Navigating the Waves of Change: Swedens Journey towards Electrification in Maritime Shipping

Bachelor thesis for Shipping and Logistics Program

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Cover: The cover pictures for this assignment was a AI-generated picture, where given instruction to make a picture with the “electric power” and “vessel”, and picture above being the final result (Dream by WOMBO, n.d.).

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PREFACE

This study was made by two students at Chalmer University of Technology, at the department of mechanic and maritime sciences. The program of who we study at is called international logistics, which has a 180 higher education point, of which the total duration is 3 years. This study was made in accordance with the class “Bachelor thesis for international logistic – MMSX17”, which has a total of 15 higher education point, and is the last peace in our bachelor’s degree. We would like to thank our mentors for their vital instruction in this assignment. We would also like to thank the companies’ chosen representatives, Port of Gothenburg, Furetank, and Forsea, for their participants in this study, and their ever long patience with our interviews.

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SAMMANDRAG (in Swedish)
Elektrifiering är den moderna vägen att för att minska sina utsläpp och öka sin hållbarhet, oavsett om det handlar om bilar, lastbilar eller tåg, men inom sjöfarten har det inte gjort samma framsteg som andra transportmedel inom det logistiska nätverket. Denna studie genomfördes från Sveriges industrihuvudstad, Göteborg. Det är en utmärkt utgångspunkt eftersom det finns många rederier i detta närområde. Studien gjordes för att förstå varför företag idag har elektrifierat sig samt, hur de tror att framtiden för elektrifiering kommer att se ut, vilka incitament det finns för att övergå till det, och slutligen vilka de största hindren med elektrifiering är idag. Denna studie begränsade sig till att endast intervjua företag baserade i Sverige på grund av dess närhet till Chalmers universitet. Genom att använda en kvalitativ forskningsmetodik, framkom de mest prominenta problemen med elektrifiering att det är brist på incitament från staten, som subventioner, skattereduktioner eller några finansiella fördelar för att övergå till elektrisk energi. De reglerande instanserna som IMO, EU eller den svenska staten har heller inte varit uppdaterade med hur eller vilka regler och bestämmelser som bör gälla när det kommer till elektrifieringen idag, vilket innebär att det finns många osäkerheter om hur man ska använda elektrisk kraft idag. Detta tillsammans med bristen på funktionell och dyr infrastruktur har gjort övergången till elektrisk kraft svårare än den behöver vara. Även om dessa problem förväntas lösas inom en nära framtid kommer de stora delarna av det logistiska nätverket inte att övergå till ett helt elektriskt drivet framdrivningssystem på grund av bristen på energi som kan bäras i ett batteri, vilket gör det opraktiskt med att använda batterier för längre resor på grund av dess totala vikt och storlek.

Nyckelord: Elektrifiering, Reglerande instanser, Batterier, Infrastruktur, Logistiska nätverket, IMO, EU.

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ABSTRACT
Electrification is the modern way to achieve greater sustainability, whether it's applied to cars, trucks, or trains. However, in terms of maritime transportation, it has not yet progressed to the same level as other modes of transportation within the logistical network. This study was conducted in Gothenburg, the Swedish capital of industry, which serves as an excellent starting point due to the large number of shipping companies in the area. The purpose of this study was to understand why companies have chosen electrification, envision the future of electrification, explore incentives for transitioning to it, and identify the main obstacles that need to be overcome for its widespread adoption in the future. The study was limited to interviewing Swedish-based companies, as their offices are near Chalmers University in Gothenburg. By employing qualitative research methodology by surveys interviews, the study revealed that the most significant problem with electrification is the lack of incentives from the state, such as subsidies, tax returns, or other financial benefits for transitioning to electric power. Regulatory bodies like the International Maritime Organization (IMO), the European Union (EU), and the Swedish government have not kept pace with the rules and regulations concerning electrification, leading to considerable uncertainty regarding the use of electrical power today. Additionally, the lack of functional and expensive infrastructure has further complicated the transition to electric power. Although these issues are expected to be resolved in a near future, most of the maritime logistical network will not fully embrace electric propulsion due to the limited energy storage capacity of batteries and the impracticality of using batteries for longer voyages, given their total weight and size requirements.

Keywords: Electrification, Regulatory instances, Batteries, Infrastructure, Logistical network, IMO, EU.

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ACRONYMS AND TERMINOLOGY

CO2	Carbon Dioxide
EC	European Commission
ETS	Emissions trading system
EU	European Union
GHG	Greenhouse Gases
GWP	Global Warming Potential
HELCOM	Helsinki Commission
IMO	The International Maritime organization
Li-ion	Lithium-oin
MEPC	The Marine Environment Pollution Committee
NGO	Non-Governmental Organization
NOx	Nitrogen Oxide
OPS	Onshore Power Supply
PB-acid	Lead-acid batteries
ROI	Retur in Investment
ROPAX	Car And passenger vessel
RPM	Revolutions per minute
SOx	Sulphur Oxide
TEU	Twenty foot-equivalent unit
UN	United Nations

1. INTRODUCTION

New regulations aimed at reducing pollution from various sources have become increasingly important in recent years. One area of focus has been the maritime industry, which is a significant contributor to air and water pollution (Bach & Hansen, 2023). As such, there has been a push to develop and implement new regulations and technologies aimed at reducing emissions and improving environmental sustainability in shipping. This has led to increased interest in the electrification of shipping, which has the potential to significantly reduce the environmental impact of the industry.

This report will explore the future, the past, and the current state of electrification in shipping in Sweden, as well as the opinions and perspectives of key stakeholders on the future development of this technology. Through interviews and analysis, the aim is to gain a deeper understanding of the opportunities and challenges associated with electrification, as well as the potential pathways for future development.

As the maritime industry seeks to reduce its impact on the environment and meet increasing regulatory pressures to reduce emissions. Initiatives have been made such as the one from the International Maritime Organization (IMO), derived from the United Nations (UN) multiple sustainable development goals in which they aim to reduce the amount of greenhouse gas emissions produced from international shipping in half, by the year 2050 (IMO, 2018). This has resulted in for example regulations that limit the amount of sulfur that can be used in fuel or the newly introduced green shipping corridors.

Electrification of ships involves the use of electric power sources, such as batteries or fuel cells, to propel vessels, reducing or eliminating their dependence on fossil fuels and associated emissions. The shipping industry right now, contributes to 3% of the annual greenhouse gas emissions, which are assumed to increase by 150-200 % by 2050.
Consequently, the maritime industry is currently confronted with the imperative of substantial greenhouse gas (GHG) emission reduction in alignment with global efforts to mitigate the impacts of climate change. The transition to electrified vessels is therefore seen as one of the key steps in reducing these emissions and improving the sustainability of the sector (Bouman et al., 2017).

