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PORTS IN TRANSITION

ANALYSIS OF SUSTAINABLE TRANSITION IN DIFFERENT PORTS OF EUROPE

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Abstract

Ports are key exchange points in global supply chains. Simultaneously they are part of their local and regional communities interacting with them and having a huge impact in their areas. Therefore, ports, as an infrastructure present in these three dimensions (global, regional and local), have to answer to the challenges that the current worldwide situation is experiencing. Ports have an incredible potential in addressing different issues in which the major ones are climate change, digitalization of major infrastructures, global mobilization, political cooperation and social integration. The objective of this paper is analyzing what are the main trends in port sustainability and how are they being implemented and how can they be put into practice in different kind of ports. Throughout this document I will explain how ports in Europe have been established and are currently transitioning towards a sustainable future, what indicators they should follow in order to become more sustainable and how their transition affects the entire maritime industry and the relations with the cities and regions where they are located. Finally, I will compare different ports of Europe analyzing what have they done to become sustainable and what is left to be done.

Keywords:

Sustainability, seaports, governance, global reporting, European ports, Port Authorities

Table of contents

INTRODUCTION

Our recent history is based in communications improvement. Ever since we, as humanity, started developing the world one of the main focuses has been improving the communications systems in all kinds of ways. In Europe specially, ports have had a major importance in the creation of Europe as we it know today. The ancient Greeks where the first ones to develop a port-based culture creating a network of port cities, polis, all over the Mediterranean and establishing a trade empire. Afterwards, Cartage created also a trade economy with special importance of ports in the eastern Mediterranean. The Romans also used their ports to conquer the Mediterranean and establish their empire. The list of examples goes on and on, Portugal and its empire, the Venetian trade empire, Spain and its empire, the Hanseatic League, … Ports have been the way in which Europeans have found the way of exploring and conquering the world, it has been the way through which new ideas, materials, philosophies, religions… have been introduced in many parts of the world. Ports are one of the main gateways for transport around the world, shipping accounted for 80% of the worlds trade transport (UNCTAD, 2018). Even though the number of people they move from one side to the other is not significant waterborne transport accounts for 90% of global trade and 2,5% of greenhouse gas emissions. Ports play a major role in today's world as interconnection points for transport networks but also with multimodal nodes of transport and trade linking the maritime industry with other means of transport and the port cities. As such, a sustainable transition of this kind of infrastructure is key in order to tackle the current climate change condition.

In the current business climate sustainability is seek and organizations and companies are under pressure by their stakeholders and society in general to pay attention to sustainability when they report their performances. Sustainability can be understood under three large domains that are economic, social and environmental. This is also called the Triple Bottom Line or TBL dimensions (people, planet and profit). (Geerts & Dooms, 2020). The economic output had been the only important indicator to report until the social and environmental consequences that came with that economic profit started being taken into account. As a matter of fact, around 96% of the top 250 companies listed in the Fortune Global 500 ranking and 80% of the N100 (the biggest 100 companies by revenue in the 52 countries studied) are investing to report better sustainable performances much more than

ever before with an increase of 60% since KPMG started tracking this value in 1999 (KPMG, 2020).

Despite it being initially a debate around more the private world, the scope of sustainability has broadened to almost every aspect of the private and public world. Public organizations and partially or fully public owned companies are facing an increasing accountability expectation from their citizens. Thus, everywhere around the world there is an increasing interest of transitions to sustainability. However, the concept of sustainability is heavily debated, the one I am going to use on this paper is the Triple Bottom Line. This definition understands that for a port to reach sustainability it must achieve a balance among the environmental, economic and social structures of a port. Thus, a sustainable port is the one that functions with energy-efficient and environmentally friendly systems while being socially acceptable and is able to maximize the revenues it generates (Kuznetsov, Dinwoodie, Gibbs, Sansom, & Knowles, 2015). The examples are everywhere in the port industry, according to British Petroleum 2019 was the global peak of oil used, now we decrease. According to this article by Financial Times almost 70% of the world has embraced clean energy transitions.

In this document I turn my attention to the port industry with an aim to research what initiatives are taking place in the world and how Europe is transforming its ports, how are they taking place. The global picture is clear; ports, as the rest of the maritime industry must evolve into a sustainable one in order to be part of our new order. If the states or the companies that are a major part of it in today's world refuse to take immediate action, they will be displaced to a second spot while the ones that embraced transition and sustainability would get the major achievements and comparative advantages. Europe is in a really important and crucial position. The Green Deal initiative added to the COVID-19 Relief funds called New Horizon could become the leaders of this change as it has been with the Data Protection laws or many other European initiatives adopted later globally.

The scope of review for this paper is limited by scientific and technical publications in English between 2010 and 2021 identified through searches in Google Scholar, Library Genesis and ScienceDirect. As a matter of fact, science evolves increasingly fast, so this paper has tried to capture the main trends, but the different priorities of the world are

heavily influenced by the contextual reality of the world. Although the global context influences which kind of initiatives are to take place by port decision makers this paper does not focus on that. Nonetheless, I aim to review and analyze the different policies and initiatives and evaluate them while they are taking place while recommending alternative aspects to put the focus on.

This paper is organized as follows, Section 1 provides an introduction to the historical evolution of European ports and how is the general current situation. Section 2 contains the current situation of sustainability reporting and a development of sustainability reporting initiatives and benefits. Section 3 contains the theoretical approach of my research with the different global initiatives that I have found. Section 4 provides a practical analysis of the theoretical indicators explained in the previous sections. A general conclusion and suggestions are presented in Section 5.

PART I – GENERAL INFORMATION OF SUSTAINABLE PORTS

1. DEFINITION OF PORT SUSTAINABILITY AND REVIEW OF ITS LITERATURE.

As I have explained, maritime transport plays a key role in the modern globalized world. International logistic chains heavily depend on it as it was evident with the *Ever-Given* Accident on the Suez Canal in April 2021 (Samaan, Deng, El Sirgany, Salem, & Said-Moorhouse, 2021). They are also pivotal in economic growth in regions and countries. In recent years the world has increasingly enacted and approved different regulations covering environmental and climate issues such as the MARPOL (Marine Pollution) convention adopted after the Exxon Valdez incident in Alaskan waters, the IMO target for 2050 of reducing GHG emissions a 50% compared to 2008 levels (known as the Paris Agreement for shipping (GreenPort, 2018) or the more generic Kyoto Protocol or the Paris Agreement (UN Climate Change, 2019). Ports have increased the volumes they trade with and the port activities and other related cause huge environmental pollution. Operational consequences of the port activities comprise among others: noise, water pollution and discharge, greenhouse gas emissions, dust at the same time that they cause on the port workers safety and health issues. Thus, ports that have reached a higher level of environmentally friendly standards attract more shipping companies and government support. However, to achieve these standards ports must undergo a heavy investment process that goes against the aim of maximizing the profits from its revenues. This incompatibility between a sustainable climate-friendly advantage and economic profit is to this date still present on port sustainability and its related activities (Lim, Pettit, Abouarghoub, & Beresford, 2019).

Port sustainability then is rooted on three pillars that I mentioned before known as the Triple Bottom Line. These three are environment, social and economic standards. The main definition of a sustainable port is the one that provides a safe, socially acceptable energy efficient and climate and environmentally friendly port management approach while at the same time it maximizes the profits (Kuznetsov, Dinwoodie, Gibbs, Sansom, & Knowles, 2015). The three dimensions are present and the goals of each of the pillars can be explained as:

1. Environmentally sustainable: the goal is to minimize the negative and polluting impact generated by the operational and shipping activities within the port and its neighboring areas. This is the pillar that has received more attention both academically and in the real world. The majority of the sustainable initiatives account for strategies or techniques that once implemented will address this issue (Lim, Pettit, Abouarghoub, & Beresford, 2019).

2. Socially sustainable: in order for a port to achieve a socially sustainable standard it must contribute to the improvement of the people quality of life. This can be reached by backing port activities that meet socioeconomic preferences like employment opportunities, education for employees, gender equality in the port workforce, a good dynamic between the port and the city where its located (in case there is a city) or improving social cohesion in the vicinity of the port (Carpenter & Lozano, 2020). A socially sustainable port is the one that contributes to the well-being of the area surrounding the zone and how through partnerships with the city where is located the y both can achieve a dynamism with an equilibrium among the economic, environmental and social aspects of each entity. The social dimension of ports is increasingly taking off in interest and importance, but the initiatives and research are still lacking a push (Lim, Pettit, Abouarghoub, & Beresford, 2019).

3. Economically sustainable: this aspect refers to maximization of the economic profit from the revenues generated resulting from the sustainable development initiatives that had been implemented in the port. This economic profit cannot affect in an adverse way the social and environmental development (Lim, Pettit, Abouarghoub, & Beresford, 2019).

As Figure 1 in the Appendix (Lim, Pettit, Abouarghoub, & Beresford, 2019) portrays, the three major aspects of port sustainability and how they interact with each other with their areas in common. As for reviewing the different literature around this topic there are different papers that cover and analyze it. Since 2006 green ports and maritime logistics have become increasingly important research area. Even though it is still on its early ages of development the field is expected to grow and continue to influence governments and port authorities towards sustainable transitions (Davarzani, Fahimnia, Bell, & Sarkis, 2015). Analyzing the literature there are different trends and conclusions to draw from the review. First, it can be affirmed that sustainability performance has had a decisive impact on the industry economic

performance and that further research is needed on the drivers and stoppers of such growth to maximize the impact of sustainability transitions. Second, despite an exponential increase in scientific publications towards port sustainability it still is behind the interest that other methods of transport attract such as road or urban transport. Moreover, the literature has not extended to cover that many social and economic facets of sustainability limiting it mainly to different environmental studies.

