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Evaluating the Carbon Intensity Indicator (CII): Challenges and Recommendations for Improvements

In Company Project:
Royal Belgian Shipowners' Association (RBSA)

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Preface

In presenting this Master's thesis, we embark on an exploration of critical challenges and potential improvements within the Carbon Intensity Indicator (CII) formula, a key metric for assessing the environmental performance of sea-going vessels. The CII plays a central role in the shipping industry's efforts to reduce its carbon footprint and align with global sustainability goals. This research represents the culmination of months of rigorous study and analysis, driven by a commitment to contribute to the evolving discourse on sustainable maritime practices.

Our journey began with a thorough review of the existing CII framework, identifying its strengths and limitations. This work spans from March to May 2024 and reflects a dedicated effort to address the urgent need for improved environmental assessment tools.

Our interest in the CII has grown over the past seven months as we have explored the topic in various courses within our Master's programme. While some of us had a preliminary understanding of the CII, its complexity and limited coverage in standard curricula motivated us to delve deeper. We chose this topic to challenge ourselves and broaden our knowledge of its importance in the maritime industry's efforts to improve the environmental performance of global shipping.

We extend our deepest gratitude to our promoter, Prof. Christa Sys, whose continuous guidance and unending support have been crucial throughout this research journey. Prof. Sys' rigorous academic standards, combined with her deep understanding of the maritime industry, have significantly benefited our research process. Her constructive feedback, encouragement and dedication to our academic growth have been key in shaping the direction and quality of this thesis. We appreciate her commitment to excellence and her unwavering belief in our potential.

We are also indebted to the Royal Belgian Shipowners Association. We especially thank Celine Audenaerdt, the supervisor of this project, for her overall project coordination and for constantly providing us with insights. In addition, we thank the participating shipping companies for providing us with crucial data and valuable insights on this pertinent topic. Their cooperation and openness significantly enriched our research and allowed us to ground our theoretical findings in real practices and challenges.

Finally, we would like to express our sincere gratitude to our families, whose support provided us with a nurturing environment during our research. Their support in hosting us and providing us with delicious cuisines from different parts of the world fostered a collaborative atmosphere that was invaluable to our group. We also express our deep appreciation to our friends and all those who have supported us throughout this endeavor. Their encouragement and understanding have been indispensable in bringing this study to fruition.

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Abstract

The maritime industry, a key driver of global trade, is under increasing pressure to reduce its environmental footprint in response to growing concerns about climate change and regulatory requirements. Going greener is important for the sector, but it comes with challenges. For example, the Carbon Intensity Indicator (CII) as part of these greening efforts has faced significant criticisms.

This study conducts a comprehensive data analysis to identify the shortcomings of the current CII regulatory framework and calculation metrics as applied to different vessel segments within the Belgian merchant fleet. The primary objective is to investigate specific issues related to the existing CII regulatory framework and corresponding formula and to identify additional factors that could improve its accuracy and fairness. The analysis focuses on ship performance data for the year 2023, with particular attention to ship type and segment from the Belgian merchant fleet.

By examining key performance metrics such as distance traveled, number of port calls, port waiting time and other relevant parameters, this master thesis aims to uncover the limitations of the current CII formula. Particular emphasis will be placed on comparing sister vessels or vessels of the same type to identify the factors leading to discrepancies in CII ratings. The findings will provide recommendations for an improved CII formula that more accurately reflects the relevant factors and produces fairer results.

The study concludes with recommendations for the Royal Belgian Shipowners' Association (RBSA) and the Belgian shipping companies involved, urging them to consider the different factors affecting the CII rating of different ship type segments in the Belgian merchant fleet. By understanding these factors, the CII ratings of the Belgian fleet could be improved, thereby enhancing their environmental performance and compliance with regulatory standards.

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List of Abbreviations

AER	Annual Efficiency Ratio
AG	Arabian Gulf
BIMCO	Baltic and International Maritime Council
cgDist	capacity gross ton Distance
CII	Carbon Intensity Indicator
CLIA	Cruise Line International Association
CO2	Carbon Dioxide
COC	Certificate of Compliance
CP	Charter Party
CSC	Clean Shipping Coalition
DOC	Document of Compliance
DPP	Dirty Petroleum Products
DWT	Deadweight Tonnage
ECA	Emission Control Area
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
EEXI	Energy Efficiency Existing Ship Index
EPL	Engine Power Limitation
ESD	Energy Saving Devices
EU	European Union
EUA	European Allowance
EU ETS	European Emissions Trading System
FBOG	Forced Boil Off Gas
FSRU	Floating Storage Regasification Unit
GFS	Global Fuel Standards
GHG	Greenhouse gas
GT	Gross Tonnage
HFO	Heavy Fuel Oil
IACS	International Association of Classification Societies
ICS	International Chamber of Shipping
IMO	International Maritime Organization
IMO DCS	IMO Data Collection System
IMO DOC	IMO Document Database
JKTC	Japan, Korea, Taiwan and China
IPTA	International Parcel Tankers Association
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environment Protection Committee
MGO	Marine Gas Oil
MR	Medium Range
MRV	Monitoring, Reporting and Verification
MSGC	Mid-Size Gas Carrier
NGO	Non-Governmental Organization
NM	Nautical Mile
NOC	National Oil Company
NSA	Norwegian Shipowners' Association
PSC	Port State Control
RBSA	Royal Belgian Shipowners' Association
RINA	The Royal Institution of Naval Architects
RO	Recognized Organization
RORO	Roll-On-Roll-Off
SEEMP	Ship Energy Efficiency Management Plan
SME	Small and Medium-sized Enterprises
SOC	Statement of Compliance
SOLAS	International Convention for the Safety of Life at Sea
STS	Ship-to-Ship
SIRE	Ship Inspection Report programme
TCP	Time Charter Party
UAE	United Arab Emirates
USEC	United States East Coast
USA	United States of America
USG	United States Gulf
UGS	Union of Greek Shipowners
UN	United Nations
USWC	United States West Coast
VLCC	Very Large Crude Carrier
VLGC	Very Large Gas Carrier
VLOC	Very Large Ore Carrier
WSC	World Shipping Council
WWF	World Wide Fund for Nature

1 Introduction

Sustainability and decarbonization are expected to be key drivers of global economic trends in the coming decades. Different supranational organizations such as the International Maritime Organization (IMO) or the European Union (EU) have set net-zero goals for 2050. To achieve this, these institutions are pushing legislation in different economic sectors so as to promote the green transition. For example, in this legal environment, the Carbon Intensity Indicator (CII) has been introduced to guide the maritime industry towards overall emission reductions.

On 1 November 2022, amendments to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL) entered into force. These were developed within the IMO framework agreed in 2018 to reduce greenhouse gas (GHG) emissions from ships (IMO, 2024a). The IMO is a body of the United Nations (UN) responsible for providing a regulatory framework for the safety and security of shipping and the prevention of marine and air pollution from ships (IMO, 2015). The 2022 amendments introduced the Energy Efficiency Existing Ship Index (EEXI) and the CII (IMO, 2024). The EEXI will apply to all ships above 400 Gross Tonnage (GT) and the CII will apply to ships above 5,000 GT and the following types: bulk carrier, gas carrier, combination- and vehicle carriers, container ships, tankers, general cargo ships, Roll-On-Roll-Off (RORO) cargo/passenger vessels, and cruise ships (DNV, 2023a).

From 1 January 2023, each shipowner, shipping company owning ship(s), is required to calculate its attained EEXI and gather data to report its annual CII rating to IMO. The EEXI measures the Carbon Dioxide (CO_2) emissions per transport operation, considering only the ship's design parameters. The EEXI is a one-time certification. Several technical options exist to improve the carbon intensity of existing ships to achieve the required EEXI. In order to calculate the attained CII and the CII rating, ships should collect and report fuel consumption data. Based on this data, each ship will be assigned a CII rating from A to E. Operational and technical measures could improve the CII rating. Ships with a poor rating should implement a corrective action plan by updating Ship Energy Efficiency Management Plan (SEEMP) part III (IMO, 2024a).

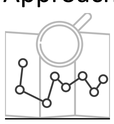
The IMO plans to review the CII regulations by January 2026. Flag States, IMO Member States, international organizations representing shipowners and/or charterers and other stakeholders are invited to submit data to the IMO in support of the review process by autumn 2024 at the latest (Baekmark Schiolborg, 2023). The Royal Belgian Shipowners' Association (RBSA) is an association representing all Belgian shipowners (RBSA, 2024). It intends to draw up its own list of suggestions for the revision of the CII regulations, based on data, information and experience from the Belgian shipowners and their classification societies. Through this thesis, the following questions will be answered: What are the problems with the current CII formula?, and how can the formula be improved?

To answer these questions, the RBSA established contacts with four shipping companies. These four companies provided operational data on their fleet of 2023, including the data needed to calculate CII. The four shipping companies own and operate vessel segments including container vessels, bulk carriers, crude tankers, chemical tankers, and Liquified Petroleum Gas (LPG) carriers. Shipping companies are required to report CII data from 2023, so the first annual reporting should be completed based on the data in 2023 and the first CII ratings will be issued in 2024.

2 Methodology

The primary objective of this research is to comprehensively identify the issues at all stakeholder levels concerned with the CII regulatory framework and to assess their relevance to the four Belgian shipping companies that serve as the key stakeholders in this paper. Secondly, the research aims to assess the impact of the identified issues on specific vessel segments owned and operated by the key stakeholders. Finally, the research aims to draw data-driven conclusions based on the results of the comprehensive data analysis, thereby providing valuable insights into potential improvements to the CII framework and calculation metrics. To achieve this, the research used both qualitative and quantitative approaches, as shown in Table 1.

Table 1. Approach of methodologies (own work)

<table>
<tr><th>Approach</th><th>Methods</th><th>Stakeholders</th><th>Aim and Objective</th></tr>
<tr><td rowspan="3">Qualitative Approach
</td><td>Literature review</td><td>● IMO Documents
● Academic papers
● Industry reports</td><td rowspan="3">● Identify issues with the CII regulatory framework and calculation metrics from a holistic industry perspective
● Identification of critical issues related to the CII regulation and calculation metric with the four Belgian shipping companies and other maritime stakeholders</td></tr>
<tr><td>Interviews (Face-to-face and online)</td><td>● Four Belgian shipping companies
● Stakeholders from maritime industry (operator, seafarer, ship manager…)</td></tr>
<tr><td>Online Survey</td><td>● Stakeholders from maritime industry at all levels</td></tr>
<tr><td>Quantitative Approach
</td><td>Data Analysis</td><td>● Ship operating data of 2023 from four Belgian shipping companies</td><td>● Analysis of the relevance of the identified problems to the CII regulatory framework and calculation metrics based on the fleet performance data of the Belgian fleet in 2023</td></tr>
</table>

2.1 Literature review to identify major problems with CII

The literature review was conducted by collecting information from the IMO Document Database, academic research, and articles dealing with the CII to ensure a comprehensive understanding of the CII regulatory framework and the related issues. The IMO Document Database contains documents and resolutions submitted by various stakeholders and that are published by the IMO. Table 2 lists the stakeholders that have already provided feedback to the IMO already.

Table 2. List of stakeholders who have submitted comments to the IMO on the CII regulation. Own work based on (IMO DOC (n.d.))

Category	Name of Stakeholders
Industry Representatives	Intercargo, Interferry, Intertanko, Cruise Line International Association (CLIA), ICS, World Shipping Council (WSC), International Parcel Tankers Association (IPTA), BIMCO, IACS and RINA
Environmental NGOs	CSC, World Wide Fund for Nature (WWF), Pacific Environment
Member States	Norway, United Arab Emirates (UAE), Panama, Malaysia, Liberia, France, Germany, Japan, New Zealand, Bahamas, India, Republic of Korea, China

The result of the literature review served as a valuable foundation to identify issues related to the current regulatory framework and calculation metrics of the CII from a comprehensive and holistic perspective. These identified issues were used as a basis for further research in relation to the CII regulation during both quantitative and qualitative analysis.

2.2 Identification of stakeholders

The four Belgian shipping companies that provided data for the quantitative analysis of our research are identified as the key stakeholders in this study. Due to the sensitivity of the data, the company names are only known by the authors. The data analysis focused on investigating the relevance of the issues identified by qualitative analysis for their fleet in relation to the CII regulatory framework and the calculation metrics. In order to analyze the gaps between the broader industry perspective and the Belgian shipping company's perspective on the issue, it was decided to also involve stakeholders directly relevant to the CII regulatory framework within the maritime industry. This approach aims to gather high quality insights and ensure a comprehensive understanding of the challenges and concerns related to the current CII regulatory framework.

2.3 Framework and approach

Having identified the main issues with the current regulatory framework for CII and the metrics used to calculate it, the framework and approach were defined. The qualitative approach included both interviews and an online survey, with a focus on obtaining high quality insights. The aim was to reflect the findings during the literature review in order to identify the critical issues that key stakeholders concern with the CII regulatory framework. For the quantitative approach, data analysis was chosen to investigate the relevance of the identified issues for the ship's operational data of 2023 in relation to the CII ratings. This approach was chosen to provide a deeper understanding of the impact of the identified issues on the CII rating in real cases and finally to provide recommendations to improve the limitations of the current CII regulatory framework. The data collection framework is outlined in Figure 1.

The first step was to request a complete set of fleet operating data of 2023 from each key stakeholder. The full ship's operational data was crucial information to access the CII calculation metrics with the identified problems. As it may take some time for the key stakeholders to provide the data, this data was considered as the first priority for data collection.

In the second step, a literature review was conducted with the main purpose of obtaining comprehensive data on how industry identifies issues with the current CII regulatory framework and calculation metrics. The identified issues were then used to develop interview questions and online survey questions with the main purpose to gain quality and comprehensive data from stakeholders in the maritime industry.

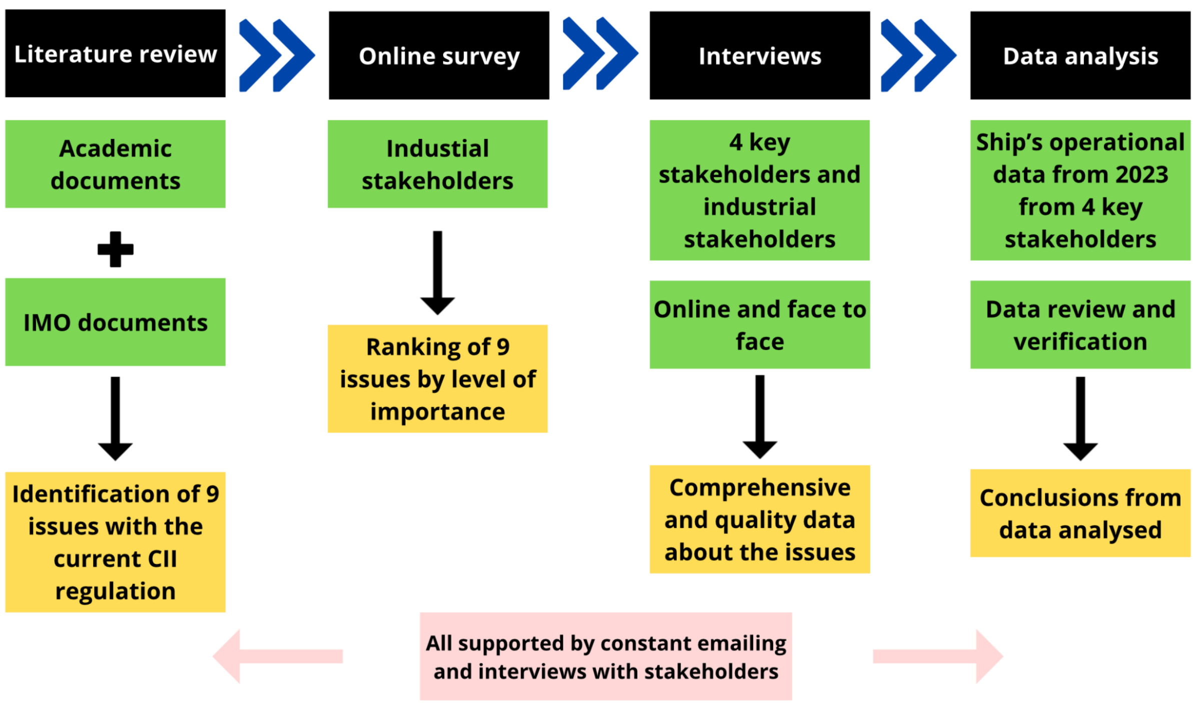


Figure 1. Data Collection Framework (own work)

3 Carbon Intensity Indicator (CII)

The IMO has adopted the CII as a GHG reduction measure to promote the decarbonization of shipping (IMO, 2024a). The CII measures the efficiency of ships in transporting goods or passengers. The result of the calculation is the number of grams of CO_2 emitted per ship capacity and distance traveled (DNV, 2023a). This is expressed as a number and then converted into a CII rating between A and E.

3.1 CII calculation method and formula

As each vessel has technical and operational differences such as specification, design, engines, generators, cargo type, or trading patterns, the IMO has provided detailed guidelines for calculating CII based on the 2019 reference data in the documents listed in Table 3. The IMO has also provided correction factors in the *IMO 2022 CII Guideline G5* for specific vessel types such as Liquified Natural Gas (LNG) carriers, ice class, reefer containers, self-unloading bulk carriers, Ship-To-Ship (STS) tankers, and shuttle tankers (IMO, 2022a).

To calculate the CII, three fundamental data are needed: Deadweight Tonnage (DWT) or GT, total CO_2 emissions, and distance sailed for a calendar year. Total CO_2 emissions are derived from fuel consumption multiplied by emission factors which is outlined in the table 4 below. Fuel consumption data and distance traveled are already recorded and monitored through IMO Data Collection System (IMO DCS) and other emissions such as Methane (CH_4) and Nitrous Oxide (N_2O) are not currently considered in the CII calculation metrics (Antony Veder, 2023).

Table 3. IMO Guidelines for CII calculation. own elaboration based on (IMO, 2022b, 2022c, 2022d, 2022a)(IMO, 2021))

#	Documents	Guideline	Summary
1	*Resolution Marine Environment Protection Committee (MEPC).352(78) - 2022 Guidelines on operational carbon intensity indicators and the calculation methods*	CII Guidelines, G1	Elaborate on attained CII calculation methods. Formula: $\frac{\textit{Fuel Consumption * CO2 Factor}}{\textit{DWT (or GT)}^{1} \textit{ * Distanced sailed}}$
2	*Resolution MEPC.353(78) - 2022 Guidelines on the reference lines for use with Operational Carbon Intensity Indicators*	CII Reference Lines Guidelines, G2	Development of reference lines for each ship type. The reference value is benchmarked the reporting data of the 2019 IMO DCS fuel reporting. This different reference value, depending on vessel type and the given capacity, will be used to calculate the required annual operational CII.
3	*Resolution MEPC.338(76) - 2021 Guidelines on the operational carbon intensity reduction factors relative to reference lines*	CII Reduction Factor Guidelines, G3	Elaboration of reduction factor (Z) based on the reference data in 2019 and the year between 2023 and 2026 are given with the value of reduction factor (Z) as fixed parameter. This reduction factor (Z) will be used when calculating Required annual operational CII. Required annual operational CII = (1- Z/100) x $CIIRef$
4	*Resolution MEPC.354(78) - 2022 Guidelines on the operational carbon intensity rating of ships*	CII Rating Guidelines, G4	Elaboration of the methods of CII rating between A and E, and how the rating range is determined by the *dd* vector which is varying depending on type of ships and capacity.
5	*Resolution MEPC.355(78) - 2022 interim Guidelines on correction factors and voyage adjustments for CII calculations*	CII Guidelines, G5	Explanation of the correction factors. Specified vessel sub-segment such as LNG carrier, ice-class, refrigerated container, self-unloading bulk carrier, tanker vessels in ship-to-ship and shuttle operation have correction factors which are to be reflected when calculating the CII. It also outlines voyage adjustment factors.

[1] DWT is applicable to ship types of bulk carrier, tanker, containers, gas carrier, LNG carrier, general cargo ships, refrigerated cargo carrier, combination carrier. GT is applicable to cruise passenger ships, RoRo cargo ships (vehicle carriers), and Ro-ro passenger ships (ClassNK, 2023).

To determine the CII rating, the attained CII must first be calculated and the resulting value will then be matched with alphabetical grades corresponding to the *dd* vector. The attained CII is a value derived from a vessel's performance for a calendar year, typically between 1 January and 31 December. Specific details of the calculation are outlined in *the IMO's 2022 CII Guideline G1* (IMO, 2022b). The required annual operational CII has a specific parameter and reduction factor. Each year has an increasing reduction factor relative to the year 2019. The details are specified in *the IMO 2022 CII Guideline G3 (IMO, 2021).* Once the attained CII has been calculated, the value will be identified as AER (Annual Efficiency Ratio) or capacity gross ton distance (cgDist). AER indicates emission per dwt-mile, while cgDist is for emission per gross ton-miles (DNV, 2023b). Ton-mile is calculated by multiplying the total weight of cargo carried by the total distance traveled. The result of attained CII determines the vessel's final alphabetical rating, ranging from A to E. This is determined by specific value ranges of the *dd* vector outlined in the I*MO's 2022 CII Guideline G4.* The *dd* vector is determined by the required annual operational CII which includes different fixed parameters of both vessel segment and capacity (IMO, 2022d). The calculation process and methods are further explained in the following paragraph.

The formula for calculating the attained CII is as follows:

$$Attained\ CII = \frac{Annual\ Fuel\ Consumption\ x\ CO2\ Factor\ of\ Fuel}{Annual\ Distance\ Traveled\ x\ Capacity\ (DWT\ or\ GT)} \ * \ Correction\ Factors$$

(DNV, 2023b)

The calculation formula for the required annual operational CII is outlined below and Z is already given as a fixed parameter, depending on the year of CII calculation, in the *IMO 2021 CII Guideline G3.* The required annual operational CII plays a significant role in determining the *dd* vector and this indicates that each vessel, even though within the same segment, will have a different value of the *dd* vector due to differences in capacity.

$$Required\ annual\ operational\ CII = (1 - Z/100)\ x\ CIIRef$$

(IMO, 2021)

The calculation method of *CIIRef* requires a fixed parameter of ‘a’ and ‘c’ which is already specified in the *IMO 2022 CII Guideline G2* and it is variable depending on the type of vessels. The calculation of *CIIRef* is as follows:

$$CIIRef\ = a\ Capacity^{-c}$$

(IMO, 2022c)

Required annual operational CII plays an important role in determining the *dd* vector as shown in Figure 2. Within the calculation metrics, vessel segment and capacity play a crucial role in determining the *dd* vector. This indicates that each vessel within the same segment would have a different value of required annual operational CII and thus a different rating band of *dd* vector.

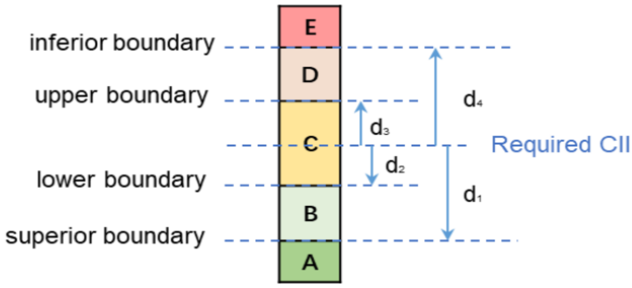


Figure 2. dd Vector and rating band. Retrieved from (IMO, 2022d)

The CII rating is determined by the methods set out in *IMO 2022 CII Guideline G4* and each vessel type has a different range to determine the rating between A and E (IMO(c), 2022). The CII ratings consist of five different alphabetical levels of an A (major superior), B (minor superior), C (moderate), D (minor inferior) and E (inferior performance level) (IMO(c), 2022). Each vessel is assigned a specific rating based on the attained CII, reflecting its relative performance during the calendar year. Any vessels receiving a CII rating of D for three consecutive years or a rating of E for a single year are required to implement a corrective action plan by updating the SEEMP Part III (DNV, 2023b).

