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**THE CIRCULAR ECONOMY IN THE SPANISH
PORT INFRASTRUCTURE. A COMPARISON WITH
THE EUROPEAN CONTEXT**

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1. INTRODUCTION

Environment concern is an issue that is increasingly gaining more weight in world politics. This is because of the worrisome figures that are being quoted in terms of climate change. Climate change is the modification of weather and temperatures caused by the increased presence of greenhouse gases. Human activities cause this increase in greenhouse gas emissions such as the use of electricity, fossil fuels, waste generation and industrial processes, among others. This rise in temperatures has economic and social repercussions, affecting the entire population.

Likewise, the generation of polluting waste or the excessive use of materials, all related to the concept of programmed obsolescence, are aspects that have been identified as detrimental to sustainability and environmental care. Programmed obsolescence refers to the programming of the end of the useful life of a product, from the moment of its programming or elaboration, it is designed how long the useful life of the product will last, thought in such a way that, instead of repairing it, it is easier to buy the same product again or a substitute product. This promotes consumerism, resources consumption and the consequent waste of materials and the generation of waste, as well as it promotes the introduction of a linear economy culture in our society.

According to data provided by Green Peace (2018), climate change is the major threat that we as human beings have to face. Although society realizes the need to care for the environment, in a study carried out by the Elcano Institute (2019), 81% of citizens think that Spain is not doing enough to fight climate change. It seems to be a generalized opinion where we have a lot to do in order to improve our actions so they can benefit sustainability and care for the environment.

For this reason, environmental care is an issue that must be increasingly present in the management strategies of industrial sectors. Finding solutions to these issues involves abandoning the use of non-renewable and highly polluting energies, such as oil or coal, and switching to the use of renewable energies as they were principal energy sources. In this line, a new economical paradigm has been developed, in the last years, more and more policies and actions have come up related to the circular economy (CE) (Sauvé et al. 2016; Sariatelly, 2017; Prieto et al. 2017) are being included. The primary goal of the circular economy is to keep resources and materials in circulation, in constant use, while reducing the generation of resources (Schroeder et al. 2018).

As for the field that concerns us in this academic work as we will explain later, the maritime port sector, being a segment of high importance in relation to the world economy, is an important waste-generating and polluting industry. For this reason, more

and more sustainable alternatives have to be sought, such as reducing the use of fossil fuels or controlling waste management adequately. Because of the increasing awareness of environmental care, more and more policies and practices aimed at reducing waste, emissions and other environmentally friendly practices are being implemented within the port sector. For this reason, the aim of this work is to study how circular economy is changing the dynamics of ports and to analyze the degree of implementation of this new paradigm into this important sector.

Although this is a path that has begun, much remains to be done, especially in terms of information and training on the use of sustainable management strategies, as well as by government agencies, to encourage and promote the implementation of circular economy strategies.

In this context and more in detail, the aim of this paper is to make a comparison of the degree of implementation of circular economy strategies in Spanish and European ports. With this objective, using a qualitative methodology, we will propose and compare different key indicators which will give us an idea about how circular economy, is been introduced not only in Spanish port context but also in European port context. In a second stage, we are going to describe in detail the situation of circular economy transition in the 28 Spanish ports trying to find out who's of these infrastructures are doing a real transition towards circular economy

Finally, we will describe in detail the case of the LOOP-Ports project as we think that this kind of initiatives could be an interesting catalyst for circular economy transition. This project suggests a series of indicators that in our opinion could be a very good way to control the circular transition in the port infrastructures.

Doing this, this work is trying to contribute to understand how port sector is doing the green transition as well as how public institutions can help these semi-private infrastructures to shift from linear economic paradigm to circular one.

2. THEORETICAL FRAMEWORK

2.1. What is a Circular Economy? Its impact in the port industry

According to the European Parliament, the circular economy is "a model of production and consumption that involves sharing, renting, reusing, repairing, renewing and recycling existing materials and products as often as possible to create added value". In this way, the life cycle of products is extended. Despite the growing interest in the

concept of circular economy, it is not a recent concept, the interest comes from its increased presence in governments and industry. On the other hand, the circular economy has been shown to be the answer to achieve true sustainable development (Prieto, 2017).

This concept clashes head-on with the linear economic model of "use and throw away", in which the life of products is shorter, which generates a greater expenditure of materials for production and a greater amount of waste. With the circular economy model, waste is reduced as products are reused, extending their life. These strategies are aimed at reducing waste and reducing pollution, an aspect that is increasingly present in world policies. The change towards a circular economy has to be systemic with a long-term persistence, being the logical alternative to the current economic model (Arroyo, 2018).

Another definition of the concept by The Ellen MacArthur Foundation is "a circular economy is a systemic approach to economic development designed to benefit businesses, society, and the environment. In contrast to the 'take-make-waste' linear model, a circular economy is regenerative by design and aims to gradually decouple growth from the consumption of finite resources" (Ellen MacArthur Foundation, 2021).

As for the situation in Europe, the regulations in force are increasingly moving towards integrating the circular economy into their policies, with a view to improving current waste management. According to data from the European database, the European Union produces 2.5 billion tons of waste per year (European Parliament, 2019).

To reduce this figure and create a path towards sustainability, the European Commission presented in March 2020, within the European Green Deal, an Action Plan for the Circular Economy, with the aim of designing more sustainable products, reducing waste, and giving a more active role to citizens, such as "the right to repair" (European Commission, 2020).

In February 2021, the Parliament voted on the Circular Economy Action Plan, with the aim of having a fully circular economy by 2050. The Circular Economy Action Plan aims to adapt the economy to the green future by strengthening competitiveness, protecting the environment and giving consumers new choices and rights. The design of this plan focuses on ensuring that the resources used are kept in the economy of the European Union for as long as possible. The measures established within this plan cover the following points (European Commission, 2020):

- Sustainable products: established legislation that includes policies for more sustainable products in order to make them more durable, easy to repair, reuse

and finally recycle. Obsolescence is minimized, single-use products will be restricted.

- Empower consumers: more information about aspects such as repairability and durability of the product must be available. The aim is to help the consumer to make a decision to opt for sustainable alternatives.
- Focus on those sectors that use more resources for production: in order to regulate the massive use of resources, sustainable strategies will be established to be applied in aspects such as the use of containers and packaging, the use of plastics and textile products, use of construction materials, etc.
- Reducing waste production: the main focus will be on reducing waste and residues and transforming them into secondary resources that can be used and reincorporated into production processes.

According Frans Timmerman, Executive Vice-President for the European Green Deal: “To achieve climate-neutrality by 2050, to preserve our natural environment, and to strengthen our economic competitiveness, requires a fully circular economy. Today, our economy is still mostly linear, with only 12% of secondary materials and resources being brought back into the economy. Many products break down too easily, cannot be reused, repaired or recycled, or are made for single use only. There is a huge potential to be exploited both for businesses and consumers” (European Commission, 2020).

Circular economy aims to optimize the use of materials and waste, extending their useful life. Contrary to the linear disposable system that requires large amounts of resources, this model advocates respect for the environment based on reducing the waste generated and using it as a resource.

In Recycling Economy’s waste management strategy, the *3R*’s model has always been visible in our society: reduce, reuse and recycle. But this model is becoming vague and the concept of the circular economy proposes new solutions to extend the useful life of the products and minimize the waste produced. The circular economy apart from the *3R*’s includes 4 new key elements to take into account, known as *7R*’s (Zulfikar, 2020):

- Redesign: through creativity and innovation, design products that when they reach their useful life can be used again.
- Reduce: consume what we need and not consume excessively. Try to use products that do not produce waste by opting for the use of reusable products.
- Reuse: reuse things for the same purpose or a different one than the one they were created for, thus extending their useful life.

