



# **Challenges and Opportunities in Sustainable Port Infrastructure: A Swedish Ports Perspective**

Governance, Policy Awareness, and Regional Collaboration for  
Infrastructure and Energy Deployment

Master thesis for Maritime Management Program

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CHALMERS UNIVERSITY OF TECHNOLOGY  
Göteborg, Sweden, 2025



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## **PREFACE**

This study was conducted as a master thesis of 30 credits during the spring of 2025. It was conducted at the department of Mechanics and Maritime Science at Chalmers University of Technology. The Study was conducted and written by Henri Bassin and Carl Ottosson.

We would like to thank Associate Professor Henrik Ringsberg who has been our supervisor and helped us throughout the whole project with great knowledge, feedback and guidance. Furthermore, we would like to thank the representatives of the municipalities and regions of that have been interviewed in this thesis for sharing their expertise and knowledge with us. We have gained great insights into the port sustainable development.

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## ABSTRACT

The transition to renewable energy and the climate target has shown the critical role of port infrastructure in enabling low-carbon maritime transport. This thesis explores how public authorities in Sweden and Germany navigate regulatory uncertainty, technical and financial constraints and governance challenges in developing sustainable shipping ports. The thesis was conducted through semi structured group interviews with municipal and regional representatives across eleven public authorities. Including both seaports, archipelago and inland ports this study addresses three central research questions:

1. How do public authorities handle uncertainty in regulations and policies for development of port infrastructure?
2. What are the barriers hindering sustainable development of port infrastructure?
3. What enablers exist at public authorities in sustainable development of short sea shipping ports?

Key findings reveal wide variation in regulatory competence: authorities proactively interpret complex EU and national legislation, further showing there is a lack of knowledge and resources. Further result shows absence of structured collaboration across municipalities, regions and with industry stakeholders. Physical and technical barriers, such as limited space, outdated quay structures, and minimal local expertise is a large issue in maintaining port infrastructure. Financial constraints and uncertain demand for alternative fuels compounds the challenges for sustainable port development.

The results highlight the importance of institutionalized communication forums, dedicated regulatory support, and shared investment frameworks. Delimitations include a focus on public actors rather than private port operators, and a focus on Swedish ports and one German port. These insights inform on strengthening governance structures and strategic planning to accelerate the deployment of renewable energy nodes and resilient port infrastructure.

**Keywords:** Sustainable Shipping, Governance, Renewable Energy, Sweden, Germany, Public Actors

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## ACRONYMS AND TERMINOLOGY

<b>Abbreviation</b>	<b>Full Term</b>
<b>REC</b>	Renewable Energy Communities
<b>ESG</b>	Environmental, Social, and Governance
<b>IMO</b>	International Maritime Organization
<b>SDG</b>	Sustainable Development Goals
<b>SLR</b>	Systematic Literature Review
<b>RQs</b>	Research Questions
<b>EU</b>	European Union
<b>EEG</b>	Renewable Energy Sources Act ( <i>German: Erneuerbare-Energien-Gesetz</i> )
<b>MARPOL</b>	International Convention for the Prevention of Pollution from Ships
<b>MEPC</b>	Marine Environment Protection Committee
<b>GHG</b>	Greenhouse Gases
<b>SEA</b>	Strategic Environmental Assessment
<b>EIA</b>	Environmental Impact Assessment
<b>EMP</b>	Environmental Management Plan
<b>EMS</b>	Environmental Management System
<b>ISPS</b>	International Ship and Port Facility Security Code
<b>NVivo</b>	Qualitative Data Analysis Software
<b>Business Forum</b>	Place where private actors organise meetings for development
<b>Chicken and Egg Problem</b>	A metaphorical problem to describe where neither side of too possibilities wants to move first due to unclarity

# 1. INTRODUCTION

This chapter introduces the topic of the report while also explaining the importance of the chosen research subject. In addition, the purpose of the study along with research questions are shown. Finally, the delimitations of the study are concluded.

## 1.1 Background

Ports are a vital part of European transportation with 74% of all goods going through ports and facilitating 1.5 million work opportunities. (European Alternative Fuels Observatory, n.d). DeSombre, et al. (2023) Due to shipping's nature as one of the most globally interconnected industries, it is very hard to for policies of single countries to impact this industry hence making the IMO an important ruling institution for the industry.

To remain active and competitive, ports must provide both economic and social value otherwise, they risk being replaced by more efficient alternatives that can offer a better service/function. The continued development of ports often relies on the principles of sustainable development, which emphasize a balance between environmental, economic, and social sustainability (Jing et al, 2024). Further it very important to balance economic growth and environmental protection (Jing et al, 2024). In response to the amount of emissions caused by port operations many regulations both nationally and internationally have been introduced. However, these require heavy investment and advanced technologies creating a high operational and financial barrier (Wan et al, 2025).

The IMO (International Maritime Organization) is a United Nations organization with the purpose to create a sustainable shipping industry (IMO, 2023). One of the key challenges of the organisation is to reduce GHG emissions. To achieve this goal in support with sustainable development, goal 13 of the UN Climate Goals the development of a sustainable shipping industry is a priority. Despite the importance of fossil fuels which is by far the largest energy source compared to renewable energy (Hou et al, 2023) and the fact that transportation is largely dependent on oil and the oil derived fuels is about 94% of the final energy demand (Mouratidis, 2020). To create this the IMO has ratified several port regulations and renewable energy regulations (IMO, 2023).

Being both a facilitator for trade and society along with creating a sustainable development and following a new set of environmental regulations creates a large challenge for port operators and public actors. Sustainable development has become a key priority in the maritime and transportation sectors, as industries seek to address environmental, social, and governance (ESG) challenges. (IMO, 2025). New climate and energy goals are set for 2030 with 32% of all energy supply should be from renewable energy sources, In the gross final energy consumption (Lu et al., 2020).

In Sweden, the urge to align with the United Nations' Sustainable Development Goals (SDGs) and the Paris Agreement has driven efforts to enhance infrastructure in inland ports. These efforts focus on reducing carbon emissions, improving multimodal transportation efficiency, and strengthening safety measures to support sustainable growth. (Swedish Government, 2025).

A component of sustainability in Swedish ports is the transition to low-carbon fuels, such as electricity, hydrogen, and ethanol, which aim to reduce dependence on high-emission energy sources (Platias & Spyrou, 2023). However, the maritime industry faces challenges related to energy management and security, as ports strive to incorporate renewable energy sources into their operations (Platias & Spyrou, 2023). The emergence of marine-based renewable energy presents new business opportunities for ports to serve as energy producers or service providers. This expansion introduces complexities, requiring substantial infrastructure investments and raising economical, security, and environmental risks (LiVecchi, et al 2019). One of the most common incentives is a polluter pays fee system which gives a fee or a discount depending on each ships individual pollution (Van Marle, 2018).

Renewable Energy Communities (RECs) consist of groups including citizens, social entrepreneurs, public authorities, and community organizations that collaboratively engage in the energy transition by investing in, producing, selling, distributing, and consuming renewable energy (Cohen et al, 2016). Beyond mitigating climate change, RECs offer additional benefits such as economic development, job creation, reduced energy costs, enhanced self-sufficiency, strengthened community cohesion, and improved energy security. These advantages significantly contribute to increasing public acceptance of renewable energy initiatives (Cohen et. al. 2016).

Despite a wide range of published studies on strategic planning of ports such as Lu et al (2020) Cohen et al (2016) and Su et al (2024), there are few published studies on local and regional strategic planning of sustainable development of ports. This thesis seeks to fill the literature gap and enhance knowledge on strategic planning and cooperation between local/regional authorities and port authorities. Furthermore, the findings of this thesis in a best case should enable industry and politics to work together more closely and therefore more efficiently, reducing the chance of unnecessary government or private spending into projects which are hard to realise or require extensive additional spending after launch to make them work. This should decrease the burden of public spending on society and privately financed industry money. The increase in investments made in the sustainable fuel and multimodal transport infrastructure should help society and industry to reach to goals set by the Paris agreement and therefore reach the goals the IMO and Swedish government sets for themselves respectively.

## **1.2 Purpose**

The main purpose of this study is to explore how public authorities manage regulatory uncertainty and to identify key challenges and enablers influencing the sustainable development of port infrastructure and energy nodes. In addition to the stated main purpose, the thesis aims to identify ways in which public authorities can support stakeholders in sustainable port infrastructure. Additionally, the study aims to show the largest challenges in port management, to improve communication, funding mechanisms and transparency in planning and decision-making.

## **1.3 Research Questions**

Based on the stated purpose and aim the following Research Questions have been used:

1. How do public authorities handle uncertainness in regulations and policies for development of port infrastructure?
2. What are the challenges hindering sustainable development of port infrastructure?
3. What enablers exists at public authorities in sustainable development of short sea shipping ports?

## **1.4 Delimitations**

This thesis discusses the sustainable development of Port Infrastructures in seaports and explores how public authorities manage uncertainties and challenges of sustainable development for shipping ports in Sweden, and Germany. The primary purpose is to analyse policies and challenges faced by public authorities in the sustainable development of these ports, particularly within the context of low-carbon fuel adoption and multimodal transport. As such, no individual port infrastructure projects or extensive economic analyses will be closely investigated.

The political and economic motivations behind the adoption of sustainable practices in ports will not be examined in detail. The focus of this research will be exclusively on public authorities in Swedish and German ports, providing a comparative perspective to help understand regional differences. Given the challenges associated with conducting interviews with foreign port stakeholders, this study will rely on available semi structured focus group interviews in Sweden and scientific literature. While Sweden and Germany are central to the study, the research will not explore the situation in other countries or ports outside of these regions. While the findings offer valuable insight into public sector challenges, they are not intended to represent all ports in Sweden or Germany. The geographical scope will be limited to these regions, focusing on the environmental and regulatory aspects within the EU.

The sample of interviewees may not represent all stakeholders in the port industry, as it was limited to several key informants from Swedish and German authorities

This report is limited to the time between January 2025 and May 30th. Further the literature research will be limited to only include scientific data from peer reviewed sources. This report is not biased as neither of the writers have political interest or a bias in the result of the study.

## **2. THEORY**

This section presents the literature review conducted using a systematic literature review method. It includes a general overview of ports, sustainable development, relevant European and national legislation and the barriers hindering sustainable development.

### **2.1 Ports**

Ports are well known as the backbone of maritime trade and therefore modern society which heavily relies on globalisation and maritime trade for goods and supply chains (Diniz et al, 2024). Ports offer the unique possibility to change cargo from land to sea born means of transport and vice versa (Su et al., 2024). Logically Ports are also a centre for other industries and value-added services such as packaging, storage, handling and distribution. Furthermore, a stronger integration in the transport networks, with better links to the rail and road networks help ports to develop. (Belmoukari, 2023).

Ports can be run with different management methods concerning the questions of responsibilities and ownership. These different methods include the public-, private-, tool-, and landlord port models (Merkel & Sløk-Madsen, 2019). For the private or public port, the named party is responsible of handling all operations including ownership and operations. Levels where both parties interact with each other are the landlord and the tool ports where the questions of control, different levels of responsibilities and ownership are clearly defined between public and private stakeholders, making it somewhat easier for each party to focus and run their business respectively (Merkel & Sløk-Madsen, 2019).

Seaports play a central role in logistics networks by facilitating the movement of cargo, people, or both and serve as crucial links between maritime and land transportation (Knatz & Chambers, 2022). Furthermore, a seaport connects land and sea transport by facilitating the ability to change the cargo from one mode of transport to the other. Lastly, such a port should be constructed at one or more navigational waterways to make excess as easy as possible for ships. Additionally, the inland transportation networks such as roads or railways play a big factor in the performance of the port (Knatz & Chambers, 2022).

Concerning Inland waterway ports, the literature shows a major difference between the US and the EU, while in the US an inland port is a large freight storage facility which focuses on train transport in Europe the inland port focuses on the ability to switch cargo from water-based means of transport to land based means of transport. This means that Inland waterway ports in Europe must be connected to a waterway and usually are able to facilitate a variety of cargos which boosts the ports resilience and ability to facilitate future growth (Wiegmans et al, 2015).

