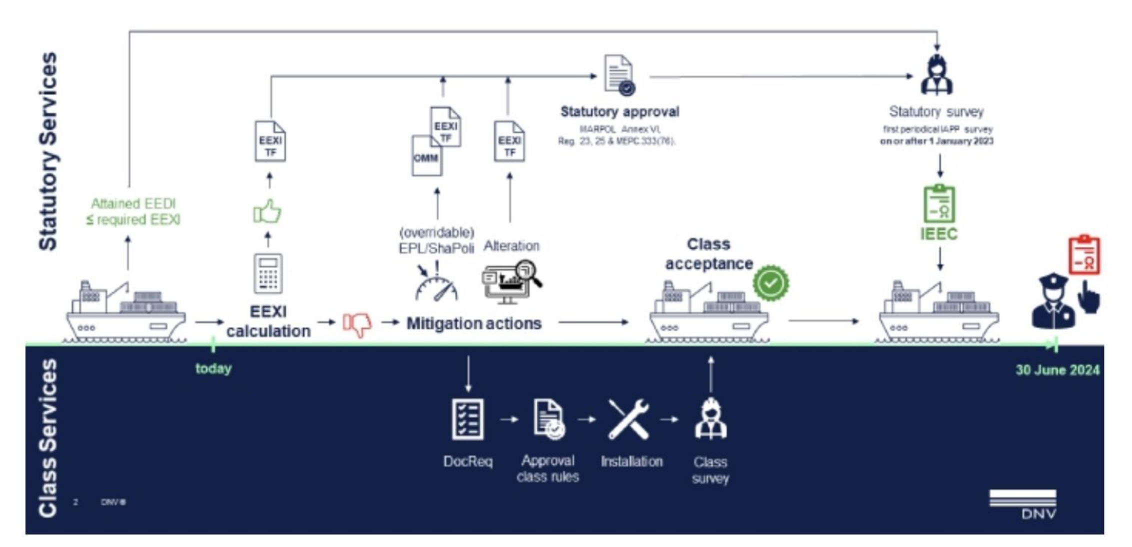
Note. Source: Bureau veritas (2022), standard club (2022)

All ships of 400 GT or more that are actively engaged in international voyages, regardless of the date of delivery, are subject to EEXI requirements, with the same exceptions as for EEDI: -ships that are not propelled by mechanical means; platforms, such as FPSOs and FSUs, and drilling rigs, regardless of propulsion; and ships that are not engaged in international voyages. Other than LNG carriers and cruise passenger ships, ships that use diesel electric, turbine, or hybrid propulsion systems are classified as Category A in the Polar code. Wang et.al(2016 cited by Rutherford et.al., 2021), whereas dwt (deadweight tonnage) is used for most ships, (gross tonnage) is used for cruise ships (gt)(IMO, 201, Resolution MEPC.328(76) . The EEDI mandates higher fuel efficiency standards for ships built after 2015. Ships in the first phase of the EEDI (delivered in 2015), the second phase (delivered in 2020), and the third phase (delivered in 2022/25, depending on ship type), are required to reduce their carbon intensity by 10%, 20%, and 30%, (Daniel, et. al, 2021) respectively, compared to a baseline of ships of similar size and type produced between 1999 and 2011.

According to (IMO, 2021), EEXI compliance will be verified primarily by an Administration or a lawfully authorized institution, such as a classification society acting on behalf of the flag state. If a ship does not meet the set standards, technical changes will be required to improve the EEXI of the vessel. Sanctions will be levied as a result. To verify and re-issue the IEE Certificate, the Administration and/or any other body officially authorized by it will require an EEXI Technical file, which will comprise the fundamental information required for EEXI calculation. If a vessel's current EEXI value is less than or equal to the Required EEXI, no EEXI Technical File is required, and the IEE Certificate can be reissued without further review, if the ship is compliant with EEDI phases 2 and 3 depicted in figure 16.

Figure 13

Steps to be followed to attain EEXI and timeline for EEXI



Note. From "EEXI – Energy Efficiency Existing Ship Index" DNV, 2022a https://www.dnv.com/maritime/insights/topics/eexi/index.html?gclid=CjwKCAjw4JWZBhApEiwAtJUN0JSiW0rHhGpaLwjrkzla0T-3RHTz04SaHtAUfnFk1jxuOMIo65_vRBoCxOwQAvD_BwE

3.1.2 Means of complying with EEXI

The EEXI would give shipowners four main options for complying with the rules. New vessels certified to EEDI targets for 2022 and beyond will meet EEXI criteria without any additional changes. Other vessels can comply by retiring sooner, installing energy-saving retrofits, or reducing main engine power (IMO, 2019).

a) Hull and propeller retrofit

Fuel consumption is computed using a conventional marine engine specific fuel oil consumption curve and assuming constant hull, shaft, and propeller efficiency (Huotari et al., 2021). One of the most cost-effective ways to comply with the regulations and improve the ship efficiency is to install highly efficient propellers and rudders and/or equip them with stationary flow-directing devices, generally called Energy Saving Devices (ESDs) (Stark et al., 2022; Spineli et al., 2022). Alamoush et al., (2021) list additional methods including stabilizers, bulbous bow, hull coating (Uzun & Turan 2022), hull cleaning robots (grooming), and air trapping fern; propeller trailing edge modification; electric propulsion via a pod propulsion system(Korlak, 2021); hull performance monitoring techniques; air lubrication; and more (Hope et al., 2021).

Bademo et al. (2022) neither the literature review nor the interviews yielded any definitive conclusions about the future of alternative propulsion. Since each of the options that have been developed has its own set of advantages and disadvantages, the business community is at a loss as to which path it will choose.

b) Modification of engines

Rehmatulla et al. (2017a), noted, reducing speed and de-rating one's engine are common practices for lowering carbon dioxide output. Turbo charger, piston, and pump improvements are typically implemented together when an engine is upgraded. It is unclear if derated engines or engines with reduced power are being installed for existing ships and without changing a propeller resulting in lower speed. In the case of new construction, the propeller can be designed to absorb this horsepower at a lower-than-normal shaft speed, resulting in a higher top speed for the vessel (Rehmatulla et al. , 2017a.)

The only practical refit for existing ships is to reduce the speed of the vessel or the amount of specific fuel consumption per engine, both of which can be accomplished through derating (Wiesmann, 2010). Engine de-rating allows a ship to have a more powerful engine installed yet still operate at a slower speed than is typical. In addition to decreasing the amount of special fuel oil needed, this could also increase the efficiency of the propellers (Rehmatulla et al., 2017a). The design time will not change. Per (DNV, 2014), the main engine on a large percentage of extant vessels was initially designed for one specific, high vessel speed. The specified maximum continuous rating (SMCR) of a vessel is altered to lower load points by de-rating the main engine; as a result, improved efficiency with lower specific oil consumption (SFOC) is achieved.