- Repair: make the necessary changes to an object to take full advantage of its useful life.
- Renew: update to maintain and continue providing the function or service for which they were created.
- Recover: collect and classify used materials to re-process them as resources.
- Recycle: reintroduce waste materials into processes so that they serve as raw materials for new products.

The concept of circular economy requires reflection, conscious and critical thinking about the actions that are carried out and how they are executed. The circular economy is a viable, sustainable and unavoidable alternative capable of meeting the challenges of the current economic crisis (Sariatli, 2017). This concept is applied from the beginning, during design, production, consumption and disposal. Processes and products must be designed considering environmental criteria, in such a way that they are functional, practical and respectful with the environment. It implies a cultural change in the conception and understanding of the productive and consumption system as society knows until now.

According to Martínez and Porcelli (2008), although the implementation of the circular economy is the most feasible sustainable measure, it is necessary to make a series of parallel changes that accompany this transition, such as the importance of reducing consumerism, but this requires changes in habits and customs that are deeply rooted and would therefore require years of education, being a long-term plan. It is therefore clear that the circular economy is not only about recycling, it must be present in the very approach of the product, so that it can be reused and generate only waste that can be used.

Regarding the circular economy within the port industry, the Green Deal position papers mentioned that ports are a key point for the European Green Deal to take place. The maritime ports are established in locations that allow a good development of circular economy projects. The presence of port industry close to urban locations allows interactions that leads into transforming waste and residues to products. (Ballini, 2020)

The port industry with the incorporation of circular economy makes possible to close flows of material and energy resources through circulation and synergies between interest groups. Opportunities are introduced to reduce the negative impact of port activities on the environment. The shift towards the circular economy promotes the protection of the companies involved in the industry port regards geopolitical risks and environmental sanctions (World Maritime University, 2020).

According to the European Sea Ports Organisation, around 40% of all goods shipped to and from European ports are energy related (European Sea Ports Organisation). European ports are crucial nodes in Europe's energy supply network. Energy transition is a real game changer for many ports. At the same time, the energy transition agenda offers new business opportunities to many European ports (including production and supply of renewable energy, off-shore renewable energy projects, bio-fuel industry, carbon capture and storage, circular economy). Consequently, many European ports are an essential business partner in guiding Europe's economy and society through the energy transition" (European Sea Ports Organisation, 2020).

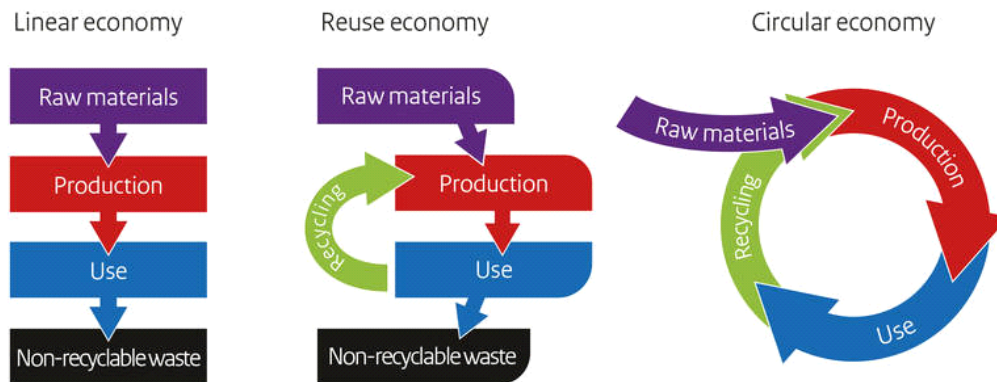
The port sector has a great potential to incorporate the concept of circular economy in its operation system, in addition to achieving sustainable and environment objectives, it can generate opportunities for job creation and the achievement of economic benefits (The European Federation of Inland Ports, 2020). The actions that must be carried out in this industry to facilitate a transition towards the circular economy should consider the following points (Ballni, 2020):

- Support seaports in the transition
- Reduce conflicting regulations against concept of circular economy
- Reduce bureaucracy
- Adopt an open mind about valuing waste more as a resource
- Increase training and knowledge of the concept
- Encourage and promote innovative ideas and measures
- Settle quality standards in the management of resources and materials
- Make a long-term investment and sustainable
- Harmonize the regulatory framework for safety requirements

2.2 Comparison between Linear Economy and Circular Economy

The linear economy is based solely on the use of materials and the generation of waste that is not recycled. This model has been the predominant one to date and is depleting natural resources. These resources are finite, in addition to generating high levels of pollution, as for example with the use of fossil fuels. The circular economy seeks a new model that pursues to optimize and make efficient use, converting waste into resources for other processes, or in other words, converting waste into raw materials (Ellen MacArthur Foundation, 2013). Below we can see an image representing the three models of economy: linear, reuse and circular.

Image 1. From linear to circular economy



Source: *Journal of Architectural Research and Development Vol 2 No 5 (2018)*

Serrano Acitores and Zubiaur Chalmeta (2018) point out that the most characteristic of this linear model is that goods or products have an absolute end, i.e., a state is reached where they become totally useless and there is no productive cycle. Natural spaces are seriously damaged and the environment is polluted, pollution indexes reach a high level and accumulate until reaching harmful and worrying dimensions. In addition to the fact that this model is the predominant one in the global industry, the current world society is immersed in the phenomenon of consumerism, where the purchase of non-essential products is encouraged.

In short, the linear economy and its predisposition to waste valuable materials is a major problem on a planet with finite resources. In contrast, the circular economy is respectful with the environment, its essence is evident in nature, the planet functions in a completely circular way where infinite cycles are formed that take advantage of all resources without emitting anything resembling waste. Lack of awareness of these natural systems, the extraction of natural resources and the detrimental impact of procurement processes are huge drivers of environmental degradation. And the waste and residues generated within the linear economy are an important expression of this linear model (Taylor 2020).

In contrast, according to Taylor (2020) the circular economy aims to mimic the planet's natural cycles by applying similar principles to the economic system replacing the traditional linear one. This innovative concept of circular economy proposes a complete change in the approach to the production of products and goods and how they are to be consumed.

Essentially, the circular economy aims to achieve a better use of resources, shorten and close the trend of the linear model, recovering as many materials as possible and preventing the generation of waste and pollution through better design of processes and products.

"Transitioning to a circular economy does not only amount to adjustments aimed at reducing the negative impacts of the linear economy. Rather, it represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits" (Ellen-MacArthur-Foundation, 2013).

According Webster (2012) the planet earth faces bigger problems every day and most of them are part of the economy. Today the largest proportion of the economy is based on using what is needed and after use simply dispatching what is no longer needed or useful as raw material, something characteristic of linear economics. This linear model does not take into account the negative impact that it may be causing to the planet, there is no ideology of reuse nor the idea of using the waste generated as important resources. However, the circular economy is presented as a viable and logical alternative, which remedies the most important problems of the linear economy. Assets are limited and generate huge amounts of waste that are difficult to manage. The circular economy aims to ensure that products and derivatives maintain their full utility value at all times, that is, generate zero waste.

3. METHODOLOGY

In this section, we will describe the methodology followed in this study. To do so, we will divide this unit into two sections, the first one to learn about the design of this research and the second one, in which the context of the research will be given, which is the port industry in the Spanish and European context.