This lack of research on a gradually increasing area of interest as social responsibility may be justified to the puzzling nature and subjective interpretations of social indicators (Lim, Pettit, Abouarghoub, & Beresford, 2019). Lastly, there is a need for more research towards the positivity or negativity for port economic performance of the impacts of sustainability collaboration with internal and external stakeholders. Stakeholders should include a wider variety of members such as: communities, companies, and shippers who are involved in port sustainability performance. For example, recently there was a takeover within the board of directors of Exxon Mobile by a group of shareholders who wanted to push the company towards a more sustainable path (Hiller & Herbst-bayliss, 2021). Generally, collaboration among different organisations has proved to have had a positive impact on the sustainable performance of ports. Nonetheless, further research into the economic aspects from the sustainable development collaboration is still needed. In other words, if the heavy investments needed to turn a port sustainable are profitable enough to be attractive to port authorities. Therefore, more research that focuses on the consequences of cooperation with the external stakeholders can be addressed in two directions: the collaboration mechanism with intra-and inter-organisations to resolve effectively the conflicting interest; and the effect of costs and social benefits on the collaboration with external stakeholders, for example, in terms of the reduction of risks in uncertain port environments and the improvement of social legitimacy and reputation (Lim, Pettit, Abouarghoub, & Beresford, 2019).

PART II –DEVELOPMENT OF SUSTAINABLE TRANSITION IN PORTS

1. THE WORLD PORT SUSTAINABILITY PROGRAM (WPSP) AND THE INTEGRATION OF SDGS IN PORT GOVERNANCE AND PRACTICE

The WPSP was launched in 2018 with the objective of creating an online portfolio of projects taking place and to create a platform that would work both as a think-tank and as an incubator for arising sustainable initiatives (World Port Sustainability Program, 2021). The spirit behind it is to contribute to the sustainable development of world ports in line with the Sustainable Agenda and the 17 SDGs of the United Nations. This initiative is led by the International Association of Ports and Harbors (IAPH) in partnership with most of the major port-industry organizations like Ports of Australia, Baltic ports Organization, European Seaports Organization, …. Its mission is stated in the report as "*to empower port community actors worldwide to engage with business, governmental and societal stakeholders in creating sustainable added value for the local communities and wider regions in which their ports are embedded* " (World Port Sustainability Program, 2020). The 2020 WSPS report draws some really interesting conclusions. As the first comparable report of analysis and descriptive snapshot of the different initiatives and trends in port sustainability it is a really useful report to analyze the different realities of the port industry. Since it was launched it comprises the most coherent and complete database of port related projects towards sustainable development. Of the 120 projects that were submitted, 72 came from European ports, followed by Asia 32, America, Oceania 22 and 1 in Africa (World Port Sustainability Program, 2020). For further information, refer to Figure 2 in the Appendix.

In the begging of January 2016, the 17 Sustainable Development Goals came into force. These goals aim to achieve a better and more sustainable future (United Nations Department for Social and Economic Affairs, 2021). Port sustainability is closely related to the UN SDG's. In 2019 the World Ports Sustainability Program organized a workshop at the UNCTAD Headquarters in Geneva, Switzerland gathering the main players of this industry (more than 30 IAPH member ports, the Trade and Logistics branch of UNCTAD, UN Global Compact, …) the group agreed on a roadmap that prioritizes potential port decisions to address the 17 Sustainable Development Goals.

The WSPS realized that ports could contribute to every single one of the SDGs and decided to implement them along five different themes that are the pillars of sustainable transition in ports today. As seen in chart 1 (World Port Sustainability Program, 2021) the major priorities of ports are based in SDGs; 9 industry innovation and infrastructure; 11 sustainable cities and communities and 8 decent work and economic growth. These priorities translate in the following objectives, but the different initiatives cover almost all the different SDGs (World Port Sustainability Program, 2020).

1. Resilient infrastructure
2. Climate and energy
3. Community outreach and port city dialogue
4. Safety and security
5. Governance and ethics

These factors will be explained later as I focus on understanding sustainable transition of ports. These five concepts make up the core of my research on explaining what has been done and what can be done to reach a sustainable transition of the ports and their industry.

2. INSTITUTIONAL PUSH

Since the early 2000s the European Union has developed different legal documents which try to convert the port are into a more environmentally friendly one. This is the case of Directive 2008/98/EC (European Commission, 2008) of handling of waste at port states or the European regulation on the provision of port services and common rules on ports financial transparency (European Parliament and Council, 2017). However, the European ports have pursued sustainability beyond their legal requirements imposed by the institutions. Port Authorities specially have been one of the main drivers of strategies and initiatives developed (Carpenter & Lozano, 2020).

In December 2019, the European Commission led by Ursula Von der Leyen adopted the program European Green Deal. The idea of this program is to transform Europe into the first climate neutral continent by 2050. One of the basic commitments of this

program is the idea that "*transport should become drastically less polluting*". The Green Deal remarks the importance of reducing greenhouse gas emissions (GHG) in some areas including waterborne transport. Waterborne transport is in a continuous growth (with the exception of 2020 due to the pandemic) so tackling this issue will prevent from further emissions as the industry develops. Green ports as hubs for sustainable development have a huge potential to drive GHG emissions down (European Comission, 2020).

The Green Deal offers a wide range of initiatives to address the port sustainability objective. Among the initiatives that the Commission proposes are the following: (1) supply and production of energy from clean sources to ports and onshore distribution systems providing fuel alternatives refilling within port facilities (European Comission, 2020); (2) improve the sustainability and innovation of the port beyond the energetic field. Special emphasis on smart and green logistics and daily port operations such as more environmentally friendly buildings and facilities, greener and more efficient use of the land or innovative buildings (European Comission, 2020); (3) continuous and extremely efficient logistics operators that allow for a dynamic port-hinterland connection through rail or road enabling modal shifts and multimodal nodes of passengers and freight (European Comission, 2020); (4) performing of innovative initiatives that showcase the positive consequences of digitalization within the port. Some examples of this are the connection and automatization of transport vehicles and cranes or smart grids and improvements in vessel routing to decrease the time that ships are at port allowing for more efficient logistic chains and multimodal nodes of freight and passenger transport (European Comission, 2020). (5) delivery and optimization of new techniques and mechanisms for passenger and freight flows that provide a better port access and reduce the traffic from and to the city allowing for a more sustainable port-city relation (European Comission, 2020); (6) development and promotion of original multi-actor agreements on port governance that meet the different interest of the stakeholders, shipping companies, workers, vessel owners and cities that surround them to meet different objectives like production and use of renewable energy (European Comission, 2020).

The last initiative that the European Commission proposes is a Master Plan for the upcoming Green Port that serves as a roadmap in which the different objectives that the port needs to achieve are portrayed in it. This Master Plan would work as a conjunction of the measures previously mentioned and should include in all cases: the broader socio-economic perspective covering the different sustainable and social aspects relevant with the creation of a Green Port and its integration with the city and the hinterland. Also, the different ideas to tackle GHG emissions and the plans to improve biodiversity and protection of the fauna in the surrounding area. An analysis of the different alternatives to provide onshore supply power through smart grids and other climate efficient ideas. The Plan should also assess whether to transitions towards Liquid Natural Gas or other alternative fuels to facilitate the avoidance of carbon fuels (European Comission, 2020). This Plan should also include different collaboration working groups in which the different stakeholders could provide their insight creating a pathway for the deployment of innovative solutions across European ports. Lastly, the EC proposes a report and a handbook in which other ports could compare themselves. The use of Port Community Systems is something that could boost sustainability among the ports creating pathways for the industry to become GHG neutral and could provide insight in how successful these initiatives are in the different ports of Europe varying from size and use. The idea behind this to provide also scalable solutions to ports that could be gradually deployed in other ports once their viability and success are proved (European Comission, 2020).

The ideas explained on this Green Deal section will be put together with the indicators that the WPSP provides to put together a coherent roadmap for ports to follow as they aim to become sustainable infrastructures towards a greener future.

