Chartering the Future: How FuelEU Maritime Shapes Strategic Decisions for Swedish Tanker Shipowners

An in-depth study focusing on pooling, alternative fuels, financial implications and investment in new tonnage

Bachelor thesis for International Logistics Program

SEBASTIAN CLAESON
FILIP MODIGH

DEPARTMENT OF MECHANICS AND MARITIME SCIENCES

CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2025

Chartering the Future: How FuelEU Maritime Shapes Strategic Decisions for Swedish Tanker Shipowners

An in-depth study focusing on pooling, alternative fuels, financial implications and investment in new tonnage

Bachelor thesis for International Logistics Program

SEBASTIAN CLAESON
FILIP MODIGH

Department of Mechanics and Maritime Sciences
Division for Maritime Studies
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2025

Chartering the Future: How FuelEU Maritime Shapes Strategic Decisions for Swedish Tanker Shipowners

An in-depth study focusing on pooling, alternative fuels, financial implications and investment in new tonnage

SEBASTIAN CLAESON
FILIP MODIGH

Department of Mechanics and Maritime Sciences
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

Cover:
The picture is AI-generated with the help of ChatGPT and depicts a tanker ship by the key side.

Department of Mechanics and Maritime Sciences
Chalmers University of Technology
Göteborg, Sweden 2025

PREFACE

This study is a bachelor thesis at Chalmers University of Technology under the department of Mechanics and Maritime Sciences. This thesis is a part of the program International Logistics which consists of 180 hp and this study consists of 15 hp. The idea of writing about FuelEU Maritime came from Olle Engström. We soon became very invested in the topic and found that it had grounds for becoming an interesting bachelor thesis. So, we would like to direct our appreciation to Olle Engström for putting us on this path and a special thanks to our supervisor Martin Larsson for all the help along the way. Finally, we would also like to thank every individual and company that took part in the interview process, without you this would not be possible!

Chartering the Future: How FuelEU Maritime Shapes Strategic Decisions for Swedish Tanker Shipowners
An in-depth study focusing on pooling, alternative fuels, financial implications and investment in new tonnage

SENASTIAN CLAESON
FILIP MODIGH

Department of Mechanics and Maritime Sciences
Chalmers University of Technology

SAMMANDRAG (in Swedish)

Europeiska unionen har för att uppnå de europeiska hållbarhetsmålen infört det som kallas FuelEU Maritime, som ingår i det större regelverkspaketet ”Fit for 55”. Målet med FuelEU Maritime är att driva på redare att övergå till bränslen med lägre växthusgasintensitet genom att begränsa mängden växthusgaser som får släppas ut per MJ från ett ton bränsle och att den maximala mängden växthusgaser som får släppas ut minskas var femte år. Denna studie undersöker vilka strategier den svenska tankersektorn kommer att använda för att uppnå efterlevnad av EU:s regleringsåtaganden. Detta görs genom att intervjua rederier i Göteborgsområdet samt andra intressenter.

Tre huvudsakliga strategier har identifierats: Pooling av fartyg för att fortsätta driva äldre, mer ineffektiva fartyg med hjälp av nyare fartyg. Nyttjandet av dual-fuel motorer i nytt tonnage för att skapa en mer flexibel flotta som kan utnyttja upp- och nedgångar i marknadspriser mellan gröna bränslen och fossila bränslen. Framtidens bränslen är en avgörande komponent för att kunna uppfylla de allt strängare miljökraven inom sjöfarten. Utan en övergång till mer hållbara bränslealternativ blir det svårt för rederier att möta kommande regelverk och driva en långsiktigt hållbar verksamhet. Redarna hoppas att de nyupprättade kostnaderna för FuelEU Maritime så småningom kommer att betalas av deras kunder. Eftersom regleringen träder i kraft år 2025 är det fortfarande osäkert vad resultatet av regleringen kommer att bli i slutändan. Trots begränsningarna att endast svenska företag deltog i intervjuprocessen och att det ännu är tidigt i implementeringsfasen, utgör denna studie ett viktigt första steg i att undersöka hur FuelEU Maritime kommer att påverka och hanteras av rederier.

Nyckelord: FuelEU Maritime, växthusgaser, efterlevnad, redare, tanker-segment

Chartering the Future: How FuelEU Maritime Shapes Strategic Decisions for Swedish Tanker Shipowners
An in-depth study focusing on pooling, alternative fuels, financial implications and investment in new tonnage

SEBASTIAN CLAESON
FILIP MODIGH

Department of Mechanics and Maritime Sciences
Chalmers University of Technology

ABSTRACT

The European Union has in order to achieve the European sustainability goals put in place what is known as FuelEU Maritime, which falls under the larger regulatory package "Fit for 55". The goal of FuelEU Maritime is to push shipowners to transition to less greenhouse gas intense fuels by restricting the amount of GHG allowed to be released per MJ from one ton of fuel. With the maximum GHG allowed to be emitted decreasing every five years. This study explores what kind of strategies the Swedish tanker segment will employee to reach compliance with EU's regulatory obligations. This is done by interviewing shipowners located in the Gothenburg area and other stakeholders.

Three main strategies have been identified. Pooling of vessels to continue to operate older more inefficient vessels with the help of newer vessels. The incorporation of dual-fuel engines in new tonnage to create a more flexible fleet that can utilise the ups and down of market prices between green fuels and fossil fuels. Future fuels are a crucial component in meeting the increasingly stringent environmental regulations in the maritime sector. Without a transition to more sustainable fuel alternatives, it will be difficult for shipowners to comply with upcoming legislation and operate in a long-term sustainable manner. The shipowners hope that the newly incurred cost of FuelEU Maritime will eventually fall upon their customers. As the regulation was put into practice in 2025, the outcomes remain uncertain. Despite the limitations of having only Swedish companies participate in the interview process and the early stage of implementation, this study represents an important first step in examining how FuelEU Maritime will affect and be managed by shipowners.

Keywords: FuelEU Maritime, greenhouse gases, compliance, shipowner, tanker segment

TABLE OF CONTENTS

1. Introduction 1

1.1 Background 1

1.2 Aim of the study 2

1.3 Research questions 2

- How will the implementation of FuelEU Maritime impact the strategies for Swedish shipowners within the tanker segment? 2

- Will pooling be used as a strategy in order to comply with FuelEU Maritime, and what are the potential advantages and disadvantages of such an approach? 2

- What fuel will be the future dominant choice? 2

-What investments will be made in new tonnage and associated technologies in light of FuelEU Maritime requirements? 2

- What are the expected financial implications of FuelEU Maritime for Swedish shipowners within the tanker segment? 2

1.4 Delimitations 2

2. Theory 3

2.1 FuelEU MARITIME- Background 3

2.2 FuelEU MARITIME- Obligations 3

2.3 FuelEU MARITIME- Ships covered and Scope 4

2.4 On-shore power - Exceptions 4

2.5 FuelEU MARITIME - Well-to-wake perspective 5

2.6 The transition towards compliance with FuelEU Maritime 5

2.7 Alternative fuels 7

2.7.1 Biofuels 7

2.7.2 LNG & LBG 7

2.7.3 Hydrogen 7

2.7.4 Ammonia 8

2.7.5 Methanol 8

2.8 Green technologies and increase of efficiency 8

2.9 Pooling and how it works 9

3. Methods 11

3.1 Interviews and sampling 11

3.1.1 Structure of the interviews 12

3.1.2 Transcription of interviews 13

3.2 Literature 13

3.3 Artificial intelligence (AI) 13

4. Results 14

4.1 Pooling as a strategy 14

4.2 Fuel of the future 15
4.3 Investments in new tonnage and associated technologies 15
4.4 Expected financial implications of FuelEU Maritime 16
5. Discussion 17
5.1 The Significance of the Study's Results 17
5.2 Pooling as a Strategy 17
5.3 Fuel of the future 19
5.4 Investments in new tonnage and associated technologies 21
5.5 Expected financial implications of FuelEU Maritime 21
5.6 Method discussion 22
6. Conclusion 24
7. Recommendations for further research 25
References 26
Appendix 1 1

LIST OF FIGURES

Figure 1 Function of pooling …………………………..……………………………………….9

LIST OF TABLES

Table 1 Calculation for possible penalties (Regulation EU 2023/1805) ……………………...6
Table 2 Interviewee composition by sector and sampling technique ………………………..11
Table 3 Participant Profiles: Position, Experience, and Interview Length …………………..12

ACRONYMS AND TERMINOLOGY

AI	Artificial Intelligence
AIS	Automatic Identification System
DNV	Det Norske Veritas
DWT	Deadweight Tonnage
ECIDS	Electronic Chart and Display Information System
EEA	European Economic Area
EU ETS	European Union Emission Trading System
GHG	Greenhouse Gases
GHGIE	Greenhouse Gas Intensity of Energy
HFO	Heavy Fuel Oil
HVO	Hydrotreated Vegetable Oil
IMO	International Maritime Organization
LBG	Liquefied Biogas
LNG	Liquefied Natural Gas
MJ	Megajoule
NO_X	Nitrogen Oxides
N_2O	Nitrous Oxide
OPS	On-shore Power Supply
PM	Particulate Matter
SO_x	Sulfur Oxides
TC	Time Charter
TtW	Tank-to-Wake
WtT	Well-to- Tank
WtW	Well-to-Wake
WAPS	Wind-Assisted Propulsion Systems

1. INTRODUCTION

Global warming has become a worldwide known topic during the last decade. Global warming is a term that describes the rise of the world's global temperature (Drake. F., 2000). The decade of 2011-2020 was the warmest documented, with an increase of 0,2°C per decade driven by human activities (European Commission, n.d.). In 2015 at the UN Climate Change Conference (COP21) held in Paris, where 196 countries signed The Paris agreement. An agreement that became active on 4th November 2016. The agreement aims to ensure that the global temperature increase remains well below 2°C (United Nations Framework Convention on Climate Change, n.d.). The most discussed greenhouse gas (GHG) emission is carbon dioxide (CO_2) due to it being the GHG emission that has contributed the most to global warming (Union of Concerned Scientists, n.d.).

The human activities that drive global warming include elements of energy production, transportation, deforestation and industrial processes (Bajoria et al., 2024). These elements contribute to global warming due to their processes release GHG or diminishing natural absorbents of GHG. The transportation sector is driven by the trade of goods, where shipping stands for 90% of international world trade. Although shipping demonstrates strong energy efficiency compared to other modes of transport, it still accounts for approximately 2.2% of global CO_2emissions (International Maritime Organization, 2015). If effective mitigation measures are not implemented, overall CO_2 emissions from shipping are projected to rise by 50–250% by 2050 (Smith et al., 2014).

In order to reduce the greenhouse gas emissions from the industries that are the contributing factors to global warming, different regulations were created for different industries by the European Union. In July 2021, the FuelEU Maritime regulation was proposed by the European Union, but was fully implemented 1st of January 2025 (Directive of the European Parliament & Council 2009/16/EC). FuelEU Maritime was established as the primary regulatory framework for the shipping sector, aiming to mitigate the environmental impact of maritime activities and reduce their contribution to global warming (European Commission, n.d.)

1.1 Background

The shipping industry is undergoing significant regulatory changes as part of the European Union´s effort to reduce GHG emissions. One of the most impactful regulations in this regard is FuelEU Maritime, whose purpose is to encourage the use of cleaner fuels and alternative energy sources within the maritime sector and is a part of EU’s fit for 55 package. The regulation sets distinct regulations of the carbon intensity of the fuels used on the vessels, with a stricter regulation level of carbon intensity implemented every 5 years until 2050 (Directive of the European Parliament & Council 2009/16/EC).

