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Conversion of ferries in the coastal areas

Towards a sustainable, accessible and integrated transportation

Master's thesis in Maritime Management

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DEPARTMENT OF MECHANICS AND MARITIME SCIENCES

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2023
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Cover: Ferry used on Orust to transport passengers and goods between Tuvesvik, Gullholmen and Käringön.

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Abstract

It is important to consider the ferry transportation of passengers and goods in the rural coastal areas. There is a lack of research in the integration of passengers and goods in the rural areas. This has resulted in the thesis whose purpose is to explore how the integration of passengers and goods in the rural coastal areas in Bohuslän could be improved. This includes the accessibility aspect, both for passengers and the goods. Further, the purpose of the thesis is also to explore the potential renewable fuels that could be used onboard the ferries. The method that was conducted was a multiple case study with a mixed method approach. The case studies were conducted on different islands outside of Tjörn and Orust and were conducted to explore the current situations and the differences. The collection of data was both quantitative and qualitative data collected by observations, interviews and questionnaires. The collection of data resulted in a triangulation that enabled comparisons between the different data collections.

The result showed that to increase both accessibility for passengers and goods, a floating pontoon together with hydraulic ramps could be used. It was found that if the accessibility for passengers increased, it could also lead to an improvement in the integration of passengers and goods. The design of the ferries needs to be developed to increase the efficiency of the integration of passengers and goods. Regarding the conversion to renewable fuel, the result showed that the best current solution would be to operate on battery ferries, together with a back-up system operating on HVO. An alternative to this could be to operate on a hybrid system with a smaller battery and HVO.

Key words: Integration of passengers and goods, accessibility, renewable fuels, coastal areas, ferry transportation, regulations, connecting infrastructure.

Konvertering av färjor i kustnära områden
Mot en hållbar, tillgänglig och integrerad transport
Examensarbete inom Maritime Management
SIMON ELIASSON & JOHN LARSSON
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Sammanfattning

Det är viktigt att ta hänsyn till färjetransporter av passagerare och gods på landsbygden i kustnära områden. Det saknas forskning om integrering av passagerare och gods i dessa områden. Detta har resulterat i denna studie vars syfte är att undersöka hur integrationen av passagerare och gods på landsbygden i kustnära områden i Bohuslän skulle kunna förbättras. Detta inkluderar tillgänglighetsanpassning, både för passagerare och gods. Vidare är syftet med studien att utforska de potentiella förnybara bränslena som skulle kunna användas ombord på färjorna. Metoden för studien var en flervals fallstudie samt en kombinerad metod. Fallstudierna utfördes på olika öar utanför Tjörn och Orust och genomfördes för att utforska nuläget samt skillnaderna. Insamlingen av data var både kvantitativ och kvalitativ data genom observationer, intervjuer och enkäter. Insamlingen av data resulterade i en triangulering som möjliggjorde jämförelser mellan de olika typerna av data.

Resultatet visade att för att öka både tillgängligheten för passagerare och gods kan en flytande ponton tillsammans med hydrauliska ramper användas. Det visade att om tillgängligheten för passagerare ökade skulle det också kunna leda till en förbättring för integrering av passagerare och gods. Utformningen av färjorna behöver även utvecklas för att effektivisera integrationen av passagerare och gods. När det gäller omställningen till förnyelsebart bränsle visade resultatet att den bästa lösningen i dagsläget vore att använda elektriska färjor, tillsammans med ett reservsystem som opererar på HVO. Ett alternativ till detta kan vara att operera på ett hybridsystem med ett mindre batteri och HVO.

Nyckelord: Integration av passagerare och gods, tillgänglighet, förnybara bränslen, kustnära områden, färjetransporter, regelverk, anslutande infrastruktur.

Table of content

Preface

Throughout the entirety of the writing process, the authors have received assistance from various individuals who have shown their support. Firstly, we would like to express our gratitude to our supervisor and examiner, Associate Professor Henrik Ringsberg from the Department of Mechanic and Maritime Sciences. Henrik has provided invaluable guidance and support throughout the entire writing process, and his expertise in the field of research has been particularly intriguing. Furthermore, we wish to extend our appreciation to the Chalmers library and specifically acknowledge Liza Nordfeldt for her valuable assistance. Liza has provided us with essential guidelines and resources that have greatly contributed to the refinement of our work. Lastly, we would like to express our heartfelt thanks to all the respondents and participants who willingly contributed their time and input during the data collection phase. Their valuable contributions have played a significant role in the success of our research. We are sincerely grateful to all these individuals for their unwavering support and assistance throughout our writing journey.

Göteborg March 2023

SIMON ELIASSON & JOHN LARSSON

List of figures

List of tables

1. Introduction

The introduction chapter presents background regarding transportation of passengers and goods in the rural coastal areas. The academic need is to explore the possibilities to integrate and convert the ferries in the archipelago in Bohuslän, Sweden. Further, the introduction chapter presents the purpose, research questions and limitations.

1.1 Background

The shipping industry is a crucial part of transportation from a global perspective. 80 percent of all the goods in the world have been transported by sea and the marine traffic is intense on the oceans. (UNCTAD, 2021). Västra Götalands Regionen (2019) argues that the accessibility in the rural areas is important to develop the society. It is mentioned that the accessibility to the transportation network is a prioritization from the region with the aim to increase efficiency of the public transportation. There is also a need to increase the sustainability and the infrastructure for public transportation. Västra Götalands Regionen also emphasizes the importance of an equal public transport where all passengers are considered and included.

Lindkvist and Melander (2022) describes the concept Mobility as a Service (MaaS) where the passengers should be able to book a transportation service through the use of a single digital tool. Västra Götalands Region (2019) also discusses the combined mobility to increase the transportation service. The use of MaaS could increase the accessibility for the passengers because of the shared service solution (Västra Götalands Region, 2019). Region Stockholm (2022) also discusses the need for increased accessibility for the ferry network. It is described that the current infrastructure needs to be developed to increase the accessibility for people with reduced mobility.

Ferries can be important for the people living in rural areas because they are the only way they can be transferred back and forth to their homes. A system that enables the planning of the combination of passenger and goods needs to be adopted where the space and utilization could be maximized in order to improve efficiency. Cavallaro & Nocera (2022) describes that the usage of a freight network integration and to improve the digitization of the booking could be a possible solution to increase the utilization and effectiveness. An adoption of this type of digitalization could be to digitalize the schedule for the departures, together with the goods that will be shipped. This could for example be implemented on a ferry network system (Cavallaro & Nocera, 2022).

The climate impact of the ferries can be considered in order to be a part of the United Nations (2022) sustainability goals that should be achieved by 2030. The ferries currently used could affect some of those goals negatively. For example, goal number nine about infrastructure, goal number 13 about climate action and goal number 14 about life below water (UN, 2022). Andersson et al. (2016) argues that battery as fuel could be an efficient solution for short sea shipping. The technology for batteries is very fast and the development with cost for this type of solution is rapidly decreasing. This would enable the ferries in those coastal areas to be driven with electricity instead of traditional fossil fuel and therefore not affect the environment to the same extent.

Maretic & Abramovic (2022) describes that it is challenging and complex to be able to plan and implement an efficient transportation network in rural areas. According to the authors, a major challenge is that the frequency of passengers in those areas is low, and it is therefore hard to find an economically feasible transportation solution. A possible solution is integrated passenger transportation where passenger and freight are combined in order to increase the efficiency in the transportation flow. By combining the different modes in the planning and implementation phase, it would be a more economical sustainable solution to adapt. It is also mentioned that to succeed with this integration in the rural areas, the pattern in the behaviors of the passengers could be beneficial to use. This could be performed with implementation of artificial intelligence to analyze and make the flow more efficient in the combination of the different modes. This is argued to increase the accessibility in those rural coastal areas. The authors also explain that the areas that used integrated transportation solutions had higher mobility and accessibility compared to those who had not implemented such a system (Maretic & Abramovic, 2022).

Makkonen et al. (2013) states that an important aspect to increase the accessibility in rural areas is support and involvement from the state. The willingness of the state and the politicians to preserve and protect the population is crucial for this success. This support and long-term plan, together with the investments lead to a well-functioning ferry network in many islands in the rural coastal areas of Finland. Another aspect that has led to the success is the authorities that oversee the implementation have shown an eagerness and willingness to invest in the equipment and tools that have been necessary to develop the ferry network. The authorities have been interested in the design and planning of the network and have also been responsive to the people living in those areas. These are other factors that are mentioned and argued to have led to the success of the transportation network of the ferry service in those areas. However, it is also noticed that there are still some areas in the archipelago that still lack an efficient ferry network, and this is factor that could be developed and improved (Makkonen et al., 2013).

Miller (2017) emphasizes that it is important that the port in rural areas cooperates with the local and regional economy and the different actors that are involved. This is important in order to develop the port and for the community living in those areas. The author also explains that it is important to notice that the cooperation with the local communities is different from more urban areas. Both in terms of an even closer cooperation, but also that the governance, planning and investments needs to be implemented in order to succeed in an efficient port in those rural areas (Miller, 2017). Despite published studies there is still a need to explore how this could be performed in practice in those areas.

This master thesis explores the possibility to convert ferries to renewable fuels used for coastal transport of people and goods. The master's thesis will consider the different aspects and how the technical infrastructure of the ports should be designed in order to supply the demand of renewable fuels. Further on, the thesis will explore how the transportation of passengers and goods could be combined in a more efficient way regarding accessibility. This includes the design of the ferries to increase the utilization and how the exchange of relevant information should be performed in an efficient way. The thesis also aims to examine how the infrastructure in those areas need to be developed in order to improve the efficiency of the transportation of the passengers and the goods.

1.2 Purpose and research questions

The purpose of this master's thesis is to explore the integration of passengers and goods in the coastal area. This includes the accessibility, both for passengers and goods in the ports and onboard the ferries. Further, the thesis will explore the conversion and design of the ferries.

- How can conversion to renewable fuels of coastal ferries used in integrated transport be possible from a cost, technical infrastructure, and regulatory perspective?

- How should ferries and connecting infrastructure be designed to facilitate integrated transport to increase accessibility for people and goods?

1.3 Limitations

The limitation of the thesis is to explore how ferries could be converted to renewable fuels. This includes the cost, technical infrastructure and regulatory perspective. The thesis also focuses on the design of ferries and connecting infrastructure and how to increase the accessibility for people and goods. For the renewable fuels, limitations have been made to some fuels which have been considered relevant, these are: Electric, hybrid, hydrogen, hydrotreated vegetable oil (HVO) and methanol. The thesis also has a geographical limitation, and the focus is on the Swedish coastal area. More specifically, the geographical areas are: Tuvesvik, Gullholmen and Käringön. Also, Rönnängs brygga, Åstol and Dyrön. From Tuvesvik on Orust, the ferries are transporting passengers and goods to both Gullholmen and Käringön. From Rönnängs brygga on Tjörn, one of the ferry operators is transporting passengers and goods to the islands Åstol, Dyrön and Tjörnekalv. However, the thesis will exclude the stop of Tjörnekalv due to the small number of passengers, goods and limited time. The thesis has time limitations where the exploration was conducted during the period between January and May 2023. This also resulted in a methodological limitation regarding the number of interviews, surveys and qualitative methods used.

2. Frame of reference

The frame of reference chapter presents the literature review regarding the integration of passengers and goods. This includes previous studies regarding accessibility, integration, infrastructure, and different regulatory frameworks. Further, the frame of reference includes different renewable fuels.

2.1 Integrated transport

Cavallaro & Nocera (2022) explore the option to use an integrated passenger and freight logistic solution. The aim of the integration between passengers and goods is to increase the efficiency and optimization of the logistic service. It is argued that this integration could result in lower capital investment costs and more accessibility and mobility. Although it is also mentioned that some other research found that this integration solution could have for example social challenges, especially in areas with low density flow. They mentioned that this is a field of study without a lot of research and the design of the vessel is not considered in the study. However, it is described that an area to improve is the digitalization of the integration network in order to increase efficiency. The study also argues that there is a potential for a more integrated passenger and freight logistics when the different transport modes are trying to decrease the cost of transportation. The cost will decrease if this type of service is implemented in an efficient way where the different actors cooperate with each other. It also emphasizes that the authorities need to facilitate the adoption of this integration (Cavallaro & Nocera, 2022).

Makkonen et al. (2013) also investigates the ferry network system and focuses on how to improve the efficiency of the system. Makkonen et al explores how this is performed in the rural archipelago of Finland and it is discussed that there are challenges for the transportation system in those areas. Compared to the number of people living in those rural areas, the network of ferries could be argued to work rather well. It is stated that in the areas where the population was higher, it was in general also a more efficient and available ferry network and infrastructure. It is emphasized that the biggest reason why the ferry network in those rural coastal areas is functioning rather well is that there has been a long-term plan from the beginning. It is discussed that the infrastructure and design of the ferry network was developed and designed under a long time (Makkonen et al., 2013). The design of the ferry network was also discussed in Cavallaro & Nocera (2022) and it was emphasized that the design needs to be implemented efficiently to be able to succeed.

As has been discussed by Cavallaro & Nocera (2022), Jansen (2014) also discusses the integration of passenger and goods and how these two transportation systems could be performed in an efficient way. It is mentioned that many of the rural areas today have problems with the integration of passenger and goods service and the research that has been performed is in the Netherlands. During the day where there is not that high traffic of passengers, the utilization of the transportation systems is low. This unused space could be used to transport the goods to the rural areas and would result in a higher utilization of the transportation system. The integration of passengers and goods would, according to Jansen, enable a more efficient transportation system and use the space available during lower trafficked times. It also discusses the last-mile delivery problem that exists in those areas. A suggestion to solve this last-mile challenge was to implement a drop-off station where goods could be stored. For example, a box is mentioned where the goods could be stored and protected until it could be transferred together with other goods. To have an efficient

integration of those transportation systems, Jansen explained that it is important to know how high the demand for goods transportation is and which volume that exists. According to Jansen, the design of the network is important to consider, and this was an aspect that was emphasized by Makkonen et al. (2013) as well. Jansen also emphasized that before the implementation of the integrated passenger and goods system could be performed, there are regulations and laws that need to be considered (Jansen, 2014). This could be connected to the aspect that was explained by Cavallaro & Nocera (2022), that it is important that the authorities facilitate the necessary aspects regarding the adoption of integrated transportations.

2.2 Infrastructure of multimodal ports

Yau et al. (2020) describes that the infrastructure of the port and the port as a smart port is important to be able to increase the efficiency of the operations. The use of information and communications technology is crucial in order to increase the effectiveness and also the sustainability of the port. Yau et al also emphasize that it is important that the different technologies and systems are integrated with each other to improve the information and communication between different actors. It is argued that the use of information and communications technology would decrease greenhouse gasses when the efficiency of the operations are improved (Yau et al., 2020).

Krile et al. (2021) also explores the modernization of the passenger port and the development of the infrastructure. Instead of the technology development described by Yau et al. (2020), Krile et al main focus is regarding the flow of passengers and goods in the port. A challenge that exists is how to solve the structure of the passenger port regarding all the services and processes that exist. Krile et al mean that it is important to consider the environment in the areas and which types of limitations that exist. Another challenge is to improve the accessibility in the port and ensure that there is enough space for the transportation flow of passengers and goods. It is explained that initial investments and the time needed is rather low for the implementation of the ferry service in comparison to other transport systems. The reason for this is because the main equipment needed for the service of the ferry to work is an adjustable ramp, which can easily be implemented. It is explained that the adjustable ramp is important because different needs and space could be demanded (Krile et al., 2021).

Acciaro et al. (2014) discuss the increased attention of the ports to become more sustainable and require new infrastructure of ports. As has been described by Krile et al. (2021), the port infrastructure is important to consider. Acciaro et al mentioned that ports need to develop and implement the necessary infrastructure to be able to supply the vessels with the new alternative fuels that exist. It is emphasized by Acciaro et al that to implement this in an efficient way, it is important to have strategies for energy management. Currently, there are not that many ports that are working with energy management and the study explains that this is a big challenge. Acciaro et al mean that this is because it is necessary to have an efficient flow of fuels and to be able to plan and coordinate the activities. It is argued that it is of great interest and benefit for the ports to be able to supply the fuels that are requested from the shipowners. They mention that it is important to have the right fuel bunkering facilities and services to meet this demand. It is also explained that it is crucial that the implementation and development of the infrastructure in the ports are in close collaboration with the authorities and regions. This, together with the implementation

of energy management strategies is important to improve the infrastructure and the energy efficiency in the ports (Acciaro et al., 2014).

2.3 Regulations in maritime shipping

Gagatsi et al. (2016) describes that the shipping industry leads to emissions because of the high volume of trade. It was calculated that the maritime sector is the second largest emitter of carbon emissions. Calculations from the European Union show that if there is no action taken, the emissions of sulfur dioxide and nitrogen oxide will be more than all other land-based transportations combined by 2030. This has led to the introduction of SECA (Sulfur Emission Control Areas) that was adopted in 2015. The SECA regulates the emission of sulfur to be maximum 0,5 percent of the emissions in the fuel. Kortsari et al. (2022) emphasize the urgent need for the shipping industry to reduce their emissions and argues that electrical ferries are an important area to investigate. Laasma et al. (2022) described many of the targets from the International Maritime Organization (IMO) and European Union (EU) to minimize the emissions from shipping. It is important to consider those smaller vessels as well because together they emit a lot of emissions.

2.3.1 Environmental shipping regulations

Sadiq et al. (2021) discuss that the port has grown attention from policies and regulations regarding their contribution to the climate effects. It is of great importance that the ports develop their operations and infrastructure in order to become more sustainable. There are a lot of challenges that exist and one of the greatest is the surrounding infrastructure in order to be able to supply all the potential renewable fuels that ship owners require. It is also emphasized that in order to become a more sustainable port, there has to be implementations of technology that could increase efficiency. It is argued that today, the infrastructure with, for example, renewable fuels are not in place and the technological development in the ports needs to be further improved. In the directive (EC/2014/94) it is discussed the deployment of new infrastructure for the alternative fuels that would enable ports to provide the necessary fuels to the shipowners (European Commission, 2014).

Al-Enazi et al. (2021) discusses the regulations that IMO has adopted and argues that this is an important action in order to reduce the emissions from the shipping industry. To succeed with the goal to reduce emissions, renewable alternative fuels are important to investigate. The greenhouse gas emission goal from IMO contributes to the move towards more renewable fuels. It is also argued that the Sulfur Emissions Control Areas have had a big impact on the interest for alternative fuels in order to comply with this regulation. It is noted that in order to reduce emissions it is important to consider the different benefits and challenges that exist with the different fuels. The importance of considering the aspects that are included in the choice of renewable fuels that exist are also emphasized in the study. The aspects that need to be considered are for example the distance, supply of the fuel, cost of the fuel, and which potential emissions that will be emitted (Al-Enazi et al., 2021).

In 2018, the International Maritime Organization (IMO, 2021) adopted a strategy to be able to reduce the greenhouse gas emissions from the shipping industry. The goal is to reduce greenhouse gas emissions by 50 percent by 2050, compared to the 2008 level. The aim includes eliminating the emissions of greenhouse gas emissions from

shipping as soon as possible during this century. It is also stated by IMO (2021) that the aim is to reduce the carbon intensity by 40 percent by 2030 and 70 percent by 2050, with a starting point in the 2008 level. In MARPOL Annex VI (International Maritime Organization, 2019a) some measurements are stated to track and reduce the greenhouse gas emissions from the shipping industry.

2.3.2 Ergonomic regulations in shipping

In Sweden, Arbetsmiljöverket (AFS 2012) states in paragraph 5 that the employer should ensure that the workplace and the work tasks should be designed in order to avoid long term use of similar positions. It is also stated in paragraph 6 that the workplace should be designed to reduce the handling load of the workers, especially regarding heavy lifts. The risks of manual handling are described, and it is important to consider different types of goods. For example, it is mentioned that heavy goods or goods that are too large could result in damage to the person performing the manual handling. Regarding the handling of goods on the quay, it is stated in paragraph 2 that there should be areas that are made for the transport of the cargo in order to secure a functioning handling. Those regulations include the handling of cargo carts which could be used in terminals and quays. It is also mentioned in the regulation that the person that is performing the handling could have injuries due to stumbling if the ground is uneven or if it is wet (AFS, 2012).

Arbetsmiljöverket (AFS 2001) states in paragraph 23 that goods cannot be stored on the quay that would hinder the mooring of the vessel. It is also important that the goods are not stored in places that makes the accessibility to the vessel harder. The distance between the goods on quay needs to be a minimum 1,5 meters in order to ensure the mooring and accessibility to the vessel. It is however stated that the goods could be placed closer to the quayside if it is that close to the quayside that nobody could not pass. It is described in paragraph 34 that it is important to not handle overloaded goods and if this is the case, it should be reciprocated. The protection of the personnel is also important to consider and equipment that is used to protect them is stated in paragraph 36. Protective helmets and protection shoes are important to use if there is a risk of injuries. In paragraph 37 it is also stated that if some accident is occurring, the right equipment should be available to minimize the damage to both the person and the goods (AFS 2001).

2.3.3 Regulations transport of passengers

The European Parliament (2016) describes that there are multiple risks associated with ferries that are combining passengers and goods. When an accident occurs, the damage could be dramatic, which could include that humans die, are injured or that goods are being damaged or destroyed. Those risks are also closely connected to the geographical areas where the ferry is operating, and the level of risk could for example be higher in open water compared to coastal areas. The risk that could occur onboard a ferry could have different reasons. It could for example be human or technological errors, but it could also be other reasons such as weather conditions or fire. There are rules and regulations regarding the safety and risks associated with the operations of ferries. These are regulations that have been implemented by the European Union, but also rules and regulations from IMO such as SOLAS (European Parliament, 2016).

According to the regulation by the European Union (EU, 2011) the definition of a disabled person is a person that has a reduction in mobility. This means that it can be a reduction of their physical, intellectual, or other disability issues. According to the European Union, reduction of mobility due to age is also an aspect that can be considered as a disability and therefore needs special service when transporting people. Zając (2016) mentions that it is possible to divide persons into different categories regarding their reduction of mobility. Some categories that are mentioned are elderly people, people that have difficulties walking, people that transport large or heavy baggage, and people that use wheelchairs.

Safety Of Life At Sea (SOLAS) is mentioned by the International Maritime Organization (IMO, 2019b) and how to secure the safety of the vessels operating at sea through equipment, construction and also through operation. It is described that smaller ferries also need to be emphasized under the SOLAS convention and that it is important that all ferries, including inland ferries adopt this convention. IMO cooperates with the organization Interferry with the aim to enhance the safety of non-conventional ferries and increase the safety of those (IMO, 2019b). According to the Directive of the European Parliament and of the Council (2009/45/EC) it is stated that ferries should have appropriate life-saving equipment onboard the ship. The equipment could for example be boats for rescue, life jackets and flares, among other safety equipment.

In the Regulation (EU/1177/2010) the rights of the passengers are described when traveling by sea and the regulations that exist. It is stated that the European Union is aiming for a level of safety that is as high as possible for the passengers and the level of safety that is stated in the regulations is the minimum level that is required. Transportation by sea should according to the European parliament be equal for all people in society and therefore it is important to have the same protection and accessibility regardless of any disability or reduced mobility. The passenger rights in the European Union also state that the use of different transport modes should be as easy as possible and the change from one mode of transport to another should apply the same safety requirements. It is also noted that the passenger rights included a safe operation and could for example be to consider different weather conditions such as strong wind and different water levels (European Union, 2010).

In the Directive (EU/2017/2110) it describes necessary procedures and inspection for a safe operation at sea. It is mentioned that before performing the voyage, it is important to check that the vessel is not overcrowded. This procedure should include the availability of seats and if there are some passengers or luggage that are blocking the passageways, emergency exits and stairs. It is also stated that safety equipment is needed onboard the vessel. There should for example be lifejackets available, emergency plans and equipment necessary in case of a fire (2017/2110). Another aspect to consider is the handling of dangerous goods and that the different dangerous cargoes are following respective regulations. It is described that it is important that there is some type of stowage plan if dangerous goods are placed onboard and ensure that the dangerous cargo is allowed to transport together with passengers. It is also important to make sure that the dangerous goods are marked with some type of label and stowed in the right way. The EU emphasizes that the dangerous goods need to be secured and separated from the passengers and other goods onboard. The carrier that is carrying the dangerous goods is also important to consider. This carrier should be secured in a safe way to make sure that the handling of the goods is performed safely.