In this report, an archipelagic port is defined as an inland port situated within a group of islands and serving the region through a waterway transport corridor.

## **2.2 Sustainable development of port infrastructure**

Sustainable development focuses on environmental and socio-economic aspects in consideration with ports being forced to compromise between economic growth and environmental protection (Su et al, 2024). Ports have a severe environmental impact including water pollution, atmospheric pollution and quality of life impacts on nearby communities. A sustainable developed port offers the possibility for port cities to increase and steadily improve local productivity, stabilize and increase economic development and additionally strengthen local social networks. (Diniz, et al, 2024).

### **2.2.1 Environmental concerns**

Naturally the development of a port comes with a lot of changes to its surrounding natural environment, since many changes must be made to protect the port area from undesirable natural impacts. Addressing these environmental challenges in ports and balancing environment and economics, was long only seen as an additional way to increase competitiveness of a port due to the need for increased efficiency and smarter use of resources, thus increasing the performance of the port (Taljaard et al, 2021). In recent years and due to the increasing amounts of regulation concerning environmental issues ports are now forced to evolve into green ports to keep operating within the limits of law and regulations (Taljaard et al, 2021).

The EU has implemented energy and climate targets for its member states which aim to reduce the amount of greenhouse gases emitted by 20% by 2020 with the base year level at 1990 (Lu et al., 2020). Further the European Union has also published directives such as 2009/28/EC promoting renewable energy sources in 2020 and minimum 20% of final energy consumed should be renewable by 2020 (Lu et al, 2020).

This development has been seen as a hindering factor in the planning process of a port in some parts of the world, since approval for new projects might be delayed or totally denied due to environmental issues, but with the implementation of SEA (Strategic Environmental Assessment), EIA (Environmental Impact Assessment), EMP (Environment Management Plan) or EMS (Environmental Management System) environmental concerns could successfully be integrated into the ports planning process allowing the port to develop both economic and environmental (Taljaard et al, 2021).

The European Union prioritizes transitioning to a low-carbon economy, but renewable energy adoption varies significantly among member states (Dóci & Gotchev, 2016). To address the transition, effective policy frameworks are crucial for promoting the sustainable deployment of renewable energy. One important mechanism for accelerating this transition is the development of Renewable Energy Communities, which are comprised of residents, jointly investing in renewable technologies this plays a pivotal role in transitioning from fossil to renewable energy (Dóci & Gotchev, 2016). They not only contribute directly to renewable energy deployment but also foster technical and social innovations and enhance public acceptance of renewable technologies, providing for a demand on renewable energy in port and cities.

Further Dóci & Gotchev (2016) examines how national support instruments in Germany and the Netherlands influence renewable energy communities. Despite both countries implementing similar support schemes, their renewable energy adoption rates differ. Germany has achieved a 25.3% renewable energy share in gross electricity consumption by 2013, with citizens establishing over 800 renewable energy cooperatives by 2014. In contrast, the Netherlands falls behind, with less than 5% of electricity consumed from renewables in 2014 and an estimated 150–300 renewable energy communities.

Renewable and green energy, neglected for a long time shifted into public and political focus in recent years due to the new climate goals set by the Paris agreement and the EU policies for

decarbonization (Lu et al., 2020). The development of energy being made from water, air or crops opens new discussions and rivalries in terms of resource allocation. (Schwanitz et al., 2017). Clausen & Rudolph (2020) also found that for large investments in renewable energy there is a need for a policy framework to support the investment from both national and international levels. Further Han & Kim (2019) made a calculation on a complex renewable supply system in Korea and discovered that with an interest rate of 8% an investment would reach the net present value after 36 years. Including investment of 260 million dollars to reach a new renewable supply system.

Since renewable energy is increasingly developing there is a need for investment and financing. This is often referred to as green financing. Hou et al, (2023) found that green financing has a strong positive impact on renewable energy deployment, particularly in developed countries with strong economies, well-developed green finance systems, and strong environmental regulations. Furthermore, Hou et al, (2023) study shows that the impact of green financing has the largest impact in the solar energy sector, followed by wind, biomass, and finally hydropower.

### **2.2.2 Socio-economic concerns**

Development of port infrastructure depends not only on the volume of investments made but also on socio-economic indicators of the region (Fedorenko et al., 2021). In addition, aimless investments in port infrastructure without strategic planning that include local economy, or the economics of the port will hamper economic growth and allocation of economic resources since these resources might go to waste (Kong & Liu, 2021). To contribute to regional development and economic growth, a port also needs to increase its involvement in international or national trade networks as a part of integrated supply chains. The impact of investments in port infrastructure depends on the type of port (i.e. archipelago, inland or sea), the level of the hinterland infrastructure linked to the port, regional policies, and the current level of the regional economic growth (Song & Geenhuizen, 2014). There is also a connection between financing of renewable energy and rural development, as rural areas often provide a crucial role in hosting wind farms, solar panels, and other energy nodes (Clausen & Rudolph, 2022)

## **2.3 Policies and Regulations on Sustainable Development of Ports**

This section will show the policies and regulations of IMO, EU and National regulations of Sweden and Germany.

### **2.3.1 IMO Regulations**

The International Maritime Organisation (IMO) that was created in 1958 under the United Nations and represents an international organisation that regulates the maritime transport industry. The IMO plays an important role as a policy driver and theoretical guide for energy efficiency as well as emission reductions in ports (Wan et al, 2025). Therefore, the IMO regulation is important both for environmental safety but also for the development of port infrastructure & energy infrastructure (International Maritime Organization, 2023). Although the IMO is not legally binding authority itself, it exerts significant influence on the maritime industry and on national statutory bodies.

The IMO serves an important role in the UN Sustainable Development Goal 13 Climate Action, and in the Paris agreement, to globally limit greenhouse gases (Mollaoglu et al 2024). IMO started its climate work in 2018 with an initial greenhouse gases (GHG) strategy, setting a vision to phase out GHG emissions from the shipping industry (Nguyen, Nguyen, & Nguyen, 2022). In 2023 the vision was revised and now outlines comprehensive policy framework including mid- and long-term targets and a plan for decarbonising international shipping (International Maritime Organization, 2023). The 2023 strategy includes a 40% reduction of carbon intensity from 2008 (Singh & Ballini, 2025). Adoption of zero or near zero emission fuels and technologies with an adoption rate targeted at 10%. Further the IMO also regulates port related emissions, with the IMO recognizing the essential role a port plays in achieving maritime decarbonization. IMO first created Maritime Environment Protection Committee (MEPC) 74 released in 2019 which encouraged voluntary cooperation between the port and shipping, however now with MEPC 79 in 2022 the wording has been changed to facilitating and supporting cooperation, further ports are urged to facilitate and offer renewable energy and to develop infrastructure fuels with zero GHG (Wan et al, 2025). A review of the goals and measures will be conducted 1 January 2026 (Singh & Ballini, 2025).

Further emission control and reductions at ports are implemented through the IMO. The combination of IMO controls including reduction strategies along with modern technologies,

gives the possibility to achieve a green port with low GHG emissions (Nguyen et al, 2022). However, considering the political difficulties and economic investments needed it is still a large challenge. Port emissions are a key factor in the overall environmental impact of shipping. In addition to the efforts of the IMO, it is essential to implement specific measures to reduce these emissions. These measures include the electrification of ships and ports, the integration of renewable energy sources, and improved energy efficiency by optimizing logistics to meet the targets established for ports (Wan et al, 2025).

The transition to low and zero carbon fuels (including biofuels, hydrogen, electricity, and hybrids) is critical. Biofuels are supported for their potential but must be sustainably sourced. The IMO has given guidance on their use under MARPOL Annex VI (IMO, 2023). However, zero-carbon solutions will require sustained research, innovation, and investment, with the IMO encouraging first movers through potential incentives and best-practice sharing.

### **2.3.2 European Regulations**

EU policy documents suggests that the transport and accessibility (T&A) criteria of infrastructure, accessibility distance, and multimodality can positively contribute to sustainable development (Sakib et al., 2018)

To support this goal the European Commission (2024) has published rules in context with the “Fit for 55” package. The regulations aim for three main objectives:

- “To ensure minimum infrastructure to support the required uptake of alternative fuel vehicles across all transport modes and in all EU Member States to meet the EU’s climate objectives
- To ensure full interoperability of the infrastructure; and
- To ensure comprehensive user information and adequate payment options at alternative fuels infrastructure”

These regulations ensure that a certain range of alternative fuels are present in close to medium-close proximity to the Port and are publicly accessible including hydrogen refuelling stations within 200km, electricity supply for vessels ensuring the use of shore-side electricity for large seagoing vessels and stationary aircraft and refuelling points for liquefied methane (EU, 2024).

Further the European Union has also published directives such as 2009/28/EC promoting renewable energy sources in 2020 and minimum 20% of final energy consumption which should be renewable by 2020 (Lu et al., 2020). The directive also forces national renewable energy source targets for each EU member state and there is also a target for 10% of renewable energy sources for transportation. Furthermore, the directive also establishes a requirement for each member state to develop a national renewable energy action plan, which should include policies and measures that are mandatory to accomplish for the renewable energy sources within heating and cooling, power and transport sectors.

### **2.3.3 National Regulations**

This section presents an overview of national regulatory and frameworks in Sweden and Germany regarding alternative energy and sustainable port infrastructure, particularly in the maritime sector

Sweden has implemented a comprehensive framework on its national regulations and policies to promote the entry of alternative fuels especially in the maritime sector (Regeringskansliet, 2019). The measures are aligning with the European Unions (EU) directives such as regulation 2014/94 on the deployment of alternative fuels infrastructure. In 2016 the Swedish government adopted a policy framework for targets and measures to alternative fuels and infrastructure development (Regeringskansliet, 2019). This framework was subsequently supplemented in 2018 to ensure full compliance with the EU requirements. The legal measures aim to support the adoption of alternative fuels infrastructure and ensure following of standards for fuelling and recharging nodes. Sweden started with a tax reduction for cleaner fuels in the Taxation Act (1994:1776) in which fossil fuels are heavily taxed upon and renewable fuels such as biogas gain tax reliefs (Regeringskansliet, 2019). Further Sweden has the Pumps Act (2005:1248) which entails an obligation to provide for renewable fuels and larger refuelling nodes are required to provide renewable fuels since April 2006 in Sweden. Furthermore, the Swedish Energy Agency was tasked with the deployment of charging infrastructure in 2018 including gas and other renewable fuels which require specialized infrastructure. Further The Climate Leap Initiative is a part of the government budget through ordinance (Act 2015:517) on support for local climate investments allocating for alternative fuels and have allocated 4.7 billion between 2015-2018. For specific port regulations the clean shipping index was introduced 2018

which made a different port charge based on the environmental standard (Act 2018:672) on differentiated fairway dues. Some of the other acts that are implemented from the Swedish parliament related to port infrastructure, services and handling of energy are.

- Act (2019:152)  
Implement the EU's Port Services Regulation (EU) 2017/352 into Swedish law. Establish a framework for the provision of port services and ensure financial transparency, facilitating the development of energy supply infrastructure within ports (SFS 2019:152).
- Act (2004:487) on Maritime Security  
Incorporate the ISPS Code into Swedish legislation, improving the security framework for ships and port facilities. Secure port operations are essential for the safe handling and supply of alternative fuels and energy (SFS 2004:487).
- Act (1980:424) on Prevention of Pollution from Ships  
Establish environmental protection measures specific to Swedish waters, including regulations on waste reception and pollution prevention. They support the environmental sustainability of port operations and the integration of clean energy solutions (SFS 1980:424).

Renewable energy has been placed high on the political agenda in Germany for a long time, as energy production from renewable energy supply has been a central strategy from the German government since greenhouse gas emission debates in the early 1990s (Dóci & Gotchev, 2016). The introduction of the “Erneuerbare Energien Gesetz”, EEG or the renewable energy sources act is among the most important regulatory policy for the establishment of renewable energy. The policy addresses all trade and strategic instrument-risks hindering community investment although the policy was not originally created to create development of renewable energy supply it created a support for renewable energy communities. This created a large group of people who wanted to invest in electricity production, with favourable conditions for private investors and community based renewable energy supply electricity production. The policy created very favourable terms which rendered Germany a large renewable energy supplier. (Dóci & Gotchev, 2016).