3.1 Research design: the case study and sources of data

In this study a qualitative methodology has been used, developing a case study with the aim of studying the level of application of the circular economy in the Spanish port industry and perceive the comparison with the European ports. More specifically, being this project closely linked to the implementation of initiatives to improve environmental actions, implementing for this purpose the circular economy.

Case study is a qualitative methodology which uses representations and discourses as a source of information, achieved under rigorously designed conditions and subsequently analyzed (Ibáñez, 2002). The case study methodology is a trend that is increasingly present in research works, however, regardless of prejudices, this methodology is empirical research in the real context where the phenomenon to be studied occurs, obtaining information from various sources, using subjective information, which hinders the application of statistical inference, this being the main weakness that its detractors cling to. However, quantitative methodologies have shown limitations in terms of the study of more complex and changing scenarios, which has promoted the resurgence of this study methodology, with more and more studies in prestigious journals using this methodology. The case study methodology, therefore, allows the explanation of complex phenomena in their context (Jiménez, 2012).

As for the sources of information, firstly the primary source used was interviews, which provided valuable first-hand information about how the circular economy is applied to the Spanish and European port sector. To carry out this research, two interviews have been carried out.

The first one was conducted with the international creator and coordinator of the LOOP-Ports project, Mr. Jorge Miguel Lara López. This interview has served to obtain first-hand information on the degree of implementation of the circular economy in Spanish and European ports. It was a semi-structured interview (see Annex I: Mr. Jorge Miguel Lara López interview questionnaire), with online video call format. This interview has been recorded in order to later analyze the information provided, the questions can be divided into three blocks: (a) a first block in which we talk about the LOOP-Ports project, about how the project arises, the characteristics of the organization who lead it (employees, offices, organization chart,...); (b) a second block in which we talk about the process of implementation of the initiative in European ports and finally, (c) a third block that evaluates the presence of the project in Spanish ports and the results obtained.

On the other hand, another semi-structured interview was held with the head of safety and environment of the sustainability department of Castellón Port, Ms. Inés López Arias (see Annex II: Ms. Inés López Arias interview questionnaire), with online format video call, which has allowed to get a general idea of the port context and how it works. This interview provided insight into the role and functioning of the sustainability department within a state port, and also provided information on how a port implements circular economy actions in its operations, as well as the external support they have received to implement these measures.

Secondly, as a secondary source of information, we have accessed information from the LOOP-Ports project website, which has served to complement the information obtained through interviews, as well as other websites such Spanish Ports of the State, Eurostat, European Commission, Ellen MacArthur foundation, Fundación Valencia Port, EIT Climate-KIC Spain, among others.

3.2 Context of the research

In this section, we will describe the context of the research, we will talk about the port industry making first a brief comment about what a port is, and secondly talking about concepts such as port authority, system of governance, among others. Finally, we will describe firstly the European industry and later, specifically, the Spanish port industry, mentioning general characteristics as well as the way they perform and manage the state ports.

3.2.1 European port industry

The European Union defines a port as "an area of land and water provided with works and equipment principally for the reception of vessels, their loading and unloading, and the storage, receipt and delivery of goods, as well as the embarkation and disembarkation of passengers". (European Commission, 2014).

Seaports are a key and vital factor for trade, they are nodes that allow a commercial network to exist. According to data collected in 2014 by the European Commission, regarding the traffic of goods and merchandise, 74% of exports and imports and 37% of intra-Community operations in Europe were carried out through seaports (European Commission, 2014).

The European Commission highlights in the White Paper (strategic document that establishes the basis of the European policy in the field of transport and sets the first step for the transport system until 2050) presented in 2011 the need for port infrastructures to be efficient and reliable, allowing a correct development of operations for the European Union to be competitive in world markets. The purpose is to boost growth and create a more sustainable and inclusive transport system, as well as to strengthen the internal market (European Commission, 2014).

According Laxe F. (2020) ports have played an important role in the growth of the European Union in the world. There are four major areas of European maritime-port

development: the Northern Range (encompassing the coast from the ports of Hamburg to Le Havre), the Mediterranean, the Baltic, and the Atlantic; the first two are the ones that record the largest movements of goods and are home to the most important ports. In short, two major groups stand out in maritime Europe: the countries that move more than 100 million tons per year (headed by the Netherlands, Spain, the United Kingdom, Italy, France and Germany).

Within the port sector there are many ports with very different characteristics in terms of type, organization, size and way of relating to the environment, it is a very heterogeneous field. Productivity and efficiency vary in each port in the European Union, based on the port's own characteristics (Obermayr et al 2016). With the passage of time this variation between ports has become more evident, increasing the difference between some ports with others based on their management of exports and imports and intra-community operations.

In Europe, many of the port authorities (internationally coined designation for the management bodies of seaports) have a public character and are responsible for managing and governing the ports. The port infrastructure is owned by the port authority, which operates them by leasing them to port operators through concessions while retaining all regulatory functions. Activities within the port are carried out by private companies (waste management, cargo handling, mooring services, etc.). Examples of fully privatized ports include Manchester, Liverpool in the United Kingdom, among others. On the other hand, in northern ports, such as the port of Rotterdam, management is carried out by the city council itself and does not fall into the hands of the port authority.

In the case of Spain, state ports are governed by their own port authorities, with a total of 28 ports under the coordination and control of "Puertos del Estado", a body under the Ministry of Transport, Mobility and Urban Agenda.

The port sector is motivated to adopt and implement better sustainability by several actions of the European Union. The most important and recent initiative that affects this sector is the Green Deal of 2020, which includes a package of initiatives for the adoption of climate initiatives, for the year 2050 has set the goal of being the first climate neutral continent (European Commission 2021). These objectives set by the European Union directly affect the port sector, which has a great impact on the environment, generating problems such as the alteration of natural waters, air pollution (due to particles of bulk cargo such as red clay and feldspar), construction of artificial infrastructures and waste generation (waste from merchant ships, waste produced in terminal operations, etc.), among others (European Commission 2021).

3.2.2 Spanish port industry

Law 27/1992, of November 24, 1992, on State Ports and the Merchant Marine (LPEMM), as amended by Law 62/1997, of December 26, 1997, distinguishes between ports owned by the Autonomous Communities (fishing ports, marinas and ports of refuge), which depend on the Autonomous Community where they are located, and ports owned by the State, which are classified as ports of general interest, mainly ports authorized for cargo traffic. In Spain there are a total of 46 ports, where 28 different port authorities are in charge of governing the state ports while the management of the rest of the ports (ports with low commercial activity) are managed by the Autonomous Communities themselves (Rúa Costa, 2006). Below is exposed a map showing the distribution of the 28 port authorities throughout the national territory:

Image 2. Spanish port authorities' distribution in the national territory



Source: *Puertos del Estado* (2021).

These 28 port authorities are managed by “Puertos del Estado”, an entity that has responsibility for the entire state-owned port system and is in charge of implementing the government's port policy. "This body has its own legal personality and assets, as well as full capacity to act, its activities will be in accordance with the private legal system, except in the exercise of public authority functions" (Rúa Costa, 2006). Regarding port authorities they have the following functions:

- The conduct, authorization, and control of maritime and land operations.

- The management of the port service area and port uses, in coordination with the competent administrations.
- The planning, design, construction, conservation and operation of the works and services of the port, and of the maritime signals entrusted to them, subject to the provisions of law.
- The management of the port public domain and of the maritime signals assigned to it.
- The optimization of the economic management and the profitability of the patrimony and resources assigned to them.
- The promotion of industrial and commercial activities related to maritime or port traffic.