It is also noted that the potential freight vehicle or carrier needs to be lashed in a safe manner and whether it should be lashed together with other goods or separately (European Union, 2017).

2.3.4 Regulations freight transport

Zhang et al. (2020) argues that the IMDG code is the most important regulation regarding the transportation of dangerous goods in the maritime industry. It is discussed that the risks associated with the transportation of dangerous goods are important to consider and strict regulations are required.

Baryshnikova and Li (2021) also mentioned that there is a risk with the transportation of goods with dangerous properties. It is explained that the risk of transporting dangerous goods can for instance have consequences for the environment, society and economy. Baryshnikova and Li also explain that actors involved in the process should follow some rules in order to achieve higher safety when transporting dangerous goods. Some of the rules mentioned are for instance that the actors should follow all agreements and available conventions, also that the dangerous goods should be transported in packages or containers that are intended for the transport.

It is described in the International Maritime Dangerous Goods Code by the International Maritime Organization (IMO, 2016) regarding the safety aspects for carriage of dangerous goods which can otherwise have an impact on persons, the cargo, the ship or the environment. As stated in the IMDG code, it is according to SOLAS prohibited to transport goods that classify as dangerous unless some certain requirements are fulfilled which is stated in chapter 7 in the IMDG code. The requirements are applied to dangerous goods transferred in packaged, bulk and solid form. It is also stated in the IMDG code in the regulation 11-2/19 in SOLAS convention, that if a ship wants to carry goods classified as dangerous, some requirements regarding the ships also need to be fulfilled. It should be noted that some statements in the IMDG code are still just recommendations, while others are requirements as stated in SOLAS. The code consists of details regarding all the different materials and substances that could be carried. It is mentioned that the code has been changed many times during the consequences of the development in the industry.

The IMDG code (IMO, 2016) describes that it is important to segregate certain types of goods in order to secure safety onboard the vessel. If two dangerous goods substances are incompatible with each other are necessary and the segregation could be different for different types of goods. It is also mentioned that a segregation could be to place some other type of goods between two incompatible goods to minimize the risks of accidents. Other types of segregation requirements could be that certain substances are sensitive to for example heat or must have a certain temperature to remain safe onboard the vessel. There are also requirements regarding if the dangerous goods should be placed fore or aft the vessel or if it is optional. These requirements depend on which type of dangerous goods that is transported and which type of segregation requirements that are applicable. For the stowage of the dangerous goods, it is stated that the loading and unloading needs to be performed by authorized personnel. The space where the dangerous goods are placed should be closed and no unauthorized person should be able to enter those areas. It is also mentioned that for example flammable gases or liquid that has a lower flashpoint than 23 degrees Celsius

should not be stored in a closed space onboard the vessel. In those cases, the goods should be stored on the open deck unless certain exceptions apply such as that the ventilation system in the closed space applies with the regulations (IMO, 2016).

In the IMDG code by IMO (2016) it is described how important it is that personnel who handle dangerous goods are aware of the risks and understand what the law says. In order to achieve higher safety, the code suggests that the handling is planned well and that personnel involved in the handling have training in the field. For people on the shore side, it is also necessary that they have training in the area to understand the risks involved in handling the goods considered dangerous. The persons that can be considered as shore side personnel are for example persons who load or unload the transport units that the cargo is being transported in (IMO, 2016).

There are also regulations regarding dangerous goods in the Directive of the European Parliament and of the Council (2008/68/EC). It is described that there are rules regarding the transportation of dangerous goods. It is stated that for inland waterways, there is an agreement in the European Union regarding the international carriage of dangerous goods (ADN). This agreement consists of regulations regarding the transportation of dangerous goods. However, it should be noted that these regulations need to be complemented with national regulations in the specific countries. The reason for this is to ensure that the regulations and transportation are working efficiently (2008/68/EC).

2.3.5 Regulations for integrated of passengers and freight

If the European Union is going to reach its climate neutrality by 2050, it is important according to the European Commission (2019) that the transport sector reduces its emissions. The shipping sector is, according to the European Commission, one of the sectors that is included in the transport sector and therefore the reduction of emissions must also be conducted in this sector. To achieve the reduction of emissions, one alternative to reach higher efficiency in the transport sector is to have multimodal transport. It is also described that the capacity for inland waterways needs to be increased in order to be able to reach the goals. To be able to increase the efficiency in multimodal transportation, it is argued by the European Commission that the traffic management system will be more automated. This, together with an increase in the digital mobility of the traffic system will, according to the European Commission, lead to an increase in efficiency. The increase in efficiency will also result in less congestion and therefore also reduction of the pollution in those areas (European Commission, 2019).

The European Commission (2023) emphasizes the importance of using both combined and multimodal transportation solutions. In order to provide increased efficiency and facilitate multimodal solutions, four general aspects could be considered. The first aspect is regarding the external costs that exist when transporting goods in different types of transportation modes. This could be for example social and environmental costs that need to be distributed among the different modes of transport in a sufficient way. The second aspect is regarding the necessary investments that are needed in the infrastructure in order to be able to achieve a more efficient connection between the different modes. The third step considers the use of information and how to use it in a more efficient way. It could for example be information regarding where the cargo is or the traffic situations. This would result in more accurate and efficient

planning between the different modes of transportation. The last aspect is regarding the support that is needed for intermodal transportation which is needed in order to make those solutions more competitive compared to other transportation solutions. The Combined Transport Directive (Council Directive 92/106/EEC) emphasizes the importance of the development of intermodal transportation in order to ensure the requirements that are necessary when combining different types of modes. It is noted that the measurements are needed to make sure that the combination of road and for example the sea transportation are efficient. The Combined Transport Directive aims to encourage the use of a combination of different transportation modes. They are trying to eliminate and facilitate the procedures that are needed by the authorities and the different types of restrictions that exist for combined transportation (Council Directive 92/106/EEC).

2.4 Sustainable fuels in short sea shipping

2.4.1 Electrical ferries

To be able to reduce the carbon dioxide and air pollutants, Kortsari et al. (2022) mentioned that an electrical ferry would create a better climate in the coastal areas. Especially in Europe where there are a lot of ferries being used and some people living on islands. But it is also beneficial for other coastal areas and inland waterways. According to Gagatsi et al. (2016) the implementation of electrical ferries could be one possible solution to comply with the current regulations and the possible future regulations. The demand for electrical power propulsion and battery increases and there is, according to Gagatsi et al, progress made in the field. The technology can be used in designing ferries that can transport passengers and for the coastal areas this could be an opportunity because of the shorter distances. This would also enable the ferries to charge in the port while the ferries wait for the passengers and goods (Gagatsi et al., 2016).

According to Sæther & Moe (2021) Norway has shown that they want to be in the front row when it comes to different types of solutions that make the shipping industry cleaner, where smaller vessels are included. Norway has added electrical ferries and hybrid ferries in the coastal areas in order to have a more sustainable transportation sector. In the study, it is mentioned that the implementation of the first electrical ferry in Norway led to a chain reaction where there have been multiple ferries which followed. Sæther & Moe explained that the reason for the change towards electrical ferries in Norway could be argued to be driven by political forces. They also explained that political forces could be strong and could be an important factor in the change to a cleaner shipping industry. Though, Sæther & Moe mentioned that it is still hard to fully electrify the ferry industry because there is still a lot of fossil fuels that are used and more common to use. The infrastructure that has been built up is in many cases intended for just fossil fuels. In Norway there have been some challenges with the infrastructure regarding for example upgrades in the power grid and where the power station should be placed (Sæther & Moe, 2021).

Costs

An evaluation by Kortsari et al. (2022) regarding the cost in the implementation of electrical ferries has been conducted in Denmark. The result showed that from a cost perspective, the electrical ferry prototype is a solution that is feasible. It was shown that the cost for constructions is higher than for fossil driven ferries and vessels. However, it could be seen that the overall operational costs for the electrical ferry were lower and particularly the costs associated with the energy and fuel. Kortsari et

al concludes that the payback time in 2022 would be between 5-8 years for the electrical ferries which could justify the shift towards this solution. One of the biggest costs in the construction of the electrical ferries is the battery, but as the technique and demand develops, the cost of the battery is expected to decrease. Another aspect to consider according to the study is the cost for the implementation of the electrical ferry is the power grid and infrastructure.

Kortsari et al. (2022) describes that for the future, it is preferable that the charging system that is needed is divided between different stakeholders and different ownerships of the whole system. This would, according to the study, lead to a decrease in the initial investment that is needed when designing and implementing the infrastructure connected to the electrical ferries. It could lead to reduced use of electricity because more ferries could share the same infrastructure and charging system (Kortsari et al., 2022). Williamsson (2022) also discusses the potential to reduce investments through shared ownership for the installation of charging systems. It is mentioned in the study regarding the infrastructure and costs related to the charging stations. The cost for the charging stations is considered as a fixed cost in the study and a cost of big importance since it is viewed as a large cost. It is also mentioned in the study that costs such as fire safety equipment for the charging station could be of significant value (Williamsson, 2022).

Technical infrastructure

Purnell et al. (2022) mention that the electrification of ferries has a lot of positive aspects, but it is important to consider all the potential obstacles and challenges that might occur. To reduce the emissions from the transport sector a lot of energy and electrification is needed in order to meet the increasing demand. A challenge that needs to be addressed is how the increasing demand for electricity will affect the electricity grids. It is explained that the electricity grid is in many places a system network for voltage that is low and the increased demand for electricity will lead to higher pressure on those networks. The electrical grids in areas where the network is mostly designed for low voltage have a challenge to handle the pressure on the network. Purnell et al explain the potential impact that electrification in the transport sector could have on the electrical grid. The result shows that the change towards a more electrified transport sector will lead to much higher peaks in electrical demand in many cities. This leads to higher peaks and could be critical for the electrical grid if the whole transportation sector was electrified (Purnell et al., 2022)

Bergek et al. (2021) also discuss the technical challenge with charging ferries regarding the short laytime they have in the port. It is emphasized in the study that different charging infrastructure technologies are tested to find the most effective ways of charging the batteries. The different charging technologies are also mentioned by Khan et al. (2022) and it is explained that it could for example be both wired charging systems and wireless charging systems. They also mentioned in the study that a charging system could be both fast charging but also a slower variant of charging which has an impact on the required time for charging the battery.

It is described by Gagatsi et al. (2016) the possibility to charge the batteries of the ferry when the ferry requires more electricity. As mentioned by Gagatsi et al, this is a process that requires both scheduling but also time. This is something that is different in comparison to ferries that are powered by traditional fuels. The charging of the ferries is also something that is mentioned in the study and that the charging creates a

pressure on the electrical infrastructure on land which also can be a constraint or barrier for the electric ferries. The operation of transferring electricity to the ferry from the infrastructure on land is also something that the text considers as a barrier. The reason for this is because the operations are done outside where there are contributing factors in the form of weather and wind which can make the transfer of electricity unsafe (Gagatsi et al., 2016).

Gagatsi et al. (2016) describes that there is also a technical challenge in relation to electric ferries and their energy efficiency. For example, the design of the ferries is not completely optimal. This is due to the weight of the ferries which is added by the batteries. Therefore, it would have been optimal to use composite materials, but there is currently a lack of beneficial legal frameworks to support this. This makes it a higher price to design ferries where the weight is reduced using composite materials. Gagatsi et al states that the human factor is a barrier in relation to electric ferries. For example, the competence of the ferry's crew is not completely up to date. This is also related to the fact that today there is a partial lack of training requirements for the crew in relation to the electrical operation of ferries. This creates a barrier to being able to operate the ferry efficiently. Also, it is mentioned in the text that the industry is not aware that electric operation is an alternative solution to the traditional fuels (Gagatsi et al., 2016).

2.4.2 Hybrid ferries

Al-Falahi et al. (2018) mention that there is a growing interest in the maritime sector to use more electrical power in the propulsion system. A complement or alternative to the fully electric ferry is a hybrid ferry. The authors concluded that using a Hybrid Power System and Battery Energy Storage System could reduce the emissions from the ferries. The reduction could be eliminated when the ferry is in berth and some reduction was also succeeded in the other part of the voyages. Another study by Ritari et al. (2020) investigated a battery system with a diesel engine. The study showed that the inclusion of a battery system reduced the fuel oil consumption. A conclusion is that the battery system did not even need to be used and still the ferry will reduce the fuel consumption. The main reason why the battery was beneficial was to replace the auxiliary engines, which are used in order to comply with the marine safety regulation regarding availability of power. It is argued that even if the battery system is not used, it will be beneficial because of the replacement of the auxiliary engines. One reason for this was because the maintenance costs decreased, the lifetime increased and the efficiency was higher (Ritari et al., 2020).

Costs

Anwar et al. (2020) describes that it is important to consider the cost in use of a hybrid ferry. They mentioned that the cost for the batteries for a hybrid ferry is lower in comparison to a pure electric ferry. This is because hybrid ferries use a battery with less capacity. Also, in relation to the use of a battery with lower capacity, the cost of charging will be lower in comparison to a completely electric ferry.

Ritari et al. (2020) argues that the installation of a battery system onboard the ferry would be economically beneficial. They mentioned that this was the case even when the battery was not in use, and just worked as a power source reserve. The reason for this was according to Ritari et al because the battery acting as a reserve source of power would be useful in a single diesel engine that could work on high efficiency. In contrast, they described that it would otherwise be more than one diesel engine that operates at a lower efficiency. According to the study, the battery would function

more as a reserve power for emergency situations when maneuvering was needed was another beneficial aspect of the battery according to the study. It is also discussed that another economic aspect is to know when the battery is an advantageous investment. Ritari et al also mentioned that the installation of the battery could reduce the operating hours by the auxiliary engines, which would lead to lower maintenance costs and increase the operating life cycle of those engines (Ritari et al., 2020). The cost aspect is also discussed in the study by Al-Falahi et al. (2018). Al-Falahi et al also mentioned the economic factors regarding infrastructure in port to be able to charge those potential electrical or hybrid ferries. The need for a shore power station is, according to Al-Falahi et al, an economic aspect that needs to be investigated in order to have the supply of electricity.

Technical infrastructure

Anwar et al. (2020) mention that the hybrid ferry is a ship that has multiple energy systems. This means that the ship has an engine but also a battery which can move the ship forward. A technical aspect of this is that it enables the ferry to drive longer distances without having to charge the battery in port. They mentioned the operation regarding the density of energy in the battery. It is also explained that if the energy density is too low, it can lead to the use of more batteries. It is argued in the study that this is a problem because more batteries occupy larger areas onboard the ferries. Kunicka & Litwin (2019a) mentioned the size of the battery and argued that by decreasing the size of the battery on the ship, the savings when constructing the hybrid ferry can be noteworthy. Charging the battery of the ferry from the electrical grid instead of using the engines could also have a significant meaning to the consumption of energy. By using less batteries for the construction of the ferry, this can also have a reduced impact on the environment in comparison to if more batteries were used (Kunicka & Litwin, 2019a).

Al-Falahi et al. (2019) conducted a study to investigate, including a hybrid ferry that was charged onshore. It also evaluates the optimal size of the battery that should be used in the ferries. It is described that a common hybrid electric ferry consists of different types of energy sources and how they are stored. It is proposed and emphasized that it is important to find the right optimal size of the battery in order to store it on board in an efficient way. It is described that an energy storage onboard could be used as a battery bank that works as an onboard charge. This type of solution would reduce the idle time when the ferry needs to be charging from onshore. Instead, the on-board-charge bank could be used to increase the efficiency in the operation. A first action in order to optimize the utilization process is to decide how much space that should be used for the energy storage system and the size of the battery bank. When this is conducted, the power management system could be implemented in order to reduce the costs and also to secure a high safety onboard (Al-Falahi et al., 2019).

Anwar et al. (2020) describes that hybrid ferries consist of more than one energy system. This means that the ferry has a propulsion system that builds upon for example a diesel engine that generates electricity and a battery which stores the energy. The battery of the ferry can be charged from the shoreside, and it can then be an alternative to use green electricity and less environmental impact. However, Anwar et al explained that, because it is a hybrid with two types of energy systems, it also has an engine which also can produce electricity for the battery onboard (Anwar et al., 2020).

Kunicka & Litwin (2019b) argues that there are several technical challenges with the operation of hybrid ferries. One challenge is the safety aspect in relation to the use of batteries. The reason for this is because the batteries used onboard a ferry can be a significant risk for both the environment where the ferry operates, but also a risk to the crew and passenger onboard the ferry. To handle this, one solution could be to put the batteries in casings which can protect the different batteries. The casings can then also have some ventilation which can help to maintain a functional temperature (Kunicka & Litwin, 2019b).

In the study by Anwar et al. (2020) it is described that there are three challenges with overall electrification of ferries and therefore also affects the hybrid ferries because of the use of batteries. The challenges that are mentioned in the article are aspects regarding technical, legislation and the operational aspect. The technical aspect is regarding the electrical grid in coastal areas. It is mentioned that the system is not powerful enough for the delivery of electricity for the ferries. Because of this, they mentioned one solution that could be to build a new power system for the delivery of electricity, however it can be an expensive solution according to the study. Another solution to the problem regarding the inadequate electricity distribution system is to have, for example, wind or solar energy and store the generated energy. However, there are some safety aspects to take into consideration with this (Anwar et al., 2020).

Regulations for battery and hybrid ferries

It is described in the article by Bellone et al. (2019) that the SOLAS regulations are implemented in the local law which are applicable in the specific area. However, it is described that the rules and regulations regarding electric batteries are not that straightforward and there is a lack of support regarding the regulations from the maritime authorities in Sweden. It is also mentioned that the support from the classification societies regarding electric batteries for ferries is not sufficient. There are however guidelines that exist, for example the International Electrotechnical Commission, which support the different components used in the electric ferries (Bellone et al., 2019). In SOLAS chapter 2, regulation 1-45 (IMO, 2009), it is stated the necessary actions to prevent accidents that have their origin from battery. It includes fire, shocks and other types of hazards and could for example be requirements regarding the construction and the insulation.

Transportstyrelsen (2023) states that battery installation onboard the vessels need to be classified by a classification society. For vessels that only use batteries for the propulsion system, the EES (Electrical Energy Storage) system needs to be controlled by EMS (Energy Management System). They also state a description regarding the charging equipment and the necessary criteria's that need to be considered. Transportstyrelsen states in (TSFS 2014:12) that electrical installations should consist of necessary equipment to protect against electric shock, risks that could lead to fire hazards and other risks that are related to the use of electrical equipment. Anwar et al. (2020) describes that there are not enough favorable laws around the electrification of shipping. For example, IMO prevents growth through laws. In addition, as previously mentioned regarding electrification, there is not yet any beneficial energy tax (Anwar et al., 2020).

2.4.3 Hydrogen ferries

Berkehan Inal et al. (2022) describes hydrogen in their study as the source that is most available in the universe and also the lightest one. One problem regarding hydrogen mentioned in the study is that it is most common in impure form and is normally in the form of gas. Hydrogen is common as a carbon-free source which has led to a lot of attention in the aim to reduce the carbon footprint in the maritime industry. Berkehan Inal et al explain that hydrogen can be produced by for example biomass, natural gas or diesel oil, but could also be produced by wind and solar via the use of electrolysis. It is also noted that it is important that hydrogen is produced by renewable resources in order to be carbon free and this is an aspect that needs to be considered. Van Hoecke et al. (2021) discussing the potential to use hydrogen as a shipping fuel in order to reduce emissions from vessels. The reason why it has gained attention is because of the renewable production that could be used in order to produce hydrogen. Van Hoecke et al explained, to be able to produce renewable hydrogen, the hydrogen can be produced through electrolysis. It is mentioned that it is possible to produce directly from solar and wind energy as well.

Cost

Berkehan Inal et al. (2022) discuss the cost aspect of hydrogen and explain that the storage of hydrogen onboard ships could be expensive. They also explained that the hydrogen needs to be either cooled to minus 253 degrees Celsius in order to remain liquefied in a cryogenic tank or it could be compressed as a gas. Berkehan Inal et al also explained that those are expensive and energy intensive processes which also cover a lot of space onboard the vessel. A study by Menon & Chan (2022) explores the use of hydrogen as a fuel for a tugboat. In the study it is mentioned some of the costs that need to be considered when choosing hydrogen as a fuel for the propulsion system. They mention that a large cost could be the capital needed for fuel cells and research costs associated with safety aspects. Aarskog et al. (2020) also discuss different costs to consider and mention, among others, the cost for hydrogen storage tanks, which could be a large cost. They explain that other costs are for example the piping system, safety systems and costs associated with the approval from classification societies.

Technical infrastructure

Yue et al. (2021) explain how the electrification of hydrogen is performed and that it could be electrified via combustion. It is described in the study how fuel cell technology works with different types of electrolysis. An issue is the storage of hydrogen, and it is discussed that the high mass energy density makes hydrogen an interesting future fuel. Though, it is mentioned that the storage of hydrogen requires larger space compared to other fuels. The storage techniques that have traditionally been most common is to store hydrogen as compressed gas and cryogenic liquid. For a larger scale, it is also possible to store the hydrogen underground. During the transportation of hydrogen, it is most common to compress hydrogen via pipeline or tube trailers. Another technical aspect to consider is that there is a lot of heat that is extracted during the compression of the gas. The temperature will increase in the tank which could lead to damage if it is not under control (Yue et al., 2021).

Berkehan Inal et al. (2022) mention that there are risks when considering the use of hydrogen as a fuel. Because of the low temperature, there is a risk that handling the fuel can get a cold burn from the fuel. Hydrogen also has an explosion or fire risk that needs to be considered. It is emphasized that the potential leakage of hydrogen could have devastating consequences and is therefore a risk that needs to be considered with

caution. Yue et al. (2021) also describes a technical challenge regarding the transportation of hydrogen. It is mentioned that the transportation of hydrogen is limited to the weight that the gas cylinder has which could be a problem for larger implementation. Another technical issue mentioned in the study regarding hydrogen is the efficiency and durability of both the fuel cells and the electrolysis systems. The efficiency and durability of those systems are still not as sufficient as needed in order to implement the hydrogen on a larger scale (Yue et al., 2021). Van Hoecke et al. (2021) explain that the storage of hydrogen for the maritime industry is complex. The reason for this is because the amount that needs to be stored is often large when it is used for vessels. The development in ports is not implemented on a larger scale that would enable the use of liquid hydrogen as a marine fuel (Van Hoecke et al., 2021)

In the article by Ustolin et al. (2022) it is explained that there is insufficient infrastructure for hydrogen in the maritime industry and this hinders the growth of hydrogen in the industry. It is mentioned that today, the delivery infrastructure that can be used to deliver the hydrogen to the end customer is for example by trucks, barges, ships or pipelines. More specifically, in the use of hydrogen for the marine industry, it is mentioned that there are four different alternatives for bunkering. Those are containers that can be changed, stations for bunkering, ships that deliver the fuel to another ship and trucks that deliver to the ship. It could also be added that some of these require more infrastructure in order to be sufficient for the bunkering process. For example, if a truck is intending to bunker a ship, it can be required to have a fixed installation on the quay that is both attached to the truck and to the ship (Ustolin et al., 2022).

Regulations

IGF-code is covered in the Swedish regulation as a part of "Transportstyrelsens föreskrifter och allmänna råd" (Transportstyrelsen, 2020). This is applicable for vessels that are covered by SOLAS regarding the safety for vessels that are supplied with fuels with low flashpoint. It is noted that the IGF-code should regulate all low-flashpoint marine fuels, but currently it is only covering LNG vessels. The coverage of all other types of fuels are ongoing to be able to secure the safety for all the different types of low-flashpoint vessels. Aarskog et al. (2020) explain that the IGF-code also emphasizes the importance of risk assessment when using this type of alternative design which is the case in the use of hydrogen or fuel cells. It is stated that the consequences from a potential accident need to remain isolated and not disperse to other parts of the vessel. It is also mentioned that the safety of the passengers is an important factor to consider and needs to remain at a high level even in the case of alternative fuel.