The EEG (Erneuerbare Energien Gesetz) imposes a very specific vision for Germany's energy consumption future, one example is the way it specifies the energy categories and volumes

which should be in place by 2030 with 115 GW from wind energy based in land, 215 GW from photovoltaic installations and 8,4 GW of electricity generated from Biomass. This according to the official calculations should be sufficient to generate 80% of Germanies electricity from renewable resources. Furthermore, the EEG regulates in which capacity and which markets energy companies are allowed to sell the electricity and in which capacity the energy companies will receive substitutions to the selling price or the building of new facilities. Additionally, every four years the EEG forces the federal government to present the Bundestag with a testimony concerning the stage of development which is then used to reevaluate and improve the EEG. There are several other mechanics in place in the EEG to ensure fair substitutions and continued development to achieve the set goals. (Umweltbundesamt, 2023)

In 2016 the German federal Government introduced the “National Port Concept” which had a planned timeframe of 10 years, which included all sea and inland waterway Ports in Germany recognizing the immense importance of Ports to the German economy (Bundesregierung, 2024). In 2024 the German government doubled down on its continued commitment to Port infrastructure with the “National Port Strategy”. This new Strategy includes five main strategic goals which are (Bundesregierung, 2024):

- Strengthening of the economic competitiveness which includes increased cooperation and should establish German ports as a spearhead of economic efficiency, innovation and sustainability.
- Ports should be developed to become “energy hubs” providing necessary infrastructure for climate neutral Maritime transport and connected Industries helping to achieve the climate goals for 2045
- Accelerate and shape digital transformation
- Ensure continues jobs and education opportunities to continue Germanies and Europe’s involvement in global trade
- To ensure the upkeep and security of needed transport and communication infrastructure since Ports are classified as critical infrastructure to ensure the wellbeing of the German population

This national Strategy includes 139 concrete actions which support the goals mentioned above. (Bundesregierung, 2024)

To decrease pollution from shipping in German waters the “Verordnung über das umweltgerechte Verhalten in der Seeschifffahrt (See-Umweltverhaltensverordnung - SeeUmwVerhV)” was declared in 2014 which was updated in 2019 to ensure further effectiveness to combat further pollution. This Law includes passages to Oil treatment, ballast water and wastewater treatment as well as ship waste and bunker operations (Bundesamt für Justiz, 2019)

## **2.4 Barriers in Sustainable Development of Port Infrastructures**

Lu, et al., (2019) pointed out five mayor barriers to the development of sustainable infrastructure. Following five barriers the “social barrier”, “Economic barrier”, “technological barrier” “regulatory barrier” and “Planning barrier” will be explored and described.

### **2.4.1 Social Barriers**

Social barriers are happening due to the public blocking new project due to various reasons, mainly land used by these new projects which could otherwise be used for other industries like tourism, farming or fishing making this use more pleasing to the public opinion (Lu et al, 2019). The study identified the “Not-In-My-Backyard” Syndrome as a driving social barrier (Lu, et al.,2019).

Public opinion and political decision-making further challenges renewable energy (Panarello & Gatto, 2023). With multiple actors across many industries which have interests that are not aligning with this and therefore creating conflicts and priorities which slows down decision making. Furthermore, Panarello and Gatto (2023) discuss EU citizens’ perceptions of renewable energy transition, they discover that public support is crucial however largely varies based on region. Although public opinion has an influence by voting for politicians or supporting green businesses, it is often economic concerns that take precedence over environmental concerns. Panarello and Gattton (2023) further finds it especially challenging in with eastern and southern European countries compared to Northern and Western which are more economically stable, therefore not as hard to invest in.

A study by (Azarova, et al, 2019) investigates the acceptance of renewable Energy source within local energy communities within the EU. The study (Azarova, et al, 2019) finds that factors influencing acceptance include attitudes, visual perceptions, perceived environmental

impact, energy costs, and personal risk. The proximity of energy infrastructures to residences also plays a role, though its impact varies by type. Social norms, particularly regarding climate change and renewable energy perceptions, significantly affect acceptance levels.

Findings indicate that configurations featuring solar farms and power to gas infrastructure enhance acceptance, whereas wind farms have mixed effects, and gas power plants and power lines tend to decrease acceptance (Azarova, et al, 2019). The estimated monthly willingness to pay for technologies that increase acceptance is from €8.50 for power to gas infrastructure to €29.50 for photovoltaics. Additionally, the study (Azarova, et al, 2019) examines how state support from political leaders at local, national, and EU levels influences acceptance. In Italy, EU and national governmental endorsements increase acceptance by 3.5% and 2.7%, respectively, while in Switzerland, local political support increases public acceptance by 2.3% (Azarova et al, 2019).

#### **2.4.2 Financial Barriers**

Economic and financial barriers shift the focus toward the challenge of financing new infrastructure, with issues such as high upfront investment costs and long payback periods. These factors often result in unattractive investment prospects and limited access to loans from banks or other financial institutions (Lu et al., 2019). Renewable energy has large effects on rural - regional areas in which investments are the most common (De Laurentis, 2021). However, this is also a challenge as regions have different capacity, capability and ability to act with economy, natural environment, and competing social goals within renewable energy deployment (De Laurentis, 2021).

#### **2.4.3 Technological Barriers**

Technological barriers raise the point of slow development due to the lack of infrastructure, R&D and insufficient maintenance capacity compared to the overall complexity of developing and building sufficient green energy production plants (Lu, et al.,2019).

The production processes of solar power and the reliance on scarce resources such as lithium are limiting the growth of the industry (Maka, et al. 2022). Developing countries heavily ramped up their hydropower production in the recent years predicted to replicate the same problems which already occurred in the US and Europe in the past (Moran, et al, 2018).

Following the rise of questions concerning the sustainability of hydropower several non-profit and state organizations have been formed including the Low Impact Hydropower Institute (LIHI), Swiss Federal Institute of Aquatic Science and Technology (EAWAG) and others which all concern themselves with the question of sustainability of existing and newly planned hydropower projects (Zhang et al, 2021). Furthermore, academics such as Zhang et al (2021) conducted studies and formulated concepts to realistically evaluate the level of sustainability of existing and future hydropower projects to help policy makers and developers in the decision-making process regarding hydropower projects.

Windpower production technology advancement and the ability to construct larger tower with bigger blades make the energy cost very competitive (Sadorsky P. 2021). The extensive amount of land needed to construct onshore wind farms is a concern but the land underneath the turbines can still be used for agricultural or livestock farming purposes meaning that these wind farms have to be planned in very specific places (Olabi, et al., 2023).

#### **2.4.4 Regulatory and Planning Barriers**

Ports are under the influence of actors including both political and regulatory. Thus, slow development due to political unwillingness, anti-renewable energy lobbying and other factors such as economy and taxes can occur hindering and slowing down progress (Lu et al, 2019). To ensure and achieve fast development, political support is crucial which includes a regulatory framework that is supportive and promotive towards this new industry (Lu, et al,2019).

The establishment of Energy nodes avoiding expensive charging and longer charging times than individual stations would be possible with a better locating of charging stations and an increased number of charging stations (Gorbunova et al, 2020). The researchers found that high demand also puts a large pressure on infrastructure and infrastructure planning. As the number of electric vehicles increases so does the pressure on charging stations and they become more crucial. However, with charging being unpredictable the infrastructure needs to be capable of handling demand with large need for optimal placing and enhancing long term sustainability.

Further De Laurentis (2021) explains how the Italian government sought to strengthen renewable energy deployment by national planning guidelines, however with regional governance actors having variations between institutional arrangements the plans ultimately

failed as the deployment of infrastructure varied. Furthermore, many uncertainties and allocation of competence is a large difference between national and regional levels. Thus, renewable energy investments are complex, with national government playing a major role, with guidelines and policies however due to regional government struggles due to site specific challenges, low renewable energy goals or institutional obstacles such as cognitive or cultural effects progress was hindered (De Laurentis, 2021).

A study by Liu et al (2022) highlights how the use of effective renewable infrastructure planning contributes to balancing cost and the reduction of carbon emissions, improving the overall performance and sustainability of charging stations. A key takeaway from the study, using data from Beijing, shows that incorporating power energy storage system, and infrastructure allocation planning, in the public transit system can significantly lower recharging costs and carbon emissions. Specifically, the study estimates an annual saving of \$11.3 million in recharging costs and a reduction of 48,784 tons of carbon emissions. Further the study (Liu et al, 2022) also suggests that the joint design of smart power grids and bus charging stations using optimization techniques could offer valuable insights for future city planning and policy decisions. The results may vary depending on regional capabilities. However, the savings with optimisation and planning is of great importance for reducing carbon emissions and promoting renewable energy and the planning of allocation for the infrastructure significantly impacts the result for the electricity supply. Showing that planning and collaboration within areas and regions are key drivers to promote renewable energy and infrastructure deployment (Liu et al, 2022).

### **3. METHODS**

This section explains the different methods used within this thesis. The selected deductive research approach and a theoretical construct according to Gulati (2009). This thesis was conducted through a systematic literature review (Sauer and Seuring, 2023). In addition, a case study of Swedish ports and inland ports and one German port was performed.

#### **3.1 Literature Review**

The literature review follows the guidelines of a Systematic Literature Review presented by Sauer and Seuring (2023) following the six steps. First (step 1) the definition of research questions in this thesis resulted in three research questions which were defined (see Section 1.2 “Aim of the Study”). Secondly (step 2) the criteria for the selection of relevant papers were defined which limited the inclusion of papers to any paper published from October 2014 which marked the implementation of the European Directive 2014/94/EU (deployment of alternative fuels infrastructure by the European Commission) and the end date of the SLR on the beginning of February 2025. Additionally, papers needed to satisfy following requirements:

- Published in English,
- Peer-reviewed,
- Scientific studies,
- matching the purpose of this thesis.

Following the setting of criteria in the second step which included journals within maritime transport, sustainability, ocean engineering, business management and policy development. Scopus databases, the Web-of-Science and Chalmers library were used to find relevant scholarly papers (step 3). Search strings used in the literature review are presented in table 1. Additionally scholarly papers and laws from both Sweden (in total 9) and Germany (in total 4) on development of port infrastructure, renewable Energy use and avoidance of Environmental harm from shipping operations have been used as references. These were identified with Google and taken from the original governmental website. An exception has been made to the criteria of English as a published language since national laws are available in the country's language. In addition to the SLR, relevant international, European policies on development of port infrastructures were identified in EUR-lex and IMO databases. In total this yielded a total of 24 relevant regulations (6 international, 5 European and 13 national).

In step 5, the potentially relevant scholarly papers and laws (in step 4) were fully analysed based on direct content analysis (Hsieh & Shannon, 2005). This reduced the number of pertinent papers to totally 39 (marked with a “\*” in the reference list of this paper), included as references in the methods (Section 3.1, Table 1 “Search strings, Databases and the Total Amount of Selected Papers”) of this thesis.

*Table 1 Search Strings, Search Fields, Databases and the Total Number of Selected Papers*

Search strings	Search field	Web of Science		Scopus		Total amount of papers included
		Number of identified papers	Number of selected potential papers	Number of identified papers	Number of selected potential papers	
“Port Infrastructure” AND “Sustainable Development”	Article Title, Abstract, keywords	36	4	72	6	10
“Port Infrastructure” AND “Regulations”	Article Title, Abstract, keywords	29	1	58	3	4
“Archipelago” OR “Inland” AND “Port”	Article Title, Abstract, keywords	13	1	19	2	3
“Renewable energy” AND “Infrastructure” AND “PORT”	Article Title, Abstract, keywords	43	4	178	10	14

“Inland Waterways” AND “Ports”	Article Title, Abstract, keywords	31	1	106	0	1
“Sustainable Energy Development” AND “Infrastructure”	Article Title, Abstract, keywords	79	3	80	2	5
“Last mile Transportation” AND “Policy”	Article Title, Abstract, keywords	2	0	14	2	2
Total						39

## **3.2 Case Study**

A case study was performed in accordance with Yin (2009) which will be explained in depth including the context, data collection, semi structured interviews and data analysis.