3. PROCESS FOR MORE SUSTAINABLE PORTS

Academic research finds that ports are lacking to embrace digitalization to become Smart Ports, network cooperation systems that allow for the formation of Port Community Systems and sustainability reporting initiatives

- The first trend I want to explain are digital technologies. These tools have supported the development of new business models in ports and in their relation to the cities

they are surrounded by. Digitalization has also revamped cargo-handling and data handling systems. Digitalization can both assist speeding up of the trans-shipment of goods from vessels to the hinterland and decrease inefficiencies in port operation while protecting the well-being of local communities and the environment (Acciaro, Renken, & El Khadiri, Technological Change and Logistics Development in European Ports, 2020). Digitalization of ports leads to the concept of smart port, which allow the port to gather information from different sensors and then later apply it to plan ahead and better. This smart port structure affects communication systems, ship traffic services, and intelligent transport systems. Smart Ports systems need to be blended within the traditional systems of ports. Digitalization can extend and sustain the relationship among port and cities surrounding them incentivizing local and regional development of the area by offering new jobs or energy sources. With the upcoming fourth industrial revolution or era of automation ports are on their way to become "ports 4.0" which would make them adopt and embrace the different technologies of the internet of things (Acciaro, Renken, & El Khadiri, 2020). These advancements would implement a boost in automation and monitoring of the port management in all its aspects. Digitalization is a one of the main drivers of strategic planning. A more digitalized port can plan ahead improving its competitiveness while it can help avoid social tensions and also predict behaviors of the nature and humans that foster the wellbeing of workers, citizens around the port and biodiversity

- Another major change is a comprehensive framework to assess the performance in sustainability indicators in seaports. As Port Authorities have increasingly reported their efforts on sustainable development their efforts have mainly been directed at environmental issues and as the port as an individual not in a collective way with the rest of the actors involved (Fobbe, Lozano, & Carpenter, 2020). As for sustainability reporting, the best tool available is the Global Reporting Initiative (GRI) which comprises 400 different port sustainability related indicators that are later compared with GRI guidelines. The indicators of the GRI had been organized to create one tool that is incredibly helpful in developing "Holistic Assessment of Sustainability in Seaports" (HASPS) framework. This framework covers the different dimensions of port sustainability while it links issues with the port systems

dimensions. This assessment technique will enable ports and Port Authorities to interconnect all port operation management and conduct comprehensive changes (Fobbe, Lozano, & Carpenter, 2020). The HASPS is applicable to all kinds of seaports and allows them to grade their performance and compare it to other ports

- The development of a Port Community System (PCS) network is one of the main pending tasks of the maritime industry. PCS allows for a better communication and a simpler administration for cooperation and data exchange across the port value chain. As key players of this supply chain, ports connect with the different stakeholders and the exchange of information can only be done if the systems are integrated by the majority of them (Mayanti, Kantola, Natali, & Kytola, 2020). The limited use or even lack of PCS and its use has some undesired consequences. If a port relies on more conventional systems of information exchange it can evolve in mistakes provoked by different manual entries, missing documents or absence of real time information. Thus, a dynamic system that harmonizes across the different players of the maritime network could provide certainty reducing the administrative burden. PCS, which are digital open platforms improve communication among the different parties of the port community. PCS are a technology that needs to be developed and installed within port communities to enhance their performance. Once a port has installed a PCS system there are three stages to be looked at: pre-PCS network, PCS network emergence, and PCS network expansion (Mayanti, Kantola, Natali, & Kytola, 2020). Installing and implementing PCS is a progressive process which needs the cooperation and recognition of the different actors involved in port operations to use this technology. PCS are described as one of the main tools to stimulate port transition to sustainability.

PART III – VARIABLES TO ANALYZE TRANSITION TO SUSTAINABILITY IN PORTS

1. RESILIENT INFRASTRUCTURE:

It is understood as "*the aims at anticipating, both physically and digitally, demands of maritime transport and landside logistics, at being resilient to changes in climate and weather conditions whilst at the same time developing in harmony with local communities, nature and heritage*" (World Port Sustainability Program, 2020). This variable focuses on two kinds of initiatives done by ports. A first one that comprises the majority of initiatives in which digital and data exchange solutions are applied to the port operations and processes to optimize them. And a second one which covers the initiatives towards the adaptation of the port infrastructure to the climate change challenges that ports face such as rising sea levels, or extreme variation of weather.

Digitalization can improve the efficiency of port processes and operations assisting them to transform into more environmental, sustainable and economically efficient infrastructures while managing the increase of traffic that is expected as global trade increases. Moreover, it also facilitates trade by removing unnecessary administrative processes and simplifying data exchange. The COVID-19 crisis has painfully demonstrated the heterogeneous landscape that currently exists across ports worldwide when it comes to digitalization. While some port communities seized the opportunities of the fourth industrial revolution and developed into full-fledged 'smart' ports, many others have barely grasped the essentials of digitalization and continue to struggle with larger reliance on personal interaction and paper-based transactions as the norms for shipboard, ship-to-shore interface and shore-to-hinterland based exchanges.

- ChainPORT: The best embodiment of this digitalization is ChainPORT, a global initiative where members share their experiences and knowledge to codevelop initiatives and highlight common topics of interest. The idea is to apply technology in the most effective way to secure long term investments (PierNext, 2018). Initiatives like this have made the International Port Community Systems Association launch the Port Community Systems (PCS) initiative, summarized as a

"*neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders in order to improve the competitive position of the sea and air ports' communities. PCS optimizes, manages and automates port and logistics processes through a single submission of data and connecting transport and logistics chains"* (International Port Community Systems Association, 2021)

The main advantages of this platform are a higher efficiency in port automatization that translates in a contribution to sustainable transport logistics

As for climate proof infrastructure, it is vital for ports to adapt to the climate change reality. These constructions are subject to different challenges such as more frequent extreme weather conditions and rising sea levels. The most important initiative to counterattack with these drawbacks is the "Navigating a Changing Climate" (NaCC) launched by the World Association for Waterborne Transport Infrastructure (PIANC) (UN Enviroment Programme, 2021). The members committed themselves to develop an inland and maritime navigation facilities that face climate change. It is important in this sense the encouragement given to reduce operational greenhouse emissions and preparedness for a changing climate. One of the main problems that this initiative has encountered is the lack of data on the consequences of inaction. To address this, they launched a global survey in 2019 to which 53 ports worldwide responded (25 in Europe, 13 in America, 8 in Asia and 7 in Oceania) where they answered to extreme weather and oceanographic events experienced by the ports focusing on the cost and consequences of damage, clean-up, maintenance and downtime and delays costs. Some of the report results are shown in Figure 3 in the Appendix (World Port Sustainability Program, 2020) where we can see the reported effects. Other key information to extract from it is that 41% of respondents considered that the events were unprecedented and that this type of event is happening more frequently. The most worrying part of this survey is the fact that only 15% of the respondents had an extreme weather assessment, contingency plan and warning system in place and 25% of them don't have any kind of procedure (World Port Sustainability Program, 2020).

Thankfully, in the beginning of 2020 PIANC published the "Climate Change Adaptation Planning for Ports and Inland Waterways" guide. This guide, among other

content, contains a four-step plan to help ports resilience and the process towards an effective adaptation (PIANC (World Association for Waterborne Transport Infrastructure), 2020).

Step 1: improves the knowhow on how assets, operations and systems could be affected and who should be in charge of identifying effective climate change requirements.

Step 2: Research for the necessary information to prepare a strategy against climate change effects. Moreover, it relates to how previous climate change situations can assists in the planification of future changes

Step 3: developing an assessment and a risk analysis to understand the vulnerability of the port infrastructure, systems and operations.

Stage 4: create a Portfolio of potential measures to be undertaken by the port authorities to effectively adapt against climate change. This last stage is especially interesting because it is related to the Green Deal portfolio that the European Commission has proposed with the Master Plan (PIANC (World Association for Waterborne Transport Infrastructure), 2020).

With the analysis of this section, I plan to analyze further how my port case studies have or have not undertaken any initiatives towards digitalization in the port system or improve the infrastructure to effectively adapt to climate change. Also, what measures could be implemented to transform today's ports into Green Ports

2. CLIMATE AND ENERGY

The main focus of this section is how can ports and similar infrastructure comply to the Paris Agreement that they have subscribed in a majority of cases. The goal to keep the average world temperature under a 2ºC increase from preindustrial levels is what drives the aim of this section (United Nations, 2015). Ports can develop tools and initiatives to tackle the GHG emissions from shipping port and landslide operation in addition to improving energy efficiency, transition and stimulate the circular economy. The latter one is where there's little to no innovation or projects, so it needs to be taken more into account.

As the previous one, this section is also divided in two major areas. The first one is not so much related to ports as it is to ships because it addressed the GHG reduction from ships with initiatives related to onshore power supply, best-performing vessels and infrastructures to supply low carbon fuels. As for an international reference to this challenge, the International Maritime Organization and its initial Strategy on GHG emission expect to cut emissions by half in 2015 compared to 2008 levels.

The second one is improving energy efficiency of operation in the port area. To achieve this there's disrupting processes and technology which focus on production and implementation of renewable energy. Also, as I mentioned previously, there's little initiative towards projects addressing circular economy.

1. Some global initiatives that have set recent examples on reducing the GHG emissions from ships are:

   - The IMO GHG strategy and the Ports Resolution**:** During 2018 IMO's Marine Environment Protection Committee (MEPC) adopted an Initial Strategy on the reduction of GHG emissions from ships, with the goal of reducing them at 50% by 2050 compared to 2008 levels. Later that year a follow up program was approved to create a planning tool with different measures to meet these timelines (Serra & Francello, 2020). In May 2019, the Marine Environment Protection Committee adopted Resolution MEPC.323 inviting Member States to support voluntary cooperation among the port and the shipping sectors to reduce GHG emissions from ships. Some of the provisions of this Resolution include onshore power supply from renewable energies, promotion of low-carbon and zero-carbon fuels and shipping (Marine Enviroment Protection Committee, 2019).