With regard to the concept of the 'CO2 Factor of Fuel' in the numerator of the formula, it is important to check which fuels have the lowest CO2 intensity. The fuels with the lowest values will be very relevant when determining the CO2 efficiency performance. In Table 4 below, it can be seen that methanol is the least CO2 intensive fuel while compared to the worst performer, marine gas oil (MGO), it more than doubles its impact measured in Mt CO2/Mt fuel.

Table 4. CO2 emission factor (fuel oil mass to CO2 mass). Retrieved from (MEPC, 2018)

Type of Fuel	C_F **(t CO2/t fuel)**
Diesel/Gas Oil	*3.206*
Light Fuel Oil (LFO)	*3.151*
Heavy Fuel Oil (HFO)	*3.114*
Liquefied Petroleum Gas (LPG): Butane	*3.030*
Liquefied Petroleum Gas (LPG): Propane	*3.000*
Liquefied Natural Gas (LNG)	*2.750*
Ethanol	*1.913*
Methanol	*1.375*

In addition, other formulas, such as Energy Efficiency Operational Indicator (EEOI) and Energy Efficiency Design Index (EEDI), are included in the CII framework for information purposes only, but do not determine the final rating. Their purpose is simply to provide an additional perspective on the vessel's performance. Firstly, the EEOI measures the efficiency of a ship in tonne miles. *"EEOI is defined as the ratio of mass of CO2 (M) emitted per unit of transport work"* (IMO, 2009). Transport work, as used here, refers to the metric tonnes transported, for example on a gas tanker, multiplied by the distance traveled in a voyage. A voyage is defined as the time from departure from one port to the departure from the next port. Equation 1 expresses the value for each voyage, regardless of whether it is loaded or ballasted. Equation 2 (average EEOI) expresses the average of all the voyages over the year. In summary, the result is a measure of the tonne-mile efficiency of the ship in terms of fuel and its comparative CO2 emissions.

$$\text{Average EEOI} = \frac{\sum_i \sum_j (FC_{ij} \times C_{Fj})}{\sum_i (m_{cargo,i} \times D_i)}$$

(IMO, 2009)

Secondly, the EEDI is a measure of energy efficiency of a ship's design (IMO, 2018). It consists of a complex formula that takes into account various nautical engineering specifications. It applies to ships of more than 400 GT that entered service after 1 January 2013, as well as to older ships that undergo a major retrofit. It has been in force since 2013 for the sub-segments of shipping with the highest emissions and is constantly being revised to include new ship types. Due to the EEDI, vessels delivered after 2013 onwards have gradually higher efficiency (MAN, 2024).

3.2 Correction factors and voyage adjustments within CII calculation metric

Within the current CII circulation formula, there is a correction factor. The *IMO 2022 CII Guideline G5* has established a detailed methodology of voyage adjustment and correction factors when calculating the attained CII. The current IMO rules have only adopted correction factors certain types of vessels, including reefer containers, Ice-class vessels, tankers in STS operations, shuttle tankers and self-unloading bulk carriers. Voyage adjustments have only been considered for special occasions such as endangering safe navigation and ice-class vessels sailing in a sea area within the ice edge (IMO, 2022a).

3.3 CII reporting timeline, process, and results

The CII came into force on 1 January 2023 and all shipowners must comply with the regulation. From 2024, shipowners will be required to calculate the attained CII for the calendar year of the previous year. Before 31 March each year, the IMO DCS data from the Fuel Oil Data Collection System, together with the attained CII, must be submitted to a Recognized Organization (RO) or the classification society in most cases. In this process, the RO or classification society acts as a delegation on behalf of the flag states to verify the data. The verification process can take up to two months by the end of May. Ships receiving CII rating D for three consecutive years or rating of an E for a single year are required to develop a corrective plan and update the SEEMP Part III. If approved, a Certificate of Compliance (COC) for SEEMP Part III will be issued. Ships with a CII rating of C or above do not need to take any action and a Statement of Compliance (SOC) for CII will be issued when the verification process is completed (Bureau Veritas, 2023). Once the certificates have been issued to the ship, the data must be submitted to the IMO DCS by 31 May each year at the latest (IMO, 2023a).

4 Research question & rationale

The CII formula, while intended by the IMO to be simple, raises concerns on closer inspection. For example, it favors ships that sail longer distances, potentially rewarding higher fuel consumption. This is because the distance sailed is included in the denominator (IMO, 2023b). In addition, the use of capacity (DWT or GT) does not reflect the utilization rate of the vessel, allowing manipulation for a better CII rating, resulting in perverse incentive. In addition, the correction factors are not comprehensive and favor some types of ships to the detriment of others (IMO, 2022). These and other issues will be discussed in the following chapter.

The IMO has recognized that the CII regulations are not optimal and has invited stakeholders and members to propose changes (Baekmark Schiolborg, 2023). Different stakeholders are doing this and they all have a different view on what should be changed according to their data, and interests. There is not yet a document with proposals made from the Belgian fleet and the RBSA wants to take the opportunity to submit a document. This thesis will answer the questions: "What are the problems with the current CII formula, and how can the formula be improved?”. The answer to these questions will give a good picture of where the CII formula is lacking and what amendments in the current CII formula could be made.

5 Literature review

Since the CII came into force on 1 January 2023, there have been considerable arguments, debates and opposition from various stakeholders such as shipowners, charterers, non-governmental organizations (NGOs), flag states, and researchers who have expressed different opinions. The IMO has acknowledged the shortcomings of the current CII formula and invited stakeholders to submit data to support the review process, which will conclude with a revision of the current CII formula by January 2026 (Baekmark Schoolbord, 2023). The main source of the literature was the IMO DOC which is a public website operated by the IMO that provides access to the full text of documents and resolutions issued by the Organization's main bodies and committees since the late 1990s (IMO, n.d.). Stakeholders relevant to the CII regulatory framework have already submitted documents to the IMO and these are available on IMO DOC under the IMO document format. In addition, the literature review included research papers published by universities, statements by NGOs, and organizations representing shipowners, and articles on related topics. Finally, the literature review identified nine primary issues covering regulatory, commercial, technical, and operational perspectives (IMO, 2024b). Each issue was categorized based on its relevance and practicality within the characteristics of each issue.

5.1 Issues identified about CII regulation and the current formula

The literature review highlights issues related to the existing CII calculation formula and regulatory framework from an industry perspective and elaborates on issues relevant to the scope of this paper for data analysis. Table 5 outlines the nine main issues, categorized into commercial, operational, technical and regulatory perspectives. The problems are sorted according to how they are addressed in the literature review. Regulatory operational, commercial and technical impacts arise from the CII framework, including the current formula. The commercial aspects relate to the impact on a ship's potential employment, operational restrictions or charter parties. Operational refers to the impacts arising from the operation of the ship in relation to the CII. The technical category covers factors such as ship design, specifications or technical aspects of operation. Details of findings about the nine issues during the literature review will be outlined in the following section. Additionally, arguments and discussions from the perspectives of NGOs and industries will also be discussed.

Table 5. Issues identified with the current CII formula. Based on (IMO, 2024b)

Clause	Issues	Category
4.1.1	CII clause restricts charterer's right under Time Charter	Commercial and operational
4.1.2	Inconsistency of CII formula and correction factors	Regulatory and operational
4.1.3	Drydock negatively affecting CII	Technical and operational
4.1.4	Port delays and idle periods negatively impact CII	Technical and operational
4.1.5	Adverse weather conditions negatively impact CII	Operational
4.1.6	Use of only DWT and/or GT in CII calculation metric creates adverse impact	Regulatory and operational
4.1.7	Perverse incentive	Operational
4.1.8	Neglecting of ship's substantial differences	Regulatory and operational
4.1.9	No clear enforcement mechanism	Regulatory and commercial

5.1.1 CII clause restricts charterer's right under Time Charter

Under IMO rules, shipowners are responsible for the CII rating of their ships. This has led to a division between shipowners and charterers. This is because the charterer decides on the ship's operational aspects such as trading routes and cargo type and the shipowners should follow the instruction in accordance with the Charter Party (CP). Shipowners are held responsible for the CII rating and have no influence on the operational aspects when the ship is time chartered. The impact of a charterer should not be underestimated, as changes in CII waiting time and voyage speed can significantly affect the CII rating. This is illustrated in the chart developed by Intercargo in Figure 3. A difference in speed of 1 knot can change the CII rating, or a change in waiting time of 25 days can also change the CII rating. The speed is the charterer's choice and the shipowner must bear the consequences. Lastly, the waiting time is beyond the control of the charterer and shipowner (IMO, 2022).

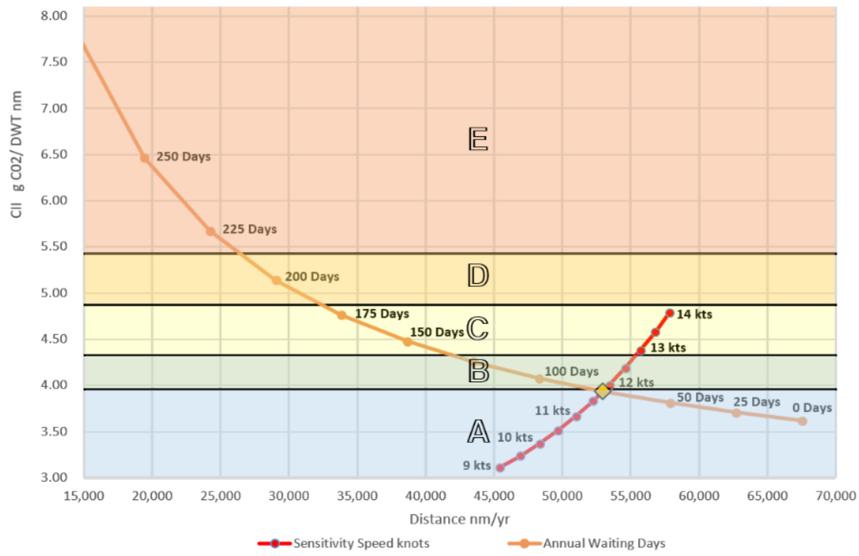


Figure 3. Modern bulker CII sensitivity speed and waiting days, sensitivity impacts of two voyage parameters on CII rating grade scores. Retrieved from (IMO, 2022)

However, there is an argument that a new CII clause introduced by the Baltic and International Maritime Council (BIMCO) restricts the rights of charterers. Under the new CII clause, the charterer has two main obligations, to operate the vessel in accordance with the CII regulations and to operate the vessel so as not to exceed the agreed CII, which is agreed between owners and charterers during negotiation of the CP. For example, charterers may be required to adjust the speed of the vessel to achieve and maintain the agreed CII (Austin, Adamson, & Hyne, 2022).

In addition, the shipowners are entitled to issue warnings in case the attained CII may deviate from the agreed CII. In any case, if it is reasonably predicted that the charterer is unable to fulfill their obligations about CII, the shipowner is entitled to request the charterer to submit a corrective plan for the next voyage, simply the way to keep the vessel within the agreed CII. If the corrective plan does not look to be adequate for the vessel to keep the CII rating within the agreed CII, the shipowner is then entitled to work on developing the corrective plan together with the charterer. Until the plan is mutually agreed by both parties, the owner may hold the right not to follow the charterers' voyage instructions (Austin et al., 2022).

As a result, the BIMCO's new CII clause may restrict the Charterers' right against the CP. This has disrupted the previous owner/charterer relationship before the CII came into force. This shift in power is causing some dissatisfaction among charterers. The Royal Institution of Naval Architects (RINA) is a member of the IMO and represents the views of the organization and members of the global naval architecture community. RINA says that the BIMCO CII clause forces owners and charterers to work together on the CII rating of the ship, but that there is a lack of clear clauses in the charter parties which make it difficult to share responsibilities and work together (IMO, 2024b). Charterers are contractually responsible for the CII rating of the chartered vessel while Owners are responsible for the compliance to CII regulation and if there is a lack of partnership between owners and charterers, it becomes difficult to share responsibility (Lowry, 2022).

This is due to a lack of understanding of the CII clause and the requirements (Bakhsh, 2022). Charterers claim that the BIMCO CII clause is unfair and illogical to charterers, much to the disappointment of shipowners that include the BIMCO CII clause in every CP. Law firms such as Clyde & Co and Whatson Farely Williams also claim that there is something wrong with placing the burden of CII solely on the charterer. Oldendorff, a dry bulk carrier company, suggests that rather than focusing on complicated CII rating and responsibilities, the industry should prioritize emissions reductions (Osler, 2022). The BIMCO's CII clauses for both Time Charter Party (TCP) and Voyage Charter are attached in the Appendix D.

5.1.2 Inconsistency of CII formula and correction factors

The current CII formula has been the subject of extensive debate and discussion within the maritime industry due to its perceived limitations in accurately reflecting the carbon emissions of ships. The inconsistencies in the correction factors used in the current CII formula have been identified as a cause for concern (IMO, 2023b). These inconsistencies may disproportionately benefit certain ship types and market segments while disadvantaging others, leading to an unfair and inaccurate comparison of carbon emissions across the maritime industry. As a useful indicator for assessing and mitigating the carbon footprint of ships, the credibility and effectiveness of the CII is compromised by these discrepancies (IMO, 2023b).

The IMO has been reluctant to include correction factors in the CII calculation metrics for a number of critical aspects, including adverse weather, port waiting times, particular ship types, and sizes. Failure to take these factors into account has raised significant concerns about the fairness and accuracy of the CII assessment, particularly when assessing the efficiency and operational performance of individual ships. This refusal by the IMO to include significant correction factors has raised concerns about possible unwarranted and disproportionate impacts on ship ratings resulting from inherent flaws in the CII mechanism (IMO, 2022). The following five factors, outlined in Table 6, were proposed to be included in the correction factors but were ultimately rejected.

Table 6. Five factors that were suggested to be considered in the correction factors (IMO, 2022)

#	Correction Factors that were addressed but refused
A	Adverse weather voyage adjustment
B	Adoption of a dedicated CII reference line for self-unloading bulk carriers
C	Port waiting time
D	Application of Forced Electrical to LNG carrier discharge pumps and vapor return compressors when relevant to cargo transfer
E	Adoption of Forced Boil Off Gas (FBOG) to LNG carriers

The discourse on exceptional case correction factors within the maritime industry has attracted attention and scrutiny, particularly in relation to exceptional scenarios involving STS operations. According to paragraph 2.8 of the *IMO 2022 CII Guideline G5*, *"a tanker shall be considered to be engaged in an STS voyage between loading and unloading locations, or a voyage between unloading and loading locations does not exceed 600 nautical miles (NM) and the time is limited to 72 hours"*. However, complexities and inconsistency also arise in cases where a tanker undertakes a multi-leg voyage, such as loading at port A, conducting a partial discharge at port B via STS, and then proceeding to final discharge at port C. Based on the definition of the STS voyage, the correction factor in this case may be ambiguous, as the voyage from port B to port C is a voyage between two places of discharge. A suggested approach to resolve this ambiguity is to specify in the relevant IMO guidelines that correction factors should be applied to each leg of the voyage, taking into account the distance and duration of the voyage for the respective voyages between the respective locations. For example, in the scenario described, correction factors would be applied separately to the voyage from port A to location B during STS operations and from location B to port C for final discharge. This approach recognizes the different nature of each leg of the journey and ensures that the carbon intensity assessment accurately reflects the emissions associated with each segment of the voyage (IMO, 2023d).

In addition, the Republic of Korea and the International Association of Classification Societies (IACS) have pointed out the discrepancy and inconsistency in the definition of capacity in the *IMO 2022 CII Guidelines G1* and *G5*. In the *G1 guideline*, capacity, either DWT or GT, is used as a fixed parameter in the calculation of the attained CII. However, *Guideline G5* defines capacity to refer to the *IMO 2022 CII Guideline G2*, where capacity is specified with correction factors ‘a’ and ‘c’ based on the reference line in 2019. Capacity will therefore be a variable factor (Republic of Korea and IACS, 2024). China raised the same issue and proposed amendments to the *IMO 2022 CII Guideline G5* to adopt the *CII Guideline G1* instead of *the CII Guideline G2* (IMO, 2024c).

5.1.3 Drydock affecting CII

Each ship under 15 years of age should drydock for every 5 years and ships of 15 years of age and over should drydock twice for every 5 years (IMO, 2011). During the drydocking period, consumption is taken into account, but there is no distance traveled. This has a negative impact on the CII rating as the distance in the denominator remains the same while the numerator increases due to the constant consumption. Drydocking has the same effect on CII as waiting in port or idling. The longer a ship is idle, the worse the CII rating (Toft Valeur, 2022).

Ships can improve CII through operational measures such as slow steaming. However, technical measures such as the installation of energy saving devices (ESD), retrofitting, design changes or new anti-fouling coatings can also improve CII (IMO, 2024b). These works are usually carried out in shipyards and take up to a few weeks to complete. The current CII formula would discourage shipowners from making such investments because of the downtime involved, which is not compensated for by distance. As distance, which serves as the denominator in the attained CII calculation formula, plays a significant role in the CII calculation, shipowners will be reluctant to lose any time out of service. In addition, ships are likely to consume fuel for heating, lighting, communications, etc. Therefore, the period in drydock would result in a worse CII rating. (IMO, 2023b).

5.1.4 Port delays and idle periods negatively impact CII

Waiting times and delays in port have been identified as significant variables that are not sufficiently taken into account in the current CII formula. Ships often experience unexpected delays in ports due to congestion, inefficient port operations or other logistical difficulties. These delays can result in long idle periods while ships need to continue to burn fuel without making any progress on their voyage. Long waiting times due to port inefficiencies pose a significant challenge for ships operating under long-term charter contracts, the terms of which are determined by the charterer's cargo volumes, loading and unloading procedures, freight rates, termination dates and anchorage waiting conditions. Prior to the implementation of the CII regulation, the prolonged berthing periods during the voyage of long chartered ships were not a significant concern. This was mainly because cargo owners compensated shipowners for delays through demurrage charges. However, given the potential for worse or deteriorating CII ratings resulting from extended waiting times to adversely affect the value of a vessel, shipowners are now being forced to address and mitigate these waiting times, even for vessels on long-term charters (IMO, 2024d).

Short voyages have been identified as an additional factor to be considered in the revision of the CII formula. Short voyages can be described as voyages under 200 NM according to the International Convention for the Safety of Life at Sea (SOLAS) (SOLAS, 1974). Ships with a lower deadweight tonnage often undertake a large number of short voyages, largely due to their relatively compact size and specific operational profiles within a certain trading route. For example a VLCC with 300,000 DWT on average will travel more distance between two ports than a Medium Range (MR) tanker with 50,000 DWT (Baltic Exchange, n.d. a). These short voyages inherently involve a significant amount of time spent in port and maneuvering, mainly due to the higher number of port calls. As a result, this operational characteristic leads to a disproportionate increase in emissions relative to the actual NM traveled. The current CII regulatory framework unjustly disadvantages ships that frequently engage in short voyages compared to their counterparts of similar size and category that undertake limited or no short voyages. This inequity arises for three primary reasons (IMO, 2023b):

1. While underway (voyage leg), due to additional main engine load transient operations, maneuvering and reversing within the calendar year;
2. While at berth, due to additional cargo loading/unloading operations; and
3. Due to waiting time in port or anchorage

(IMO, 2023b)

5.1.5 Adverse weather conditions negatively impact CII

The inability of the formula to take into account the many uncontrollable factors that can affect a ship's carbon emissions is a cause for concern. A ship's fuel consumption and carbon footprint can be greatly affected by adverse weather conditions. These conditions, such as high winds and rough seas, can force a ship to divert routes and operate at sub-optimal speeds, resulting in more fuel being used to maintain the ship's schedule and thus higher emissions. Ships operating predominantly in a harsh metocean region throughout the year cannot and should not be assessed on the same basis as those operating in a benign metocean region without an appropriate weather adjustment. Although a range of each ship type has been considered in the CII reference lines and therefore reflects the average metocean conditions experienced by the entire sample of ships, there is significant variation in global metocean conditions and the sea states experienced by individual ships may be harsher than the average (IMO, 2022e).

In addition to the increased fuel consumption and CO_2 emissions that adverse weather conditions can cause for ships, there is also a safety concern associated with the CII regulation. When ships are caught in unexpected adverse weather conditions, prioritizing the safety of navigation becomes paramount. However, without incorporating adverse weather into the voyage adjustment factors, there is a potential risk that crew members may hesitate to increase power due to the fear of adversely affecting CII ratings. This hesitation could ultimately increase the risk for ship's safety (IMO, 2022e).

5.1.6 Use of only DWT and/or GT in CII calculation metric creates adverse impact

The purpose of CII is to reduce CO_2 emissions per tonne or volume of cargo during transport (IMO, 2024f). The current attained CII formula only reflects the capacity of vessels in terms of DWT or GT, depending on the type of vessel. This means that the CII does not properly reflect and depict the utilization rate of vessels. It therefore does not meet the objective of the CII regulation. Taking the capacity of a vessel over the actual cargo weight carried will be a more effective proxy for calculating the attained CII than the current metric. This is because the current metric does not provide reward for reducing the ballast leg and increasing the utilization of ships (IMO, 2024e). Without taking into account the utilization rate, a potential perverse incentive behavior of shipowners can be expected. It is clear that vessels emit less CO_2 when they carry less cargo or when they are in ballast. Therefore, the current CII metric incentivizes ballast legs while penalizing loaded legs (Mærsk Mc-Kinney Møller, 2023). By using the utilization rate instead of the capacity of the vessel in the denominator, the potential behavior of a perverse incentive could be avoided.

5.1.7 Perverse incentive

The current factors used to calculate the CII rating include fuel consumption and distance traveled. In particular, distance serves as a parameter in the denominator and has a significant impact on the resulting calculation. One of the concerns about the current CII formula is the idea of perverse incentives (IMO, 2023b). Ships typically have a slower speed in ballast condition, resulting in lower fuel consumption and CO_2 emissions (Adland, Cariou, & Wolff, 2020). This could create perverse incentives. Ships could prioritize ballast voyages over laden voyages and simply increase their distance to maintain the CII range between A and C. The problem of perverse incentives will eventually lead ships to further navigate to increase distance, resulting in increased absolute emissions due to higher fuel consumption (IMO, 2023b). However, vessels are unlikely to incur additional fuel costs to increase distance (IMO, 2024b). This is mainly due to the fact that fuel costs account for around 50% of a ship's operating costs (Stratiotis, 2020). However, the concern about perverse incentives is not in line with the objective of the CII, which is to take action to decarbonize shipping.