For Swedish shipowners in the tanker segment, the implementation of FuelEU Maritime presents both opportunities as well as challenges. In order for Swedish shipowners within the tanker segment to comply with the regulations of FuelEU Maritime, it will require adjustments of operational strategies regarding alternative fuels and future investments. The main difficulty within the implementation of FuelEU Maritime is to navigate the financial and technical complexities of meeting new emission standards while ensuring profitability and maintaining competitive positioning on the market.

1.2 Aim of the study

The aim of this study is to analyse how the implementation of FuelEU Maritime will influence the strategic decisions of Swedish shipowners within the tanker segment. The four key focuses in the study are the financial implications of the regulation, whether pooling will be used as a strategic approach, which fuel types are likely to dominate in the future and shipowners' strategies regarding new tonnage and associated technologies. By examining these factors, the study aims to provide insights into how Swedish shipowner within the tanker segment will navigate the shift toward stricter emissions regulations and still be competitive on the tanker market without compromising their financial stability.

1.3 Research questions

- How will the implementation of FuelEU Maritime impact the strategies for Swedish shipowners within the tanker segment?
    - Will pooling be used as a strategy in order to comply with FuelEU Maritime, and what are the potential advantages and disadvantages of such an approach?
    - What fuel will be the future dominant choice?
    - What investments will be made in new tonnage and associated technologies in light of FuelEU Maritime requirements?

- What are the expected financial implications of FuelEU Maritime for Swedish shipowners within the tanker segment?

1.4 Delimitations

This report focuses only on the tanker segment of the Swedish shipping industry and includes solely shipowners and stakeholders located in Gothenburg. The decision to narrow the scope both geographically and sector-wise was made to ensure a more focused and in-depth analysis. By narrowing the scope of the study in this way, the study aims to stay focused and avoid covering too broad a range of topics.

2. THEORY

The shipping industry has undergone significant transformation, moving from a traditional facilitator of global trade to a sector facing increasing regulatory and environmental demands. As operational complexity and environmental impact grow, regulatory frameworks have expanded accordingly. International and regional institutions, including the IMO and the European Union, play a central role in this development.

2.1 FuelEU MARITIME- Background

In July 2021, the European Commission introduced the "Fit for 55" package, of which FuelEU Maritime is a part of. This initiative outlined the basic framework for reducing the GHG intensity of energy used by ships (European Commission, n.d.). Similar to the "Green Paper" for European Union Emission Trading System (EU ETS), the proposal served as the foundation for stakeholder consultations and discussions, gathering feedback from industry participants, policymakers, and environmental organizations to create a robust, inclusive system (von Malmborg, 2023). In the Directive of the European Parliament & Council (2009/16/EC) Article 3 (1) the following definition is found of which GHG are covered under the regulation "'greenhouse gas emissions' or 'GHG emissions' means the release of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) into the atmosphere".

The European Commission introduced in March 2000 a "Green Paper". The "Green Paper" was a preliminary policy document, which outlined initial ideas for an emission trading framework (European Commission, n.d). The purpose of a green paper is to stimulate discussion and gather feedback on proposed ideas before a formal legislation is developed (European Commission, 2000). The "Green paper" served as a basis for extensive stakeholder consultations, shaping a system that could balance economic efficiency with environmental responsibility. The discussions culminated in the adoption of the EU ETS Directive in 2003, providing the legal framework for a cap-and-trade system (European Commission, n.d.). The regulation of FuelEU Maritime was formally adopted in 2023, providing a legal framework to measure, monitor, and progressively reduce the carbon intensity of fuels used in international maritime transport. FuelEU Maritime became fully implemented 1st of January 2025 (European Commission, n.d.). The goal of FuelEU Maritime is to ensure that maritime emissions reduce at an accelerating rate, aligning with the EU's broader objective of achieving net zero emissions by 2050.

2.2 FuelEU MARITIME- Obligations

The Directive of the European Parliament & Council (2009/16/EC) sets two key requirements for vessels operating in EU ports. First, it mandates a gradual reduction in the GHG intensity of the energy consumed on board, with targets increasing every five years—starting with a 2% reduction in 2025 and reaching 80% by 2050, the reference value is from 2020, which is 91,16 grams of CO_2 equivalent per MJ. Furthermore, the regulation covers a well-to-wake perspective, meaning that GHG emitted during the production phase of the fuel also is taken into account when calculating the vessels annual emissions (European Commission, n.d.). Additionally, on the 1st of January 2030 ships active in the container and passenger segment when docked at EU ports are required to rely on shore-side electricity or other zero-emission alternatives to minimize emissions while at berth, if the port of call is covered by Article 9 of Alternative Fuels Infrastructure Regulation (AFIR) (The Directive of the European Parliament & Council 2014/94/EU).

The regulations of a decrease in carbon intensity promotes the urgent need for shipowners to start the transition to alternative fuels that are renewable and contain low-carbon levels (von Malmborg, 2023). The transition towards alternative fuels that are more environmentally friendly is a must for shipowners if they still want to operate their vessels within the EU or European Economic area (EEA). FuelEU Maritime aligns well with the European Union's broader objective of reaching climate neutrality by 2050 (European Commission, n.d.). The implementation of FuelEU Maritime promotes the usage of renewable and low-carbon fuels in EU ports, as well as it supports the development of bunkering infrastructure for sustainable fuels in EU ports (Ingwersen et al., 2025).

The FuelEU Maritime regulation introduces mandatory requirements for the use of alternative power sources in ports to reduce greenhouse gas emissions and air pollution. Ships are required to utilise either on-shore power supply (OPS) or other zero-emission technologies while at berth. However, in Directive of the European Parliament & Council (2009/16/EC) article 6 (1) determines when vessels must use OPS in ports that are covered by Article 9 (The Directive of the European Parliament & Council 2014/94/EU). Only the vessel types “container” and “passenger” are required by the regulation to connect if possible, from the 1st of January 2030 Article 6 (4) (Directive of the European Parliament & Council 2009/16/EC). This results in tanker ships not having to install OPS-systems, but they can still benefit from OPS in their annual GHG calculations if they choose to install such systems onboard. This regulation aims to significantly decrease emissions produced by auxiliary engines typically used to power ships during port stays (European Commission, n.d.).

2.3 FuelEU MARITIME- Ships covered and Scope

The FuelEU Maritime will include CO_2 intensity in emissions from all ships with a gross tonnage (GT) of 5,000 DWT or more, regardless of their country of registration, that call ports within the EU (Directive of the European Parliament & Council 2009/16/EC). This expansion ensures that emissions from both EU and non-EU flagged vessels are accounted for (Flodén et al., 2024.)

The scope of FuelEU Maritime regulation applies to all ports within the EU and in the future the EEA. The implementation has been delayed in the EEA meaning that calls to both Icelandic and Norwegian ports will count as third-country ports in the context of FuelEU (European Commission, n.d.) Voyages within the EU/EEA and international voyages that involve at least one EU/EEA port (European Commission, n.d.). FuelEU Maritime accounts for 100% of the energy used during voyages within the EU/EEA (intra-EU voyages) and 50% of the energy used during voyages between EU/EEA ports and ports outside this geographical area (extra-EU/EEA voyages). Furthermore, the regulation includes 100% of the energy consumed by ships while at berth in EU/EEA ports, ensuring comprehensive coverage of greenhouse gas emissions within its jurisdiction (European Maritime Safety Agency, n.d.).

2.4 On-shore power - Exceptions

Certain situations exempt ships from the requirement to connect to onshore power supply (OPS) while at berth, as outlined in Article 6 (5) (Directive of the European Parliament & Council 2009/16/EC). Ships are not required to use OPS during short port stays of less than two hours, when they rely on zero-emission technologies as an alternative, or when making unplanned port calls due to emergencies, safety concerns, or life-saving situations beyond their control. Exemptions also apply if OPS connection points are unavailable, if there is insufficient shore power due to grid stability issues, or if the ship's onboard system is incompatible with shore-side equipment, provided the installation is certified under Annex II of the AFIR (The Directive of the European Parliament & Council 2014/94/EU).

Additionally, ships can generate onboard energy in cases of immediate risk to life, the vessel, or the environment, as well as during urgent maintenance or functional tests required by authorities or classification societies. These exceptions ensure flexibility when OPS connection is not feasible or presents operational challenges (European Commission, n.d.)

2.5 FuelEU MARITIME - Well-to-wake perspective

The well-to-wake (WtW) perspective provides a comprehensive framework for assessing GHG emissions in maritime transport by considering the entire fuel lifecycle, from its extraction to its consumption on board ships. This approach is divided into three key segments: upstream, downstream and fuel consumption, ensuring a holistic evaluation of emissions across the entire supply chain (Kramel et al., 2021)

The upstream phase within the well-to-tank segment covers emissions generated before the fuel reaches the ship. This includes the extraction of raw materials from oil and gas plants, their refining, liquefaction, and transportation (Kramel et al., 2021). Various factors, such as geospatial references, production statistics, and the national energy mix, are considered to determine the environmental impact of fuel production. Facility emissions, including venting, flaring, and energy consumption, further contribute to the total emissions in this phase (Kramel et al., 2021).

The downstream phase, still within the well-to-tank segment, involves the final processing and distribution of the fuel before it reaches the vessel. This includes the refining and liquefaction of fuels, which are essential for ensuring the fuel meets the required standards for maritime use. The emissions from these processes are accounted for alongside those from logistics and supply chain operations involved in transporting the fuel to the bunkering location (Kramel et al., 2021).

The fuel consumption phase, represented by the tank-to-wake segment, focuses on emissions produced when the fuel is burned onboard (Zamboni et al., 2024). This phase considers key operational factors such as engine configuration, vessel resistance, sea state, and weather conditions to determine actual emissions during voyages. The performance and emissions of vessels are continuously assessed through data sources such as Automatic Identification System (AIS) calls, ship databases, weather data, and technical performance records (Kramel et al., 2021).

By integrating upstream, downstream, and fuel consumption emissions, the well-to-wake perspective is meant to ensure an accurate assessment of the environmental footprint of maritime fuels. Through this framework, common emission are systematically monitored and regulated (Comer, B., & Osipova, L., 2021).

2.6 The transition towards compliance with FuelEU Maritime

The Swedish Club (Ohlman & Sbraga., 2024) explains 5 ways of complying with the new FuelEU regulation. Ships that are within the scope of the regulation will be evaluated on an annual compliance balance, which means that the vessel will either have a surplus or deficit of compliance balance. In the case of a surplus the complying ship will receive a FuelEU Document of Compliance (FuelEU DOC) and a vessel which is non-compliant will be forced to pay a FuelEU Penalty. In the Directive of the European Parliament & Council (2009/16/EC) under Annex IV A the formula for calculating a ship's compliance balance can be found and a non-compliant vessel must pay the penalties according to the equation that can be found in Annex IV B. Under Article 23 (11) the regulation states that revenue generated from FuelEU Penalty shall be invested into green efforts, such as easing the use of renewable and low-carbon fuels in the maritime sector, stimulating production, facilitating production of bunkering facilities and investing in OPS in ports. By June 30 2030 all member states shall report to what endeavours the revenue generated by penalties have been used on, and every five years after 2030 a new report shall be issued. The report must also include details regarding the beneficiaries and the expenditure levels associated with the objectives.