Sweden, with its strong maritime heritage and commitment to sustainability, is well-positioned to play a leading role in the electrification of shipping. The country is home to several companies working on electrification and has a supportive regulatory environment that is encouraging the development and deployment of electrified vessels. As electrification of shipping continues to evolve, it is important to understand the challenges and opportunities facing this transition, and the role that stakeholders, including companies, governments, and Non-Governmental Organizations (NGO), will play in shaping its future.

1.1 Background

A great number of industries are today ready or in a process to transit from conventional fuel to fully electrified, and they are slowly but surely trying to solve the problems that comes with it (Wei et al., 2019). The Shipping industry however has been slow in its progress to adapt towards electric energy. (Wei et al., 2019). Whilst the shipping industry is slow to adapt to new ways in general, and their approach towards electrification is also encapsulated by this (Perčić et al., 2021).

1.2 Aim of the study

The aim of this research study is to gain insights into the current state of electrified shipping in Sweden and examine industry stakeholder's perspectives on the future development of this sector. This research study is made to showcase the current progress and identify areas where future advancements are most advantageous, as well as areas that may encounter challenges due to technological constraints.

1.3 Research questions

- *How does the future of electrification within shipping look like?*
- *What are the barriers for the future development into electricity?*
- *What are the incentives to change to electric propulsion system?*

1.4 Delimitations

This study will limit itself to focus on Sweden and Swedish stakeholders within the shipping industry. The mode of transport will only be water based as per research question. This study is not made to show the difference in the present or future technology of electrification, but to showcase the current and future limitations/hardships the shipping industry will face because of the need to lower its emissions. Whilst important this study wont focus too much on the “conventional” fuel types nor focus on any type of transport, just that its need to be commercially used and on the sea.

2. THEORY

This chapter aims to provide a comprehensive overview of the electrification industry's status. It covers the existing regulations and laws in this field, as well as the technological and infrastructural advancements that have taken place over the past decade or two.

2.1 Current ship types that uses electric power.

In the beginning of 2023, the world merchant fleet consisted of a total of 103 000 ships according to the United Nations Conference on Trade and Development (2022). Based on statistics procured by the database “Alternative fuels insight platform” provided by DNV GL (2023), 586 of these were either fully or part-electrically powered. Which means an equivalent to less than 0,6 percent of the total fleet of the world. Out of these 586 ships, 23 percent were pure-electric, 20 percent plug-in hybrids and 51 percent hybrids according to the same database.

The database also provides some insight into the progression of the worlds electric fleet and shows how there has been a growth of 325 percent in the last five years, the battery fleet has grown from 180 ships in 2018 to 586 in 2023 and with at least another 195 currently on order for delivery in the year 2026 (DNV GL, 2023).

These ships are primarily categorised as “car/passenger ferries” (ropax) amounting to 43 percent of the worlds operating electrical fleet. “Offshore supply ships” is the second largest identified category with almost 13 percent and the rest of the categories individually corresponding to less than 5 percent of the total fleet (DNV GL, 2023a).

As of today, there are a few ships operating in the Swedish fairwater that are driven through electrical power. The main segment for these ships is currently within the ropax or pax market and are in the smaller size-range, largely consisting of ferries or offshore-ships (Sjöstrand & Lindgren, 2022). One of the reasons for this is because these types of ships usually operate at suboptimal revolutions per minute (rpm), due to the characteristics of their routes. While larger ships such as container ships operates at more constant levels of speed, designed for the most favourable performance of a diesel-engine (Sjöstrand & Lindgren, 2022).

Though it has been made some investments in other segments of the maritime market. One of these are the ship Yara Birkeland, which is the result of a collaboration between the Norwegian industry conglomerate Yara International ASA and the technological company Kongsberg. Yara Birkeland is the world’s first fully electric and autonomous container vessel, producing zero emissions and will according to Yara International ASA reduce the need for 40 000 diesel-powered truck trips per year (Yara, n.d.).The ship with a capacity of 120 twenty-foot equivalent unit (TEU).

Yara Birkeland which was introduced in the spring of 2022, will operate between Herøya and the port in Brevik at 7 nautical miles and with plans of potentially adding another port call at in Larvik at an estimated distance of 30 nautical miles (Kongsberg, n.d.). Hybrid electric ships, which combine traditional combustion engines with electric propulsion systems, are becoming an increasingly popular option in the maritime industry and corresponds to 71 percent of the worlds battery fleet (DNV GL, 2023b). These ships offer several advantages over traditional vessels, including increased fuel efficiency, reduced emissions, and improved performance (Sui et al., 2020a).

One of the key features of hybrid electric ships is their ability to switch between different power sources, depending on the conditions and operational requirements. For example, they may use traditional diesel engines when traveling at high speeds, and switch to electric propulsion when manoeuvring in port or operating in areas with strict emissions regulations (Sui et al., 2020b).

2.2 The current regulation and incentives.

International shipping is responsible for a significant amount of global air and water pollution. To address this issue, various regulations and policies have been implemented at both the national and international levels (Christodoulou & Cullinane, 2020).

2.2.1 International regulations

Sweden is a member of many international organizations, including both the UN and the European Union (EU). That means that a lot of the laws and regulations constructed these organizations gets ratified into Swedish law and apply to the Swedish shopping sector. EU laws, even overrules already established Swedish laws if they contradict each other (*EUR-Lex - Primacy_of_eu_law - EN - EUR-Lex*, n.d.).

2.2.1.1 MARPOL

The IMO is a specialized agency of the UN, responsible for regulating international shipping. Its main role is to promote safe, secure, and environmentally sustainable shipping through the development and adoption of global standards and regulations. The Marine Environment Pollution Committee (MEPC) is a sub-organization of the IMO that is specifically responsible for drawing up regulations to prevent ships from polluting the ocean and the atmosphere (Han, 2010).

One of the most important international agreements developed by IMO regarding the prevention of pollution within international shipping is MARPOL, or the International Convention for the Prevention of Pollution from Ships(IMO, n.d.). Formulärets överkantThe MARPOL convention was first signed in 1973 and was later modified in 1978, several addendums has been added during the years and today, the convention contains six annexes. Were of Annex VI focuses on the prevention of air pollution from ships, particularly emissions of sulfur oxides (SOx), nitrogen oxides (NOx), and other harmful pollutants. It sets limits on emissions and requires ships to use cleaner fuels or emission control technologies (Han, 2010).

The MARPOL treaty has been ratified by more than 150 countries, including Sweden (IMO, n.d.).This means that the regulations of MARPOL have been implemented into Swedish law and is applicable to all ships with Swedish origin or ships traveling through Swedish-controlled waters (Transportstyrelsen, 2009a).