Bach et al. (2022) also explain that currently, there are not that many regulations regarding hydrogen and fuel cells as a marine fuel. It is mentioned that there are some guidelines and regulations that cover installation onboard the vessel. Beyond the IGF-code that has been mentioned before, Bureau Veritas and Det Norske Veritas have some guidelines and handbooks regarding the installation onboard vessels. According to Bach et al, the IMO are also working on the development of Interim guidelines that consist of safety considering the installation of fuel cells onboard vessels. It is explained in the study that the IGF-code consists of, among other parts, the requirements for installation, control and equipment regarding fuels with low flashpoints. The guidelines from, for example Bureau Veritas consist of guidelines regarding installation of hydrogen systems onboard the vessel. The Interim guideline from IMO covers the installation of fuel cell systems onboard and hydrogen

installations. It should be noted that according to the study, the Interim guideline does not cover hydrogen storage (Bach et al., 2022).

2.4.4 Methanol ferries

Chatterton (2019) argues that methanol is a fuel that could be used in order to reduce the emissions from the shipping industry. It is argued that this is a beneficial fuel that could be produced in many ways and the supply should therefore not be a big challenge. Methanol could be described as a fuel that has similar characteristics as distilled fuel and much of the existing infrastructure that currently exists could be used (Chatterton, 2019). Ančić et al. (2020) also argues that methanol could be a potential renewable fuel for the shipping industry. It is emphasized that the use of methanol as a fuel can result in a lower carbon footprint from the marine industry if it is produced from a green source such as biomass. It is also explained that the infrastructure needed for the use of methanol is already in place. The reason for this is because the established existing infrastructure from other fuels can be adapted to the use of methanol.

Cost
According to Svanberg et al. (2018) there are many economical aspects to consider in regarding methanol as fuel for the maritime industry. For example, the investment cost and the cost associated with operating the ship on methanol as a fuel. For the investment cost, it is necessary to convert the ship and the existing engine to be able to run on methanol. The cost for converting the engine can however be considered less than for example a conversion to LNG. The cost to produce a new ship with a methanol engine is also lower in comparison to a ship with an LNG driven engine (Svanberg et al., 2018). Olah (2005) describes that the use of methanol would be beneficial in terms of cost for infrastructure needed. It is argued that the current existing infrastructure is well-functioning with some adjustments and there will therefore not be any need for implementation of new infrastructure that could be costly.

Technical infrastructure
Brynolf et al. (2022) mention that methanol has an energy density which is lower in comparison to traditional marine fuel such as MGO. Svanberg et al. (2018) describes that for smaller methanol engines such as for ferries, these engines are under the phase of development. Regarding the storage tanks of the fuel, it is not required to have special pressure for these fuel tanks. The storage tanks for the methanol can be placed closer to the hull in comparison to traditional fuels that for example require tanks with double hulls. The reason for this is because IMO doesn't classify alcohol as a marine pollutant (Svanberg et al., 2018).

Verhelst et al. (2019) explained that one challenge with methanol is that there can be problems regarding the compatibility of the materials used in the fuel system. Methanol has properties which can result in degradation and destruction of softer parts such as lines to the fuel system and seals. Verhelst et al explained that methanol has a low flashpoint, this makes it less safe to have onboard than for instance if the ferry would store and run on traditional diesel. Svanberg et al. (2018) explained that ships that want to use methanol as a marine fuel must undergo a process that evaluates the risk of using the fuel. In order to be allowed to use the fuel, it must then be possible to demonstrate that the risks of using the fuel are to the same degree as using traditional fuels.

Svanberg et al. (2018) describes that in Sweden, it is common that smaller vessels such as ferries, are bunkering methanol via trucks. It could therefore be argued that for these types of vessels, no additional infrastructure would be needed in order to implement methanol as an alternative fuel. The current transportation chain of methanol in Sweden could therefore be used for vessels. The reason for this is because methanol is already used by industries and transported by trucks which would make the implementation for bunkering vessels easy. Regarding the storage of methanol, it is argued that this is also already existing to a large extent due to the use of methanol in chemical industries. There are just some smaller changes that are needed in order to use the same storage facilities regarding implementation for methanol as a vessel fuel. It could therefore be argued that implementing methanol as a fuel vessel does not have that many challenges regarding the storage of the fuel. In the study it is also argued that for smaller vessels, the use of trucks for distribution is already existing (Svanberg et al., 2018).

Regulations

Regarding the implementation of methanol as a fuel, "Transportstyrelsens föreskrifter och allmänna råd" (TSFS 2019:4) is applicable. It is stated that the installation and electrical installation in the engine room should, beyond the regulations in SOLAS, also have certificates regarding the safety of the installation and the safety of a passenger ship. This regulation could be applied for the use of methanol as a fuel onboard the vessel (TSFS 2019:4).

Sjöfartsverket (2020) states that methanol driven vessels need to comply with the regulations stated in the IGF-code. MSC (2019) describes that the IGF-code is an international code regarding the safety for vessels that are using gases or other low-flashpoint fuels. The IGF-code is a mandatory part of the SOLAS convention. In addition to the IGF-code, Sjöfartsverket (2020) mentions that the vessel needs to comply with the classification rules that are stated in the classification societies such as Lloyd´s Register. In those classification societies it is for example stated the necessary actions needed for the installation that could
differ from the traditional fuels (Sjöfartsverket, 2020).

2.4.5 Hydrotreated Vegetable Oil

Bohl et al. (2018) argues that hydrotreated vegetable oil (HVO) could potentially be an alternative fuel to marine diesel. One great advantage of HVO is that it has similar characteristics to diesel regarding combustion. This results in an ease in the change of fuel because the engine does not need that large rebuild as could be the result for other alternative fuels. This aspect, together with the lower exhaust gas emission shows the great potential that HVO fuel has. Bohl et al. (2018) further describes that the HVO is a biofuel that is produced from processed vegetable oil and is produced by adding for example hydrogen in a catalytic reaction. Carvalho et al. (2021) also discuss that biofuels could be alternatives for a more sustainable maritime industry. It is described that HVO could be produced using agricultural residues and the vegetable oils to be used as feedstocks (Carvalho et al., 2021). Brynolf et al. (2022) also mentioned the production of HVO and describes that the fuel can be produced from different raw materials such as palm oil, tall oil, oil from rapeseed and also waste that comes from slaughterhouses.

Cost
Hansson et al. (2019) describes HVO as a marine fuel that has a lower cost regarding the cost for necessary investments. It is described that HVO requires less changes and it is also ranked high in the study. It is also described in the study by Julio et al. (2022) that HVO is a fuel which can be considered attractive in economic aspects since the use of already established infrastructure is possible. This will, according to the study by Julio et al, also have an impact on the utility, maintenance and also the required initial investment for the use of HVO. It is described in the study by Lorenzi et al. (2020) that the use of existing infrastructure and to use the fuel in existing diesel engines will also have an impact on the environmental cost since it contributes to the reduction of greenhouse gas.

Technical infrastructure
Easter et al. (2022) explains that an advantage with HVO is that it could be applied together with the existing infrastructure. It is mentioned that the integration of HVO into the existing infrastructure for the current fuels could easily be used. Another aspect that is beneficial with HVO is that it could be used in the same diesel engine without any need for blending (Easter et al., 2022). The availability of the infrastructure for HVO is something that Brynolf et al. (2022) mentioned in their study. It is shown in the study by Brynolf et al that the availability of infrastructure is one of the highest compared to other sustainable fuels. No (2014) also argues that a great advantage of HVO is the compatibility with the current infrastructure and the use of HVO in the current engines. Another technical infrastructure that No (2014) is arguing for is the flexibility that exists with HVO regarding the feedstock.

Xiao et al. (2022) discuss HVO as an alternative fuel and the pathway of the fuel. It is argued that, if produced in a renewable way, the HVO could have the potential to meet the IMO greenhouse gas emission target for 2050. An obstacle that is discussed is the supply of the HVO and the problem that the limited feedstock will not be enough. It is mentioned that the demand for HVO will not be able to be met with the production of HVO that exists today. Xiao et al. (2022) also explains that the adoption of biofuels in the shipping industry is very low and the reason for this depends on different aspects that could be uncertain and complex. The biofuels that are produced could be from different feedstocks and different routes in production. This technical aspect affects the performance of biofuel, both economically and environmentally (Xiao et al., 2022).

Regulations
Hansson et al. (2019) investigate alternative marine fuels and discuss that the Swedish government authorities prioritize the environmental and social criteria highest regarding the use of alternative fuels. The environmental criteria that were found most important were greenhouse gas emissions and the potential of alternative fuels to meet the regulations. In this context, the HVO was ranked among the top three as an alternative fuel. But at the same time, it was argued that there is a need for policy initiatives that could be used to promote the adoption and implementation of alternative fuels (Hansson et al., 2019).

The directive of the European Parliament and of the Council (2014/94) describes the infrastructure for alternative fuel. Is it stated that HVO could be used in almost all the current diesel engines. It could therefore use the same infrastructure that already existing which also includes the distribution and storage. The European Commission

(2014/6/EU) describes that HVO should be recognized as a renewable diesel scheme and to be able to comply with sustainability criteria for biofuels. The scheme should include all the different feedstocks that could be used in order to produce HVO biodiesel. This could for example be the use of animal fat, soybean oil and crude palm oil. This scheme includes the whole supply chain including production of the raw material to the transportation of the biofuel (European Commission (2014/6/EU).

2.5 Accessibility passenger transport

Lindkvist & Melander (2022) describes two different types of transport services, which are Mobility-as-a-Service (MaaS) and Urban Consolidation Centers (UCC). The Maas focuses on the transportation service of people, and it is emphasized that this service considers the needs of the user. The aim of this type of transportation service is to supply the passenger with a flexible and on-demand transportation service. Elbert & Rentschler (2022) also discuss the integration of passengers and goods and focus more on urban areas. It was explained that a solution to solve the problem could be to include the goods in the public transportation system. Further, Lindkvist & Melander describes that the MaaS could consist of different types of transportation modes such as car sharing, public transportation and bikes. This results in multiple stakeholders being involved in the supply of this mobility service. In order to have an efficient transportation flow, Lindkvist & Melander explained that it is important that the availability and information sharing are considered, and this could be a complex challenge to solve. The systems that need to be integrated with each other for the different modes of transport could be traffic data and timetables. Another concept that has gained attention is the electric MaaS which consists of transportation modes that are more sustainable. This concept could for example consist of electric cars and other types of sustainable modes of transportation (Lindkvist & Melander, 2022).

For the integration of passengers and the transportation of goods, it is mentioned in the study by Lindkvist & Melander (2022) that the integration of passengers and goods could increase the efficiency and sustainability of the transportation services. It is argued that considering and including freight transport in the Maas, this could increase the utilization in the transportation of passengers. This could also lead to a reduction in the freight transport needed in certain areas. Similarities could be found in Elbert & Rentschler (2022) who also argued that the inclusion of goods in public transportation could increase the utilization. A challenge that is mentioned are the digitalization and the lack of digital tools that could integrate the transportation of passenger and goods in an efficient way. In order to integrate the passenger and goods, there is a need for further development and the implementation of digital tools needed. One aspect to consider is that the users of this type of concept need to share data and access different types of digital solutions and it is noted that this development could lead to an exclusion of a specific type of people. Another aspect that needs to be considered is that when developing and implementing the new sustainable modes of transportation, it will also require that economic sustainability is emphasized (Lindkvist & Melander, 2022).

Mulley et al. (2023) also discuss the Maas concept and explain the benefits that this could have for accessibility in rural areas. They mentioned that there are challenges existing within the rural transportation service. It is described that the Maas concept in the rural areas is important because the transportation is not that efficient in those

areas. The increase in efficiency that Maas could result in was also mentioned by Linkvist & Melander (2022). There is also a challenge regarding the level of integration of the Maas. They explain that many Maas projects do not succeed beyond the integration of information and the integration of the booking and payment systems. The integration of information includes information regarding multimodal planning, while the integration of booking and payments include the finding, booking and purchase of the transport (Mulley et al., 2023). Sharing the data and communication was also emphasized by Lindkvist & Melander (2022) as an important aspect that needs to be considered.

2.5.1 Technical infrastructure accessibility

Chou et al. (2020) explains in their study that there is a lack of knowledge in the field regarding the accessibility for passenger ships and ports. They mention a number of improvements that can be relevant for the development of better accessibility. Improvements that are mentioned in the study are for instance floating wharfs, ramps that are universal but also mobile ramps that can be adjusted in the height difference. In the study it is also mentioned that there are factors that can have an impact on accessibility, some of them are effectiveness and safety (Chou et al., 2020).

Kim et al. (2010) argues that the design of the ramp is an important aspect to consider with regard to disabled passengers. It is emphasized that the slope of the ramp is important and that a main challenge that exists is that the slope is too high. This causes problems for passengers in a wheelchair without any type of aid or help (Kim et al., 2010). In the article by East (2018) it is mentioned that the society has passengers that rely on the infrastructure connecting to getting on and off different transport modes using ramps and gangways. The passengers that rely on the infrastructure are for example elderly people, people that have been involved in accidents and disabled people. It is described that the infrastructure of the terminal consists of three different areas that need to be considered regarding their design. Those are the infrastructure onshore which is the waiting area, then there is the gangway that leads to the ferry, and the pontoon where people are waiting for the ferry (East, 2018).

According to the article by East (2018), many of the older terminals are currently designed where the waiting areas are placed onshore to avoid movements from the waves when the vessel arrives or other harsh weather conditions. The design of the gangway is according to the study important to consider because the degree of inclination from the vessels changes during other weather and water conditions. The pontoon is described as an infrastructure that can be exposed to weather conditions and therefore it can be moving up and down and leaning in different directions. The gangway is defined as the connecting part that links the infrastructure on land and the infrastructure that is floating, for example pontoons. Where the height of the infrastructure onshore is fixed and the height of the infrastructure on the pontoon varies depending on the level of the water. It is also explained in the study that the differences in heights can result in a high degree of slope of the gangway, which could make it hard to access. This also makes the design of the gangway complex where the gangway needs to comply with different regulations.

El-Shihy & Ezquiaga (2019) also discuss the potential for floating structure in order to be able to adapt to changes in sea levels. It is argued that the floating pontoon

structure has a lot of advantages, for example the fact that they are not that complicated to install and are a cost-effective solution. In order to have a well-functioning floating structure, it is important to have a mooring facility that makes sure that the pontoon keeps its positioning. It is also discussed that the accessibility to the pontoon could be either a bridge or a floating passage where people could enter the pontoon (El-Shihy & Ezquiaga, 2019).

It is mentioned in the study (East, 2018) that users of wheelchairs may experience that it is difficult to pass over a gangway or a ramp that is steeper than 1:20. It is explained that this is applicable to the wheelchair user regardless of how the condition of the weather is like. The incline of the gangway or ramp is also affected depending on how long it is. In order to secure a relatively flat slope for the fixed onshore terminal, the ramp consists of elements that are rigid vertically. This will result in a flat slope of the ramp regardless of the water level and to secure safe loading or unloading. It is also noted that the ramps could be designed to be able to increase and decrease the length depending on the conditions. They explained that this would enable the ramps to decrease the inclination level and become flexible. The width of the walkway is also considered to make it possible for a person that uses a wheelchair to get together with two helping people. In order to have enough space to be able to have one person on each side of the wheelchair when transporting on and off the connecting infrastructure, a certain width is required. It is concluded in the study that a width of 260 cm is something that would enable this. It should be noted that the article is written in accordance with other countries' laws regarding the design of the infrastructure (East, 2018).

Ercoli et al. (2014) discuss that it is important to consider the accessibility to the transport system for people that have some disabilities or other types of reduced mobility. It is argued that this is important in order to be able to be included in society and increase the quality of life for those that are living with some type of disability. The mobility of people has a strong correlation with age and many elderly people have some type of decreased form of mobility capacity. The entrance to the ferry from the wharf is a lot of the time associated with challenges regarding differences in heights. To solve this problem, some suggestions are mentioned which could facilitate boarding and disembarkation. These suggestions were argued to be easily applicable and consist of gangways that could be extended, the use of extra floating docks, ramps that were fixed intermediate, and gangways that made it possible to enter the deck of the vessel. Those suggestions resulted in a decrease of the challenges that exist. Some challenges that did, however, exist were the gap that existed between the end of the wharf before entering the ferry. For people with wheelchairs, it was mentioned that another problem was the ramps could have a high inclination which made it harder to entering the ferry. This problem could be solved with the use of hinged flat plates in the beginning of the ramp, and it is mentioned that many of the gangways already have this solution available (Ercoli et al., 2014).

2.5.2 Accessibility regulations

In a report by Sveriges Riksdag (2013) it is mentioned that one major challenge that exists in ferry transportation in the archipelago in Sweden is that the wharfs have different heights and standards. This is a challenge for some people that have reduced mobility and could lead to the need of assistance when boarding and deboarding the ferry. Another challenge that is described in the report is regarding the issue that older

ferries have less compliance with the adjustment to people with adjusted mobility. The report mentioned that it is expensive to upgrade those ferries and therefore the necessary investments do not materialize because of this. There is also a problem regarding that some areas do not have enough space to install a floating wharf due to the design of the terminal. A solution for this is to install a ramp that could be used instead of a floating wharf, which would also be a cheaper solution. However, the solution of using a ramp instead of a floating wharf can be problematic in relation to the tide of the water. The ramp is functioning in a better way when there is a normal tide and will not work in the same way when the tide is high or low due to the slope of the ramp (Sveriges Riksdag, 2013).

In the Regulation of the European Parliament and of the Council (1177/2010) it is stated that the waterway transportation should be beneficial for all the passengers. People with some type of disability or reduced mobility such as age, should have equal opportunity to use the same transportation services as all citizens. This includes the free movement and non-discrimination of this passenger group. It is described that the design and infrastructure of new terminals and ports should be adapted with consideration of the need from people with reduced mobility. The regulations also emphasize that the design should be considered for all the requirements necessary and passenger vessels should also consider the design of the vessel regarding accessibility for all people. Disability-assistance training is also mentioned and the importance of the right procedure. The boarding and deboarding should be performed with the right equipment and knowledge in order to proceed with concern to the safety and dignity of the person with disabilities (1177/2010).

In the regulation Sveriges Riksdag (SFS 1980:398) regarding adjustment for persons with reduced mobility in the public transport it is stated that Sjöfartsverket and Trafikverket should have a planning, implementation and monitor the development in accordance with the regulations. In paragraph 2 it is also mentioned that the adjustment should be developed based on what can be considered reasonable in relation to both the financial and technical capabilities of the party responsible for the transportation. In the law by Sveriges Riksdag (SFS 1979:558) regarding public transport that is adjusted to people with reduced mobility it is stated that when public transport is in the phase of planning, this should be done in accordance with needs of people that have reduced mobility. Regulations regarding the design and execution of buildings that are adjusted to people with reduced mobility should be designed in accordance with the law *''Plan- och bygglagen (2010:900)''*.

According to Boverket §3:1222 (BBR, 2011) there are rules regarding the design of the ramp that persons with reduced mobility should use. It is stated that the inclination of the ramp should maximum be 1:12, otherwise there is a risk that the user of the ramp could fall over. It is however recommended that the ramp should be 1:20 because in order to make it even safer. It is also stated that the ramp should have a width of at least 1,3 meters, and that there should not be any obstacles in the way. Another aspect to consider in the law is that the ramp should have a protection of the runway that is at least 4 cm high, this will then prevent the user from rolling off the ramp.

In the regulation by Sjöfartsverket (SJÖFS 2004:25) it is stated that the ship should be adjusted to people with reduced mobility. The ship should, according to the regulations, be constructed in a way that makes accessibility for people with

disabilities. The passengers with reduced mobility should be able to enter the ship in a safe way, and this should be done by elevators, ramps or a table with a lift. Regarding the ramp, it is stated that if the ramp does not have any personnel that operates the ramp, it should not have an inclination that is higher than 1:20. Also it is stated in the regulation that the ship should have at least one entrance that is adjusted to persons with reduced mobility. This means that this entrance should not consist of any steps or stairs that could hinder the person from entering the ship. In the regulation (SJÖFS 2004:25) it is also covered regarding the spaces for passengers. In this part it is stated that the doorway for the spaces should be at least 0,8 meters, in order to ensure the access for people with wheelchairs. Another concern regarding access to the passenger spaces is that thresholds should be eliminated with the help of ramps or other types of equipment. However, thresholds that are necessary for keeping freeboard provisions should not be removed (SJÖFS 2004:25).

3. Methodology

The methodology chapter presents the methods used for the literature review. It also presents the methods that were used to collect the data from observations, interviews and questionnaires.

3.1 Methodology approach

The thesis aim can be divided into two different aspects that will be explored (Hyde, 2000). Firstly, the thesis has explored if it is possible to convert the ferries to a more sustainable fuel alternative. Secondly, the thesis explored how transportation of integrating passenger and goods can be performed in order to increase accessibility. In order to evaluate and test the previous theory and apply those to this specific case, a literature review was conducted with a deductive approach, according to Hyde (2000). The reason for the choice of literature review, and as stated by Hyde (2000) was to read and analyze previous research to collect information for the theory part.

For the collection of data, both qualitative and quantitative methods were used, which resulted in a mixed method approach (Hesse-Biber, 2010). It is mentioned that the mixed method approach could increase the knowledge by the researchers because there is both qualitative and quantitative data that could be interpreted. The quantitative data provides information that is used to be able to understand the situation, while the qualitative data provide a deeper understanding of the result that has been researched (Hesse-Biber, 2010). The mixed method of data collection through questionnaires, observations and qualitative interviews resulted in an increase of validity.

3.2 Literature review

To collect relevant and trustworthy data, a systematic literature review was conducted according to Tranfield (2003) which resulted in a theoretical foundation. In a systematic literature review it is important to review the sources in a methodical way to the relevance and trustworthy sources (Booth et al., 2021). The systematic literature review was performed by collection of data and systematic reviews of the sources and evaluates if they were relevant. Thereafter, the data was processed in order to ensure that it was sources that were in line with research questions and the purpose of the thesis.

Tranfield et al. (2003) describes three different stages in order to conduct a systematic review. The three steps are planning the review, 1) conducting the review, 2) reporting and 3) dissemination. In the first step, the aim is to identify the need for the review and thereafter conduct a suggestion for the review (Tranfield et al., 2003). The aim of the literature review in this thesis was to conduct a review on sustainable, accessible, and integrated transport of passengers and freight in rural coastal areas. This included literature search on the phrases of keywords included in table 1. In step two, the aim is identifying which type of research should be performed and to conduct the review (Tranfield et al., 2003). In step three, the aim is to collect the result and conclude some suggestions (Tranfield et al., 2003). Results from conducted literature review have been used in the discussion to compare with the frame of reference. According to Snyder (2019) a literature review can be conducted because it is important to understand previously made research in similar areas and subjects. Previous research by other authors can be used to be able to understand what has

previously been done in the subject of study. It has also been important to have previous knowledge to know what type of questions need to be investigated and what type of method that would be used for the result in the thesis.

In compliance with the selected deductive research approach, the literature review was conducted to find relevant papers. Snyder (2019) explains that it is important in all types of research to first point out and understand previously made research in similar areas and subjects. Published studies in the area were used in order to argue for what the purpose and the research questions are for the thesis (Snyder, 2019). Bell et al. (2022) argues that it is important to be a critical reader when searching for relevant literature. It is mentioned that it is important to read multiple different literature in order to broaden your knowledge and in order to decide which literature is relevant or not. To ensure that the literature was relevant for the thesis, the authors have studied different sources.