Table 1

Calculation for possible penalties

FuelEU Penalty = $\frac{\lvert \text{Compliance Balance} \rvert}{\text{GHGIE}_{\text{actual}} \times 41\,000} \times 2\,400$			
1.	FuelEU Penalty	2.	Is in EUR
3.	$\lvert \text{Compliance Balance} \rvert$	4.	Is the absolute value of the compliance balance
5.	41 000	6.	Is 1 metric ton of VLSFO that is equivalent to 41 000 MJ
7.	2 400	8.	Is the amount to be paid in EUR per equivalent metric ton of VLSFO

Note: Cut out taken from Regulation 2023/1805, Annex IV B. Describing how to calculate potential penalties for failing to comply with the regulation. GHGIE-actual means yearly average of the GHG intensity of the energy used on-board a ship calculated for the relevant reporting period.

The reporting period is classified as a calendar year, so it starts on the 1st of January and ends with the 31st of December. The year after the reporting period the verification period starts with the 1st of January in the subsequent year. At the end of January, the company must submit all necessary information in regard to FuelEU, then by the 31st of March the company's compliance balance will be stated by a verifier. The company at hand must then choose their pathway to compliance by the end of April. The company must pay any applicable FuelEU Penalty by 30 June. If the FuelEU Penalty remains unpaid for two consecutive Reporting Periods, expulsion orders and/or flag detention may be enforced (Ohlman & Sbraga., 2024).

The first way to comply according to The Swedish Club (Ohlman & Sbraga., 2024), with the FuelEU Penalty is by using prior surpluses from previous years. Secondly, the use of pooling to spread the risk over multiple vessels and to receive a commercial edge, importantly to note is that a pool's total compliance balance must be positive and a vessel can only be pooled once. Thirdly, it is possible to borrow from future compliance surplus, this is a risky strategy, since a multiplier of 1.1 is applied to the borrowed surplus, resulting in that the future Verification Periods will be harder to comply with (Ohlman & Sbraga., 2024). Fourth, switching to a fuel with lower carbon-intensity such as LNG, biofuels etc. According to the Swedish Club (Ohlman & Sbraga., 2024) this will most likely result in higher operational risk and fuel costs. Fifth, is to simply pay the penalties. In order to try and make this option less than optimal of a strategy in the long run, ships with two or more deficit periods will have an increase of 1/10 to their total penalties.

2.7 Alternative fuels

In this chapter we will go through strengths and weaknesses and explain the alternative fuels characteristics and how these alternative fuels could be used to comply with FuelEU Maritime.

2.7.1 Biofuels

As a maritime fuel, diesel-like biofuels such as HVO, FAME, bio-oil are currently the closest direct replacement for conventional fuels and can be used as drop-in fuel with little to no modification of current propulsion systems and engines (Balcombe et al., 2019). However, some biodiesels needs to be blended to function properly, whereas some can be used neatly such as HVO (Solakivi et al., 2022). Therefore, in the short term, biofuels appear to be the only commercially and technologically viable alternative within the current regulatory landscape (Solakivi et al., 2022). In comparison with HFO, Biofuels produce significantly lower amounts of sulphur, as well as reduce the CO_2 with 60-100% (Bouman et al., 2017).

2.7.2 LNG & LBG

Low-carbon fuels often refer to "cleaner" fossil-derived fuels, such as LNG, which have smaller carbon intensity compared with conventional petroleum-based ship fuels. Within this category, LNG and fossil-based methanol (MeOH) show promise, at least in the short term, when it comes to the decarbonization of shipping (Svanberg et al., 2018). Of these two, LNG is already in wider commercial use, and it has gained attention recently, especially because it passes the IMO 2020 sulphur content regulations that capped bunker fuel sulphur content at a maximum of 0.5 % globally or 0.1 % in emission control areas (ECAs) (Solakivi et al., 2022). Currently, Liquefied Natural Gas (LNG) is the most widely adopted alternative fuel, accounting for approximately 0.1% of global fuel consumption (Solakivi et al., 2022).

LNG-powered ships rely on a dedicated engine architecture that is not compatible with conventional marine diesel, necessitating specialized fuel storage systems, such as double walled fuel tanks and pipelines (Solakivi et al., 2022). Like other alternative fuels, LNG has lower volumetric energy density compared to traditional marine diesel, which requires approximately twice the tank space, which can result in payload losses (Solakivi et al., 2022). The majority of the LNG used today is derived from fossil sources, and not renewable sources (Balcombe et al., 2021).

Bio-methane is produced from organic matter, like the fossil variant natural gas, it also can be converted into a liquid form. The liquid form is known as Liquified Biogas (LBG) and has a similar structure to its fossil form LNG, and is considered near identical in regard to the combustion within the engine (Spoof-Tuomi & Niemi, 2020). What sets the two fuel types apart is the wake to tank phase, the bio-methane contains impurities which have to be cleaned and upgraded in order to increase the CH_4 content in the fuel, to mimic the properties of natural gas.

2.7.3 Hydrogen

Hydrogen fuel has the highest energy-to-weight ratio compared to other alternative fuels (Ampah et al., 2021). Energy-to-weight ratio refers to the amount of energy stored in a fuel per unit of its mass, usually measured in megajoules per kilogram (MJ/kg). A high energy-to-weight ratio indicates that a fuel can provide more energy while weighing less. Additionally, hydrogen does not emit CO_2, particulate matter (PM), or sulphur oxides (SO_x) during combustion (Ampah et al., 2021).

This makes it a strong candidate for decarbonization. Although hydrogen is widely available, it is usually found in compound forms like water or hydrocarbons. Because of this, some of its energy is lost during the process of refining it into a usable fuel (Xing et al., 2021).

When hydrogen is used as a vessel fuel, hydrogen requires specialized storage facilities, which adds both ongoing operating expenses as well as initial costs for the shipowners. Since hydrogen has a low energy density by volume, it also needs significantly more tank space. In comparison, hydrogen storage takes about four to eight times more space than conventional diesel fuel (Gray et al., 2021).

2.7.4 Ammonia

Ammonia is a fuel which is carbonless in its structure, and when burned it produces no carbon dioxide or sulphur dioxide emissions (Solakivi et al., 2022). Ammonia can generate high levels of nitrogen oxide (NOx) emissions, but usage of catalytic converters can prominent reduce these levels (Ampah et al., 2021). Ammonia is generally easier to store onboard than hydrogen, making it an attractive alternative fuel. However, its lower energy density presents a significant challenge for maritime applications, as it requires nearly five times the storage space compared to diesel (Solakivi et al., 2022). This can lead to a reduction in payload capacity, impacting the efficiency of shipping operations. Another obstacle is the lack of a well-established bunkering and fuel supply network for ammonia in the maritime industry. Significant investments and infrastructure upgrades would be needed before ammonia could become a viable mainstream fuel for ships (Solakivi et al., 2022).

2.7.5 Methanol

Methanol is a low-carbon, liquid fuel that can be used directly or blended with conventional fuels (up to 20%) without major engine modifications (Balcombe et al., 2019). It can also function as a drop-in fuel. Methanol is a liquid at ambient conditions, methanol is relatively easy to store and transport. However, it has a lower volumetric energy density compared to HFO, which necessitates larger storage volumes onboard (Solakivi et al., 2022).

Methanol offers certain safety advantages: it is biodegradable, water miscible, and burns with a cooler flame, reducing environmental and fire risks. However, it is toxic to humans and requires careful handling onboard (Solakivi et al., 2022). Some existing infrastructure already supports methanol due to its industrial use, but current production relies heavily on fossil sources such as natural gas and coal (Balcombe et al., 2021). A shift to renewable methanol is necessary for it to serve as a truly sustainable option. From an emissions perspective, fossil-derived methanol can reduce CO_2 emissions by approximately 25% compared to conventional marine fuels and is free of sulphur content (Balcombe et al., 2019).

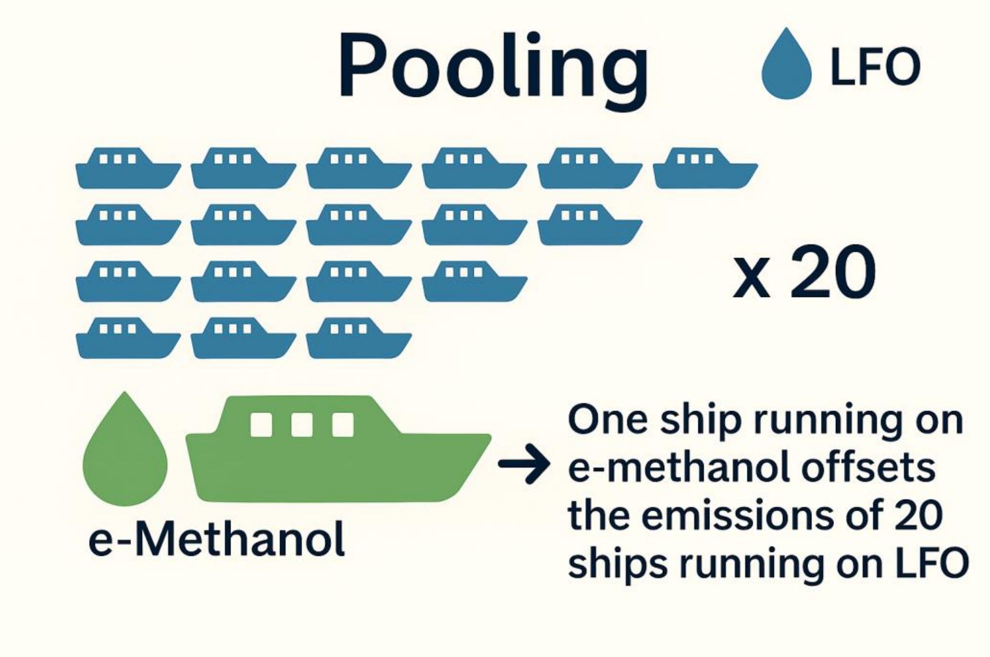
2.8 Green technologies and increase of efficiency

Improving energy efficiency is a key strategy for reducing both fuel consumption and the associated compliance costs under the FuelEU Maritime regulation. One example of such an approach is the adoption of wind-assisted propulsion systems (WAPS), which can significantly lower a vessel's greenhouse gas intensity by decreasing reliance on conventional fuels (Skåre, 2025). Energy-efficiency technologies play an important role in reducing fuel consumption, thereby improving the economic viability of strategies such as blending bio-marine gas oil However, with the exception of WAPS, these technologies alone are generally not sufficient to meet the GHG intensity targets set by the FuelEU Maritime regulation (Skåre, 2025).

2.9 Pooling and how it works

To provide flexibility for shipowners during the transition towards cleaner fuels, the regulation introduces several compliance mechanisms, one of them being pooling (European Commission, 2023).

Figure 1
The function of pooling



Note: Figure 1 is an illustration inspired by Wärtsilä (2023) and generated using AI. It illustrates how one green vessel in a pool of 20 can enable the entire group to comply with the regulations.

Pooling allows shipowners to consolidate the compliance performance of multiple vessels into a single, collective compliance pool. Within this pool, vessels that outperform the regulatory GHG intensity target generate a compliance surplus, which can be used to offset the compliance deficits of vessels that fall short of the required GHG intensity limit. This strategy gives shipowners greater flexibility to manage compliance at the fleet level, rather than vessel-by-vessel, enabling them to balance emissions reductions across all participating vessels within the pool (Hamilton, 2024).