2.2.1.2 Paris Agreement

The Paris Agreement is a global effort to address climate change, adopted in 2015 by 196 countries. While the Agreement primarily focuses on reducing greenhouse gas emissions from various sectors, including transportation, the shipping industry was not explicitly included in the initial agreement (Unfccc, n.d.). However, in 2018, the International Maritime Organization (IMO) adopted a strategy to reduce greenhouse gas emissions from international shipping, which aligns with the Paris Agreement's target of limiting global warming to well below 2°C above pre-industrial levels. The strategy aims to reduce total annual greenhouse gas emissions from international shipping by at least 50% by 2050 compared to 2008, while also pursuing efforts towards phasing them out entirely. While the strategy is not legally binding, it provides a framework for the shipping industry to work towards reducing emissions and meeting the goals of the Paris Agreement (Bach & Hansen, 2023).

2.2.1.3 EU

The slow process of the IMO has according to the EU triggered the development of their own strategy to reduce greenhouse gas emissions from the shipping industry, since they believe that there are to date no adequate solutions in place to meet the goals of the Paris agreement. The strategy includes monitoring and reporting CO2 emissions, setting reduction targets for the sector, and implementing market-based measures (European Commission, n.d.).

European Commission adopted the 'Fit for 55' package, a series of legislative proposals aimed at delivering the European “Green Deal” and reducing net greenhouse gas emissions by at least 55% by 2030. Among these proposals where several measures to reduce the climate impact of maritime transport, including extending the EU Emissions Trading System (ETS) directive to the sector, setting a maximum limit on the greenhouse gas content of energy used by ships calling at European ports to boost the demand for low-carbon fuels, accelerating the supply of renewables, and revising the Energy Taxation Directive.

The ETS is an economic incentive system where stakeholders are permitted a certain amount of emission rights and if said amount is exceeded, the stakeholders are obligated to purchase more or face repercussion. The system will be applicable for all members of the European union and is being implemented gradually starting 2023, coming into full force 2026 and will affect 100 percent of intra-

EU voyages and at berth in EU-ports, as well as 50 percent of the emissions for extra-EU voyages to/ from an EU port (European Union, 2018). These measures aim to improve energy efficiency and promote the use of cleaner fuels. The EU will also support research and innovation towards decarbonization of maritime transport (European Commission, n.d.).
Formulärets nederkant

2.2.2 National regulations

Sweden, a country that has set ambitious targets to become fossil fuel-free by 2045 (Naturvardsvarket, n.d.). Due to the international characteristics of the shipping sector, most of the regulations with the intent to reduce pollution from shipping are of international descent (Transportstyrelsen, 2009b). The most prominent one being MARPOL. Additionally, supplementary measures concerning ship pollution prevention are delineated in various resolutions and codes promulgated by the IMO, recommendations by the Helsinki Commission (HELCOM), as well as directives and regulations issued by the European Commission (EC). These provisions have been integrated into Swedish legislation and regulations to ensure their applicability within Sweden (Transportstyrelsen, 2009b).

2.3 Electrification

When a vessel is using electric power for its propulsion system there will be a lot of positive effect, but to fully utilize electricity one needs both good batteries and a quick and easy access to a predetermined place of charging. Whilst this will create new problems and/or opportunities, the positive effect will most likely outweigh the negatives (Tarkowski, 2021).

2.3.1 Environmental aspects

The electrification of ships has the potential to provide significant environmental benefits. One of the primary benefits of electrification is a reduction in greenhouse gas emissions, which are a leading cause of climate change. By using electricity as a power source, ships can eliminate or reduce their use of fossil fuels, which emit significant amounts of carbon dioxide and other harmful pollutants into the atmosphere. In comparison, a diesel-powered vessel emits approximately 2.9 g carbon dioxide (Co_2), 17.84 g sulfur dioxide and 43.6 g of nitrogen oxides per ton of combusted heavy fuel oil (Statistisk sentralbyrån, n.d.). While an operational fully electric ship emits zero emission.

This is though only during the actual operation of a vessel. According to a study also taking in the consideration of the origin of the electricity, was made in South Korea. Which resulted in using batteries instead of diesel engines would potentially reduce 35.7% of the global warming potential (GWP) and does therefore not truly emit zero emission in practice. This is due to the consequences of the environmental impacts connected with the production and transportation of electricity that contribute substantially to the total impact. The same study therefore also suggests that battery powered ships would be effective in countries with higher proportion of renewable energy production, but less effective in countries were production stem from fossil sources (Jeong et al., 2020).

Sweden is one of those countries where a large proportion of the electricity generation comes from renewable sources. In fact, does 45 percent come from hydropower, 17 percent from nuclear power, 17 percent from wind power and 1 percent solar power. While the remaining 8 percent of Sweden’s electricity generation is derived from combustion-based power (Swedish Energy Agency, 2022).

Another potential benefit of electrification is a reduction in noise pollution. Ships that use fossil fuels may produce high levels of noise, which can be disruptive to both marine life and nearby communities. Electric ships, on the other hand, are generally much quieter, which can help to minimize these negative impacts, especially in the processes of docking and discharging from ports (Anwar et al., 2020; Perčić et al., 2021).

At shore, it is also possible for hybrid ships to connect into the shoreside power supply. Instead of operating their auxiliary engines to produce electrical power for the ships, which may represent up to 15 percent of a ships total fuel consumption but also reduces the pollution in ports significally (Sui et al., 2020a). According to Walker et al., 2018)), the adoption of onshore power supply (OPS) systems results in a complete elimination of all emissions that otherwise would have been produced by onboard power generation using other types of fuels.

2.3.2 Reduced operation costs

As batteries are one of the main components in a fully electrical driven vessel as well as in a hybrid vessel, the price of the battery will then be highly important. And the cost has decreased a lot over the last 10 years, this is mainly since the technology is not new, but the production has gone up in total volume. Whilst this is important for the whole industry there is some concerns from the scientist side about the availability of some of the materials used in the batteries (Anwar et al., 2020).

The batteries used will be the substitute for the more conventional fuel tanks used in most vessels today, and according to Tarkowski (2021), using an electric propulsion system will lower one's "fuel" consumption. Meaning that the electrical prolusion system is more efficient in its capabilities to utilize its fuel to a higher degree. This does mainly only apply to newer models in the industry, and difference compared to the older models are that the newer propulsion systems models can convert a higher proportion of its energies which is stored in the batteries, this will result in more propulsion with lesser amount of energy. Due to the nature of how an electrical propulsion system works it will have a lot fewer moving parts in its system, this will inherently make the operation cost lower. Since fewer parts will be needed to change over time (Tarkowski, 2021)

2.3.3 Charging infrastructure

Sweden is making significant progress in the electrification of its transportation sector, including the use of electric ships. When it comes to the use of onshore power supply a lot of the major ports in Sweden are developing their infrastructure to be able to accommodate ships seeking this possibility. In the year 2000 the port of Gothenburg for example became one of the first ports in the world to commercial on power supply(Kumar et al., 2018). And in 2023 the same port also became one of the first in the world to be able to connect onshore power to tankers in an area classified as highly explosive (Port of Gothenburg, n.d.). However, there are still some challenges that the country is facing regarding the charging infrastructure for these vessels.