   - Global Maritime Energy Efficiency Partnerships (GloMEEP): This project is executed by a Project Coordination Unit within the Environmental Division of IMO. They describe their aim as "s*upporting the uptake and implementation of energy efficiency measures for shipping, thereby reducing greenhouse gas emissions from shipping*." It is a collaboration project of GEF-UNDP-IMO.

Toolkits to measure and understand the emissions of both ports and ships have been developed in the framework of this program (GloMEEP, 2021).

- Port Call Optimization and Just-In-Time arrival of vessels Port call optimization aims to reduce GHG emissions from shipping, next to producing efficiency and safety gains. The International Harbor Masters Association (IHMA) and IAPH foster the work of the International Taskforce on Port Call Optimization, which the objective of improving the quality and availability of master and event data which will deliver benefits to ports, shipping lines, terminals, service providers and society. The goal is reaching lower costs, cleaner environment, more reliability and safety for shipping, terminals and ports (International Maritime Organization (IMO), 2020). This Taskforce has provided its insight to the Support Low Carbon Shipping initiative, a public-private partnership, whose objective is bringing together maritime industry leaders to develop energy-efficient and low-carbon maritime transport system (International Maritime Organization (IMO), 2020).

- Incentive schemes - Environmental Ship Index (ESI): Established in 2011, the ESI works by giving incentives to best performing ships. This way ports can contribute to climate action. ESI awards the vessels which reduce their GHG emissions lower than the IMO standards. It works purely on a voluntary basis and the awards comprise discounts on port dues, bonuses or other benefits. Over half of the world containers ships are part of the Index and throughout time it has proved its success among ports and vessels (Paris Prcoess on Mobility and Climate (PPMC), 2021).

- Clean Marine Fuels: The IAPH Clean Marine Fuels (CMF) Working Group objective is to assist ports to establish a safe and efficient bunker operation as they transition to clean marine fuels. The aim is to support the transition of the shipping industry towards decarbonization and improve air quality. The CMF initiative goal is to tackle together climate change and improve air quality by focusing on safe bunker operations for new fuels, which can contribute to both objectives. Through an open, data-sharing information platform, the Working Group is building a knowledge base that will enable ports to supply and transfer clean marine fuels to ships (World Port Sustainability Program, 2021).

- Onshore Power Supply The plan of the Onshore Power Supply (OPS) if for ships at berth to connect to the grid and turn-off their engines. Back in 2009 IPAH identified this as an effective solution to reduce air pollution in ports and overall GHG emissions from vessels creating a Working Group that developed a website with all relevant technical and operational information to promote OPS installations in ports. As of today, 66 ports worldwide provide high voltage OPS with an increasing number of ports implementing it (European Alternative Fuels Observatory, 2019).

- Getting to Zero Coalition: An alliance of more than 100 companies from the maritime, energy, infrastructure and finance industries, joined by governments and international NGOs, including IAPH. Launched in September 2019 during the UN Climate Action Summit it is committed to getting viable commercially deep sea zero-emission vessels powered by zero- emission fuels into operation by 2030. The idea is that starting in 2030 the number of these vessels will increase exponentially reaching the full decarbonization goal (Global Maritime Forum, Friends of Ocean Action, World Economic Forum, 2019).

- World Ports Climate Action Program (WPCAP): international initiative by leading ports around the world committed to cooperate in taking climate action focusing on five major areas: (1) efficiency of supply chains, (2) common and ambitious policy, (3) power-to-ship solutions, (4) low carbon fuels and (5) decarbonization of cargo handling (WPSP, 2021).

- UNCTAD's Review of Maritime Transport: The United Nations Conference for Trade And Development (UNCTAD), in its 2020 "Review of Maritime Transport", approaches the sustainability of the industry is seen as a one of the major priorities. However, it is stressed that with the current initiatives is not enough to reach the IMO standards of cutting 50% of emissions compared to 2008 levels. It realizes the advantages that have been carried out such as the IMO 2020 Sulphur limit, reduction of pollution from plastics and microplastics, alternative marine fuels, … (United Nations Conference for Trade and Development (UNCTAD), 2020)

3. COMMUNITY OUTREACH AND PORT CITY DIALOGUE

This section aims to understand, develop an improve the relation between the port and the local communities. One of the main quests for port sustainability is addressing the social and environmental impact that these infrastructures have in the populations around. Sustainable port developments need the involvement of the port community from the start until its completion. Moreover, port communities can engage urban investors by promoting new projects that are reciprocally beneficial and make the port more sustainable and the city more attractive and resilient. In this section I will analyze the initiatives addressing the environmental impact of ports and those focusing on the social impact of ports. Here the main focus areas are the ones the initiatives that: (I) address environmental externalities such as pollution, noise, waste, etc.; (II) address the demands and needs of society such as education, green spaces, etc.; (III) protect the ecosystem and promote the recovery of biodiversity and (IV) Target the sustainable port management, planning and development (World Port Sustainability Program, 2020).

1. As for those targeting environmental, they try to focus on air quality which is a worldwide priority for ports. This area is closely related to some of the initiatives mentioned previously that tackle the GHG emissions by ships

- IAPH Cruise Project: This project launched in October 2019 is aimed towards the performance of cruise vessels. Despite the economic and social benefits that this industry provides with, their environmental impact measured in the noise and air emissions in ports is increasingly worrying. Even though these vessels applied the IMO Regulations and Guidelines to reduce the air emissions local authorities are restricting the entrance of these ships into ports (WPSP, 2021).

- NEPTUNES project: NEPTUNES stands as the acronym for Noise Exploration Program To Understand Noise Emitted by Seagoing ships. The consequences and complaints from the noise provoked by vessels have make it an environmental issue. Thus, investigating and reducing it is the aim of this project that is focused on the

causes and characteristic of noise and how to mitigate it. For now, they have created a universal noise measurement protocol that allows to classify and compare vessels based on their noise. Also, they have created a Best Practice Guide with different measures to control the noise from vessels at port (Noise Exploration Program To Understand Noise Emitted by Seagoing ships (NEPTUNES), 2021).

- EcoPorts: this European initiative was launched in 1997 and later integrated in the European Sea Ports Organization (ESPO) IN 2011. The target of it is to raise awareness on environmental protection by sharing information and knowledge among ports leading to and improved environmental management. With its two tools (the Self Diagnosis Methodology (SDM) and the Port Environmental Review System (PERS)) they provide ports with the means to self-evaluate their environmental management while comparing their performance against the sector average. Furthermore, the PERS is the only port sector-specific environmental management standard and it is independently certified. Around 136 ports worldwide are members of the EcoPorts network with 106 of them within Europe (EcoPorts, 2021).

2. For the societal integration of ports, the main focus of the initiatives is improving the relationship between the port and the city helping them become port-cities instead of port/city. These initiatives focus on collaboration in projects to strengthen their relationship

- AIVP Agenda 2030: in 2018 the International Association of Cities and Ports (AIVP) initiated the Agenda 2030 influenced by the UN 2030 Sustainability Agenda. The AIVP target is to adapt the SDGs of the UN to port-city relationships. Since port cities are some of the most affected areas by climate change, they are the ideal place to test innovative solution to see the outcome of transitions in energy consumption, mobility or cultural development. The main goals are set in Figure 4 in the Appendix with every goal of the agenda matching different SDGs (AIVP, 2018).

- ESPO Award on Societal Integration: launched in 2009, it awards every year a port that has developed an important aspect of societal integration contributing to smooth the port-city relations by way of pioneering projects. Every year the specific aspect of societal integration changes and since it was created there has been these different categories: creative strategies to communicate the port to the wider public, youth, heritage, innovative environmental projects, relationship with schools and universities, nature in ports, the arts and cultural involvement of the port and ports as a good working environment for everyone and transparency and the role of social media in reaching out to the local communities and this year edition "*Role of ports in the recovery of the city and the local community*" (ESPO Award 2021 On Social Integration Of Ports, 2021)

4. SAFETY AND SECURITY

This indicator contains a mixture of the regulations and responsibilities that exist when providing safety to the vessels and shipping operations within the port. It has gained a rising importance as the threat of global terrorism, cross-border criminality and the rise of digitalization and cyber criminality have taken these measures to a whole new level. The main focus areas of this indicator are: (I) health and safety emergency readiness and response; (II) port area security, and (III) cybersecurity (World Port Sustainability Program, 2020).

Within this framework there are different global initiatives that tackle these issues and as the previous sections will be explained further.

- Liquid Natural Gas (LNG) Bunker Supplier Accreditation Model and bunkering checklists: developed by the Clean Marine Fuels (CMF) Working Group of the IAPH it consists of a model for ports creating their accreditation systems. This model aspires to establish safe operations and LNG bunker suppliers attractive by making them comply with the established criteria in order to get a license for it. The CMF has created a checklist of LNG bunkering scenarios which mirror the additional necessities of ports with respect to LNG bunkering tasks in or near their port area. Using this tool facilitates an undeniable degree of value and duty of the

LNG shelter administrators. Furthermore, executing them in ports benefits vessels (and their team) while bunkering LNG in different ports as it lessens potential turmoil brought about by conforming to various standards and guidelines in various ports. The CMF Working Group has created three bunkering checklists to implement in ports: Truck-to-Ship, Ship-to-Ship and Bunker Station-to-Ship. The WG aims to use this tools and knowledge with all other alternative fuels that the maritime industry will use in its path to zero carbon.