De-rating modifies engine power and speed distribution. The engine responds to slow-steaming vessel speeds. Reduced power permanently lowers the engine's maximum continuous rating. Top speed is restricted. De-rating an engine comprises altering fuel valves, shimming the x-head and piston rod, and re-matching turbochargers. Cylinders can be deactivated (DNV, 2014).

c) Engine power limitation

Schoroer et al. (2022) noted IMO strongly supports engine power limitation as a technological solution, MEPC evaluated EPL as a potential bypass over the EEXI regime and, as a result, produced rules describing its usage as an energy efficient alternative - if additional steps were considered[11](Czermaski et al., 2022). EPL implies a mechanical or electrical fuel intake blockage activated when the main engine's power exceeds a specific threshold (Schroer et al., 2021). This limit eventually leads to slower speeds and, as a result, lower CO2 emissions. EPL’s limit can only be exceeded in urgent cases, which must be documented. (IMO ; 2020; Rutherford et al., 2020). EPL does not alter the underlying performance of the engine (MAN & PrimeServ, 2016). When a ship is equipped with EPL, the maximum amount of power it can generate, and hence its maximum speed, is set in a manner that is both semi-permanent and overridable (Andersen, 2017). This would be accomplished in mechanically operated engines by means of a stop screw that is sealed off from fuel entry by means of a wire (IMO, 2019a). EPL would be implemented in modern, electronically controlled engines with the help of a secure software fuel limiter that requires a user password to access. If a ship is operating in hazardous weather and needs additional engine power for safety reasons, the EPL can be overridden; nevertheless, this event must be documented and notified to the relevant regulatory authority (IMO, 2019).

Engine power limitation is a cost-effective yet simple alternative, but it can have a significant impact on a ship's operational schedule.

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[11] IMO 2021, Resolution MEPC 335(76)

3.1.3 EEXI Concerns

1. During operation, the ship's hull fouls, requiring more power (Liu et al., 2021). A fouled hull will almost likely increase the power needed to maintain the same rotational rate, which could push the operating point past the engine's torque/speed limit. This compromises the ship's safety (Rigos, 2022).
2. EEXI requires strict main engine limits. By restricting the engine, ship safety is compromised. The recommendations include minimal power needs, which can be waived in bad weather, but they do not account for engine wear and tear. Many ships with EEXI issues have been in service for over a decade, so their engines are likely worn. This must be incorporated in the co-estimation of minimum power requirements to avoid dangerously huge engine limits (Rigo, 2022)
3. EPL acceptance rules are groundbreaking because they prevent Level 1 prerequisites, broadening the EPL's applicability. This prohibits most ships from satisfying EEDI Phase 2 criteria. Although compliance standards are voluntary, charterers may be unwilling to accept a contract if the ship may not meet them (Rigo, 2022).

Low economic value (and advanced depreciation) necessary to meet EEXI requirements has led to considerable reservations regarding the ability (technical and economic) to upgrade some of the fleet at this time (Czermaski et al., 2022). Equally unreasonable is investing in a ship without port infrastructure and assistance. A puzzle ensues.

3.2. Carbon Intensity Indicator

Carbon intensity indicators (CII) are essential variables for measuring performance in energy and climate studies (Sou et al., 2022). They have been applied to evaluate global energy performance (Allen et al., 2014) and to establish regional (European Commission), national (Nationally Determined Contributions of Singapore, India, and China), and sectoral (IMO, 2018) climate targets. The effectiveness of mitigation measures can be monitored and improved with the help of CIIs. Indicators able to capture substantial and verifiable energy efficiency trends are essential for evaluating mitigation efforts and ensuring that goals are met at both the international and national levels (Ang & Xu, 2013). Economically, transportation CO2 intensity is defined as CO2 emissions per unit of transport GDP (Chen; 2011; Fan et al., 2007). Tonne kilometers (TKM) are used to measure freight transportation activities (Sims et al., 2014).

Rodriguez et al. (2019) noted that intensity indicators are enticing for emerging nations since they are compatible with high rates of economic growth. Also, they do not imply emission/energy caps. These factors diminish uncertainty about emission commitment costs. They also encourage low-energy and low-carbon economic development. Intensity indicators have major limitations in gauging factors such as absolute carbon emission and energy consumption, which must be reduced to meet climate-related environmental concerns. Rodriguez et al. (2017) Empirical evidence shows that decreasing carbon intensity can paradoxically lead to increasing emissions

The carbon intensity index (CII) is used to calculate how efficiently ships are run. It does, in fact, compute the actual CO2 emissions. CII is applied to all cargo, RoPax (Roll-on/roll-off passenger vessel) and cruise ships above 5 000 gigatons meaning it affects most of the shipping industry (IMO, 2021). Wang et al. (2016 cited by Rutherford et al., 2021), Most ships' targets are based on their dwt (deadweight tonnage), but for cruise ships, it's the gt (gross tonnage) (gt). EEDI will mandate ships built after 2015 to meet the highest fuel efficiency standards. Ships delivered during Phase 1 (2015), Phase 2 (2020), and Phase 3 (2022/25), dependent on type of vessel) of the EEDI shall decrease their carbon intensity by 10%, 20%, and 30%, respectively, equated to a benchmark of similar size and type ships built between 1999 and 2008. When CII is fully implemented in 2023, it will increase ship efficiency. A ship's performance is rated by comparing its operating carbon intensity to the average of similar ships. To fulfill IMO's goals for international shipping, reductions for each ship type will likely increase or remain stable.

3.2.1 Carbon Intensity Indicator Calculation.

Fourth IMO GHG Study (2020) identifies CII variations: - g/dwt/nm2 for supply-based, g/tonne/nm for demand-based, kg/nm for distance-based, and tonne/h for sailing time-based (IMO 2020). MEPC 76 was unable to settle on a CII variant. Resolution MEPC.352(78)[12] reflects IMO's consensus on the two CII variants:

1. Demand-based CII refers to a specific CII calculated by an actual or projected volume or mass of the cargo carried on board a ship; -

Demand - based CII: CII Demand = $\dfrac{\textbf{Annual carbon emissions of the ship (g)}}{\textbf{Actual tonne miles carried by the ship in the year}}$ (Wang et al., 2021)

2. Supply-based CII refers to a type of CII in which a ship's capacity is utilized as a proxy for the real mass or volume of the cargo carried on board.

Supply- based CII: CII supply = $\dfrac{\textbf{Annual carbon emissions of the ship (g)}}{\textbf{The ship's deadweight tonnage times the sailing distance in the year}}$ (Wang et al., 2021)

The supply-based CII concept utilizes DWT as capacity is defined as AER, and the supply-based cgDIST is a CII that engages GT as the capacity.

MEPC78, Resolutions, MEPC.352(78)[13], MEPC.353(78)[14], MEPC.354(78)[15] changed how Carbon Intensity Indicator is computed and confirmed. Eliminating non-propulsion energy use, such as boilers or freezers. Enforcement, if the lowest-rated ships were not penalized, supply and shipping operations would not be affected significantly.