5.1.8 Neglecting of ship's substantial differences

Each vessel has a different capacity, design, year of construction, cargo, and trade routes. One concern is that the current CII has neglected these differences among ships. For example, cruise vessels are typically affected by the current CII calculation metric. Cruise vessels are designed to provide hotel services to passengers, which results in increased time in port with constant fuel consumption (Braidotti et al., 2023). Due to the characteristics of the industry and the vessels, cruise vessels spend about 20% more time in port than other categories of vessels (IMO, 2023c). One of the concerns with the current CII formula is that it does not contain calculation factors that are unpredictable. Issues such as port delays, idle time, drydocking time, and adverse weather conditions are clear factors that have a negative impact on the CII rating (IMO, 2024b). These factors are beyond the control of both shipowners and charterers (Tunagur, 2024b).

Another example is self-unloading bulk carriers, vessels equipped with self-handling systems on board. These systems, which are used during cargo handling operations, require power from the ship's electrical system, resulting in increased fuel consumption. As a result, less power is drawn from external sources for the supply or receiving side. According to a study by CE Delft, self-unloading bulk carriers consume on average 21% more fuel than bulk carriers of similar size without self-unloading cargo-handling systems (IMO, 2022f). The *IMO's 2022 CII Guideline G2* did not consider the ship's difference between bulk carrier and self-unloading bulk carriers when determining the value of 'a' and 'c' which is used in calculation of CII*Ref* (IMO, 2022c).

5.1.9 No clear enforcement mechanism

While the CII stands out as a crucial aspect of decarbonizing shipping, one concern is the unclear enforcement mechanism. The benefits or penalties associated with compliance or failure to achieve an E or D rating for three consecutive years remain unclear. Currently, the primary enforcement strategy for ships falling below the required rating is to update SEEMP Part III to achieve compliance with a C rating. This is then verified by the Recognized Organizations (RO), usually classification societies. Furthermore, the lack of a clear IMO regulation providing guidance for situations where ships do not achieve the required ratings contributes to the perception that the CII enforcement mechanism is relatively soft (Mærsk Mc-Kinney Møller, 2023).

In contrast, the EEDI, also introduced by the IMO, has a clear enforcement mechanism that ships must hold an EEDI certificate to operate, otherwise will face operational restrictions (Mærsk Mc-Kinney Møller, 2023). The CII is currently under review until 2026 and the lack of an enforcement mechanism raises concerns that it could potentially undermine the reputation, credibility and regulatory effectiveness of the IMO (Tunagur, 2024a).

5.2 Arguments and opinions from the maritime industry

Various maritime stakeholders around the world have mentioned the unfairness of the CII framework for different sub-segments. Melina Travlos, president of the Union of Greek Shipowners (UGS), said: *"In the end, it [the CII] is unfair to all ships"*. The UGS has also set up an internal working group to highlight the weaknesses of the measure. The aim is to collect and analyze data in order to develop and present proposals to improve the scheme and reduce its negative impact on the industry. At the same time, Andrea Olivi, Head of Liquid Freight at global trader Trafigura, commented on the possibility of using the EEOI instead of the AER. In the same line, the focus on DWT multiple by distance traveled could potentially encourage anti-decarbonization situations such as ballasting. A switch to the EEOI, which is still not ideal or equally fair, would put the emphasis on demand-based ton-miles rather than DWT. It would therefore not result in such ballast legs (Glass, 2023). However, this would also result in an unfair situation for those business models that focus on parcel shipping or the shipping of commodities with low vessel fill rates (Das Aschan, 2024).

Similarly, according to Intercargo president Dimitris Fafalios, the CII rating system rates ships based on distance traveled, speed and intensity of use. As a result, the desired decarbonization targets cannot be achieved under real-world operating conditions and therefore do not offer fair and transparent emission reductions (Karageos, 2023). To add further complexity to the assessment of the ship, many factors are beyond the control of the shipowner. Such factors include adverse weather conditions, voyage distance, port waiting times, port infrastructure, and charterers' orders (Sandrelli, 2024).

The UGS, the shipowners' association of the world's leading shipowning nation, stated that the fact that the net-zero sustainable fuels, equipment and specifications are not yet available makes the CII framework rather unworkable. At this stage, the legislation is more aspirational and prescriptive than based on existing technologies in the market. As described above, critiques from the maritime industry are plentiful. Many national shipping associations are criticizing CII. Differently, some of these maritime stakeholders have no faith in CII and propose other alternatives which could be more workable to reach IMO's goals of net zero for 2050. For example, the International Chamber of Shipping (ICS) proposes a 'fund and reward' mechanism, funded by a carbon levy. Ships would be taxed by the IMO per tonne of CO2 emitted. This method would discourage ships from emitting carbon and reward ships that limit CO2 emissions through alternative technologies such as carbon capture or e-fuels. Differently, remarking the unfairness of these new carbon regulations, such as the European Emissions Trading System (EU ETS) and CII, these have a significant impact on the administrative burden for small and medium-sized enterprises (SME). Which do not have the same economies of scale to invest in decarbonization solutions. A global decarbonization framework should be promoted for equality and not to only those with higher investment possibilities. In addition, the factors that determine a ship's CII rating (ship speed, route, utilization, refueling) are often determined by the commercial operator/charterer of the ship and not by the shipowner (Union of Greek shipowners, 2023).

Other stakeholders have decided to step up their actions. Meaning by this, having to comply not only with CII but with their own extra targets. It can be appreciated that some countries which are current leaders in the decarbonization race are incurring higher initial costs, differently they will be in a much safer position CII is finally revised. The Norwegian Shipowners' Association (NSA), for example, launched its own climate strategy in 2020, setting a zero-emissions target for 2050 and putting a price on CO2 emissions. In addition, their members will only order ships based on zero-emission technology from 2030. This could prove to be a very effective strategy for maximizing the CII ratings of the Norwegian fleet. However, the NSA also criticizes the current CII regulatory framework, arguing that it has significant weaknesses. In the worst case, it could lead to less efficient travel patterns, higher fuel consumption and higher overall GHG emissions. It also insists on a CO2 levy as a more efficient tool to develop the green transition by using its funds for research into alternative fuels (Solberg, 2023).

It can be appreciated that the average sentiment of the industry is a constant critique towards the lack of usefulness of CII in Western countries. Also, in developing countries there is a general lack of interest in the framework as there are no current penalties or incentives linked to the topic.

5.3 Arguments and opinions from NGOs

During the Marine Environment Protection Committee (MEPC) 81 last March, some key issues were brought up. During this discussion, the CII framework was actively criticized by NGOs as being too soft. An alliance of NGOs, the Clean Shipping Coalition (CSC), identified specific areas for improvement, including increasing transparency of ship emissions and forcing the industry to improve ship efficiency. It is relevant to mention from the perspective of CII, that this will not be the only legislation to be taken into account, as there are other options being contemplated by the committee such as the development of enforceable Global Fuel Standards (GFS). These will drive the transition to clean energy in shipping alongside CII (IMO, 2024). The promotion of zero-carbon fuels was suggested, such as investments in wind power, green methanol and ammonia (CSC, 2024). These fuels have a lower CO2 emission factor than HFO and MGO. If the GFS was adopted, vessels using these fuels will most probably relate in better CII ratings due to this CO2 factor reduction.

At European level, NGOs sent an open letter to the EU Commission last March calling for CII to be included in the Port State Control (PSC) Directive. They emphasized that the inclusion of climate pollution performance in the EU inspection risk framework would be a crucial tool for the EU and member states to mitigate emissions-related risks and minimize the environmental impact of shipping (EDF, 2024). However this is still to be revised and not final. At the same time, it can be appreciated that NGOs are in favor of CII and even hardening it. In contrast with the harsh critiques of SOs and their willingness to even remove it in some cases.

Differently, not only NGOs but also the Pacific Island countries and Belize emphasized the need for a GHG carbon levy based on total fuel consumption. The proposed levy is $150 per tonne of CO2 equivalent. These funds could be used to finance an equitable energy transition, incentivizing greater efficiency and the adoption of zero emission energy, while also generating funds for research and development in the sector (UMAS, 2024). The push from these IMO stakeholders in the direction of a carbon taxation system leads to the probability of a scenario in which the CII will be just one of the pieces of a bigger global legal decarbonization scenario. With the inherent social benefits and difficulties it will bring to business development.

5.4 Conclusion of literature review

The literature review highlighted key areas of concern for maritime industry stakeholders. Firstly, operational factors have a significant impact on CII ratings. These include waiting times, port delays and adverse weather conditions. Despite their significant impact, these factors are not included in the current CII calculation metrics. Secondly, several ship segments are disadvantaged by the CII scheme. For example, the cruise ship segment experiences long delays in port with constant fuel consumption to provide services to passengers. This results in higher CO2 emissions for the same distance traveled. Thirdly, the issue of perverse incentives was identified as a major concern. The current CII framework does not take into account utilization rates, which incentivizes ballast shipping as distance is increased with less fuel consumption. Finally, the lack of an enforcement mechanism is highlighted. There is no clear penalty or incentive under the current CII regime, which undermines its effectiveness. While industry stakeholders have pointed out the unfairness and weaknesses of the CII Regulation, NGOs representing the environment and Pacific Island countries are in favor of the CII Regulation. These groups argue for even stronger measures, such as a carbon levy, to further promote the decarbonization of the shipping industry.

6 Data collection for qualitative analysis

Data collection for the qualitative analysis included interviews and an online survey. The nine problems identified during the literature review, outlined in Table 5, were used as the foundation for questionnaires in both the interviews and the online survey.

6.1. Interviews - qualitative analysis

Interviews were conducted in order to gain comprehensive stakeholder insights. The four key stakeholders and their chosen representatives were selected for the interviews. In addition, interviews were also conducted with stakeholders within the maritime industry in order to extend and gain a comprehensive insight from both a commercial and technical operational perspective. The list of stakeholders selected for interviews is presented in Table 7 and Appendix A with dates of interviews. Both face-to-face and online interviews were conducted. In the end, a total of thirteen interviews were conducted with stakeholders listed in Table 7.

Table 7. List of stakeholders selected for interviews (own work)

Stakeholders	Category	Functions & Position	Vessel Segment
Company 1 (Belgian Shipowner)	Technical	Project Manager, Container Fleet Manager	Container ships, bulk carriers, and chemical tankers
Company 2 (Belgian Shipowner)	Technical	Technical Operations Manager	Bulk carrier
Company 3 (Belgian Shipowner)	Technical	Head of Fleet Performance, Junior Fleet Energy & Performance Engineer	Crude tanker
Company 4 (Belgian Shipowner)	Technical	Fleet Manager	LPG carrier
Ship Management Company	Technical	Head of Performance	All vessel segment
Non-Belgian Shipowner	Commercial	Vessel Operator	Bulk carrier
Non-Belgian Shipowner	Commercial	Vessel Operator	LNG carrier
Non-Belgian Shipowner	Commercial	Vessel Operator	Crude and product tanker
Non-Belgian Shipowner	Technical	Seafarer (1st officer)	Crude Tanker

6.1.1 Interviews with Company 1

Company 1 is a Belgian shipping company that owns container vessels, bulk carriers, and chemical tankers. In the interview, it was highlighted that Company 1 chartered out their container fleet and emphasized that the CII results are influenced by the trading patterns or voyage instructions of the charterer. Shipowners cannot make influence over slow steaming, port waiting time, etc. However, container ships are less affected by port waiting times as most terminals are also operated by the charterers (or carriers). Depending on the vessel segment, such as bulk carriers and chemical tankers, short voyages and a higher number of port calls, depending on the region and waiting time, can have a significantly negative impact on CII.

They have included a CII clause in their CP and it holds the charterer responsible for redelivering the vessel with the same CII rating as it had upon delivery. However, there are no quantified penalties if the charterer fails to comply with this requirement. It was pointed out that the current CII is not consistent as it is unrealistic to expect the efficiency of the vessel to remain the same as it was a decade ago if the contract period is 10 years. The efficiency of the vessel will naturally decrease with age, making it challenging to maintain the same CII rating over time.

The current CII can be improved by technical measures. From a question if drydock negatively influences over CII rating, it was answered that it improves fuel efficiency through renewing the anti-fouling paint on the hull. Therefore, no negative impact from drydock. It was also pointed out that CII can be improved by installing ESDs, performing hull cleaning or propeller polishing as this will increase fuel efficiency of the vessel. However, operational measures such as slow-steaming are much more difficult to implement, as they are determined by the charterers and the owners cannot influence the charterers' voyage planning and instructions under TCP.

6.1.2 Interviews with Company 2

Company 2 is a Belgian shipping company that owns bulk carriers and (time) chartered out their fleets. The interview with them highlighted that their vessels are all time chartered out and this limits the influence of shipowners on the CII rating as the charterers determine the voyages and operation of the vessels. The charterers determine the speed of the vessel according to their commercial interests. They have outsourced ship management to a ship management company, which monitors the CII and manages vessel performance data.

Shipowners are investing in technical measures such as ESDs to improve their CII rating. The Company is also planning to install ESDs for their fleet to improve efficiency. They have installed Engine Power Limitation (EPL) on one of their vessels which has relatively higher fuel consumption in 2023 and they have seen an improvement in performance this year. Additionally, a vetting agency for bulk carriers, Rightship, has introduced the GHG rating system. This rating ranges also from A to E and indicates the sustainability of a ship. However, the method or formula the platform uses to calculate the GHG rating is not clear or transparent to the user. The Rightship's GHG rating and safety score, which is derived from the vessel's PSC score, incident history, Flag, and Document of Compliance (DOC) performance are available to potential charterers and play an important role in the vessel selection process in the market.

For the data verification process, the 2023 EU Monitoring, Reporting and Verification (MRV) and IMO DCS data verification was significantly delayed due to the implementation of EU ETS since the MRV responsibility was shifted from the DOC holder to the shipowner. This shift necessitated the relocation of vessel's DOC holders and verification entities to a new MRV account and as such, it delayed the verification of monitoring plans and 2023 MRV/DCS data. The entry of EU ETS also necessitates the verification of data at voyage level, which has increased the verification work drastically which caused further delays. Voyage level verification is required to make sure that the correct amount of European Union Allowances (EUA) are transferred from charterers to owners.

As the results of Rightship's audits have a significant impact on commercial decisions as it relates to the safety of vessels, sustainable ratings like GHG ratings may play a more prominent role in commercial activities in the future. The Company is currently overseeing both CII rating and EU ETS but the complexity of regulations and substantial workload have caused delays in the data verification process.

6.1.3 Interviews with Company 3

Company 3 is a Belgian shipping company that owns crude oil tankers and operates its fleet on the spot market, but also time charters its fleet. In the interview, it was highlighted that the current CII calculation only takes into account capacity and not the actual cargo carried on board. Although no commercial impact has yet been seen, charterers and Ship Inspection Report Programme (SIRE) inspectors are increasingly asking for the CII ratings. They expect that there will be commercial impacts in the market.

Operational patterns play a significant role in determining the CII rating, which is especially disadvantageous for vessels operating with short voyage legs. Older vessels also face difficulties in complying with CII ratings. For the question if drydock negatively influences over CII rating, they answered that vessels become more efficient after drydock and drydock usually positively influences over CII rating even with the initial extra CO_2 emissions during drydock operation. When the CII was introduced, it did not significantly impact changes in trading patterns for vessels. Therefore, operational patterns of vessels are not influenced. Instead, changes in operational patterns were influenced by external factors such as the Red Sea crisis or Panama Canal drought. These events have a more immediate and tangible impact on trading patterns than the CII regulatory framework.

6.1.4 Interviews with Company 4

Company 4 is a Belgian shipping company that owns and operates LPG carriers. Their business model is to time charter out their fleet. During the interview with Company 4, some critical insights and challenges related to the CII regulation were highlighted. One notable example discussed was a voyage that would be completed in May, where a ship due to geopolitical situation in the Gulf of Aden was forced to sail around Africa instead of going through the Suez Canal to reach its destination. This route resulted in higher overall CO_2 emissions but a better CII rating for the voyage. This illustrates the inconsistencies and counterproductive results of the current system.

The majority of Company 4's fleet is on time charters where the charterers have considerable decision-making power. The company mentioned the inclusion of a BIMCO clause which allows them to recover from the charterer any direct loss resulting from the charterer's failure to comply with CII regulations.

A subsidiary is analyzing the CII data on an ongoing basis and will review the rating as early as next year with a view to making changes where necessary and possible. We asked if drydock negatively affects CII ratings due to the downtime it causes and if this also makes shipowners reluctant to invest in ESDs. They answered that CII is not the main motivation for the decision. Instead, it is related to the downtime (or off-hire period), during which vessels are not paid charter hire, thus leading to secondary costs. For drydock itself, ships become more efficient after drydocking and the CII score improves immediately. In addition, shore power can be used during the drydocking period. Despite these efforts, the company has been highly critical of the CII regulation, stating that it serves no practical purpose and does not make a meaningful contribution to decarbonization efforts. They believe it should be scrapped because of its shortcomings.

The company identified waiting times as the most significant factor affecting its CII rating, suggesting that operational inefficiencies beyond its control play a crucial role. They also mentioned that trade routes and varying weather conditions affect CII ratings. The company strongly disagrees with the inclusion of utilization rates in the CII formula, as LPG carriers due to the nature of the cargo, have no option but to sail back in ballast.

Finally, Company 4 strongly objected to the application of penalties under the CII framework, finding the current framework not fair when comparing gas carriers to other segments. Also noting the political nature of the choices in correction factors that are accepted. Overall, the experiences and perspectives of Company 4 highlight significant concerns about the effectiveness and fairness of the CII system in promoting real decarbonization within the maritime industry. Being convinced that including a global GHG intensity system, with a fuel levy based on Well-to-Wake (WTW) emissions, would be much more efficient for decarbonizing the industry.

6.1.5 Interview with ship management company

An interview was conducted with a ship management company that manages 655 vessels from 80 shipowners and monitors 24,000 voyages per year, covering 40 million NM and generating 380,000 reports. It was highlighted that the company had implemented a daily monitoring program with a purpose to collect consumption data from machinery engines, auxiliary engines and boilers. Correct tracking was essential to correct any deterioration in consumption and save fuel. For example, after an idle period of about 10 days near the Brazilian coast, rapid fouling and marine growth can lead to a +15% increase in consumption if the hull of a vessel is not cleaned promptly. As a result, this practice saved 34,979 tonnes of fuel last year.

It was highlighted that the company has a specific budget for maintenance. Depending on the case, they will carry out the repair or check with the owner beforehand if the cost of the repair would exceed the given budget. Vessels of a certain age will require improvements to the existing design of the vessel, in which case retrofitting adjustments are possible.

The CII is a useful tool to raise awareness of emissions among charterers and shipowners. Together with the BIMCO clause and the fact that poor ratings, D and E, can have a negative impact on the charter rates. Regardless, from a ship manager's perspective, the only option is to advise clients on the rating situation. As the CII is only an operational value, the shift and division of responsibility between charterer and shipowner is still unclear. From both sides, charterers will need to take the CII increasingly seriously and shipowners will need to arrange improvements and retrofits accordingly to get out of the D and E danger zone.

Overall, the impact on trade is also relevant, with ships that regularly call at certain congested ports performing worse in terms of CII. Factors that are known to affect ratings include delays, idling, number of ports of call and waiting times, all of which have a clear impact on CII. It must also be clear that the aim of CII is to reduce emissions, not to increase them. In this way and to avoid the side effect of ships going on unnecessary ballast legs, the distance factor should be removed from the denominator and a design efficiency factor should be added, similar to the RightShip GHG rating scheme.

Regarding the possibility of changing DWT to a more demand-oriented factor such as ton-miles. This would lead to an 'unfair' result in cases where, for example, ships are partially loaded, as ships will have almost the same consumption whether they are fully or partially loaded.

From this company's available data on different vessel segments, it can be appreciated that gas carriers perform best. This could be explained by their very specific itinerary with few ports of call, as well as the high safety standards required for this segment. Crude oil tankers would be in the middle. Finally, bulkers and containerships have the worst results.

It is also important to remember that the CII is still in a test phase. The SEEMP Part III will be reviewed in July. What is foreseeable in terms of alternative fuels and biofuels is that, for example, for ships over a certain age of 15 years with a negative rating, some retrofitting to include the possibility of using biofuels could be an interesting way out of the danger zone.

6.1.6 Interviews with LNG carrier and LNG bunkering vessel operator

An interview was conducted with the operator of LNG carriers and LNG bunkering vessels. The operator operates the vessel commercially together with the technical ship manager in accordance with voyage instructions from the charterers. Their business model is to secure long term business and the team is responsible for both vessel operation and chartering. The interview highlighted that the CII is not very effective from the interviewee's perspective. Several of their vessels have signed an addendum to include the CII clause in their TCP, although this is not the case for all vessels in their fleet. There is one vessel that carries LNG cargo from Australia to Far East Asia and this is the only vessel that is required to slow down the speed since the charterer is a public company and carries the country's strategic cargo. Some vessel segments are at a disadvantage, particularly their LNG bunkering vessels operating in the Caribbean and Western Europe, as there is a significant waiting time before the vessel can secure bunkering operations. The distance remains unchanged while consumption remains constant. The lack of attention to CII is primarily due to the lack of penalties for non-compliance, coupled with the perception that it is currently a data collection process. This has also led to the perception that the penalty will not be introduced until 2026. However, there is increased attention to the EU ETS because it has a direct commercial impact, as costs must be settled after each voyage or on an annual basis, depending on the type of vessel or contract.

6.1.7 Interviews with bulk carrier operator

An interview with a bulk carrier operator revealed that while the CII regulatory framework has raised awareness, it has not had the same impact as EU ETS. The company's commercial department is divided into chartering and vessel operations, each with a different role. The chartering department directly negotiates and executes charter parties, while the vessel operation department takes over the vessel along with the CP once the vessel is fixed. This business process creates a gap between the chartering and vessel operation department. Their business model is a mix of time charter and voyage charter for bulk carriers as well. Under the voyage charter, they make voyage plans and instruct vessels with details, but this is made based on the commercial simulation and cargo details. The CII is not considered in this process.

As EU ETS costs are settled directly between the vessel operators and charterers, more attention is paid to the EU ETS. In addition, as the CII does not currently have clear penalties, it is not a primary focus for them as vessel operators. The company has an internal ship performance management team that provides information on CII but focuses primarily on operational measures to improve fuel efficiency, such as hull cleaning and propeller polishing. They have a software to track the unverified attained CII and the corresponding estimated CII rating, but the vessel operator is not fully aware of the CII regulatory framework and calculation methodology and only sees the rating that comes out of their system. Operators lack knowledge of the critical factors related to CII, as this is usually overseen by the vessel (technical) superintendent or fleet manager.

6.1.8 Interviews with a tanker vessel operator

An interview was conducted with a tanker vessel operator whose primary role is to operate vessels in accordance with the charterer’s voyage instructions. It was highlighted that the operator is aware of the CII, although the CII clause has not yet been included in their TCP. Their primary business strategy involves long term time charters with several oil majors and they plan to negotiate the inclusion of the CII clause with charterers in due course.

Instead of specifically addressing the CII, they have incorporated a broader legal context concerning CO2 emissions into their CP. This clause specifies current and potential legislation or regulations regarding ship-borne CO2 emissions, imposed by international regulatory bodies such as the EU, the USA and the IMO. They have agreed a CO2 emissions clause requiring the shipowner to cooperate with the charterer to ensure charterer's compliance with the required ship-borne CO2 emissions regulations. Any costs incurred due to the shipowner's cooperation will be compensated by the charterer. They added that this clause was originally agreed upon due to concerns about the EU ETS and similar levies.

They are currently focusing on collecting EU ETS data and analyzing the impact and cost calculation, as this cost is due to be settled with their charterers in the near future. CII is being monitored but receives less attention due to the lack of an enforcement mechanism.