Cybersecurity: It is a major issue in ports, but it is a sensitive issue for the port community, so it is mostly left untouched. However, such an important aspect of ports needs to be addressed. It is vital because through the ports passes through around 90% of global trade so their cybersecurity is crucial. A great variety of business and government actors interact in port communities to ensure multimodal flows of vital medical and food supplies, critical agricultural products, energy streams and other goods and services reach their intended destinations in time. Their interactions comprise physical interactions, such as cargo handling operations, vessel-related services, and multimodal transfers, as well as exchanges of data that facilitate clearance of cargo between jurisdictions. The pandemic has just shown us the very urgent need for ports to digitalize processes and data exchanges as we move towards a post-COVID19 modus operandi. The COVID-19 crisis did emphasize the critical role of seaports in keeping supply chains moving and economies across the world functioning. As all infrastructures move towards a more digital environment ports are not left behind and increased digitalization of port communities means we need to pay more attention to cyber security risks.

- Port Community Cyber Security Report: In this sense the IAPH, the International Cargo Handling Coordination Association (ICHCA) and the TT Club (the market-leading independent provider of mutual insurance and related risk management services to the international transport and logistics industry) met in London in 2019 to push this issue further. After their meeting they decided to create a "Port Community Cyber Security Report" that would serve as a general basis of a wider propaganda campaign. The Report is divided in five different chapters and its main themes are: why is it important; what is missing in port security and suggestions on how to improve cyber resilience; essential building blocks for a cyber resilient port

community; and the current framework of cyber security rules under IMO and the future evolution of them (TT Club, ICHCA, IAPH, 2019).

Handling of the shipping products within the port: Port operations include a huge amount of moving shipping containers and raw materials from one side to the other (ship to truck, truck to port, port to ship…). All these movements cause a safety hazard for the workers carrying out these tasks. In order to establish some general guidelines, there has been the initiative of some Asian ports explained below

- Stowage and safe securing of steel cargo on board ships: Another joint project of ICHCA and the IAPH has been the fostering of a guide for a proper stowage and safe securing of steel cargo on board ships. The purpose is ensuring port workers safety and reinforcing terminal operations. The Port of Singapore-Jurong which is member of both associations has published these guidelines in collaboration with Johor Port, Northport, Westport and Penang Port (World Port Sustainability Program, 2021).

5. GOVERNANCE AND ETHICS

The last criteria in which to analyze ports is governance and ethics. During recent times port authorities have focused on implementing principles of good corporate governance and social responsibility. These principles are very ambitious, and they normally go beyond traditional port responsibilities addressing crucial communities' necessities such as gender and social inclusion and equality, ports contribution to zero carbon future and circular economy or education and health. Moreover, port authorities, regardless of their ownership public or private, have increased their bars in matters of ethics and transparency as well as reporting and sustainability. The main focus areas of this indicator are as follow: (I) Initiatives regarding Corporate Social Responsibility; (II) Sustainability reporting, planning and policy; (III) promoting innovation; (IV) gender equality and inclusion initiatives (World Port Sustainability Program, 2020).

It is a reality that women are a minor part in the maritime industry, since it has been traditionally considered as a man's sector. Thus, the IAPH launched some time ago the Women's Forum to promote gender equality in this industry (IAPH, 2021).

- IAPH Women's Forum Mentoring Program: Since 2012 this initiative has empowered women in the maritime industry. The Forum fosters discussing women's issues in the industry, ways to attract female talent and maintain and develop the one currently employed in the industry. It also has training and education program to help women compete for all kinds of positions. Furthermore, the Forum has developed a Mentoring Project where man and woman in more senior positions connect with women in lower positions for one year. The aim of this program is to increase women presence in roles that are usually taken by men like autonomous vessel operation or smart shipping technology platform (IAPH, 2021).

Sustainability reporting: there's different initiatives that have focused on this area. Some of them have a broad focus analyzing general industry transitions and others have a focus on the maritime sector. The benefits of sustainability reporting is generally consider the increasing transparency towards the port stakeholder which are normally port authorities and public companies. However, the benefits are also extended to the users, customers and local community. Moreover, there is also a reputation, corporate culture and risk management increase. As for the barriers the main one is the lack of resources. Sustainable reporting requires a budget for time, data analytics and management, analysis and financing the initiatives. Other barriers expressed were the data availability, the difficulty to select relevant indicators and the limited participation of some port users (Global Reporting Initiative, 2021). The main one is:

- Survey of the Vrije Universiteit Brussel (VUB): Promoted by the IAPH and launched in 2019, this survey collected insights about ports actions towards sustainable reporting identifying the barriers and benefits of it. The principal objective is to promote sustainable transitions by reporting about it. Even though European ports dominated the sample (59 out of a total of 97) some interesting conclusions could be drawn. For example, the study showed how mor than 1/3 of ports report on sustainability but 25% of them do not report at all on sustainability.

The researchers of this survey published afterwards a PHD report paper in which they analyzed the inland port of Brussels. Despite it being an inland port, they highlighted the importance that stakeholders have in managing the transition to sustainability of these infrastructures (Geerts, Dooms, & Stas, 2021).

- Global Survey on Port Governance: since 2019 this global survey aims to analyze today's global port governance functions and structures laying out the basis for future discussions on port governance models. The research is focused around different categories, namely, port policy responsibilities, regulatory responsibilities, technical management of the port area, market and port regulation, management of concession agreements, and management of trends in the maritime and port sector. To do this survey they asked port professionals, users and stakeholders to provide their insights on the situation of port governance and to whom should assume the responsibilities of these tasks. The goals are provided Figure 5 in the Appendix (World Port Sustainability Program, 2020) as we can see, the main goals are to facilitate trade and business with the maximization of the added value as the second one. The participants also provided their insight into the existing port governance models with a majority defending a primary role in representation of ports in the international context and adopting international legislation related to port by the national port authorities and carrying out strategic studies in the area by local/regional port authorities.

- UNCTAD Train for Trade Port Management Program: launched in 2013, it has been implementing networks all around the globe and activities covering over 60 countries since 1996. This program has developed a performance scorecard to keep track of the achievements of the members allowing them to keep a position and compare themselves to the others. This scorecard basis are 26 variables grouped in six different categories: finance, human resources, gender, vessel operations, cargo operations and environment (UNCTAD, 2021).

- Maritime Anti-Corruption network (MACN): consolidated business network with the aim of a maritime industry free of corruption. Founded in 2011 it is today an organization with over a hundred members from around the world, it is today one

of the main examples to tackle corruption. To this day, the MACN has done over 28,000 reports and in partnership with the Danish Foreign Affairs Ministry is on the process of launching the Global Port Integrity Index. The objective of this Index is to provide an overview of illicit demands in ports in a global scale (MACN, 2021).

One aspect that is difficult to classify is the impact that COVID-19 has done to the industry. It is mentioned everywhere as a persistent challenge that has affected the world and this industry as well. It has set in motion new trends that will reshape the maritime industry future. The pandemic has increased ongoing challenges such as shifts in supply-demand chain de sign, has affected the way in which the world is globalized (UNCTAD, 2020).

The United Nations Conference for Trade And Development (UNCTAD), in its 2020 "Review of Maritime Transport", approaches also the Post Pandemic world situation with six different policy actions that need to be taken in: (I)support trade so it can sustain growth and development. (II) helping reshape globalizations for sustainability and resilience, (III) promote greater technology uptake and digitalization, (IV) harness data for monitoring and policy responses, (V) Enable agile and resilient maritime transport systems, and (VI) Maintain the momentum on sustainability, climate-change adaptation and resiliencebuilding (UNCTAD, 2020).

PART IV – CASE STUDIES

As I have thoroughly explained the different indicators providing examples of global initiatives that are reshaping the port model into a sustainable one. Explaining each indicator with some examples allows me now to see whether the European ports under analysis are currently performing or underperforming according to sustainability criteria. I now begin to analyze three different ports of Europe: the ones of Barcelona, Hamburg, Rotterdam and Le Havre. I have chosen these ports for three different reasons. The first one, their geographical variety, I have chosen a German, a Spanish and a Dutch port so I can do an analysis of the different situations comparing the approaches that these countries and the Port Authorities within these ports are taking towards a sustainable future. The second reason is their incredible importance: the ports I have chosen are all among the ten biggest of Europe with Rotterdam and Hamburg being among the three first places respectively (Notteboom, 2021). The third reason I have chosen these ports is for the variety of their operations, they are all major shipping ports but some of them also host a booming cruise industry or are focused on raw materials transportation (Shipa Freight , 2021).

The way in which these four ports are governed is under Port Authorities (PA). There have been different initiatives trying to classify the different kind of governance in ports. In the one I classify these four ports are under the landlord system (Fernández-Izquierdo, Ferrero-Ferrero, & Muñoz-Torres, 2020). The landlord port is the governance model more extended throughout Europe. It consists of a dual model in which there's public infrastructure and land and private ownership of the supraestructure and the port operations management namely big shipping companies like Maersk. The Port Authority, a public entity, owns the land and the infrastructure to lease them afterwards to the private companies via administrative concessions (Fernández-Izquierdo, Ferrero-Ferrero, & Muñoz-Torres, 2020). In the last twenty to thirty years with the globalization and scaling up of the maritime industry, PAs suffered the pressure of becoming economically self-sufficient while seeking to be more environmentally friendly and socially responsible. The PAs business model is based on making profit while leasing land and charging fees to the incoming vessels (Berghe & Daamen, 2020). Part of the following study is overseeing what the PAs have been doing and oversee if their governance is increasingly sustainable or not.