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[12] Guidelines on Operational Carbon Intensity Indicators and the Calculation Methods (CII Guidelines, G1)
[13] ibid
[14] Guidelines on the Reference Lines for use with Operational Carbon Intensity Indicators (CII Reference Lines Guidelines, G2)
[15] Guidelines on the Operational Carbon Intensity Rating of Ships (CII Rating Guidelines, G4)

Figure 14

Implementation of CII

Note. From, "Carbon Intensity Indicator (CII) & CII Dashboard", Verifavia, 2022, https://www.verifavia-shipping.com/shipping-carbon-emissions-verification/service-carbon-intensity-indicator-cii-cii-dashboard-321.php

CII is a rating system based on the reported IMO DCS data vessels will be assigned a rating between A and E (with A being best) based on performance. IMO-DCS 2023 includes CII. After submitting and validating emission data, the vessel will receive a CII rating (from A to E) based on annual carbon intensity. Grzelakowski et al. (2022) advise computing the CI Indicator utilizing the CII for the entire year of operation and comparing it to the given values on a scale from A (the best) to E. (the worst). If the ship gets D or C in the next two years, it should obtain C in the third year. Ship owners should aim for C or higher. The port maritime administration may hold it and demand it be scrapped if it does not obtain C (Herdzik, 2021). Time reduces CII references, MEPC 76 requires ships to reduce emissions by 1% a year until 2023 and 2% from 2023 to 2026, keeping reductions open until 2030. (Wang et al., 2021). In 2030, CII should be 40% lower than in 2008. (Wang et al., 2021).

MEPC78 had divergent views on the degree of enforcement for the CII implementation plan, as well as clarity on what constitutes a detainable deficiency, such as a ship rated D for three consecutive years or E that does not have a plan of corrective activities in place at the time of inspection, b efore adoption, the subcommittee will investigate and advise MEPC 79 (IMO, 2022, Resolution A.1155(32)[16]).

3.2.2 CII Compliance

Ship service speed limitations necessitate operational modifications. While a ship is in operation and striving to reduce its carbon footprint, its speed has a significant impact on its competitiveness and economics (Papanikolaou, 2014). Masodzadeh et al. (2022) cited contractual obligations, fuel quality,hull roughness, inclsusion or absence of ballast legs Loading factor, navigation, sailing speed, and weather, all affect carbon indicator(Masodzadeh, 2018). Hull efficiency is the ship's speed at a given propulsion power. *Maximizing ship speed through water (STW) while holding engine power constant or minimizing power required for a set STW optimises energy efficiency in propulsion* (Alexiou et al., 2022). Successful implementation of all measures is contingent on efficient communication and behavior, particularly during operations (Fridell et.al., 2013).

Shipowners and operators recognize that hull cleaning is vital for "fuel efficiency" In-water hull cleaning is an instant and effective way to improve CII, which is in line with SDG 13 from the IMO's standpoint. CII's regulatory drive will increase the frequency of in-water hull cleaning for the annual verification of the new regulation (Kim, 2021). The vessel hull coating factor was not directly reflected in the 2015 EEDI formula (primarily indirectly in the case of vessel sea trials in confirmation), however it will have a direct impact on the 2023 CII.

In some cases, CII standards may raise the carbon emissions of some ships (Wang et al., 2021). Elaborate models should be constructed, in tandem with actual data, that examine each CII choice; ships whose carbon emissions will increase, the average amount of

[16] Procedure for Port State Control related to enforcement of the short term GHG Measures By Port State Control.

increase and decrease for the other ships. Then instead of each individual ship, the design of indicators to maximise the average carbon intensity of ships owned by a firm in order to complywith the CII (Adamopoulos, 2021).

3.3 SEEMP - The Ship Energy Efficiency Management Plan

The ships subject to the CII rating are obliged to construct a SEEMP Part III on or before December 31, 2023, stipulated in MEPC.346(78) 2022[17] in compliance with the CII rating standards. SEEMP gives alternatives for monitoring ship and fleet efficiency over time and optimizing ship performance (IMO, 2012). The IMO has adopted mandatory SEEMP part i rules (Resolution MEPC.213(63)[18], that helps shipmasters, operators, and owners develop SEEMP (IMO, 2012). SEEMP part I affects ships over 400 gross tonnes (IMO, 2012). SEEMP is governed by Regulation 22 and comprises SEEMP Part I, Chapter 4, MARPOL, which really is necessary for all ships, and SEEMP Part II, which is mandatory for ships weighing more than 5000Gt. Like a measure, SEEMP Part 1 seeks to decrease CO2 emissions by progressing the PDCA cycle. SEEMP Part II specifies the mechanism for DCS, which was established as a reporting system to assess CO2 emissions, analyze emission data, and enhance control measures specified. Yan et al (2021) proposed strengthening of the SEEMP with mandatory content achieving the CII targets. SEEMP is used for operational shipping control and management. It improves a ship's energy efficiency by indicating real-time CO2 emissions (Czermaski et al., 2022). SEEMP is a cost-effective and a pathway for increasing a vessel's energy efficiency over four stages (planning, implementation, monitoring, evaluation, and improvement) as shown in Figure 18 that the owner can use as a benchmark(Dawangi & Budiyanto, 2021). Each stage of the SEEMP invites ship owners and operators to consider new technology and practices.

In these stages, planning is recommended as the most crucial stage of the whole plan (IMO 2012). The SEEMP is a dynamic ship-specific document that must be kept on board and used actively to increase energy efficiency. The regulation, however, only requires the presence of an energy efficiency plan on board and does not specify requirements as to

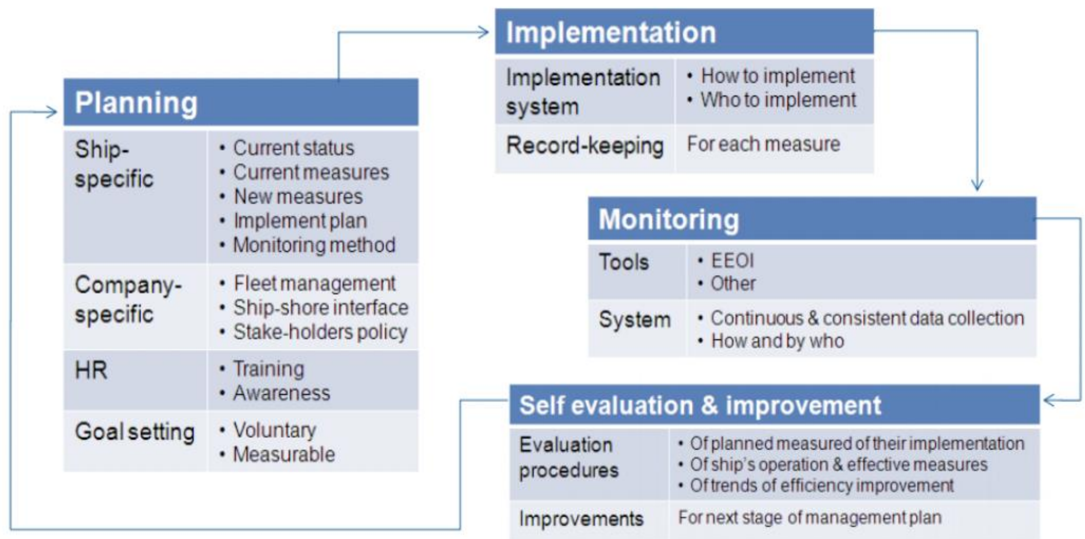
[17] Adoption of the 2022 Guidelines for development of SEEMP and the 2022 Guidelines for SEEMP verification by Administrations