6.1.9 Interviews with 1st Officer Dirty Crude Oil Suezmax Tanker

One of the roles of the interviewee is to verify the data that is automatically dumped from the data recapitulation system into the daily noon report recapitulation system. The Noon Report, our main tool for data analysis in this dissertation, consists of an Excel spreadsheet in which certain columns of data such as cargo weight, speed, distance traveled, main engine consumption, auxiliary engine consumption, engine power, etc. are added to the spreadsheet every day at noon. There is a minimum of one daily update, but some days have 1+ entries. In addition to the noon update, all of the above variables are recorded each time an event occurs that changes the state of the vessel, such as noon in port, arrival, departure, drift, noon maneuver and anchor.

One of the problems in analyzing the noon reports is the lack of information on the weight of the cargo between arrival and departure and at noon in port. This situation makes it difficult to determine exactly when the loading operations were carried out. Not to mention that it complicates the utilization rate. An interview with a crude oil tanker officer was useful in understanding how tanker loading operations are managed and how long it takes for the crude oil pumps to take in and discharge all the crude oil from the tanks. When asked about the time required for full operations, it was mentioned that it really depends on how many shore hoses are connected. The maximum is 3, so technically the maximum flow could be 105,000 barrels per hour. However, this is not common, it is usually 2 or 1 hose, due to flow limitations to avoid corrosion of the elbows of the suction system. The inlet speed must be limited by specific calculations, but viscosity usually limits this to 7 m/s. In summary, with two hoses this is usually 70,000 barrels per hour. Differently, the limitations of the facilities are a major factor, in areas with limited infrastructure the flow is usually 30,000 barrels per hour. To add to the complexity of the operation, there is the example of a loading in the Netherlands and Texas. This port is located in an inland river with draft restrictions (around 10m), so when the ship reaches this maximum draft, it has to leave the port partially full to be fully loaded outside the draft restriction area. Here, another specialized tanker will pump the remaining cargo to the vessel via an STS operation. These operations have an impact on CII, as the loading operation will take much longer than 1.5-2 days due to the increased technical complexity. An additional correction factor is also included for tanker STS operations. This situation of longer days in port and waiting time is directly linked to a reduction in CII performance. However, crude oil tanker trade routes are based on the geography of production and consumption, where consumption areas are usually far away from production areas. This favors ton-miles and the reduced number of ports of call. As a result, this segment has an overall better rating than others such as dry bulk or short sea container ships.

The interviewee mentioned that geopolitics is affecting trade routes. Suezmaxes are no longer going through the Suez Canal, so there is more of a market split between East and West from Suez. At the same time, since the war in Ukraine, there have been more operations originating in the US, which have been exacerbated by the Houthi blockade of the Bab El Mandeb Strait. For these carriers in particular, the inability to transit the region limits their main advantage. Furthermore, the scarcity of Suezmaxes has a major impact on their market volatility.

The owner of the tankers works mainly with a Spanish National Oil Company (NOC) and has entered into several time charter contracts with them. In the same line, the charterer has provided an Excel tool to carry out CII calculations for the vessels. According to the interviewee, the ability of seafarers or shipowners to influence CII is very limited. Overall, the charterer dictates the speed, routes and port call schedules, so the scope for maneuver and corrective action is limited. The current CII framework also poses problems for existing ships, with the required CII decreasing each year. A ship that is a C in 2023 could be a D in 2024. Taking into account that once the ship is built, it is very costly to make improvements or retrofits to the ship's design beyond the usual measures such as antifouling maintenance, painting, more efficient propellers, etc., the Spanish seafarer mentioned this issue. Referring to this issue, the Spanish seafarer mentioned that adding a few hours of unplanned maintenance during scheduled stops would greatly increase fuel efficiency. As an example, he recalled a time when piston cleaning would have greatly increased engine power.

Permission was requested from the charterer to add a few extra hours at an existing port of call. This was refused by the charterer. This also resulted in a loss to the charterer as fuel consumption would have been reduced. Alternatively, freight rates may have been peaking in another area, putting pressure on the market to position the vessel in that area, or deriving laytime penalties for not arriving on time that would be higher than the actual fuel savings. Finally, the interviewee also mentioned a crucial case to explain a key CII contradiction. One of his voyages was from Turkey to Malaysia and the resulting CII via Durban was lower than that via Suez Canal. Contradictorily, the total emissions were higher for the longer route. Unexpectedly, the lower CII performance is not only due to the extra miles, but also to the many stops during the transit through Suez. On the other hand, the Cape of Good Hope is a full sea voyage with fewer stops and a full deep sea voyage.

6.1.10 Conclusion of interview

During the interview, stakeholders in the maritime industry expressed concerns about the unfairness and issues with the current CII regulatory framework.

Firstly, most shipowners operate vessels under TCP with charterers. Under this type of contract, shipowners are required to follow the voyage instructions of the charterers, which limits their ability to control factors affecting the CII rating. Some shipowners have already included CII clauses or similar provisions in their TCPs, requiring charterers to compensate for direct commercial losses due to non-compliance with the CII or to redeliver the vessel with the same CII rating as when it was delivered in the first place.

Secondly, each vessel has significant differences, resulting in different trading patterns and cargo operations primarily related to their specific cargo activities. This results in vessels calling at congested ports, spending more time in port due to the complexity and characteristics of the cargo, and making shorter voyages. These factors increase the waiting time and thus affect the distance traveled. Waiting time has been identified as a key issue but is not included in the current CII calculation metrics. Meanwhile, it has also been pointed out that some vessel segments, typically those with long voyages and fewer port calls, benefit from the current CII regulation.

Thirdly, the CII rating can be significantly influenced by operational patterns, which are usually determined by the charterers based on their commercial interests. While the purpose of the CII is shipping decarbonization, the introduction of CII regulation has not influenced over changing trading patterns in a more efficient way. Instead, the current geopolitical situation has created unusual scenarios. For instance, vessels traveling around the Cape of Good Hope instead of the Suez Canal receive better CII ratings, despite an increase in absolute emissions. Some pointed out that vessels' design efficiency should be considered rather than operational variables. The design efficiency can be improved by technical measures such as the installation of ESDs.

Lastly, the absence of penalties has led to less attention to CII from the industry. Stakeholders pointed out that the CII is not a top priority due to the lack of penalties. Instead, the EU ETS and EUAs are more important as they have a direct financial impact. There was also a perception that the current CII regulatory framework is in the process of data collection and reviewing and that penalties will not be introduced until 2026.

6.2 Online Survey - result and qualitative analysis

To gather valuable insights and opinions from professionals in the maritime industry, an online survey was conducted using the Qualtrics platform. The survey was distributed via LinkedIn and private messages to ensure a diverse range of responses. This approach allowed us to reach a wide audience of industry stakeholders, thereby enhancing the quality and depth of feedback.

The questionnaire was designed around nine key issues related to CII regulation that were identified during the literature review. Full details of the questionnaire can be found in Appendix B. The primary objective was to obtain comprehensive views from industry experts in order to prioritize these issues and identify which are considered most critical and which are considered less critical within the current CII regulatory framework.

There were seven questions in the survey:

1) Country of residence: to understand the geographical distribution of our respondents.
2) Job function: to gain insight into the professional role of the respondents.
3) Specialization in ship types: to identify the respondents' areas of expertise.
4) Ranking of the problems: participants were asked to rank the nine issues identified from 1 (most important) to 9 (least important).
5) Reason for top choice: participants explained why they ranked a particular issue as the most important.
6) Reason for bottom choice: participants explained why they ranked a particular issue as least important.
7) Additional Comments: an open-ended question for any further insights or comments.

Through this survey, the aim was to capture the perspectives of maritime industry professionals, which are critical to understanding the practical implications of the CII regulation and identifying areas that need attention for improvement.

6.2.1 Results - online survey

Seventeen people completed our online survey, described in Table 8. They come from nine different countries and have different roles, all in the maritime industry. There were respondents specialized in LNG carriers, LPG carriers, bulk carriers, product tankers, crude tankers, chemical tankers, and container vessels.

Table 8. Participants of the online survey (own work based on survey results)

Country	No. Participants	Job Function	Specialization
Belgium	2	Software Development Lead, Vessel operator	No Specific, bulk carrier
Greece	1	Technical Superintendent	LNG carrier
India	1	Ship Broker	LPG carrier, LNG carrier
Norway	1	Operations Manager	LNG carrier
Pakistan	1	Terminal Manager	LNG carrier, crude tanker, product Tanker
Singapore	1	Vessel Manager	LNG carrier
South Korea	6	Electric Supervisor, Fuel Oil Supplier, Shipbroker, Chartering Manager, Vessel Operator, Manager for LNG Projects	LNG Carrier, bulk carrier, container vessels, product tanker, LPG carrier
UK	2	Shipping Research Assistant, Charterer	Chemical tankers, LPG carrier, crude tanker, product tanker, LNG carrier
US	2	Performance Analysis Manager, Charterer/Shipbroker	LNG carrier, chemical tanker, product tankers
Sub-Total	**17**		

Each participant ranked the nine defined problems in relation to the CII rating from 1 to 9. To define the overall rating, points were assigned to the problems. The higher the ranking (closer to 9) of a particular problem, the more points it received. The points were then added together to produce a final ranking. Taking all responses into account, the overall ranking is as follows:

1) No incentive to reduce ballast voyages and cargo utilization ratio is not reflected, but only DWT
2) Inconsistency of CII formula and correction factors
3) Neglecting of substantial ship difference
4) Port delays and idle periods negatively impact CII

5) Drydock negatively impacts CII
6) CII clause restricts charterer's rights under time charter
7) Adverse weather conditions negatively impact CII
8) No enforcement mechanism
9) Perverse incentive

There was also a question to explain why the respondent ranked a certain problem first or last. There were not many replies to this question and perhaps it is because respondents did not have enough knowledge or background information of the CII regulation to explain it further. The answers received that are worth mentioning are given here.

Reason why 'No incentive to reduce ballast voyages and cargo utilization ratio is not reflected, but only DWT' is chosen as the most important: according to the only answer given in the survey question.

- *"Positive impact of ballast voyages on CII ratings contradicts the purpose of the CII regulation to reduce the CO2 emissions."*

Reasons why 'Inconsistency of the CII formula and correction factors' is chosen as the second most important problem: according to the answer to the survey question.

- *"LNG trade has moved closer to crude oil trading, meaning many operators "float" cargos waiting for the right market to deliver them into. Since LNG carriers burn boil off gas for fuel, this idle time can significantly hurt their CII scores and this affects the CII much more than crude due to the natural boil off rate producing more gas than is needed for just hotel loads. CII is also completely not designed for any floating LNG terminal, especially Floating Storage Regasification Unit (FSRU), which sit still while performing their operations and therefore have an astronomical CII rating due to the lack of miles traveled. When the ship is in the same location this is irrelevant as the denominator is 0, but one move to anchorage or sailing to drydock makes the CII impossibly large as the emissions are judged over the entire year and not that small voyage."*

Reasons why Perverse incentive is the least important: according to the only answer to the survey question.

- *"The goal is to reduce CO2 and it does that, more or less, so I don't see this as a real problem."*

Looking at the ranking of problems and reading the comments in the survey, something unusual stands out. The issue ranked as the most important is directly related to the issue ranked as the least important. The CII regulation aims to reduce CO_2 emissions while transporting cargoes, goods, or passengers from merchant ships. However, ballast voyages, which improve a ship's CII rating, contradict this objective. It could be questioned whether the participants correctly understood the problem of perverse incentives. There is also the consideration that the participants do not know enough about the CII regulations to assess the importance of each problem. As mentioned in several of the interviews included in this thesis, not many people are aware of the CII regulations as the current CII regulation has no direct penalties or importance for the performance of the fleet.

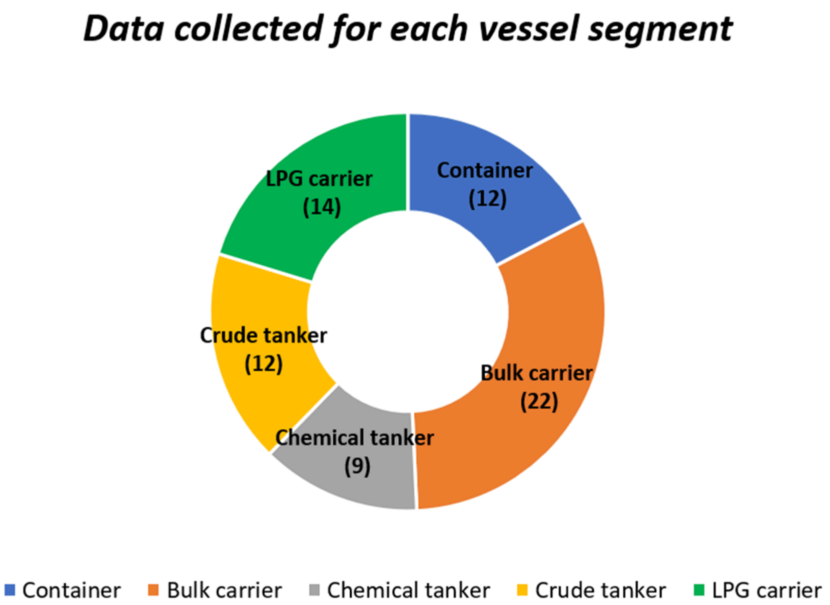
6.2.2 Conclusion of online survey

The survey shows that the parameters that directly influence the CII rating are quite well understood by the respondents. For example, the influence of distance, ballast voyages, waiting time, correction factors, etc are entailed in the parameters. However, the problem of perverse incentives is not so well understood. It is normal that companies do not pay much attention to the CII regulation as there are no penalties for non-compliance. This is also mentioned and noticed in the interviews with the different stakeholders. Companies rather focus on complying with the reporting of CII data. From this survey it can be concluded that the utilization rate, which is not reflected in the CII calculation, is an important problem according to the respondents. These include the inconsistency of the CII formula, correction factors, the negligence of significant vessel differences, and port delays. Solving these problems of the current CII regulation should be a top priority in order to have a fairer regulation for all ship types.

7 Data collection for quantitative analysis

As part of the data collection process, a full year vessel operating data for 2023, as well as verified CII ratings and attained CII data, were requested from each key stakeholder. To ensure consistency and reliability, the attained CII and verified CII ratings were specifically requested to avoid any potential discrepancies between our own calculations and the stakeholders' actual data. Consequently, the attained CII and CII ratings reflect the raw data provided by the key stakeholders. A total of 69 data sets were collected, with details for each vessel segment outlined in Figure 4.

Figure 4. Number of data collected from each vessel segment (own work *based on the data collected*)



Several challenges were encountered in this process. Firstly, there were several newbuilding ships and acquisitions of secondhand vessels that were delivered during the course of 2023, resulting in incomplete operational data for the full year 2023. Second, the deadline for submission of verified CII data to the IMO was set for the end of May. Each key stakeholder has already requested data verification from the classification societies, but most of these requests are still under review and verification. Alternatively, unverified CII ratings and attained CII data that appear in each stakeholder's system were collected. Overall, it was noted during the interviews that there could be a difference between the verified data provided by the classification societies and the results obtained by the key stakeholders' own calculation systems. However, key stakeholders also confirmed that this data gap is minimal, as both results are based on the same fleet operational data.

7.1 Data processing

The main source of data for this study is the noon reports, a summary of ships' performance and condition on a daily basis, as ship's operational data. This information was requested from key stakeholders as it is the optimal data source to obtain specific information regarding consumption, distance sailed, speed, port calls, waiting time, engine power, among others, on a daily basis. Data was also requested for the period from 01.01.2023 to 31.12.2023. This is the first full year that the CII framework has been effective. A full analysis of the results of this first year would therefore be revealing in order to determine the impact on the Belgian commercial fleet. In addition, this data has a high commercial value. Consequently, one of the challenges of this study was to introduce a data analysis without going into the specific details of the data analyzed. This is because some of the information within data is commercially sensitive for the key stakeholders. As a result, it was decided not to show the full datasheets and to present them mainly in graphs or tables without commercially sensitive information.

7.2 Data analysis

The primary objective of the data analysis is to formulate recommendations aimed at improving the current CII regulatory framework and calculation metrics to be fairer and consistent. The analysis is based on the full operational data of ships for 2023, including noon reports and both provisional and verified CII data. The ship segments analyzed include container ships, bulk carriers, crude oil tankers, chemical tankers, and LPG carriers, with data provided by four key stakeholders.

In the quantitative data analysis, three parameters were selected: waiting time, number of port calls, and distance. The primary reasons for the selection were their quantifiability, relevance to the nine identified issues, and relevance to the CII calculation formula. The impact of drydock was analyzed but only for the LPG carrier segment due to a lack of availability of data and verified CII data for other ship segments, as well as some segments with no drydock being carried out. The detailed reason for selection of three parameters is elaborated in the following:

1. Distance: it serves as the denominator in the CII formula and is one of the most significant factors. It is related to several identified issues and is quantifiable from the given data.

2. Waiting time: it is one of the most critical factors affecting the CII rating. It was also considered for inclusion as a correction factor but was ultimately not included by the IMO.

Waiting time includes port stay days for loading and discharging periods, as well as port waiting times for days of anchoring and drifting.

3. Number of port calls: it was quantifiable from the given data. It is assumed that a larger number of port calls will result in increased waiting times. Additionally, it was assumed that the number of port calls may vary depending on vessel segment and size due to trading routes, indicating substantial differences in operational patterns among ships.

Furthermore, a comparative analysis of sister vessels was utilized mainly due to differences in vessel segment and capacity resulting in different required annual operational CII. As shown in Table 9, the range of each CII rating band is significantly different between capesize and ultramax bulkers as well as for MSGC. The analysis of sister vessels will suggest the main reasons causing different CII ratings on the basis of data-driven analysis and findings from qualitative analysis, especially in cases where the results were found not relevant to the three parameters.

Table 9. Attained CII and Rating ranges for ultramax, capesize and mid-size gas carriers (MSGC) for 2023 (Author's own elaboration using classNK calculator)

Bulker 290,000 DWT	**Attained CII range**	**CII Rating**
Capesize	0- 1.59	A
	1.60-1.74	B
	1.75- 1.95	C
	1.96-2.17	D
	2.18 - >	E

GasCarrier 28,500 DWT	**Attained CII range**	**CII Rating**
Mid Size	0- 9.32	A
	9.33-10.40	B
	10.41-11.61	C
	11.62-13.70	D
	13.71 - >	E

Bulker 60,000 DWT	**Attained CII range**	**CII Rating**
Ultramax	0-4.13	A
	4.14-4.52	B
	4.53- 5.10	C
	5.11-5.67	D
	5.68 - >	E

This insight was crucial in order to carry out a differentiated analysis of each company, segment and ship size. In the following section, each vessel has been divided into its own category according to the type of cargo.

7.2.1 Bulk carriers

In this part, the primary aim is to analyze the operational characteristics and CII ratings of bulk carriers operated by two distinct companies: Company 1 and Company 2. These companies are operating a diverse fleet of bulk carriers with segments entailing ultramax, capesize and Very Large Ore Carriers (VLOC). A total of 22 full year vessels' operational data from the year of 2023 were received. The dataset consists mainly of noon reports that includes data on voyage distances, fuel consumption, weight of cargo loaded, and other operational metrics. In addition, a provisional CII rating together with the value of the attained CII was obtained for each bulk carrier, as the classification society is still reviewing and verifying the data. Only two of the 21 bulk carriers were sister vessels. The details of the data collected are presented in Table 10.

Table 10. Data obtained and analyzed for 22 bulk carriers (own work based on the data collected)

#	Name	Size (Ice Classed)	CII Rating	Attained CII	Distance (NM)	No. of Port Call	Sailing Days	Total Waiting Days
1	Bulk Carrier 1	Cape Size	D	2.8	71,605	13	253	113
2	Bulk Carrier 2	Cape Size	B	2.3	66,859	25	261	105
3	Bulk Carrier 3	Cape Size	C	2.5	67,099	18	247	118
4	Bulk Carrier 4	VLOC	A	1.7	30,695	9	201	164
5	Bulk Carrier 5	Cape Size	C	2.5	62,156	14	246	119
6	Bulk Carrier 6	VLOC	B	2.0	66,595	22	269	97
7	Bulk Carrier 7	VLOC	B	2.1	62,799	20	227	138
8	Bulk Carrier 8	Cape Size	C	2.3	65,928	17	243	122
9	Bulk Carrier 9	Cape Size	C	2.4	60,343	22	224	141
10	Bulk Carrier 10	Cape Size	B	2.2	69,703	12	236	129
11	Bulk Carrier 11	Cape Size	B	2.1	63,695	26	243	122
12	Bulk Carrier 12	VLOC	B	2.0	71,298	17	282	83
13	Bulk Carrier 13	VLOC	A	1.7	29,956	9	265	101
14	Bulk Carrier 14	Cape Size	C	2.4	68,710	32	260	105
15	Bulk Carrier 15	Cape Size	C	2.5	63,238	11	261	104
16	Bulk Carrier 16	Cape Size	C	2.4	57,636	11	197	168
17	Bulk Carrier 17	VLOC	A	1.8	64,403	16	269	96
18	Bulk Carrier 18	Cape Size	C	2.302	68,076	14	253	112
19	Bulk Carrier 19	Ultramax	A	3.43	58,486	21	233	132
20	Bulk Carrier 20	Ultramax	A	3.91	57,777	13	209	156
21	Bulk Carrier 21	Ultramax	C	4.5	59,999	21	210	155
22	Bulk Carrier 22	Ultramax	A	3.93	53,699	19	192	173

** Total waiting days entails port time and waiting time.*
*** columns with the same color indicate a sister vessel.*

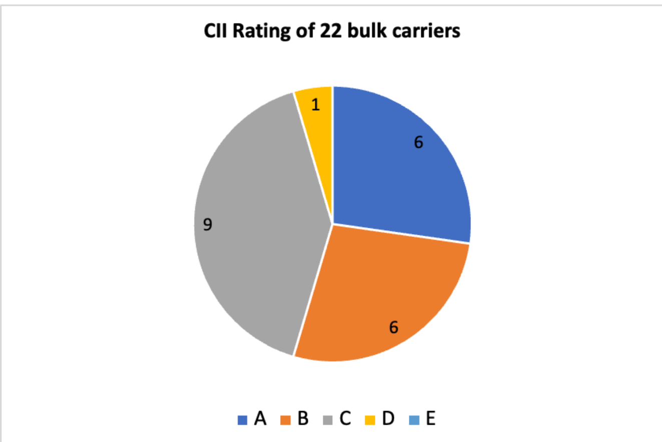


Figure 5. CII rating of 22 bulk vessels (own work based on the data collected)

It was observed that six bulk carriers received an A rating, another six a B rating, nine a C rating, and only one a D rating. Notably, receiving a D rating for three consecutive years necessitates the implementation of a corrective action plan and an update to SEEMP Part III (ClassNK, 2022). Given the current ratings, none of these ships will be required to undertake a corrective action plan.