When conducting the literature review, an initial search with the keywords (table 1) that were used. The sources that were found relevant for the research questions were used as an initial sample. In step 1, the authors read the titles of the references included in the paper to look for other relevant sources. In step 2, the abstract was read to be able to decide if the paper was relevant to include or exclude. In step 3, the author searches for where the references were cited and also explores for more relevant studies in the reference list of the study that has been found. A limitation was that the authors search through a maximum of the first 150 scientific articles shown for each of the keywords in the different databases. For the initial search for scientific papers the search engines Scopus and Web of science were used. The different scientific articles were then initially reviewed by reading the abstract, discussion and conclusion of the paper, to get an understanding if the article is relevant or not for the thesis. For the regulations and guidelines parts of the thesis, the authors search for regulations that were linked to the field of study. The authors used the EUR-Lex, International Maritime Organization, Transportstyrelsen, Arbetsmiljöverket, Boverket and Sveriges Riksdag for information regarding regulations.

For the selection of the sources, they should not be too old in order to be up to date and have the latest information available (Booth et al., 2021). According to Tranfield et al. (2003), the keywords that are considered to be most relevant for the research questions and purpose of the study. It is also emphasized by Tranfield et al that the method that is used when collecting information should be simple to replicate for another researcher.

Table 1 list of phrases of keywords used for the literature search.

Ferries, passengers and fuels.	Number of results in Scopus and number of relevant papers ():	Number of results in Web of science and number of relevant papers ():	**Infrastructure.**	Number of results in Scopus and number of relevant papers ():	Number of results in Web of science and number of relevant papers ():	**Accessibility.**	Number of results in Scopus and number of relevant papers ():	Number of results in Web of science and number of relevant papers ():	**Dangerous goods.**	Number of results in Scopus and number of relevant papers ():	Number of results in Web of science and number of relevant papers ():
Ferries in coastal areas.	172 **(9)**	162 **(3)**	Infrastructure of ports with renewable fuels.	33 **(8)**	23 **(0)**	Accessibility for ferries.	86 **(5)**	36 **(3)**	Regulation goods maritime	136 **(2)**	236 **(2)**
Combination of goods and passengers.	59 **(3)**	143 **(2)**	Infrastructure and design of ferries.	81 **(5)**	46 **(3)**	Accessibility in port areas.	191 **(3)**	165 **(2)**	Marine dangerous goods transport	89 **(2)**	37 **(1)**
Ferries with sustainable fuels.	32 **(8)**	17 **(2)**	Infrastructure for marine fuels.	276 **(6)**	302 **(6)**	Accessibility for passenger ferries.	25 **(3)**	12 **(2)**			
Conversion of ferries.	149 **(8)**	82 **(6)**	Infrastructure for Hydrogen marine fuel.	34 **(3)**	46 **(5)**	Accessibility for people with reduced mobility.	187 **(7)**	220 **(4)**			
Marine renewable fuels.	943 **(19)**	1 404 **(5)**	Infrastructure for battery ferries.	13 **(3)**	9 **(1)**	Accessibility in rural areas.	8608 **(2)**	2 928 **(7)**			
Battery marine fuel	391 **(8)**	460 **(5)**	Infrastructure for hybrid	10 **(2)**	7 **(1)**						
Battery hybrid marine fuel	175 **(5)**	214 **(7)**	Infrastructure methanol marine fuel	9 **(2)**	8 **(0)**						
Hydrogen marine fuel	777 **(6)**	1 317 **(10)**	Infrastructure HVO	13 **(4)**	15 **(1)**						
Methanol marine fuel	245 **(7)**	400 **(8)**	HVO investment cost	5 **(1)**	4 **(1)**						
HVO marine Fuel	10 **(3)**	11 **(1)**									
HVO fuel	334 **(5)**	230 **(3)**									

3.3 Case study

3.3.1 Case description

For collection of primary data, a multiple case-study was conducted according to Yin (2014). Yin (2014) also states that a case study is relevant if the research questions aim to explain some present natural setting. This thesis aims to explore the current natural setting of the ferries in the rural coastal areas and how they could be developed. The thesis also aims to explore and investigate how the ferries in those areas could be more sustainable and combine the transportation of passengers and goods and increase accessibility. Furthermore, Bell et al. (2022) describes that a case study is research that focuses on limited situations or any system that consists of a well-functioned purpose and sections.

Yin (2014) emphasized that before conducting the interviews to the case studies, it is important that some different aspects have been considered. Some of the mentioned is to be able to ask questions that are relevant for the research questions. Another aspect that is emphasized is that when collecting the data in the interviews, the authors need to listen to all the information. It is also crucial that the authors are able to understand a lot of new information that is given and not be biased (Yin, 2014). To be able to collect and ask relevant questions, the authors have conducted a literature review in order to enhance knowledge, but also to deepen the knowledge. To collect information, interviews were conducted, together with observations and questionnaires.

3.3.2 Interviews

The thesis has conducted a qualitative research interview where information has been collected through interviews with actors with knowledge in the field of study. Qualitative methods were found to be most suitable for the purpose of the thesis and in order to answer the research questions. The interviews were conducted with people with knowledge about the subject and people working in the industry. Yin (2009) emphasizes that one part of the case study is known for the investigation of previous research and interviews with people with knowledge of the subject. It is also emphasized that it is important to know the positive and negative aspects of the case study and closely investigate how this can affect the result. Another aspect to consider that Yin (2014) also explains is that it is important to know that in case studies, there are no requirements for the control of behavioral events. The thesis has therefore conducted interviews that are semi-structured in order to not control the behavior of the persons being interviewed to full extent.

According to Merriam & Tisdell (2015) the qualitative method is used when the authors rather seek to understand and discuss subjects. The interviews were conducted to collect data from participants with practical and theoretical information about the subject. Semi-structured interviews were conducted and Adams (2015, p.492-505) emphasizes that the questions of a semi-structured interview approach need to be more flexible and adaptable in order to collect as much relevant data as possible. It is also argued that it is important to have an agenda for the interview, to have a clear topic and decide the order in which the questions will follow. The interviews were conducted and were planned in advance and the authors used questions that were promoted for discussions.

Adams (2015) points out aspects that need to be considered when designing the agenda for the interviews. The recommendations were:

- To have enough time to find out relevant questions and to have feedback on the questions before starting the interviews (Adams, 2015). Before the interviews, the authors planned the questions based on the research questions and the theory part. Also, the research questions were structured and revised according to the guidance by Maxwell (2013). This is in order to design questions that were relevant for the field of study. To ensure that the interview questions were relevant, the authors also got feedback from the supervisor to make sure that it was questions that would answer the research questions in an accurate way.
- Do not have too many issues on the agenda for the interviews and if there are a lot of issues, make sure to know which one of them is most critical (Adams, 2015). When the agenda was organized, the authors had some questions that were thought to be more important than others. These questions were asked first, and then if the time allowed, the other questions could be asked as well to be able to collect even further information.
- After asking the more straightforward questions, it could be effective to ask questions to further research the question (Adams, 2015). In the interviews that were conducted, the authors had planned extra time between the closed questions in order to be able to ask follow-up questions to further gain useful information.
- Be careful with translation of the interviews, otherwise it could be misunderstanding, and incorrect information collected from the people being interviewed (Adams, 2015). In order to secure accurate and trustworthy

information without misunderstanding, the authors recorded all the interviews in order to be able to listen to them afterwards. This enables the authors to carefully listen and interpret the answers in a more accurate way.

- Make sure that the questions do not make the recipients insecure regarding for example what will happen if they answer in a specific way (Adams, 2015). This will lead to inaccurate answers and will therefore lead to wrong conclusions. In order to secure safety, the authors informed the recipients that it was anonymous interviews, and no answers could be tracked to them specifically.
- Even if the agenda is set, do not interrupt if the answers from the recipients lead to another order than was anticipated at the beginning (Adams, 2015). During the interviews, the authors had, as mentioned before, some critical questions that were more important and even when the interview took another order, the authors made sure that these questions were answered. When the recipients answered a question that led to another topic, the authors continued that path and then at the end of the interview returned to the critical questions.

Selection of participants

To facilitate the selection of participants for interviews for the research, a snowball sampling was performed (Biernacki & Waldorf, 1981). The initial step in the snowball sampling was to ask the first interview persons if they had any connection to other relevant persons for the research. Once participants of the interviews gave suggestions, it was possible for the authors to accomplish new participants for the interviews. The suggested participants could also give suggestions for other participants to contribute. This could be described as a snowballing sampling.

Adams (2015) describes that it is important that the people that are being selected for interviews are relevant and the right target group. For the thesis, interviews were conducted with people in the field and that was found to be relevant. When an interview was performed, the authors asked the person that had been interviewed if they had some other persons that they thought would be relevant to the interview as well. This also leads to more trustworthy information because the new person is then considered to have the right knowledge because of the suggestion from another person. The snowball selection also made it more time efficient for the authors. As Denscombe (2018) emphasizes, the snowball process can give authors an advantage because of the reference from the previous person being interviewed.

Husband (2020) argues which type of ethical aspects need to be considered when collecting data through semi-structured interviews. There are issues regarding which type of ethical aspect to consider during the collection of data. A question that is emphasized is if the ethical aspect should be considered, beyond for example anonymity and conformity of the person being interviewed. The thesis considers the ethical aspect regarding the anonymity and comfort of the recipients. The recipients have remained anonymous, and no information would be available to track which recipients answered in a specific way. As mentioned, the interviews were recorded after acceptance from the respondents according to global data protection regulation (GDPR) and color coding was used in order to sort the data anonymously. Regarding the ethical aspects beyond the common ethical aspects presented, the authors ensured that the recipients felt comfort and were not judged in any way regardless of their opinions or answers. Table 2 shows the number of respondents in the interviews.

Table 2 List of the numbers of respondents in the interviews.

Professions	**Numbers of respondents**
Total	12
CEO shipping company	3
Manager shipping company	3
Goods owner	1
Expert in accessibility	2
Procurer	1
Municipality	2

3.3.3 Observations

Yin (2014) describes that in the collection of data the on-site observation could be performed together with for example interview. It is emphasized that the observation needs to be relevant, and it could enable the authors to interpret the result from interviews and other data collection methods. Maxwell (2013) mentions that the method used can have a complementary approach to broaden the aspects. For instance, it is possible to use observations that can have a descriptive function of behaviors and settings. For the part where interviews are being conducted, these can have a function towards the understanding of the goals and perspectives of the actor. It is also mentioned that the observations could broaden the understanding and accuracy of the interviews. The observations conducted were done by photographs in the area related to the subject. The authors also took field notes during the observation to be able to analyze the data from the observations afterwards. The observations were conducted both on Orust, including Tuvesvik (figure 1) and the islands Gullholmen (figure 1) and Käringön (figure 3), and on Tjörn, including Rönnängs brygga (figure 3) and the islands Åstol (figure 3) and Dyrön (figure 3).

Figure 1 illustrates the map including the terminal of Tuvesvik and the harbor of Gullholmen.

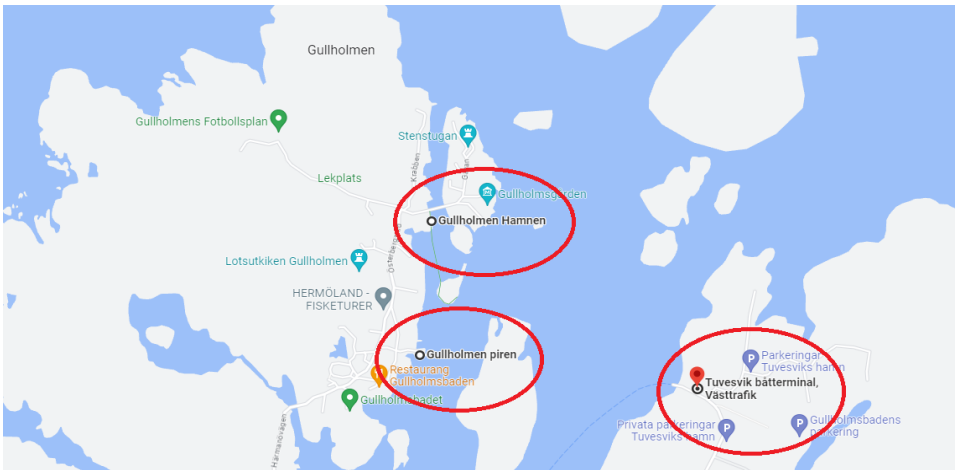

Figure 1 The terminal of Tuvesvik, the harbor of Gullholmen and The Pier of Gullholmen (Google maps, 2023).

Figure 2 illustrates the terminal of Tuvesvik located in the upper right corner and the port of Käringön in the bottom left corner.

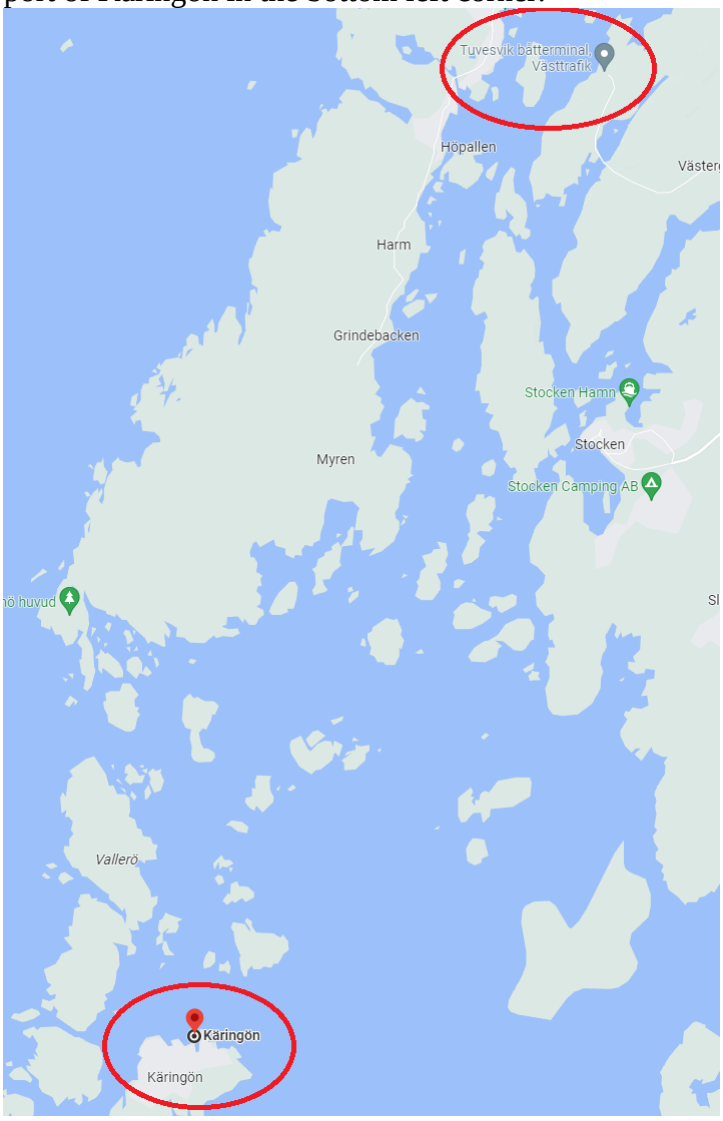

Figure 2 The terminal of Tuvesvik and the port on Käringön. (Google maps, 2023).

Figure 3 illustrates the port of Rönnängs brygga located to the left in the middle of the map, the port of Åstol located in the bottom of map, and the port of Dyrön to the right.

Figure 3 The map of Rönnängs brygga, the island of Åstol and the island of Dyrön (Google maps, 2023).

3.3.4 Questionnaire

Gillham (2008) emphasizes the importance of preparation before conducting a quantitative questionnaire. For the questionnaires, the authors have conducted quantitative questions, which made the interpretation more efficient. Neuman (2014) describes that when constructing the questionnaire, two main aspects need to be considered, try to avoid confusion of the questions and use the perspective of the respondents. The questionnaire that has been conducted includes questions with predetermined answers in order to be able to analyze the data in an efficient way. The questionnaire included questions regarding where they are commuting from, how satisfied they are with the current ferry network, and how the combination of passengers and goods should work. The main purpose of the questionnaires was to understand how the passengers access the port functions. Table 3 shows the number of participants in the questionnaire.

Table 3 List of the numbers of participants in the questionnaire.

Commuting area	**Number of participants**
Total	70
Ferry between Rönnängs brygga, Åstol and Dyrön	34
Ferry between Tuvesvik, Gullholmen and Käringön	36

In the construction of the questionnaire, following parameters were considered:

1. Gender of the respondent.
2. Age interval.
3. Resident area, Tjörn, Orust or other.
4. Commuting area, Gullholmen, Käringön, Åstol or Dyrön
5. Reason for commuting.

3.4 Data analysis

Yin (2014) describes that the analysis of the data from a case study can be conducted by five different techniques. The method used for this thesis was the *Cross-Case Synthesis,* and this is a technique that is only used when conducting a multiple case study. It is also described that using a multiple case study will probably result in a more robust result compared to a single case study.

This thesis has focused on the *Cross-Case Synthesis* that is commonly used when a multiple case study is conducted. Yin (2014) describes that this technique enables the authors to interpret the result from the different cases. This thesis used a multiple case study and therefore the authors were able to interpret and compare the results from the different cases. This technique was used in combination with the methodological triangulation which is described by Denzin (2017). This was used to compare and interpret the results from the different methods used for collection of data. The collected data from the interviews were transcribed to be able to understand and interpret the result in an efficient way. During the interviews, the authors recorded the interviews to be able to just listen during the interviews. After the interviews were

finished, the authors could then listen to the interview multiple times to collect useful data to analyze.

Denzin (2017) explains that multiple methods or triangulation is used in order to ensure that deficiencies from the different methods could be decreased. It is mentioned that methodological triangulation is mainly used when there are at least two different strategies methods used in the research. This type of triangulation could be complex, and it is emphasized that each method needs to interact to be able to increase the validity (Denzin, 2017). This thesis has used a methodological triangulation where data has been collected through interviews, questionnaires and observations, according to figure 4. The data from these different methods has been analyzed and integrated with each other in order to increase the validity and reliability of the collected data. The reason for the increase in validity was because the authors collected data from different types of sources and could therefore interpret the data.

Figure 4 illustrates the methodological triangulation that is used.

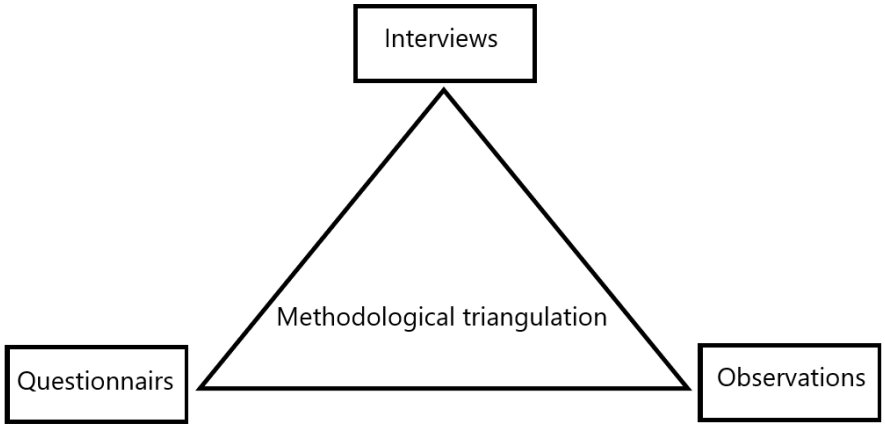

Figure 4 Illustrative figure of methodological triangulation. Inspired by Denzin (2017).

3.4.1 Units of analysis

Yin (2009) explains that the unit of analysis could be defined in a similar way as the case. The unit of analysis should be related to the research questions that have been selected.

To answer the first research questions the unit of analysis is linked to renewable fuels. The unit of analysis used was to explore the potential of renewable fuels with aspects regarding economic, technical infrastructure and regulations. Västra Götalandsregionen (2019) has set goals and strategies focusing on how to reduce emissions and explains that this is a challenge that needs to be addressed. Gagatsi et al. (2016) describes that the shipping industry leads to emissions because of the high volume of trade. It was calculated that the maritime sector is the second largest emitter of carbon emissions. Laasma et al. (2022) conducted an analysis on different types of alternative fuels for the ferries. Some of the fuels that were found to be relevant for ferries were electric hybrid, fully electric, hydrogen, methanol. Brynolf et al. (2022) also describes different types of fuels that could be potential renewable fuels for the shipping industry to reduce its emissions. They also discuss the infrastructure needed for those potential renewable fuels. In the report, hydrogen, electricity, hydrotreated vegetable oil (HVO), and methanol are some of the fuels

discussed to be potential fuels for a greener shipping future. The unit of analysis is which type of renewable fuels that could be used for the ferries in terms of costs, technical infrastructure and regulations.

To answer the second research question, the unit of analysis is linked to the exploration of accessibility. This includes accessibility for people with reduced mobility, distance between ferry and quay, accessibility of renewable fuels, the integration of passenger and goods, and space on the quay. Västra Götalandsregionen (2019) emphasizes the importance of accessibility regardless of the geographical areas that people are commuting from. Region Stockholm (2022) describes that accessibility for people with reduced mobility is important to consider regarding transportation with ferry. It is explained that there are different standards regarding accessibility onboard the ferries and different ramps between quay and ferries. Difference in heights is mentioned in a report by Sverige riksdag (2013) and explains that a major challenge is that there are differences in heights of the wharfs. This is a challenge because passengers with reduced mobility could have problems boarding and leaving the ferries. There is also mentioned that there are different accessibility standards on the quay and the infrastructure of the terminals. It is explained that there is a need to increase the accessibility for all passengers that are commuting with ferries (Sveriges riksdag, 2013). Cavallaro & Nocera (2022) describes that there is a need for more investigation in the area of integrated passengers and goods. The conducted studies in the field is more of an explanatory approach rather than investigating. Makkonen et al. (2013) also describes that there is a lack of an efficient ferry network in some parts of the archipelago and emphasizes that there is a need for more research in the field. The integration of passengers and freight is another unit of analysis used in the collection of data. Table 4 below shows the unit of analysis that was conducted for the different data collection methods used.

Table 4 Unit of analysis used for the different data collection methods.

The unit of analysis used for interviews:	**The unit of analysis used for observations:**	**The unit of analysis used for questionnaires:**
Infrastructure and accessibility in port.	Infrastructure and accessibility in port.	Infrastructure and accessibility in port.
Accessibility for passengers.	Accessibility for passengers.	Accessibility for passengers.
Integration of passengers and freight.	Integration of passenger and freight.	Integration of passengers and freight.
Renewable fuels in terms of costs, technical infrastructure and regulations.	Passenger freight onboard the ferries.	Transportation of dangerous goods.
Transportation of dangerous goods.		

3.4.2 Thematic analysis and coding

The analyzing process of the data from the interview was also conducted using the thematic analysis described by Bell et al. (2020). In order to search and analyze the data to find different patterns, it made it easier for the authors to interpret the results. When a pattern was found, it was explored if the same pattern occurred for all of the interviews. If there were different patterns for the different interviews, the authors evaluated why this could be the case.

In order to structure the data from the interviews, the authors have used thematic analysis together with the concept of coding and color coding. Bell et al. (2020) describes that thematic analysis is a commonly used method to analyze qualitative data. This method consists of an aim to find out what type of theme and the search for the right themes. An example of themes that could be found is "*repetition"*, which means that some statements or facts are recurrent. Another example is "*similarities and differences"* and refers to the similarities and differences that exist in different interviews (Bell et al., 2020). In the interviews that were conducted, there were some repetitions in certain subjects that were addressed. This led to a type of saturation of the results and when this occurred, the authors could be quite certain that the information regarding that subject was trustworthy and correct. The authors also found similarities that were closely connected to repetition but with some differences. These were also considered to contribute to the reliability of the data that was collected during the interviews. The differences that were found were used to discuss what the reason for this could be and how to interpret those differences.

To structure the thematic analysis, the authors have conducted different phases of the thematic analysis. This is described by Braun & Clarke (2006) and consists of 6 phases to be able to organize the thematic analysis. The phases include:

1. Understand the data collected: in this phase, the authors transcribed the data during the interviews, read and reread the data from the interviews that were conducted.
2. Conduct the first codes: in this phase, the authors conducted the coding of the data with the use of colors depending on the collected data.
3. Exploring themes among the data, in this phase, the authors explored the data and divided the data based on themes using the codes.
4. Analyzing themes, in this phase, the authors analyzed the themes and ensured that the themes were accurate based on the codes and dataset used.
5. Definition and creating names for themes, in this phase the authors defined themes based on the unit of analysis of the thesis. This ensured that the right data were used in the most relevant themes.
6. Conducting the result of the report, in this phase the authors analyzed the final themes that were conducted. This was conducted based on the unit of analysis to be able to present the result in the most accurate way.