[18] Guidelines for the development of a ship energy efficiency management plan (SEEMP).

the content of the plan. Ship owner decides. The content of the SEEMP is formulated by the shipping company and targeted at the specific vessel. The IMO provides best practices. However, it is up to the shipping firm to decide the steps to be implemented

Figure 15

SEEMP four stages



Note. From, "*Design the Prediction Model of Low-Sulfur-Content Fuel Oil Consumption For M/V NORD VENUS 80,000 DWT Sailing on Emission Control Areas by Artificial Neural Networks.", Tran, 2019 Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for The Maritime Environment, 233(1), 345-362.*

IMO Guidelines for development of a SEEMP is given in Resolution MEPC.282(70) . The guidelines underline the need for coordination between diverse stakeholders with regard to energy efficiency. Human resources are another focus. Raising awareness and providing the necessary training for the crew are very important elements. The last element is goal settings, which serve as guidelines for involving people and creating an incentive for proper implementation as well as increasing commitment to energy efficiency operation. The SEEMP Guidelines are an example of a goal-based regulation, where the authorities demand certain results without giving description of how to reach them, thus leaving room for interpretation, in this case by the ship owners.

The SEEMP includes best practices for fuel-efficient ship operation and manages ship and fleet efficiency over time. This is done through the optional use of a monitoring instrument, the Energy Efficiency Operational Indicator (EEOI), which allows ship operators to measure fuel efficiency by implementing operational measures such as trim optimizing, optimizing routes to mitigate environmental consequences. weather routing, and slow steaming(Dewan et al., 2018), on-time arrival consistency using route optimization tools, reducing routing judgement discrepancies, reducing inordinate vessel motions to lessen ship and cargo damage, and increasing fuel efficiency. increasing crew comfort, (Ballou, 2013) decreasing the ship's structural maintenance costs. using existing ship technologies such as voyage optimization, hull and propeller maintenance, engine management, energy management, fuel management, and crew awareness and training on energy efficiency(Beşikçi,et al. 2016) If a corporation has an SMS, the SEEMP may be included . MEPC.1/Circ.683 requires all ships to have a SEEMP on board by 1 January 2013 and to operate according to the plan.

MEPC 78 as advised by the twelfth session of the Intersessional Working Group on GreenHouse Gasses (ISWG-GHG 12) amended Ship Energy Efficiency Management Plan (SEEMP)

1. Revised SEEMPs must be submitted and approved by Administrations or Recognized Organizations by 31 December 2022.

Shipowners and managers must have a Confirmation of Compliance for the amended SEEMP by 31 December 2022. The verifier needs the updated SEEMP urgently

2. SEEMP development standards include speed optimization for LNG carriers and other methods for monitoring fuel consumption for ships using LNG or other cargo as fuel.

3. MEPC Resolution on 2022 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP), effective immediately.
4. MEPC Resolution on Guidelines for the verification and company audits by the Administration of the Ship Energy Efficiency Management Plan (SEEMP) Part III.

Table 1

Summary of SEEMP PART I, II & III

	SEEMP PART I	SEEMP PART II	SEEMP PART III/CII RATING
Introduction and Effective Date	1 January 2013 Resolution MEPC.203(62)	28, October 2016 Resolution MEPC.282(70)[19]	1 January 2023 Resolution MEPC.328(76)
Application	Vessels weighing 400 GT Engaged in international voyage	Vessels weighing 5,000 gt (*Reg. 22.2 of MARPOL, Annex VI)* IMO DCS must develop a ship fuel oil consumption data collecting plan (Reg 22A.1 Annex VI) (SEEMP Part II) and verify it with the Administration or a RO.	Vessels weighing 5,000 gt defined in (*Reg. 2 MARPOL, Annex VI)* Bulk carrier, Combination carrier, Containership, Cruise passenger ships Gas carrier, General cargo ship, LNG carrier Refrigerated cargo carrier, Ro-ro cargo ship, Ro-ro cargo ship(vehicle carrier), Ro-ro passenger ship, Tanker,
Recommended procedure	Ship management plan to improve energy efficiency	Administration or RO evaluate ship fuel oil consumption data collecting plan Collecting annual data on fuel oil consumption and pertinent variables from 1 January to 31 December (calendar year). (Reg 22A. MARPOL, Annex VI)	Review of the "Ship operational carbon intensity plan (SEEMP Part III)" by the Administration or a RO, 1. incorporates CII calculation methodology, 2. obligated CII in the next three years, 3. an execution strategy for achieving the requisite CII, 4. processes for self-evaluation and improved performance, and retention of SEEMP Part III and Confirmation of Compliance-Part III on board.
Documents on board	Ship management plan to improve energy efficiency	SEEMP Part II, and Confirmation of Compliance-Part II.	verified SEEMP Part III, corrective action plan and verified before the DCS SoC (Statement of Compliance)
Development	ship management plan to improve energy efficiency	Develop, ship fuel oil consumption data collection plan SEEMP Part II pursuant IMO Resolution MEPC.34620 (78)	ship operational carbon intensity plan (SEEMP Part III), which comprises CII calculation methodology, needed CII values for the next 3 years, implementation plan for attaining required CII, and self-evaluation and improvement methods using IMO Resolution MEPC.346(2178)

Note. by Author.

[19] 2016 Guidelines For The Development of a Ship Energy Efficiency Management Plan (SEEMP)

[20] Ibid 15
[21] Ibid

The CII rating of a vessel is indicative of both its ability to comply with regulations and its market competitiveness. Higher CII-achieved vessels may be able to command a higher charter rate because of their "green" status. Whenever determining charters, the CII should be considered. Although the onus for ensuring a high CII rating rests on the owner, the owner and charter may need to collaborate to accomplish their separate emission reduction goals.

Carbon credit trading and the financial markets will undoubtedly be impacted by the CII.

4. CHARTER PARTY CLAUSES AFFECTED BY RESOLUTION MEPC 328(76).

There is a need to replace bargain theory with a less dogmatic and more responsive contract theory in the era of decarbonization in the maritime industry for effective compliance of IMO 2023 regulations. Contract enforceability that appears to benefit two parties as assessed by their own desires while harming no one. Pareto efficiency demands modifying the law whenever it makes one party better off without making anyone worse off (Stiglitz, 2009). A responsive legislation is referred to as the Pareto efficiency law. A law theory based on pareto efficiency is responsive rather than dogmatic. If the promisor and promise want enforceability when the promise is made, economic efficiency necessitates enforcing the promise.