One of the main issues with the charging infrastructure is the lack of standardization in charging technology. Different manufacturers have developed their own charging systems, which are not always compatible with each other (Karimi et al., 2020). Another common technology difference is the power frequencies between the shore-side electrical grids that typically uses 50 Hz and the on-board electrical networks that mostly uses 60 Hz. This lack of standardization poses a significant challenge for both ports and shipowners, as they may need to purchase and install multiple charging systems to accommodate different vessels or invest in frequency and high voltage converters which can be both time-consuming and costly(Krämer & Czermański, n.d.; Kumar et al., 2018).

Additionally, there are concerns about the capacity of the electric grid to support the charging of large electric ships. As the number of electric ships continues to grow, there may be a strain on the electric grid, especially during peak demand periods. This could lead to power outages and other disruptions, which could negatively impact the reliability of electric ships(Krämer & Czermański, n.d.; Kumar et al., 2018). Electricity scarcity in urban or regional areas can hinder the implementation of high voltage onshore power supply (OPS) systems due to the inadequate capacity of local grids, particularly in smaller cities. To establish OPS systems in such locations, substantial investments are necessary to upgrade and transform the ports electric network. Furthermore, the source of electricity must be considered, as only renewable energy sources should be utilized to supply shore power to ships to benefit from the sustainable advantages (Jeong et al., 2020; Krämer & Czermański, n.d.; Kumar et al., 2018).

2.3.4 Limited battery capacity

Due to the vast length of a voyage for an ocean-going vessel, there is a massive need for energy to make the ships engine to keep moving. Today however the is no option for such a vessel to transit from the old fuel such as fossil fuels to an electric propulsion system that use of energy stored in batteries. Since the number of batteries needed for any longer length of voyage would be enormous. Not only would the number of batteries be high, the laytime of each voyage would also increase a lot since ships will need to be recharged, which takes a lot of time depending on the port's infrastructure, and because of the amount of energy needed. (Tarkowski, 2021).

Whilst the price of batteries is dropping at rapid pace (Anwar et al., 2020), the energy it carries has not changed in with the same pace needed for the shipping industry. During the last 20 years there have been a lot of new technology in batteries and the performance has been increased a lot, and different types of batteries can give one the power they need, and choosing one's batteries will be important due to fact that each one will have a stronger point or weak point depending on its use. The two most used types of batteries are, Lead-acid batteries (PB-acid), and Lithium-ion (Li-ion) (Per et al., 2022).

2.3.5.1 Lead-acid batteries

PB-acid batteries as its more commonly known as are often utilized in more traditional vehicles to provide a rapid burst of high current of power, which is used for starting an engine, store electrical power whilst the vehicle is in operation, and provide power the electrical system when the engine is not running. These batteries are however prone to a shorter lifespan (5-15 years) and has a higher amount of defect in the production stage and are both heavy and bulky in size (Per et al., 2022).

The reason for actors to invest in such batteries is often due the lower cost around 165 €/kWh compared to the other available options on the market. Also, since they often have the same general lifetime in operation of 15 years, which industry standard as of 2022 its still highly useful (Per et al., 2022)

2.3.5.2 Lithium-ion

Li-ion batteries are currently the cutting-edge technology option for most fully electrical vessels. Li-ion batteries are composed of a cathode, anode, electrolyte, and separator. Li-ion batteries have an almost unmatched combination of important characteristics, this includes a high energy density of 200-700, which is a lot higher than its counterparts (Per et al., 2022).

It most important feature and biggest outlier is its amount of battery cycles, from 400 – 9000.
Meaning it has the highest amount of rechargeability of all the batteries on the market, which makes it the clear choice for fully or partial electric propulsion system today. Whilst the cost is high compared the other chooses, the prise has halved in the past 10 years, making it more of clear choice for actors making the transition into electrification (Per et al., 2022).

2.3.6 High initial investment

The shipping industry has high thresholds for new actors to join due to numerous reasons. One main reason for the high investment cost has to do with economy of scale, for instance vessels is not a massed produced product compared to other electric subsidies such as electric cars, whose prices is falling with the scaling of its production and demand, one can't do the same with sea vessels. Vessels are mostly highly customized for each individual customer and thus will rarely be any standardization when it comes to spare parts and components, thus resulting in the price being lowered slowly compared to the cars industry (Sjöstrand & Lindgren, 2022).

3. METHODS

This study was conducted using a qualitative approach and involves interviews with different marine transport companies operating within the shipping industry, as well as key stakeholders in the sector. This research study utilizes survey interviews as a qualitative research method, based on the Steinar Kvale's book "Den kvalitativa forskningsintervjun." Survey interviews are used to gain a deeper understanding of participants' perspectives, experiences, and attitudes regarding the chosen research topic.

3.1 Literature review

The literature review used in this study will mostly originate from different databases, mainly from the databases of Chalmers library and Google scholar. To evaluate the source's credibility and relevance to this research study, the CRAAP-test will be used to determine the information is to be determined suitable for the purpose this subject (Fielding, 2019).

Furthermore, governmental websites of the intended Scandinavian countries will be used to analyse the political influences on the matter. Other European authorities relevant to the future development of electrification within the maritime sector such as the EU and UN will also be examined to see how their supranationally influences the Scandinavian shipping market.

3.2 Thematic analysis

Thematic analysis is a qualitative research method used to identify themes and patterns in qualitative data. By organizing and categorizing the raw data, researchers aim to uncover underlying themes that emerge from participants' responses. In this study, the main themes that emerged from the analysis were:

- Regulation,
- Infrastructure,
- Technology,
- The general future.

These themes were prominent in the discussions among the interviewees, and a significant portion of the transcribed data revolved around these topics. The data that did not fit within these themes were deemed less relevant and discarded from further analysis, as it did not contribute significantly to the study. This focused approach allowed for a deeper exploration of the important themes and establish a deeper understanding of the chosen research topic (Kvale & Brinkmann, 1997).