According to Martín Bofarull (2010): "the current port model in Spain is oriented towards the reduction of the direct management of port services by the Port Authorities. Ownership of infrastructure remains in public hands, although private sector participation in certain investments is allowed. Investment in basic infrastructure corresponds to the State, but the possibility of financing the construction of certain terminals, together with their subsequent operation, is encouraged. In addition, there is a tendency to cede to the private sector both the ownership and the operation of port superstructure".

Spanish ports therefore combine the public sector with private companies. This combination is linked to a regulation that is efficient through the competences assigned to state ports and port authorities. At the end of the process, it is the port authority that is in charge of planning and financing the port structure, setting tariffs, preventing monopoly situations, etc.

On the other hand, the geographical situation of Spain is privileged, being the European country with the longest coastline (8,000 kilometers). This situation benefits Spain as a strategic area in the international maritime transport sector and as a logistics platform in southern Europe. According to "Puertos del Estado" (2020): "This national port system contributes close to 20% of the GDP of the transport sector, which represents 1.1% of the Spanish GDP. In addition, it generates direct employment of more than 35,000 jobs and about 110,000 indirectly".

Besides all the above, the port system has a high impact on the economy and environment, since, within this sector, many freight transport operations take place, for example, which can affect the environment, through the generation of waste or because of the use of fossil fuels.

According to the study Climeport Project, the principal environmental aspects in ports are the following (CLIMEPORT PROJECT, 2013):

- Emissions to air (gases, solid particles)
- Discharges into water
- Noise (which causes a great impact on the population and fauna)
- Development of the port, in terms of occupation of the sea and land
- Degradation of the natural habitat

The importance of these aspects is linked to the characteristics of the port in question, that is, location, activities, size, etc. As an example, to observe the environmental impact that the port industry causes on the environment, specifically, greenhouse gas emissions, we will take the case of the Valencia port Climeport project. The aforementioned study was created in 2013 by the port authority of Valencia having the objective of finding out how much pollution was taking place within its port area. They took 3 key processes for the pollution analysis: port normal activities (those carried out in the port), related-to-port land transport (which includes all those vehicles that transport goods from the port to the outside and vice versa) and ship activities. The following results were collected in 2013 as shown in the following table:

Table 1. Total greenhouse gas emissions in TCO₂Eq in the Port of Valencia 2013

Port activities	TCO₂Eq
Port normal activities	65.428,00
Related-to-port land transport	20.031,00
Ship activities	77.024,00
Total	162.483,00

Source: Adapted from CLIMEPORT PROJECT (2013).

We can see that the activities carried out by the Valencia port itself account for 40% of the total emissions produced annually. Unlike the transport activities that are usually carried out by totally private companies outside the port and the ships that are managed by the shipping company and / or shipowner, the port can directly affect port activities by making changes to reduce emissions. This example of Valencia can be considered as a paradigm of the port industry as well as a representative example of how far we are in sustainability issues in the port industry.

And, as mentioned before, in addition to greenhouse gas emissions, the port industry produces enormous amounts of waste (construction materials, metals, plastics, etc.) and causes land changes for extensions and construction of new terminals. It is an industry that needs to incorporate an ideology such as the circular economy to mitigate its impact on the environment and society.

4. ANALYSIS AND RESULTS

4.1 Implementation of CE in Spanish ports and European ports.

Comparative indicators

This section briefly shows, as a way of focusing the context of the analysis, the degree of implementation of the circular economy at the national level compared to the European level (EU 27). To evaluate this, indicators established by the European Statistical Office (Eurostat) will be used to measure the progress of the circular economy in European countries, comparing the data of Spain with the European average.

Subsequently, the current situation of the degree of implementation of the circular economy within the Spanish port sector is shown, making a comparison between the Spanish port industry and the rest of European ports,

4.1.1 Circular economy in the national and European general context

The European database Eurostat established a specific section on circular economy within its data, setting indicators to observe and measure the progress of the circular economy. The following is an analysis of these indicators, comparing national results with the European average. We have divided these indicators in different categories which are:

- Waste generation
- Waste management
- Recycle management
- Competitiveness and innovation management

Now, we are going to present the comparative data between Spain and EU27:

Waste generation indicators

The table below (table 2) shows waste generators indicators that measure Spain's production and consumption compared to the average for European countries. As we can see, Spain scores slightly below the European average in the indicators: Generation of waste excluding major mineral wastes per GDP unit (Kg per thousand-euro, chain linked volumes (2010)) and Generation of waste excluding major wastes per domestic material consumption (percentage).

Table 2. Production and consumption

Indicator	EU 27 value	Spain value
Generation of municipal waste per capita (Kg per capita)	50 [2019]	476 [2019]
Generation of waste excluding major mineral wastes per GDP unit (Kg per thousand-euro, chain linked volumes (2010))	66 [2018]	62 [2018]
Generation of waste excluding major wastes per domestic material consumption (percentage)	12.7 [2018]	16.4 [2018]
Food waste (million tonne)	69 [2018]	N/A

Source: Adapted from Eurostat data (2021).

Regarding the indicator of Generation of municipal waste per capita (Kg per capita), Spain obtains a very high score compared to the European average. This large difference may be due to the fact that not all European countries carry out a systematized data collection in relation to waste generation, in addition, the countries whose protocols for collecting information on waste generation are usually countries with greater awareness and commitment to sustainability and the environment, so that, in turn, waste generation will be lower, which makes the European average low.

Analyzing this table, it can be seen that Spain is generally above the average in terms of waste generation. The difference in municipal waste generation between the European and Spanish average is 426 KG per capita, which is a very high figure.

Waste management indicators

As for the indicators related to recycling rates (table 3), Spain scores lower than European countries, but the difference does not exceed 15 points. The indicators related to recycling and waste recovery by inventory (by type of waste), Spain has better scores for recycling in general, plastic packaging, wood and electronic scrap waste. It has lower scores than the average for European countries in organic and construction waste. This difference is not very high. This may be due to the fact that, despite the circumstance that a lot of waste is produced, there is a good level of recycling awareness.

Table 3. Waste management

Indicator	EU 27 value	Spain value
Recycling rates		
Recycling rate of municipal waste (percentage)	47.7 [2019]	34.7 [2019]
Recycling rate of all waste excluding major mineral waste (percentage)	55 [2018]	47 [2018]
Recycling / recovery for specific waste streams		
Recycling rate of overall packaging (percentage)	66.3 [2018]	68.8 [2018]
Recycling rate of plastic packaging (percentage)	41.5 [2018]	50.7 [2018]
Recycling rate of wooden packaging (percentage)	34.5 [2018]	67 [2018]
Recycling rate of e-waste (percentage)	38.9 [2018]	43 [2018]
Recycling of biowaste (kg per capita)	87 [2019]	80 [2019]
Recovery rate of construction and demolition waste (percentage)	88 [2018]	75 [2018]

Source: Adapted from Eurostat data (2021).

Recycle management indicators

In the table below (table 4), the Circular material use rate (percentage) indicator directly alludes to one of the key points of the circular economy. We note that Spain is behind the European average, perhaps due to the lack of information regarding the importance of waste reduction and the reuse of materials. The indicators related to Trade in recyclable raw materials (measured as tons):

- 13% of imports into Europe from non-European countries of recycled materials are carried out by Spain
- 3.7% of exports to non-European countries of recycled materials come from Spain
- 9% of intra-European Community operations are carried out by Spain.

We can therefore see that Spain imports more recycled material than it exports, which should not be the case due to the high production of waste.