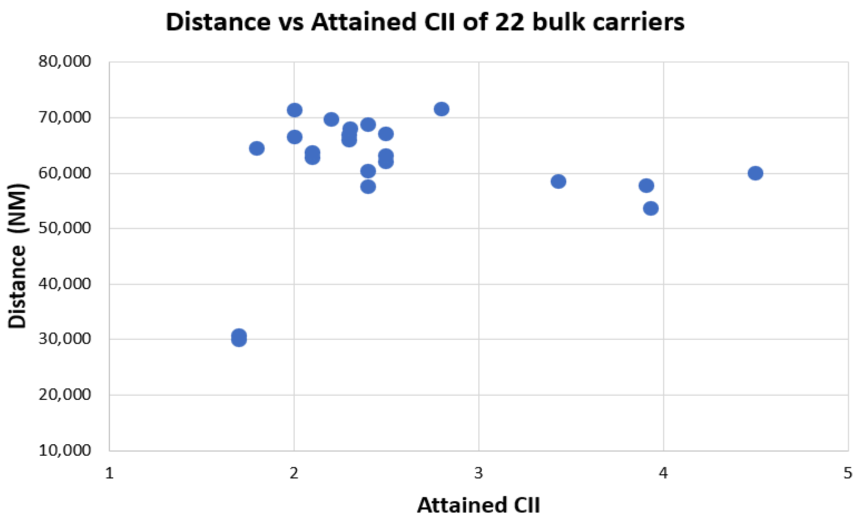


Figure 6. Distance vs Attained CII of 22 bulk carriers (own work based on the data collected)

As shown in Table 10 above, the analysis shows that among the ultramax vessels, Bulker 21 traveled the longest distance and received a higher attained CII and the worst CII rating. Conversely, the other three ultramax vessels (Bulker 19, Bulker 20, and Bulker 22), which traveled shorter distances, received a lower attained CII and a better CII rating. The relation between attained CII and distance is unclear as these vessels are ultramax within the same segment. This result suggests that although distance traveled is an important factor in the CII formula, it is not the sole determinant of CII ratings. For example, what has influenced CO2 emissions, which is a parameter in the numerator, should be investigated as well. The capesize segment presents a similar scenario. Bulker 1, which sailed the longest distance in 2023, received the lowest CII rating of D. This is in stark contrast to other capesize vessels that sailed shorter distances and received better CII ratings. This discrepancy further challenges the notion that longer voyages, which also mean more distance traveled, will inherently lead to better CII ratings. The results indicate that operational efficiency and fuel consumption patterns are critical in determining CII results. For the VLOC segment, Bulker 12, which sailed the greatest distance, received a CII rating of B. This is better than the worst rating in other segments. This pattern suggests that while distance traveled influences CII ratings, other operational parameters such as fuel management, speed optimization and cargo handling efficiency are also critical.

Figure 7. The major trading routes of bulk carriers. Retrieved from (Baltic Exchange, n.d.)

Bulk carriers, which are essential for the transport of commodities such as coal, iron ore and grain, operate worldwide on a tramping basis or on fixed routes, depending on their size and capacity. Figure 7 shows the main trade routes for bulk carriers. Ultramax vessels often undertake long voyages and have the flexibility to transit major canals. In contrast, larger vessels such as capesize and VLOCs have size restrictions that limit their routing options. Understanding how these trade patterns affect CII ratings can provide valuable insights into optimizing vessel operations for better environmental performance.

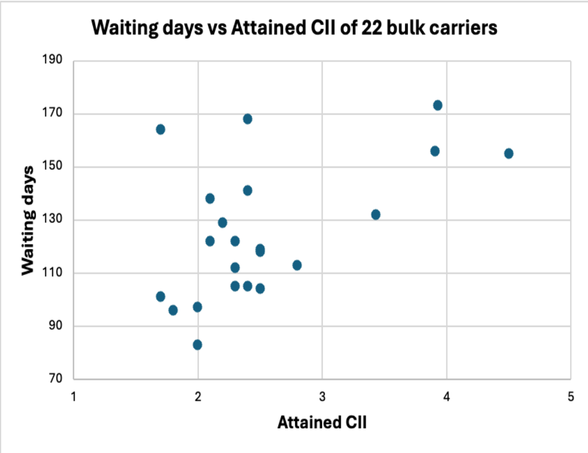
The trading routes from the different bulk carriers can be summarized as follows:

- South America - Far East Asia - Australia - Far East Asia: bulk carriers 1, 3 and 5.
- Australia - Far East/South Asia: bulk carrier 2, 6, 7, 11 and 14.
- US East Coast - Europe - South/East Asia - South Africa - Australia: bulk carrier 8, 17, 18 and 22.
- India - Mozambique - South Africa - Singapore - Australia - China: bulk carrier 9 and 10.
- Australia - Far East Asia - South Africa - Europe - Canada East/West - South America: bulk carrier 12, 15, 16, 20 and 21.
- Arabian Gulf (AG) - US East - South America - Europe - Far East Asia - Australia: bulk carrier 19.

In the data provided by Companies 1 and 2, Bulker 21 stands out among the ultramax vessels for receiving the lowest CII rating of C. This vessel's trading pattern involved multiple transits through the Panama Canal, sailing between the Pacific Ocean, and the Caribbean Sea. The lengthy drought in the Panama Canal in 2023 caused widespread disruption, resulting in longer waiting times at anchorage, which likely contributed to higher fuel consumption and emissions (Tandon, 2024). Conversely, the other ultramax vessels, which avoided such disruptions and primarily traded on routes between Far East Asia, Australia, and South America received A ratings. The trade routes of capesize vessels are significantly influenced by their size, which prevents them from transiting major canals such as the Suez and Panama Canals. As a result, these vessels often transit the Cape of Good Hope, which inherently results in longer distances traveled. This characteristic of capesize vessels might be expected to confer an advantage in terms of achieving a favorable CII rating, as distance traveled is a critical component of the CII formula. However, despite this potential advantage, the data analyzed shows that some capesize vessels still receive lower CII ratings. This observation suggests that factors other than distance traveled have a significant impact on CII ratings. Elements such as fuel efficiency, port delays and waiting time and weather conditions may play a critical role in determining the overall environmental performance of these vessels. Therefore, a more comprehensive analysis including these additional factors is needed to fully understand the determinants of the CII ratings for capesize vessels.

For the VLOC segment, Bulker 17 received an ‘A’ rating, operating routes between Far East Asia, Australia, and South America. This vessel's efficient trading pattern, avoiding major congested canals, likely contributed to its low CII rating. On the other hand, Bulker 6 and Bulker 7, which also traded between Far East Asia and Australia, received ‘B’ ratings. These ratings are similar to those of capesize vessels operating in the same regions, suggesting that trading patterns and regional operational conditions, which may either extend a vessel's distance traveled or result in ship’s idling and prolonged waiting times, can significantly influence CII ratings outcomes.

In the analysis of the provided data, the waiting days for all bulk vessels range between 85 and 175, as depicted in Figure 8. The data also reveals complexities in establishing a direct relation between waiting days and the attained CII ratings. In Figure 8, it can be observed that bulk vessels with waiting days ranging from 90 to 130 tend to have relatively lower attained CII. However, as the number of waiting days exceeds 130, establishing a clear and consistent relation with the attained CII becomes more challenging. The lack of a clear trend for vessels with waiting days beyond 130 underscores the necessity of considering other influential factors.



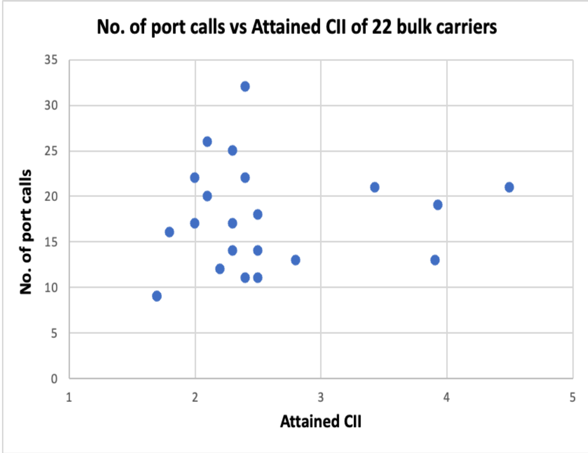


Figure 8. Waiting Days vs Attained CII of 22 bulk carriers (own work based on the data collected)

Figure 9. No. of port vs Attained CII of 22 bulk carriers (own work based on the data collected)

The analysis of the number of port calls for bulk vessels reveals a range between 10 and 35, as illustrated in Figure 9. However, it has been observed that the mere number of port calls does not clearly validate or justify its relevance to the attained CII. Specifically, the data indicates that bulk vessels with port calls ranging from 10 to 20 tend to achieve relatively lower attained CII, suggesting a more favorable environmental performance. On the other hand, as the number of port calls exceeds 20, the relation between port calls and attained CII becomes increasingly ambiguous. Vessels with a higher number of port calls do not exhibit a consistent pattern in their attained CII, making it challenging to draw definitive conclusions based solely on this variable.

Given these complexities, it is evident that the waiting days and number of port calls alone are not sufficient to fully explain the variations in CII ratings among bulk vessels.

7.2.2 Container vessels

Company 2 provided data for 12 container vessels. This included all noon reports for the year 2023 as well as the CII data. However, the data for container vessels 3 and 12 were incomplete and were therefore excluded from the analysis. All the container vessels are mid-sized and ice-classed. A segment of the full data which was analyzed and calculated is shown in Table 11. Their trade routes can be divided into four areas:

Trading Area:

1. From the Mediterranean Sea to East Canada.
2. From South America, through West Europe, to the US East Coast and the Caribbean.
3. From the Mediterranean Sea to the Adriatic Sea and Baltic Sea.
4. From the Baltic Sea to West Europe and the Mediterranean.

Table 11. Data obtained and analyzed for 12 container vessels (own work based on the data collected)

#	Name	Size (Ice Classed)	CII Rating	Attained CII	Distance (NM)	No. of Port Call	Sailing Days	Total Waiting Days	Trading area
1	Container 1	Mid-size	B	7.8	76,532	87	223	141	1
2	Container 2	Mid-size	D	12.7	95,669	69	251	114	2
3	Container 3	Mid-size	Incomplete Data						
4	Container 4	Mid-size	B	12.0	51,026	118	154	211	3
5	Container 5	Mid-size	A	10.5	53,791	125	162	203	4
6	Container 6	Mid-size	B	11.3	52,720	126	158	206	4
7	Container 7	Mid-size	C	13.7	57,053	123	156	208	3
8	Container 8	Mid-size	A	7.3	81,182	84	216	149	1
9	Container 9	Mid-size	A	7.7	78,448	82	214	151	1
10	Container 10	Mid-size	A	7.3	76,933	86	223	142	1
11	Container 11	Mid-size	C	11.7	99,995	70	257	107	2
12	Container 12	Mid-size	Incomplete Data						

** Total waiting days entails port time and waiting time.*
*** Columns with the same color indicate vessels with the same CII rating.*
**** Mid-size container is container vessel capacity between 1,000 - 11,000 TEU.*
***** Trading area numbering can be matched with numbers in the Trading Area section above table.*

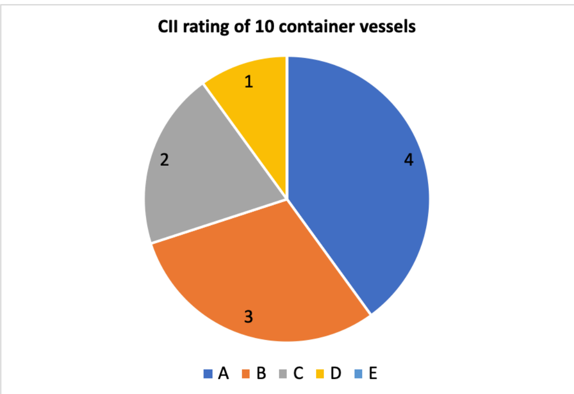


Figure 10. CII rating of 10 container vessels (own work based on the data collected)

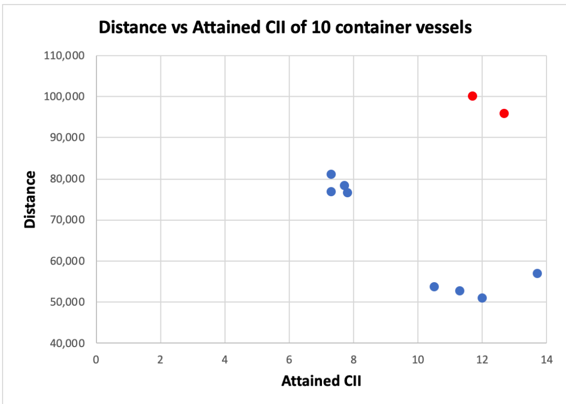


Figure 11. Distance vs Attained CII of 10 container vessels (own work based on the data collected)

The container vessels have most of the CII ratings A and B, as shown in Figure 10. As depicted in Figure 11, which compares the total distance traveled with the attained CII of the 10 container vessels, it was observed that there is a trend for most of the vessels except for two. As the distance traveled over one year is in the denominator of the attained CII formula, this is the expected result. The CII rating improves as the distance increases. In Figure 11, the two red dots were observed, each representing a container vessel with a high distance traveled but an attained CII of 11.7 and 12.7 respectively. These are container 2 and container 11. To see why they are out of the range, it will be crucial to look at more characteristics of these two ships and compare them with the others.

An analysis of the number of port calls in relation to the attained CII for 10 container ships shows a trend in Figure 12: an increase in the number of port calls relates with a higher attained CII. This suggests that the frequency of port calls has an impact on the CII rating. It is important to note, however, that this trend may not be applicable for all types of vessels.

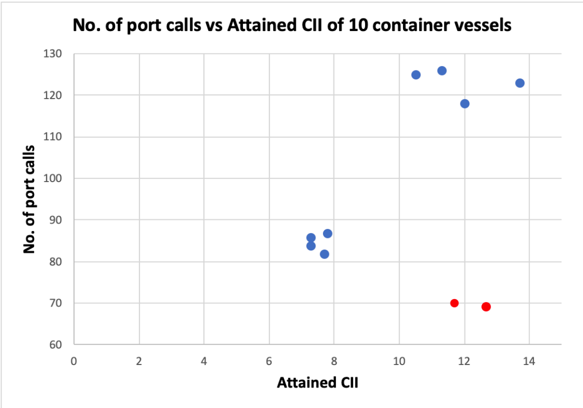


Figure 12. No. of port calls vs Attained CII of 10 container vessels (own work based on data collected)

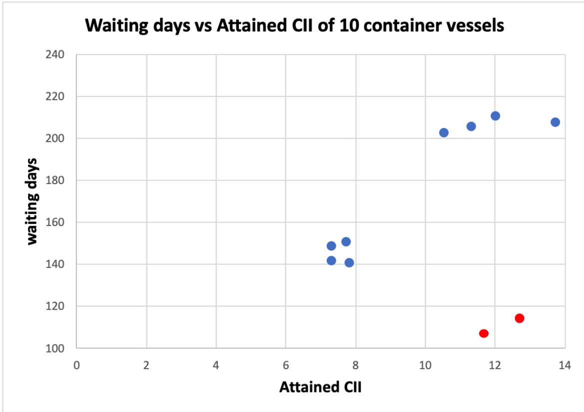


Figure 13. Waiting days vs Attained CII of 10 container vessels (own work based on the data collected)

Similarly, the relationship between waiting days and attained CII, shown in Figure 13, also indicates a trend. In particular, an increase in waiting days corresponds to an increase in attained CII. This relationship can be explained by the fact that during waiting the distance traveled does not increase, while fuel is still being consumed. Distance traveled is a critical factor in reducing the attained CII and therefore, improving the CII rating, as it has a direct impact on the result of the CII formula. The waiting time is something the shipowner or charterer has no influence on. As the current CII calculation metric does not take into account the waiting time, maybe it should be considered.

Container ships that make frequent port calls tend to have more waiting days. It should also be noted that the waiting times for container vessels are relatively consistent between different ports. This consistency is due to the nature of container ships as liner vessels, which often call at the same ports where the container terminals are owned by the container shipping companies, thus minimizing waiting times. Consequently, for the container vessels there is a clear relation between the number of port calls and the number of waiting days per year.

When comparing the attained CII with the waiting days and port calls, it is clear that the container vessels 2 and 11 still deviate from the observed linear trend. A closer look at these two ships compared to the other nine container ships in the given data set reveals differences in the year of built and trade routes. In particular, the container vessels 2 and 11, are older than other containerships. It is possible that these older vessels lack the technological advances, engine efficiencies, and other efficiency improvements that are present in the younger vessels. As a result, the older ships have a higher attained CII potentially due to the less fuel efficiency, highlighting the impact of technological progress on the performance of the maritime industry. The real impact of the age of the vessel on the CII rating could not be confirmed in this case, because there is not enough data available to prove.

In one of the interviews it was learned that the different trading routes can also have influence on the CII rating. Certain routes can have more adverse weather which will require more power of the ship, certain ports can cause more fouling on the hull of the vessel, which can reduce the efficiency by 15%. The data received does not show this kind of parameters so it is difficult to say if these factors also had an influence on container vessels 2 and 11, but it is possible.

7.2.3 Chemical tankers

Company 1 provided data for nine chemical tankers as shown in Table 12. This included noon reports for the year of 2023 and unverified CII as it is still under verification with classification societies. Most of the data were incomplete, primarily because seven of the nine ships were acquired as secondhand vessels or delivered as newbuilding ships during 2023. In the end, only two chemical tankers were provided with complete operational data for the period 2023, including noon reports. Nonetheless, waiting days and distance among the three parameters for all nine vessels were provided. In this section, two newbuilding vessels were excluded from the data analysis. Additionally, there were no sister vessels among the chemical tankers.

The main trading routes and operational patterns of chemical tankers were predominantly focused on intra-regional trade with multiple partial cargo operations within the region. For example, nearly 70% of chemical tanker trades in 2019 took place within intra-Northeast Asia, intra-Europe, intra-North America, and intra-Southeast Asia (ShipsFocus Intelligence, 2019). Chemical tankers typically transport any liquid chemicals in bulk (Wartsila n.d.). This suggests that trading patterns for chemical tankers involve relatively shorter voyages with a higher number of port calls. This was found in the operational data from chemical tankers 4 and 5, which indicated that their trading routes were focused between North American and South American regions, involving multiple partial cargo operations within these regions.

Table 12. Data obtained and analyzed for 9 chemical tankers (own work based on the data collected)

#	Name	Size	CII Rating	Attained CII	Distance (NM)	No. of Port Call	Sailing Days	Total Waiting Days
1	Chemical tanker 1	N/A	B	8.6	42,851	N/A	183	182
2	Chemical tanker 2	N/A	A	8.2	46,781	N/A	174	190
3	Chemical tanker 3	N/A	Incomplete Data					
4	Chemical tanker 4	N/A	B	10.2	51,748	45	145	220
5	Chemical tanker 5	N/A	A	8.8	55,327	64	180	185
6	Chemical tanker 6	N/A	B	8.4	54,595	N/A	171	194
7	Chemical tanker 7	N/A	A	7.1	40,217	N/A	211	154
8	Chemical tanker 8	N/A	Incomplete Data					
9	Chemical tanker 9	N/A	C	12	15,406	N/A	108	257

** Total waiting days entails port time and waiting time.*
*** Columns with the same color indicate vessels with the same CII rating.*
**** Size is range between 19,990 - 33,000 DWT.*

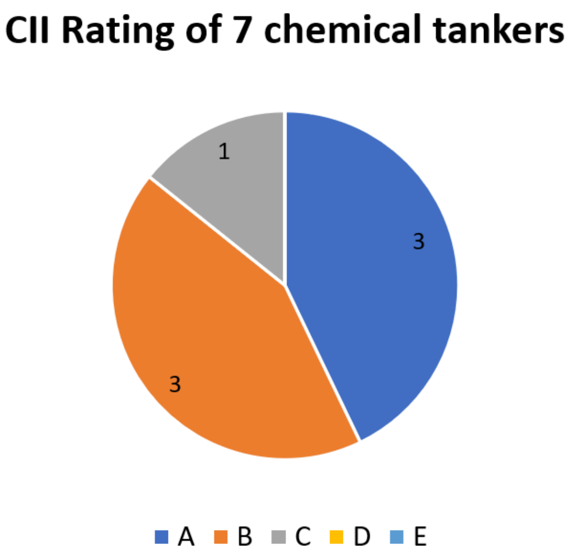


Figure 14. CII rating of 7 chemical tankers (own work based on the data collected)

As shown in Figure 14, the majority of the chemical tankers received CII ratings of A or B. This is based on the given data which is unverified CII data. However, during the interview, the Company 1 confirmed that the given (unverified) CII data is reliable as it was calculated on the basis of actual vessel operational data and therefore, verified CII data will likely be similar to the given data.

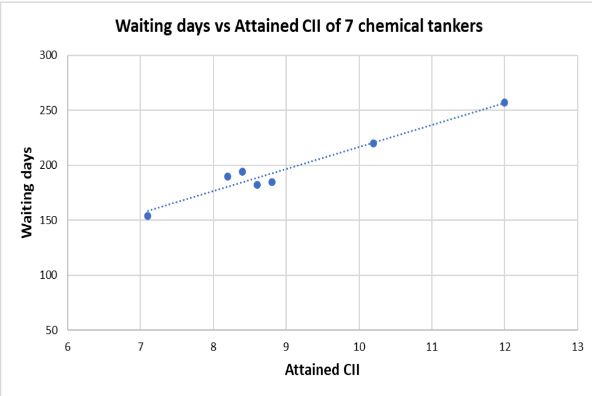


Figure 15. Waiting Days vs Attained CII for 7 chemical tankers (own work based on the data collected)

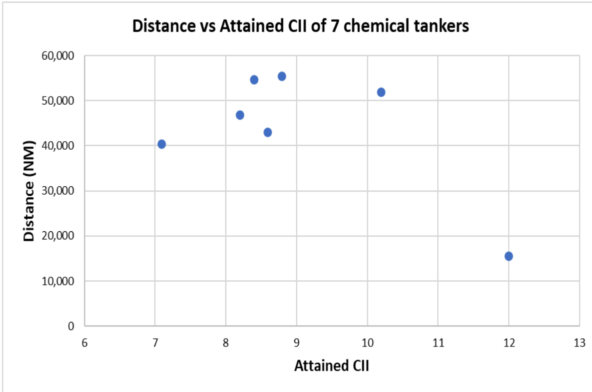


Figure 16. Distance vs Attained CII for 7 chemical tankers (own work based on the data collected)

Figure 15 shows a clear trend line of relation between waiting days and attained CII. The longer the waiting time, the higher the attained CII, thus worse CII rating. Interestingly, it was observed that the average waiting time for the given seven chemical tankers was nearly 200 days over a full calendar year. Supposedly, it should be related to distance traveled, but no clear relationship was found with distance traveled as depicted in Figure 16. From the literature review and qualitative analysis, it was noted that waiting time plays a significant role, but this is also relevant to trading areas and operational patterns. Due to the limited data availability for the majority of chemical tankers, it was difficult to further investigate and analyze the reason for this result. In this part, it was clear that waiting days had a clear relationship with attained CII with linear trend, as longer waiting days resulted in higher attained CII. Therefore, it can be suggested that waiting time may need to be considered in IMO's review process for these vessel segments.

7.2.4 Crude tankers

A total of twelve crude tankers were analyzed. Sub-vessel segments within crude tankers are divided by seven Very Large Crude Carriers (VLCCs) and five Suezmax tankers. Crude tankers typically transport Dirty Petroleum Products (DPP) such as crude, fuel oil, bunker oil, or unrefined products (Danmarks Skibskredit A/S, 2024). Table 13 shows the data received for the twelve crude tankers. Three of the twelve vessels are sister vessels of VLCCs, and another three are sister vessels of Suezmax. Additionally, there is another pair of VLCC and Suezmax sister vessels. In this part, data analysis will focus on the three sister vessels for each vessel sub-segment.