3.3 Methods of interviews

The chosen method is the qualitative research interviews, due to its numerous positives and applications for this chosen subject. This is according to Steinar Kvale & Svend Brinkmann (1997) some of the positives: *in-depth understanding* from the industry and the reality and experience of the problems. *Flexibility*: meaning that the interviewer often adapts and give new question to the actor of whom they are questing, since new and interesting information can arise during the non-rigid format. *Context*: it's important to take abstract information and problems and put them into context of practicality, this often done with qualitative research method, since the theoretical information is then explained in the practical concept by the actors in the industry.

According to Kvale & Brinkmann (1997) one need to have a precise methodology and a well thought out plan to secure one's reliability and validity. Due to this fact and in accordance with the method of the qualitative research interviews there are seven step which will be followed:

Thematization – Which is defined as the purpose of the interviews and the research study. Which was done by defining the chosen problems in terms of the research questions want to ask or have answered by end of this report.

Design – How and what the actual question should be in this study. This was done by having a large question regarding the problems of the future of electrification within shipping, and funnel it down to a few different questions, that will as whole give a larger understanding of the given problem.

Interview – It's important to not have a too strict and rigid plan on how the interview should be conducted, it's important to have a natural flow and the person who's interviewed should be able to freely give his or her opinion on the question given. This is due to fact that new angels of approach might be created if the interviewee has no restrictions on the matter at hand. During this stage a lot of extra information given since the non-rigid aspect, thus also resulting in larger transcript stage.

Transcription – Which is done by listing and understanding ones recording of the interview, it's important to get the notation and non-verbal communication into text form also, since it might change the argument given. The transcript with through an ai program called *Transkriptor* which automatically made speech to text. Whilst effective it was still important that one listened to the whole recording and compared it to programs results and change what was wrong or was faulty in its transcript.

Analysis – To take the large set of data and take out the relevant information, this done by using different analysis methods, but it's important to find the patterns and the themes. Here its important to identify patterns and tendencies and important themes of the information collected.
By first setting up the three question that this research study wanted to have answered in the result, then thinned out the long transcription text, to fill in the questions, this part used thematic analyses as stated previous.

Verification – When the analysis is done, one need to turn back and compare the data which was extracted and compare it to the original data, this done to make sure that the data extracted is in accordance with the original data.

Reporting – The last step which is take the extracted and verified data and present it in a suitable way, such as a research paper or journal.

The main ide of choosing this research method for this specific study is to get the relevant understanding and experience from a small number of actors. And by choosing this method one will get an insight into the reality of the industry and by rigorously identifying personal biases and removing them, the result should then be close as possible to a window into the reality of electrisation in Sweden today.

3.4 Question asked to the selected actors.

What are the biggest or most prominent obstacles or problems today with electrification?

What incentives do you think exist to make the transition to electric power today or in the future?

How does the future of electrification with shipping look like?

3.5.1 Selection of companies

When selecting the companies to interview, the main objective was to find companies that already have or that are in the process of electrifying their fleet of vessels. The reason behind this is because companies working on the electrification of shipping have in-depth knowledge and experience in this field, providing valuable insights and information on the current state of the industry and the challenges and opportunities facing electrified shipping. It also enables to get more practical insights in how these processes are to complement the findings of the literature study. Except for companies operating the actual vessels, port-authorities are also a key stakeholder during an electrified transition of the maritime sector and are also of interest while conducting these interviews. The selection process for the company interviews were based on a chain-link referral system and began with the Port of Gothenburg, chosen for their position within the industry. Following their recommendations, Furetank was interviewed and subsequently recommended FORSEA.

FORSEA – Private ferry operator within the ropax segment, based in the south of Sweden. Operating fully electric vessel between Helsingborg to Helsingör.

Furetank – Private tank-operator based in Gothenburg, mainly operating within the Baltic- and Nordic Sea. The vessels are equipped with the option to utilize shorepower, as well as battery powered auxiliary engines.

Port of Gothenburg – The largest port in Sweden and the whole Nordic, the port has a reputation of being modern and efficient and is today on its way to be one of the few ports in Europe that can offer vessels to charge directly from the port itself. The port has also been working intensely with its sustainability goals.

3.5.2 The interviews

Port of Gothenburg –After a short email communication with one of their representatives, and a metting was confirmed on the twenty fourth of February. It was also confirmed that time and place of the meeting, which was 10.00 at their head office in the central part of Gothenburg. The meeting duration was 55 minutes which all was recorded on both the interviewees phones, to minimize loss of information. At 11.00 the meeting was finished and both partis seemed happy with the meeting, and the information given.

Furetank: After a short email communication with one of their representatives which was initiated on the first of mars, a meeting was confirmed on the twelfth of April at their headquarters on the outskirts of Gothenburg. The meeting duration was 40 minutes which all was record of both the interviewees phones to secure that no information was lost.

ForSea: After an extensive email communication with their representatives which started on the tenth of February, a meeting was confirmed on the fourteenth of April at 13.00. The meeting was online through a videocall due the geographical differences of both parties, one being in Gothenburg the other in Helsingborg. The meeting duration was 55 minutes with no digital difficulties. The whole meeting was recorded on both the interviewees phones, to minimize loss of information.

3.6 Ethics

In a research study there are ethical considerations when one is conducting interviews, and thus is important to ensure the well-being of the participant and the validity of the data. Thus, will this study be conducted with the following in mind:

- Obtaining informed consent
- Protecting participants confidentiality
- Ensuring honesty in representation of the data
- Respecting participants right to withdraw from the study at any time
- Avoiding harm or discomfort

The information obtained from the participants from the interviews was treated with utmost ethical consideration and care in accordance with established guidelines. Prior to the interview's, informed consent was obtained, ensuring that participants were fully aware of the purpose, procedures, and potential risks or benefits associated with their involvement. The possibility for confidentiality and anonymity of the companies were discussed, but not put into practice. Since it was not a desire from any of the participants. Personal identifiers, however, was removed and anonymized to protect the privacy and confidentiality of the individuals. The data was securely stored and accessible only to authorized researchers involved in the study. Requests for the submission of finalized interview transcripts were also made but were declined by all participants involved in the study.

4. RESULTS

In this chapter the accumulated and analysed information and data from the interviews will be presented and analysed using a thematic analysis method, and the major themes found was, *Technology*, *Regulation*, *Infrastructure*, and *the general future*. The different companies are divided into the actor A, B, and C. Which A is the representative of the Port of Gothenburg, Actor B is the representative of FureTank and Actor C being the representative of ForSea. The results have then been categorised into the three focus questions of the study to prevent repetitive statements and to deliver the results more clearly.

4.1 What are the biggest or most prominent obstacles or problems today with electrification?

The obstacles and the most prominent hurdles for the three companies are different but based most of the time on the same basic principle, *technology*. According to actor A the most prominent of the technological problems today is the carrier of energy, batteries. According to Actor A is the amount of energy needed to take a ship from Sweden to England would be enormous, and therefor the number of batteries needed would also be equally enormous, and all in all the vessel would be inoperative and too expensive to charter. And not only would the batteries take an especially long time to recharge since of the amount needed, the need for the correct infrastructure to recharge the batteries would also already be in place in every port the vessels would go to, which makes the whole operation not realistic according to actor A.