According to Linneberg and Korsgaard (2019), color coding was used as a complement to thematic analysis and contributed to a more simplified analysis of the data that was collected during the interviews. For the color coding it is explained that it could be efficient to use a specific color for the different people being interviewed. This is something that has been conducted in this thesis in order to make the coding even more straightforward and simple to understand. It was used in order to efficiently and easily find what has been said and by who and it contributed to a more time-efficient interpretation of the data that has been collected. It also enables the

authors to structure the data, integrate and compare the different results without any loss of information regarding who the information was collected from.

As a complement to the thematic analysis, the authors also used coding of the data that is used in grounded theory (Bell et al., 2020). This led to a more accurate and time efficient transcription and interpretation of the data that had been collected. The thesis used open coding that, according to Bell et al. (2020) is a process used in order to break down the data and thereafter study the data, compare the results and sort the data into different categories. This type of coding enables the authors to collect the information and sort the information, making it simpler to interpret and understand the results. The coding process was conducted by listening to the interviews afterwards and at the same time transcribing the results that were presented.

4. Results

The following chapter presents the results and the analysis of the study to answer the research questions. The chapter presents the results of the observations, interviews and questionnaires. The analysis part of the chapter presents the similarities and differences in the triangulation between observations, interviews and questionnaires.

4.1 Observations

The results of the thesis were conducted by observations, interviews and questionnaires. The observations were on ferries and ports in different geographical areas of Tuvesvik, Gullholmen, Käringön, Rönnängs brygga, Åstol and Dyrön. From Tuvesvik it is possible to travel to Gullholmen and Käringön. On Gullholmen, there are also two different stops for the ferry, the harbor and the pier of Gullholmen. From Rönnängs brygga it is possible to travel to the island of Åstol and the island of Dyrön. The observation section includes description of the different ports in the areas and some figures to illustrate the findings.

4.1.1 Onboard the ferries

Orust
The ferry operates from Tuvesvik to Gullholmen and Käringön and according to the observations, the ferry is transporting passengers and goods. It was observed that when entering the ferry there is a mobile ramp that is used. On the foredeck, it was observed that some goods could be stored. To enter the salon, there is a threshold which has a ramp that could be used to transport, for example a wheelchair. In the salon of the ferry there is dedicated space for people with reduced mobility. It could also be observed that the ferry has a crane that can lift the goods in the back of the ferry. The goods are placed either in the back or in the foredeck as mentioned before. It could also be seen that some smaller goods were placed in the saloon together with the passengers.

Tjörn
The main ferry that operates between Rönnängs brygga, Åstol and Dyrön is observed to transport both passengers and goods. The goods that are transported on the ferry are rolled on the ferry and placed on the foredeck. Located on the foredeck, there is also a storage room that the goods can be placed in. To protect the goods from outer forces, there is also a door in the storage room which can be locked. If bigger goods such as pallets are being transported with the ferry, it is also possible to use a crane to lift the goods on and off onboard the ferry.

To enter the ferry as a passenger, there is a hydraulic ramp that the ferry lowers towards the gangway. The hydraulic ramp makes the surface flat which increases accessibility for people with reduced mobility. If passengers want to enter the saloon of the ferry, it is necessary to cross thresholds for the doors, however there are ramps connected to the thresholds which makes it easier to cross over. Inside the saloon, the floor is flat and there is a possibility for people with reduced mobility to use the front row of the seats. To enter the back of the ferry and sundeck, it is necessary to cross a threshold. Furthermore, to enter the sundeck, it is also necessary to climb a stair in the back of the ferry.

For the second ferry operator on Dyrön, the observations showed that the ferry is not that adjusted, neither for passengers nor goods. To enter the saloon, there are stairs, which could affect accessibility. Further, the observations showed that the ferry does not have any dedicated space for the cargo. Instead, the goods are placed either on the foredeck or in the aft of the ferry.

4.1.2 Port infrastructure

Tuvesvik

Through observations, it can be seen that the terminal in Tuvesvik consists of a gangway that passengers are using when entering the ferries. The gangway connects the fixed infrastructure in the terminal with the floating structure where the passengers and goods enter the ferry. The floating structure is designed in such a way that it will enable the quay that is resting on the pontoon to move vertically up and down depending on, for example tidewater. The horizontal movement is however limited due to a construction that keeps the floating quay fixed with the help of piles. The observations also showed that the connection between the floating quay and the ferry is performed with a mobile ramp which can be seen in figure 5. This ramp is placed on the floating structure and enables the passengers and goods to board the ferry. This ramp is transferred to the floating quay when the ferry is entering the terminal. The infrastructure of the terminal in Tuvesvik is not that large, but there is a waiting terminal close to the quay, together with a storage room for the goods.

Figure 5 illustrates the terminal of Tuvesvik and the interface between ferry and pontoon. The ferry is using their mobile ramp to create a connection between the ferry and pontoon.

Figure 5 The terminal in Tuvesvik (the authors, 2023).

Gullholmen

According to the observations, it is possible to see that there are two different ferry stops on the island of Gullholmen. The first one is in the harbor of Gullholmen and the second stop is on the pier of Gullholmen. In the harbor stop, the ferry is docking with the bow and there is no direct accessibility adjustment that changes with the water level. The reason for this is that the ferry just docks at the wharf, which is a fixed infrastructure and is at the same level regardless of the water level. When the

ferry docks, the staff on board the ferry use a mobile ramp that is placed between the ferry and the quay as shown in figure 6. This is used for passengers and goods to enter and exit the ferry. For the pier of Gullholmen which is another stop, some other observations can be made which can be seen in figure 7 and 8. This stop has a floating pontoon that adjusts to the water level and means that the ferry can always dock at the same level. For passengers to enter or leave this floating pontoon, the same mobile ramp is used as in the harbor stop. This is lifted on and off by the personnel onboard the ferry when passengers and goods are to be taken on and off the ferry. Once the passengers and goods have disembarked on the pontoon, they can walk on a ramp that takes them to the quay. However, it can be observed that the ramp from the pontoon to the fixed quay is affected by the water level which therefore changes the inclination of the ramp.

Figure 6 illustrates the ferry that has approached the quay in the harbor of Gullholmen. The ferry is using a mobile ramp to enable loading and unloading of goods and passengers.

Figure 6 A ferry that has docked towards the quay on Gullholmen (the authors, 2023).

Figure 7 illustrates the connection between the pontoon and ramp that is used to enter the pier on the island of Gullholmen.

Figure 7 The pontoon and ramp to the pier of the island of Gullholmen (the authors, 2023).

Figure 8 illustrates the ramp between the pontoon and the pier of the island of Gullholmen. On the pontoon, the ferry can dock and use its mobile ramp to create a connection between the ferry and the pontoon.

Figure 8 Ramp between the pontoon and the pier of the island of Gullholmen (the authors, 2023).

Käringön
On Käringön, several observations can be made. The first observation is regarding the infrastructure. It can be observed that the ferry is docking towards a fixed wooden quay. This quay has a level that is fixed and is not regulated based on the level of water. In order for passengers and goods to enter or leave the ferry, mobile ramps are used as infrastructure. For the goods, it is also possible to load and unload the goods with the crane placed on the ferry. The reason for this is because the ferry lays down with the side towards the quay and the mobile ramp can connect the ferry to the quay. It could also be observed on Käringön that the quay is narrow and therefore has limitations regarding storing goods or placing infrastructure on the quay.

Rönnängs brygga
On Rönnängs Brygga the ferry docks against a floating pontoon fixed to the quay. This floating pontoon allows the ferry to dock regardless of the water level. In order for goods and passengers to be able to get off and on board the ferry, a hydraulic ramp is used. This ramp is installed on board the ferry and is hoisted down onto the floating pontoon when the ferry approaches the port. At Rönnängs brygga it can be observed that the quay has a limitation in terms of space. In front of the pontoon there is a turning zone for cars, trucks and other public transport. On the sides of the pontoon there is some space for placing goods or other infrastructure.

Åstol
On the island of Åstol, a pontoon is also used as an infrastructure for the interface between the ferry and the quay. As in Rönnäng, this enables the ferry to dock regardless of the water level. The ferry docks with the bow towards the floating pontoon and hoists down its hydraulic ramp to create an interface between the ferry and the pontoon. The quay that the ferry docks at Åstol is also limited in space directly next to the ferry. However, there may be space for storing goods or placing infrastructure some distance away.

Dyrön main port
On the island of Dyrön, the infrastructure is similar to the infrastructure used on Rönnängs brygga and on the island of Åstol. The pontoon used on Dyrön thus enables the interface between the ferry and the quay. Also, as described for the pontoon on Rönnängs brygga and Åstol, the pontoon allows the interface to be uninterrupted regardless of the level of the water. Regarding the space for storage on Dyrön there are limitations of where goods and other infrastructure can be stored and placed.

Dyrön port
The other ferry operator on Dyrön has a smaller port compared to the main port on the island. The observations showed that there is a fixed quay where the ferry is docking in the port. The fixed quay results in a decrease in accessibility that is dependent on the water level. The observation also showed that the port is not adjusted in order to increase accessibility and the quay is quite small.

4.2 Interviews

The interviews were conducted on port accessibility on Orust and Tjörn, including the different ports on the islands. The section includes the integration of passengers and goods and how other actors in more urban areas have solved the problem. The section also consists of renewable fuel, including the different aspects to consider. Lastly,

there are also sections about the work environment and the procurement on ferry transportation.

Port accessibility on Orust
Most of the respondents mentioned that the coastal ferry segment needs to be improved in terms of accessibility. It was explained that quays and terminals in the archipelago need to be improved and adjusted. The accessibility needs to be improved both in terms of the infrastructure in the port and the accessibility for ferries. The ferries that are transporting the passengers from Tuvesvik to Gullholmen and Käringön is an actor that has an assignment from Västtrafik for public transportation.

Port accessibility Tuvesvik
During the interviews, it was mentioned by respondents 6, 8, 9 and 10 that the port accessibility in Tuvesvik is relatively good. Respondent 8 described that the port in Tuvesvik is rather new and that there have been investments to have a well-functioning port. Respondent 8 further argued that the reason why there has been investment in this port is because this is on the mainland. This makes Tuvesvik important for both passengers and goods that commute or transport themself to the islands outside Tuvesvik. Respondent 6 also argued that the port of Tuvesvik is important because it is the main port for the people living on the islands. It was described that the accessibility in Tuvesvik needs to work well because all the goods and passengers are transported through this port. Respondent 10 mentioned that there is positive that there has been investment in the port of Tuvesvik. It was explained that this level of accessibility should, in the best scenario, be the case in all the ports around the islands on Orust.

Further, respondent 10 explained that the accessibility in the port regarding the handling of the goods in Tuvesvik is working relatively well. There is a storage operated by personnel where the goods could be stored inside while waiting on the ferry. In the storage, there is also a possibility to store refrigerated goods as well. To transport the goods onboard the ferry, it was explained by respondents 6, 8 and 10, that the goods could either be rolled onboard the ferry using the gangway or lifted by the crane in the back. Respondents 6, 8 and 10 also described that the gangway leads to a floating pontoon which is important in order to have as low slope as possible when boarding the ferry with the goods by the ramp. Respondent 8 and 10 argued that this floating pontoon is really important to be able to facilitate the transportation of the goods. The reason for this is because when there is for example a high or low water level, the slope of the ramp to enter the ferry could be high, which makes it hard to board the cargo. Respondent 8 also explained that another positive aspect of the infrastructure of Tuvesvik is that the floating pontoon is fixed vertically and will therefore not move horizontally. This is, according to respondent 8, important because otherwise, it could be dangerous to have a floating pontoon. Respondent 10 also discussed that it is sufficient to use a floating pontoon to ease the handling of rolling the goods onboard the ferry. Another way that the goods are transported on and off the ferry were, according to respondents 6, 8 and 10, with the use of a crane. This crane is fixed to the back of the ferry which enables it to lift the goods on and off the ferry. All three respondents described that this was a time efficient way to handle the cargo when there were heavy goods being handled. But respondent 6 and 10 also argued that there are a lot of risks involved in this type of movement. For example, respondent 6 explained that it could be devastating if the goods dropped from the crane and in the worst case landed on some passengers.

Regarding the port accessibility for passengers in Tuvesvik, this was discussed by respondent 6, 8 and 10. All of them described the importance of the accessibility of the port and emphasized that in Tuvesvik, the port is relatively adjusted to have a high degree of accessibility for the passengers. Respondents 6, 8 and 10 described that on the islands outside of Tuvesvik, there are a lot of elderly people or people with reduced mobility. This was argued to be the main reason why it is of high interest and importance to have a well-functioning port with high accessibility for the passengers. Respondent 10 mentioned that when people enter the port, there is a waiting terminal where people could be waiting inside. A problem that was mentioned by respondent 10 was that there could be some more signs on the road before entering the port. It was described that during summer times when there is a lot of tourism, it could be hard to know which que that you are supposed to be in. This could be especially hard for people with reduced mobility or elderly people, where there are no clear signs which que that are leading to which islands. This is an improvement area according to respondent 10 because it has happened that people are standing in a long queue that leads to the wrong ferry. Respondent 6 mentioned that in general, Tuvesvik has a high degree of accessibility for the passengers but there could still be improvements. It was for example described that the mobile ramp that is used to connect the ferry with the floating pontoon is not that well-functioning. Respondents 6, 8 and 9 thought that it is not sufficient to use that kind of mobile ramp with a floating pontoon. The reason for this was, according to the respondents, that the mobile ramp is not that wide and also that the slope could be high. Respondent 9 explained that this mobile ramp reduces some of the advantages that the floating pontoon has. The floating pontoon enables a high degree of accessibility with wide gangway and vertical movements which result in a more efficient handling of both passengers and goods. According to respondent 9, the mobile ramp that is used to enter and leave the ferry results in a decrease in accessibility. The mobile ramp makes connection harder and the purpose of the floating pontoon decreases.

Port accessibility Gullholmen

Respondents 6, 8, 9 and 10 described during the interviews that Gullholmen has two different ports that the ferry can use for docking. The first one is the quay in the harbor of Gullholmen where the ferry can dock against a fixed quay which causes multiple issues in terms of accessibility. It was described by all of the respondents that the quay itself can be slippery due to some weather conditions and it is not adjusted to the movement of people and goods. Another issue that was raised by respondent 6, 8 and 10 was that the quay is fixed and does not move up and down with the level of the water in which the ferry does. The respondents explained that this causes problems because it affects the inclination of the mobile ramp that the ferry uses. Respondent 9 explained that the inclination of the ramp is important to consider in both terms of accessibility for people but also for the goods. The respondent explained that if the ramp is too steep, there is a risk that persons with reduced mobility could fall, and accidents could occur. The respondent also explained that the inclination of the ramp also affects the handling of the goods and the safety of the personnel onboard the ship. It was explained that if the ramp is too steep, the goods, for example a roll container could tip over and cause injuries to the person handling the container.

A problem that was mentioned by respondent 6 and 8 was the handling of the refrigerated goods. The port accessibility regarding this issue is not sufficient on Gullholmen and the reason for this is because there is no storage that could be used to protect the goods. Respondent 10 also described similar issues and that it is therefore

important for the goods owner to take care of their goods directly when it has been placed on the quay. Respondents 6 and 8 described that this problem could be hard to solve because there is not that much space available to store the goods. Respondents 6 and 10 described another problem with the port accessibility on Gullholmen and it was the space available to place the goods. This is a problem both regarding the accessibility of the goods in the port, but also for the passengers. The major reason for this problem is, according to respondent 10, that there are a lot of empty return pallets that are occupying the already limited space on the quay. This problem needs to be solved and respondent 10 argues that this could be solved relatively easily. One suggestion was to always load the return pallets right away on the ferry when departing back to Tuvesvik. This would result in more space to place the goods when rolled off the ferry and would increase accessibility for both the passengers and the goods.

The second port is according to respondent 6, 8, 9 and 10 located on the pier of Gullholmen. This is according to the respondents a relatively new investment which also has a floating pontoon that adjusts to the water level. According to respondent 6, 8 and 9, this enables the ferry to be on a similar level as the pontoon, and the ramp of the ferry will always be in the same inclination. It is however mentioned by respondent 9 that there are problems with the accessibility at this ferry stop. It is explained that the mobile ramp that the ferry uses is a bit narrow, and this can cause a feeling of insecurity among people with reduced mobility. It is explained that some people with reduced mobility need to be supported on both sides when crossing a ramp, and due to the narrow ramp, this might not be possible. Respondent 9 also explained that the pontoon has a connection between the pontoon and the ramp that is connected to the island of Gullholmen. It is explained that this connection might be too steep and angular which can be problematic for people with reduced mobility. It is explained by respondent 9 that it could be good if this connection could be somewhat flattened out which could make it easier for people with reduced mobility to cross over it.

The space available for placing goods on the pier of Gullholmen is also limited, similar to what has been discussed for the harbor of Gullholmen. Respondents 6 and 8 argue that the harbor does also have problems with the limited space. Another problem that respondent 6 mentioned was that the connecting infrastructure on the pier is not sufficient for handling goods. It was mentioned that there is a gravel road in connection to the harbor and that this could be problematic when transporting goods around the island. Respondent 8 also mentioned a problem with the gravel road and that it could be an uneven road which also affects the accessibility for passengers. It was emphasized by respondent 8 that this could especially be a problem for elderly people and people with reduced mobility.

Port accessibility Käringön

Respondents 6, 8, 9 and 10 also describe the port of Käringön during the interviews. It was described by respondent 8 that the port of Käringön has a fixed quay that the ferry docks when approaching the harbor. The respondent also explained that the quay can in some situations be problematic due to it being fixed. The reason for this is for example when there is a high degree of difference in the water level compared to the quay. This affects the slope of the ramp which could be a problem for the passengers and goods entering or leaving the ferry.

Respondents 6 and 10 described that the port accessibility regarding the handling of the goods is not that sufficient. Respondent 6 explained that the quay is narrow which makes it hard to find enough space to place goods that come and leave with the ferry. Also, respondent 9 explained that if there are too much goods occupying the quay, it also affects the accessibility of people. Another aspect that affects the space available is, according to respondent 6 and 8, that some empty return pallets are placed on the quay as well. This is a similar problem that has been discussed on Gullholmen. Respondent 8 explains that this needs to be solved in order to release some of the space on the quay that is already limited.

Respondent 6 and 10 also described another issue regarding the accessibility of the quay. The problem that was raised was that the quay is relatively long, but as has been described, it is narrow. Respondent 10 explained that the length of the quay can be a problem if there are heavy goods that are being transported. This results in a more complex handling of the cargo on the quay which needs to be fixed in order to increase the accessibility on the quay. Another aspect of this is the accessibility for the passengers who, according to respondent 6 need to walk a long distance before they have the possibility of leaving the quay. Respondent 6 explains further that this will then have a negative impact on the port accessibility regarding the passengers. It was argued that special emphasis needs to be on the elderly people and people with reduced mobility, who will be most affected by this problem. Respondent 9 explained another issue concerning the quay that has affected the accessibility level of the port. The problem that was mentioned by respondent 9 was that when there is, for example rain, the quay could be very slippery. This will affect both the accessibility in the port regarding passengers, but also the handling of the goods.

Passenger accessibility for the ferries on Orust

Respondent 6 and 8 explained during the interviews that the ferry used for passenger transportation is to some extent adjusted for accessibility. It was explained that the ferry has a flat floor onboard the ship, however, there are some thresholds that can affect people with, for example, wheelchairs. Respondent 8 explained that these thresholds are necessary to fulfill the requirements that make the ship seaworthy. It was also explained by respondent 8 that there are ramps that could be placed out to help people with, for example wheelchairs, to get over the thresholds more easily. Further on, respondents 6 and 8 also explained that if a new ferry were planned, it would be good to include a ramp that is more adjusted to be more accessible. It was mentioned that a hydraulic ramp could be a suitable solution for making the ramp more accessible. Another suggestion that was mentioned by respondent 8 was that the ramp should be wider to increase accessibility on the ferry.

Port accessibility on Tjörn

Respondents 1 and 3 explained during the interviews that Tjörn also has some problems with the accessibility on the islands. It was explained that there are multiple stakeholders that operate in the islands outside Tjörn based on their assignments from Västtrafik. Some of the actors have older ferries and port infrastructure that is not adjusted enough for accessibility. Another actor was explained to be more adjusted regarding accessibility in terms of both the ferries and the infrastructure used in the ports.

Port accessibility Rönnängs brygga
Respondent 3 explained that the port infrastructure in Rönnängs brygga is well developed. It was mentioned that the gangway in the port is wide, and it is easy to enter and leave the ferry. The reason for the high port accessibility was because there were large investments that were made about 25 years ago to develop the port infrastructure. Respondent 3 argued that those were a result of a state fund in order to implement better infrastructure on Rönnängs brygga, Åstol and Dyrön.

Those funds developed both the accessibility in the ports with gangways and more sufficient ramps that made it possible to roll goods on and off the ferry more easily. Respondent 3 explained further that the hydraulic ramp and gangway facilitate the handling of the goods and enable, for example, craftsmen to bring their van to the islands. It was discussed that the floating pontoon that is used in Rönnängs brygga results in an adjustment when there are different water levels. This is, according to respondent 3, an important aspect in order to facilitate the handling of the goods in the port. Respondent 3 mentioned that Rönnängs brygga has a refrigerated storage that is rather large, which could store the goods that are sensitive to heat. It was explained that at some times, there must be a prioritization of the goods when there is a lot of demand for storage. Respondent 3 argued that this is not any big issue because many of the refrigerated goods are packaged in refrigerated containers which keeps the goods cold. It was also mentioned that there is a dry storage where other goods could be stored while waiting on departure. According to respondent 3, their port infrastructure regarding accessibility is well-functioning and this is the result of the large investments that were made with the stated funds.

Respondent 3 further explained that this investment also resulted in an increase in the accessibility of the port for the passengers as well. It was mentioned that the investments made it possible to transport a smaller car and especially an ambulance to ensure the safety of the islands outside Rönnängs brygga. It was also explained by respondent 3 that there is a large number of elderly people living on the islands and therefore accessibility is important. Respondent 12 explained that the hydraulic ramp used by the ferry, gangway and floating pontoon increases the accessibility in Rönnängs brygga. It was explained that the infrastructure keeps the ferry and gangway at a sufficient level regardless of the water level. Respondent 12 also explained that this makes it easier for passengers with reduced mobility because the hydraulic ramp that the ferry uses will always be in the same inclination. However, it was explained that the gangway that is attached to the quay is resting on the floating pontoon and can therefore be steeper if the water level changes. Respondent 3 explained that if the scenario with a steep gangway would occur, the width of the gangway allows one person on each side to help the person with reduced mobility and result in safe handling.

Port accessibility Åstol
Respondent 3 explained that the island of Åstol was also a part of the larger investment that was made about 25 years ago to develop the infrastructure in the port. Therefore, both a floating pontoon and a gangway are used on the island of Åstol. The respondent explained the ramp and gangway makes the surface flat and this increases the accessibility for both the handling of goods and also for passengers that travel with the ferry.

The port infrastructure regarding the accessibility for the goods was, according to respondent 3, rather good on Åstol as well. It was explained that when goods are being transported to, for example stores on Åstol, the personnel on the ferry call the stores and let them know that the goods are being transported. Respondent 3 describes that this enables easier handling of the goods and has a positive effect on port accessibility because the store owner could collect the goods directly when it arrives. Further, it was mentioned that for return pallets and other goods, it could be placed on the quay until there is enough space on the ferry to return it to Rönnängs brygga. The return pallets are placed at the quay and are separated from the passengers which makes the handling of the goods easier, without disruption and risks regarding passengers.