An example regarding actual pooling solutions is Gasum, a Nordic energy company, which is among the first to actively develop commercial pooling solutions. In practice, Gasum brings together shipowners with varying compliance profiles and manages the pool by ensuring a collective balance is maintained (DNV, 2025). This is achieved through continuous monitoring on a monthly and voyage-by-voyage basis, using tools such as DNV's Emissions Connect. Such real-time tracking ensures transparency and allows participants to understand their position within the pool before the formal compliance reporting deadline (DNV, 2025).

One of the key advantages for a shipowner to pool their vessels into a pool with other vessels from other shipowners is that it allows shipowners to outsource the complexity of compliance with the FuelEU Maritime regulation. Instead of individually managing certification, fuel sourcing, and GHG tracking, participants in a pooling arrangement can rely on a dedicated pool manager to handle these aspects (DNV, 2025). This is particularly attractive for shipowners operating on conventional fuels or those with limited access to low-carbon alternatives. By joining a pool that includes vessels already using bio-LNG or other sustainable fuels, these owners can achieve compliance indirectly. This means more or less that operators can “continue to operate as before”, without needing to secure certificates, validate fuel origin, or worry about issues like engine compatibility with alternative fuels (DNV, 2025).

In addition to managing the administrative and contractual aspects, Gasum also provides low-carbon fuels such as liquefied biogas to vessels in the pool (DNV, 2025). This not only facilitates compliance but also reduces the need for each individual operator to secure certified sustainable fuels on their own, an increasingly complex and uncertain process (DNV, 2025). Gasum highlights the importance of initiating pooling arrangements well in advance of the April 30th declaration deadline, as successful compliance requires coordination and planning throughout the reporting year. Delaying such arrangements risks leaving operators with unresolved compliance gaps and potential financial penalties (DNV, 2025). Pooling thus offers a practical and strategic approach for operators navigating the regulatory challenges of decarbonization, particularly when access to alternative fuels or retrofitting options is limited (DNV, 2025).

For a shipowner to join a commercial pool, in this example Gasum´s commercial pool, there is a three-step process to join. Registration of Vessels, shipowners begin by registering their vessels with Gasum’s commercial pool (Gasum, 2025). This includes entering into contractual agreements and confirming the regulatory responsibility DOC holder of each participating vessel. This step ensures that all parties involved meet the eligibility criteria for inclusion in the pooling arrangement. Compliance Planning and Commitment, following registration, shipowners place orders for the required amount of compliance units based on their vessels’ expected emissions performance and shortfall against the FuelEU Maritime targets. Gasum manages the supply of these units through its portfolio of low-carbon fuels, such as biogas and LNG, ensuring a surplus is generated within the pool. Operational Continuity with Regulatory Confidence, once enrolled and committed, vessels can continue normal operations while Gasum monitors compliance levels on an ongoing basis. With monthly and voyage-level tracking, shipowners benefit from real-time visibility and assurance that their fleet remains compliant throughout the reporting period (Gasum, 2025).

3. METHODS

This study uses a case study approach to examine how FuelEU Maritime will impact the strategies of Swedish tanker shipowners, since it is well-suited for this form of research as it allows for an in-depth understanding of real-world challenges within their specific context (Denscombe, 2014). The case study is conducted through 7 semi-structured interviews with different Swedish shipowners within the tanker segment, as well as bunker operators and different stakeholders. The purpose of not solely interviewing shipowners, but also interviewing different stakeholders is to gather diverse perspectives and objective insights regarding different strategies on how Swedish shipowners within the tanker segment will approach the implementation of FuelEU Maritime.

Three of the interviews were conducted face-to-face to increase the quality and depth of the information gathered. Interviewing a person face-to-face enable more comprehensive and in-depth data collection (Denscombe, 2018). However, four participants were unable to attend in person, and in those cases, the interviews were carried out via Zoom.

3.1 Interviews and sampling

In selecting individuals to interview, we have used the snowball sampling method. This non-probability sampling technique is particularly effective for accessing hard-to-reach or specialized populations by leveraging existing social networks (Shaghaghi et al., 2011).

Table 2

Interviewee composition by sector and sampling technique

	Sector	Convenience	Snowball	Total
1	Shipowners	1	3	4
2	Bunker operator	0	1	1
3	Industry experts	1	1	2

Note: The table presents the three sectors included in the study, along with the number of stakeholders represented in each.

The process begins with identifying two initial subjects, often referred to as "seeds". After conducting interviews with these two seeds, these individuals are then asked to recommend other individuals who also fit the research parameters. This referral process continues, with each new participant providing further contacts, thereby expanding the sample size, similar to a snowball growing in mass as it rolls downhill (Kirchherr & Charles, 2018). As shown in Table 2, interviews were conducted across three different sectors to broaden the scope beyond the perspectives of shipowners and gain a more comprehensive understanding of viewpoints within the wider shipping industry. All of the individuals interviewed within the shipowner sector and the bunker operator possess either a technical or environmental capacity within their role of their company. However, the industry experts does not specific work solely with environmental questions but still has good insight of the industry.

Table 3
Participant Profiles: Position, Experience, and Interview Length

	Interviewee	Position/Focus Area	Years in Position	Interview Length (min)
1	Shipowner 1	Sustainability	3	56
2	Shipowner 2	Technical	13	63
3	Shipowner 3	Sustainability	6	57
4	Shipowner 4	Sustainability	3	50
5	Bunker operator	Business Growth	1	67
6	Industry expert 1	Managing Director	13	44
7	Industry expert 2	Sustainability	11	32

Note: The table shows a breakdown of the interviewed individuals' current positions and time spent within that role.

Sampling process began by interviewing individuals who were readily accessible and knowledgeable about our research topic. The initial participants were selected based on recommendations from our "seeds", which was our supervisor and a former colleague, both highly knowledgeable within the subject. At the conclusion of each interview, we asked the participants to recommend others who in their opinion, possessed expertise in the subject matter. This approach not only facilitated the identification of additional qualified interviewees but also helped in building a network of participants with relevant insights. By employing snowball sampling, we aimed to construct an extensive and informed sample, making use of the connections between professionals in the field to improve the depth and quality of our research.

Before conducting any interview's, informed consent was obtained from each participant using a pre-designed template which included information about the project and what was the expected from the interviewee. This ensured transparency throughout the interview process and upheld ethical standards for data collection. Approval of transcription using AI were verbally done in the beginning of all interviews.

3.1.1 Structure of the interviews

To analyse the data gathered through these interviews, a thematic analysis were applied, which is a commonly used qualitative research method for identifying, analysing, and presenting patterns or themes within interview data (Cernasev & Axon, 2023). Thematic analysis is both flexible and organized, making it useful for handling complex information from different perspectives.
The interviews were divided into five different themes: Background questions, Future fuels, new technologies, investments in new tonnage, financial implications. Before each interview, we prepared a set of questions that were sent to the interviewees in advance. However, these

questions served primarily as a foundation for the conversation. In many cases, the discussions naturally evolved beyond the predefined questions, allowing for deeper exploration of the themes. The semi-structured format of the interviews was aimed at encouraging an open dialogue. At the end of each interview, two final questions were asked: whether the interviewee felt that any important topics had been overlooked during the discussion, and whom they would recommend for follow-up interviews to support the snowball sampling method.

3.1.2 Transcription of interviews

All interviews were recorded and subsequently transcribed using Klang AI. To ensure accuracy and preserve the content of the data, each transcription was manually reviewed to verify that no essential information was omitted or misinterpreted. This step was crucial for maintaining the reliability of the qualitative analysis.

3.2 Literature

To gather the information needed for this study, a literature review was carried out, following guidance from Denscombe (2014). Relevant academic sources were identified using databases such as Google Scholar, Scopus, and the Chalmers Library. These platforms offer filtering tools to select peer-reviewed material, helping ensure the use of credible and scholarly references throughout the research. Keywords used for finding reports and information were FuelEU Maritime, GHG intensity FuelEu Maritime, alternative marine fuels, sustainable shipping, Well-to-wake FuelEU Maritime, OPS FuelEU Maritime, Tanker sector FuelEU Maritime.

To narrow down the search and ensure more relevant results, FuelEU Maritime was consistently used as an additional keyword alongside most primary search terms. For instance, using the keyword "alternative future marine fuels" alone on Google Scholar generated approximately 582,000 results, whereas combining it with FuelEU Maritime reduced the number to just 981. Similarly, the search term "well-to-wake FuelEU Maritime" gave 502 results, "OPS FuelEU Maritime" 339, "tanker sector FuelEU Maritime" 312, and "GHG intensity FuelEU Maritime" 1,090 results. Searching solely for FuelEU Maritime resulted in 1,740 findings. To further refine the selection, we focused on reports that appeared repeatedly across multiple keyword combinations, as these were considered particularly relevant and authoritative.

3.3 Artificial intelligence (AI)

Artificial Intelligence (AI) refers to computer-based systems that are designed to carry out tasks that usually require human intelligence, such as learning from data, recognizing patterns, and making decisions (Guzman & McEwen, 2023). These systems can interact with their environment, improve over time, and support complex processes like data analysis and communication. In research, AI can be used to increase efficiency and assist in organizing and interpreting large amounts of information. It is not just a technical tool, but also a way to better understand patterns in human behaviour and decision-making (Guzman & McEwen, 2023). In the context of this study, AI is used to support the analysis and bring structure to the qualitative data collected. Artificial intelligence tools were employed in this study to support both the data collection and analysis processes. Scopus AI, an integrated feature within the Scopus database, was used to streamline the literature search by identifying relevant academic sources more efficiently (Elsevier, 2024). For the transcription of interviews, Klang AI was utilized. This tool, designed specifically for transcription and communication tasks, contributed to a more organized and time-effective handling of qualitative data (Klang.Ai, n.d.).

4. RESULTS

4.1 Pooling as a strategy

According to both industry experts and the bunker operator, pooling can serve as a way for shipping companies to protect their investments. Having one or more vessels that significantly outperform others in terms of environmental performance, they can then compensate for the vessels in their fleet that cannot meet these same environmental standards set out by EU. This reflection is echoed by the shipowners themselves, three of the shipowners that were interviewed stated that they in some form intended to use pooling in their business. Shipowners 3 and 4 lifted the aspect that pooling in their older vessels with the newer ones could help their entire fleet reach FuelEU maritime regulations, since the more efficient vessels can assist the whole fleet to reach the obligations that are set upon the company. Shipowner 2 is the only shipowner that does not see any reason for utilising pooling based on their current trading patterns. Industry expert 2 noted that pooling may not be compatible with all types of contracts, limiting its applicability depending on the nature of a company's agreements.

The bunker operator mentions that usage of pooling as a strategy can be beneficial from an economic standpoint, as it often results in cheaper cost for the shipowner´s instead of taking a penalty fee. Aside from the penalties, the bunker operator also mentions that pooling is usually not as expensive as buying biofuel, which in certain regions often can be fairly expensive. Industry expert 2 mentions that joining a pool in order to comply is cheaper than investing in new technology and alternative fuels.

Moreover Shipowner 1 stated that they as well intend to utilise pooling, but only on their time charter hires. Reason being the shipowner of the vessel has the obligation to ensure that said vessel reach the minimum threshold set by FuelEU maritime and when the vessel is on TC they have no operational control over it, meaning the charter can use chooses which fuel to use and the shipowner will be responsible for paying the fine if required by the regulation. To avoid this issue they, together with the charter will let the vessel be part of the charters pool, this will transfer the liability to pay fines to the owner of the pool and not the shipowner, but rather the total emissions of the pool itself. The bunker operator also highlights the strategic and safety benefits regarding using pooling when having vessels on T/C contracts, due to the shipowner´s control over the fuel being used is limited.