Table 4. Secondary raw materials

Indicator	EU 27 value	Spain value
Contribution of recycled materials to raw materials demand		
Circular material use rate (percentage)	11.8 [2019]	10 [2019]
Trade in recyclable raw materials (tonne)		
Imports from non-EU countries	8,282,207 [2020]	1,107,917 [2020]
Exports to non-EU countries	27,490,340 [2020]	1,020,422 [2020]
Intra EU trade	46,850,227 [2020]	4,292,568 [2020]

Source: Adapted from Eurostat data (2021).

Competitiveness and innovation management indicators

As last one, the table below (table 5) shows indicators related to competitiveness and innovation. The differences in the indicator's Gross investment in tangible goods (percentage of gross domestic product (GDP) at current prices), Persons employed (percentage of total employment) and Value added at factor cost (percentage of gross domestic product (GDP) at current prices) are not very significant. It is worth mentioning that with regard to the indicator Number of patents related to recycling and secondary raw materials, Spain has a percentage of 10% of the patents registered in Europe. From this it can be deduced that Spain is on a par with the rest of the European countries in terms of the degree of competitiveness and innovation.

Table 5. Competitiveness and innovation

Indicator	EU 27 value	Spain value
Private investment, jobs and gross value added related to circular economy sectors		
Gross investment in tangible goods (percentage of gross domestic product (GDP) at current prices)	0.12 [2018]	0.1 [2018]
Persons employed (percentage of total employment)	1.71 [2018]	2.01 [2018]
Value added at factor cost (percentage of gross domestic product (GDP) at current prices)	0.97 [2018]	1.08 [2018]
Number of patents related to recycling and secondary raw materials	269.14 [2016]	29.09 [2016]

Source: Adapted from Eurostat data (2021).

After analyzing and comparing the five category of indicators that we have considered related with circular economy, we can conclude that Spain is slightly below the European average in these indicators. In waste generation, it has been observed that, as a country, Spain is a huge producer of waste per capita, far exceeding the European average, which is a major social problem due to the lack of awareness of sustainability within the country.

In the aspect of waste management, Spain is below the average recycling ratios of Europe, this indicates that the country is in a situation where the recycling ratio is not favorable for the quantities produced, i.e., for a high amount of waste produced, a high recycling ratio is expected to contribute to greater sustainability. This is an important aspect to take into consideration, as we must be aware of the large amounts of resources that are consumed and we should do an important effort to analyze the key points to reduce consumption, to decrease inefficiencies and to promote sustainable alternatives to favors a real transition to the circular economy.

However, it is worth mentioning that the indicators of competitiveness and innovation in the aspect of circular economy show good results in favor of Spain, this gives us an indication that this country is in the process of implementing measures to improve the actions already being carried out or to promote new measures.

4.1.2 The circular economy in the national and European port context

Regarding the measurement of the progress of the circular economy in the port sector, there are no clear indicators, nor are they established by the European Union. There is little information on this subject, although labor is being done to establish an index of clear indicators, for example, as proposed by the United Nations with the 17 Sustainable Development Goals.

In any case, we can say that the indicators established by Eurostat, despite not having been designed for use in the port sector, give an indication and an overview of the degree of implementation and use of the circular economy in the ports of each country. Even so, it is considered necessary to create specific indicators for the sector, due to its complexity and the numerous agents involved in it. For example, waste management in ports is mostly carried out by private companies, which would make it difficult to obtain data and information, and most emissions and waste production are not monitored in the port sector, so it would not be possible to develop indicators based on objective data.

To this paper, we selected a series of indicators to analyze the degree of implementation of the circular economy in Spanish ports with respect to European ports. These indicators have been extracted from the LOOP-Ports project database (more details on this project later), which collects data from 480 European ports analyzed, however, the analysis and interpretation of this information is specific to the objective of this work.

These indicators have been chosen because, although they do not measure circular economy in particular, they measure the degree of commitment of the ports to sustainability and care for the environment, so, in our opinion, they can be used to know the degree of implementation of the circular economy in Spanish and European ports, in the absence of specific indicators.

In the last part of this section, we will describe and show in detail the comparative situation between Spain and Europe according to these proposed indicators.

The indicators used and analyzed for the purpose of this work are:

- Number and type of ports with environmental certifications.
- Number and type of ports with environment / sustainability reports.
- Number of European Sea Ports Organization members (ESPO) per country and port type.
- Number of ECOPORTS member per country and port type.
- Number and type of ports belonging to World Ports Climate Initiative (WPCI).

Number and type of ports with environmental certifications

The first indicator to be analyzed is the number and type of ports with environmental certifications. This indicator can provide us with information about the degree of commitment that ports have regarding environmental care, since certifications require port authorities to comply with and adopt a series of actions and commitments.

Among what we can consider as representative certifications, the following have been considered:

- *European Eco-Management and Audit Scheme (EMAS)* defines an environmental management and audit scheme with a renewal frequency every 3 years. It is the most widely recognized certification, but it requires a higher degree of commitment and a higher level of demand than ISO 14001 and PERS certifications.

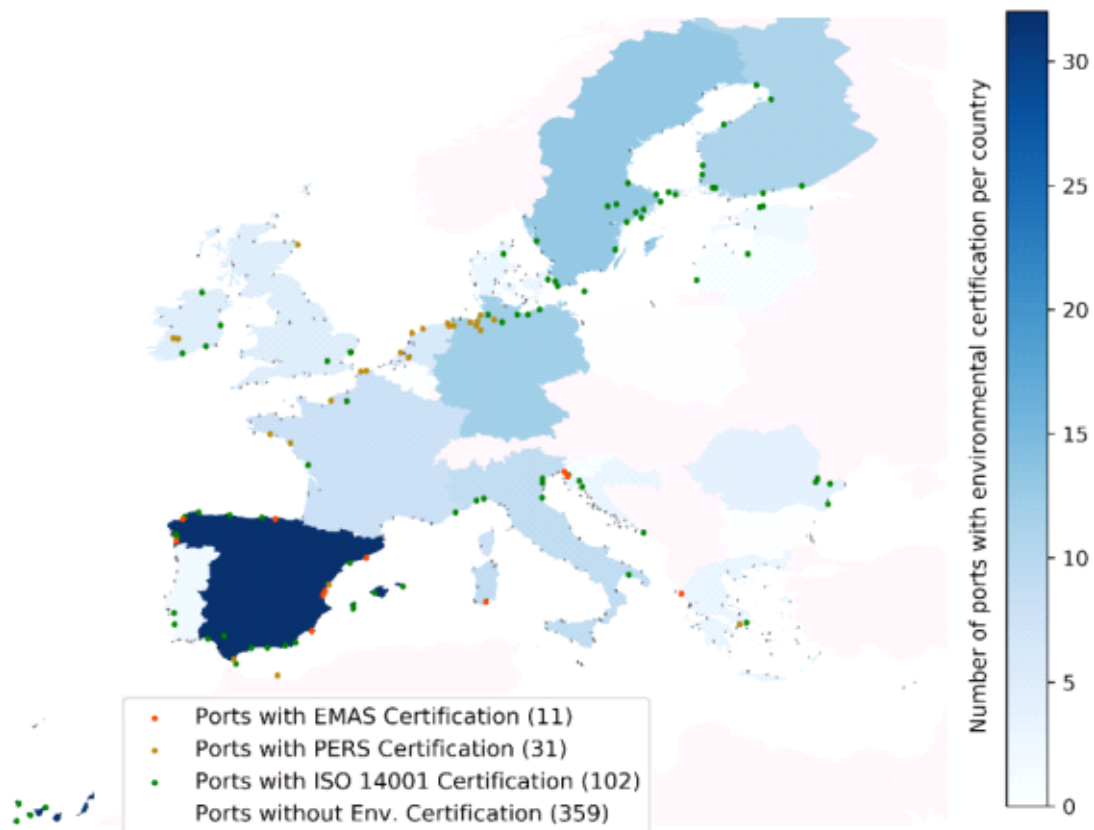
Only 4% of the ports analyzed have this certification in Europe. Of a total of eleven certified ports, seven are Spanish ports, which is a considerably high number, accounting for almost 64% of the total.