Table 13. Data obtained and analyzed for 12 crude tankers (own work based on the data collected)

#	Name	Size	CII Rating	Attained CII	Distance (NM)	No. of Port Call	Sailing Days	Total Waiting Days
1	VLCC 1	VLCC	B	1.96	72,608	18	271	95
2	VLCC 2	VLCC	B	2.03	73,457	25	245	120
3	VLCC 3	VLCC	C	2.12	73,134	25	251	114
4	VLCC 4	VLCC	B	2.01	81,116	31	282	83
5	VLCC 5	VLCC	B	2.06	80,833	21	238	100
6	VLCC 6	VLCC	B	1.87	85,137	17	284	81
7	VLCC 7	VLCC	A	1.57	75,833	16	274	92
8	Suezmax 1	Suezmax	C	3.65	52,549	20	206	160
9	Suezmax 2	Suezmax	B	2.98	58,058	27	229	136
10	Suezmax 3	Suezmax	A	2.64	71,586	23	259	105
11	Suezmax 4	Suezmax	B	2.98	64,051	30	220	145
12	Suezmax 5	Suezmax	B	2.88	54,435	23	208	158

** Total waiting days entails port time and waiting time.*
*** Columns with the same color indicate sister vessels.*

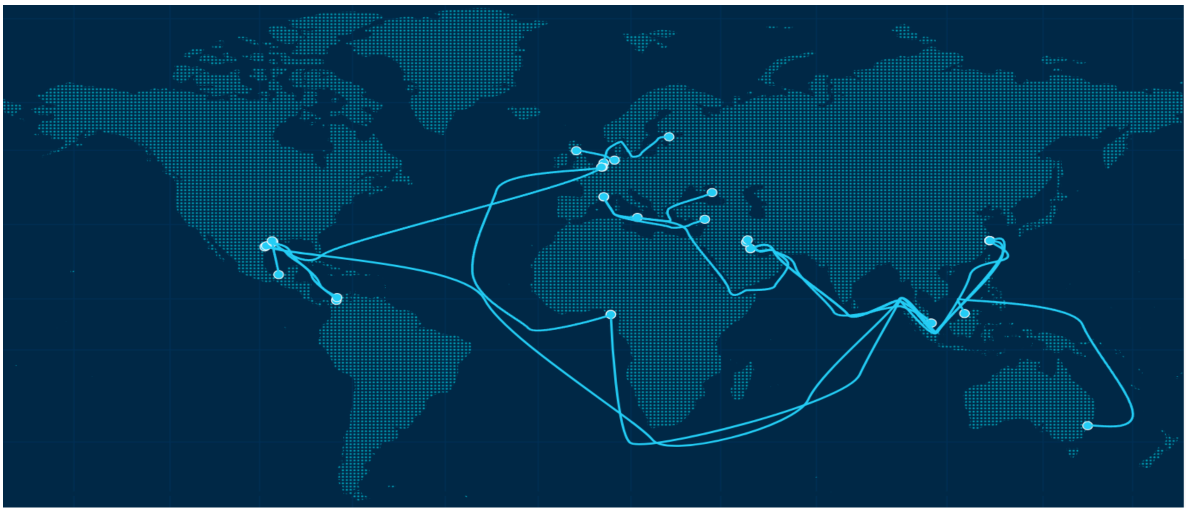


Figure 17. The major trading routes of DPP. Retrieved from (Baltic Exchange, n.d.)

Baltic Exchange has outlined the main trade routes for DPP, as shown in Figure 17. The trading region was divided into two categories: one for import regions and the other for export regions. The main export regions were identified as the AG, Black Sea, North Sea, West Africa, and the United States Gulf (USG). The main destinations were identified as Mediterranean, Western Europe, Singapore, and the JKTC countries (Japan, Korea, Taiwan, and China) (Baltic Exchange, n.d.). The data provided from Company 3 revealed that their crude tankers had similar trading patterns.

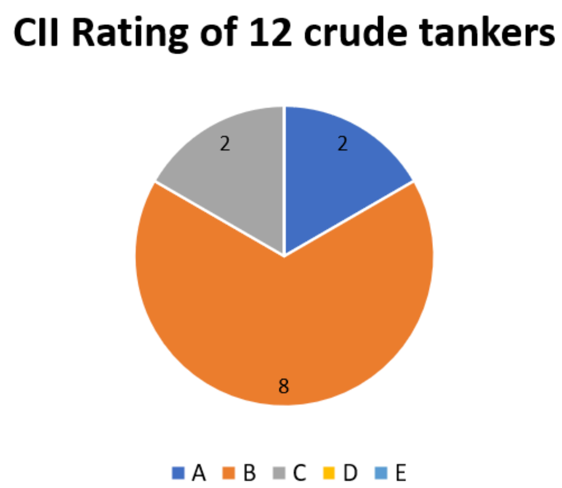


Figure 18. CII rating of 12 crude oil tankers (own work based on the data collected)

From the data collected, most of the crude oil tankers were assigned CII ratings of A and B, with two vessels assigned a C rating, as depicted in Figure 18. It can be interpreted that the performance of their fleet was quite good for the year of 2023. Since the current CII regulatory framework does not require any corrective measures on vessels receiving ratings within this range, none of their fleet will have to implement any measures.

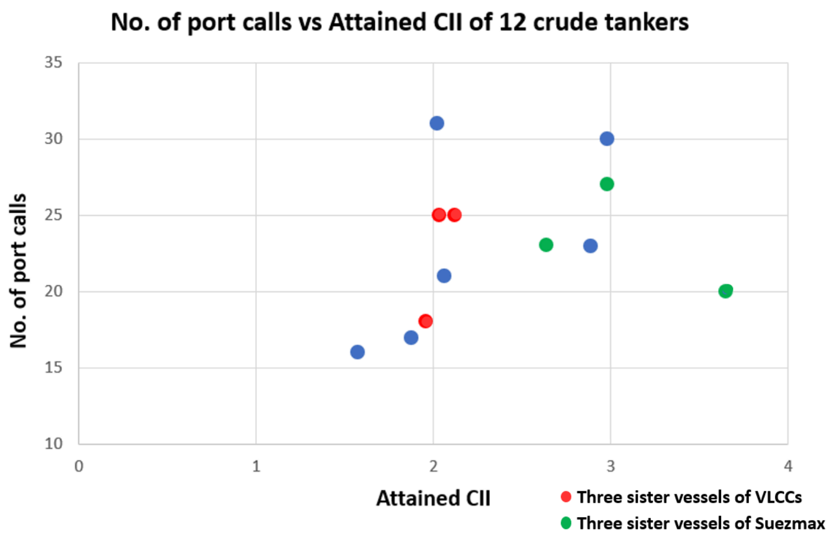
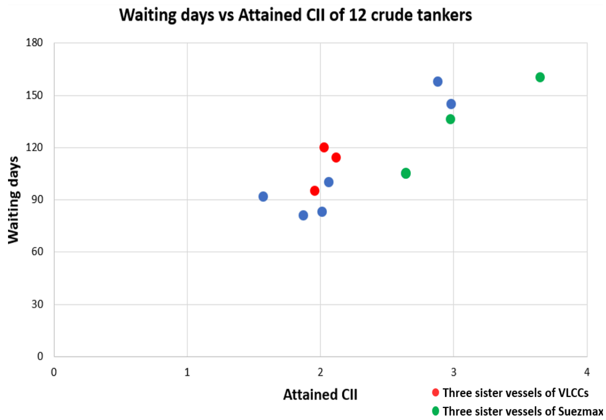


Figure 19. No. of port calls vs Attained CII for 12 crude tankers (own work based on the data collected)

In general, the number of port calls for all crude oil tankers ranges between 15 and 35, as depicted in Figure 19. However, it was noted that the number of port calls does not provide a clear validation or justification for its relevance to the attained CII. It can also be interpreted from the figure that crude oil tankers with 15 to 20 port calls tend to have a relatively lower attained CII. As the number of port calls exceeds 20, it becomes more difficult to find its relation with the attained CII. Therefore, a further analysis with other factors is necessary and will be continued in the following paragraph.



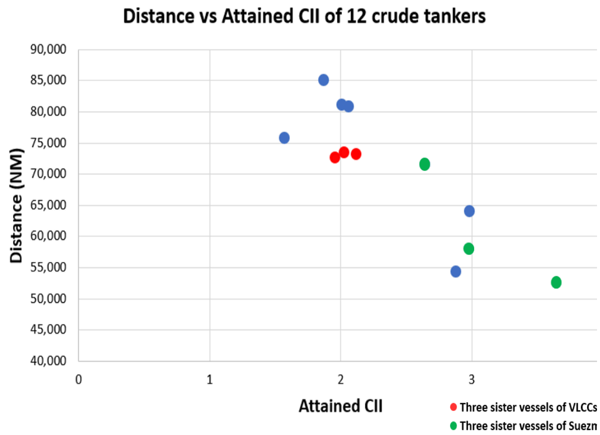


Figure 20. Waiting days vs Attained CII for 12 crude tankers (own work based on the data collected)

Figure 21. Distance vs Attained CII for 12 crude tankers (own work based on the data collected)

Waiting time and distance were found to be interrelated. As shown in Figure 20 and Figure 21, it was clearer that crude oil tankers with longer waiting days would have less distance traveled, resulting in both cases with a higher attained CII and thus, worse CII rating. The number of port calls could be related to waiting time, but it was found not to be clearly related in this case. It is possible that crude tankers are less influenced by variables affecting port waiting time due to their trading patterns compared to other vessel segments. The 12 reference crude tankers have an annual average number of port calls of 23. This indicates that they usually have a long-haul voyage between one loading port to the other for discharging.

Table 14. *CII rating and variables comparison for three sister vessels of VLCC (own work based on the data collected)*

Name	CII Rating	Attained CII	Distance (NM)	Trading Routes	No. of Port Call	Sailing Days	Total Waiting Days
VLCC 1	B	1.96	72,608	Brazil - via Cape of Good Hope - China and USG - China	18	271	95
VLCC 2	B	2.03	73,457	AG - USG , USG - Singapore, WAF - China, South America - Southeast Asia	25	245	120
VLCC 3	C	2.12	73,134	AG- South Europe, USG - China, AG - India, US West Coast - China	25	251	114

Furthermore, three sister VLCCs were brought in for further detailed and comparative analysis. All of them were built in the same year and have identical technical specifications. It was observed that there were not many differences in terms of distance traveled, sailing days, or total waiting days, as shown in Table 14. However, VLCC 1 and VLCC 2 received a CII rating of B, with attained CII values of 1.96 and 2.03 respectively, while VLCC 3 received a CII rating of C, with an attained CII value of 2.12. As the distances of three VLCCs are similar, it was not the determining factor for the differences in the CII rating between B and C. As VLCC 3 has a shorter waiting days than VLCC 2 but having a higher attained CII, it can be interpreted that it did not play a significant role either.

In this case, there may be other unidentified or external factors that played a role affecting CII rating . As highlighted during the literature review and interviews, events of adverse weather and hull fouling could have played a role in this case. These factors are related to vessel efficiency and usually lead to higher fuel consumption. Adverse weather is currently not considered in the CII formula and therefore, it can be suggested that this may need to be considered in the CII formula during the review process. Alternatively, the Company may improve fuel efficiency of vessels through hull cleaning and propeller polishing.

Table 15. *CII rating and variables comparison for three sister vessels of suezmax (own work based on the data collected)*

Name	CII Rating	Attained CII	Distance (NM)	Trading Routes	No. of Port Call	Sailing Days	Total Waiting Days
Suezmax1	C	3.65	52,549	North Europe - Brazil - South Africa - Brazil - Chile -Brazil - South Europe - Red Sea via Suez Canal - India - China - Singapore	20	206	160
Suezmax2	B	2.98	58,058	South America - US West Coast - East Coast of Canada	27	229	136
Suezmax3	A	2.64	71,586	US East Coast - South America - Mediterranean - West Africa - Middle East - Southeast Asia	23	259	105

In addition, three sister suezmaxes were brought in for detailed and comparative analysis. All of them were also built in the same year and have identical technical specifications. The three sisters show a greater difference in CII rating and attained CII, as shown in Table 15. Firstly, a difference in distance was observed: the longer the distance, the lower its Attained CII, resulting in a better CII rating. It is because distance serves as a denominator in the CII formula. Secondly, it was found that longer waiting days resulted in a higher Attained CII, indicating a better CII rating. This suggests that both waiting days and distance are again interrelated. Therefore, IMO may need to take waiting time into account during the review process for crude tankers.

7.2.5 LPG carriers

A total of 14 LPG carriers were analyzed based on full operational data in 2023. Data was collected from the key stakeholders. The data for each ship includes noon reports and verified CII data. It is presented in Table 16.

Table 16. Data obtained and analyzed for 14 LPG carriers (own work based on the data collected)

#	Name	Size	CII Rating	Attained CII	Distance (NM)	No. of Port Calls	Sailing Days	Total Waiting Days
1	LPG1	VLGC	B	N/A	104,656	17	282	83
2	LPG2	VLGC	B	N/A	105,681	15	278	87
3	LPG3	MSGC	A	8.74	76,363	22	237	128
4	LPG4	MSGC	C	10.47	66,988	31	192	173
5	LPG5	MSGC	B	9.51	76,836	35	215	150
6	LPG6	MSGC	B	9.58	97,187	36	257	108
7	LPG7	MSGC	C	N/A	51,330	46	148	217
8	LPG8	MSGC	B	9.93	85,134	31	226	139
9	LPG9	MSGC	B	9.42	73,539	21	225	140
10	LPG10	MSGC	C	10.77	47,269	55	129	236
11	LPG11	MSGC	C	11.48	54,043	32	165	200
12	LPG12	MSGC	B	10.13	74,761	23	217	148
13	LPG13	MSGC	D	13.76	38,421	28	123	242
14	LPG14	MSGC	C	11.49	62,929	29	174	191

** Total waiting days entails port time and waiting time.*
*** Columns with the same color indicate sister vessels.*
**** LPG1 and LPG2 were not provided with verified data, while the rest of the MSGC vessels were provided with verified data.*

As mentioned in the first lines of this chapter, trade routes, society and supply chains have a substantial influence on consumption, waiting time and other key factors for CII. For example, the United States West Coast (USWC) is the largest gateway for imports from the Far East into North America. In 2022, these ports were heavily congested due to the dock labor crisis and unexpected demand growth. In this case, the International Longshore and Warehouse Union started negotiations with the Pacific Maritime Association in May 2022 and reached an agreement in August 2023 (Port of Los Angeles, 2023). Also, in July 2023, Canada's largest port, Vancouver, experienced a 13-day dock strike that had a bullwhip effect, causing prolonged port delays and congestion in the Canadian economy (Argus, 2024). These situations have nothing to do with the efficiency of a vessel. On the contrary, a ship operating on this route will see its CII rating underperform due to the need to drift and anchor around the port. Add CO_2 emissions to the numerator and almost 0 NM to the denominator.

More specifically, the cargoes carried by LPG tankers include butane, propane and ammonia. Firstly considering the economic geography of these commodities, butane is a gas used as a refrigerant, solvent and feedstock for the petrochemical industry. In 2022, the main exporters were the USA 26.4% and the AG countries 40.51% (Saudi Arabia, Qatar, UAE, Oman & Kuwait). The main importers were India 24.5%, China 12.1%, Indonesia 6.81% and Morocco 5.23%. This represents a global trade of USD 31.3 billion in 2022 (OEC, 2024). For propane, a gas used mainly for cooking, the largest producers were the USA 44.9%, Canada 6.95% and the AG countries 28.53% (Saudi Arabia, Qatar, UAE, Oman & Kuwait). The largest importers were China 17.8%, Japan 14.6%, India 11.8%, South

Korea 6.31% & Mexico 5.44% (OEC, 2024). Finally, ammonia is a colorless gas used as a refrigerant, oxidiser, detergent and reducing agent. The main exporters are Trinidad & Tobago 20.8%, Saudi Arabia 13.6% & Indonesia 10.8%. Major importers are the USA 13.6%, India 12.7%, Morocco 10.3%, South Korea 6.7% & Belgium 6.23%. The total value of world trade is around USD 17 billion (OEC, 2024).

A combination of all these socio-economic factors has resulted in three distinct routes for LPG carriers. Firstly, a short haul route from AG to India and Southeast Asia. Also from AG, a long-haul route to JKTC. Secondly, an Atlantic Basin cargo flow from USG, United States East Coast (USEC) (propane and butane) and the Caribbean (ammonia) on a long-haul route to the continent, Morocco, West Africa and Latin America via the Panama Canal when required. For all these routes, MSGC with around 29,000 dwt were used, which consume HFO and MGO. On the other hand, for the last and longest trade, USG-JKTC via the Panama Canal, economies of scale allow for larger vessels within the size restrictions of the Panama Canal. The longer voyages for both loaded and ballast trades are associated with fewer ports of call and reduced port waiting times. These characteristics of the trade, together with the larger size of the vessels, suggest that these vessels will have a more efficient CII rating than the rest of the fleet. The two ships in this final analysis were around 55,000 DWT Very Large Gas Carriers (VLGC) using dual-fuel LPG engines as it was noted during the interview with Company 4. As mentioned in Table 4, the fact that LPG is used with a Cf of 3,000 compared to the Cf of HFO and MGO of 3.114 and 3.206 Mt CO2/Mt fuel, will also result in a lower CO2 impact in the CII rating.

It was therefore interesting to determine the average CII rating of the ships operating in these different trade lanes.

1. AG to Asia:

- AG to India: LPG10 (2017) C, LPG11 (2014) C, LPG13 (2014) D (MGO, HFO Fueled)
  Average CII rating = 12.002 → D

Route characteristics: Low distance (38-54,000 NM), many ports of call (28-55), high waiting time plus port stay days (200-243 days), reduced sailing time (123-163 days).

- AG to Far East & Med: LPG3 (2017) A, LPG9 (2016) B, LPG12 (2014) B (MGO, HFO Fueled)
  Average CII rating = 9.430 → B

Route characteristics: Increased distance (73-76,000 NM), few ports of call (21-23 under 2 calls per month), lower waiting time plus port stay days (129-149 days), reduced sailing time (217-317 days).

2. Atlantic Basin : LPG4 (2018) C, LPG5 (2015) B, LPG6 (2016) B, LPG8 (2016) B, LPG14 (2015) C (MGO, HFO Fueled)

   Average CII rating = 10.197 ⟶ B

Route characteristics: Higher distance (62-97,000 NM), few ports of call (29-36), high range in waiting time plus port stay days (108-192 days), medium high sailing time (173-257 days).

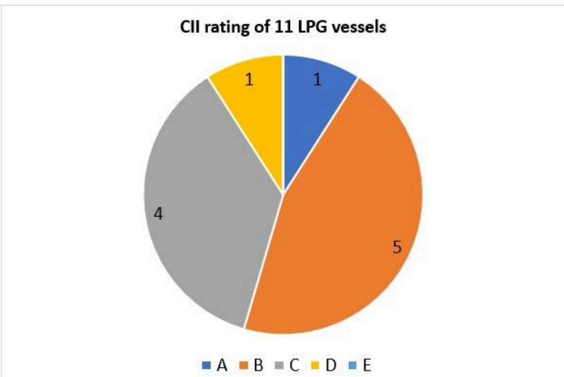
3. TransPacific : LPG1 (2021) B, LPG2(2021) B (LPG, HFO, MGO)

Due to the unfinished deadline for the DCS Fuel Report submission to the IMO for 2023 data, not all the verified data was provided. Including the information for these two VLGCs.

Differently, the Company confirmed their rating was a 'B', altogether with the data input in the NK calculator. Average CII rating = B

Route characteristics: very high distance (105,000 NM), very low ports of call (15-17), very low waiting days plus port stay days (83-87 days), very high sailing time (278-281 days), fuel (LPG lower CO2 emission factor).

Various figures from the LPG fleet are presented in Figure 22. CII compliance is the norm for ten out of eleven vessels. Only one is out of compliance, with a CII rating of D. This means that this ship has another two years to move into compliance. If this does not happen, the ship will be subject to a SEEMP Part III plan of correction.



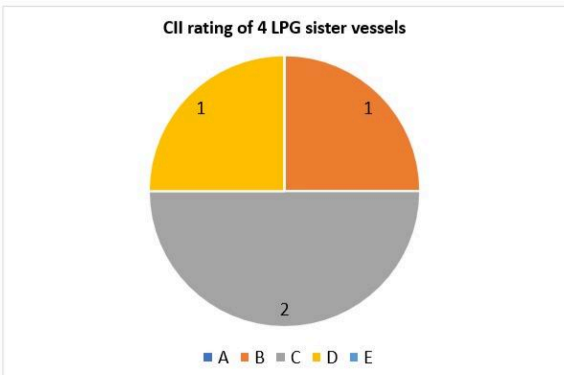


Figure 22. CII rating of 11 LPG carriers (own work based on the data collected)

Although not a strictly linear configuration can be seen in Figure 23, there is a trend linking high distance traveled with lower attained CII (better performers) and conversely high attained CII (worst performers) with low distance traveled.

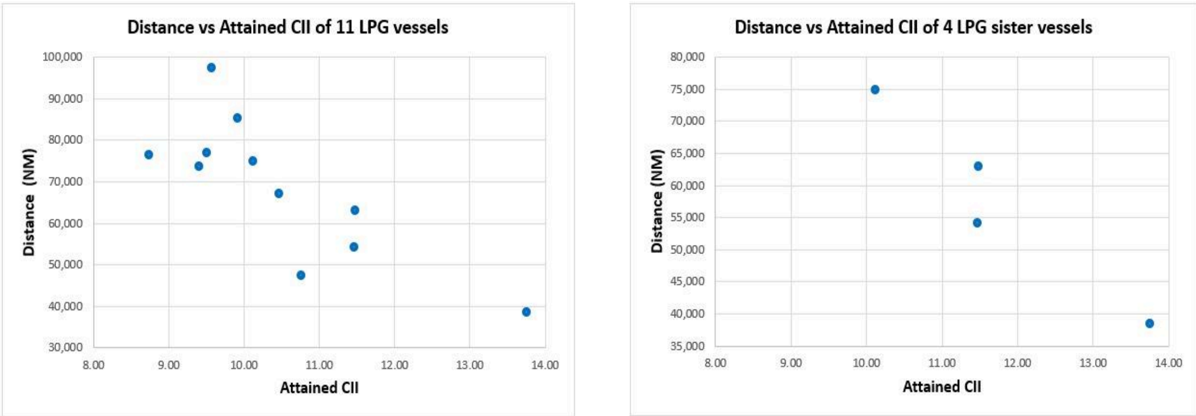


Figure 23. Distance vs Attained CII for 11 LPG carriers (own work based on the data collected)

As regards to ports of call, shown in Figure 24, there seems to be no relation with CII. It is more likely that total waiting days is a more important reason for determining CII.