### **3.2.1 Case Study Context**

A case study concerning the sustainable development of ports in Sweden and Germany was used to find and analyse relevant answers to the research questions, these interviews included relevant focus groups from the local and regional authorities and industries involved.

The ports selected in this thesis include Swedish ports and a German port. These ports have been chosen because of their national importance sea or inland ports.

### **3.2.2 Semi Structured Focus Group Interviews**

The focus on the interviews was to gain insight into legislation & policies, barriers and sustainable development within the port area. The chosen method of interviews was decided because these yield answers to complex situations and investigate phenomena in the real-life context. (Yin, 2009) In order to have semi structured focus group interviews (Steinar & Kvale, 2015) public authorities from Sweden and Germany have been selected to be interviewed in this case study as shown in Table 2 “statutory level and public authorities included in the case study” below. These interviews have been conducted in semi structured focus groups interviews on a local level.

The interviews were mostly conducted as face-to-face semi structured focus group interviews in Sweden except for three of the ten interviews which were via teams as was the one interview with German representative. All interviews have been recorded to later be transcribed and analysed to get the results. The participants in the study were chosen from a combination of factors like availability, experience in the field of work and academic status. The respondents interviewed resemble the best candidates which could be found within the time and the scope of this thesis.

In the following table all respondents which have been interviewed can be observed due to anonymity reasons the entities cannot be named directly.

*Table 2 Interviewee Workplace, Regional level & Municipality level*

Regional Level:
Business Region Northern Germany
Business Region Stockholm
Business Region Gothenburg
Municipality Level:
Öckerö Municipality
Tjörn Municipality
Munkfors Municipality
Grums Municipality
Kristinehamn Municipality
Kils Municipality
Sunne Municipality
Torsby Municipality

*Table 3 Interviewees Title & Years in Current Position*

Entity	Title	Years in Current Position
Port A German	Manager Environmental & Climate Port Strategy	1,5
Port B Sweden	Port Manager & Infrastructure manager	3 & 5
Port C Sweden	Traffic and Goods Coordinator	4
Port D Sweden	Regional Industry and Developing Planner	9
Port E Sweden	Regional & Developer Planner	2
Port F Sweden	Regional Planner / Infrastructure Manager	2

Port G Sweden	Technical Chief / Port Manager	2
Port H Sweden	Port Manager	12
Port I Sweden	Port Manager	8
Port J Sweden	Infrastructure Architect & Project leader infrastructure	5 & 5
Port K Sweden	Department Chief, Strategic Societal developer	3

Denscombe (2009) defines a semi-structured interview as an approach in which the interviewer has a predetermined set of topics and questions that should be covered, while also allowing the interviewee to provide a detailed answer that gives flexibility to the interview process. The focus of the interviews was to let the interviewee develop their own opinion and thoughts on the questions and topics.

According to Denscombe (2009) the interview should as previously stated have a topic and questioner previously collected. For this report the area of interests was, port infrastructure, energy nodes and sustainable development. If the researcher found something interesting or wanted details on the matters which were discussed, the method allowed for follow up questions and a discussion around thoughts of the interviewee, however the researcher's own opinion and question style was reserved to minimize biased and outcomes. Therefore, the follow up questions were asked to describe or to explain what was previously said.

Further the format of the interviews was made for the final section to rate challenges on a scale from 1 to 5, in which 1 is no challenge and 5 was major challenge. However, due to it being a semi structured interview it automatically became an explanation and discussion around all questions. The interviews time length was varying in time based on answers and length of explanation, however no interview was shorter than 45 minutes or longer than 2 hours. This was possible thanks to scheduling and planning allowing for a flexible semi structured interview format. All the Swedish interviews were carried out in Swedish since this is the mother tongue

of both researcher and interviewee. The interview with the German regional port representative was carried out in English as a common ground.

### **3.2.3 Data Analysis**

The interviews conducted have been recorded and later transcribed, furthermore these interviews have been analysed using the Nvivo software to ensure reliable and consistent results. Nvivo in this case was used to analyse the data and visualize it easily. The software was used to highlight important data the method for this was done with thematic coding analysis (Braun & Clarke, 2006). The first step was to transcribe the interviews manually, secondly the transcribed interviews have been imported into the Nvivo software. Thirdly, some overarching themes based on the interview questions and the overall theme of the research have been chosen. Fourthly, the most important sections of the interviews have been highlighted. Fifthly the coded sections have been summarized into the categories in step number 3. Lastly the result of each theme has been collected and described in the results section. This resulted in a data collection for each theme highlighting common results between the interviews.

The analysis for this study was conducted in Swedish, the native language of both participants and the researcher, allowing for a nuanced understanding of expressions, terminology, and context during the coding process. However, the presentation of results is in English, requiring careful translation to preserve the intended meaning of key concepts, professional terminology, and expressions. As Larkin et al, (2007) mentions, translation is an interpretive act that must aim for conceptual equivalence, not just literal accuracy. While subtle shifts in tone or meaning are possible, these risks were mitigated through the author's familiarity with both languages, as well as by cross-checking translated segments against field notes, observational memos, and the recorded dynamics in recordings from interviews to ensure that interpretations remained as close as possible to the original context. Since themes originated from patterns across multiple data sources, minor linguistic variations are unlikely to undermine the validity of the findings (Larkin et al., 2007)

Based on the conducted literature review the following units of analysis were used in the analysis of the transcribed interviews to the Nvivo software.

- Policies & Regulations
- Financial Barriers
- Infrastructure Barriers
- Sustainable Development

### **3.3 Ethical Considerations**

Ethical considerations have been in place for this study. All the data resulting from the interviews was anonymised for ethical reasons and to be more appealing to the interviewees to share their actual views on the subject. The interviews were conducted voluntarily, prior to the interview taking place the interviewees have been informed about the purpose of the interviews, questions asked and how the data gathered would be used and informed consent has been collected from all participants. Furthermore, anonymity has been a major point within this thesis and all data published has been anonymized. Storage of interview data has been considered for further academic research which will be done anonymously as well to not compromise the data gathered in this thesis and violate the trust of the interviewees. Any bias has been kept to a minimum, but the authors acknowledge that with interpretation of qualitative data some small bias can't be avoided.

The interviews were conducted all in a closed room or over a private zoom call with only the interviewees and the researcher. This was to prevent the interviewees from receiving external influence. Additionally, this also made it easier to control and steer the interview into the wished topic.

## **4. RESULTS**

This chapter presents the results of the case study. Based on the thematic analysis of the interview material several key findings are presented regarding how policy and regulatory frameworks influence port development, planning and sustainable development.

### **4.1 Policies and Regulations Influence on Port Infrastructure**

The section will present the results related to regulations and policy knowledge, long term investment uncertainties in regulation, and regulatory challenges for rural cities.

#### **4.1.1 Levels of Competence**

The interviews showed that respondents particularly at the municipality level had zero knowledge of any regulations and could not recall knowing any of the examples mentioned by the researcher.

One of the most notable findings from the interviews was the general lack of knowledge regarding EU regulations and national legal instruments relevant to the development of port and transport infrastructure among local and regional stakeholders in Sweden. Across the interviews, when directly asked about specific EU regulations such as Regulation (EU) 2023/1804 on alternative fuels infrastructure and Regulation (EU 2017/352) concerning port services many respondents either did not recognize the names or were entirely unfamiliar with their content.

For instance, when prompted about these regulations, respondents from municipalities openly acknowledged their lack of familiarity.

Respondent H:

“No, unfortunately, I am not familiar with either of them.”

In two cases, a superficial recognition of the regulation’s title occurred, but this was not accompanied by an understanding of its practical implications. Only 1 respondent on the municipal level demonstrated partial awareness of 1 theme, such as environmental obligations under EU directives for example, those concerning onshore power supply and reducing emissions at port facilities. Yet even in these instances, the discussion remained abstract,

lacking specific references to legislation or direct engagement with regulatory compliance. This suggests that practical application and integration of EU policy into local strategies is minimal, even among municipalities actively involved in port development or energy planning.

At the regional level, interviewees noted the disconnect between national objectives and regional implementation. For example, respondent C emphasized the lack of national focus on regional maritime transport, which in turn limits the extent to which regions can align with national or EU environmental and infrastructure priorities. This gap in recognition of regional needs was described as a major barrier to effective coordination and policy uptake.

Furthermore, two municipalities pointed to outdated or missing policy documents, such as energy or mobility plans, that had not been updated in decades. Respondent J, noted that the municipality's energy plan dates back to 1999, rendering it largely irrelevant in today's policy context. These outdated planning instruments further hinder the capacity of municipalities to comply with or integrate current EU regulations.

According to the interviews there exists a significant gap in policy knowledge and engagement among Swedish municipal and regional actors, particularly in relation to EU-level instruments and even some national frameworks. While there is an awareness of general themes such as sustainability, climate goals, or the need for electrification, this is not matched by a detailed understanding of the legal tools available or required.

Furthermore, 7 respondents from Swedish municipalities expressed a lack of clarity how to implement them even if they would know that they existed. One of the regional respondents B explained when asked about the significance of EU policy and impacts:

“Yes, if I have understood correctly, I think it is very important. So, I think that both at government level, ambiguities, so I'm not thinking about funding but like strategic direction”

He further detailed that he thinks that there is a miscommunication due to clarity from the national level and that there should be a larger focus on strategic development, and port infrastructure development in terms of national coverage, financial support and regulatory support.

Comparing this to one respondent there is a large contrast in which he showed a high degree of competence and regulatory knowledge. Respondent A claimed that they actively used these policies to frame their investments and development.

“Speaking of that also the EUETS. These are two more regulations, which are important for us since within 2024.”

Notably is that respondent A states it has a communication channel with the EU commission. He further explains that the pace in which the communication can occur with the regulator largely impacts the development.

The result from the conducted interviews shows that there is a large gap within the Swedish port governance lacking knowledge of the EU regulations however several Swedish respondents showed a deep knowledge of national and Regional Policy and Regulations. While the respondents were not deeply detailed in how they used these regulations many concluded that it was a good tool for planning, and sustainability work.

At the municipality level many Swedish interviewees referenced the detailed development plans and the processes in which they developed the port and surrounding infrastructure. This was often the main strategy behind development and risk assessment both for environment and safety. Furthermore, they claimed it was a good way to legally anchor a process and for support to prevent future conflict. In addition, Respondent E claimed that many risks and planning strategies were set from the committee in which the respondent were a part of thus they had policy and legislative backing for the development.

“Yes, exactly. No, but if you think about the detailed planning process, you simply need to manage risks and make a risk assessment. So that's what you do, or we do within the detailed planning process.”

### **4.1.2 Long Term Investments, Political and Policy Support**

A majority 7 out of 11 respondents addressed that they felt an insecurity with the length of the investments. A recurring theme was the impact of shifting political priorities, particularly at the regional level. Respondents noted that political cycles and changes in leadership often lead to shifts in strategic direction, which in turn create hesitation around infrastructure investment.

One such perspective is provided by Respondent B who highlights the vague formulation of regional strategies and their political reinterpretations:

“It also has a certain significance because the strategic directions we take for the region are, how shall we say, they are a bit vaguely formulated so that they can be adopted by all political parties over a longer period. And this means that they can be interpreted slightly differently depending on which politicians come next. Because they have four-year terms of office”

Respondent B elaborates that while these long-term strategies are intended to foster political inclusiveness, their ambiguity often leads to inconsistent interpretations across election cycles. This, in turn, poses challenges for operational implementation of these policies, as unclear directives hinder effective execution. The respondent emphasizes that such ambiguity not only complicates implementation but also delays investment decisions and slows down port development:

“And that creates huge uncertainty, so people don't dare to invest in anything. And that stops sustainable development.”

This concern was echoed by Respondent G, who emphasized the lack of adequate planning and understanding when it comes to the investment requirements for long-term environmental and infrastructure goals. The respondent highlighted the disconnect between the lifespan of infrastructure investments and the short-term perspective often seen in policy cycles:

“It has to be long-term planning. ... We have to know that what we are doing now is perhaps a depreciation of 8-10 years and we have to feel secure that this is what it will look like. .... It is a little bit like that that it is too short-term perspectives. There must be a long-term perspective

in everything. Whether it's for me as an individual or a company or a municipality or whatever it is. Long-term perspective.”