Only shipowner 4 acknowledged that pooling may lead to greater administrative burdens, since managing contributions across multiple vessels and trying to predict the same vessels future compliance obligations requires significant co-ordination, especially for a global fleet. They see an internal pool as a short-term strategy and have incorporated biofuels to stay ahead of current requirements. However, they see potential in collaborating with other companies to form joint pools, which could support compliance efforts and lower costs in the future. Industry expert 2 highlights a concern regarding that companies may become dependent on others who set the terms and pricing for the pool, which could shift over time and impact competitiveness. There are also marketing challenges in defining what constitutes a green transport when emissions are aggregated across multiple vessels.

4.2 Fuel of the future

During all the interviews the consensus was that diesel will remain the most frequently used fuel type, due to diesel already having an existing and functioning infrastructure, is energy efficient and is today the most cost-effective option for shipowners. Aside from diesel, all of the interviews expect drop in fuels like bio-diesel will take on a larger market share because it can be incorporated directly into many of the shipowners' vessels without having to undergo vessel retro fitting.

All of the interviews aside from shipowner 4 mentions that biodiesel is the most realistic future fuel aside from diesel, because of its existing and growing infrastructure and has already been proved to work on these vessels. Shipowner 4 believes that LNG and LBG could be the fuel to replace the conventional diesel as a transition fuel, due to its already established infrastructure. Industry Expert 2 suggests that while LNG, LBG, and even methanol may become realistic alternatives in the future, however diesel and biofuels will continue to dominate as the primary fuels for a considerable time before these newer options can fully replace them.

None of the shipowners have expressed any big interest in fuels such as ammonia or hydrogen, as shipowner 2 and 4 states that it lacks the infrastructure to accommodate their fleets and due to the fuel types lower density of energy they would require larger volumes onboard resulting in a lowered intake for cargo. Shipowner 2 also mentioned the safety concerns regarding using hydrogen and ammonia as fuel. Shipowner 4 highlights that aside from the lacking infrastructure, the cost of using hydrogen and ammonia would be much higher than diesel.

Both shipowners 1 and 2 share the sentiment that not a single fuel will dominate the far future. Shipowner 1 highlights that different segments in the industry and geographical areas will adopt fuels based on availability and operational needs for the company. Meanwhile, shipowner 2 shows its belief of a future divide amongst many fuel types by having their newer vessels built with the option to run on several different fuels, such as conventional fuel but also methanol and biodiesel. Furthermore, they lift the advantage of possessing the ability to run its fleet on different fuel types with the flexibility of following market prices on both green fuel types to achieve compliance with FuelEU but also take advantage of lowered diesel prices if the opportunity presents itself.

4.3 Investments in new tonnage and associated technologies

All of the shipowners interviewed already have vessels capable of operating on both conventional and alternative fuels, as well as they are planning to continue to invest in dual-fuel vessels. The dual-fuel vessels are widely viewed by all of the interviewed as essential, not only to ensure regulatory compliance but also to enable operators to switch between fuels depending on price, availability, and infrastructure development. The bunker operator and industry expert 2 mentions the importance of dual-fuel vessels due to nobody knowing which fuel will be used in the future, and investing in new tonnage that is flexible is necessary in order to adapt if changes in the fuel market occurs. Industry expert 2 mentions that when investing in new tonnage, shipowners may also involve preparing vessels with additional space or infrastructure to enable the integration of new technologies or systems in the future. It is also mentioned that the tanker industry only contains young vessels in the European market, with a maximum age of 20 years. This results in less pressure on making the correct strategic decision regarding new tonnage in comparison to the container or RO-RO segment since their vessels has much longer lifespan, according to Industry expert 2.

Shipowner 1 and 2 both mention that aside from investing in dual-fuel vessels that can run on methanol, LNG and bio-diesel, they retrofit their existing vessels. But for both shipowners, their primary focus is on switching fuels. Shipowner 3 focuses more on the technical aspects regarding their already existing vessels, where they implement WAPS and battery systems to increase the vessels energy efficiency. These types of WAPS investments is something that Industry expert 2 highlights will become more common among shipowners. These technological upgrades are often pursued in collaboration with customers and partners. Shipowner 1 and 2 although does not mention any concrete technical implementations to their already existing vessels.

4.4 Expected financial implications of FuelEU Maritime

Everyone that was interviewed agreed that FuelEU Maritime would lead to increased operational costs and the shipowners intended to pass the cost on to its customers. All of the interviewed agreed that the increased cost is because of the transition and future usage of alternative fuels. In addition to the rising fuel costs, Shipowner 4 and Industry expert 2 points out that shipowners will also face significantly higher administrative expenses. Shipowner 4 points out that managing and reporting all the data required under FuelEU Maritime will demand considerable extra work from personnel or force companies to invest in costly digital systems to streamline and automate the reporting process. Shipowner 1 explained that the growing number of regulations introduced by the IMO and the EU in recent years led them, for the first time in 2022, to establish a dedicated sustainability role. Previously, environmental reporting and related administrative tasks were handled by staff within technical management. However, as regulatory demands continued to increase, this approach was no longer sustainable. Industry expert 2 points out that shipowners also face increased costs linked to the risks associated with technology choices. There is a risk that investments in new technologies may turn out to be not the most optional choice if better and more affordable alternatives become available later.

Shipowner 1 lifts the idea that in the beginning the cost may have to be covered by the shipowner alone, since the fuel blends are not that prominent, for example 2 % for year 2025. This reasoning could then in their opinion lead to them having to take on this cost. However, in the future, as regulations become stricter and associated costs increase, these expenses will need to be passed on to the customers. They believe that in the end the costs will balance out, as long as the regulation is adapted to not harm the maritime industry, how to adapt it to the industry was not mentioned. Shipowner 4 mentions that unlike the Emission Trading System, where costs are fixed and predictable, the costs associated with FuelEU Maritime are more abstract and difficult to forecast, making them more complex to manage from a financial perspective. Shipowner 1 highlights that due to the increased costs associated with FuelEU Maritime, shipowners will no longer be able to undercut competitors on price to the same extent as they can today. This will result in a more equal playing ground for the shipowners within EU.

5. DISCUSSION

The strategic efforts and initiatives of shipowners can be evaluated against existing research to determine how closely their actions align with established theories. By analysing and comparing these real-world measures with prior studies, we gain insight into their effectiveness in promoting sustainability and how well they reflect theoretical expectations. This comparison can also reveal potential gaps or limitations in earlier research, providing valuable direction for future studies.

5.1 The Significance of the Study's Results

Our study shows that FuelEU Maritime will lead to both operational and strategic changes for Swedish shipowners within the tanker segment. The results indicate a potential pathway to adapt through investments in dual-fuel tonnage and strategies such as pooling to manage upcoming emission reduction requirements. However, the results also suggest a degree of caution among the actors, where traditional fuels and cost-efficiency continue to be prioritized over more radical transitions, such as to hydrogen or ammonia. The study shows that the increased costs related to the FuelEU Maritime regulation will mostly pass onto the customer´s, although some additional costs might be added for the shipowner´s account related to the increased administrative work.

It becomes evident that the Swedish tanker sector perceives FuelEU Maritime more as a necessary regulation to comply with rather than as a genuine driver of technological innovation. This confirms an aspect of our theoretical framework that regulation alone is not always sufficient to create true sustainability-driven change; commercial incentives and technological opportunities must also be present.

5.2 Pooling as a Strategy

The results from the interviews clearly shows that pooling is not solely a theoretical option but something that several Swedish tanker shipowners are actively planning to adopt. Shipowners 1, 3 and 4 expressed an intention to use pooling, either internally within their own fleets or through commercial pooling arrangements. As well as industry expert 1 and the bunker operator, both express their positive thoughts towards pooling and that pooling can be used as a strategic benefit for shipowners in order to comply with the FuelEU Maritime regulation. This reflects a practical adaptation to the structure of FuelEU Maritime, where vessels with surplus compliance balances can compensate for those failing to meet the regulatory targets (European Commission, 2023). Especially for older tonnage, pooling enables continued competitiveness without requiring immediate investments in costly technological upgrades or alternative fuels (Hamilton, 2024).

Shipowners 1, 3, 4 as well as the bunker operator suggest that pooling is perceived as an effective strategy for managing the increased demands for reduced greenhouse gas intensity. This observation answers the research question that pooling will indeed become a significant strategy for shipowners. Although pooling is viewed as an effective strategy by shipowners 1, 3, 4 and the bunker operator, shipowner 2 and industry expert 1 expresses their view on pooling as a "risk management strategy" rather than a permanent solution. However, it is important to note that Shipowner 2 does not currently see any reason to utilise pooling, based on their existing trading patterns and vessel operations. This highlights that the use of pooling may vary significantly depending on a company’s operational profile, market exposure, and the types of routes their vessels typically operate.

One of the advantages by using pooling is that it provides economic flexibility by reducing individual compliance costs and avoiding immediate investments in new vessels or retrofitting for alternative fuels (DNV, 2025). It also offers greater strategic freedom, allowing older vessels to remain operational by balancing their emissions against newer, more energy-efficient ships (Hamilton, 2024). Shipowner´s 3 and 4 mentions that pooling allows them to compensate their older vessels through more modern and efficient vessels, which offers them a greater economical flexibility on their investments.

A particularly important advantage mentioned in the study is the opportunity for shipowners to join commercial pooling solutions, where third-party operators, Gasum for example, handle coordination and compliance management (DNV, 2025). Shipowners can register their vessels, purchase the required amount of compliance units based on projected emissions, and then transfer the responsibility for monitoring and reporting to the pool administrator. This significantly reduces the administrative burden for the shipowners. During the interviews, no shipowner mentioned the current intent to join a commercial pool. The reasoning behind this could be that all of the shipowner´s vessels already meet and sometimes exceed the current regulations, which minimises the need of joining a commercial pool. The usage of a commercial pool might be more of interest for shipowners whose vessels do not meet the regulatory requirements, and is a strategy to comply without ordering new vessels. Shipowner 3 highlights that pooling is especially beneficial for vessels operating under Time Charter agreements, where the shipowner has limited control over the vessel’s actual fuel choices. Although, the shipowner is still responsible to ensure that the vessel meets the FuelEU maritime requirements. By joining a pool, the compliance responsibility for individual vessels can be distributed across all pool participants, minimizing exposure to penalties.

Despite these clear advantages, the study also identifies significant challenges associated with pooling, particularly depending on the type of pooling structure chosen. Industry expert 2 mentioned that one challenge regarding pooling is the increased administrative complexity that arises when operating an internal pool or an informal pooling setup rather than joining a commercial scheme. In such cases, shipowners must independently manage multiple vessels’ compliance statuses, compile reports, monitor ongoing compliance, and communicate with regulators, requiring substantial internal resources and coordination.

Another major risk is strategic vulnerability. If one or more vessels within a pool fail to meet the regulatory requirements, it may compromise the compliance status of the entire pool, potentially resulting in collective penalties and commercial disadvantages (European Commission, 2023). Industry Expert 2 points out that the vulnerability is particularly high when a ship is part of a commercial pool managed by a third-party operator. In such cases, shipowners have little to no control over ensuring the pool's compliance, as they are removed from the day-to-day management of the vessels within the pool. By contrast, when managing their own internal pool, shipowners have full visibility over each vessel’s status and can take direct action to prevent compliance issues. In a commercially managed pool, the shipowners rely solely on the third-party operators, making it a strategic risk that shipowners must carefully consider.