The port accessibility for the passengers is according to respondent 3 high and as has been mentioned, there is a similar gangway and hydraulic ramp as on Rönnängs brygga. This, together with the floating pontoon, makes accessibility for people with reduced mobility easier. Respondent 12 also discussed that the accessibility for people with reduced mobility is high on Åstol as well. It was argued that this type of port infrastructure has a high standard to fulfill the requirements to ensure the safety of passengers with reduced mobility. As has been described by respondent 3, the goods are often collected directly because the personnel call the owner of the goods to inform them that the goods are being transported. This is, according to respondent 3, another action that has increased accessibility for passengers as well. Another aspect that respondent 3 argued to contribute to the high accessibility of the passengers is that the return pallets are separated from the passengers using dedicated space on the quay.

Port accessibility Dyrön

Respondent 3 explained that on the island of Dyrön, the port infrastructure is also a part of the larger investment that was made. The respondent explained that the port has similar infrastructure as in the other mentioned ports and has therefore both a floating pontoon and a gangway attached to the quay. The port accessibility regarding the handling of the goods on Dyrön, is according to respondent 3 similar as has been described on Åstol. The gangway connects to the floating pontoon which makes it easy to handle the goods. The goods are according to respondent 3 commonly rolled on and off the ferry and the width of the gangway makes the handling easier. Respondent 12 discussed the accessibility in the port regarding the passengers. It was mentioned that this is functioning well and the investments that have been made on Dyrön have resulted in a high level of accessibility.

The other actor that operates public transportation in the area operates on Dyrön as well, but on the other side of the island in the smaller port. Respondent 1 describes that their port infrastructure is not that well developed in regard to both accessibility for goods and passengers. It was mentioned that the company is not that large and therefore it would be too costly to invest in new infrastructure on all the ports that they are operating in. Respondent 1 described that there will not be any floating pontoon and that the accessibility for passengers may therefore not be that sufficient. It was mentioned that there is no storage available in those ports for goods handling.

The port infrastructure regarding the accessibility for goods on Dyrön is according to respondent 1 limited. As has been described, it would not be feasible to invest in new infrastructure because of the limited budget. It was explained that if for example, a

passenger wants to transport goods, it could just be transported subject to availability. This was according to respondent 1 a problem because they could not store the goods. So, in cases where goods could not be transported, the goods owner needs to take care of the goods and leave it somewhere else. Respondent 1 described that this is a problem that needs to be solved and the aspect that the problem will end on the personnel on the ferry that need to decide if there is any available space. It was argued that this is not their responsibility to transport goods and this problem needs to be coordinated in a more efficient way. Respondent 12 also discussed the accessibility of the goods for this other actor and explained that the goods handling could be hard because of the fixed quay. The reason for this is that the slope could be high when the water level differs from the quay.

Regarding the accessibility for the passengers in the port, respondent 1 explained that there is not that high accessibility. As has been mentioned, there is a fixed quay which makes it hard for people with reduced mobility to enter and leave the ferry when there are bad weather conditions. This affects the accessibility and especially for elderly people or people with reduced mobility due to the height differences. This is according to respondent 12 not optimal and there is a higher risk of injury when there are different water levels. There is, according to respondent 12, no hydraulic ramp that is used which makes the accessibility even harder. Another problem that respondent 1 mentioned was that the quay could get slippery when there is a lot of rain. This also affects the accessibility for people with reduced mobility in a negative way.

Passenger accessibility for the ferries on Tjörn

Respondents 1 and 3 describe the passenger accessibility for the ferries used to transport goods and passengers between different stops on Tjörn. Respondent 3 explained that the ferry used by the stakeholder who is more adjusted, the ramps, floors and thresholds are well adjusted for people with reduced mobility. As has been mentioned, the ferry has a hydraulic ramp which makes the connection to the quay easier when there is a high difference in water level. The respondent explained that the ferry enables people with for example wheelchairs to roll onboard the ferry and into the saloon, without any larger interference. The respondent also explained that if the gangway is steep due to changes in water level, it is possible that a person with reduced mobility can be assisted. The person with reduced mobility can then have one person on each side assisting them to get on and off the gangway. Respondent 3 explained that the ferry has a sundeck, and this might be hard for people to reach with reduced mobility due to the steps that are necessary to climb to reach the sundeck. Instead, the respondent suggested that people with reduced mobility stay on the main floor or on the front deck of the ferry.

Respondent 1 explained that the stakeholder that is less adjusted to accessibility uses a ferry that is older and less adjusted to accessibility for people with reduced mobility. The respondent mentioned that if the passenger wants to reach the saloon of the ferry, it is necessary to take the steps inside the ferry. It was also explained that the ferry does not always level up with the quay and this makes it harder and less safe for passengers to get on and off the ferry.

Integration of passengers and freight on Orust

Respondents 6, 8 and 10 explained that in Tuvesvik there is a terminal where goods can be handled and stored before transportation is performed with the ferry. The

respondents described that when the ferry arrives at the terminal, the personnel take the goods and places it on the ferry before the passenger enters the ferry. A problem that respondent 10 mentioned is the handling of sensitive goods, such as refrigerated goods, where the goods are being placed onboard the ferry before the passengers board. The problem with this is that the refrigerated goods are placed onboard the ferry and it takes some time before the ferry departs. This is especially a problem during the summer when it is hot and it is therefore a risk that the refrigerated goods, such as fish, are being destroyed. Respondents 8 and 10 described that currently, it is common to use rolling containers to transport, for example, goods to the restaurants. It was argued by respondent 8 that one solution could be to have some kind of thermostat or refrigerated containers that keep the temperature during the waiting time.

Further, respondent 8 explained that if the goods owner changed to, for example, a refrigerated container instead, there are some adjustments regarding the stowage that are needed on the ferry. Another solution that respondent 10 mentioned was instead to have some sort of modular refrigerated storage onboard the ferry. In this case, the goods could be placed in this space and will keep the temperature for the sensitive goods. In this case, respondent 10 explained that the rolling containers that are common today could still be used. Another benefit of this solution was, according to respondent 10, that it would enable it to remove and add the modular refrigerated storage depending on the demand of the ferry. So, when there is a high demand of passengers, the modular refrigerated storage could be removed and when there is a lower demand of passengers, it could use more modular refrigerated storage. Respondent 11 also described that a solution is to use modules on the ferry in order to find a balance between the demand and supply for passengers and goods. The solution was to have a ferry that uses modules that are easy to place and remove from the ferry depending on the demand. When there is a larger number of passengers, the modules could be removed to enable more space and when there are less passengers, more modules for goods could be placed onboard.

Respondent 8 and 10 described another problem with the transportation of dangerous goods and the safety of the transportation. One suggestion from the respondents was to have a dedicated storage for the dangerous goods that could sustain different forces, for example fire. Respondent 10 also described a problem regarding the spaces that are occupied by goods that are being transported by the ferry. The respondent explained that if a person with for instance a wheelchair is commuting with the ferry, it can be problematic due to the lack of space when entering and exiting the ferry. The respondent also described that if the deck in the bow is occupied by cargo, it might be problematic if evacuation is necessary. Respondent 10 explained further that goods normally are placed in the back of the ferry and are loaded when the ferry is docked with its side against the quay. The loading and unloading can then be supported by a crane when it is necessary to lift the goods. Respondent 10 describes that this is a system which enables the passenger to enter the vessel simultaneously as the goods are being loaded in the back of the ferry. However, the respondent explained that there could be a problematic situation if the ferry is being evacuated and the goods in the back of the ferry are blocking emergency exits or other lifesaving equipment.

Respondent 8 also discussed the problem with the space onboard the ferry that is dedicated for people with reduced mobility. The problem that was described was that it is common that there are goods that are placed in those areas, and it could therefore

be a problem if a person with reduced mobility commutes. This could result in a decrease of the accessibility for passengers with reduced mobility. A solution that respondent 8 explained was to have some kind of compartments for private goods. This would result in more structure and space onboard the ferry and increase accessibility for both goods and passengers. Respondent 9 explained that the space onboard the ferry that is dedicated to people with reduced mobility is important to keep free from goods.

Integration of passengers and freight on Tjörn

Regarding the accessibility of the goods on the ferry, respondent 3 described that it is possible to handle smaller cars for craftsmen, golf carts and other types of smaller vehicles. It was mentioned that it is also possible to transport an ambulance to be able to serve the islands outside of Rönnäng. It was mentioned that when there is a large number of passengers, it will normally not be possible to handle any vehicle because of the limited space. Further, it was mentioned that there is also handling of food, such as refrigerated goods. In the bow of the ferry, on the foredeck, it was described that there is a storage room. In the room, six refrigerated containers or other types of smaller containers could be stored. According to respondent 3, it is possible to store the goods in this storage room in a safe manner, regardless of the weather conditions. It was however mentioned that when there is bad weather condition, it will not be possible to have any transportation of other goods on the foredeck due to the safety of the ferry and the passenger. It was also described that one of the reasons for this is because the stakeholder follows the regulations by Transportstyrelsen which says that it is not necessary to lash the goods and therefore it endangers safety if goods are placed on the ferry outside the storage in bad weather. Respondent 3 described the following citation: *''The safety of the passenger is always the number one, however if the safety allows, we try to combine passenger and goods as much as possible''.* Respondent 3 also described that it is not allowed to bring any larger units of dangerous goods onboard the ferry. It is however allowed to bring a smaller consumer package of goods that are considered as dangerous goods. If this consumer package with dangerous goods is transported with the ferry, respondent 3 explained that the package shall be placed on a dedicated place on the foredeck of the ferry. Respondent 9 discussed the accessibility on the ferry and emphasized that it is important to secure the accessibility on the ferry when combining passengers and goods. It was mentioned that the storage room is important to be able to secure the safety of the passengers. Another aspect that was mentioned by respondent 9 was that to be able to secure the accessibility, it is important that the goods are not placed all over the ferry. The reason for this is because this will decrease the accessibility for the passengers and also the safety.

It was explained by respondent 3 that if a passenger wants to transport any larger goods on the ferry, it is possible to call them and book the space onboard. For example, if someone wants to transport a craftsman car to Åstol, the person needs to book that space in order to secure the space. Respondent 3 argues that this is an efficient way to be able to plan the space available onboard and also for the passengers that know that the goods will be transported. There is a charge when people want to book space onboard the ferry, such as a golf cart or food to the store on the islands. Regarding the food to the store, respondent 3 explained that there is an agreement between, for example, the grocery store on Åstol and the ferry operator. In this case, the agreement is that the central warehouse of the grocery store pays the charge for the transportation to, for example, Åstol.

During the interview, respondent 3 also described that a new ferry is being planned that has improved properties in comparison to the existing vessel. The new ferry will have a larger focus on the integration of passengers and goods and one of the main improvements is a larger foredeck, another one is a larger storage area. The respondent described that this new larger storage area will allow for the transportation of larger goods. It was described that a new model of ambulances is an aspect that is problematic to transport on the existing ferry, and therefore when the new ferry is planned, they take the new larger ambulance into consideration.

Regarding the integration of passengers and goods on the smaller ferry operator in the area, it was described by respondent 1 to be problematic. Respondent 1 explained that some assignment from Västtrafik just involves passengers and not goods. In that case, Västtrafiks assignment is just to make sure that the transportation of passengers between the islands are working in a sufficient way. According to respondent 1 it will therefore be hard to integrate the passengers and goods because the ferries are not adjusted for goods. If people want to transport any larger goods, they have to book a separate ferry for goods, but in many cases, people do not want to do this. Instead, respondent 1 described that people want to bring the goods on the passenger ferry instead and this is problematic. It was explained that the passenger ferry will only transport goods subject to availability and the goods will in those cases be placed on the foredeck, back of the ferry or in the aisle to the saloon. Respondent 1 described that this leads to irritation from the passengers that cannot transport their goods. Another problem with this is according to respondent 1 that if the goods are placed on the foredeck, it affects the accessibility for the passengers. There is no place onboard the ferry that is dedicated to goods and this makes it hard to secure accessibility and safety on the ferry. As has been mentioned, respondent 1 explained that the reason for this is because the ferry is not designed to transport goods. It was however mentioned that there is an exception regarding the transportation of bicycles. In this case, respondent 1 explained that there is a requirement that passengers should be able to transport their bicycle with public transportation. This is a problem because it was explained that the ferry does not have enough space to transport all the bicycles. It was mentioned that it is similar to other goods, that the bicycles could be transported subject to availability. This is according to respondent 1 not optimal and is an aspect that needs to be improved.

Respondent 1 explained that if a new ferry were designed it should be better space available for goods onboard the ferry. It should be a dedicated space that is designed for the goods. Another suggestion for improvement was to compensate for the height differences that occur during the docking of the ferry. The reason for this is because the ferry operates on fixed quays in the different ports, and it is therefore hard to enter and leave the ferry when the water level differs. A solution for this would, according to respondent 1 be to use ballast water to compensate for the height differences and be able to have a flatter slope. Another important aspect was according to respondent 1 to dock the ferry with the bow first to be able to have a more efficient flow of both the passengers and the goods. It was explained that in this case, the goods and passengers are entering and leaving the ferry in the bow which makes the handling easier. Another solution to this that was described was to have a docking alongside the quay. In this case, respondent 1 described that the loading and unloading of passengers and goods could be more efficient because the goods could for example be loaded and unloaded in the aft and the passengers in the bow. Respondent 1 mentions that there

are problems with this solution as well, such as extension of the quays and more personnel required.

Alternative solutions for integration of passenger and freight

Respondents 4 and 5 described how other stakeholders in the coastal areas conducted their integration of passenger and goods. Those actors operate ferries in more urban areas in the coastal areas. Respondent 4 described that the integration of goods and passengers is well-functioning. It was explained by the respondent that smaller goods are accepted to transport on the ferry, such as passengers' luggage and smaller packages. The respondent also described that vehicles for contractors are accepted to be transported on the ferry. For larger goods, the stakeholder has a collection where people could leave their goods, which will be collected and transported together with other goods in a smaller truck onboard the ferry. Respondent 4 described that the collection of goods is not an economically beneficial solution, but that it is important from a societal perspective. For refrigerated goods, it was mentioned by respondent 4 that those trucks could directly enter the ferry to not risk any disruption of the supply chain for those sensitive goods.

Respondent 5 is another ferry operator in the coastal urban areas. It was described that the operator has a different strategy in the integration of passenger and goods. Their solution is to separate the passengers and goods to a large extent, especially regarding the transportation of larger goods. If companies or private persons want to transport any larger goods, it is possible to book and leave the goods to the operator, which will transport the goods in combination with other goods. This solution was according to respondent 5 beneficial because it increased the accessibility of the passenger ferries. It was however mentioned that there is a problem regarding for example bicycles on the passenger ferries. The problem is that the ferry is not adjusted for bicycles and other similar goods, which makes it hard to transport bicycles. Respondent 5 also mentions that passengers are allowed to transport smaller goods such as luggage that will occupy some spaces onboard the ferry. Respondent 5 further argued that to be able to solve the problem with the bicycles, there has to be some sort of bike rack that could keep the bicycles in place. There should also be dedicated spaces available onboard the ferries for bicycles in order to have a structure which will increase the accessibility and safety for the passengers.

Renewable fuel

Respondents 1, 3 and 8 explained that there is a discussion regarding which fuel to use for future projects. There have been discussions if some alcohol could be used, for instance methanol. The respondents also described that hydrogen has been discussed to use as a fuel. The respondents explained that the conclusion that has been made is that there is not enough knowledge regarding these fuels, and the focus has therefore been moved towards electrification with a back-up system. Respondent 8 also explained that there is an uncertainty regarding hydrogen connected to the safety when it comes to passenger ferries. Respondent 3 explained that contractual panthers also have a large impact on the choice of fuel for the ferries, and the focus has now been towards electrification. Respondent 2 mentioned that their ferries already operate on electrification and argues that this is the best solution for transportation of shorter distances. The majority of the respondents argued that the best solutions were to use electrification driven ferries, together with a back-up system if some error occurs. Respondents 2, 3 and 8 explained that this back-up system should preferably be HVO in order to have less impact on the environment.

Renewable fuel cost
Respondent 3 described the cost of investments for renewable fuel and in many cases, it is hard to find it economically justifiable. It was mentioned that especially for smaller ferry operators, it could be difficult to invest in renewable fuels. Respondent 1 also argued that converting into renewable fuels is costly and therefore it would be difficult to change fuels. But it was mentioned by respondent 1 that they want to change the fuel, but their strategy is to see which renewable fuel is most efficient and tested by other actors. The cost aspect was also emphasized by respondent 4 that described the problem with the cost of renewable fuels. It was mentioned by respondent 4 that HVO was used before, but due to higher prices for HVO, they have been forced to return to fossil fuels. It was explained that it is difficult to decide which renewable fuel to use due to the economical aspect such as fluctuation in price connected to supply and demand.

At the same time, respondent 3 argued that it will be necessary to convert into renewable fuels to be able to fulfill Västtrafiks aim to be fossil free by 2030. Further, respondent 3 described that they have taken the large costs for investments in consideration when procuring a new contract with for example Västtrafik. According to the respondent, this allows the company to invest in renewable fuel, such as batteries for the upcoming ferries. It was also mentioned that Västtrafik will require more renewable fuels in the upcoming procurement to be able to reach their goals. In this scenario, respondent 3 argued that the ferry operator will not have any other choice than to convert it into renewable fuels. Respondent 1 also discussed that it is important to change to renewable fuels because Västtrafik will require it when negotiating for a new contract.

Respondent 2 emphasized that the cost for renewable fuels is higher in comparison to traditional fuels used by the industry. The respondent described that they have made investments in battery propulsion and HVO fuel which have been costly for the company. It was however argued that those investments will pay off in the future because of environmental awareness and the environmental requirements. Respondent 2 also described that the investment costs are high due to the lack of current infrastructure necessary for renewable fuels. For instance, it was mentioned that new cables and charging infrastructure were needed, which was a large investment.

Technical infrastructure
Respondents 1 and 3 described that the technical infrastructure is important to consider when planning for future development of the infrastructure. Both respondents emphasize that the supply of renewable fuels is an aspect that needs to be investigated carefully. It was described that the use of batteries requires a large amount of electricity. Respondents 1 and 3 emphasized that this could only be possible to be achieved in ports that are not too small. Respondent 3 for example mentioned that this was possible on Rönnäng brygga, but maybe not possible for example on Åstol. Respondent 3 also stated that they have an agreement with the electricity provider that has solved the supply of electricity to Rönnängs brygga. Respondent 2 and 5 also described a safety aspect regarding electrical ferries, with batteries onboard the ferries. It was mentioned that they have solved it with monitor systems that will detect overheating or other potential errors in the batteries. Respondent 3 described that under some circumstances, it will be necessary to have a back-up system instead of just battery propulsion. They described for instance if the ferry would go to a shipyard for maintenance or if any error occurs, it would be a

scenario that requires a back-up system. The back-up system that was described could then for example be a generator that could be powered by HVO.

Respondent 1 argued that one renewable fuel that has been discussed is HVO and mentioned that this has similar characteristics as for example diesel fuel. The problem with HVO that respondent 1 described was that the supply of the HVO is not that reliable, which also affects the price of fuel, as has been mentioned by respondent 4 as well. Another aspect to consider according to respondent 1 with HVO was the storage, it could either be stored in the port in a tank or that a tank vessel supplies the ferry with the fuel. But the main problem with HVO was according to respondent 1 the supply of the fuel.

Regulation

Respondent 1 explains the problem with the supply of education for handling of, for example batteries. It was mentioned that there will be other types of requirements for the personnel that are operating an electric ferry. According to respondent 1 it is important to ensure that the right knowledge exists and especially if there is any accident onboard such as fire. Respondent 3 also discussed the importance of new education and requirements regarding handling of renewable fuels. It was mentioned that the personnel need further education in order to be able to have a safe operation with for example, battery driven ferries. Respondent 1 further explained that there is a problem regarding the regulation connected to the handling of batteries. It was argued that Transportstyrelsen has not fully decided how the regulations should be designed. Respondent 2 also mentioned a similar problem in the beginning of the battery conversion of their ferries, the lack of requirements and information. It was described that in many cases, operators follow the recommendation that the classification societies have. However, both respondent 1 and 2 explained that the requirements and information will be better when more operators convert into renewable fuels.

Respondents 2, 8 and 10 describe that there is an issue regarding the regulation for other types of fuel such as hydrogen and methanol. It was explained that this contributes to a larger uncertainty due to the fact it requires the user of the fuel to explore more and find out what is possible and not.

Procurement of ferry transport

During the interview by respondent 1, 3 and 7 it was described that when a procurement of a ferry transport is needed, different parties are involved. It was described by respondent 7 that the municipalities constitute the region which also owns Västtrafik. Further on, it was described by respondent 7 that when a procurement is initiated, it is Västtrafik that specifies the requirements. According to the respondent, the requirements can for instance be the accessibility, fuel and the construction or design of the ferry. According to respondent 3 the discussions regarding renewable fuels are mainly focused on electrical ferries and that Västtrafik wants that for the upcoming procurement. It was also mentioned by respondent 1 that the region makes decisions about what Västtrafik should do and are compensating Västtrafik to perform the transportation.

Work environment

It was described by respondent 1 that the personnel onboard the ferries have a work environment that depends on the tasks given by the passengers. Respondent 1 describes that the ferry has not any assignment to transport goods, and therefore the

personnel should not assist with the goods. Even though the personnel should not lift any goods, the personnel often do it. The respondent described that there are scenarios when passengers come with goods that they cannot handle themself to get onboard the ferry. Respondent 1 mentioned for instance that if a passenger is old and comes with a lawnmower, then the personnel onboard the ferry may help to get it on and off the ferry.

During the interview with respondent 3 it was described that the work environment is well functioning onboard their ferry. There are some occasions when the personnel may help the passengers with goods, but most of the time the goods are not lifted by any of the personnel. Instead, it was described that the goods are being rolled on and off the ferry either by hand or with the help of an electrical truck or pallet lifter. Also, because of the commonly flat surface, it is a task that contributes to a well-functioning work environment. If the water level is high or low and the goods are being rolled off by hand, it was described that the personnel may require some extra help with pushing the goods on and off the ferry. Respondent 9 emphasized that it is important that the slope of the ramp is not too high because this could lead to injuries due to the handling of heavy goods. The respondent argued that this is another aspect that has to be considered in order to secure a safe working environment, both for the personnel or private persons that are handling goods on and off the ferry. Respondent 3 further explained that if it is not possible to roll on and off the goods, for example if the passenger wants to transport building materials such as wooden planks, the ferry has a crane. With the use of this crane, respondent 3 described that they can lift on and off goods. The goods will be placed on the foredeck of the ferry where it will stay under transportation.

Respondents 8 and 10 also described the environment and mentioned that on Käringön and Gullholmen, the work environment is affected by multiple aspects. For example, it was described by respondent 8 that the work environment is affected by the ramp of the ferry due to the inclination of the ramp. It was described that there are occasions when there is high and low water which creates a difference between the ferry and the fixed quays. If the ferry transports goods on the foredeck, it is necessary to load it on and off the ramp. Respondent 10 also described the work environment of Käringön and Gullholmen. It was described that when goods such as rolling containers are being handled on the quay the work environment is not well functioning. The respondent argued that the surfaces of the quays are worn down which creates friction between the goods and the quay. This then creates a strain on the personnel handling the goods due to the increase in force necessary to move the goods.

4.3 Questionnaires result

The questionnaires were conducted on the selected geographical areas. The questions in the questionnaires are based on quantitative data.

Figure 9 illustrates the gender of the participants in the questionnaire. There were approximately 54 percent women and 46 percent men.

Figure 9 Gender of the participants in the questionnaire.

Figure 10 shows the age of the participants of the questionnaire. It is shown that most of the participants are 50 years old or older. About 18 participants were between 70-79 and 15 participants were between 60-69 years old.