All the regional respondents described that their long-term strategy was intentionally broad to maintain a consensus and development, also there were some flexibilities in where it was applicable in most cases, regarding port or just infrastructure. However cross-party consensus and overall political inclusiveness was a source that led to policy vagueness. Thus, showing a trade-off between political adaptability and operational clarity for the persons that should interpret and implement the policy.

#### **4.1.3 Policies for Rural Areas**

Interviews with inland port representatives stated that due to limitations of geographics and financial capacity there is a lack of policy to address this and that collaboration between municipalities often occurred as a critical strategy and that there are not any official communication channels rather in official channels were used. However, these channels such as “Business forums” were often used to pool expertise and understand the different needs more. However, according to respondent H due to the lack of official support it is hard to track and get valuable long-term insights.

While three municipalities from the inland ports reported an overall positive experience with inter municipality cooperation as “Business forums”, most interviewees described the system as flawed. Multiple respondents concluded that the national policy framework needed to be revisited and largely change to fit all. Further the lack of cooperation is not thought of as just a vertical issue (between areas) but also as a horizontal meaning that there is a limited coordination and alignment between different levels of governance, municipalities, regional, national and EU. This underscores the need for institutionalized mechanisms that facilitate sustained and inclusive communication. As all information charring is critical for planning and developing of infrastructure and energy.

Further even with collaboration, geographical distances and infrastructure limitations remain a large challenge. Respondent G further lifts that he feels this issue is not addressed by any legislative unit and that hinders development completely. When talking about collaborating and

planning for a network of energy supply, he simply concluded that, it isn't possible due to the large geographical distance.

As representative G explained:

“But we can't travel 3.6 miles one way to refuel our cars. It is not possible”

These constraints shows that although some planning into energy localisation and collaboration between municipalities as previously shown would be beneficial it is frowned upon by some and simply unimaginable.

A recurring theme across seven of the interviews was the dissatisfaction among smaller Swedish municipalities regarding current funding mechanisms for infrastructure and sustainability projects. Four out of five municipalities expressed frustration, citing that the process of securing funding is too slow or complex and does not reflect their financial realities. These municipalities, located in low-tax regions, argued that their limited local tax base makes them heavily dependent on national funding which they perceive as difficult to access under existing models.

However, one participant said the opposite and claimed that there is not a problem and that both national and EU easily fund needed projects if wanted.

Thus, the interviews indicates that there is a need for communication and clarity into legislation and policies regarding grant seeking and funding, which could be a result both of complexity and competence.

## **4.2. Challenges into achieving sustainable development of port infrastructure**

The section highlights key barriers in achieving sustainable development of port infrastructure and energy. It covers governance issues, physical and financial barriers. These barriers show the need for better collaboration and strategic planning.

### 4.2.1 Governance Barriers

This section explores key governance barriers affecting port and energy infrastructure. The result focuses on communication, coordination with stakeholders and infrastructure financing and decision making.

#### *Communication*

The missing communication was often seen as very negative factor with many talking about delays, missed efforts and cooperation opportunities disappearing. A common barrier shared between 8 out of the 11 interviewees was the lack of structured and institutionalized collaboration, as previously mentioned also lacks policy and support. Interviewees often said that there was not any working communication. Interviewees highlighted that the communication is mostly informal and driven by personal networks or in some cases by industry stakeholders. This makes the communication channels in best case scenario very dependent on staff and unreliable sources. However, this result indicates that there is a will and a desire for change. This informal approach highly limits the capability of the governance of the ports.

Not all respondents shared this view. For example, Respondent E expressed that structured communication with other municipalities was not seen as necessary, stating that they were not dependent on regional collaboration and instead relied more on market conditions and national-level decisions. Additionally, they pointed out that they do not have operational control over their port, which reduced the perceived need for local coordination. Similarly Respondent G stated that they had clear communications with other municipalities, further stating that communication is a clear importance for a municipality. Further respondent G identified communication between municipalities is a 4 out of a scale between 1 to 5 in how important it is considered in which 5 was seen as immensely important. However, further on the interview it became evident that this communication was limited to four neighbouring municipalities and focused mostly on basic services such as sanitation and maintenance, rather than strategic infrastructure or energy issues.

These findings highlight a misalignment between perceived and actual collaboration, suggesting that governance coordination is overestimated by some actors. The ideal situation, as proposed by several interviewees, would involve, recurring forums for cross-municipal and

regional collaboration, ideally institutionalized through policy mandates and supported by dedicated staff and funding. Such governance mechanisms are crucial to enable long-term planning, joint infrastructure development, and efficient use of public resources. Without improved communication and collaboration structures, many opportunities for synergy in the transition to sustainable transport and energy systems may continue to be lost.

### *Coordination with Stakeholders*

The interviews showed that coordination with market and industry stakeholders is in seven out of 11 interviews something deemed priority or regularly mentioned as a barrier in why greater sustainable development is not achieved. five out of the seven considered the communication to be insufficient or to be improved. The Interviews showed that the two of those who did consider it important however not insufficient but rather considered that the communication was working very well, also didn't experience any communication. Both respondent F and J didn't have any communication channel, and their idea was then that this is a good thing since it meant that there was not a need for it.

The result shows that they did not put effort into communicating with the market or ask about needs of local stakeholders.

Further the lack of communication that was expressed by five interviewees attributed it due to absence of structures and unclear responsibilities. eight respondents noted that even though there is a need and large importance there is no one to take lead. The absence in this case was thought to lead to even more unclarity of what to invest in and what port infrastructure and energy needs there are. This was thought to lead to longer waiting times or delays and cancellation of projects. The results shows that there is a clear need for coordination platforms for planning infrastructure to align investments across public and private actors.

Moreover, the coordination does not simply stop at local actors and stakeholders. Rather many decisions affecting logistics and port development are shaped by forces beyond the local, regional and even national control. This was also noted by one respondent explaining when asked about if the communication between public and private actors are important.

Respondent D explained:

” There are many interests that meet on the quay, they probably have a high importance. but I think it is an issue that is bigger than us. So it's more based on what's happening on the international market and things like that.”

This perspective highlights the complexity of port governance where local actors are expected to coordinate on issues influenced by global market dynamics, international policies and organisations like the IMO. However, the perspective also highlights the somewhat non prioritized local actors. Although the details to the commitment of coordination with private actors is unknown it is explained to be an important part of the port infrastructure for the public actor although unknown and undefined.

#### **4.2.2 Financial Barriers**

Infrastructure financing emerged as a governance barriers in all interviews. Combined financing between private, municipal, national and EU programmes provide for a complexity that many experienced as very challenging and the need for further financing was considered necessary. When asked about how the port was being financed respondent E explained:

“Yes, it is through public funds and taxes. It is the municipality's financier. We own our port... But there is a constant dialog with the Swedish Transport Administration... Now we are part of an EU project, so we also have EU funds to provide for this.”

This quote illustrates how funding is collaborated from multiple layers this creates a necessity to constantly balance multiple funding streams each requiring specific needs and deliverables.

Five respondents repeatedly commented on their lack of expertise and personnel to navigate these systems. They often felt as they were not given an equal opportunity to acquire funding. As respondent I noted:

“It is very difficult when you have a limited workforce to be able to procure or access such funds... it takes a staff of people.”

The quote shows that the funding process is quite complex and that the possibility for funding is felt to be largely up to the possibility of matching strength and personal to larger actors and

not based on the needs of the port. Considering the process to acquire financing from larger actors such as National or the EU is then considered troublesome and hard to navigate. This could lead to a difference in what ability a port has to maintain their market competition, further challenging the capability for investment between urban and rural areas.

### *Infrastructure Financing and Decision Making*

Interviewees identified a significant governance related barrier in infrastructural financing and decision-making with 10 out of 11 noting it to be a barrier. The interviews showed that in eight of the case studies the cause was the unclear mandates, lack of operational capability and competence, political hesitation regarding long term investments. Three of the respondents explained that even where there was a willingness to act municipalities often find themselves without the authority, technical or financial structure to implement or maintain infrastructure for port and especially energy nodes.

As respondent C described:

“If we want to do something, there has to be continuous work to get it. And then we have to get a temporary permit to show that we can (for example) move traffic to somewhere else.”

This statement highlights the complex planning demands placed on municipalities and regions, which often require long-term strategic thinking to enable even temporary operational adjustments. It reflects the bureaucratic and procedural challenges involved in implementing infrastructure changes, even when the will to act is present.

Another recurring theme in four of the interviews was the gap between a municipality's ambition and its technical capacity. For instance, Respondent J, representing a smaller municipality, noted:

“We could build charging stations in the port, but we do not have the expertise to operate them”

The interview shows that even though public authorities may be motivated to support sustainable development they could still lack the technical knowledge or resources to manage and maintain such infrastructure. This becomes a large financial issue as there is a large uncertainty about expanding knowledge and investing in future technology, which makes it so investment and evolution is hindered. This issue arises from the uncertainty around

ownership and maintenance. It is especially hard to overcome these challenges in a rural municipality with very few habitants as stagnation could occur of the common infrastructural development. This then leads to a need for people to move away or to choose more technologically advanced municipalities.

The interviews revealed concerns about long-term maintenance and financing responsibilities also emerged. The idea of taking a new decision that overrules previous decisions set only after a few years, is very troublesome. The interview showed a 5 out of the respondent concerned of who shall finance and who shall be the responsible of what for both private actors and public actors.

During the interview with Respondent K explained:

“It is a maintenance issue, who will do the maintenance dredging? How will maintenance dredging be financed? That challenge, you think there are as many quays as possible in the municipality, but it does not come in with a boat that pulls ten meters.”

This points to the hidden costs and responsibilities that often makes infrastructure investments unattractive or unfeasible for municipalities, even when demand exists.

### *Investment Challenges in Renewable Fuel Infrastructure*

A recurring challenge which was raised in ten of the interviews was the difficulty of developing renewable fuel infrastructure in the absence of a clear and stable demand. A few respondents referred to this as the “chicken and egg” problem. The municipalities and regions hesitate to invest due to low or uncertain demand from logistics operators and shipping companies. Meanwhile the industry actors are waiting for public investment before they themselves can transition to alternative fuel. This is very problematic since neither can basically go first without a safe demand or supply, this leads to a slow development.

A regional stakeholder involved in port infrastructure described this dilemma by highlighting how public infrastructure providers are structurally dependent on industry demand signals, Respondent A said:

“Is it because in the end it's a demand question? Demand. What are the shipowners asking for? And this is kind of a chicken and egg problem, you could say, because we as infrastructure

landlord, we can only supply the demand. But in the end the demand is not coming from us but from the industry and the shipowners.”

This quote illustrates how investment stalls, not due to unwillingness but to a systemic mismatch between who controls infrastructure and who drives fuel transitions. Without a coordination between the public and private actors, there is often a misalignment and hesitance from both sides to push further investments. Ideally a shared risk management and coordinated investment on both sides would see faster development.

Another issue that was raised by an interviewee was the lack of guidelines and alignment between national policy and local implementation. An example comes from respondent D which claimed it was difficult to make investments into renewable fuels by stating

“If we are going to talk about strategy and guidelines for renewable fuels or charging infrastructure and things like that, I don't think it's very good, at least not for me.”

This highlights the gap between national and international lack of guidelines and local interest into investing into new technology. In which the local actors are navigating unclear roles and expectations. Because of the lack in communication.

While nine interviewees emphasised large barriers, there was also a degree of optimism. One respondent believed that increased industry demand and national guidelines could help justify infrastructure investment. However, no municipality had invested into other renewable energy sources than electrical charging stations. Two interviewees expressed this project to be a part of highlighting the needs and barriers of renewable fuel investment.

#### *Cost Barriers of Renewable Energy for Transport*

Nine respondents claimed that the renewable energy might not be market ready because of high competition from fossil-based alternatives. Further pointing out technical and cost barriers as large barriers. However, the largest issue mentioned by many is simply that the largest market is the ones wanting traditional fuels with a large hesitation to change, as it is considered a slow industry and with high barriers for investing into uncertain energy.