Contract law helps parties to make credible commitments to cooperate with one another by optimally enforcing obligations. Contract law provides incentives for efficient cooperation, when the promisor invests in performing at the efficient level and the promisee relies at the efficient level and performing their best reducing opportunistic behavior.Contract law helps parties collaborate by enforcing duties and encourages collaboration.

This chapter will review contracts of affreightment, specifically Charter parties that regulate private law in the maritime industry. Universally all commercial contracts of carriage must allocate functions, risks, costs either to the owner or the charterer (Gorton & Ihre, 1990), and the parties must sort liability questions both between themselves and against third parties.

4.1 Charter parties

A contract of affreightment is the legal term for an agreement between a shipowner and a shipper to transport goods by sea or to provide a vessel for that purpose. Contract of affreightment became effective when the merchant ceased to accompany his goods in person. Numerous agreements were reached between the ship owner and the owner of the goods, which were subsequently codified in a contract known as the "*Charter Party*."

"Charter Party" is derived from Latin "*Carta/Charta Partita.*" The charta partita was an agreement, that documents are written in duplicate on a single sheet of paper, then torn or cut in half and given to each signatory, eventually, Common Law adopted the practice of cutting or indenting a deed, which was later coined as a "indenture (David, 1975).

Todd (1988 as cited in Brown, 2006) defined charter parties as "*written deed or contract for the hiring for freight as a whole or part of the merchant vessel either for a pacific voyage or on a time basis* . The charter party is divided between demise and non-demise. A demise charter, the shipowner gives the charterer exclusive custody, management, navigation, and control of the vessel for a specified amount of time, with broad rights to select how to use the vessel. A demise charter is a bailment of the vessel. non-demise charter, the shipowner retains possession, management, navigation, and control of the vessel, but leases the whole or part of his carrying capacity to the charterer, either for a particular voyage ("voyage charter") or for a fixed period ("time charter"). Contracting practises include the voyage charter (short-term negotiated spot contract of a particular cargo between a load port and discharge port), the time charter (the cargo owner obtains the service for a fixed period (often relatively long-term contracts where the ship owner agrees to carry cargo within a specific period on a specified route, which can include several vessels).

Charter-party describes the contract. Shipowners must report speed, fuel consumption, and cargo capacity. If the ship does not satisfy these specifications, hire terms will change. The charter-party will also state when the vessel is 'off-hire,' such as during emergency repairs or if the charterer does not pay. Long-term charters also address the rental charge adjustment if the vessel is laid up and the conditions under which the charterer may terminate the arrangement, such as if the owner fails to run the ship efficiently.

The current position in the shipping sector is an example of an agency game that occurs frequently in business. The empirics of chartering are so complex but instead apply well established concepts and approaches. The chartering negotiations between a ship-owner/carrier and a charterer/shipper are aimed at inaugurating consensus. Thus, the entailed interplay dynamics is modeled through game theory, a mathematical study of strategic decision making between intelligent and rational players.

Technical description, surveys, speed, and consumption guarantees may need upgrading. Compliance with operations to conform with CII conflict with the accepted standard of commercial shipping has an impact on the privileges charterers have previously enjoyed under time charters.

The onus of compliance with maritime law relies entirely primarily with ship owners. The EEXI regulations will apply if the ship's flag is from a MARPOL member state. The risk and expense of compliance might be split between parties in a contract. The provisions of the charterers should be considered when deciding who is responsible for the costs associated with commercial risk. Energy efficiency is not a stipulation in most charter contracts; instead, bunkers, performance, speed, and consumption are prioritized (Hill, 2003).

Provisions for improved ship energy efficiency should be made in contract. These may be indicative of the hopes of those investing in energy-saving technology. Second, it may place a premium on checking in on the ship to make sure it's doing its job. Third, it has the potential to resolve any inconsistencies that have arisen during negotiations for a freight rate. Lun et al. (2015), motivated by Rai et al. (2012) work on contractual flexibility, suggest that contracts establishing the vessel's energy efficiency can enhance environmental performance, absentism of such provisions, shipowners are likely to remain liable either under the seaworthiness / due diligence responsibilities [22]or legal fitness obligations.

[22] Hague / Hague-Visby Rules

Elli and the Frixos[23] is fairly novel in terms of MARPOL; ruled ***a shipowner must update a ship or fleet to conform to the industry's most recent standard".*** The issue of which party would bear the commercial risk was to be interpreted in light of the charter party's relevant terms. The primary duty of due diligence necessitate strict adherence to an existing statute's modified criteria. The shipowner would be in breach of due diligence because he would be obligated to take all reasonable steps, such as modifying or fitting new equipment in accordance with shipping industry regulations, to maintain the ship's seaworthiness.

Golden Fleece Maritime Inc and Another v St Shipping and Transport Inc. Golden, , chartered its vessels Elli and Frixos to Defendant under two-time charters on the Shell time 4 form, as revised and extended (ST). The fundamental issue raised was who, Golden or ST, accountable for the financial fallout from a change in international legislation that limited the types of cargo that the Elli and Frixos could transport? Regulations 13F, 13G, and 13H of MARPOL were adopted on 4 December 2003 and had an effect of establishing requirements for the carriage of fuel oil effective as of 5 April 2005, a date that fell 19–20 months e two charter periods came to an end. That "***the warranty in Clause 52 of the charter applicable implemented accordingly then after delivery of the vessel to the charterer"*** was ruled. the same clause allude to the SOLAS and MARPOL Conventions, extending to all future voyages, Court held: *the ship was not seaworthy since it did not meet the requirements of Clause 52 of the revised MARPOL.*

Contrary to the set precedent, it ***is not the responsibility of a ship's owner to implement all the latest innovations. Held*** in ***Mount Park Steamship Co v Grey (1910) Shipping Gazette (12 March 1910***), ***a ship "need not be always, in all aspects, up to date."*** Scrutton LJ ratio decidendi, ***"[The vessel] surely need not contain fittings or devices which had not at the time been invented, because by subsequent enquiry a hazard has been revealed which these fittings and instruments, when invented, would avert."***

[23] *Golden Fleece Maritime Inc and Another v St Shipping and Transport Inc: CA 23 May 2008)*

In cases where an improvement in fittings becomes common knowledge or a risk is discovered and proven, the shipowner may be obligated to make the necessary changes. However, in cases where the discovery or danger was unknown at the time of the journey, the situation is completely different. The question is whether or not ship owners can use this example to justify failure to have EEXI retrofits.

The contractual obligations, warranties, duties, rights and remedies clause that will be affected by CII and EEXI implementation: -

4.1.1 Seaworthiness and due diligence

The success of a ship's operations hinges on many elements. The hull form and propulsion system configuration make up a ship's design (Psaross, 2017). When retrofits are introduced, a gradual shift toward a redefinition of seaworthiness is more likely than a sudden one. No rule from the Nomos Rhodion Nautikós (the maritime age) demands ship owners provide seaworthy vessels. The notion of seaworthiness has varied as the shipping industry has developed. The outside of a ship has traditionally played a vital part in determining its seaworthiness.