According to shipowner 4, in the long term, pooling is also seen as a limited solution. Shipowner 4 considers pooling more as a temporary tool rather than a sustainable long-term strategy. As emission reduction targets become progressively stricter toward 2050 and the costs associated with non-compliant vessels rise, pooling alone is unlikely to ensure competitiveness and regulatory compliance.

One negative aspect of using pooling as a compliance strategy under FuelEU Maritime lies in the difficulty of marketing individual transport operations as sustainable or climate neutral. As Industry Expert 2 points out, when a shipowner participates in a commercial pool where fuel and emissions are shared across multiple vessels, it becomes challenging to claim that any single voyage or vessel is green. Even if the pool as a whole uses 100% renewable fuel, the environmental benefit is distributed among all participants, making it unclear who can legitimately take credit. This creates a credibility risk for companies that brand themselves as environmentally friendly. If a shipowner promotes climate neutrality while still operating older vessels within a pool, it could face accusations of greenwashing. The possible inconsistency between the shipowner´s marketing and its actual fleet operations may harm its brand image and stakeholder trust. In some cases, this could even lead to reputational backlash, especially as customers and regulators demand greater transparency around environmental claims.

5.3 Fuel of the future

The answer to which fuel that will become the world's future fuel has no easy answer. All of the shipowners, as well as both industry experts and the bunker operator, all mention that the current conventional fuel, HFO, will not disappear overnight. The diesel is energy efficient, a cheaper economic option, has an already well-structured infrastructure and is a proven well-functioning fuel. Although, as mentioned in the report, in order to meet the exceeding regulations from FuelEU Maritime, the usage of HFO must eventually cease in order for shipowners to meet the regulations. According to Shipowner 1, 2, 3, industry expert 1 and the bunker operator, biofuels are the most promising current option. Shipowner 1, 2, 3, industry expert 1 and the bunker operator mentions that biofuels have good energy intensity, compared to other fuel alternatives such as hydrogen, ammonia or methanol, much more viable from an economic standpoint. Most of the current vessels are able to bunker and burn biofuels in their current machineries and setups, which results in no need of even retrofitting the vessels in order to use biofuels and makes the transition for shipowners much smoother (Balcombe et al., 2019). Biofuels are currently the only alternative fuel that offers both commercial viability and technological readiness for shipowners seeking to transition to more sustainable fuels (Solakivi et al., 2022). Shipowner 4 is the only one that highlights LNG or LBG to be one of the contenders, as it has been a proven commercial fuel during quite some time since it passed the IMO 2020 sulphur content regulation (Solakivi et al., 2022).

Shipowner 2 mentions that aside from biofuels, they are investing and planning on continuing to invest into methanol tankers within their ships. These are seen then as “methanol ready”, but need some retrofitting before actually being able to burn methanol as fuel. Methanol is still seen by most of the shipowners, as well as industry expert 1 and the bunker operator as a fuel that is a long way from being applied in reality. The energy density in methanol is lower than conventional fuel (Solakivi et al., 2022). This leads to higher volumes of methanol needing to be burned in order to generate the same output, which makes methanol an

extremely costly fuel alternative compared to HFO. Methanol production remains largely dependent on fossil fuels, with environmentally sustainable methods still accounting for only a small share of overall production (Balcome et al., 2021). In order for methanol to become a viable alternative fuel and align with the well-to-wake perspective set in the FuelEU Maritime regulation, its production must also transition to green and renewable sources to ensure it is a truly sustainable option (Balcome et al., 2021).
Some shipowners mentions that the lack of infrastructure around methanol prohibits the rest of the shipowners from choosing methanol as a future fuel, at least during the coming years.

Hydrogen and ammonia are two fuels that no shipowner, no industry expert and the bunker operator does not believe will be relevant for a long time. Hydrogen has both high operational and initial costs, which makes it an expensive alternative fuel for shipowners (Gray et al., 2021). Although in theory, hydrogen is the most sustainable option in regarding of emissions due to not emitting CO_2, PM or SO_x while burned (Ampah et al., 2021). From an operational perspective, all of the shipowners mentions it being a non-viable option at the moment.
The lack of bunkering infrastructure around Ammonia limits the current possibility towards a transition where ammonia is used as a maritime fuel (Solakivi et al., 2022).
Shipowner 2 also mentions aside from the lacking infrastructure and high cost, that the safety issues regarding ammonia and hydrogen are much larger than other alternative fuels. The safety aspect is extremely important within the tanker industry, due to the goods that are moved are different types of refined oil products which would harm the environment massively if let out due to an accident. These attributes makes hydrogen and ammonia less attractive and currently not relevant for commercial use.

Industry Expert 2 mentioned that as long as shipowners are able to continue using HFO alongside other technical upgrades or through pooling to meet the FuelEU Maritime requirements, they will stick with HFO. Shipowners will only move away from HFO if it becomes absolutely necessary for compliance - not by choice. To speed up this transition, it could be effective to introduce higher taxes on HFO, making it just as expensive for shipowners to bunker more environmentally friendly alternatives. Such a move might be the tipping point that actually pushes shipowners toward adopting cleaner fuels.

In the end, it is important to understand that the decision for shipowners regarding which fuel to bunker and burn, is connected to the financial aspect. How much does the fuel cost per metric ton and how good on an energy intensity does the fuel have? The reason behind more or less all of the shipowners still consuming HFO as their main fuel is due to the price. It is the cheapest option per metric ton in regard to how much energy you get per metric ton consumed. At the moment, all of the alternative fuels that are discussed and researched in this study are significantly more expensive per metric ton. As all of the shipowners, the industry experts and the bunker operator mentions, the additional cost of FuelEU Maritime will be transferred to the customer's account. For the customers, it is important to receive good service but for the best possible price. If a shipowner is seen as too ambitious regarding the usage of new alternatives fuels, which results in higher costs for the customer, the customers will most likely switch to a cheaper alternative. Then the shipowners will not only need to cover the increased fuel costs themselves, but they might also lose some of their revenue to loss of customers. In the end, the shipping industry is a business like any other. Profitability is critical, and economic survival often outweighs environmental ambitions. No matter how important sustainability becomes, shipowners and their customers will make decisions that primarily protect their financial interests. Until alternative fuels can compete more closely with HFO on price and energy efficiency, widespread voluntary change is unlikely.

5.4 Investments in new tonnage and associated technologies

The interviews showed that the most frequent decision in new investments were to have new tonnage be able to use multiple types of fuel. Their reasoning being that their fleet can utilise the fluctuation in prices between the different fuel types. It is also seen as an advantage due to not having to solely rely on fuel. However, only one of the shipowners mentioned during the interview that they are intent on installing wind propulsion on their newer vessels. In the background research we found that WAPS could help companies to comply with FuelEU maritime regulation (DNV, 2025). Although in reality, it is not something that a majority of the shipowners are intent on implementing since only shipowner 3 mentions the use of WAPS. A more realistic approach is to increase the energy efficiency of the vessel's propulsion in order to increase the MJ output of a single ton of fuel that is consumed (DNV, 2025). Since the FuelEU Penalty is calculated on GHGIE-actual, increasing the energy output of the fuel will directly correlate to the potential penalty (The Directive of the European Parliament & Council 2009/16/EC).

Industry expert 2 explained that the tanker segment differs from the rest of the maritime sector, especially in Europe where a typical vessels operational lifespan is around 20 years because of the safety requirements from the oil companies. Resulting in investments that are not equally as permanent as in other sectors, due to this short lifespan. So, taking the wrong choice regarding fuel to propel the vessel might not be as disastrous for a Swedish tank shipowner in comparison to a ferry shipowner which trafficate the same lines for up to 50 years. This same short lifespan of tanker vessels could be the same reason as to why the interviewees vessels are so up to date and already meet and often surpass the current regulations from FuelEU Maritime.

5.5 Expected financial implications of FuelEU Maritime

During the interviews, all of the shipowners, the industry experts and the bunker operator agreed that FuelEU Maritime will result in higher operational costs. These costs are connected to the future need of switching to alternative fuels instead of using HFO. These alternative fuels that exist in today's market such as hydrogen cost more per ton than regular HFO (Gray et al., 2021). Higher fuel prices result in a higher cost. In other words, it is ultimately the customers within the EU who will be most financially affected by the FuelEU Maritime regulation. The exponential reduction targets for GHG intensity between 2025 and 2050 would impose such significant additional costs on shipowners that continuing operations without passing these costs on would become economically unviable. As a result, the increased costs will inevitably be transferred to customers.

Since the regulation will apply across the entire EU, this dynamic will affect all shipowners operating within the region. Shipowner 1 highlights that shipowner will not be able to "undercut" competitors in the way that is possible today, as all operators will face the same compliance-driven increases in bunker costs. For customers, this means there will be far less variation in pricing between shipping options. Price competition will narrow, and freight rates will become more standardized across the market. If a shipowner were to attempt to absorb the additional fuel costs themselves in order to offer lower rates, it would severely impact their profitability and, in the long term, threaten their ability to stay in business. This creates a more level playing field between different shipowners.

Only shipowner 1 resonates that they as shipowners might be needed to take some of the additional bunker cost themselves in the beginning due to the regulations only requiring a 2% decrease in 2025, and a 6% decrease of GHG intensity (European Commission, n.d). These extra costs are quite small for the shipowner and does not make a huge difference. Shipowner 4 is the only shipowner that highlights the increased financial costs for shipowners connected to the increased administrative work related to FuelEU Maritime. This perspective draws attention to a less visible yet significant impact of the regulation, one that goes beyond fuel choices and technical upgrades. While much of the industry tends to focus on operational and fuel-related costs, the administrative side including the need for detailed emissions tracking, reporting, and verification requires either increased personnel resources or investment in advanced digital systems (Ohlman & Sbraga., 2024). This shows that compliance costs connected to FuelEU Maritime are not only tied to technical implementation but also to organizational capacity. Smaller shipowners or those with limited administrative infrastructure may find this particularly challenging, which might result in a disadvantage for smaller shipowners and therefore an advantage for larger shipowners.

5.6 Method discussion

Using a case study allowed us to explore how FuelEU Maritime may affect Swedish tanker shipowners in a specific, real-world context (Denscombe, 2014). This method aligns well with our study on FuelEU Maritime, as it provides us with diverse perspectives from various shipowners, bunker operators, and stakeholders. A key strength of this approach was the opportunity to include not only different shipowners, but also other relevant stakeholders, such as two industry experts and one bunker operator. By combining the subjective views of shipowners with more external, objective perspectives, we were able to gain a broader and more nuanced understanding of the topic. This mix of voices contributed to the depth of our study. However, since case studies are based on a limited sample, in our case, Swedish shipowners all located in Gothenburg, the findings cannot be generalized to the wider industry. Although, our findings can most likely be applied towards other Swedish shipowners within the tanker segment located in Gothenburg. Nevertheless, the method was well-suited for our aim in order to gain insight into early strategies and reactions during the initial phase of the regulation.