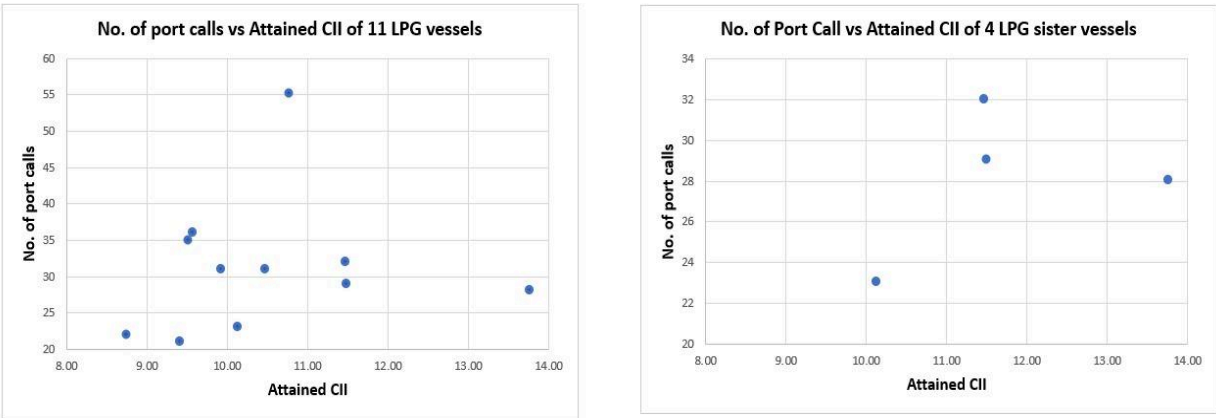


Figure 24. No. of port calls vs Attained CII for 11 LPG carriers (own work based on the data collected)

As the research has shown and the figures depict, waiting days are one of the most important variables in determining CII performance. A clear linear trend links the best CII performers to lower waiting times in Figure 25. According to this, as waiting days increase, so does the attained CII. There is a direct link between increased waiting time and reduced attained CII, so better CII rating. A clear example is:

- LPG3 CII Rating: A Waiting time (days): 129
- LPG13 CII Rating: D Waiting time (days): 243

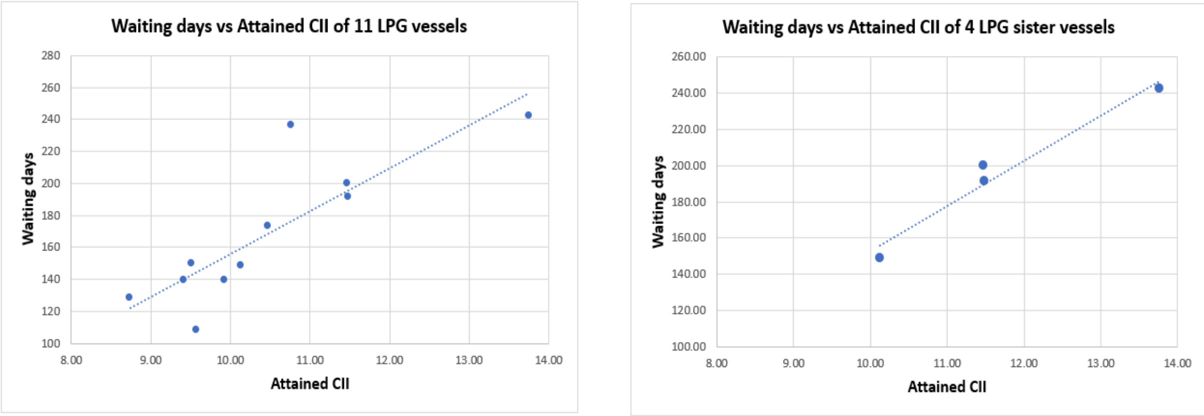


Figure 25. Waiting days vs Attained CII for 11 LPG carriers (own work based on the data collected)

In terms of trading routes, it would be worth looking at the average results of the fleet per route. There was a tendency towards a CII rating of B, with the exception of vessels operating on the AG to India route, which scored with CII rating of D. These results indicate that trade routes with a notorious incidence of port congestion can have a very negative impact on CII. This is even worse when the trade is relatively short, as the trading route from AG to West India is around 1,400 NM and takes around 4-5 days for sailing.

On the contrary, the most efficient route is that of the modern LPG-powered VLGCs. Crossing the Panama Canal on their way from the US to the Far East. The long voyages require about 9-10,000 NM each way, almost a month-long sailing for one leg. In addition, the absence of heavy port congestion, the few ports of call, the choice of LPG as a fuel in combination with HFO and MGO and the fact that these vessels are the most modern of their Belgian flagged fleet, result in them being the best performers in average CII per route.

In contrast, the sampled vessels that made most of their annual voyages from the AG to India, but included one or two voyages to the Mediterranean or Far East, received better ratings due to the increase in NM, sailing days and their reduction in waiting days compared to those that only made voyages to and from India. To examine a case further, two sister mid-size gas carriers operating on the following two routes were selected. On the one hand, AG to India, Far East Asia & Mediterranean. On the other hand, AG to West India. The motivation behind this is to select the most similar ships, as well as significant differences in the trade routes, in order to isolate specific factors that determine CII performance. In this case, two sister ships were chosen as depicted in Table 17. This means that these ships were built and designed with the same technology and DWT in the same year. In this way it can be observed that their EEDI is almost the same. In parallel, there is a significant difference in their CII rating from a CII rating of B for LPG12 to D for LPG13.

Table 17. CII Rating and variables comparison for vessels LPG12 & LPG13 (own elaboration on received data)

Name	CII Rating	Attained CII	EEOI	EEDI	Tonne-Mile	Utilization Ratio	Distance (NM)	Trading Routes	No. of Port Call	Sailing Days	Total Waiting Days
LPG12	B	10.13	26.17	8.04	864,978,817	37%	74,461	AG-East India, Korea	23	217	148
LPG13	D	13.762	50.42	8.15	320,019,048	41%	38,421	AG-West India	28	123	242

LPG13 with a CII rating of D and attained CII of 13.762 has, not surprisingly, the highest waiting time of 242 days. As a result, the distance and time sailed are greatly reduced compared to LPG12, which scored a CII rating of C. LPG13 almost half of the distance traveled compared to LPG12. On the other hand, it can be seen that the utilization rate is higher for the poorly performing LPG13. This could be due to the large number of days spent in ballast on the way back to the loading port in the AG. The poorest performing LPG13 spent many days drifting or anchored outside the port waiting for the cargo to be unloaded. Another factor that is interesting to analyze is the difference in EEOI, which is around twice as high for LPG13s.

As the EEOI is directly related to the transport work carried out by each vessel, the tonne miles produced by each vessel are directly related to this indicator. Therefore, the large difference in EEOI of around 2 times can be understood by looking at the distance traveled by the two vessels. In summary, the most relevant variables for determining CII performance in this case are distance traveled and total waiting days. As a conclusion of the analysis, ships operating on highly congested short trade lanes are severely disadvantaged in terms of CII compared to ships operating on long trade lanes with fluid port call procedures. Put into CII framework terms, highly congested short trade lane routes, (AG-India) relate into long waiting time at ports and very scarce distance navigated. This makes the value in the denominator low. Also, during this time in which the vessel is drifting or at anchorage waiting for assigned berthing and port operations, fuel is being burned for hotel consumption and drifting around the port. This relates into a high consumption when compared to the miles navigated. Resulting in a clear disadvantage for a ship operating in this trade lane.

On the other side of the table, the advantaged trade lanes are situated, those with long traveling distance requirements and fluid port call processes. This relates into a large quantity of NM added to the denominator, also the consumption will be higher, differently this is compensated by the Distance covered in the denominator. In the future, the fuel choice will have a great impact on CII performance. For our study most ships were running on HFO and MGO, as can be observed in Table 4, other fuels such as LPG and LNG have lower CO2 emission factors. In this line, some stakeholders in the industry are betting on LNG and LPG as transition fuels. These fuels, when utilized with modern technologies such as 2–stroke high-pressure dual fuel engines can achieve a 15% CO2 equivalent emission reduction when compared to MGO (Pawelec, 2020). As from marine engine manufacturers, LPG dual fuel vessels can also achieve a similar rate of 15% emission reduction. (Laursen, 2018). Differently, these 15% emission reductions will also relate into a better CII rating, due to a lower amount of fuel consumption and a lower Cf factor. Given the current state of technology these are the only available fuels that can serve as transition fuels. While in order to achieve Net Zero, other energy sources with a much higher emission reduction would be required. Presently for LPG carriers due to the fact they are already accustomed to transport ammonia, this fuel is seen as the fuel of the future for this specific segment due to much lower relative CO2 emissions than traditional fuels (Pawelec, 2020).

Company 4 was the only shipowner to perform drydock repairs in the study. Therefore our results are only linked to the two ships which performed this repair and maintenance operations. During the interview, the fleet manager had an impression that drydocking might impact CII positively. From our initial perspective, it was expected to see a similar effect as that of waiting time plus port stay days. As during this repair and maintenance period there are no NMs being added to the denominator and fuel is still being added to the numerator in the equation. Differently, from the shipowner's perspective this was not the case. The consequences of drydocking would be neutral for CII or even positive. Backing this on the fact that the fuel consumption is much lower than that of drifting, anchorage and noon in port. Also, this amelioration service for the vessel results in efficiency gains for the ship's performance. For example, propeller polishing, hull painting, anti-fouling works, engine oil lubrication, piston cleaning or similar. These will all result in increased fuel consumption efficiency for the moment in which the ship goes back to the water. Resultantly, impacting on a more efficient CII performance. When looking at the data, there were two ships which went to drydock between months 5 and 6, roughly splitting in half the year in two stages. Leaving us with 5 months of data with pre-drydock activity and another 6 months with post-drydock activity.

For this analysis, the two periods taken into account were calculated so as to have the most similar NMs performed possible. Our initial assumption was the CII rating per period should be better in the last half of the year. Going to the two case analysis:

Case 1: LPG4: 05-12 to 06-10 (4 weeks) in specialized drydock port

Using the ClassNK CII calculator and splitting the data so that the navigated distance is as equal as possible in both cases, two different periods were obtained. Firstly, one previous to Dry Dock (Period

1: 26,470 NM 01-01-2023 to 12-05-2023) and afterwards (Period 2: 26,488 NM 12-05-2023 to 11-10-2023). The data for the HFO, MGO and NM was introduced. Obtaining the following results:

1. Attained CII (Period 1): 10.86 CII Rating: C
2. Attained CII (Period 2): 10.86 CII Rating: C

   * Details of calculation can be found in Appendix E

Vessel LPG4's CII rating is maintained constant before and after the drydocking. However, it is not safe to make this a firm conclusion taking into account it is very difficult to isolate all the parameters for both cases, such as routes, charterer speed requirements, ports of call, wind and sea conditions etc.

Case 2: LPG7: 05-20 to 06-09 (3 weeks) in specialized drydock port

Again using the ClassNK CII calculator and splitting the data so that the navigated distance is as equal as possible in both cases, two different periods were obtained. Firstly, one previous to dry dock (Period 1: 23,395 NM 01-01-2023 to 20-05-2023) and afterwards (Period 2: 26,488 NM 06-09-2023 to 05-11-2023). The data for the HFO, MGO, and NM was introduced. Obtaining the following results:

1. Attained CII (Period 1): 10.80 CII Rating: C
2. Attained CII (Period 2): 8.21 CII Rating: A

Vessel LPG7's CII rating had a great amelioration after dry docking. More specifically, the HFO consumption was more than halved. Of course this could be due to sailing an Emission Control Area (ECA) zone. However, also after checking the area of operation of this vessel, it was appreciated that in both periods the ship was operating mainly in Continent trade and a few transatlantic voyages. Each case will be different, however a ship with a severe engine malfunction might highly increase its consumption efficiency after drydocking. Therefore in a case of this kind, it is reasonable to state repair and maintenance at drydock will positively affect the CII rating performance. Still, each case will be different and depending on the condition of the ship at the moment of calling.

7.3 Conclusion of quantitative analysis

After analyzing three parameters of the distance, waiting time, port of call and, in some cases, trade routes and drydocking periods for the five different ship segments, different conclusions were made for each segment. This is because all the factors analyzed have a different impact on the different ship types. For some ship types, certain factors have a greater impact on their CII rating than for others.

The analysis of bulk carriers highlights the need for a more refined and comprehensive approach to understanding and improving CII calculation metrics, particularly in this segment. While distance traveled remains an important factor as a denominator in the CII calculation, the results suggest that it is not the sole determinant factor of CII ratings. Other elements such as trade routes, fuel efficiency of ships due to age, design and external factors such as hull fouling, ship maintenance and operational efficiency may play a critical role in influencing CII results and should be considered in further studies. The analysis of waiting days and port calls also shows a complex picture in this segment. The different operating conditions and trade routes, such as port congestion and canal transit, were found to be relevant to waiting days, which ultimately affect the CII results.

The analysis of container ships underlines the multifaceted nature of CII ratings. Factors such as distance traveled, port calls, waiting times and ship-specific characteristics (e.g. age and technological advances) have a significant impact on CII results. The findings argue for a comprehensive CII formula that integrates these different factors to better reflect the fairness of the CII regulatory framework. Container ships tend to have a high number of port calls. Although respondents indicated that container ships tend to be less exposed to terminal congestion because the terminal operator company is part of the same holding group as the charterer, it was clear that a high number of port calls is still relevant to waiting time, which ultimately affects the total distance traveled and is related to higher fuel consumption. As the current CII calculation metric does not take this factor into account, consideration should be given to take waiting time into account.

For chemical tankers, the study found that chemical tankers tend to have relatively short voyages within intra-regional trade. In addition, due to the characteristics of the vessel carrying various chemical cargoes, a large number of port calls with multiple partial cargo operations are usually expected for operational patterns. For data, because most of the vessels were either acquired as secondhand vessels or delivered as newbuildings during 2023, this resulted in most vessels having incomplete operational data availability. Despite this fact, the analysis found that longer waiting times result in a higher attained CII. It can therefore be suggested that IMO may need to consider waiting time and characteristics of the ship type in the CII calculation metric during the review process.

The data analysis for crude oil tankers highlights factors influencing the CII ratings. Firstly, waiting time and distance were found to be interrelated. The data revealed that longer waiting times resulted in higher attained CII, while shorter distances traveled also led to higher attained CII. This is due to the fact that distance serves as the denominator in the CII formula, thereby playing a significant role in impacting CII results. However, waiting time is not under the control of the shipowner or charterer due to many variables such as cargo complexity, port congestion, weather, and others. Secondly, during the comparative analysis of three VLCCs as sister ships, it was observed that differences in CII ratings still occurred even though three parameters (waiting time, number of port calls, and distance) were within similar ranges. In this case, external factors such as adverse weather or hull fouling may be affecting CII rating with different results. Thirdly, In the comparative analysis of three suezmax tankers as sister ships, it was clearly observed that waiting time was a critical factor influencing the total distance traveled, resulting in different CII ratings for A, B, and C respectively. For the case of crude tankers, waiting time was found as a critical factor affecting distance. Also, external factors such as adverse weather and hull fouling may affect vessel's fuel efficiency. IMO may need to consider waiting time and adverse weather in the CII calculation metric during the review process. Shipowners may need to take measures to improve the fuel efficiency through hull cleaning and propeller polishing.

In the case of LPG carriers, there was a clear interconnectivity between waiting days and attained CII. Gas carriers, in particular those carrying one of the three main products propane, butane and ammonia, operate on the main shipping routes due to geographical economic factors. These core characteristics place some vessels operating on disadvantaged routes in an unfair situation. In fact, their efficiency design is the same as that of other vessels operating on advantageous routes. This is demonstrated by our sister-ship comparison. A shipowner or charterer has no choice about port congestion. At the same time, an international regulatory framework should not penalize ships for trading in an area due to inefficient characteristics, as the shipping industry is simply meeting the demand for a cargo that needs to be transported by sea and is essential for the economies of developing countries. In particular, butane and propane are cited as key to reducing household air pollution from cooking in economically depressed regions (WB, 2017).

In conclusion, the study highlights the complexity of the factors affecting CII ratings. The issues identified in the literature review and qualitative analysis are relevant to the factors that determine CII ratings, and many of them are not addressed in the current CII regulatory framework. The research shows that the inclusion of factors such as waiting time, ship specific characteristics such as trade routes and other external variables such as adverse weather conditions would be crucial to a more accurate and fair assessment of a ship's environmental performance.

The results from each segment highlight the multifaceted nature of CII ratings and the need for continuous improvement in technological and operational practices as well as port efficiency. For example, the installation of ESDs, the adoption of new alternative fuel technologies, and regular hull cleaning and propeller fouling can help ships achieve better fuel efficiency. By adopting a more comprehensive approach, key stakeholders would better align themselves with global initiatives to reduce CO2 emissions and promote a sustainable future. The maritime industry consists not only of ships, but also of many other segments such as ports. If ports were to improve their efficiency, waiting times would be reduced and the CII rating of ships would improve as a result. In the maritime industry, there is a whole chain reaction of factors that influence the CII rating of ships, which makes CII calculations and possible improvements so complicated.

8 Conclusion

Through qualitative analysis, including interviews and an online survey, it has been discovered that the CII has been effective in raising awareness within the shipping industry about the necessity of tracking emissions and identifying variables leading to poor performance. However, as 2023 marks its first fully operational year and the annual reports have yet to be submitted, it is too early to definitively assess CII's success or failure.

In respect of the most essential factors to determine CII, distance traveled and waiting days have proved to be constant factors determining CII ratings through all the vessel segments and sizes. Parallelly, the results of this study suggest these are not the sole determinants of CII ratings. Other factors, including trade routes, hull condition, adverse weather, engine efficiency, ship design, maintenance, and operational efficiency, also play critical roles in influencing CII outcomes.

The consistent communication with the stakeholders, along with a comprehensive literature review and data analysis, has revealed that certain segments hold a clear advantage with respect to CII due to their inherent characteristics. For instance, vessels engaged in long, intercontinental voyages with fewer port calls, such as VLCCs, suezmaxes, and VLGCs, benefit from their trade routes. These voyages, often exceeding 6,000 nautical miles (e.g., US Gulf to JKTC or AG to Europe), typically involve fewer port calls compared to ships operating in intraregional trades or multi-port calls due to their cargo characteristics with chemical tanker and container vessel as examples. Conversely, vessels on shorter haul voyages such as, AG to India (approximately 1,000 nautical miles), with port calls in congested ports, thus start from a disadvantageous position for CII, likely resulting in poorer performance.

Nevertheless, this study concludes that the current CII framework is somewhat ineffective and requires further revision. At present, CII primarily functions as an informational tool for assessing a ship’s annual operational efficiency. The effectiveness of CII could be significantly enhanced by integrating it into a broader, more robust legislative framework. Feedback from our ongoing discussions with Belgian shipowners has been insightful; while companies are keen to participate in decarbonization efforts, they find CII overly complex, leading to administrative burdens and inefficiencies. This complexity is particularly frustrating when fleet managers realize that the current framework inadvertently promotes ballast trips to improve CII ratings, creating a perverse incentive.

This unintended perverse incentive contradicts the IMO’s original goal of reducing emissions by phasing out the oldest and least efficient vessels. There is a trend among shipowners from developed countries to sell their oldest ships on the secondhand market, as in the developed countries the environmental standards are higher (Lloyd's, 2024). However, the market price of these "old ladies" is still too high compared to the scrap value for this to be an option. Then they are acquired by buyers from emerging economies. These older ships continue to operate at lower freight rates, maintaining high pollution levels. Without incentives to retire these vessels, such as a carbon tax similar to the levy proposed by Pacific Island countries, these ships will continue to pollute heavily. This is a tendency that should also be revised by the IMO, as the main intention should be to remove the most polluting ships from the seas.

A potential improvement for the CII in its 2026 revision would be to eliminate the perverse incentive by switching to the EEOI. Given the steady increase in tonne-miles over the past decade, except for 2020 and 2022 (UNCTAD, 2023), focusing on demand rather than supply variables such as deadweight would be more in line with the current market. It would also remove the perverse incentives of ballast trips. Although the change would not be perfect, as EEOI also has its challenges, such as penalizing ships with low utilization rates or those involved in parceling operations, it would be a step forward.

Our data analysis further reveals that there is no single solution that fits all segments of the maritime sector, each with its unique characteristics, benefits, and challenges regarding GHG emissions. Therefore, an ideal solution that ensures equal fairness across all segments does not exist.

9 Recommendations

This thesis addressed the research question and drew conclusions on the basis of both qualitative and quantitative analyses. Based on the findings and limitations encountered, the following recommendations are made to the IMO, shipowners, and academics. The aim of these recommendations is to assist the IMO in its review process of the current CII regulatory framework, to guide shipowners in improving the CII of their fleets, and to assist academics in achieving better outcomes in their future research.

For the IMO, this thesis recommends creating further awareness of the current CII regulation for industrial stakeholders as it was found during qualitative analysis. This could be done through education that provides information on how to reduce CO2 emissions from both operational and technical perspectives. Additionally, introducing an incentive program would help achieve more effective maritime decarbonization, as this would engage stakeholders more actively in decarbonization efforts. As it was found that several factors such as waiting time, short-haul voyages, and trading patterns in connection with adverse weather and port congestion significantly affect CII results, the research suggests that the IMO should consider these factors during the review process. These factors are beyond the control of both shipowners and charterers, and consideration of these factors would contribute to making the CII regulation fairer.

For shipowners, exploring both operational and technical measures to improve ships' fuel efficiency is recommended. For operational measures, this thesis provides examples including slow steaming, using a weather routing service that guides optimal voyage routes using real-time weather data (Stormglass, n.d.), hull cleaning, and propeller polishing. For technical measures, the installation of ESDs and new antifouling coatings during drydocking can also improve CII rating as this increases fuel efficiency.

Future studies should aim to conduct research with more detailed and comprehensive data to validate findings. A larger number of ship’s operational dataset, noon report as examples, accumulated over several years, and additional data indicating vessel efficiency, such as condition of hull & propeller fouling, and weather conditions per voyage leg, will help to achieve more accurate analyses and better reasoning outcomes. Additionally, emerging technologies and alternative fuels can help improve fuel efficiency and reduce the equivalent CO2. For example, a study exploring the impact of ESDs or wind assistance propulsion systems in fuel consumption or dual fuel in CO2 emissions would prove valuable to showcase shipowners effective decarbonization measures.

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Appendix A. Data collected for qualitative analysis (interviews)

Interview date and meeting with Companies and RBSA

#	Date	Company	Job Title	Location
1	March 15	RBSA	Head Of Environmental and Technical Affairs	RBSA office
2	March 15	Company 3	Jr. Fleet Energy & Performance Engineer	Online
3	March 15	Company 2	Technical Operations Manager	Online
4	March 21	Company 2	Technical Operations Manager	Company office
5	April 25	Company 4	Fleet Manager	Online
6	April 25	RBSA	Head Of Environmental and Technical Affairs	Online
7	April 26	A Ship Management company	Head of Performance	Online
8	April 26	A Shipping Company based in Asia	Vessel Operator (Product + Crude Taker)	Online
9	April 26	A Shipping Company based in Asia	Vessel Operator (LNG Carrier + LNG Bunkering Vessel)	Online
10	April 26	A Shipping Company based in Asia	Vessel Operator (Bulk Carrier)	Online
11	May 13	A Shipping Company based in Europe	1st Officer	Online
12	May 15	RBSA	Head Of Environmental and Technical Affairs	RBSA office
13	May 16	Company 4	Fleet manager	Company office
14	May 16	Company 3	Head of Fleet Performance Management	Online
15	May 17	Company 1	Fleet manager Container Project Manager	Online
16	May 21	Company 2	Technical Operations Manager	Online
17	May 28	RBSA	Head Of Environmental and Technical Affairs	Online

1) Content of interviews is outlined in section 6.1. Interviews - qualitative analysis

Appendix B. Data collected for qualitative analysis (online survey)

Online Survey Questionnaires

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Please rank the problems related to the current CII Regulation from 1 to 9 by dragging the problems up or down. "1" for the problem you consider most important and "9" for the problem you consider least important.