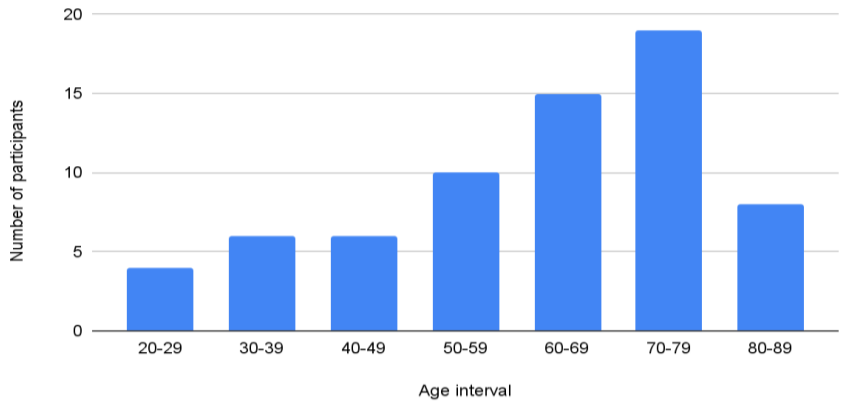

Figure 10 The age of the participants in the questionnaire.

Figure 11 illustrates where the participants most commonly commute to or from. It can be seen that it was most people that were commuting to Gullholm and Åstol among the participants. However, it was relatively similar among the different islands that answered the questionnaires.

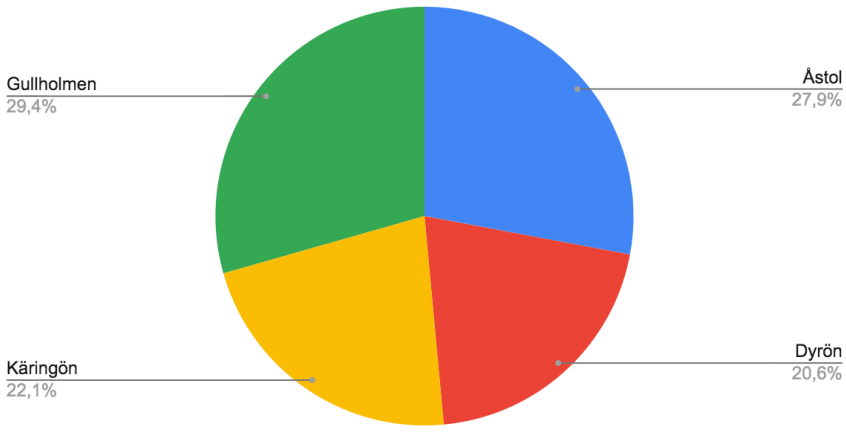

Figure 11 The islands that the participants commute to/from.

Figure 12 shows the different reasons the participants had regarding why they commute from the different islands. It was most common that there was the participant´s permanent residence where they lived. Temporary visits were another answer that was almost as common followed by tourism.

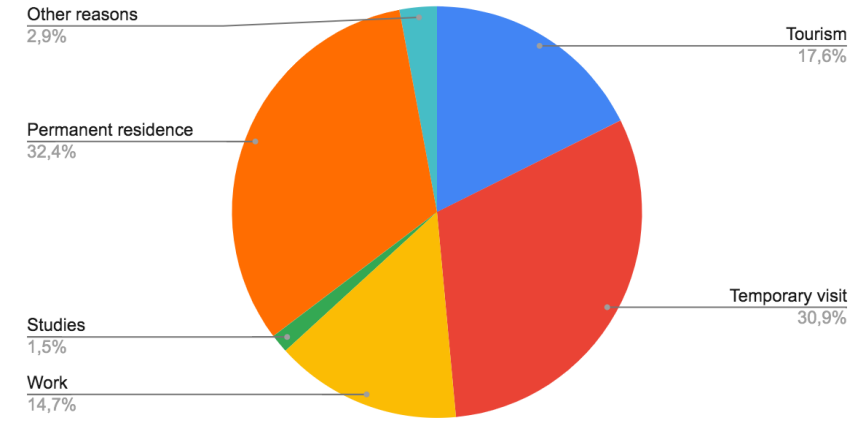

Figure 12 The purpose of the participants commuting.

Figure 13 illustrates how the participants' views were regarding the accessibility onboard the ferry for Rönnängs brygga, Åstol and Dyrön. It can be seen that about 17 participants thought that it worked decently, while about 12 participants thought that it worked well.

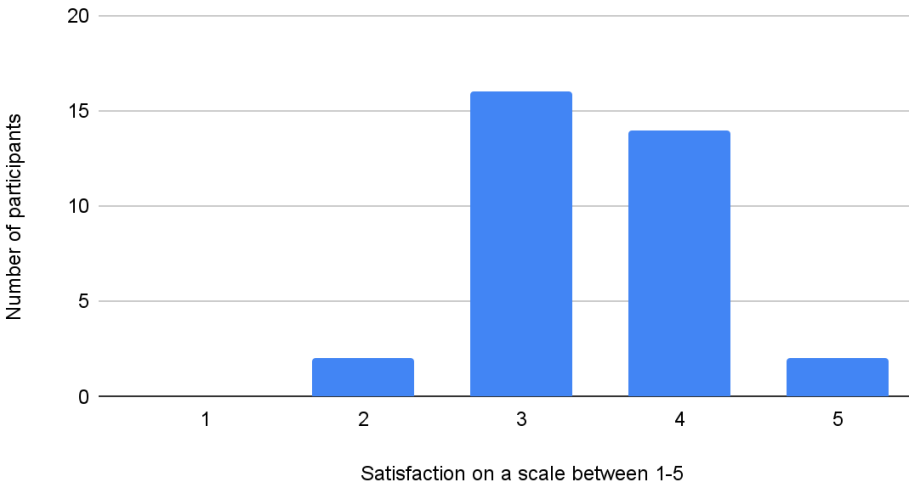

Figure 13 The participants satisfaction regarding accessibility onboard the ferry for Rönnängs brygga, Åstol and Dyrön.

Figure 14 shows the satisfaction regarding the accessibility for Tuvesvik, Gullholmen and Käringön. It could be seen that 12 participants thought that the accessibility on the ferry was decent, while 10 participants thought it was not so good and 6 thought that it was good.

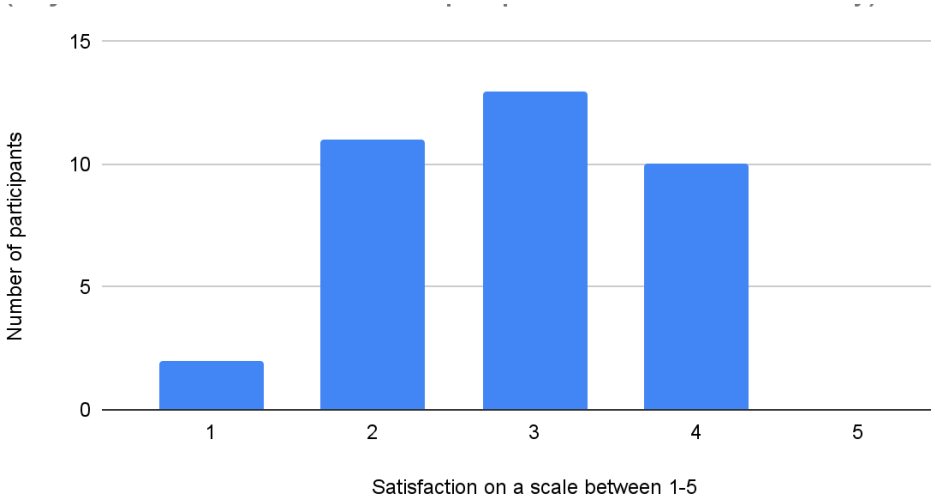

Figure 14 The participants satisfaction regarding accessibility onboard the ferry for Tuvesvik, Gullholmen and Käringön.

Figure 15 shows that about 17 participants thought that the accessibility regarding the connecting infrastructure on Rönnängs brygga, Åstol and Dyrön are working well. About 7 participants thought that it worked very well.

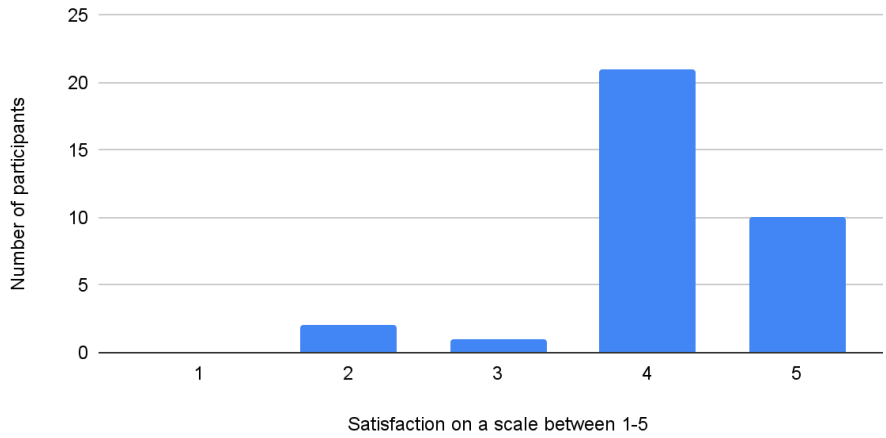

Figure 15 The participants satisfaction regarding accessibility with the connecting infrastructure for Rönnängs brygga, Åstol and Dyrön.

Figure 16 shows that most participants thought that the accessibility in the ports of Tuvesvik, Gullholmen and Käringön was not working quite well or not at all. 8 of the participants thought that it was alright.

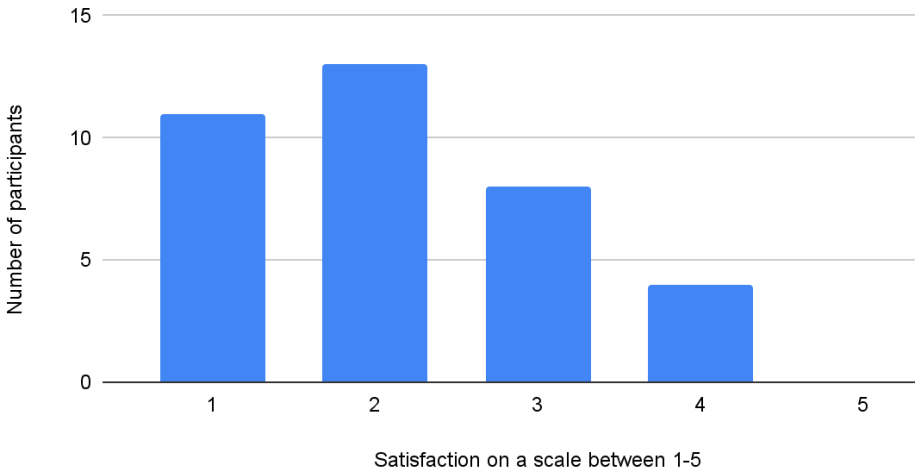

Figure 16 The participants satisfaction regarding accessibility with the connecting infrastructure for Tuvesvik, Gullholmen and Käringön.

The participants in the questionnaire were also asked, if the ferry and connecting infrastructure are adjusted to people with reduced mobility, do you think that this would enable easier handling of cargo as well. The result showed that 98,5 percent of the participants thought that an adjusted connecting infrastructure in the port for people with reduced mobility would also result in easier handling of the cargo.

Figure 17 shows how satisfied the respondents are with the current situation with combining passengers and goods on the ferries for Tuvesvik, Gullholmen and Käringön. It can be seen in figure 17 that the participants are not satisfied regarding the integration of passengers and goods.

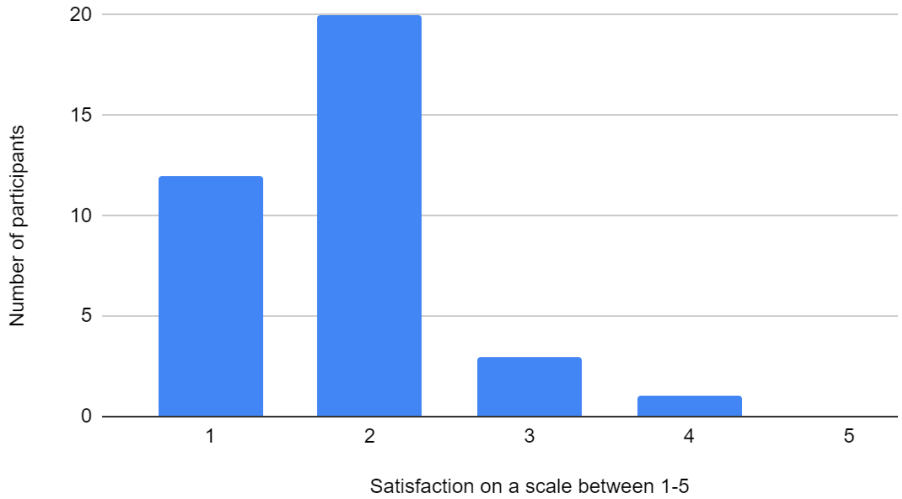

Figure 17 The participants satisfaction regarding the combination of passengers and goods onboard the ferry for Tuvesvik, Gullholmen and Käringön.

Figure 18 shows how satisfied the respondents are with the current situation with combining passengers and goods on the ferries for Rönnängs brygga, Åstol and Dyrön. It could be seen that almost all participants thought that the integration of passengers and goods are working either alright or good in Rönnängs brygga, Åstol and Dyrön.

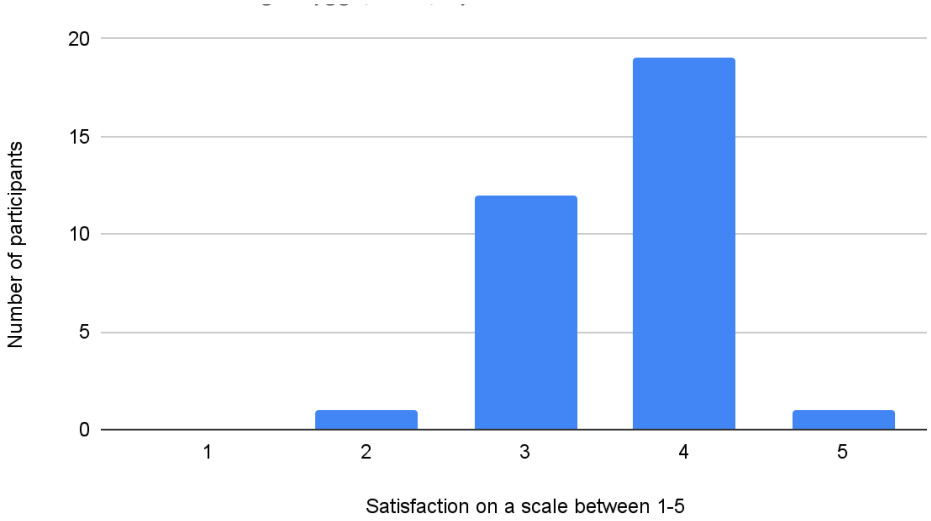

Figure 18 The participants satisfaction regarding the combination of passengers and goods onboard the ferry for Rönnängs brygga, Åstol and Dyrön.

The participants were asked about their opinions regarding the question of whether they think it is a good idea to combine passengers and goods onboard the ferry. The result showed that 88 percent of the participants thought that it was a good idea to integrate the transportation of passengers and goods onboard the ferry. About 12 percent thought that this was not a good idea. Another question that was asked was their opinions regarding if dangerous goods are transported onboard the ferry together with passengers, do they feel safe. The result showed that about 94 percent thought that they would not feel safe to be transported together with dangerous goods onboard the ferry. While 6 percent of the participants thought that it would feel safe even if dangerous goods were transported onboard the ferry. Further, the participants in the questionnaire were also asked regarding if dangerous goods would be transported in its own department onboard the ferry, would it feel safer. The result showed that about 82 percent of the participants would feel safe with the transportation of dangerous goods, if the goods were placed in an own department on the ferry. About 18 percent would not feel safe anyway. Lastly, the participants were asked a question regarding their opinion if it would be a good idea if the ferry would operate on renewable fuel. The result from the questionnaire showed that about 91 percent of the participants thought that it would be a good idea for the ferry to operate on renewable fuel. About 9 percent thought that this would not be a good idea.

4.4 Analysis

4.4.1 Infrastructure and accessibility in ports on Orust

Tuvesvik

The observations showed that the infrastructure and accessibility in the port was fairly well-functioning. The port was adjusted to increase accessibility, for example by using a floating pontoon. The observations showed that this enabled easier boarding of the passengers and also if the goods are rolled onboard in front of the ferry. This was confirmed by respondent 6, 8, 9 and 10, who argued that the port infrastructure is well-functioning in Tuvesvik. Respondents 6, 8 and 10 also argued that the gangway to the floating pontoon resulted in an easier handling of goods which also increased the accessibility of passengers. This could also be seen in the observations, where the gangway increases the accessibility for both passengers and goods. The questionnaire showed similar results, where the participants thought that an increase in port

accessibility would result in a better handling of both passengers and goods. Respondents 6, 8 and 10 described that there are many elderly people or people with reduced mobility that live on the islands outside Tuvesvik, which makes accessibility even more important. This could also be confirmed by the questionnaire, in figure 10, where many of the participants traveling with the ferry were elderly people.

Gullholmen

Respondents 6, 8, 9, and 10 explained some issues with the two ports on Gullholmen. An issue that was discussed was the problem with the fixed quay at the stop of the harbor. The problem that is mentioned both during the interview and that can be seen during the observation is that the quay, which is fixed, does not adapt to the water level. It is explained by respondent 9 that this decreases the accessibility for both passengers and goods, which could also be seen in the observations. The fact that the quay is fixed is a problem because the quay could not adjust to the height of the ferry, which affects the slope of the ramp used onboard the ferry. Respondent 9 argued that if the ramp is too steep, this could lead to accidents for people with reduced mobility.

For the pier of Gullholmen the observations showed that there is a floating pontoon used to dock the ferry. The observations also showed that this pontoon is adjusted according to the water level. It was observed that there is a ramp connecting the gangway with the floating pontoon. This could decrease the accessibility for both people and goods due to the inclination of the ramp between the pontoon and gangway. This was a problem mentioned by respondent 9 and it was argued that it could decrease accessibility. The accessibility problems with the connecting infrastructure such as ramps were also confirmed by the participants in the questionnaire. It could be seen that people were not satisfied with the current infrastructure regarding accessibility, as has been seen, both in the observations and the interviews.

Käringön

Respondents 6, 8, 9 and 10 explained similar problems mentioned at the harbor of Gullhomen, with a fixed quay that could not adjust to the water level. This was also shown in the observations, with a similar problem regarding the slope of the ramp connecting the quay with the ferry. Respondent 6 mentioned that the quay is narrow and the space available on the quay is limited. This was argued to decrease the accessibility both for passengers and goods. Similar results were found in the observations where the storage availability was limited, which also affected the accessibility for passengers to access the quay. As has been mentioned, the participants in the questionnaire thought that the accessibility in the port was not sufficient, which has been confirmed by both the observations and the respondents.

Accessibility for passengers Orust

During the observations, it could be seen that the ferry used between Tuvesvik, Gullholmen and käringön is to some extent adjusted to accessibility. The observations showed that there is a threshold to enter the saloon. However, there is a ramp that is used to be able to enter the saloon with, for example, a wheelchair. Respondent 8 argued that this threshold is necessary in order to fulfill the requirements to make the ferry seaworthy. It could also be observed that there was dedicated space in the saloon for people with reduced mobility. The result from the questionnaire, presented in figure 14, showed that the majority of the participants thought that the accessibility onboard the ferry was either decent or worse.

It is shown in the observations that the ferry uses a mobile ramp to enter and exit the ferry. This was also confirmed by respondent 6, 8 and 9 and they argued that this mobile ramp was not sufficient to use. This was also confirmed by the observation where there is no adjustment available when using those mobile ramps. Respondents 6 and 8 argued that if a new ferry was planned, it would be better to use a hydraulic ramp. This was explained to increase the accessibility both for passengers and goods. Another suggestion by respondent 8 was to widen the ramp in order to increase that accessibility further.

Integration of passenger and freight Orust
Respondents 6, 8 and 10 describe the integration of passengers and goods. It was mentioned by respondent 10 that there is a problem regarding, for example, the handling of sensitive goods. The observation also showed that there is a storage facility for goods inside the terminal of Tuvesvik. This was also confirmed by the interview with respondent 10 where it was explained that there is a storage facility where goods are stored before transportation with the ferry. A problem that was mentioned by respondent 10 was that the refrigerated goods were placed onboard the ferry before the passengers were boarding the ferry. This could take some time which affects the temperature of the refrigerated goods. This problem could also be seen in the observation where the refrigerated goods were handled before the passengers, which takes time.

Respondent 10 further explained a problem regarding goods that occupy the spaces onboard the ferry. This also affects the accessibility for passengers, especially people with reduced mobility, especially when entering and exiting the ferry. Figure 17 illustrates that the participants in the questionnaire are not satisfied with the current integration of passengers and goods onboard the ferry. The occupation of space onboard the ferry could also be confirmed by the observations.

4.4.2 Infrastructure and accessibility in ports on Tjörn

Rönnängs brygga
Respondent 3 explained that the infrastructure in Rönnängs brygga is well-developed and has a high level of accessibility. It was described that the gangway is wide and there is a floating pontoon that adjusts depending on the water level. This could be confirmed by the observations, which showed that the accessibility was high due to for example the wide gangway to the floating pontoon. Both respondent 3 and the observation showed that there was a storage room, both for refrigerated goods and dry goods. The level of satisfaction regarding the accessibility in the port was high according to figure 15 that showed that the participants were overall positive to the accessibility of the infrastructure. It was also mentioned by respondent 3 that the ferry uses a hydraulic ramp which makes the connection to the floating pontoon easier. Respondent 3 also mentioned that there are a large number of elderly people on the islands outside of Rönnängs brygga and therefore it is important to have a high level of accessibility. As has been mentioned before, figure 10 confirmed that there are many elderly people commuting to those islands.

Åstol
The observations showed that the port on Åstol also had a gangway and floating pontoon. This was confirmed by respondent 3 that mentioned that there is similar infrastructure on Åstol as in Rönnängs brygga. Respondent 12 argued that the

accessibility is high on Åstol as well and the infrastructure is well-developed. The floating pontoon makes accessibility easier both for passengers and goods due to sufficient level regardless of water level. As mentioned by respondent 3, the ferry uses a hydraulic ramp which results in a more sufficient slope of the ramp when connecting to the floating pontoon. This was confirmed by the observations that showed that this hydraulic ramp was sufficient to adapt to different water levels. As has been discussed, figure 15 showed that the participants in the questionnaire were satisfied with the infrastructure regarding accessibility in the ports.

Dyrön
Respondent 3 explained that similar infrastructure of the main port has been made on Dyrön. There is a gangway and a floating pontoon to adjust to different water levels. This was confirmed by the observations and the accessibility was high on Dyrön as well. As has been mentioned, according to figure 15, the participants were overall satisfied with the accessibility of the infrastructure in the ports.

Respondent 1 explained that the smaller actor operating a ferry on Dyrön does not have the same accessibility in the smaller port. It was mentioned that there will not be any investments in a floating pontoon due to the limited budget. This could be confirmed by the observations that showed the lack of adjustments in connecting infrastructure to the ferry. Respondent 1 mentioned that it is a fixed quay, which could be problematic when the water level changes. This was also an aspect that was found in the observations and the lack of flexibility.

Accessibility for passengers Tjörn
Respondent 3 argues that the ferry on the main route is well adjusted to people with reduced mobility. It was described that the accessibility was high with the hydraulic ramp that enabled the ferry to dock in a sufficient way. This could also be seen through observations, where the hydraulic ramp increases accessibility for people with reduced mobility or elderly people. In figure 13 it is confirmed that the participants of the questionnaire thought that the accessibility onboard the ferry was either decent or well-functioning. Respondent 1 explained that their ferry does not have that high accessibility onboard the ferry. It could be problematic to enter the saloon of the ferry if a passenger with reduced mobility is transported. This could also be seen in the observations, which confirm this description.