With the following analysis I expect to provide an interesting and different approach to how these Port Authorities can improve their sustainable transition and what can they learn from each other. The analysis I plan to do is combining the three layers of sustainability I explained on the first section aggregating within them the theory indicators explained on the third part. Consequently, I will first provide a brief historic introduction of European ports assessing how they became the key nodes of transport that they are today. Then I will do the main analysis of describing how environmentally sustainable the port is according to its resilient infrastructure and its climate and energy approaches, how socially sustainable they are according to the port-city dialogue, community outreach, safety and security and governance and ethics results. Lastly, I will provide an analysis of what the different Port Authorities can learn from each other to conduct the necessary reforms to become more sustainable.

1. HISTORIC INTRODUCTION ¿HOW THESE PORTS BECAME WHAT THEY ARE TODAY?

Ports have been key for the development of Europe as a continent and the main tool of expansion of European influence that shaped the current world from the explorations of the 15th century. The Atlantic and in a lesser level the Mediterranean ones became key infrastructures for the control and management of seal lanes that linked the colonies to its metropolis. The development of these ports shaped the evolution of the power relations in Atlantic Europe. First it was the Portuguese and Spanish ports that became dominant. Later in the 19th century it was the English ports the ones that asserted dominance. Nonetheless, from the 1900s the most powerful port range was localized between France and Germany with their ports of Le Havre and Hamburg (Marnot, 2020).

Europe's major ports supported and shaped the influence of Europe as the main Western power. The race for becoming a major port also brought major innovations during these years from the caravel to the ocean liners and the motorized ships from the industrial revolution. These technical advances changed the history of ports and of the world as it was known. It brought the diversification of maritime routes and the establishment between the metropolis and the colonies or the countries where global trade happened. Furthermore, civil engineers from Europe transferred their expertise in ports in other parts of the world. For example, Antoine Waldorp, a famous Dutch engineer, after taking part in the

construction of the Amsterdam port was part as well of the creation of the port of Batavia (Jakarta) and in the improvement of the port of La Plata (Argentina) (Miller, 2012). Or the establishment of the British ports in Singapore and Hong Kong and the Portuguese port of Macao. The 19th century was the period of time where European ports became more influential. They became the gates of the world most powerful countries that led to the heart of the world economy. Between 1850 and 1914 ports where the head of the driving force of globalization that took place during this time. Not only products were shipped from Europe, with manufactured products also left all kinds of people from missionaries to soldiers, explorers, merchants, politicians… Around 35 million people departed from European ports. The increase in merchant shipping and passenger transport translated in increasingly bigger and more modern ports over the 19th to the 21st centuries (Polonia, 2010).

In the 19th century London was the biggest European port whose only rivals where other British ports such as Liverpool. In continental Europe Le Havre had been the main gateway but starting in the 1860s until the 1890s the port of Antwerp became the heart of trade with its strategic connection by train with the German lands and their low tariff policy. Rotterdam opened in 1875 a new channel which allowed it to become the port with the best chartering market. With the industrial push of Germany Hamburg and Bremen became increasingly important. In fact, before World War I the port of Hamburg had the biggest traffic volume in Europe. During the rest of the 20th century all these ports constructed port-industrial zones building Petro-chemical installations within the ports. With these innovations the European ports aforementioned stayed as the busiest world ports with Rotterdam as the leader up until the 21st century when the rise of the Chinese economy took the supremacy to South-East Asia (Marnot, 2020).

As of today, we have the following main characteristics of each of the ports analyzed:

1. Port of Barcelona: located in Spain, it is the biggest Mediterranean port in cruise ships traffic and the fourth in the world after the Caribbean ports and the ninth of Europe biggest container ports. It is commanded by the Barcelona Port Authority and owned by "Puertos del Estado". Its strategic location at the beginning of the Mediterranean makes it the base of the main cruise companies but it also has a huge traffic of liquid

and dry bulk as well as its own energetic dock. These three activities are easily identified in the three zones that the port is divided: Port Vell (the touristic and passenger port), the commercial/industrial port and the logistics port. It is connected with road and railway access to the rest of Spain and Europe (Autoridad Portuaria de Barcelona, 2020)

2. Port of Hamburg: located in Germany it is the third biggest container port in Europe and the largest German port. It is commanded by the Hamburg Port Authority. The sea and hinterland transports are closely linked in this infrastructure. At the heart of central Europe, the port of Hamburg is Europe's largest railway port with a 50,7% of the cargo moved through railways ahead of road and inland waterway transports. The port's dominant segment is container handling, but it also moves great quantities of bulk cargo and is one of the main cruise ports of the Atlantic sea (Hafen Hamburg Marketing e.V., 2021).

3. Port of Rotterdam: located in the Netherlands, it is the largest container port of Europe and the largest seaport of the world outside of Asia. Until 2004 it was the busiest port in the world then lost to the Asian competence. The port of Rotterdam has five port concessions that are operated separately by different companies under the command of the Port of Rotterdam Authority. Its leading position can be explained through its easy accessibility for sea-going vessels. Moreover, as Antwerp and Hamburg its strategic position in the heart of Europe makes it the main gateway to Europe and one of the main global logistics hubs. The port biggest throughput is liquid bulk followed by containers and dry bulk. However, due to its massive size it is the largest container port in Europe and even the largest vessels can enter the port. Furthermore, the total length of the port is 42km long and its infrastructure consists of the elements digital, road traffic and nautical (Port of Rotterdam, 2021).

2. PORT OF BARCELONA

The port of Barcelona stands as the major cruise port in the Mediterranean. It also has become a pioneer in installing technological ideas in all the areas of port operations. As I will explain further it has developed major actions seeking environmental sustainability and energy

efficiency with smart grids, renewable energy installations or connecting the docked ships to the onshore power. It has also improved the overall port management with monitoring devices throughout the port area and drones to collect and analyze information which allows this port to plan ahead (Sayol, 2019).

Resilient Infrastructure:

Pollution: the Port of Barcelona has developed a plan against pollution. there is a risk of contamination in the port docks due to the 15.3 million tons of petrochemical products loaded and unloaded. This plan offers a proper response when there are spills (Barcelona Port Authority, 2021). There also exists an air quality network. it involves a constant monitoring of air quality in the whole area of the Port of Barcelona to measure the evolution and impact of port activity on human health. Since its implementation, the levels have been reduced to below the level set by current legislation. The latter is complemented with the environmental monitoring of construction sites that follows a protocol with preventive measures in case that the emissions from the construction exceed the limit (Barcelona Port Authority, 2021).

Digitalization: the platform Samoa. Online platform for integration and access to the data captured by the environmental sensors of the port of Barcelona. also, to the forecasts and results of the meteorological and oceanographic prediction models. these data allow to generate models of waves, wind or sea level that are incorporated to the integral planning of port management.

Energy and climate:

Waste: Floating waste collection from the port area by three different boats specialized in this kind of procedure. There is also an initiative called Marviva which consist of a study of the waste collected by the fisherman from the fishing grounds in the Barcelona shore (Barcelona Port Authority, 2021). In the same line Barcelona is part of the MARPOL Convention of treatment of ships waste which aims to prevent polluting from the vessels and the Port counts with three different MARPOL waste plants (Barcelona Port Authority, 2021).

Energy: the *Gasinera* supposes the installation of the first gas station in the port to supply LNG (Liquefied Natural Gas) and CNG (Compressed Natural Gas) for both trucks and cars (Barcelona Port Authority, 2021). Renewable energy is another pillar of the port strategy to become more sustainable. It has installed in the available space within the port solar panels to promote the generation of renewable energy. This initiative is being complemented by the Smart Grid installed in the Moll de Pescadors which consists of introducing solar panels in the buildings and the dock to store the energy that is not used and distribute it to other consumers in the area

Transport: the Port of Barcelona promotes the rail freight traffic to achieve more sustainably efficient and clean logistic chains with the objective to reduce GHG emissions. The results are slowly showing with an increase from 3 to 13% of rail freight traffic for 10 years (Barcelona Port Authority, 2021). Another project is the RePORT which are hybrid trucks running in diesel and natural gas. It is a commitment by the port of Barcelona to use natural gas as a fuel for road transport. ERDF funds have been used to transform 25 trucks into hybrids (Barcelona Port Authority, 2021). Moreover, the Port of Barcelona is on the process of electrifying the docks. Under the project On-shore Power Supply (OPS) it consists of connecting the ships to the shore power grid once they have docked so that they turn off the auxiliary engines and do not pollute while docked. it is a progressive installation in phases as demand grows (Barcelona Port Authority, 2021). Furthermore, in order to reduce the emissions of the trucks in the port, the short sea shipping initiative has been embraced. Coordinated from the EU the port joins to the initiative Freeways of the Sea (Barcelona Port Authority, 2021). Another initiative is the electrification of the road traffic within the port. In this sense the 80% of the port's car fleet is electrified and there are several charging stations along the port.