1. CII clause restricts charterer's right under Time charter
2. Inconsistency of CII formula and correction factors
3. No incentive for reducing ballast voyage and cargo utilisation ration is not reflected, but only Deadweight Tonnage (DWT)
4. Drydock negatively impact CII
5. Port delays and idle periods negatively impact CII
6. Adverse weather conditions negatively impact CII
7. Neglecting of substantial ship difference
8. Perverse Incentive
9. No enforcement mechanism

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Could you elaborate on the problem that you consider the MOST important?

← →

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Could you elaborate on the problem that you consider the LEAST important?

← →

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If you have any comments or additions related to this subject, please write it down here. If not, thanks for your participation to our survey.

← →

Appendix C. Data collected for quantitative analysis

List of data received from companies

#	Name	Size	CII Rating	Attained CII	Distance (NM)	No. of Port Call	Sailing Days	Total Waiting Days
1	Container 1	Mid-size (Ice-class)	B	7.8	76,532	87	223	141
2	Container 2	Mid-size (Ice-class)	D	12.7	95,669	69	251	114
3	Container 3	Mid-size (Ice-class)	Incomplete Data					
4	Container 4	Mid-size (Ice-class)	B	12.0	51,026	118	154	211
5	Container 5	Mid-size (Ice-class)	A	10.5	53,791	125	162	203
6	Container 6	Mid-size (Ice-class)	B	11.3	52,720	126	158	206
7	Container 7	Mid-size (Ice-class)	C	13.7	57,053	123	156	208
8	Container 8	Mid-size (Ice-class)	A	7.3	81,182	84	216	149
9	Container 9	Mid-size (Ice-class)	A	7.7	78,448	82	214	151
10	Container 10	Mid-size (Ice-class)	A	7.3	76,933	86	223	142
11	Container 11	Mid-size (Ice-class)	C	11.7	99,995	70	257	107
12	Container 12	Mid-size (Ice-class)	Incomplete Data					
13	Bulk Carrier 1	Cape Size	D	2.8	71,605	13	253	113
14	Bulk Carrier 2	Cape Size	B	2.3	66,859	25	261	105
15	Bulk Carrier 3	Cape Size	C	2.5	67,099	18	247	118
16	Bulk Carrier 4	VLOC	A	1.7	30,695	9	201	164
17	Bulk Carrier 5	Cape Size	C	2.5	62,156	14	246	119
18	Bulk Carrier 6	VLOC	B	2.0	66,595	22	269	97
19	Bulk Carrier 7	VLOC	B	2.1	62,799	20	227	138
20	Bulk Carrier 8	Cape Size	C	2.3	65,928	17	243	122
21	Bulk Carrier 9	Cape Size	C	2.4	60,343	22	224	141
22	Bulk Carrier 10	Cape Size	B	2.2	69,703	12	236	129
23	Bulk Carrier 11	Cape Size	B	2.1	63,695	26	243	122
24	Bulk Carrier 12	VLOC	B	2.0	71,298	17	282	83

25	Bulk Carrier 13	VLOC	A	1.7	29,956	9	265	101
26	Bulk Carrier 14	Cape Size	C	2.4	68,710	32	260	105
27	Bulk Carrier 15	Cape Size	C	2.5	63,238	11	261	104
28	Bulk Carrier 16	Cape Size	C	2.4	57,636	11	197	168
29	Bulk Carrier 17	VLOC	A	1.8	64,403	16	269	96
30	Bulk Carrier 18	Cape Size	C	2.302	68,076	14	253	112
31	Bulk Carrier 19	Ultramax	A	3.43	58,486	21	233	132
32	Bulk Carrier 20	Ultramax	A	3.91	57,777	13	209	156
33	Bulk Carrier 21	Ultramax	C	4.5	59,999	21	210	155
34	Bulk Carrier 22	Ultramax	A	3.93	53,699	19	192	173
35	Chemical Tanker 1	N/A	B	8.6	42,851	N/A	183	182
36	Chemical Tanker 2	N/A	A	8.2	46,781	N/A	174	190
37	Chemical Tanker 3	N/A	Incomplete Data					
38	Chemical Tanker 4	N/A	B	10.2	51,748	45	145	220
39	Chemical Tanker 5	N/A	A	8.8	55,327	64	180	185
40	Chemical Tanker 6	N/A	B	8.4	54,595	N/A	171	194
41	Chemical Tanker 7	N/A	A	7.1	40,217	N/A	211	154
42	Chemical Tanker 8	N/A	Incomplete Data					
43	Chemical Tanker 9	N/A	C	12	15,406	N/A	108	257
44	Crude Tanker 1	VLCC	B	1.96	72,608	18	271	95
45	Crude Tanker 2	VLCC	B	2.03	73,457	25	245	120
46	Crude Tanker 3	VLCC	C	2.12	73,134	25	251	114
47	Crude Tanker 4	VLCC	B	2.01	81,116	31	282	83
48	Crude Tanker 5	VLCC	B	2.06	80,833	21	238	100
49	Crude Tanker 6	VLCC	B	1.87	85,137	17	284	81
50	Crude Tanker 7	VLCC	A	1.57	75,833	16	274	92
51	Crude Tanker 8	Suezmax	C	3.65	52,549	20	206	160
52	Crude Tanker 9	Suezmax	B	2.98	58,058	27	229	136

53	Crude Tanker 10	Suezmax	A	2.64	71,586	23	259	105
54	Crude Tanker 11	Suezmax	B	2.98	64,051	30	220	145
55	Crude Tanker 12	Suezmax	B	2.88	54,435	23	208	158
56	LPG1	VLGC	B		104,656	17	282	83
57	LPG2	VLGC	B		105,681	15	278	87
58	LPG3	MSGC	A	8.74	76,363	22	237	128
59	LPG4	MSGC	C	10.47	66,988	31	192	173
60	LPG5	MSGC	B	9.51	76,836	35	215	150
61	LPG6	MSGC	B	9.58	97,187	36	257	108
62	LPG7	MSGC	C		51,330	46	148	217
63	LPG8	MSGC	B	9.93	85,134	31	226	139
64	LPG9	MSGC	B	9.42	73,539	21	225	140
65	LPG10	MSGC	C	10.77	47,269	55	129	236
66	LPG11	MSGC	C	11.48	54,043	32	165	200
67	LPG12	MSGC	B	10.13	74,761	23	217	148
68	LPG13	MSGC	D	13.76	38,421	28	123	242
69	LPG14	MSGC	C	11.49	62,929	29	174	191

1) Columns with red highlights indicate incomplete data due to various reasons, such as secondhand vessels or newbuildings delivered during the course of 2023 or other reasons.
2) Not all CII rating and attained CII do not represent the final verified data, as not all data have been fully verified by classification societies due to the deadline at the end of May. Majority of data is still under verification process.

Appendix D. BIMCO's CII clause

1. CII OPERATIONS CLAUSE FOR TIME CHARTER PARTIES 2022[2]

Notwithstanding any other provision in this Charter Party, the Owners and the Charterers (the "Parties") agree as follows:

"Agreed CII" means the values in gCO2/(dwt.nmile)* set out in subclause (d).

"CII" means Carbon Intensity Indicator, as provided for in the MARPOL Carbon Intensity Regulations.

"CII Rating" means the Vessel's attained operational carbon intensity rating, expressed as a rating from A-E, in a calendar year, as calculated in accordance with the MARPOL Carbon Intensity Regulations.

"C/P Attained CII" means the CII value in gCO2/(dwt.nmile)* attained by the Vessel, applying any regulatory correction factors and voyage adjustments applicable to the Vessel and excluding fuel consumed and distance traveled during off-hire periods in excess of [___] accumulated days (*if left blank, zero (0) days shall apply*), measured in the relevant calendar year from the start of the calendar year to date or, if the Charter Party begins during a calendar year, from date of the Vessel's delivery under the Charter Party to date.

"Delivery Attained CII" means the CII value in gCO2/(dwt.nmile)* attained by the Vessel for the calendar year to date as calculated at the time of delivery into the Charter Party.

"Effective Date" means 1 January 2023.

"MARPOL Carbon Intensity Regulations" means the regulations contained in Chapters 1, 2 and 4 of Revised MARPOL Annex VI which relate to "Regulations on the Carbon Intensity of International Shipping" and Resolution MEPC.328(76) implementing the CII and any associated guidelines and/or subsequent amendments, including the Ship Energy Efficiency Management Plan (SEEMP).

"Projected Attained CII" means the C/P Attained CII extrapolated over the remainder of the relevant calendar year (or the charter period should redelivery be sooner than the end of the calendar year) and used to demonstrate the trajectory of the Vessel's C/P Attained CII.

"Required CII" means, for each relevant calendar year of the charter period, the middle point of CII Rating level C equivalent to the required annual operational CII set out in Regulation 28.6 of the MARPOL Carbon Intensity Regulations or as otherwise specified in the Guidelines for the MARPOL Carbon Intensity Regulations.

**use gross tons (gt) instead of dwt, where applicable to the Vessel type.*

(a) The Parties acknowledge and accept that as from the Effective Date the Vessel is required to comply with the MARPOL Carbon Intensity Regulations and that this Clause shall govern the relationship between the Parties and their obligations relating to those regulations.

(b) During the Charter Party, the Parties shall cooperate and work together in good faith to:

[2] BIMCO published CII OPERATIONS CLAUSE FOR TIME CHARTER PARTIES 2022 on here: https://www.bimco.org/contracts-and-clauses/bimco-clauses/current/cii-operations-clause-2022

(i) share any findings and best practices that they may identify on potential improvements to the Vessel's energy efficiency; and

(ii) collect, share and report on a daily basis any relevant data that may assist the monitoring and assessment of the Vessel's compliance with the MARPOL Carbon Intensity Regulations and for planning prospective voyages.

(c)(i) As from the Effective Date or date of the commencement of the Charter Party, whichever is the later, the Charterers shall:

(1) operate and employ the Vessel (including the planning of voyages and supply and selection of fuel) in a manner which is consistent with the MARPOL Carbon Intensity Regulations and subclause (c)(i)(2), which may require alternative or adjusted voyage or employment orders, instructions or sailing directions to be issued to and performed by the Vessel from time to time during the charter period; and

(2) not permit the C/P Attained CII to exceed the Agreed CII by the end of each relevant calendar year or, if the charter period or period remaining under this Charter Party is less than a full calendar year, by the time of redelivery, but always subject to the provisions of subclause (g).

(ii) Any existing warranties as to despatch, speed and consumption or to maintain the Vessel's description provided for elsewhere in the Charter Party shall continue to apply to the Charter Party. In the event of any breach of such warranties, the Charterers shall be entitled to pursue a separate claim against the Owners, save that any such breach shall not be relied upon by the Charterers as a basis to avoid meeting their obligations under this Clause, including where subclause (g) has been validly invoked.

(d)(i) The Agreed CII by calendar year shall be as follows:

Year	Agreed CII values*	Corresponding to a predicted CII Rating
2023		
2024		
2025		
2026		

** BIMCO recommends that Parties agree that the Agreed CII values should be the Required CII or better, consistent with the MARPOL Carbon Intensity Regulations.*

(ii) Where the Parties fail to agree in writing the Agreed CII for the relevant calendar year(s) of the charter period or otherwise fail to populate the above table with such values for the relevant calendar year(s), then the Parties expressly agree and acknowledge that the default Agreed CII for the Vessel shall, subject to subclause (d)(iii), be the Required CII.

(iii) If the Charter Party extends beyond 31 December 2026 the Parties shall review and incorporate the Agreed CII in accordance with any new annual carbon intensity targets under the MARPOL

Carbon Intensity Regulations as set by the IMO for the remaining calendar years under the Charter Party.

(iv) Upon delivery, the Owners shall provide the Charterers with the Delivery Attained CII together with details of the types and quantities of fuels consumed and distance traveled to date for the current calendar year. The data provided to the Charterers pursuant to this sub clause shall, to the best of the Owners' knowledge, be accurate and complete.

(e) (i) The Charterers may at their discretion provide, in writing to the Master, orders or instructions to adjust the Vessel's speed or RPM (main engine Revolutions Per Minute) to meet a specified time of arrival, or closest thereto, at a particular destination or to proceed at a specified main engine fuel consumption, which shall constitute the Charterers' orders with which the Master shall comply, but subject always to:

(1) the Charterers complying with their obligations under this Clause; and

(2) the Master's obligations in respect of the safety of the Vessel, crew and cargo and the protection of the marine environment.

(ii) The Charterers shall not be entitled to request an adjustment of speed or consumption or RPM outside the existing safe operational limits of the Vessel or which shall result in the Vessel's engine(s) and/or equipment operating outside the manufacturers'/designers' recommendations as published from time to time.

(f) From the Effective Date, the Owners shall:

(i) exercise due diligence to ensure that the Vessel is operated in a manner which minimizes fuel consumption, including but not limited to:

(1) maintaining the Vessel, its engines and hull and any of its equipment relevant to the Vessel's energy efficiency, in accordance with the Charter Party and the MARPOL Carbon Intensity Regulations/SEEMP, subject to any express provisions elsewhere in the Charter Party that place maintenance obligations on the Charterers and reporting any associated deficiencies to the Charterers;

(2) when passage planning, adjusting the Vessel's trim and operating the Vessel's main engine(s) and auxiliary engine(s);

(3) making optimal use of the Vessel's navigation equipment and any additional aids provided by the Charterers, such as weather routing, voyage optimisation and performance monitoring systems; and

(4) unless otherwise instructed by the Charterers, proceeding by the most fuel-efficient route, but the Master may deviate from the route if he has reasonable grounds to believe that such a route shall compromise the safe navigation of the Vessel or the safety of the Vessel, crew or operation of equipment.

(ii) monitor and calculate the actual consumption of the Vessel on a daily basis and provide the Charterers with details of the types and quantities of fuels consumed and distance traveled as required by the Charterers and any other relevant data the Charterers may reasonably request for the purpose of this Clause. This data shall be used to calculate the C/P Attained CII value which shall be compared against the Agreed CII for the relevant calendar year or charter period and shared with the Charterers. The Owners undertake that the data provided to the Charterers pursuant to this subclause shall, to the best of their knowledge, be accurate and complete; and

(iii) comply with the SEEMP, provided that the Charterers adhere to their obligations under this Clause.

(g) If, at any time, based on the data shared in accordance with this Clause, the trajectory of the C/P Attained CII is deviating from the Agreed CII, the Owners shall give the Charterers advance warning of this. If, despite such warning, the C/P Attained CII continues to deviate from the Agreed CII and this indicates that there is a reasonable likelihood that the Charterers may fail to meet their obligations under subclause (c), then:

(i) The Owners shall request in writing and the Charterers shall provide to the Owners within two (2) working days of Owners' written request, a written plan detailing any proposed commercial operation of the Vessel for at least the next voyage.

(ii) If, upon assessment of a Charterers' written plan, the Owners can reasonably show that following this written plan will result in the Charterers failing to meet their obligations under subclause (c) and that, on the basis of the Projected Attained CII, the Agreed CII for the relevant calendar year (or for the charter period should redelivery be sooner than the end of the calendar year) would be exceeded, then the Owners shall communicate this in writing to the Charterers within two (2) working days of receipt of the Charterers' written plan. The Parties shall cooperate and work together in good faith to agree within two (2) working days thereafter an adjusted written plan for the next voyage or voyages which brings the C/P Attained CII in line with the Agreed CII. Any such adjusted written plan agreed between the Parties shall be deemed to constitute the Charterers' orders as if they had been given by the Charterers at the outset.

(iii) Until such time that the Parties agree an adjusted written plan (or where a written plan is not received from the Charterers as per subclause (g)(i)), the Owners shall, where they have validly exercised their rights under this subclause (g), be entitled:

(1) not to follow a Charterers' order and/or a written plan and/or an adjusted written plan (which has not been agreed), without being in breach of any of the Owners' obligations under the Charter Party and with the Vessel remaining on hire throughout and instead

(2) to reduce the Vessel's speed or, where a speed reduction is anticipated by the Owners to be insufficient, to require the Charterers to provide all requisite instructions, orders and sailing directions to the Vessel which bring the C/P Attained CII in line with the Agreed CII for the relevant calendar year (or the charter period should redelivery be sooner than the end of the calendar year).

(h) Compliance with any Charterers' orders, a Charterers' written plan or an adjusted written plan validly issued and agreed in accordance with subclause (g) shall not:

(i) be deemed a breach by the Owners of any of the Owners' obligations under this Charter Party, but shall be considered due fulfillment of this Charter Party; and/or

(ii) in any way lessen the Charterers' responsibility to comply with their obligations under this Clause.

(i) *The Charterers shall ensure that the terms of the bills of lading, waybills or other documents evidencing contracts of carriage issued by or on behalf of the Owners provide that compliance by the Owners with this Clause does not constitute a breach of the contract of carriage. The Charterers shall indemnify the Owners against all consequences and liabilities that may arise from bills of lading, waybills or other documents evidencing contracts of carriage being issued as presented to the extent that the terms of such bills of lading, waybills or other documents evidencing contracts of carriage impose or result in breach of the Owners' obligation to proceed with due despatch or are to be held to be a deviation or the imposition of more onerous liabilities upon the Owners than those assumed by the Owners pursuant to this Clause.

(j) The Owners shall be entitled to claim from the Charterers any losses, damages, liabilities, claims, fines, costs, expenses, actions, proceedings, suits or demands suffered by the Vessel and/or the Owners which have been caused by any breach by the Charterers of their obligations under this Clause.

* Subclause (i) not applicable in the liner trade.

2. CII CLAUSE FOR VOYAGE CHARTER PARTIES 2023[3]

Notwithstanding any other provision in the Charter Party, the Owners and the Charterers agree as follows:

(a) With a view to reducing the carbon intensity of the Vessel, the Owners/the Master are/is entitled to adjust course and/or to reduce speed or RPM (main engine Revolutions Per Minute) provided that the Vessel's speed, basis good weather conditions (which shall mean [**parties to insert definition here**]), shall not fall below [**X**] knots during any voyage(s) performed under the Charter Party.

(b) Where the Vessel proceeds in accordance with subclause (a), this shall constitute compliance with, and there shall be no breach of, any obligation requiring the Vessel to proceed by the usual/customary route and/or with utmost and/or due despatch (or any other such similar/equivalent expressions) [or any speed and consumption warranties under the Charter Party]. The Laycan as agreed under the Charter Party shall remain unaffected by this Clause.

(c) The Charterers shall ensure that the terms of the bills of lading, waybills or other documents evidencing contracts of carriage issued by or on behalf of the Owners provide that the exercise by Owners of their rights under this Clause does not constitute a breach of the contract of carriage. The Charterers shall indemnify the Owners against all consequences and liabilities that may arise from bills of lading, waybills or other documents evidencing contracts of carriage being issued as presented to the extent that the terms of such bills of lading, waybills or other documents evidencing contracts of carriage impose or result in the imposition of more onerous liabilities upon the Owners than those assumed by the Owners pursuant to this Clause.

(d) This Clause shall be without prejudice to any other express or implied rights under this Charter Party entitling the Vessel to proceed at speeds below the minimum speed stated in subclause (a).

(e) Within [**X**]* days after completion of final discharge of the cargo carried under the Charter Party, the Owners shall make available to the Charterers: (i) details of the types and quantities of fuels consumed under the Charter Party; and (ii) distance traveled with respect to both the ballast and laden voyages.

**If number of days is not inserted in this subclause (e), the default shall be 7 (seven) days*

[3] BIMCO published CII CLAUSE FOR VOYAGE CHARTER PARTIES 2023 on here: https://www.bimco.org/contracts-and-clauses/bimco-clauses/current/cii-clause-for-voyage-charter-parties-2023

Appendix E. ClassNK CII Calculator[4]

Post-drydock efficiency calculation for LPG Tanker through ClassNK CII Calculator

1) *The calculator is the latest version that includes the most recent CII calculation methodology and metrics.*
2) *This calculator provides an approximate calculation of the attained CII and CII rating, but it does not consider correction factors. Classification societies offer their services to SOs to add the correction factors and a verified calculation to submit to IMO.*
3) *Variables introduced in the tool for CII calculation: Nm, Ship type, DWT & Fuel consumption (HFO, MGO)*
4) *Results obtained: Attained CII, CO2 Emissions, Reference CII, Required CII, CII Rating.*
5) *Screenshots for vessel LPG4 calculations.*

CII Calculation
*Please input blue cells

ClassNK
Version 0.5 June 2022

Ship Particular	IMO Number	1111111
	Ship Name	LPG 4
	Ship Type	Gas carrier
	Deadweight	29590
	Gross Tonnage	
Fuel Consumption (ton)	Diesel/Gas Oil	250
	LFO	
	HFO	2474
	LPG(Propane)	
	LPG(Butane)	
	LNG	
	Methanol	
	Ethanol	
Distance Travelled (nm)		26470
CO2 Emission		8506
Attained CII		10.86
CII ref		11.26
Rating Year		2023
Required CII		10.70
Attained CII / Required CII		1.015
CII Rating		C

CII Calculation
*Please input blue cells

ClassNK
Version 0.5 June 2022

Ship Particular	IMO Number	1111111
	Ship Name	LPG 4
	Ship Type	Gas carrier
	Deadweight	29590
	Gross Tonnage	
Fuel Consumption (ton)	Diesel/Gas Oil	349
	LFO	
	HFO	2373
	LPG(Propane)	
	LPG(Butane)	
	LNG	
	Methanol	
	Ethanol	
Distance Travelled (nm)		26488
CO2 Emission		8508
Attained CII		10.86
CII ref		11.26
Rating Year		2023
Required CII		10.70
Attained CII / Required CII		1.015
CII Rating		C

[4] ClassNK released the CII calculator in public and the calculator in Excel calculator can be downloaded from the following link: https://www.classnk.or.jp/hp/pdf/activities/statutory/seemp/ClassNK_CII_Calculation_Ver05.xlsx

Annex 1. Declaration on word of honor

Declaration on word of honor

I hereby declare that I know what plagiarism entails, namely to use another's work and to present it as my own without attributing the sources in the correct way.

I acknowledge that copying someone else's assignment or essay, or part of it, is wrong and declare that this is my own work.

I have used the American Psychological Association (APA) as the convention for citation and referencing. Each significant contribution to and quotation in, this essay/report/project/… from the work, or works of other people has been attributed and has cited and referenced.

This Master's thesis is my own original work and has not yet been handed in at any other university, nor had it been published.

I am aware of the consequences of fraud as stated in the exam regulation of the University of Antwerp.

Date : 03 June 2024

Names : Algie Donado, An-Sofie Dieltiens, Daniel Ortega Villalobos, SeungMyeong Yang

Signatures:

Annex 2. Confirmation of compliance with the GDPR (General Data Protection Regulation)

I hereby confirm, the undersigned Algie Donado, An-Sofie Dieltiens, Daniel Ortega Villalobos, and SeungMyeong Yang

that I have followed the guidelines regarding the GDPR in my research and that I have also informed my respondents about this.

I pointed out to the respondents the method of processing the collected data and the possible risks associated with the research. I have explicitly asked about their agreement to the method of processing the data. I also confirm that the respondents have given their consent to participate in the study and have agreed with the method of processing the data

Date : 03 June 2024

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