Integration of passenger and freight Tjörn
Respondent 3 explained that the main ferry between Rönnängs brygga, Åstol and Dyrön uses integration of passengers and goods. It was mentioned that smaller craftsman cars or an ambulance could be transported on the ferry. There is also according to respondent 3 a dedicated storage room onboard the ferry in the foredeck where both refrigerated containers and other cargoes could be stored. The respondent also explained that when the weather allows, goods can also be placed on the foredeck of the ferry. This was confirmed by the observations, which showed similar findings. Respondent 3 argues that the integration is working relatively well, and this is confirmed by figure 18 that shows that the majority of the participants in the questionnaire were either decent or good. Respondent 3 further explained that an improvement for the new ferry could be to focus more on the integration of passengers and goods. The suggestions were for example a larger foredeck and a larger storage room.

Respondent 3 explained that it is only allowed to transport consumer packages of goods that are considered to be dangerous goods. The safety aspect of transporting dangerous goods was considered by the participants in the questionnaire. According to the questionnaire, the majority of the participants would not feel safe to be transported together with dangerous goods. However, the questionnaire indicates that people would feel safer if the dangerous goods are transported in a dedicated space that is in an own department. A dedicated space for dangerous goods was an aspect that respondent 3 mentioned as well.

Respondent 1 explained that the integration of passengers and goods is problematic for this smaller ferry operator. Their assignment is just to transport passengers and therefore the ferry is not adjusted for goods transportation. Respondent 1 argued that the transportation of goods is only subject to availability. This could also be seen through the observations, which indicate that the integration is not that sufficient. Another problem that was mentioned by respondent 1 was that the handling of goods is harder when there is a fixed quay with mobile ramps. This makes it hard to enter or exit the ferry with the goods. This could also be seen by the observations and affects the efficiency of the integration.

4.4.3 Renewable fuels in terms of costs, technical infrastructure and regulations

Respondents 1, 3 and 8 discussed different alternative renewable fuels and that it is important to change the fuels for the ferry. The change to renewable fuels was an aspect of the participants of the questionnaire and according to the questionnaire, they were positive towards more renewable fuels. The majority of the respondents argued battery driven ferries would be the best solution. The safety aspect is important to consider when operating batteries and was mentioned by respondents 2 and 5. Respondents 2 and 5 described that one solution is to use a monitor system to be able to detect potential errors. Further, it was explained by respondents 2, 3 and 8 that it is important to use some type of back-up system if any error occurs. This back-up system would, according to the respondents, preferably operate on HVO. Other fuels were also discussed, for example the respondents mentioned different alcohols like methanol. Hydrogen was also discussed among the respondents, but a problem with hydrogen is the safety aspect. However, respondent 7 explained that it is the procurer of the contract that sets the requirements regarding fuel type.

5. Discussion

The discussion chapter presents the interpretation of the frame of references linked to the results and analysis. This includes different aspects regarding renewable fuels, accessibility and integration of passengers and goods. Further, a methodology discussion is presented.

5.1 Renewable fuels

All of the respondents discussed that renewable fuels for ferries are an important aspect to consider. The results showed that there have been discussions regarding different fuels, such as methanol and hydrogen. It was also discussed in the results that HVO is a fuel that could be an alternative to traditional diesel. HVO was especially discussed as a preferable back-up system to electrically driven ferries, that the majority of the respondents thought would be the best solution. Methanol and HVO were also discussed by Brynolf et al. (2022) as two alternative fuels for the shipping industry. The electrical driven ferry was discussed by Gagatsi et al. (2016) as a potential solution in the coastal areas. It was argued that because of the shorter distances in those areas, it would be a possible solution. Van Hoecke et al. (2021) discussed hydrogen as an alternative fuel for shipping. It was however noticed that the respondents did not have that much knowledge about hydrogen and therefore did not consider using this fuel in the near future.

It could be seen that there were some different alternative fuels that were mentioned both in frame of reference and by the respondents in the interviews. The analysis showed that the best solution was, according to the respondents, to have a fully electric driven propulsion with a back-up system operating on HVO. The electrical ferry was also described by Sæther & Moe (2021), which studied the ferries in the coastal areas of Norway which have been successful. However, as the respondents mentioned there are also other fuel types that can be considered in the future. This has also been explained by Al-Enazi et al. (2021), that different renewable fuels are important to consider in order to achieve the sustainable goals.

Cost

The results showed that the investments necessary to convert to renewable fuels require a large amount of capital. It is costly to change fuel types and therefore some respondents will wait and see what other actors choose before them. It was also explained that they have to consider the large investment costs that are required when a new procurement is negotiated with Västtrafik. It was argued in the result that it was necessary to convert into renewable fuels in order to comply with Vässtrafik´s requirements in the upcoming procurements. The result showed that Västtrafik is mainly focused on electrical ferries in the upcoming procurement and that is what the ferry operators have to fulfill. As has been mentioned by a majority of the respondents, an electrical ferry, with a back-up system operating on HVO, was found to be the best solution. However, according to Anwar et al. (2020), it was mentioned that the cost could be lower if a hybrid solution was used compared to fully electric ferries. It was for example mentioned by Anwar et al that the cost of the batteries could be lower because of less capacity needed. This could be a possible solution for operators that do not have the financial ability to fully electrify the ferries.

The result showed that one of the respondents used a back-up system operating on HVO, but it was explained that it is costly to use HVO. It was however argued that this will pay off in the future due to the environmental requirements. It was also

shown that they have been operating on HVO, but due to high prices they were forced to change to fossil fuel again. However, Hansson et al. (2019) argued that HVO is an alternative fuel that could have lower cost connected to the necessary investment. It was argued that the existing infrastructure could be used, which could result in lower initial costs for the operator. As could be seen, HVO could have both positive and negative aspects, which could be the case for all renewable fuels. This makes the decision even harder and there are many aspects that need to be considered.

Technical infrastructure

The result showed that it is important to consider the technical infrastructure to be able to convert into renewable fuels. It was for example explained that electrical ferries require a large amount of electricity and that this could be a problem on the islands. The result also indicated that the electrical infrastructure needs to be placed on the mainland, for example on Rönnängs brygga. The impact on the electrical grid was also described by Purnell et al. (2022) which describes that the higher demand will result in higher pressure on the electrical grid. Sæther & Moe (2021) described that the infrastructure and electrical grid has been successfully implemented in Norway to adapt to the higher pressure. The safety aspect is another important factor to consider, which has been shown in the result. It was discussed that a monitor system could be used to detect potential overheating or other errors in the battery system. Kunicka & Litwin (2019b) described that a potential safety solution could also be to have casings which could protect the batteries. It was mentioned in the result that an infrastructural aspect that needs to be considered is the storage of HVO if this is used as a back-up system to the electrical ferries. It was explained that the storage could either be placed in the port or that a bunker vessel could be used. Acciaro et al. (2014) also describes the importance of ports to become more sustainable with the use of renewable fuels. Acciaro et al described that ports need to develop more fuel infrastructure, and this should be in close collaboration with authorities and regions. As has been mentioned by several of the respondents, the existing infrastructure could be used to supply HVO.

Regulation

It was explained in the result that it is a problem regarding the education for handling batteries and that this is important because other types of knowledge are required. It was also mentioned that another problem is connected to the regulations of batteries and the lack of instructions. It was explained that, for example, Transportstyrelsen does not have enough information and a similar problem was mentioned in the result. It was explained in the result that when one of the respondents converted their ferries, the classification societies had more information in their recommendations that was more sufficient to use. Anwar et al. (2020) explains a similar problem regarding the lack of regulations in general connected to the electrification of the shipping industry. It was described by Transportstyrelsen (2023) that the battery installation onboard needs to be classified by a classification society. The lack of regulations and knowledge about the handling of batteries could be a major obstacle if ferry operators want to convert their ferries towards electrification.

5.2 Accessibility for passengers and goods

Port accessibility

The results from the interviews described the port accessibility on Orust. Both the observations and the result showed that the port of Tuvesvik is rather well-functioning

with regards to the port accessibility. The floating pontoon increases the accessibility for both goods and passengers. Chou et al. (2020) and East (2018) also described the floating pontoon as an important implementation to be able to adjust to the water level. It was however mentioned in the result that a problem that exists is that the ferry is using a mobile ramp, which decreases the adjustment of the floating pontoon due to the inclination of the ramp. East (2018) also explained that it could be difficult for wheelchair users to access a ramp that is steeper than 1:20. According to Boverket §3:1222 (BBR, 2011) it is stated that the inclination of the ramp should be maximum 1:12, but it is recommended that it should be 1:20.

The questionnaire showed the view of the participants regarding the accessibility for connecting infrastructure. It can be seen in figure 16 that, in general, the participants were not satisfied with the connecting infrastructure on Orust, including the Gullholmen and Käringön. Another problem was mentioned in the result regarding the storage on the islands. For example, it was explained that there is no dedicated space on the quay for goods, which decreases the accessibility for both passengers and goods.

The results from the interviews described the port accessibility in Rönnängs brygga, Åstol and Dyrön which is located on Tjörn. It was described in the result that the infrastructure used for the main ferry operator is similar in the three ports. It was described that all of the three ports have a floating pontoon and gangway which increases the accessibility. The result also showed that the gangway is wide which increases the accessibility. The width of the gangway was an important aspect according to East (2018). This could also be seen in figure 16, which indicated that most of the participants were satisfied with the current infrastructure at the three ports. The result showed that the ferry uses a hydraulic ramp, which results in a more sufficient connection between the ferry and the floating pontoon. This results in a more sufficient inclination level, as was stated in Boverket §3:1222 (BBR, 2011). The result further showed that there was dedicated space on the quay for the goods in the ports, which also resulted in higher accessibility, both for passengers and goods. The result showed that there is also a second and smaller actor which operates a ferry from the other port of Dyrön. This is a small port located on the other side of the island and the operator does not have the same accessibility adjustment compared to the main ferry operator.

With regards to the respondents, the observations and the participants in the questionnaire, it could be seen that there are some differences in port accessibility on Orust and Tjörn. In general, both the respondents and the participants of the questionnaire were more satisfied with the current infrastructure on Tjörn compared to Orust. The accessibility seems to be higher at Tjörn which is a result of the implementation of, for example, gangways and floating pontoons. This, together with the hydraulic ramp on the ferry resulted in a higher accessibility on Tjörn compared to Orust.

Passenger accessibility

The result showed that the ferry is to some extent adjusted for accessibility. The observations showed that there is a threshold to enter the ferry which could be problematic for a passenger with, for example, a wheelchair. The result explained that the main ferry operator between Rönnängs brygga, Åstol and Dyrön operates a ferry that is relatively adjusted with regards to people with reduced mobility. It was

described that the floors and threshold are adjusted which increases the accessibility onboard the ferry. The ferry uses a hydraulic ramp that creates the connection between the ferry and the gangway which also increases the accessibility. The result from the observations, interviews and the participants in the questionnaire shows that, in general, the accessibility for passengers onboard the ferry is higher on Tjörn compared to Orust. According to the respondents, this is at least the case for the main operator on Tjörn which has an adjusted ferry. This was confirmed by figure 13, which indicates that the accessibility onboard the ferry is higher than was the case on Orust, which figure 14 showed. It can be seen in figure 10 that there are many elderly people commuting to and from the islands using the ferries. It could also be seen in figure 12 that the purpose of commuting with the ferries are most commonly due to permanent residence, temporary visit and tourism. It could also be seen in the Regulation of the European Parliament and of the Council (1177/2010) that all people should have the same opportunity to commute by waterway transportation. This is also documented in Sjöfartsverket (SJÖFS 2004:25) that states that the ship has to be adjusted for people with reduced mobility. The presence of numerous elderly individuals, including both permanent and temporary residents, on the islands underscores the need for ensuring accessibility onboard the ferry.

Integration of passengers and freight

The result showed a problem with refrigerated goods, where these goods are placed onboard the ferry before the passengers board the ferry. It was explained that there is a problem regarding the accessibility for passengers with reduced mobility, where there is a dedicated space for those passengers. The problem was that some goods are placed in those areas which affects the accessibility. Cavallaro & Nocera (2022) emphasize the importance of integrated passenger and goods transport. It was argued in the study that integration could result in a more effective and optimized transportation. Another problem was shown in the result regarding goods occupying the space on the deck in the bow. This could pose challenges not only for evacuation but also for the accessibility of areas such as those required for wheelchairs. In figure 17 it can also be seen how satisfied the respondents are with the current situation with combining passengers and goods on the ferries for Tuvesvik, Gullholmen and Käringön. It can be seen in figure 17 that the majority of the participants are not very satisfied with the current situation of combining passenger and goods.

It was described in the result that the goods are mostly being rolled on and off the ferry and gangway either by hand or using an electric truck. For heavier goods, it is also possible to use the crane onboard the ferry. It was explained in the result that the ferry is planned to enable integration to some extent, with a storage room for both refrigerated goods and other goods. It was further described that when there are many passengers, it is not possible to transport, for example, a craftsman car, due to the limited space. Regarding the smaller ferry operator, the result showed that their integration of passengers and goods is not satisfied. It was argued that their assignment from Västtrafik is just to transport passengers and therefore the ferry is not adjusted to goods. Jansen (2014) mentioned that a solution could be to transport goods during times when the passenger demand is not that high. Lindkvist & Melander (2022), described the MaaS concept with, for example, digital tools to communicate and share information. The concept MaaS is a system that the ferry operators on Tjörn and Orust could implement. This could then hopefully lead to more sustainable and efficient ports where goods and passengers could be integrated in the most efficient way. The integration of passengers and goods could be seen in

figure 18, which shows that the majority of the respondents on Tjörn are moderately satisfied with the current situation. The observations also showed that the goods transported with the ferry of the main operator are being either rolled on and off or in some special cases by crane. For the smaller operator, it was shown in the observation that there is a lack of adjustments for goods onboard the ferry.

The result from the observations, respondents and participants shows that there are some differences between Orust and Tjörn regarding the integration of passengers and goods. Figure 11 illustrates where the participants in the questionnaire commute from and as has been mentioned, figure 17 and 19 shows that, in general, the participants were more satisfied with the integration on Tjörn compared to Orust. The reason for this could be that the main operator on Tjörn has adjusted the ferry in a more efficient way to be able to combine passengers and goods. However, the questionnaire showed that the passengers thought it was a good idea to combine passengers and goods onboard the ferry. Another aspect to consider is the transportation of dangerous goods. The questionnaire shows that the majority of the participants would not feel safe commuting together with dangerous goods onboard the ferry. However, the questionnaire showed that if the dangerous goods were transported in an own department onboard, the majority of the passengers would feel safer. This shows an important insight from the participants, which indicates that if accessibility for passengers increases, it would also lead to an increase in the efficiency of the handling of goods. This was an aspect that was mentioned in the result and explained that if for example the surfaces are flatter, it can be both beneficial for increasing passenger accessibility and efficiency of handling the goods. From a work ergonomic perspective this is also an aspect that Arbetsmiljöverket (AFS 2001) mentioned. If the goods are being handled easily, without heavy lifts, the work environment would be better. As has been mentioned in the result and indicated by the questionnaire, the increase in accessibility for passengers could also result in an ease in the handling of goods.

5.3 Methodology Discussion

This master thesis has been conducted by a multiple case study to be able to answer the research questions. For the collection of data, a mixed method was used with both qualitative and quantitative data. The collection of data was conducted through observations, interviews and questionnaires. This served as a foundation for a triangulation between the observations, interviews and questionnaires. The reason that the thesis used a multiple case study was because the aim was to explore specific cases in the archipelago in Bohuslän. The mixed method was used to collect relevant information from both a quantitative and qualitative perspective. The reason for using triangulation with observations, interviews, and questionnaires was to increase the validity and reliability of the research findings. The triangulation involved the use of multiple methods of data collection to cross-validate the results and help ensure that the findings are accurate and trustworthy. To further ensure the validity and reliability, the collection of data was conducted by different methods and multiple sources. The thesis has considered the ethical aspects with regard to the anonymity of the respondents in the interviews and the participants in the questionnaire. To facilitate the general data protection regulation, the participants of the interviews confirmed their approval via a signed document. This was appreciated by many of the respondents because it ensured that their data was anonymous.

The advantages of the use of a multiple case study with a mixed method was that it enabled the authors to explore several different cases in the area. Another advantage with multiple case study was that it enables comparison between the cases. An advantage with the mixed method was that the use of both qualitative and quantitative data provided a comprehensive understanding of the area of research. One disadvantage with the multiple case study was that it was a time-consuming process and could be hard to grasp a general perspective. A disadvantage with the mixed method was that the complexity increased, with regard to two different approaches that needed to be integrated. The triangulation also had some advantages and disadvantages. An advantage, as has been mentioned, was the increase in validity and reliability. Another advantage could be that the authors could find similarities and differences between the data collected with the different methods. A disadvantage with triangulation could also be that the authors of the thesis are biased, especially regarding observations.

After the thesis had been conducted, the authors found some areas in the method that could have been improved. For example, in the questionnaire, it could have been a specific alternative for the participants commuting with the smaller ferry operator at Dyrön, instead of a general answer. This could have separated the answers and distinguished which participants commute with which ferry. This was also an aspect that could be applied on Orust where it could be more sufficient to separate Tuvesvik from the other islands.

6. Conclusion

The purpose of the thesis was to answer the two research questions. The method used was a multiple case study, with a mixed method approach. The result was conducted by triangulation between observations, interviews and questionnaires.

How can conversion to renewable fuels of coastal ferries used in integrated transport be possible from a cost, technical infrastructure, and regulatory perspective?

The analysis shows that all the respondents discussed the importance of converting the ferries to operate on renewable fuels. The majority of the respondents argued that the best current solution would be to operate the ferries on batteries, with a back-up system operating on HVO. Gagatsi et al. (2016) also argued that electrical ferries would be a solution for coastal ferries. However, the result explained that it would be expensive to convert the ferry for smaller operators. A solution for this was discussed by Anwar et al. (2020), which mentioned that a hybrid ferry could be a possible solution in order to reduce costs. The respondents also mentioned other fuels such as hydrogen and methanol, but due to lack of knowledge and contractual agreements, these were not considered as relevant fuels today. It was also discussed by the respondents and Anwar et al. (2020) that there is a lack of regulations regarding electrification in the shipping industry. To operate electric-driven ferries, it was, according to the result, important to consider the electrical infrastructure in the ports. There would be a high demand on the electrical grid, which needs to be solved to ensure the amount of electricity. This was also discussed by Sæther & Moe (2021), which explained that this has been solved in Norway, in order to manage this higher demand. Regarding HVO, it was mentioned that it is possible to use the existing infrastructure which is advantageous for the implementation of the fuel.

How should ferries and connecting infrastructure be designed to facilitate integrated transport to increase accessibility for people and goods?

Regarding the accessibility, the analysis shows some differences between the Tjörn and Orust. On Tjörn, the respondents and participants were in general quite satisfied with the current connecting infrastructure and accessibility onboard the ferry. The main reason for this was because there are installments with floating pontoons, gangways and a hydraulic ramp which creates a beneficial interface for people with reduced mobility. On Orust, the respondents and participants were not as satisfied with the general accessibility of connecting infrastructure and ferry. It was argued that the ferry was not accessible enough due to the use of a mobile ramp. Another aspect was that several of the ports used a fixed quay, which decreased the accessibility for both goods and people with reduced mobility. Similar results were also conducted during the observations. The accessibility aspect is also considered in the Regulation of the European Parliament and of the Council (1177/2010), which states that all people should have the same opportunity regarding waterway transportation.

The analysis shows that in general, the participants and respondents were more satisfied with the integration of passengers and goods on Tjörn compared to Orust. A reason for this could be that the main ferry operator on Tjörn has more dedicated space for the goods onboard the ferry. Another reason could be the higher efficiency due to the hydraulic ramp, which enables easier handling of both passengers and goods. The questionnaire shows that if the accessibility in the ports and onboard the ferry would be improved, it could be beneficial both for the passengers and the goods.

After the thesis has been conducted, some practical recommendations could be presented to the shipping companies, municipalities, authorities, passengers and goods owners. It is important that the collaboration between the different actors needs to be improved in order to solve the different issues. For the shipping companies, it is important to consider how the new ferries should be designed to have a more efficient integration of passengers and goods. This also includes an analysis of which fuel the ferry should operate with to be able to reduce the emissions. As has been mentioned, some shipping companies do not have the economical possibility to convert to fully electric ferries, a possible solution for this is to use a hybrid instead. According to the result, the back-up system used onboard the ferries should preferably be operating on HVO. For the municipalities, a key factor is to collaborate closely with the shipping companies, passengers, goods owners and the authorities. The authorities could also support with funded money as has been the case on Tjörn, with new infrastructure in the ports to increase the accessibility.

After this thesis has been conducted, further research areas have been identified. For instance, the authors could conclude that it would be interesting to conduct a comparative analysis with the scope of a life cycle analysis for the different renewable fuels mentioned in this study. It could also be interesting to further explore and compare how different coastal areas have solved the integration of passengers and goods. Further, it could be investigated if this could be implemented in those areas of research in the study. Another area that could be interesting to explore is regarding the process of how to implement Maas and smart ports in the areas of research. Also, because of the lack of studies in the field, this study could possibly be conducted in other rural areas in Sweden or in other countries.

7. References

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Appendix 1- Questionnaire questions

Questions:	Answers:					
1. Gender?	Man	Woman	Other	Do not want to specify		
2. Age?	10-19	20-29	30-39	40-49	50-59	60-69
	70-79	80-89	90-99	100+		
3. Which area are you most commonly commuting to/from?	Gullholmen	Käringön	Åstol	Dyrön	Other	
4. What is the purpose of you commuting from those areas?	Tourism	Work	Studies	Temporary visit	Permanent residence	
5. How satisfied are you with the accessibility (adjustment/consideration for people with reduced mobility) onboard the ferry?	1	2	3	4	5	
6. How satisfied are you with the accessibility (adjustment/consideration for people with reduced mobility) with the connecting infrastructure such as ramps, terminal?	1	2	3	4	5	
7. If the ferry and connecting infrastructure are adjusted to people with reduced mobility, do you think that this would enable for easier handling of cargo as well?	Yes	No				
8. How satisfied are you with the current situation with combining passengers and goods on the ferries?	1	2	3	4	5	

	9. Do you think that it is a good idea to combine passengers and goods onboard the ferry?	Yes	No				
	10. If dangerous goods are transported onboard the ferry together with passengers, do you feel safe?	Yes	No				
	11. If dangerous goods would be transported in its own department onboard the ferry, would you feel safer?	Yes	No				
	12. Do you think that it would be a good idea if the ferry would operate on renewable fuel?	Yes	No				

Appendix 2- Inteview questions

Questions:
How are goods and passengers combined today on board the ferry?
What challenges and opportunities do you see with today's ferries regarding the combination of passengers and goods?
How could this be improved?
Where are the goods placed on board the ferry?
Where are potentially dangerous goods placed?
How does it work when the goods are to be transported on board the ferry, which aids are used and what does the workload look like?
If the goods do not fit, where are they placed for so long and what does the infrastructure look like in the terminal for this?
Accessibility adaptation for people with disabilities and goods handling.

How are the ferry and terminal/ramps accessible for people with disabilities?
Is there any way to improve this? Is accessibility for disabled people sufficient on board the ship?
How does accessibility adaptation affect the handling of goods in the terminal?
Is the adaptation sufficient to be able to combine passengers and goods?
How is safety and accessibility for passengers and goods affected when there is, for example, bad weather, high/low water?
If a new ferry were to be planned, how should it be designed so that it is adapted for goods and passengers? As well as availability?
On a scale between 1 & 5 (1 being the worst, 5 being the best), which fuel do you think is best suited for a ferry in coastal areas? Electric propulsion Hybrid propulsion Hydrogen propulsion Methanol propulsion Other?
When choosing renewable fuels, which technical aspects do you think are important to take into account? What barriers and opportunities are there? -When choosing renewable fuels, which economic aspects do you think are important to take into account? What barriers and opportunities are there? -When choosing renewable fuels, which environmental aspects do you think are important to take into account? What barriers and opportunities are there?
Are there any other barriers or opportunities in your opinion when choosing a renewable fuel?
What does the infrastructure in the port look like with regard to the storage of any renewable fuels? Is there room for this and what are the risks?
What kind of training is required when it comes to possible renewable fuels to be used?

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