The semi-structured interviews were an important part of our data collection. This format allowed us to guide the conversation while still giving interviewees the freedom to express their views in their own words, which is particularly useful when studying complex or sensitive topics (George, 2022). The downside is that the quality of data can vary depending on how talkative or reflective the interviewee is, and it requires interviewers to be skilled at asking follow-up questions without steering the answers too much. There is also a risk that conversations drift off-topic, which can make analysis more difficult (Denscombe, 2014). After conducting seven interviews with various shipowners, one bunker operator, and two industry experts, we concluded that no additional interviews were necessary. Since our study focuses exclusively on Swedish tanker shipowners based in Gothenburg, the responses showed a high degree of similarity. As a result, we determined that further interviews would not significantly affect the depth or breadth of our findings.

To reach relevant participants, we used snowball sampling, which is a method that is especially effective when studying professional groups that are hard to access using traditional sampling techniques (Shaghaghi et al., 2011). It worked well for identifying shipowners and stakeholders with knowledge of FuelEU Maritime. However, snowball sampling comes with the risk of sampling bias, since participants often refer to others from similar backgrounds or with similar views (Kirchherr & Charles, 2018). This may have reduced the diversity of our sample. We tried to limit this by starting with varied initial contacts, but we still recognize that the sample may not fully reflect the range of perspectives across the industry.

Thematic analysis was used to analyse the interview data. This method is well-suited for identifying and organizing patterns across qualitative data (Cernasev & Axon, 2023). By sorting responses into clear themes, we can closely look at how each person discusses certain issues. This allows us to spot similarities and differences, recognize repeating ideas, and highlight contrasting strategies among stakeholders. Thematic analysis makes it easier to manage and summarize large amounts of qualitative data clearly and effectively. By using this structured method, we will be better able to understand stakeholder strategies and attitudes, allowing us to draw practical and clear conclusions from the data (Cernasev & Axon, 2023).

Finally, it's important to highlight that this study was conducted while FuelEU Maritime is in the initial phase. Many participants spoke about future plans or expectations, which may or may not reflect how things will actually play out. As such, the reliability of our results over time is uncertain. Future studies, especially those conducted after the regulation is fully in effect, could provide more stable and possibly more measurable outcomes.
In summary, our method allowed for a deep and timely exploration of an emerging issue in the shipping industry. The combination of case study design, semi-structured interviews, and thematic analysis offered valuable insights, but also came with limitations in terms of bias, representativeness, and long-term reliability.

6. CONCLUSION

In conclusion, this study shows that the implementation of FuelEU Maritime is expected to have a clear impact on the strategic direction of Swedish tanker shipowners. A central takeaway is that several of the shipowners are planning to adopt pooling as a key compliance strategy. Most shipowners intend to either establish internal pooling systems or join commercial pools to manage regulatory risk and balance performance across their fleets. Pooling is not only viewed as a cost-saving measure but also as a way to maintain flexibility in a market with unclear fuel trajectories. Although, there are still shipowners that do not plan to use pooling as a strategy primarily based on their current trading patterns.
In terms of future fuels, there is no single solution that dominates. Diesel is expected to remain the main fuel in the near future due to cost efficiency, energy density, and an already well-established infrastructure. Aside from diesel, biofuels are identified by most participants as the most realistic alternative for compliance, thanks to its compatibility with existing engines and growing infrastructure availability. Fuels such as hydrogen and ammonia are generally viewed as not yet viable due to safety concerns, energy density issues, lack of bunkering infrastructure and mostly very costly in comparison with other alternatives on the market.

Regarding new investments, all shipowners highlight the importance of investing in dual-fuel vessels. The purpose behind dual-fuel vessels is because they allow operational flexibility and reduce exposure to future fuel market volatility. Dual-fuel technology is seen as a strategic choice for shipowners in order to not be locked into one type of fuel in the future. While some shipowners have also considered technical retrofits such as wind-assisted propulsion, the most common approach is to enhance energy efficiency through smaller technical upgrades and fuel flexibility.

Financially, FuelEU Maritime is expected to significantly increase operational costs, primarily due to the higher price of alternative fuels and added administrative requirements. All interviewed parties agree that the costs of higher fuel prices will eventually be passed on to customers, although one shipowner acknowledge that in the early years while compliance thresholds are still low, they may absorb a portion of the increased fuel costs themselves. Although, the increased administrative requirements will without a doubt result in higher costs for the shipowners, both due to higher personnel needs as well as investments into new technical systems to optimize the reporting process. There is a large risk that smaller shipowners may be disproportionately affected by the high cost connected to the additional administrative work that FuelEU Maritime brings, due to limited capacity and funds.

In summary, these strategies reflect a clear intent from Swedish shipowners within the tanker segment to adapt to the new regulations of FuelEU Maritime. But given that the regulation is still in an early phase, much remains uncertain. How these plans will be implemented and whether they lead to long-term change depends on how the regulatory, technical, and market conditions evolve. For now, their strategies are forward-looking, but the real impact of FuelEU Maritime will only become clear over time.

7. RECOMMENDATIONS FOR FURTHER RESEARCH

For future research, we recommend studying how the implementation of FuelEU Maritime has actually impacted the strategies of Swedish shipowners within the tanker segment. In our study, since the regulation had only recently come into effect, most of the results reflect what shipowners plan to do rather than what they have actually done. It would be valuable to investigate, after a few years of the regulation being in force, whether the strategic decisions shipowners initially planned were truly implemented, or if they chose different actions and in that case why.

In April 2025, the International Maritime Organization (IMO) approved a global framework to reduce greenhouse gas emission from international shipping, with formal adaptation expected in October 2025 and implementation starting in 2027. This global regulation is named IMO Net-Zero Framework. This framework includes mandatory GHG intensity limits for marine fuels, global carbon pricing, and the establishment of an IMO climate fund. Given the global scope of the IMO regulations, they may eventually reduce the relevance of regional regulations like FuelEU Maritime. Future studies could research whether shipowners adjust their strategies to prioritise global compliance over regional obligations, and how this affects their strategic decisions. Our research can serve as a baseline for such studies, offering insight into how shipowners have prepared and plan to tackle FuelEU Maritime.

REFERENCES

Ampah, J.D., Yusuf, A.A., Afrane, S., Jin, C., Liu, H., 2021. Reviewing two decades of cleaner alternative marine fuels: Towards IMO's decarbonization of the maritime transport sector. J. Clean. Prod. 320, 128871
https://doi.org/10.1016/j.jclepro.2021.128871

Bajoria, A., Kanpariya, J., & Bera, A. (2024). Greenhouse gases and global warming. In Advances and technology development in greenhouse gases: Emission, capture and conversion. 121-135.
https://doi.org/10.1016/B978-0-443-19066-7.00006-0

Balcombe, P., Brierley, J., Lewis, C., Skatvedt, L., Speirs, J., Hawkes, A., & Staffell, I. (2019). How to decarbonise international shipping: Options for fuels, technologies and policies. *Energy Conversion and Management.* 182, 72–88.
https://doi.org/10.1016/j.enconman.2018.12.080

Balcombe, P., Staffell, I., Kerdan, I. G., Speirs, J. F., Brandon, N. P., & Hawkes, A. D. (2021). How can LNG-fuelled ships meet decarbonisation targets? An environmental and economic analysis. *Energy, 227,* 120462.
https://doi.org/10.1016/j.energy.2021.120462

Bouman, E.A., Lindstad, E., Rialland, A.I., Strømman, A.H., 2017. State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. Transp. Res. Part Transp. Environ. 52, 408–421.
https://doi.org/10.1016/j.trd.2017.03.022.

Cernasev, A., & Axon, D. R. (2023). Research and scholarly methods: Thematic analysis. *Journal of the American College of Clinical Pharmacy*, 6(7), 751–755.
https://doi.org/10.1002/jac5.1817

Comer, B., & Osipova, L. (2021, March 29). Accounting for well-to-wake carbon dioxide equivalent emissions in maritime transportation climate policies.
https://theicct.org/wp-content/uploads/2021/06/Well-to-wake-co2-mar2021-2.pdf

Denscombe, M. (2014). The good research guide : for small-scale research projects. 356

Denscombe, M. (2018). Forskningshandboken : för småskaliga forskningsprojekt inom samhällsvetenskaperna (Fjärde upplagan). Studentlitteratur.

DNV. (2025). How can FuelEU's pooling mechanism be put into practice? *Maritime Impact Podcast*, Series 8, Episode 4.
https://www.dnv.com/expert-story/maritime-impact/how-can-fueleus-new-pooling-mechanisms-be-put-into-practice/

Drake, F. (2000). *Global warming: The science of climate change* (1st ed.). Routledge.

European Commission. (n.d.). FuelEU Maritime: Decarbonising maritime transport. *European Commission.*

https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime_en

European Commission, (n.d). Consequences of climate change. https://climate.ec.europa.eu/climate-change/consequences-climate-change_en

European Commission. (n.d.). Causes of climate change. https://climate.ec.europa.eu/climate-change/causes-climate-change_en

European Parliament and of the Council Regulation (EU) 2023/1804 of 13 September 2023 on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU http://data.europa.eu/eli/reg/2023/1804/oj

European Parliament and of the Council Regulation (EU) 2023/1805 of 13 September 2023 on the use of renewable and low-carbon fuels in maritime transport, and amending Directive 2009/16/EC
http://data.europa.eu/eli/reg/2023/1805/oj

European Maritime Safety Agency. (n.d.). FuelEU Maritime Regulation. https://www.emsa.europa.eu/reducing-emissions/fuel-eu-maritime-regulation.html

Elsevier. (2024). Scopus AI. *Elsevier.* https://www.elsevier.com/solutions/scopus/features/scopus-ai

Flodén, J., Zetterberg, L., Christodoulou, A., Parsmo, R., Fridell, E., Hansson, J., Rootzén, J., & Woxenius, J. (2024). Shipping in the EU emissions trading system: Implications for mitigation, costs, and modal split. *Climate Policy*. 24(7), 969–987. https://doi.org/10.1080/14693062.2024.2309167

Gasum. (2025). *Secure FuelEU Maritime compliance through pooling.* https://www.gasum.com/en/gas-for-transport/maritime-transport/pooling/

George, T. (2022). Semi-Structured Interview | Definition, Guide & Examples. *Scribbr*. https://www.scribbr.com/methodology/semi-structured-interview/

Gundersen Skåre, O. (2025) Strategies for navigating FuelEU Maritime compliance. *DNV* https://www.dnv.com/

Guzman, A. L., & McEwen, R. (2023). A scholarly definition of artificial intelligence (AI): Advancing AI as a conceptual framework in communication research. Communication Theory, 33(1), 1–24.
https://doi.org/10.1080/10584609.2023.2290497

Hamilton, I. (2024). Vessel pooling – what is it and how does it help you avoid FuelEU Maritime penalties? *Wärtsilä*. https://www.wartsila.com/insights/article/vessel-pooling-what-is-it-and-how-does-it-help-you-avoid-fueleu-maritime-penalties

International Maritime Organization. (2015). Third IMO greenhouse gas study 2014: Executive Summary and Final Report *International Maritime Organization*.

https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Third%20Greenhouse%20Gas%20Study/GHG3%20Executive%20Summary%20and%20Report.pdf

International Maritime Organization (IMO). (2020). Fourth IMO GHG Study 2020: Full report. *International Maritime Organization*. https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Fourth%20IMO%20GHG%20Study%202020%20-%20Full%20report%20and%20annexes.pdf

Ingwersen, A., Hahn Menacho, A. J., Pfister, S., Peel, J. N., Sacchi, R., & Moretti, C. (2025). Prospective life cycle assessment of cost-effective pathways for achieving the FuelEU Maritime Regulation targets. *Science of the Total Environment*, 958, 177880. https://doi.org/10.1016/j.scitotenv.2025.177880