- *Port Environmental Review System (PERS)*, which is valid for 2 years, incorporates the main general requirements of the recognized environmental management standards, in addition to taking into account the specificities of the ports. Only three Spanish ports have this certification, which is relatively low at 9.6% of the total number of ports certified with PERS.
- *ISO 14001 certification*, being the most generic and well-known, is an international standard in the field of environmental management, and all the main Spanish ports have it.

It is worrying that only 21% of European ports have the most basic certification in environmental areas (ISO 14001), and of the 480 ports analyzed, almost 75% of them have no environmental certification at all.

As a summary of this category of indicators, the image below (figure 1) shows the number of ports that have the most relevant certifications in the field of sustainability and environmental care.

Figure 1. Number and type of ports with environmental certifications



Source: LOOP-Ports project (2021).

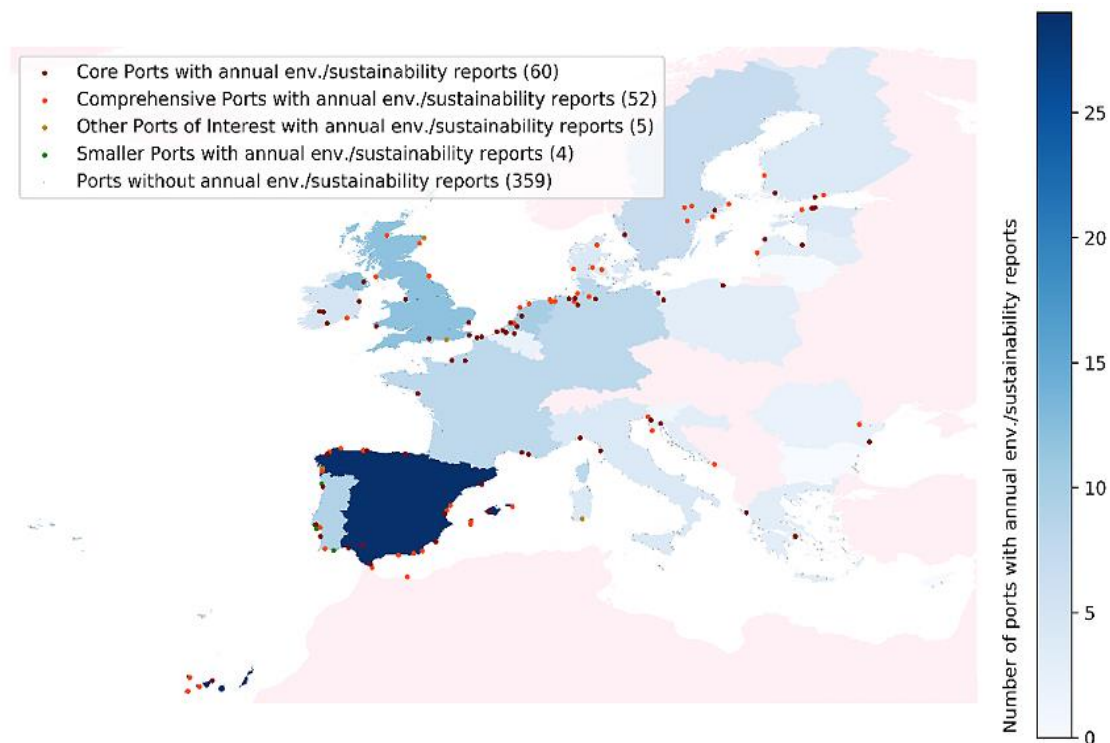
Finally, it should be noted that only 6 ports out of all those evaluated have the three types of certifications (PERS, EMAS, ISO 14001), being one port in Greece (Igoumentisa) and five ports in Spain (Barcelona, Cartagena, Sagunto, Valencia and Vigo).

According to these data, we can see that Spain stands out from the rest of the European countries in terms of environmental certification. Fulfilling the requirements of environmental certifications implies a commitment on the part of the ports towards sustainability and circular economy, but those that do not have certification does not mean that they do not develop sustainability activities, but that they have not obtained this type of certification for various reasons (lack of resources, non-compliance with the established minimums...).

Number and type of ports with environment / sustainability reports

Another possible indicator to measure the commitment to the sustainability of the circular economy are the annual sustainability reports made by the port. The preparation of these reports demonstrates that the port measures, discloses and demonstrates results to its stakeholders (parties with an interest in a company or organization) regarding the port's performance with respect to the goal of sustainable development. Clearly this is driven by a commitment to sustainability and environmental protection. The image below (figure 2) shows the number of ports that present annual reports relevant to the field of sustainability and environmental care.

Figure 2. Number and type of ports with env./sustainability reports



Source: LOOP-Ports project (2021).

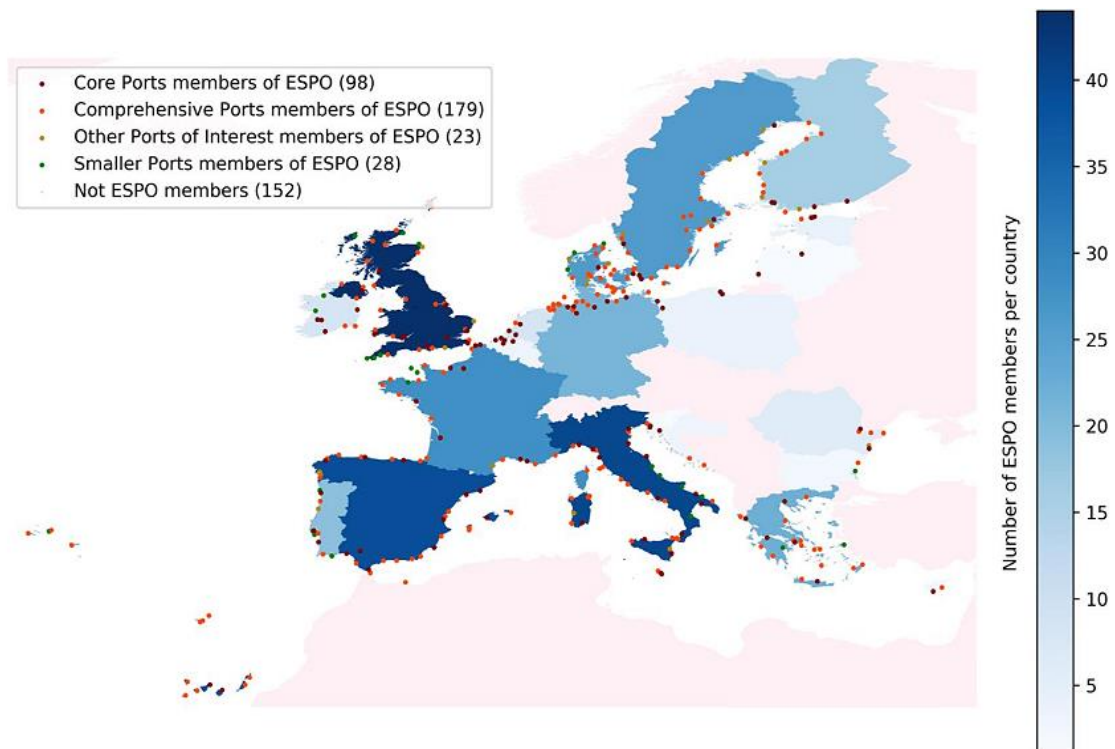
As seen before, the 25% of the ports analyzed present sustainability reports (on these group, the 57% are major ports, 23% are comprehensive ports, 15% are other relevant ports and 3% are smaller ports). The other 75%, being 359 European ports, do not present annual sustainability reports. Spain exceeds the figure of 25 ports, making it once again stand out above other European countries, being the European country with the most ports presenting sustainability reports. This information indicates that national

ports are very conscious of transmitting sustainability results to the public and stakeholders.