CII and EEXI create a new and higher standard of seaworthiness, that affects the fundamental rights of charter party, expected to affect the interpretation of due diligence[24] rules and the measure required[25].

Charterparties and other contracts involving seaborne transportation frequently lack a seaworthiness definition. Legal scholars, merchants, and shippers have always been interested in seaworthiness. Failure to offer seaworthy vessel has severe consequences for a shipowner. Unseaworthy vessels can lead to cargo claims, liability limits, and void marine insurance policies.

Charter party seaworthiness falls under: - Technical seaworthiness (structural fitness), (ii) cargoworthi- ness, and (iii) seaworthiness for the intended voyage is an unavoidable overarching requirement.

[24] Article 3(1) of the Hague Visby

[25] Article 5(1) of the Hamburg rules

When the carrier employs "*due diligence to make the ship seaworthy,*" it may avoid liability (and if the carrier can prove this). Therefore, there is no universal test for determining if a ship is "seaworthy," and the concept goes beyond technical factors. Instead, all relevant information for a given contractual journey will be evaluated retroactively for "exercising due diligence to make the ship seaworthy." Carrier cannot delegate this responsibility; therefore subcontractors, agents, and employees are not legally liable for their conduct. In ***McFadden v Blue Star Line[26].***

A court may first apply the "prudent owner test" to its inquiry. The "ordinary or conventional test on unseaworthiness," as it is commonly known, was created as early as 1905. The standard is whether "a responsible owner, had he known of the relevant deficiency, would have demanded it to be made good before releasing his ship to sea."

a) Technical (Structural fitness)

In Steel v State Line Steamship Co (1877) 3 App Cas 72[27], Lord Blackburn characterized the obligation as an obligation ***'not just that they [the owners] should do their utmost to make the ship fit, but that the ship should actually be fit.***

The deficiencies that can lead to unseaworthiness are diverse. The obligation, according to Fir Diplock LJ in The Hong Kong Fir[28], "*may be broken by the presence of small faults that are easily and quickly remediable as well as defects that must eventually result in the total loss of the vessel*."

IN CMA CGM LIBRA[29] [2021] UKSC 51, [2021] WLR(D) 577 . The UK Supreme Court has ruled that "the prudent owner test" is "not a general test of unseaworthiness," implying that any further legal analysis may be necessary. To further engage the seaworthiness hypothesis, it may be necessary to examine whether the alleged malfunction or situation "sufficiently undermines the fitness of the vessel to carry the goods safely on the contractual journey."

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[26] *[1905] 1 KB 697, 706*

[27] *(1877) 3 App Cas 72*

[28] *Hong Kong Fir Shipping Co Ltd v Kawasaki Kisen Kaisha Ltd* [1962] 2 QB 26 [1961] EWCA Civ 7

[29] [2021] UKSC 51, [2021] WLR(D) 577

Table 2

Technical defects and precedents.

Defect	Case
Leaking hull	*Lyon v Mells* [1805] 1 KB 697
Hull fracture	*Danske Sukkerfabrikker v Bajamar Compania Naviera, The Torenia* [1983] 2 Lloyd's Rep 211
Leaking hatch covers	*Itoh & Co Ltd v Atlantska Plovidba, The Gundulic* [1981] 2 Lloyd's Rep 511
Leaking sea valve	*McFadden v Blue Star Line* [1905] 1 KB 697
Porthole not capable of being closed at sea	*Steel v State Line; Dobell v Steamship Rossmore Co* [1905] 2 QB 408
Neglecting to put in a nail	*Havelock v Geddes* (1809) 10 East 555
Crankshaft with flaw in weld	*The Glenfruin* (1885) 10 PD 103
Defective propeller	*SNIA v Suzuki* (1924) 29 Com Cas 284
Insufficient spare parts	*Project Asia Line Inc v Shone, The Pride of Donegal* [2002] EWHC 24; [2002] 1 Lloyd's Rep 659
Unsuitable spare parts	*Guinomar of Conakry v Samsung Fire & Marine Insurance Co Ltd, The Kamsar Voyager* [2002] 2 Lloyd's Rep 57
Sludge in lubricating oil	*Fyffes Group Ltd and Caribbean Gold Ltd v Reefer Express Lines Pty Ltd & Reefkrit Shipping Inc, The Kriti Rex* [1996] 2 Lloyd's Rep 373
Insufficient supply of fuel	*The Vortigern* [1899] P 140
Contaminated fuel	*Island Tug and Barge v Makedonia, The Makedonia* [1962] P 190
Contaminated cargo tanks and lines	*Vinmar v Theresa* [2001] 2 Lloyd's Rep 1
Inadequate charts and navigation aids	*Rey Banano del Pacifico Co v Transportes Navieros Ecuatorianos, The Isla Fernandina* [2000] 2 Lloyd's Rep 15
Defective refrigerating machinery where the cargo was frozen meat	*Maori King v Hughes* [1895] 2 QB 550
Ship with no dunnage mats to protect dry cargo	*Hogarth v Walker* [1899] 2 QB 401
Pumps inadequate for cargo	*Stanton v Richardson* (1872) LR 7 CP 421

Note. Source: Dockary & Thomas 2007 as cited by Psarros 2017

b) Human seaworthiness

Design improvements may necessitate significant ship crew training and awareness, influencing maintenance durations. CII will cause disruptions in ship operations and increase the workload of technical management. With an unskilled crew and bad supervision, the vessel will be unseaworthy.

c) Lack of necessary documents

A vessel can be physically fit, with trained and competent human seaworthiness, and be unseaworthy due to a lack of on-board documentation required for conformity with international regulations. The International Energy Efficiency Certificate CII, SEEMP Phase 3 plan, are required on board. It is the obligation of port states to implement and verify that the Vessel has valid certificates. The vessel must be in good condition during the charter period and have the necessary certificates to call at a specific port or nation without delay.

4.1.2 Demurrage and laytime

Ship owners pay bunkers as liquidated damages for exceeding laytime limits. Demurrage can profit shipowners. the market is influenced by factors such as speed, fuel consumption, travel distance, and arrival time. Shipowners love demurrage. All voyage charter bulk cargo ships steam toward the port of destination as quickly as feasible, tender Notice of Readiness, and begin the laytime clock. Is demurrage compatible with the Decarbonization Era, or should it coexist with sail, steam, and fuel oil?

4.1.3 Utmost despatch

Despatch is a stringent absolute duty. Ship owners ought to choose the most fuel-efficient route as meeting CII targets may necssitate slowing down or sailing longer. Charterers must ensure that owners adhere to dispatch and compliance regulations.

Prolonged routes may necessitate a diversion, rendering a ship out of commission; owners should define and negotiate the terminology.