“This energy issue. It is not on the table either. There is a demand for a really low-emission fishing diesel. And that's where it is”

This quote from respondents K illustrates why renewable fuels struggle to gain market traction even though some want cleaner solution with fewer emissions. Demand remains firmly anchored for the most part in traditional fuels. The high upfront costs of new infrastructure with premium prices of fuels make them unattractive compared to cheap, well-established traditional fuels.

A similar issue was found with respondent B which explains that creating renewable energy is a significant technical barrier. Furthermore, because of the barriers the cost has increased massively making the renewable energy much more expensive than fossil-based alternatives. This makes them much harder to compete in the market. In short high production costs pushes price up and undermines the competitiveness of cleaner fuels.

Respondent B:

“It is difficult to create electricity production that is, for example, green hydrogen. Then the price goes up and then there is competition.”

Together, these perspectives highlight that without mechanisms to close the gap between high initial expenditures and uncertain demand either through pricing or coordinated public and private investment renewable energy solutions will continue to face an uphill battle against inexpensive fossil fuels.

### **4.2.3 Physical Challenges**

#### *Physical and Technical Challenges on Infrastructure Development*

The physical challenges include limited space, port depth limitations and outdated infrastructure. The technical conflict was often regarded as equally important as it created many uncertainties between function, service, safety and accessibility.

The change of ships shifting to electrification or other renewable energy sources and the constant factor that ships becomes increasingly larger to facilitate more trade resembles

another factor several interviewees identified as a large barrier and increasing issue for ports. This is because of the need of adapting to evolving needs of maritime transport, existing infrastructure around ports become incompatible.

As respondent A explained:

“Sustainable development is needed but, there is also the port which has to be renewed, and it has to be renewed because ships are growing and getting bigger and taller as well. So the ships will have a new height, but the port cannot say what impact on environmental development this new infrastructure will have”

This was a common result which was the results of all interviews with every respondent expressing similar concerns as the previous quote. The interviews highlight the challenge of planning port infrastructure in a context where standards must be met while also anticipating the evolving scale and technical requirements of future vessels and fuel systems. This creates a constantly shifting target that is difficult to align with, particularly when it comes to investment decisions and long-term planning. Similar concerns were expressed by another respondent, who acknowledged that while their current infrastructure is aligned with present market demands, anticipated increases in vessel size and forthcoming updates to canal infrastructure may soon surpass their existing capacity.

Respondent E said:

“No, the draught is good. And, other things regarding the fairway. But it will be a problem with new ships and new locks. So, we are looking at dredging measures.”

The viewpoint further extends, and it is clear the decision-making progress is seen as a dynamic and continues work. With changes in policy, regulations and renewable energy sources actively affecting ships the industry stands in front of a large barrier for ports to remain viable. The ports need to have both accessibility to different types of renewable energy source and availability of different fuels as well as making sure they are physical available for ships to access. With large uncertainties and dynamic markets many interviewees identified it as troublesome and wanted policy and regulative measures towards private actors to hinder unnecessary construction in ports.

Another barrier originates between prioritization needs both in terms of land mass and budget. Trade-offs must be made between service functions and basic infrastructure, with port areas becoming larger to facilitate for new needs in terms of renewable energy nodes. The need is for both land transportation and ships things like charging stations take up significant land space, security and other functions such as accessibility becomes a significant issue according to many participants. One participant told an example of which the issue became the removal of public toilets, which according to them was a large issue as it removed a basic function of their port. The result indicates that there is a large trade off in services and functions for a port when expanding.

Further one municipality told of the extra needed safety to facilitate new renewable energy needs. Extra measures were explained to be particularly addressed regarding placement of electric charging stations as safety of accidents could increase with more traffic. This shows of an awareness of safety as for the technical planning however it also shows for the constraints of infrastructure in ports.

An ideal scenario would involve nationally and internationally infrastructure planning, where physical constraints would be assessed in relation to evolving technical standards and future transport demands. Regions with the similar customer market and stakeholders would have access to the same planning and flexible regulatory frameworks that allow for adaptive development in cooperation with the private actors. Technical and physical constraints such as increased vessel size, safety, service and function trade-offs, as well as land mass are large issues if not taken into consideration.

### *Geographical Barriers*

Geographical factors emerged as a significant challenge to infrastructure development and the energy transition with all municipalities considering it to be a large challenge for investment and a large logistical challenge. The challenges were described to be due to remote locations, rural area, with dispersed population, few accessibility points, seasonal tourism or limited seaside access with increasing ship size. Making the planning, investment and deployment of energy nodes and port infrastructure difficult.

When asked about details of the issue many respondents claimed that even though they had possibility of collaborating with other regions and creating a grid, the simple geographical

distance becomes a large logistical burden. In rural or inland port areas dispersion between energy access points like fuelling stations are immense. This creates an issue of reliability as not all energy types are not accessible in all areas. The reason many interviewee names to why a large amount of accessibility points can't be arranged was the largest geographical distances which had to be covered which would involve which would add a large cost for construction and maintenance.

A few respondents brought up a difference in well-equipped urban areas with large amount of traffic and large ports having better opportunities to invest. However, they did not think that this was representative of a broader regional reality. Although they held the viewpoint that there should not be a centralized renewable energy hub which only is accessible in large urban areas. This was concluded by several respondents which fear that this scenario would lead to inequalities in development potential and would lead to further segregation and economical differences between rural and urban areas. One of the regional respondents pointed out a clear difference in infrastructure development today claiming that there are very many small ports that have extremely small possibilities of significant development with their small market segment.

### **4.3 Sustainable development within ports**

This section explores both the positive enablers and the limiting barriers that affect the sustainable development of ports, based on the perspectives shared by the respondents. The section highlights how ports may become both key drivers and an obstacle in the broad sustainable transformation of transport and energy.

Six respondents talked about the necessity for infrastructure as a way of connection to the rest of the nation and to global actors, to remain competitive as a region and city. As ports are essential for the ongoing trade and life of the region it is of great importance for many. A result that was noted when considering the ongoing energy transition and sustainable infrastructure planning was their potential for sustainable development in terms of energy and ambitious climate goals. Three respondents highlighted energy resilience as a key enabler, emphasizing the role of energy security and societal stability in future port planning. The integration of energy storage and renewable fuel production to be positioned in ports was key also for the development of the port to become both sustainable and more competitive.

Respondent A:

“Within this port development plan I mentioned before, we have the aim to be climate neutral by 2040. This is 10 years earlier than the whole European continent. And to reach this we implemented this sustainable energy hub”

This quote explains how ports can contribute not only by the reduction of emission but also by being a frontrunner in the sustainable development. A port being able to achieve climate targets as a large service provider and societal function is a great development.

Six respondents expressed optimism regarding the future development of the port, highlighting anticipated development in renewable energy integration as well as the attraction of new businesses to rural areas. They emphasized that the availability of space to accommodate private actors represents a competitive advantage for the municipality. As previously indicated, seven respondents identified effective communication as a critical factor for successful development, noting that strong communication facilitates smoother progress. Additionally, four respondents recognized the transition to renewable energy as both environmentally beneficial and a vital component in achieving decarbonization targets, further increasing their sustainability and competitive level. Furthermore, all respondents were asked on their preferability on sustainability, in which they were asked to rank environmental, social or economic. The result was not conclusive however many acknowledge each importance and the collaboration of all three would result in a sustainable development for the port.

Some results that were discovered during the case study indicates barriers that hinder sustainable port developments. One respondent talked eagerly about the position of Swedish port development, and the respondent thought that would be a great barrier for the development.

Respondent D explained when asked about barriers:

“Yes, but then also based on the fact that many quays along the entire Swedish coast were built in the post-war period so that they have somehow passed their expiration date ... already there are very large investment tracks that are not really linked to energy supply. And that is a bigger issue than the energy supply, I would say in many cases in this.”

This highlights the belief that it will become harder to build new infrastructure and that the barriers for investing into port infrastructure is larger. The respondent also highlights that in terms of prioritization of barriers the problem of old ports is significantly higher than the need of renewable energy. Further we can reinforce previous findings in chapter 4.2.3 that there is a high need of maintenance that is required before possibility of energy nodes and renewable energy. This result indicates that there is a need for maintenance in ports, and that the development of ports is behind today.

Further respondent C also indicated a similar perspective explained:

“But it's a huge problem. If you can be completely honest. Everyone wants us to come and go but you can't lie there and charge.”

This quote shows that even though there would be a large investment of renewable energy in ports, the port itself is not developed in a way that it could handle the logistics of in this case discussed port charging stations. The lack of standardisation and possibility of building a renewable energy node is in this case not possible before large investments are made into port development.

The result also found that some interviewees found the development of renewable energy have stagnated and that the focus peaked a while ago. This was mainly seen as a focus because of electrification and charging station being a frontrunner for renewable energy in motor industry gaining large attention. With the attention of charging network for vehicles been going down, the investments for other infrastructure such as port development have yet to be increased and the focus of energy dispersed because of lacking incentives and strategy.

## **5. DISCUSSION**

Following the results of this study will be discussed in relation to the research questions and existing literature. Key patterns emerging from the case study and thematic analysis will be placed against findings from the literature review and discussed painting a picture about the general trend of sustainable development in Swedish and German ports.

### **5.1 Interview results**

#### **Policy Knowledge**

An important result from this study is the difference in policy knowledge and regulatory competence between different public authorities. Most of the interviewed municipal actors repeatedly demonstrated limited knowledge of EU regulations like the Alternative Fuels Infrastructure Regulation (EU) 2023/1804 and other important regulation which are directly linked and very important to sustainable port development. Only one interviewee expressed a strong knowledge about these regulations which exceeded expectations. This is in line with findings by Liu et al. (2022), who noted that ineffective policies and unclear communication often results a discrepancy between national objectives and local execution.

Furthermore, by De Laurentis (2021) points out that institutional fragmentation at the regional level can significant factors hindering development and slow down stakeholders which are eager to act on this problem.

Further interview result highlights the problem of calibrating long term infrastructure investments and sustainability goals with the ever changing the face of short-term political focus in municipalities. Interviewees voiced concerns that shifting political priorities every political cycle creates planning uncertainty and delayed the execution of long-term projects. This is in line with research carried out by Clausen & Rudolph (2020), which highlights the importance of stable policy frameworks to encourage long term investment in renewable infrastructure. The revealed a lack in governance shows that broad strategic documents aim to maintain support for new sustainable development, but the vagueness of these documents limits their effectiveness in the local development. This limits the ability of municipalities to allocate their resources in an effective way.

## **Municipal** and Regional Collaboration

Between all interviewees the need for collaboration is recognized especially in rural and archipelago regions. But this study highlights that there are very little institutional mechanisms to enable and facilitate this collaboration. This can be seen in the communications channels which are mostly informal. This follows the research of Gorbunova et al. (2020) which highlights that without structure coordination and clear mandates united sustainable development is complicated.

This shows that while the value of collaboration maybe recognized by many involved, the lack of procedural and legal tools to implement it leads to inconsistent communication, insufficient or misplaced investments, and missed opportunities to further enhance sustainable development.

## **Financing**

Financial constraints and technical limitations additionally emerged as significant barriers to further development. Which impacts especially smaller municipalities or rural areas. Interviewees from these municipalities frequently voices their problems in accessing national or EU funds due to the lack of internal expertise. Furthermore, they stated their problems to operate or maintain new infrastructure such as charging stations or port electrification systems. This finding follows the findings of Hou et al. (2023) which stated that green financing can have a great impact if it is paired with the right institutional mechanisms and sufficient technical knowledge.

## **Public-Private Coordination**

Another significant result of the study is the limited cooperation between public authorities and private stakeholders. In many cases the respondents stated that little to no communication with transport operators or energy providers has been conducted. In some cases, this is even perceived as a good sign since it supposedly shows the absence of conflict and that closer coordination is not needed. This development is a worrying sign since it shows, that aligned public and private agendas concerning infrastructure development is not involved in the planning process of municipalities.

Panarello & Gatto (2023), show that the lack of a well maintained public-private dialogue is a risk to innovation and investment in renewable energy development.