Number of ESPO member per country and port type

As a third indicator, the number of ESPO (The European Sea Ports Organization) members per country and port type. ESPO is a representative body of port authorities, port associations and port administrations of the seaports of the member states of the European Union and Norway, and independently advocates the interests of its member ports. Its mission is to influence public policy in the European Union to achieve a safe, efficient and environmentally sustainable European port sector. In 2003, it approved the Environmental Code of Practice, which reflects the good practices and actions that ports can develop to be more sustainable. The image below (figure 3) shows the number of members of the ESPO organization per country and by port type.

Figure 3. Number of ESPO members per country and port type



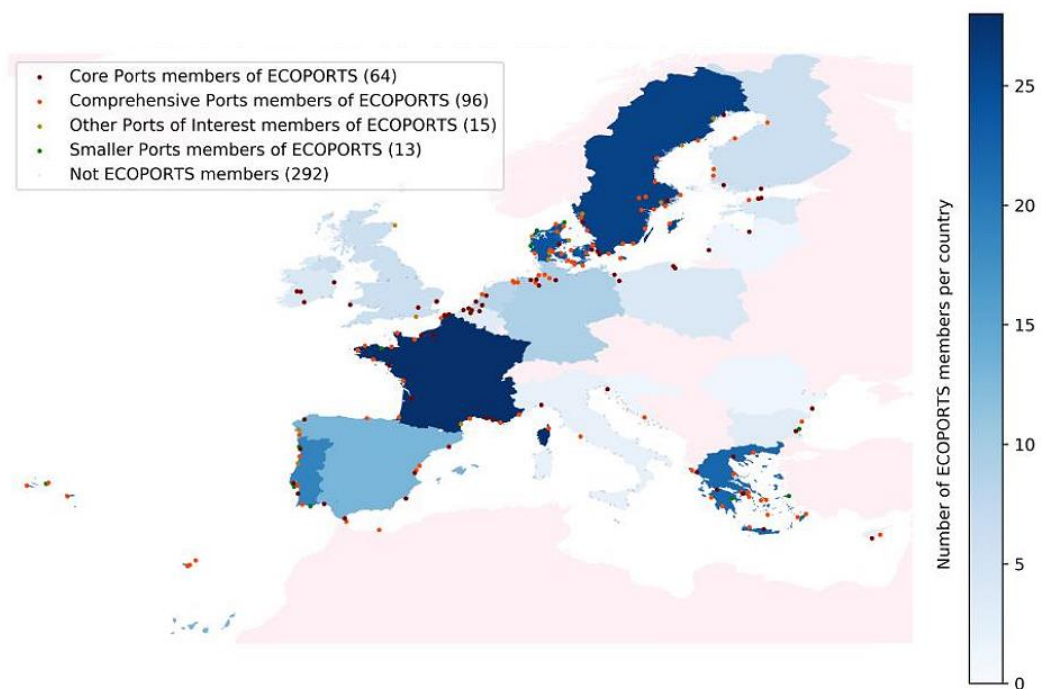
Source: LOOP-Ports project (2021).

Of the European ports sampled, 68% are members of ESPO. More than half of the European ports belong to this body that establishes the most general practices in sustainability. The countries with the highest number of ESPO member ports are the United Kingdom and Italy. In third place is Spain, with more than 30 ports belonging to the ESPO organization. This is a positive figure, but as mentioned above, membership of this organization is not remarkable, it should be mandatory, as it covers fairly simple practices and measures in terms of sustainability and care for the environment.

Number of ECOPORTS member per country and port type

The fourth indicator analyzed is the number of ports that are members of ECOPORTS, a network created by the European Sea Ports Organization (ESPO) to raise awareness of environmental protection through cooperation and knowledge exchange between ports and improve environmental management. To be part of this network, the port must implement the Self Diagnosis Method (SDM), a methodology used to identify environmental risks and establish priorities for action to achieve the given objectives. In addition, being part of this network offers the possibility of obtaining PERS certification. The image below (figure 4) the number of members of the ECOPORTS organization per country and by port type.

Figure 4. Number of ECOPORTS member per country and port type



Source: LOOP-Ports project (2021).

From this analysis we can conclude that, of the European ports sampled, 39% are members of ECOPORTS, of which 64% are core ports, 43% comprehensive ports, 44% other relevant ports and 9% small ports. The most relevant country in this aspect, exceeding 20 member ports, is France, followed by Sweden, Greece and Denmark. In sixth position, Spain is not so well positioned in this aspect, since 6 out of 13 core ports and 7 out of 20 comprehensive ports are not members of the ECOPORTS network. This is a very low ratio over the total number of Spanish ports. This is an organization that focuses on more specific and deeper sustainability objectives, aiming at concepts more focused on the circular economy, so it is important that national ports are motivated to join the initiative developed by this network.

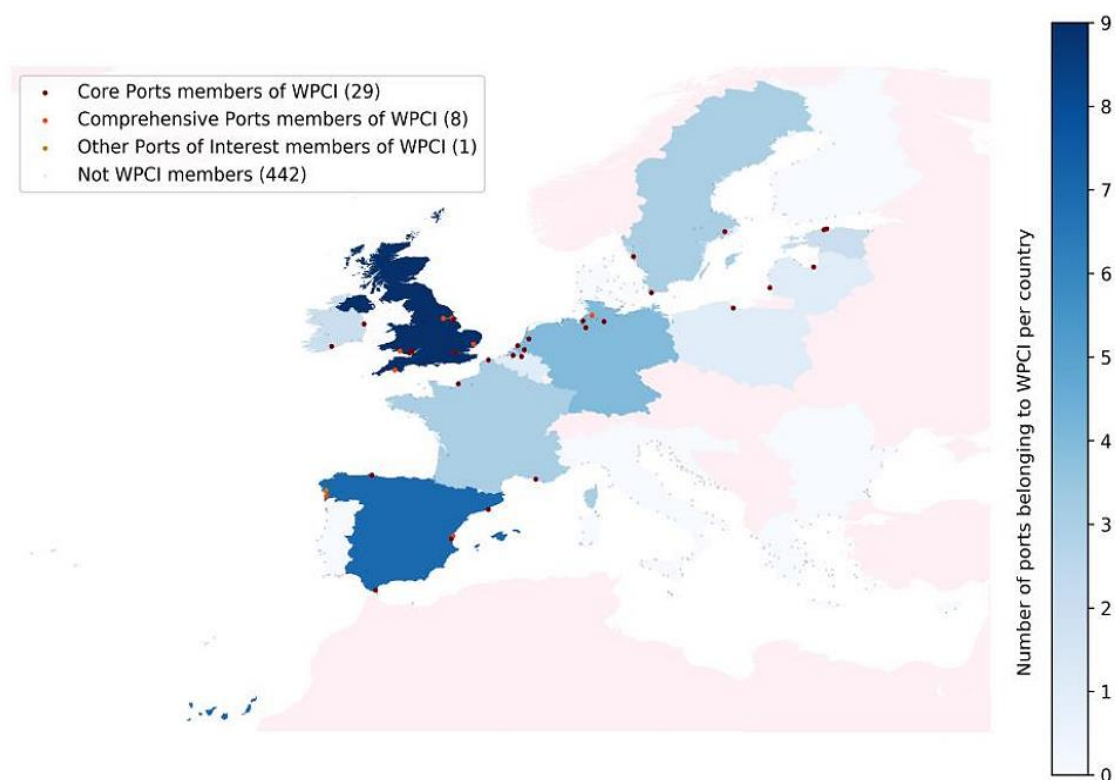
Number and type of ports belonging to WPCI