4.1.2 Off hire

Compliance with EEXI in cases of technical modification, where there is total lack of a needed modification clause, purchasing, installation, and evaluating new retrofits and when/where drydocking would happen will be important issues in mid- to long-term time charters. The shorter a charter, less probable development, and off-hire, out-of-service, and drydocking constraints become more essential

4.1.3 Redelivery

Charterers are responsible for maintaining the ship's CII rating as part of their duty to return it in good condition. Due to the delay in evaluating the ship's operating CII (and CII rating), there may be no detectable breach upon redelivery.

4.1.4 Employment order'

Time charter masters are required to follow charterers' legitimate orders within the charter parameters and to implement them efficiently and expeditiously; realistically, compliance with CII necessitates changes in how vessels are operated and how charterers issue orders.

4.1.5 Deviation

Slow steaming or diverting from the shortest or quickest route on a voyage may, in the utter lack of agreements between the parties, place Owners in breach of one's obligations to proceed on voyages with utmost/due despatch and/or comply with Charterers' orders and instructions, as well as any speed and consumption warranties in the charterparty. This could invalidate P&I coverage. Depending on the wording of applicable clauses and factual circumstances, this could also give rise to off-hire claims or alternatively claims for equitable set-off against hire.

4.1.6 Consent

Charters must obtain the shipowner's permission. before making structural or "substantial" changes to the ship or machinery to conform with CII

4.1.7 Definitions of terminologies

The regulation have left the texts open with regards to interpretation opening up legal obstacles.

4.1.8 Claims by third parties.

Third-party cargo interests may also bring claims against shipowners or the ship for cargo delay or damage under bills of lading. Any defences are likely to be restricted and challenging to implement, particularly in the case of short-term charters. To succeed, shipowners must prove a clear and determinable causal link between the charterers' order(s) and a blatant violation of the IMO regulations, which may be challenging.

4.2 CONCLUSION

The law is fluid and adapts to the demands of the maritime sector. The legislation on the carriage of goods by sea is not an exception to the rule, and courts will be directed by the same issue of liability and burden of proof in the absence of proper definition of terms in the regulations.
The CII Clause is "complicated" than the EEXI Transition Clause. The CII Clause addresses the ever-shrinking emissions "tunnel" in attempt to strike a balance between the operational constraints imposed by the low carbon regime and Charterers' ability to maximise the ship's commercial operations during the charter period.

Lun et al. (2014) and Agnolucci et al. (2014) agree that the emphasis on operational efficiency in existing charter party agreements weakens the development of information monitoring systems and cooperation between principals and agents about energy efficient equipment. Agreements containing just performance indicators may lead the agent to participate in dysfunctional activity, i.e., maximize personal margins and lessen the motivation of paid bunkers, which is not necessarily in accordance with the principal's purpose of decreasing transport cost (Baker, 1992).

5 RECOMMENDATIONS AND CONCLUSION

When it comes to decarbonization, the use of legislation as an essential instrument for equity in advancement of SDGS, particularly SDG 13 to compliment to authors identified models, studies, technology recommendations, and gaps in the implementation of EEXI, CII, and charter parties. Legislative drafters should harmonize all of them by ensuring the same is stipulated into law and reflects the research above. The journey from energy efficiency to sustainability is a complex process, and policy plays a critical role in facilitating such a transition by providing clear direction by creating concrete definitions that are compatible with other existing legal frameworks, such as "operator" to include charters.

Technical and operational solutions alone are insufficient to achieve advancements in shipping industrial energy efficiency. There are fewer patents in the shipping industry compared to other transportation sectors, and the industry frequently adopts technology and methods developed for use in other fields (Wiśnicki et al., 2021).

Energy efficiency in shipping is driven by consumer demand, financial constraints, and other considerations. Better design, operation, redesign, and lifetime intervention decisions can be made thanks to the data collected. The stakeholders now ought to comprehend their specific roles, be held accountable, and strive to achieve the same goals. Reforms influence energy efficiency and demand feedback from relevant parties (Armstrong & Banks, 2015).

5.1 Recommendations for Shipowners and Charterers

It is recommended that ship owners and charterers should revise their charter parties and have the necessary clauses as recommended below: -

1. Binding clause for charterers (Polluter pay principle.)

There should be a mandatory clause in a charter that makes polluters liable, like the new provision in the EU ETS, that requires charterers to pay for allowances out of their own pockets to promote energy efficiency.

2. Transition Clause

It is required by law that most contracts should have a Transitional clause to ensure the seamless implementation of permanent rules; nonetheless, in the event of a disagreement, the permanent provisions will take precedence. It is critical that transition clauses are interpreted correctly to minimize problems with administration and service delivery during the transition.

3. Speed Reduction Clause- Contractual consideration due to slow steaming

All new charters should include language allowing for a reduction in steam speed if necessary to meet CII regulations. that forbids the charterer from instructing the ship to proceed with the voyage at speeds in excess of those certified, would defeat the purposes of the restrictions enacted in accordance with the Resolution.

4. Speed and performance warranties

Warranties against CII deviations is something vessel owners must consider about. Charterers are liable for maintaining the ship's CII rating as part of their duty to return the vessel in the same condition as upon delivery. No observable breach may exist at the time of redelivery, however, because the evaluation of the ship's acquired operational CII (and CII rating) may not occur until months after the disaster. Fuel consumption at a set speed is typically guaranteed by Ships owners.

5. Energy Efficiency Clause

The incorporation of energy efficiency in charter party contracts is expected to imply adherence to environmental rules (i.e., lower shipping emissions) and contribute to environmentally friendly maritime operations (Lun et al., 2015).

6. Modification Clause

The incorporation of energy efficiency in charter party contracts is expected to imply adherence to environmental rules (i.e., lower shipping emissions) and contribute to environmentally friendly maritime operations (Lun et al., 2015).

7. Allocative efficiency clause.

The incorporation of energy efficiency in charter party contracts is expected to imply adherence to environmental rules (i.e., lower shipping emissions) and contribute to environmentally friendly maritime operations (Lun et al. 2015).

8. . SFFSM The Self-Financing Fuel-Saving Mechanism(Long term charters)