## 5.2 Methodology

The use of an SLR enabled the researchers with a solid foundation of appropriate literature which helped identifying research gaps and formulate reasonable research questions leading to a structured and strong footed introduction and frame of reference. Although, most studies conducted in the recent years have focussed on far larger inland ports and archipelago regions in Central and Southeast Asia largely different from the considerable smaller archipelago ports interviewed in this study. Although these studies were still deemed reliable and applicable for this study the differences in region and size should be considered reading the results.

The use of a case study combined with interviews enabled the gathering of in depth and specific qualitative data gathered from appropriate Swedish and German municipal sources which was considered optimal and sufficient for this study. Although adding quantitative data could have helped to require a larger and wider range of data this approach was deemed too difficult considering the complexity of the research. Applying a Semi-structured focus group interview method helped in choosing an appropriate range of stakeholders to gather intensive insides concerning the research project to later be represented in the results. Furthermore, interviews offered the opportunity to ask to follow up questions which increased the level of detail and dept of the gathered data compared to quantitative data.

A major advantage of this mix of methods is the combination of different data sources which offers a comprehensive view on the topic from many different perspectives. Furthermore, the use of the Nvivo software offers the possibility of systematic and transparent thematic analysis which helped to identify important patterns across the interviews. However, the use of more themes and stronger in dept coding could have highlighted more detailed results but in turn making it harder to identify general patterns and matching data as well as requiring much more time to analyse the results sufficiently.

Several limitations have been emerging within the study and especially the case study, factors like the pool of interviewees which has been missing important figures like high-ranking national policy makers and private stakeholders such as shipping companies which in conclusion paints a somewhat one-sided picture of the findings. Furthermore, the findings are not applicable to all Swedish and German ports since time restrains have denied the researchers

to reach out to all ports, the findings more resemble a general trend which could be further investigated in extended future studies.

Secondly the sample scope, while most of the interviews have been conducted with Swedish ports and only one German port has been included the scope of the project focuses heavily on Swedish development. To make a case for general differences between countries more ports from other countries should be included in further research.

Lastly, the temporal limitation from January to Mai of 2025 made follow up interviews and longitudinal observations of policy developments and changing patterns in municipal behaviour impossible.

The use of focus group interviews enabled specific answers from each interviewee but without the use of a group discussion like a hackathon due to time constrains a constructive group discussion which reveals how each stakeholder works collaboratively was not possible and therefore no conclusions can be drawn about possibility of stronger future collaboration. Furthermore, the logistical challenges of a face-to-face interview with the German port may have led to the loss of depth and nuances regarding the answers.

## 6. CONCLUSION

Following in this chapter all chapters discussed above will be concluded and presented to the reader in a shorted version.

The purpose of this study was to explore how public authorities manage regulatory uncertainty and to identify key barriers and enablers influencing the sustainable development of port infrastructure. This purpose was successfully achieved; however, the findings does not speak for the entirety of Sweden or Germany, however some indications of Swedish public authorities' barriers, enabling factors and management of port infrastructure can be made.

Although efforts have been made to enhance validity and reliability by applying consistent coding strategies, using thematic analysis, and basing interview questions on peer-reviewed literature some small amount of subjectiveness can never be neutralised within qualitative research. Therefore, and with the factor that interpretation is inherently subjective the findings of this study should be seen as exploratory rather than definitive.

### **RQ1: How do public authorities handle uncertainty in regulations and policies for development of port infrastructure?**

This study found that handling uncertainty widely differs between the interviewees while some actively interpret and try to develop ways to work hand in hand with existing legislation others lack awareness and understanding of these legislations which hinders development and makes integration and planning nearly impossible. Lacking expertise and resources to work closely with existing legislation as well as unspecific mandates makes it hard for some actors to plan and leads to inefficient investments.

### **RQ2: What are the barriers hindering sustainable development of port infrastructure?**

The main barriers for most actors can be classified into three parts. First governance and structure which involves unclear mandates, very limited sometimes non existing cooperation between municipalities as well as communication channels which are build either on personal relations or business forum in term highlighting a lack of structured communication and collaboration. Secondly technical and financial restrains especially in rural municipalities which play a fundamental role in the ability for theses municipalities to facilitate sustainable development. Lastly extensive knowledge gaps at the local level which make planning and

strategizing an overly complicated and long-lasting process sometimes leading to unnecessary investments or no investments and development at all.

**RQ3: What enablers exist at public authorities in sustainable development of short sea shipping ports?**

The result from the interviews indicates that ports are a crucial for regional connectivity, competitiveness and sustainable development which leads to the conclusion that collaboration could be an enabler. This result showed that it was important to have updated infrastructure and importance of availability of renewable energy. Further there was an optimism regarding growth, results found that communication was seen as a key barrier for respondents but can be a major enabler if done correctly.

In general, the findings of this study have been a surprise, especially the lack of legislative knowledge and the amount of unstructured communication channels between municipalities. Problems with technical expertise as well as small financial resources have been anticipated in at least some of the municipalities. On the other hand, the fact that accessing national and EU funds for further development has been mentioned as a major challenge again has come as an unexpected outcome.

Future research could benefit from an expanded scope including interviewees from private and national political positions. Furthermore, a longer project timeline and the inclusion of more ports in the region of northern Europe could offer insight in the change of development and investment strategies as well as paint a picture of different approaches in different countries. This could offer a variety of different approaches to the same problem and inspire collaboration, change and faster innovation. Adding quantitative data could unlock a larger pool of information and data probably leading to a better understanding of a trend throughout the industry and all stakeholders involved which they are identifying as leading factors hindering development.

## REFERENCES

Azarova, V., Cohen, J., Friedl, C., & Reichl, J. (2019). Designing local renewable energy communities to increase social acceptance: Evidence from a choice experiment in Austria, Germany, Italy, and Switzerland. *Energy Policy*, *132*, 1176–1183. <https://doi.org/10.1016/j.enpol.2019.06.067>

Belmoukari, B., Audy, JF. & Forget, P. (2023). Smart port: a systematic literature review. *Eur. Transp. Res. Rev.* **15**, 4 <https://doi.org/10.1186/s12544-023-00581-6>

Blumberg, B., Cooper, D. R., & Schindler, P. S. (2011). *Business research methods* (Third European edition). McGraw-Hill Education.

Braun, V., & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101 <https://doi.org/10.1191/1478088706qp063oa>

Bruzzone, F., Cavallaro, F., & Nocera, S. (2021). The integration of passenger and freight transport for first-last mile operations. *Transport Policy*, *100*, 31-48. <https://doi.org/10.1016/j.tranpol.2020.10.009>

Bundesregierung, 2024, <https://www.bundesregierung.de/breg-de/aktuelles/nationale-hafenstrategie-2266334> Accessed: 05.05.2025

Bundesamt für Justiz, 2019, <https://www.gesetze-im-internet.de/seeumwverhv/BJNR137110014.html> Accessed: 05.05.2025

Martyn Denscombe. (2009). *The Good Research Guide* (4th ed.) UK: University Press UK Limited.

Clausen, L. T., & Rudolph, D. (2020). Renewable energy for sustainable rural development: Synergies and mismatches. *Energy Policy*, *138*, 111289. <https://doi.org/10.1016/j.enpol.2020.111289>

Cohen, J. J., Moeltner, K., Reichl, J., & Schmidthaler, M. (2016). An empirical analysis of local opposition to new transmission lines across the EU-27. *The Energy Journal*, 37(3). <https://doi.org/10.5547/01956574.37.3.jcoh>

Daviter, F. (2019). Policy analysis in the face of complexity: What kind of knowledge to tackle wicked problems? *Public Policy and Administration*, 34(1), 62-83. <https://doi.org/10.1177/0952076717733325>

De Laurentis, C. (2021). What are the regionally specific institutions that matter for renewable energy deployment and how can they be identified? Some insights from Italian regions. *Local Environment*, 26(5), 632–649. <https://doi.org/10.1080/13549839.2021.1904859>

DeSombre, E. R., Knudsen, J. S., & Eider, M. (2023). Regulation from above or below: Port greening measures in the European Union and the United States. *Regulation & Governance*, 18(1), 33–52. <https://doi.org/10.1111/rego.12510>

Diniz N, Cunha D, Porte M, Oliveira C, Fernandes F, (2024). A bibliometric analysis of sustainable development goals in the maritime industry and port sector. *Regional Studies in Marine Science*, 69. <https://doi.org/10.1016/j.rsma.2023.103319>

Dóci, G., & Gotchev, B. (2016). When energy policy meets community: Rethinking risk perceptions of renewable energy in Germany and the Netherlands. *Energy Research & Social Science*, 22, 26–35. <https://doi.org/10.1016/j.erss.2016.08.019>

E.F. Moran, M.C. Lopez, N. Moore, N. Müller, D.W. Hyndman, (2018) Sustainable hydropower in the 21st century, *Proc. Natl. Acad. Sci. U.S.A.* 115 (47) 11891-11898, <https://doi.org/10.1073/pnas.1809426115>

European Commission (2024). European Commission. [https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure\\_en](https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure_en). Accessed 11.03.2025

European Alternative Fuels Observatory. (n.d.). Ports and infrastructure – Maritime (sea). Retrieved [2025-01-31], from: <https://alternative-fuels-observatory.ec.europa.eu/transport-mode/maritime-sea/ports-and-infrastructure>

European Commission. (2014). Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure Text with EEA relevance. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014L0094>

Fedorenko, R., Yakhneeva, I., Zaychikova, N., Lipinsky, D., (2021). Evaluating the socio-economic factors impacting foreign trade development in port areas, *Sustainability* 2021, 13(15), 8447. <https://doi.org/10.3390/su13158447>

Gorbunova, A., Anisimov, I., & Magaril, E. (2020). Studying the formation of the charging session number at public charging stations for electric vehicles. *Sustainability*, 12(14), 5571. <https://doi.org/10.3390/su12145571>

Han, S., & Kim, J. (2019). A multi-period MILP model for the investment and design planning of a national-level complex renewable energy supply system. *Renewable Energy*, 141, 736–750. <https://doi.org/10.1016/j.renene.2019.04.017>

Hatzioannidu F, Polydoropoulou A,. (2022) Transport modelling of the ferry network in the aegean archipelagos and its airline alternatives: Analytics, visualisation, and insights. *Maritime Transport Research*, 3. <https://doi.org/10.1016/j.martra.2022.100076>

Hou, H., Wang, Y., & Zhang, M. (2023). Green finance drives renewable energy development: Empirical evidence from 53 countries worldwide. *Environmental Science and Pollution Research*, 30, 80573–80590.

Hsieh, H.F., & Shannon, S.E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15(9), 1277-1288. [10.1177/1049732305276687](https://doi.org/10.1177/1049732305276687)

International Maritime Organization. (2023). *2023 IMO strategy on reduction of GHG emissions from ships*. <https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx>

Jing Su, Jiayi Liu, Anmin Zhang. (2024). Promoting regional coordinated and sustainable development of port, economy, and environment in archipelago-A case study of Zhoushan Port in China, *Ocean & Coastal Management*, 257. <https://doi.org/10.1016/j.ocecoaman.2024.107324>

Khan, A. R., & Khandaker, S. (2016). A Critical Insight into Policy Implementation and Implementation Performance. *Public Policy and Administration*, 15(4), 538–548.