Kramel, D., Muri, H., Kim, Y., Lonka, R., Nielsen, J. B., Ringvold, A. L., Bouman, E. A., Steen, S., & Strømman, A. H. (2021). Global shipping emissions from a well-to-wake perspective. *Environmental Science & Technology*, 55(22), 15232–15241. https://doi.org/10.1021/acs.est.1c03937

Kirchherr, J., & Charles, K. (2018). Enhancing the sample diversity of snowball samples: Recommendations from a research project on anti-dam movements in Southeast Asia. PLOS ONE, 13(8), e0201710. https://doi.org/10.1371/journal.pone.0201710

Klang.ai. (n.d.). AI-powered insights for conversations that matter. *Klang.ai.* https://klang.ai/en/

von Malmborg, F. (2023). Advocacy coalitions and policy change for decarbonisation of international maritime transport: The case of FuelEU maritime. *Maritime Transport Research*, 4, 100091. https://doi.org/10.1016/j.martra.2023.100091

Ohlman, J., & Sbraga, A. (2024, December 10). FuelEU Maritime applies from 2025 – What you need to know. *The Swedish Club*. https://www.swedishclub.com/news/club-news/fueleu-maritime-applies-from-2025-what-you-need-to-know/

Shaghaghi, A., Bhopal, R. S., & Sheikh, A. (2011). Approaches to recruiting 'hard-to-reach' populations into research: A review of the literature. Health Promotion Perspectives, 1(2), 86–94. https://pmc.ncbi.nlm.nih.gov/articles/PMC3963617/

Smith, T., Jalkanen, J., Anderson, B., Corbett, J., Faber, J., Hanayama, S., O'Keefe, E., Parker, S., Johansson, L., & Aldous, L. (2014). *Third IMO GHG Study 2014*. International Maritime Organization. https://www.imo.org/en/OurWork/Environment/Pages/Greenhouse-Gas-Studies-2014.aspx

Solakivi, T., Paimander, A., & Ojala, L. (2022). Cost competitiveness of alternative maritime fuels in the new regulatory framework. *Transportation Research Part D: Transport and Environment*, *113*, 103500. https://doi.org/10.1016/j.trd.2022.103500

Skåre, O. G. (2025). Strategies for navigating FuelEU Maritime compliance. *DNV*. https://www.dnv.com/expert-story/maritime-impact/strategies-for-navigating-fueleu-maritime-compliance/

Spoof-Tuomi, K., Niemi, S., (2020) Environmental and Economic Evaluation of Fuel Choices for Short Sea Shipping. *Journal of Clean Technologies.*, 2(1), 34-52; https://doi.org/10.3390/cleantechnol2010004

Svanberg, M., Ellis, J., Lundgren, J., & Landälv, I. (2018). Renewable methanol as a fuel for the shipping industry. *Renewable and Sustainable Energy Reviews*, 94, 1217–1228. https://doi.org/10.1016/j.rser.2018.06.058:contentReference[oaicite:63]{index=63}

Union of Concerned Scientists. (n.d.). *Why does CO_2 get more attention than other gases?* https://www.ucsusa.org/resources/why-does-co2-get-more-attention-other-gases

United Nations Framework Convention on Climate Change. (n.d.). *The Paris Agreement: What is the Paris agreement?* https://unfccc.int/process-and-meetings/the-paris-agreement

Xing, H., Stuart, C., Spence, S., Chen, H., 2021. Alternative fuel options for low carbon maritime transportation: Pathways to 2050. J. Clean. Prod. 297, 126651 https://doi.org/10.1016/j.jclepro.2021.126651

Zamboni, G., Scamardella, F., Gualeni, P., & Canepa, E. (2024). Comparative analysis among different alternative fuels for ship propulsion in a well-to-wake perspective. *Heliyon*, 10, e26016 https://doi.org/10.1016/j.heliyon.2024.e26016

APPENDIX 1

Interview question for shipowners

Background questions:

- How long have you been working at the company?
- How long have you been working in this role?
- Have you noticed a significant change in recent years regarding how discussions about global warming and environmental issues are being conducted?
- How do you think FuelEU Maritime will affect your shipping company overall?
- How do you think FuelEU Maritime will affect the industry as a whole?
- What strategic measures are you currently taking, or planning to take, to comply with the FuelEU Maritime regulations?
- What advantages and disadvantages do you see with using pooling, and how do you think it will affect shipowner´s strategies?

Future fuels:

- Which fuel do you think will dominate the tanker sector in the coming years, and why?

(Good energy capacity / Low environmental impact / Solid infrastructure / Economically viable option)
- How do you plan to determine which alternative fuel is the right one to invest in?
- Will your decisions be based on external research from organizations or other companies in the industry, or will you conduct your own research to evaluate the most sustainable options?

- How will you go about implementing this fuel transition?

- Will any technical modifications be needed to your vessel engines in order for them to run on these fuels?
- How will you ensure that there is sufficient infrastructure in place to bunker your vessels with this/these alternative fuels?

- What will freight look like in the future?

-What will be transported when oil is no longer in use?

New technologies:

- Have you already implemented, or do you plan to acquire, new technology on your vessels or in your shore-based operations to help comply with the FuelEU Maritime regulations?

Investments in new tonnage:

- Will you invest in new vessels/new tonnage with engines and technology capable of running on various alternative fuels, or will you focus on technically modifying your existing vessels to make the engines compatible with new fuel types? Why?

- What is your strategy regarding investment in new tonnage? Since no one truly knows which fuel will become the next major marine fuel, how do you think strategically as a shipping company when it comes to deciding which technology to invest in?

Financial implications:

- How will the change in fuel type affect your company financially?

-Will you bear all the increased bunker costs yourselves?
-Will you negotiate with your charterers for an increased bunker clause so that they cover part of the costs?
- Will you have different bunker agreements depending on COA / SPOT / TC – and if so, why?

- Do you think the government will be able to provide future subsidies to help shipping companies carry out this transition?

Closing questions:

- Is there anything in this interview that you feel we have missed and that you would like to bring up?
- Is there anything you think we should include in our future interviews?

- Is there anyone you would recommend us to contact for an interview? (Someone within the industry whom you consider knowledgeable in this area and who could help us expand our understanding of the subject?)

APPENDIX 2

Interview question for bunker operator & industry experts

Background questions:

- How long have you been working at the company?
- How long have you been working in this role?
- Have you noticed a significant change in recent years regarding how discussions about global warming and environmental issues are being conducted?
- How do you think FuelEU Maritime will affect your shipping company overall?
- How do you think FuelEU Maritime will affect the industry as a whole?
- What strategic measures are shipowners currently taking, or planning to take, to comply with the FuelEU Maritime regulations?
- What advantages and disadvantages do you see with using pooling, and how do you think it will affect shipping shipowner´s strategies?

Future fuels:

- Which fuel do you think will dominate the tanker sector in the coming years, and why?

(Good energy capacity / Low environmental impact / Solid infrastructure / Economically viable option)
- How do shipowners plan to determine which alternative fuel is the right one to invest in?
- Will their decisions be based on external research from organizations or other companies in the industry, or will they conduct their own research to evaluate the most sustainable options?

- How will shipowners go about implementing this fuel transition?

- Will any technical modifications be needed to their vessel engines in order for them to run on these fuels?
- How will they ensure that there is sufficient infrastructure in place to bunker your vessels with this/these alternative fuels?

- What will freight look like in the future?

-What will be transported when oil is no longer in use?

New technologies:

- Have they already implemented, or do they plan to acquire, new technology on their vessels or in their shore-based operations to help comply with the FuelEU Maritime regulations?

Investments in new tonnage:

- Will they invest in new vessels/new tonnage with engines and technology capable of running on various alternative fuels, or will they focus on technically modifying their existing vessels to make the engines compatible with new fuel types? Why?

- What is the shipowner´s strategy regarding investment in new tonnage? Since no one truly knows which fuel will become the next major marine fuel, how will shipowner´s strategically think when it comes to deciding which technology to invest in?

<u>Financial implications:</u>

- How will the change in fuel type affect the shipowner´s financially?

-Will the shipowners bear all the increased bunker costs themselves?
-Will the shipowners negotiate with their charterers for an increased bunker clause so that they cover part of the costs?
- Will the shipowners have different bunker agreements depending on COA / SPOT / TC – and if so, why?

- Do you think the government will be able to provide future subsidies to help shipping companies carry out this transition?

<u>Closing questions:</u>

- Is there anything in this interview that you feel we have missed and that you would like to bring up?
- Is there anything you think we should include in our future interviews?

- Is there anyone you would recommend us to contact for an interview? (Someone within the industry whom you consider knowledgeable in this area and who could help us expand our understanding of the subject?)

APPENDIX 3

Informerat samtycke om deltagande i examensarbetsprojekt
(” Regulatory Pressures and Strategic Responses to FuelEU Maritime”)

Chalmers tekniska högskola
Institutionen för mekanik och maritima vetenskaper
Avdelningen för maritima studier
SE – 412 96 Göteborg

Studenter:
Sebastian Claeson, claesons@chalmers.se / +46 72 213 13 46
Filip Modigh, filipmo@chalmers.se / +46 72 560 77 70

Handledare:
Martin Larsson, martin.larsson@chalmers.se / +46 70 913 61 88

Vi, Sebastian Claeson och Filip Modigh studerar internationell logistik år 3 vid Chalmers tekniska högskola. I vår kandidatuppsats vill vi undersöka hur implementeringen av FuelEU Maritime kommer att påverka strategierna för svenska rederier inom tanksegmentet.

Bakgrunden till detta arbete är att vi vill fördjupa oss i lagstiftning som reglerar mängden utsläpp av så kallade ”Green House Gases” och hur dessa regleringar kommer att påverka den svenska tanksjöfarten. Vi har valt att fokusera på FuelEU Maritime eftersom vi anser att det är den mest ”agressiva” policy som berör utsläpp från fartygs bränslen som får göras inom den europeiska sjöfarten. Därför vill vi försöka skapa mer kunskap för det svenska näringslivet vad gäller just FuelEU Maritime och hur det kommer att påverka svenska tankrederier både positivt och negativt.

Om du vill ha mer information om projektet så är du välkommen att kontakta handledare eller oss studenter.

Innan vi ber om din medverkan vill vi informera om vilka **etiska regler** som gäller i projektet:
- Du deltar i denna studie helt frivilligt och har rätt att bli informerad om varför du har blivit tillfrågad samt vad syftet med deltagandet är.

- Du har möjlighet att när som helst under studiens gång avbryta ditt deltagande utan att behöva ge en orsak till detta.
- Studien är helt anonym och insamlad data kommer att redovisas utan koppling till person, fartyg eller företag/rederi.
- Enbart studenter/lärare/forskare som är knutna till studien kommer att ta del av det insamlade råmaterialet.
- Alla personuppgifter kommer att hanteras i enlighet med EU:s allmänna dataskyddsförordning (GDPR) och på ett sätt som inte inkräktar på deltagarens personliga integritet.

Genom att skriva under denna blankett ger du ditt så kallade informerade samtycke till att delta i studien och att du tagit del av den information som presenterats ovan.

□ Jag godkänner att intervjun spelas in i analyssyfte.

Ort:	Datum:

Underskrift:
Namnförtydligande:
Kontaktuppgifter: FRIVILLIGT

DEPARTMENT OF MECHANICS AND MARITIME SCIENCES
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden
www.chalmers.se

CHALMERS