Climate: there is a periodically control of the water around the Port. The water is analyzed according to the Water Framework Directive (Barcelona Port Authority, 2021). There is also a network of weather stations and a network of marine sensors to measure both weather and marine conditions to optimize and improve the departure and entry of ships as well as unloading (Barcelona Port Authority, 2021).

Port city-dialogue: Acoustic screen placement of an acoustic screen at the estuary of the Llobregat river to isolate the nesting area of a protected gull from the projected new Llobregat Nou railway terminal of the Port of Barcelona (Barcelona Port Authority, 2021).

Bonus for good environmental practices: the activities that the port considers beneficial may qualify for a 15% or 20% bonus, subject to a series of requirements such as following a guide of practices or committing to environmental investments, among others. The facilities that can benefit are fishing activities, solid or bulk product terminal activities, general cargo terminals or nautical activities, among others (Barcelona Port Authority, 2021).

Safety and security: air quality network. it involves a constant monitoring of air quality in the whole area of the port of Barcelona to measure the evolution and impact of port activity on human health. Since its implementation, the levels have been reduced to below the level set by current legislation (Barcelona Port Authority, 2021).

Economics:

While still presented a positive turnaround, it was a heavy decrease in profits compared to their financial statement from 2019. In the case of Barcelona is important to notice that during 2020 the cruise ships practically disappeared leaving the port without some noticeable profits that other years were decisive for its economic turnout (Salvador, 2020). The Covid-19 pandemic has heavily affected this port and it will take three more years to see if the ongoing investment towards a most sustainable future pays off.

2. PORT OF HAMBURG

The importance of Hamburg as a port is crucial as it is the main German maritime hub for the German exports which comprise the heart of its economy and generates much of the wealth of the surrounding area. It connects to the north Sea through the river Elbe. The port works as a hub with established global trade routes with Asia, America and West Africa (Dohrn, 2005).

Resilient Infrastructure:

Pollution: due to its position in the border of the Elbe river and its location next to urbanized areas the air water and noise pollution are major focuses of its strategy (Acciaro, Renken, & Dirzka, 2020).

The Elbe River deepening has been a polemic issue for its contribution to pollution but is about to be finished to be able to dock the biggest cargo ships in the world.
Port Congestion: as Hamburg is a city state it cannot grow more than the physical limits of its state. The boost of the maritime industry added to the fact that Hamburg is today one of the main cruise cities in the north are affecting negatively its congestion (Acciaro, Renken, & Dirzka, 2020).

Smart Port: the Hamburg case can be divided in two different strategies of Smart Port. In one side we have the Energy, since it is a major consumer of energy the PA of Hamburg is adopting the German transitioning principles to comply with the targets of reducing emissions allowing for a more sustainable future (Acciaro, Renken, & Dirzka, 2020). The other side is the Logistics which with the SmartPort project it pretends to improve the dynamism and efficiency of transport and logistics in the port and in the city seeking to keep the competitiveness of the port (Acciaro, Renken, & Dirzka, 2020). This logistics plan wants to merge the ecological and economic requirements of a green port by optimizing information and enhancing the trade flow at the same time that it reduces the environmental impact making it a more climate friendly port.

Transport: the Hamburg port has a railway hub which is the largest of its kind. This multimodal facility assures efficient freight logistics reducing the impact of road transport. Relating the Hamburg railway with the SmartPort logistics optimizes traffic flow decreasing waiting time which also implies a lesser environmental impact

Energy and climate

Waste: the port conducts different waste management initiatives to decrease the amount of it and try to find it a way into circular economy

Energy: The Hamburg Port Authority has installed the first LNG hybrid raft focusing to supply ships with it to decrease the GHG emissions the system as previously explained allows for cruise ships to turn off their engines and make the air quality better. Without this facility the amount of pollution and noise will be much higher as ships would need to have their engines on with the cost related to that that it implies.

GHG emissions: port activities are not a major source of GHG emissions since these emissions come in their majority from shipping as different studies have proved that half of the port emissions can be attributed to the ship movements alone (Styhre, Le-Griffin, Winnes, Black, & Lee, 2017).

Port city dialogue:

During the 70s and 80s the port underwent a major growth that led to the development of the surrounding areas. However, Hamburg is a city-state such as Washington D.C. so the relocation of the Port operations outside its territory is not feasible (Acciaro, Renken, & Dirzka, 2020). The districts surrounding the port have been remodeled and offer now recreational activities, housing, offices and a cultural hub. The city is planning to develop the waterfront areas and there are many bridges that connect the two sides of the Elbe. One of the pillar of the PA Is to integrate urban structures and logistic operations within the port and the city (Acciaro, Renken, & Dirzka, 2020).

3. PORT OF ROTTERDAM

As the largest petrochemical complex in Europe which makes it the main responsible of 20% of the Dutch GHG emissions reducing this amount is the top priority of this infrastructure. The challenge to do so is huge as it still relies heavily on fossil fuels for the industrial complexes. The corporate social responsibility of this port highlights how the world is still relying on petroleum-based products, but they are aiming to make industries cleaners. The different initiatives and projects of this port are focusing on reducing carbon emissions and attracting new industry to the port that contribute to energy transition and in overall to help it transition towards a more sustainable future (Port of Rotterdam Authority, 2019).

Resilient infrastructure: as safety is one of the top priorities of this port. Rotterdam Port Authority strives to develop a healthy and attractive livable area through the following initiatives:

- Flood risk management: The port of Rotterdam water level is located higher than the New Amsterdam Water Level, so it is a port which is safe from flooding. As the PA has conducted several studies and none of them showed any evident risk (Port of Rotterdam Authority, 2019).
- Transport: the PA has established a discount for clean shipping that allows all ships that meet above the requirements of the Environmental Ship Index can apply for a 20% discount on their port duties (Port of Rotterdam Authority, 2019).
- Biodiversity: the PA has created a nature area that expands over 21 hectares that protects the animal and plant diversity (Port of Rotterdam Authority, 2019).
- Digitalization: with the E-noses project the port has installed many electronic sensors that track the emissions which could be novice or hazardous before they become a threat (Port of Rotterdam Authority, 2019).

Climate and energy: As explained above, the port of Rotterdam is one of the main GHG emitters in Europe. However, it has committed to tackle climate change. The challenge calls for a renewal of the facilities and the introduction of new technologies and industries. The focus of the Port Authority is shaping the energy transition of the Netherlands and contribute to the development of sustainable logistic chains (Port of Rotterdam Authority, 2021).

- Renewable Energy: two different initiatives are taking place. First, installing wind and solar panels in the port area. The solar panels are located floating in one of the docks and the wind power is currently under an expansion that will increase in 50% its capacity. The second one consists on a so called Heat Alliance. It aims to use the ports industrial sector residual heat to power up industry greenhouses and homes by constructing underground pipelines that would direct this heat somewhere else than to lose it in the surface, air or water (Port of Rotterdam Authority, 2019).

- Countering carbon emissions: there are three different projects. First, Carbon capture and storage. This is one of the ways to reduce carbon emissions most efficiently. The idea is to build a pipeline that would allow the por operators to

capture the carbon emissions and storage it in empty gas fields under the North Sea (Port of Rotterdam Authority, 2019). The second one is installing LED lights for public lighting. The aim is to change all the lights with LEDS due to their longer lasting period and less electricity use. Lastly, the PA is committed to decrease its carbon footprint by using hydrogen and electric vehicles or buying hybrid patrol ships (Port of Rotterdam Authority, 2019).

People and employment: the port of Rotterdam is strongly devoted to providing a socially responsible employment despite automation and other technological advances.

Social measures: there are five major ongoing initiatives. First the social agreement that provided a joint sector agreement on employment conditions and job security. Second, the RDM (Research, Design and Manufacturing) Rotterdam located in the port where a mixed group of students, companies and researchers work together to develop a new manufacturing industry. Third, Port Welfare Committee which promotes projects that benefit the seafarers in Rotterdam. Fourth, Future Land that is a major information center widely visited introducing people to the port operations world. Lastly, the StartBaan which helps young unemployed people without qualifications an opportunity to earn a diploma and improve the job market prospects (Port of Rotterdam Authority, 2019).

PART V- CONCLUSIONS

1. My interest in sustainability is the main reason I chose this topic. The maritime industry has always interested me and combining it with sustainability seemed like a great option for my final project of my international relations degree. When I first started, I did not exactly know how to approach such a broad topic and I first had five different ports in mind but due to different reasons such as data available or merge of previous port authorities I ended up with only three major European ports. My hope is that this project can be used by both institutional entities such as Port Authorities, the ones I base my focus on, to be more involved in the port and also to the general population to understand better how a basic infrastructure as ports are work and transition.

2. Historically Europe had been the main engine of innovation and testing for the port industry. Today it finds itself in a great start position to lead the necessary transition towards sustainability. European Ports have the systems and the cooperation needed to lead this revolution, but they need to take part. It is a reality that the more sustainable a port is the more attractive it is to the other maritime industry players such as shipping companies.

3. There are bright lights in the horizon for sustainable ports. The different initiatives that are taking place are already providing great results in terms of protection of biodiversity in the area surrounding the port. Also, port city dialogue is increasingly better with less and less separate entities and more union of both. Energy and climate initiatives are the driving categories of every port.