Knatz, G., Chambers, K. (2022). Seaports. In: Layne, P., Tietjen, J.S. (eds) *Women in Infrastructure. Women in Engineering and Science*. Springer, Cham. [https://doi.org/10.1007/978-3-030-92821-6\\_11](https://doi.org/10.1007/978-3-030-92821-6_11)

Kong Y, Liu J, (2021). Sustainable port cities with coupling coordination and environmental efficiency, *Ocean & Coastal Management*, 205. <https://doi.org/10.1016/j.ocecoaman.2021.105534>

Liu, X., Liu, X., Zhang, X., Zhou, Y., Chen, J., & Ma, X. (2022). Optimal location planning of electric bus charging stations with integrated photovoltaic and energy storage system. *Management of Environmental Quality: An International Journal*, 33(1), 124–142. <https://doi.org/10.1111/mice.12935>

Lu, J., Ren, L., Yao, S., Rong, D., Skare, M., & Streimikis, J. (2020). Renewable energy barriers and coping strategies: Evidence from the Baltic States. *Sustainable Development*, 28(1), 352–367. <https://doi.org/10.1002/sd.2030>

Maka A. O. M., Alabid Jamal M, (2022) Solar energy technology and its roles in sustainable development, *Clean Energy*, Volume 6, Issue 3, Pages 476–483, <https://doi.org/10.1093/ce/zkac023>

Merkel A, Sløk-Madsen S, (2019) Lessons from port sector regulatory reforms in Denmark: An analysis of port governance and institutional structure outcomes. *Transport Policy*, 78. <https://doi.org/10.1016/j.tranpol.2019.03.010>

Mollaoglu, M., Yazar Okur, I.G., Gurturk, M. *et al.* (2024) Review on Sustainable Development Goals in maritime transportation: current research trends, applications, and future research opportunities. *Environ Sci Pollut Res* 31, 8312–8329. <https://doi.org/10.1007/s11356-023-31622-1>

Mouratidis A, (2020) The 7 challenges of road management towards sustainability and development. *Journal of Infrastructure, Policy and Development*, [S.l.], p. 249–260, <http://dx.doi.org/10.24294/jipd.v4i2.1174>.

Nguyen, H. P., Nguyen, P. Q. P., & Nguyen, T. P. (2022). Green port strategies in developed coastal countries as useful lessons for the path of sustainable development: A case study in Vietnam. *International Journal of Renewable Energy Development*, 11(4), 950–962. <https://doi.org/10.14710/ijred.2022.46539>

Olabi, A. G., Obaideen, K., Abdelkareem, M. A., AlMallahi, M. N., Shehata, N., Alami, A. H., Mdallal, A., Hassan, A. A. M., & Sayed, E. T. (2023). Wind Energy Contribution to the Sustainable Development Goals: Case Study on London Array. *Sustainability*, 15(5), 4641. <https://doi.org/10.3390/su15054641>

Panarello, D., & Gatto, A. (2023). Decarbonising Europe – EU citizens’ perception of renewable energy transition amidst the European Green Deal. *Energy Policy*, 172, 113272. <https://doi.org/10.1016/j.enpol.2022.113272>

Platias, C., & Spyrou, D. (2023). EU-funded energy-related projects for sustainable ports: Evidence from the Port of Piraeus. *Sustainability*, 15(5), 4363. <https://doi.org/10.3390/su15054363>

Regeringskansliet. (2019). Sweden’s 2019 report under the Directive on the deployment of alternative fuels infrastructure pursuant to Article 10(1) of Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014[Report]. Retrieved

from <https://alternative-fuels-observatory.ec.europa.eu/system/files/documents/2022-12/SE%20NPF%202019%20Report%20ENG.pdf>

Rys, M. (2022). Characteristics of invention development during the hackathon. *Journal of Research into New Media Technologies*, 28(6), 1800-1825. 10.1177/13548565211070418

Sadorsky P. (2021). Wind energy for sustainable development: Driving factors and future outlook. *Journal of Cleaner Production*, Volume 289. <https://doi.org/10.1016/j.jclepro.2020.125779>

Sakib N, Appiotti F, Magni F, Maragno D, Innocenti A, Gissi E, Musco F. (2018) Addressing the passenger transport and accessibility enablers for sustainable development. *Sustainability*, 10, Issue 4. DOI:[10.3390/su10040903](https://doi.org/10.3390/su10040903)

Sauer, P.C., Seuring, S. (2023). How to conduct systematic literature reviews in management research: a guide in 6 steps and 14 decisions. *Review of Managerial Science*, 17, 1899–1933. <https://doi.org/10.1007/s11846-023-00668-3>.

Schwanitz V, Wierling A, Shah P, (2017) Assessing the Impact of Renewable Energy on Regional Sustainability—A Comparative Study of Sogn og Fjordane (Norway) and Okinawa (Japan). *Sustainability* 9(11). <https://doi.org/10.3390/su9111969>

Kvale, S., & Brinkmann, S. (2015). Interviews: Learning the craft of qualitative research interviewing. ISBN: 9781452275727

SFS 2019:152. *Lag om tillhandahållande av hamntjänster* [Act on the provision of port services]. [https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/lag-2019152-med-kompletterande-bestammelser\\_sfs-2019-152/](https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/lag-2019152-med-kompletterande-bestammelser_sfs-2019-152/)

SFS 2004:487. *Lag om sjöfartsskydd* [Maritime Security Act]. [https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2004487-om-sjofartsskydd\\_sfs-2004-487](https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2004487-om-sjofartsskydd_sfs-2004-487)

SFS 1980:424. *Lag om åtgärder mot förorening från fartyg* [Act on measures against pollution from ships]. [https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-1980424-om-atgarder-mot-fororening-fran\\_sfs-1980-424](https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-1980424-om-atgarder-mot-fororening-fran_sfs-1980-424)

Singh, S., & Ballini, F. (2025). Socio-economic impacts of maritime GHG emission control measures on sustainable development in SIDS: Insights from a systematic literature review. *Marine Pollution Bulletin*, 199, 117687. <https://doi.org/10.1016/j.marpolbul.2025.117687>

Song L, Geenhuizen M, (2014). Port infrastructure investment and regional economic growth in China: Panel evidence in port regions and provinces. *Transport Policy*, 36. <https://doi.org/10.1016/j.tranpol.2014.08.003>

Su J, Liu J, Zhang A, (2024). Promoting regional coordinated and sustainable development of port, economy, and environment in archipelago-A case study of Zhoushan Port in China. *Ocean & Coastal Management Volume 257*. <https://doi.org/10.1016/j.ocecoaman.2024.107324>

Swedish Parliament. (2018). *Act (2018:672) on differentiated fairway dues*. [https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2018672-om-differentierade-farledsavgifter\\_sfs-2018-672](https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2018672-om-differentierade-farledsavgifter_sfs-2018-672)

Taljaard S., Slinger J.H., Arabi S., Weerts S.P., Vreugdenhil H., (2021). The natural environment in port development: A ‘green handbrake’ or an equal partner?, *Ocean & Coastal Management*, 199. <https://doi.org/10.1016/j.ocecoaman.2020.105390>

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, 14(3), 207–222. <https://doi.org/10.1111/1467-8551.00375>

Trochim, W.K., and Donnelly, J.P. (2008). *The research methods knowledge base*, 3rd Edn. Atomic Dog.

Umweltbundesamt, (2023) Erneuerbare-Energy-Gesetz. Accessed: 05.05.2025  
<https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-gesetz#erfolg>

Van Marle, G. (2018). Ports can help reduce ship emissions by using a 'polluter pays' fee system. *Canadian Sailings*, 51.

Wan, Z., Nie, A., Chen, J., Pang, C., & Zhou, Y. (2025). Transforming ports for a low-carbon future: Innovations, challenges, and opportunities. *Ocean & Coastal Management*, 2025, 107636. <https://doi.org/10.1016/j.ocecoaman.2025.107636>

Wiegmans B, Witte P, Spit T, (2015). Characteristics of European inland ports: A statistical analysis of inland waterway port development in Dutch municipalities. *Transportation Research Part A: Policy and Practice*, Volume 78, <https://doi.org/10.1016/j.tra.2015.07.004>

Yin, R. (2009). *Case study research: Design and methods*. Sage Publications.

Zadeh I, S.B.; Perez, E, M.D.; López-Gutiérrez, J.-S.; Fernández-Sánchez, G. (2023) Optimizing Smart Energy Infrastructure in Smart Ports: A Systematic Scoping Review of Carbon Footprint Reduction. *J. Mar. Sci. Eng.* 11, 1921.  
<https://doi.org/10.3390/jmse11101921>

Zhang Y, Ma H, Zhao S, (2021) Assessment of hydropower sustainability: Review and modeling, *Journal of Cleaner Production*, Volume 321, <https://doi.org/10.1016/j.jclepro.2021.128898>.

# APPENDIX 1

## Interview questions

### Section 1 Introductory questions

1. How old are you:
2. Gender:
3. What is your current job/position?
4. How long have you held this position?
5. What is your highest level of education?

### Section 2 Planning for development of sustainable port infrastructure

1. Could you describe regulatory responsibilities in development of port infrastructure in Germany i.s. which responsibilities have local, regional, governmental authorities?
2. What legal guidelines, e.g. EU regulations, directives, national laws do you know about the development of transport infrastructure including ports? e.g;
  - Regulation (EU) 2023/1804 of the European Parliament and of the Council of Ministers on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU
  - Regulation (EU) 2017/352 of the European Parliament and of the Council of Ministers establishing a framework for the provision of port services and common rules on the financial transparency of ports (include multimodal transport)
  - Other ? which?
3. In planning to establish an energy node as a part sustainable port infrastructure, do you consider the available production of different energy sources?

If YES,

- b) Which renewable energy are included in the planning of port infrastructure?
  - HVO
  - Ethanol
  - Ammonia

- Hydrogen
- Other energy

b) Do you prioritise any of the energy sources in the planning of transport infrastructure?  
i.e. a certain type of energy must be available in the port

4. How do you collaborate with other regions, local municipalities, and private companies in planning of sustainable port infrastructure?

- On access to renewable energy?
- On access to multimodal transport?

5. In planning of port infrastructure, how is passenger safety taken into account in relation to access to new energy sources?

- 5.1 Could you describe how? E.g are there differences in how passenger safety is taken into account with regard to different types of energy?
- If passenger safety is not taken into account, what is the reason for this?

6. How is travellers mobility i.e. access to other transport modes (car, bus, train) taken into account in planning of port infrastructure?

7. How is sustainable development of port infrastructure financed in Hamburg?

8. How would you like the development of port infrastructure to be financed in the future; As it is ? or in another way- could you please describe how?

9. Do you have any other information or question you would like to add?

### **Section 3 Challenges to sustainable development of port infrastructure**

Published studies show challenges in sustainable development of port infrastructure. Please rate how important the following challenges are in planning a sustainable transport and port infrastructure. 1- insignificant; 2- low importance; 3-neutral importance; 4- high importance; 5- very high importance.

**Obstacles due to existing infrastructure e.g. power lines, pipes, roads**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Physical limitations in the existing infrastructure, e.g. load-bearing capacity of quays/bridges/roads**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Natural barriers e.g. deep draft of ferries, lack of space for roads**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Competing mobility interests from travelers, due to multimodal transport,**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Competing interests from freight owners/ transporters**

1. insignificant;
2. some importance;

3. neutral importance;
4. high importance;
5. very high importance

**Lack of existing transport infrastructure to meet requirements to ensure accessibility in ports to renewable energy**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Unclear financing in sustainable development of port infrastructure**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Uncertainty in the production of renewable energy**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Unclear communication of policies, guidelines containing requirements on multimodal transport and mobility of travellers. Between Government/ parliament and region authority**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Unclear communication of policies, guidelines containing requirements on access to renewable energy. Between *Government/parliament and region authority***

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Unclear communication of policies, guidelines containing requirements on access to renewable energy. Between *the region and local authority***

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Unclear communication of requirements on access to renewable energy from transporters (e.g. shipping company/haulage company).**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Social sustainability issues (e.g. travellers mobility) are emphasized over environmental sustainability issues (e.g., access to renewable energy) in planning of port infrastructures**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Environmental sustainability issues (e.g., access to renewable energy) are emphasized over social sustainability issues (e.g. travellers mobility) in planning of port infrastructures**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Financial sustainability issues (e.g., costs of energy node) are emphasized over social sustainability issues (e.g. travellers mobility) in planning of port infrastructures**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Environmental sustainability issues (e.g., access to renewable energy) are emphasized over financial sustainability issues (e.g. costs of energy node) in planning of port infrastructures**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;
5. very high importance

**Competing demand/ interest in traditional fuels (diesel, crude-oil)**

1. insignificant;
2. some importance;
3. neutral importance;
4. high importance;

5. very high importance

**Lack of general overview (plans) in planning of ports between authorities**

5- insignificant;

5- some importance;

5- neutral importance;

5- high importance;

5- very high importance

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