The same opinion is carried by actor B who is also inclined to think that a fully electrical vessel can´t be operational for longer distances or time frames. But the implantation of batteries is an option today in smaller quantities and operations. Actor B has stated and shown the future of their vessel which will include PB-acid batteries, which is less expensive than some other more modern options. And the uses of the batteries are numerous according to actor B. But the main reason for choosing a PB-battery is the ability for them to easily extinguish if there's a fire, since an uncontrollable fire on a tanker vessel would be catastrophic. Therefore, has Actor B chosen not to invest into the more modern batteries such as lithium batteries. The main reason for the implantation of batteries is so that they can charge the ship by using shore power. This however has, according to Actor B not been fully implemented due to the fact few ports can supply the necessary energy needed, and that there is no *regulation* to how tanker vessels should safely be charged from a port.

All three actors concur with the notion of the need for more regulation and guidelines to quicken the standardization and electrification in the industry. Actor B which uses shore power can´t today use it, according to them this is because there is no regulation of how to apply it or any written safety standard, even though they have installed all the equipment. They say that since there are no guidelines or regulations of where the electrical connection should connect from the vessel to the quay, they can't put it into full use yet.

Actor C who is one of the few that have gone with the fully electrical propulsion system and storage. The batteries used are the more modern lithium batteries that have undergone a major improvement according to the actor C. But they also think that there is a major problem with the accessibility of energy in both their port of arrival and departure since they recharge their batteries in both ports. They have noticed that especially in Denmark that the necessary amount of charge is not always fulfilled due their vast amount needed for their vessels, and thus must charge more in the Swedish port which can lengthen the laytime. According to actor C, the necessity of the vast amount of power is one of the main obstacles today with electrification, and they think this is highly due to the need for better *infrastructure*.

Both actors A and B concur with the fact that infrastructure plays a major part in the hurdles they face when it comes to electrification, but not with the same things. Actor B who is a tanker shipper is more inclined that implementation of the safety of infrastructure and the regulation around it, and they think that the need of regulation is major part why ports don't build better and more capable infrastructure, since they don't want to build something and in a few months the new rules is published and that they would need to rebuild or demolish the newly build infrastructure, if does not comply with new rules.

Actor A however represents a major port in Sweden and according to them they don't have problems with the energy capabilities in its port, because there are a lot of other major industries near them. This has given them a natural advantage in the electrification process, and they think that the ports in general will need to build more new infrastructure that include electrification in its plans. And they think that those who have not begun building with electrification in mind are going to be left behind. Actor A also mentions that there are problems in some of the largest ports in Europe, with not having enough charge or power in the electrical grid, which will only get more intense as the time goes by.

Actor C who operates in proximity to a medium sized city had to make big investment into its electrical grid, which meant not only a large capital investment, but also a large infrastructural project, which include digging up right the central parts of the city to lay new high voltage cables. This they think will be a major hurdle or obstacle for a lot of ports and cities in the world.

All three actors agree with the fact that the few regulations regarding electrification have made the standard around the globe almost non-existent. According to Actor C two ships from two different places can´t use the same type of shore connection to charge its batteries during their laytime. Since different nations will use different hz in its electric grid on the vessel. According to actor A the Swedish standard is to use 50 hz whilst in the USA they use 60 hz. Reason for the difference is because of the making of the vessels the shipbuilders did not think of having the vessel ever connected to the shore for electricity, and there were and still isn't any regulation regarding how the much hz the vessels should have. This will create problems according to actor A, since for each vessel they will need to ask its hz and then change its equipment to accommodate the vessel's hz and charge, which is not an easy and simple task.

The need for regulation has also been voiced by Actor C who needed to make a full massive declaration in terms pages and information to the Swedish traffic agency, since they were so ahead of what is regulation and ruled.

4.2 What incentives do you think exist to make the transition to electric power today or in the future?

A common denominator among all three participants was the opinion that there is a lack of distinct incentives for stakeholders to make investment towards a transition to electrically powered vessels. And that all the participants, mainly, have begun their transition based on their own accord. Actor A described that the changeover is driven more by the industry stakeholder, than it is by political guidelines or current regulations and continues to say that the politicians mainly observe and try to support where they are able. But that they've lost the position of leading the change to the industry.

The participants of this study all agree that clear incentives from the government or international organizations could make the transition to electrical power quicker and more efficient. Actor C describes how it is imperative for all private companies to turn a profit to accumulate capital which will be invested in new technologies and how these investments also need to generate a positive return on investment (ROI). Actor C also adds how their investments till this day have generated an ROI that would be considered as too low in many parts of the world. He therefore suggested how incentives in the form of lower energy-taxation on electric power or decreased fairway fees for vessels using electric propulsion could make the transition more attractive for other actors within the industry.

Actor B also mentioned how a decreased cost would be beneficial for the electrically powered vessels, but also stated how he believes that an increase in taxations of other fuels such as marine oil would incentivize more companies to turn to greener sources of energy. Since it would make electricity more economically appealing in comparison. All the participants also explained how one of the reasons they've decided to make these investments despite the lack of a financial incentive, is due to the belief that there will come regulations and demand for this transition in the future and they therefore want to be ahead instead of being left behind. Actor A shared his opinion on how it can be perceived as a business gain to be a little ahead to keep regulatory requirements, authorities and politicians satisfied and keep the demands away from yourself.

Actor C describes how their ambitions of becoming the world's first zero-emission shipping company, combined with the fact that they operate close to the city centres of both Helsingö and Helsingborg, is another reason for the transition. Since the need to reduce emissions is utterly more important in areas that's nearly populated. Which Actor C also believes is a hedge against competition. The effects of less pollutions in the form of particles and natural gases, as well as noise is also something that both Actor A and B brings up as something positive in the terms of the social aspects of the personnel working at or close to the boat. But also, for the nearby communities and environments.

4.3 How does the future of electrification of shipping look like?

Based on the different stakeholders interviewed in this study, most of the participants spoke about electrification in positive terms and that the current development within the segment seemed bright. Actor C states in his interview that he thinks that within the next 15 years will be a tremendous transition across many of the different maritime segments and emphasizes that there are solutions present today. But that the distance that can be electrified is getting longer all the time while the price of implementation has decreased since they transformed their ships by about 50%.