4. European ports are mainly specializing in transitioning towards renewable energy and digitalization, but they need more investment in these and the other categories. As I highlighted on Part II of my work, and more digitalized port can plan ahead. Here I would like to feature the Samoa platform of the Port of Barcelona. It is my belief that an implementation of similar systems in all ports would reduce time of vessels in the port and enhance the overall management of port operations. At the same time a better reporting system and a network among the shareholders would be major drivers of sustainability.

5. While reporting sustainability ports focus mainly on environmental issues leaving the social aspect of it to an anecdotic level. An increase of social sustainable initiatives and reporting is needed.

6. However, there are two aspects in which ports are not focusing enough on. Circular economy and protection against climate change. Specially the circular economy is something that I find lacking in every way. As a port becomes more sustainable it should adopt some kind of circular economy for the waste it produces and the maritime industry surrounding them. In their sustainability reports ports barely mention that they are protected against flooding but if the sea rises at the projected levels ports are going to suffer major consequences.

7. Port Authorities need to address the changing reality more than they do today. They can no longer be the landowner implementing minor reforms. For ports to fulfill the promises made under the MARPOL agreements a change of scenario is needed. Despite the reality that petroleum relatives still rule the industry the adoption and implementation of new technologies is what would allow for a change of paradigm

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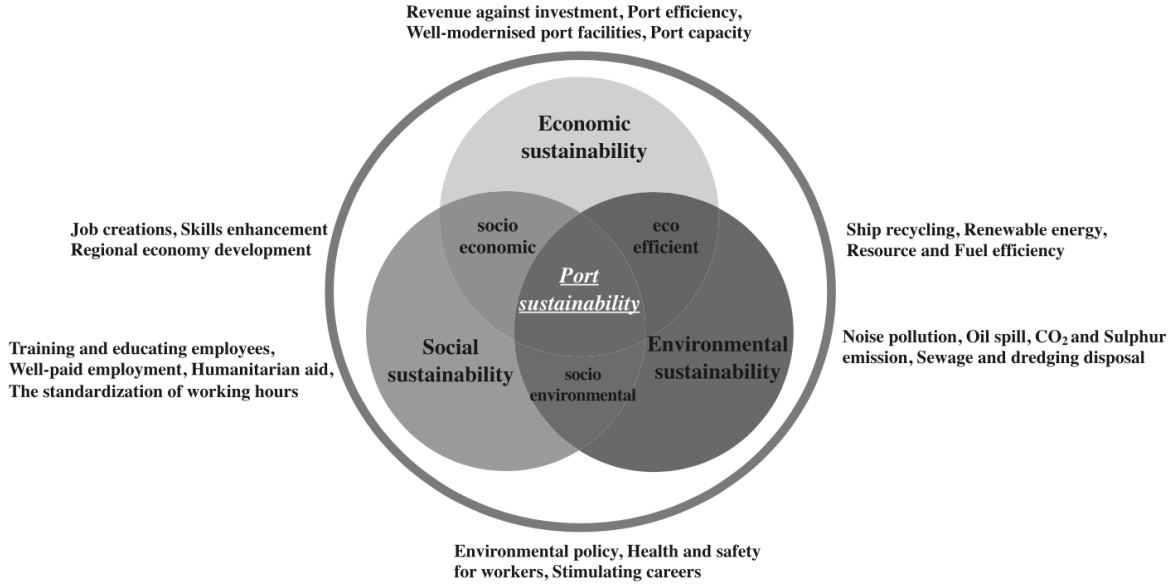
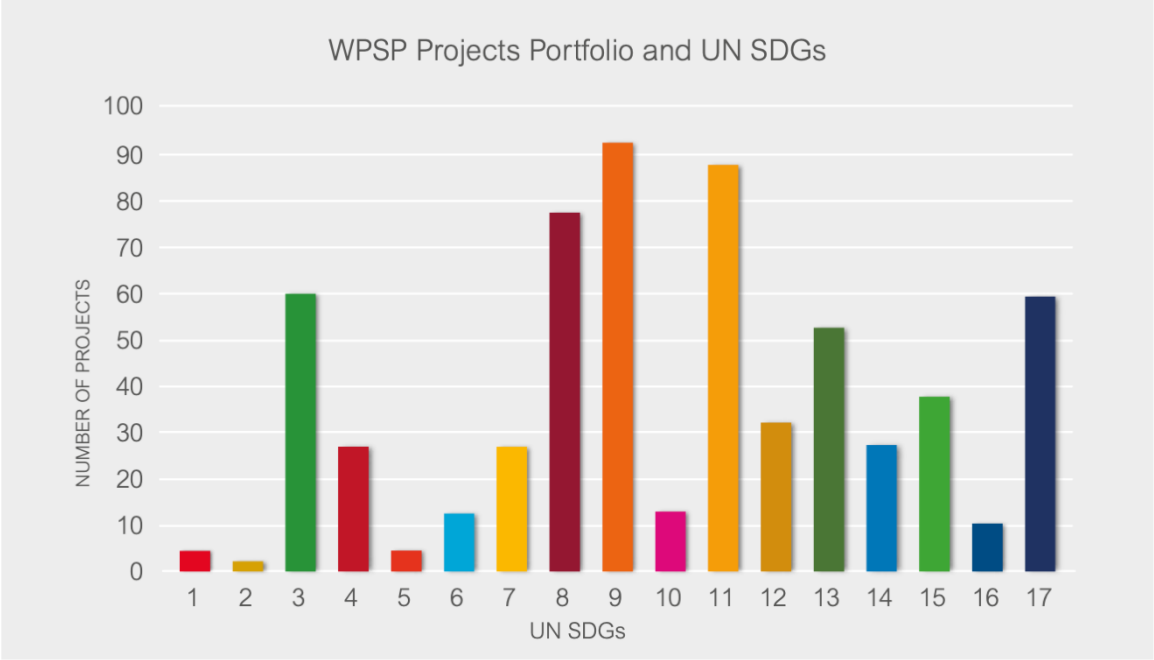
APPENDIX

Figure 1



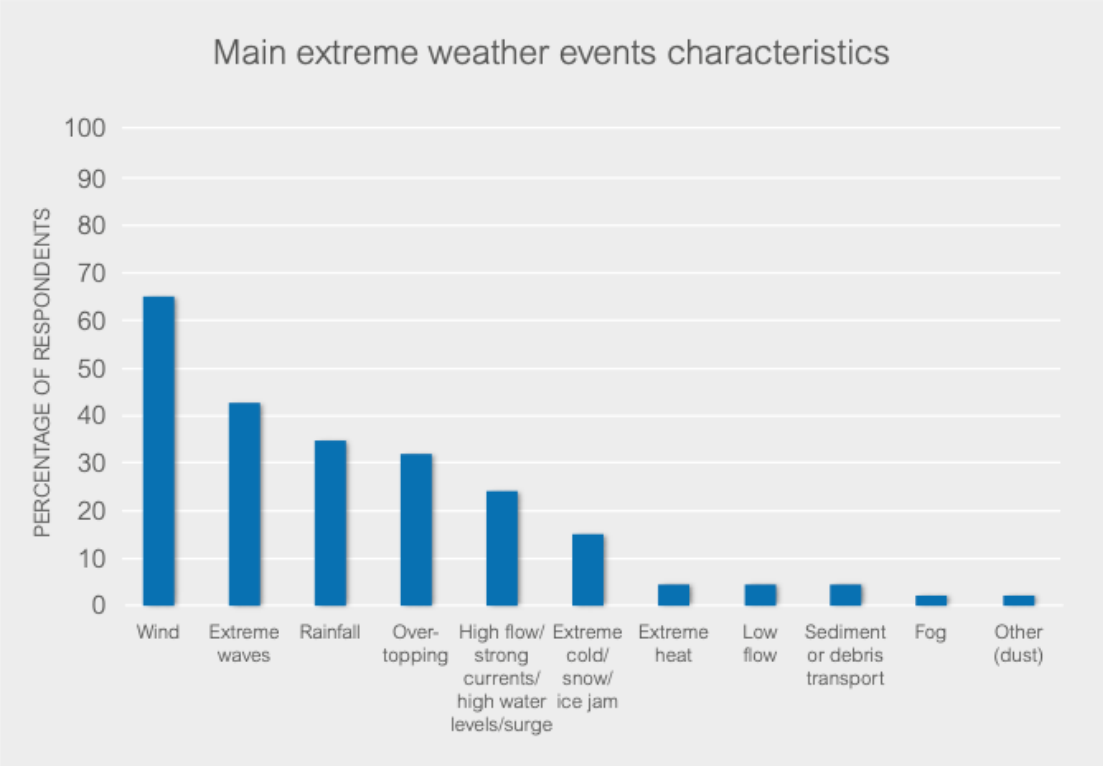
Source: (Lim, Pettit, Abouarghoub, & Beresford, 2019)

Figure 2



Source: (World Port Sustainability Program, 2021)

Figure



Source: (World Port Sustainability Program, 2021)

Figure 4

Source: (World Port Sustainability Program, 2021)

Figure 5

What should be the goals of the port system?

GOAL	%
Facilitate trade and business	87.78%
Maximization of added value to the national economy	71.11%
Social and economic growth of the nearby region	64.44%
Maximization of handled tonnage	31.11%
Maximization of the profits of the companies operating at the port	25.56%
Maximization of the returns to the government (public sector)	25.56%
Other(s)	7.78%

Source: (World Port Sustainability Program, 2021)