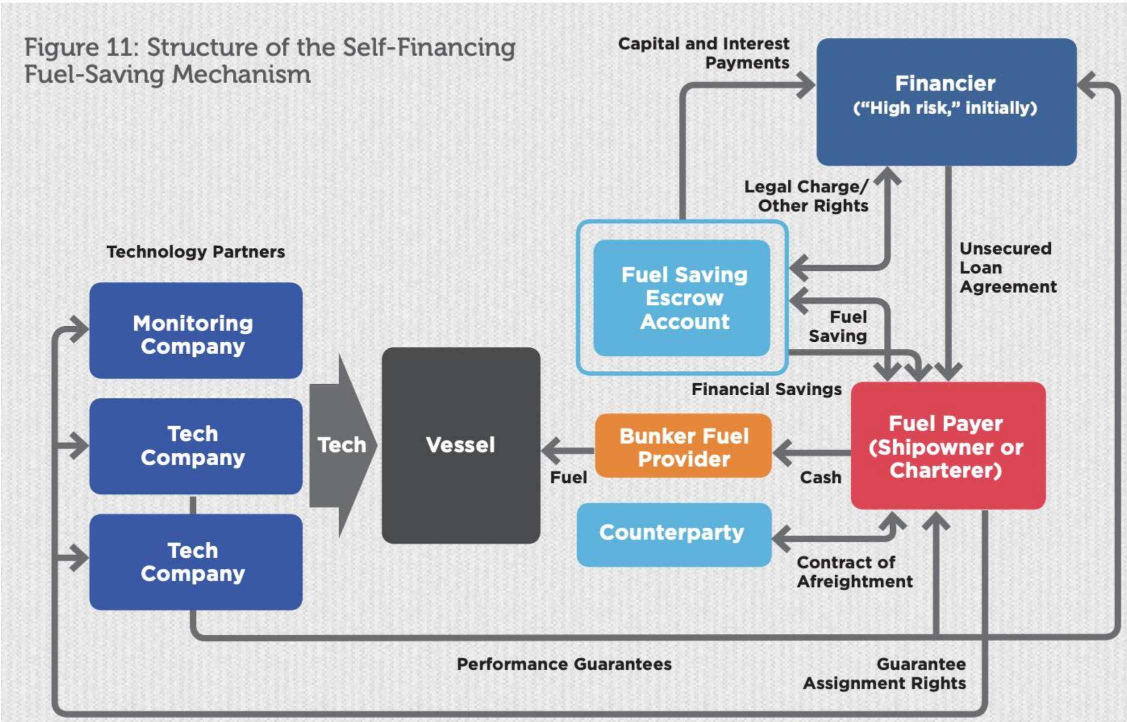
The Charters and ship owners should consider having this model to solve the split incentives as the financier only invests in vessels with a guaranteed contract of affreightment. The best technique for reducing emissions from maritime operations can be determined only through a clear cost-benefit analysis model that considers both the short- and long-term charters.

SFFSM Model for Fuel Efficiency Retrofits be amended in the charter party to include the fee. CWR worked with PwC, University College of London, and other partners to develop a fuel efficiency retrofit financing model as depicted in Figure 19.

The SFFSM tries to bridge the economic incentives of a ship's technical/capital expenditures and fuel expenses. as the financier only invests in vessels with a guaranteed contract of affreightment(Stulgis, 2014).

Figure 16

SFFSM.



Note. From "Hidden treasure: financial models for retrofits", Stulgis, et al., 2014, *Carbon War Room and UCL Energy Institute,* https://discovery.ucl.ac.uk/id/eprint/1470429/1/Stulgis%20et%20al.%20%282014%29%20CWR%20Shipping%20Efficiency%20Finance%20Report.pdf

9. Save As You Sail" (SAYS)(Short time one and two years

Any ongoing charter agreements can include the SAYS fee, which will be charged to future charters.

The "Save As You Sail" (SAYS) strategy focuses on overcomes the split-incentive problems. Under SAYS, shipowners get financing for retrofits and pay it back over time charterers. Ship owners pay a "SAYS fee" (an added monthly cost that charterers pay to the shipowners). Charterers should pay the SAYS charge because a fuel-efficient ship will save more. Past performance monitoring estimates savings.

10. A consumer focused Blockchain architecture

It is recommended for parties negotiating in chartering should use Automates policymaker-consumer/generator discussions for decarbonization. (Hua et al., 2022) A Stackelberg game-theoretic problem depicting strategic bargaining led to an agreement.

5.2 Recommendations for governments

1. The national government domesticate MEPC 328(76) into their national laws by incorporate by cross reference and ambulatory reference in national legislation.
2. The Legislator should define terms like Carrier to include charterer and do not leave room for ambiguity, guided by the (Polluter pays principle). The Legislative should emulate the EU ETS trading where charters are paying for emissions.
3. The legislators should pass laws that adopt the Kaldor kick criterion as efficient as a policy which results in better benefits for those who gain such that potentially benefit they can compensate fully all the losers and still remain better off (Ogus, 2004).
4. The national government should incorporate MEPC 328(76) into their national laws through cross reference
5. The combination of the proposed O-KPI and hybrid MBM.

IMO should propose the O-KPI and hybrid M1BM as an alternative to CII, it does support the improved SEEMP (Ghaforian et al., 2022).

6. Port incentives in port area

Carrot and stick approach should be used as identified in the study of (Becqué et al., 2017). Industry-initiated scheme that are universally applicable across countries and government initiated scheme that are exclusive to a country's ports.

Ports should incentivize ships that exceed EEXI standards. Existing non-EEDI ships can still be incentivized to reduce GHGs.

Maritime administrations, port authorities, and other stakeholders (e.g., insurers) are encouraged to provide incentives to first movers, such as A or B CII-rated ships (IMO, 2020a, 2018a), CII also includes emissions over the whole voyage, so ports that provide incentives in this case play a role in GHG reduction in wider supply chains (Alamoush et al., 2021). Ports like Hamburg, Metro Vancouver, Oman, Rotterdam, Prince Rupert, Sohar, Vancouver, and Yokohama are awarding subsidies to more fuel-efficient vessels (Alamoush et al., 2021).

5.3 Recommendation to the IMO.

a. Research

decarbonizing maritime transport requires studies that boost the economic and technological feasibility of low-carbon initiatives. Measuring emissions is a first step in lowering them, but no comprehensive, reliable method has been found. In evaluating mitigation schemes, reliable and consistent emission trajectory data is needed.

b. Mobile offshore units, be subjected to the new regulations.

It is utmost importance that Existing oil and gas businesses units be subjected to the GHG abatement Programme to ensure sustainability and profit from GHG abatement programmes (Ng et al., 2022).

c. Data collection

Examining the impact of fuel quality and type on GHG emissions in order to produce more thorough data (Rigo, 2022).Actual CO2 emission reduction is not solely influenced by the primary engine's restriction. Data collection will lead to smarter decisions throughout the ship's career, from knowledge-driven design to operation, redesign, and lifetime extension (Hüffmeier & Johanson 2021).

d. Aglobal ETS

A global ETS to be proposed for adoption, to help reduce the CO2 and non-CO2 emissions of shipping by up to 65% from 2000 to 2050. The imminent inclusion of shipping within the EU ETS is the most radical industry intervention currently on the horizon and has stimulated much more intense discussions within the IMO on the introduction of a global ETS for shipping.

d. Digitalization

Digitalization can help can make decarbonization faster and more effective. Digitalization will provide means to measure energy efficiency by providing management of data allowing informed emissions on decarbonization. Digitalization is imperative in the journey of zero carbon shipping (Singh & Sengupta 2021). The absence of standardization for data capture, transmission, and analysis is a hurdle in the shipping industry (Hüffmeier & Johanson 2021).

e. Real time monitoring of carbon emission system

Ship emissions should be measured as they sail rather than waiting for data to be submitted by organizations via electronic communication in the standard format specified in MEPC 346. (78)

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