Actor B is hesitant in the remark of going fully electric on their vessels and refers to the characteristics of their trade operations. Since his company operates on the spot market and therefore employs their vessels on different routes depending on demand, he believes that it would be difficult for their ships to operate on fully electrical propulsion. He continues to exemplify though that they would be willing to invest in a fully electric vessel if they were to receive a contract of affreightment reaching over several years, between a predetermined route. And that an investment would therefore be economically justified. Actor B is more convinced that there will be an increase in hybrid ships in the coming years and that the use of battery powered auxiliary engines along with a more common use of shore power among the maritime operators is more plausible in the future. The use of shore power is something that all the three actors interviewed agreed will be used far more in the future, once rules and regulations are in place. As well as standardized procedures have been developed.

Actor A believes that ports in the future will be a substantially greater electricity consumer in comparison to what they are today, he further explained how ports today are still mostly powered by diesel to operate handling equipment, fuelling trucks and ships. But that he can notice a trend among a lot of port authorities to transition more towards being able to provide a greater electric capacity and a more powerful grid to future-proof their competitiveness. He said that in the same way that port authorities today work with and develop railways, roads, quays, and waterways to stay competitive. They will work to establish good electricity grid capacity to stay relevant for the future growing need of vessels to charge through shore power, loading trucks and so on. And that this development will act as a core factor in the port's activities.

Actor A also explains that he believes fully electric powered vessels will only be possible in predetermined routes such as in ferry operations. And conveyed his shared doubts with Actor B about the future possibility to electrify all segments within shipping. An opinion that is also shared by Actor C, but who is more optimistic in the possibility of the technology.

5. DISCUSSION

The following part of the report is divided into three sections discussing the results of the interviews with connections to the findings in the theory, the pros, and cons regarding the selection of companies and finally the chosen method.

5.1 The result

This study began with the intention of mapping out the current and future development of electrical power's position in the transition towards a more sustainable shipping sector and the reduction of fossil fuels as an energy source.

The study was divided into three questions with the goal to determine what incentives that motivates the changeover and what obstacles current stakeholders are facing or have gone through to finally form a vision of the role that electrification might fill in the future of the Swedish shipping industry.

The first question concerns the obstacles and limitations of electrification, and the adoption of electric ships faces several challenges. One of the primary challenges is the lack of necessary infrastructure, the current charging infrastructure is in many places insufficient to support the widespread deployment of electric ships. As Actor C stated earlier, it will be difficult to obtain the same kind of development out in the archipelagos in Sweden where many ferries operate on a daily basis, as they themselves have done in the ports of both Helsingborg and Helsingör. This statement also aligns with the findings of Kumar et al. (2018), stating that less developed infrastructures may put a strain on the electric grid as the number of electric vessels increases and sequentially might lead to power outages. It also agrees with what Krämer and Czermański (n.d.) established, in that the electricity scarcity in smaller cities may hinder the implementation of high voltage OPS systems due to the poor capacity of local electrical grids. The development of new charging facilities and power supply networks will require significant investment, which could be a major barrier to the electrification of shipping, especially in rural areas.

The Swedish government could play a crucial role in facilitating the development of this infrastructure by providing support and investment to the private sector. Another obstacle is the lack of standardized regulations for electric ships. The current regulatory framework does not adequately address the unique characteristics of electric ships. There is a need for standardized regulations that consider the specific technical requirements of electric ships and ensure their safe operation. This could be achieved through collaboration between industry stakeholders, regulators, and policymakers to establish clear guidelines and standards. Karimi et al. (2020) for example describes how different manufacturers have developed their own charging systems, not compatible with all ships. While Krämer & Czermański (n.d) also explains that it usually also differs in the power frequencies between side shore electrical grid and on board electrical networks, both being time consuming and costly for vessels to adapt between the different systems. This information complies with the interviewed companies. Actor B explains for example how tanker operators are hesitant to install the necessities to connect to shore power, since they are yet to receive a decision by the regulatory instances about where the placement of the connector will be allowed. The absence of regulations and standardization therefore impede the development and even discourage efforts by the private shipowners.
The limitation of battery technology is also a significant challenge for the electrification of shipping. Although batteries have improved significantly in recent years, the energy density and durability of current batteries are still limited (Anwar et al., 2020). This poses a significant challenge for long-range shipping operations, as the capacity of batteries is insufficient to support extended periods of operation (Tarkowski, 2021). As in the case of Actor B who operates on the spot market, thus not being able to be fully reliable on battery power. The technology is however suitable for operators such as Actor C that conducts travels between predesignated routes, to which the batteries are possible to design for that specific route. Further research and development of new battery technologies and energy storage solutions are however necessary for batteries to be suitable for all segments.

Addressing these challenges will require collaboration between industry stakeholders, policymakers, and researchers to develop a clear roadmap and strategies for the transitions. The Swedish government as well as international organizations such as the EU or IMO could play a crucial role in facilitating this process by providing support and incentives to the private sector, encouraging research and development, and promoting the adoption of regulations and technical standards.

The second questions encircle the incentives to why one would electrify their vessels today or even in the future and what factors that advocate for the technology. One of the most significant incentives is the environmental benefits of electric ships, which can help reduce greenhouse gas emissions and improve air quality in port cities (Walker et al., 2018). The electrification of shipping can also, as Actor B stated, help improve energy efficiency, as electric motors are more efficient than traditional combustion engines.

In addition to these environmental and energy efficiency benefits, the participants of the interviews all believed that incentives from the Swedish government, the EU, or the IMO can play a crucial role in facilitating the transition to electric ships. Lower taxes and fees for electric- powered vessels can help reduce the cost of owning and operating electric ships, making them more economically viable and improve the ROI. This could be achieved through tax incentives, such as tax credits or rebates, or through regulatory measures, such as lower port fees for electric ships. Or even by increasing the taxes on other sources of energy, making electrical power more appealing.
Furthermore, incentives such as grants, subsidies, and funding programs can also help accelerate the development and adoption of electric ships. These incentives can be used to support research and development of new technologies and infrastructure, provide financial support for the purchase of electric ships, or facilitate the development of new charging infrastructure.
The EU has introduced several initiatives to support the transition to sustainable shipping, including the Green Deal, the ETS directive to set a maximum limit on the greenhouse gas content of energy, and the revising the Energy Taxation Directive (European Union, 2018). As well as increased funding to research and innovation towards the decarbonization of the sector (European Commission, n.d.). Which could be seen as a sign for future support and regulations that benefits the evolution of electrification of shipping.

The final question is the one with regards to the other questions that gives the possibility to ponder the potential establishment and usage of electric power as an alternative source of power. Which has been extensively turned down as the current objective for the future, whilst the application will be more extensive in the future, making the decision to fully transit will only be applicable for few actors in the industry today. This result has been explained extensively by all the actors who have been interviewed. The limitation of battery capacity makes it less feasible for companies operating at the spot or time charter market and are more likely to be established as a more usual source of energy in the shipping segments operating in predetermined routes (Sjöstrand & Lindgren, 2022). As for example in the case Actor B that carries passengers and cars on ferries, but also for ships like Yara Birkeland that carries containers and other goods between the ports in Norway (Kongsberg, n.d.). This points to the fact that the technology isn’t limited to a specific type of ship, but more depending on the intended usage of the vessels.
Instead, vessels operating with the intent to be more flexible such as Actor B will likely transition to hybrid vessels and the installment of shore power connections onboard. As it will also contribute to less pollution and higher fuel efficiency, without being fully dependent on electric propulsion.

Furthermore, all the participants believed that requirements for connection to shorepower at the ports eventually will come. Since both the EU and the Swedish government have introduced initiatives for reduction of pollution from shipping, both more regulations and incentives in the form of taxes and reduced fees is not unreasonable to be expected in the future (Naturvardsverket, n.d.).
As the price of batteries decreases, it is likely that the adoption of electric ships will become more widespread. Decreasing battery prices will make electric ships more economically viable, reducing the cost of ownership and operation (Tarkowski, 2021). This will increase the competitiveness of electric ships in the market, providing a further incentive for their adoption

5.2 The chosen companies

The selection of companies in this study, might be too small in quantity to fully translate to the actual opinions and reality about the actual view of electrification within the industry. However, the participants that partook in this study represented a wide variety of stakeholders within the Swedish shipping industry. The selection of companies involved both private and public actors, but also actors involved in different segment such as the tank segment, operating on charter terms, a ferry operator traveling pre-determined routes. As well as a public port authority, with the connections and insight in a lot of other companies within the industry. Meaning they together can provide a broader understanding, based in different circumstances and positions within the shipping market.

All these participants have also themselves invested in the transition towards electrification, this meant that they possess personal knowledge about the current development, struggles and possibilities with the technology. Although, potential limitation of selecting these companies is that they may have a vested interest in presenting a positive image of electrification to justify their investments. This aspect may lead to some bias in the information provided. Therefore, it is essential to consider this potential bias when interpreting the outcome of the study.

Efforts were made to further broaden the opinions by reaching out to other stakeholders, both in other segments. As well as companies, not working directly with electrification. But the respondents either did not respond or were unable to participate due to time constraints.

5.3 Method discussion

The chosen research method for this study, qualitative research interviews, has both positive and negative aspects to consider. Kvale and Brinkmann discuss potential flaws that may arise with qualitative research interviews, including the risk of personal biases from the interviewees, such as injecting their personal beliefs or making assumptions that could influence the collected data. This highlights the importance of critically evaluating and interpreting the information obtained.

Another factor to consider is the use of smaller sample sizes in qualitative interviews. While this may limit the generalizability of the findings, Kvale and Brinkmann (1997) argue that in-depth knowledge from relevant industry actors can outweigh the need for a large sample size, especially when there are few individuals with the necessary expertise and understanding of electrification within the shipping industry.

Additionally, the scarcity of informative sources in the relatively new field of electrification in shipping constrained the methodological choices. Whilst in other areas such as car or truck there is a multitude more written sources compared to the seaside of the logistical network. This made the choice of method quite limited, since there just a few actors operating in Sweden who has done major changes in terms of electrification.

Thus, the qualitative research study was one of the few realistic methods for this study, and more importantly to do a qualitative research interview. In Sweden and more importantly, Gothenburg has great variety of companies to choose from, comparatively to other cities and nation. Still there were only five or six companies in the area, which in of itself tells you how few actors has started to transit into electoral propulsion or storage in some way, in the world.

The chosen method was however a good option since this gave a more of an understanding of how the reality is, since the theoretical was not quite proficient enough to give a fuller picture. So going with the Kvale and Brinkmann´s idea of putting the information into context and the seven-step approach, to make this study was in our opinion the best way to go about it. Whilst as stated earlier the biases would be a problem since the researcher spoke to the companies who has made change, but the option to talk a company who hasn't made the change didn't seem logical to us, since one wanted to the answer from the industry how the future of electrification would look like, thus the few who has started already to change to it, should and could be the only who thoughts are relevant to talk to. Since if the limit were to these few companies who has changed, too instead do any within in the industry, it would instead choose from thousand companies, and there for making the option to broad. And not in line with the method that was chosen.

The validity of the study's results may be subject to questioning due to certain factors. Although the answers obtained from the participants are based on their actual experiences within their respective companies, the validity regarding the determination of future opinions on electrification development in Sweden could be compromised. This limitation arises from the relatively small sample size, which may not provide a sufficiently representative view to draw valid conclusions regarding future perspectives on the topic.
The reliability of the study also exhibits certain considerations. On one hand, the companies involved in the study sincerely shared their opinions on the subject matter, enhancing the reliability of the data collected. However, it should be acknowledged that if the study were to be repeated with the same companies later, there is a possibility that their opinions might have changed. As a result, the potential for obtaining different results from those concluded in this study suggests a lower level of reliability.

An alternative method for this study of electrification within shipping is the *case study approach*. This study involves an in-depth investigation and analysis of a specific shipping company that have undergone major electrification advances or changes. Researchers will then collect data through interviews, document analysis, and on-site observations. The case study approach will offer a wide and deeper understanding of the electrification process within specific contexts of shipping and provides rich qualitative data. However, findings may not be easily summarised and generalized, and careful case selection and data analysis are necessary. Case studies allow for the exploration of unique experiences and practical implications.

6. CONCLUSION

In conclusion, this study aimed to investigate the current and future role of electrical power with a focus on the Swedish maritime industry. The study was divided into three main questions: the obstacles and limitations of electrification, the incentives for electrification, and the potential future usage of electric power, and how the industry think it will look like.

The first question revealed that the adoption of electric vessels faces several challenges, including the lack of necessary infrastructure, the absence of standardized regulations, and the current limitation of battery technology. To make future change the need for collaboration between industry stakeholders, policymakers, and researchers is essential to overcome these challenges.

The second question identified environmental and energy efficiency benefits as the primary incentives for electrification, along with potential incentives from the Swedish government, the EU, and the IMO in the form of lower taxes and fees, grants, subsidies, and funding programs.

The third and final question explained that while the current usage of electric power may not be applicable for all actors in the industry today, it is likely to become more extensive in the future. The study emphasizes the importance of collaboration and incentives in promoting the transition towards a more electric and therefore more sustainable shipping industry.

Overall, this study provides valuable insights into the challenges, incentives, and potential of electrical power in the context of the Swedish shipping industry.

6.1 Recommendations for further research

We would recommend deeper investigation into how the regulatory agencies may incentivise the development of electrification, and how the current technological advances are hindered due to lack of said incentives.

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