As a last indicator, we will talk about the number of ports belonging to the World Ports Climate Initiative (WPCI). This initiative was launched in 2008 by the International Association of Ports and Harbours (IAPH) and regional Port Organizations. It is an organization that provides ports with a framework for mitigating their impact on climate change. Its mission is based on 4 objectives:

1. Promote the need for action within the port and maritime community.
2. Conduct studies, strategies and actions to reduce emissions and improve air quality.
3. Provide an information exchange platform for the maritime port sector.
4. Make available information on the effects of climate change on the seaport environment and mitigation measures.

Membership in this organization provides the port with information and measures on how to manage and reduce carbon emissions and learn how to implement green initiatives. The image below (figure 5) shows the number and type of ports belonging to WPCI organization.

Figure 5. Number and type of ports belonging to WPCI



Source: LOOP-Ports project (2021).

Within Europe, only 8% of 480 ports belong to the WPCI. In each port category, 27% of core ports, 4% of comprehensive ports, 3% other ports of relevance and 0% smaller ports are members. The United Kingdom stands out as the country with the most ports belonging to this initiative. In second place is Spain, where only 7 ports are members, representing 18% of the total number of ports belonging to the WPCI (4 core ports, 2 comprehensive ports and 1 other ports of interest). Spain's position is remarkable since many European countries (a total of 442 out of 480) do not have even one port member of this initiative. Belonging to this organization is relevant in the achievement and implementation of the circular economy as this initiative encompasses actions aimed at reducing emissions and waste with the consequence of reducing as much as possible the damage to the environment.

As a conclusion of the section, the following table (Table 6) summarizes the five-category indicators analyzed above. We show the results by indicator for Spain and the European average. This table allows us to see how the Spanish situation compared with the European context.

Table 6. Results of Spain and average Europe regarding indicators

Indicator	Spain	Average Europe [27]
Number of environmental certifications	33	5,3
Number of environment reports	29	4,5
Number of ESPO members	39	11,1
Number of ECOPORTS members	16	7
Number of WPCI members	7	1,4

Source: Own elaboration.

As previously indicated, Spain has good results in these indicators, standing out above all in environmental certifications and in the presentation of sustainability reports. It is true that in other indicators such as membership of environmental organizations, Spain is surpassed by specific countries such as France, Norway, the United Kingdom, among others. It is true that Spain far exceeds the European average, but this is due to the fact that European countries that have few ports relevant to maritime traffic have almost no impact on the European average, with countries such as Norway, France, Portugal, Spain, etc. being the biggest contributors to this average.

As previously explained, these indicators give an idea of the approximation of the commitment to environmental care by Spanish and European ports, i.e., Spain being the country with more certified ports does not imply that it is the country that most applies the circular economy in its maritime ports. That is why in the following section, the case of Spain is analyzed concretely to review the attitudes of the 28 port authorities towards the circular economy and how committed they are to the actions involved in this concept.

After all of the above, we can conclude that in Spain the degree of implementation of the circular economy is low. This may be due to the fact that the concept of circular economy is a very broad concept that is interpreted in different ways in different regions of Europe. For example, in the Port of Rotterdam its sustainability strategy pivots around the circular economy, which regulates all the actions carried out. Within these actions, a wide range of actions are introduced that revolve around the circular economy, such as renewable energies, recycling, materials recovery, design, etc.

Meanwhile in southern European countries, the concept of circular economy is associated only to waste management, that is, to the final part of the process, which is why the actions that are developed at national level, only focus on waste and not on other important issues such as the design of green procurement process. This example

is easily observable by visiting the websites of the ports, in the port of Rotterdam there is a section dedicated exclusively to the circular economy and even allow the registration to their newsletter, in which they send information on the progress they make in this area and the actions they take. While it is difficult to find information related to the circular economy on the websites of Spanish ports, the information they have available in the sustainability section is focused on showing the results of waste and pollution management.

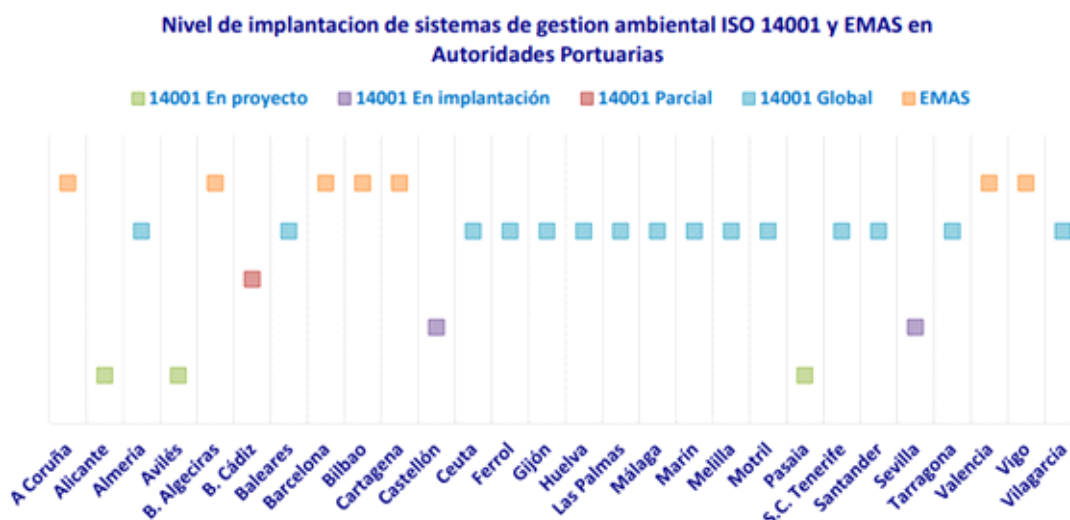
On the other hand, another cause is that northern European ports are part of the city itself (municipal in nature), in the strictest sense of the word, the management of these ports is carried out directly by the municipalities themselves, when they analyze and/or structure a strategy for the city, they include the port within this. However, in Spanish ports there is the figure of the port authority, a public entity that manages the port area, although the board of the port administration may be formed by members of the city council or other positions of the Generalitat (in the case of the port of Valencia, for example), the management does not fall under the plans of the city council, it falls directly on the governing body of the port authority.

4.2 Analysis of the Spanish situation through the 28 port authorities

In this section an analysis is made at the level of Spanish ports in the context of the circular economy and analysis of the main causes that generate the differences between the Spanish and European contexts. To analyze the degree of commitment to the circular economy of the Spanish port industry, the actions carried out by its 28 official port authorities will be taken as a reference. For this purpose, official results prepared by the sustainability area of “Puertos Del Estado” of Spain will be shown and the causes extracted from the interview with the coordinator and founder of the LOOP - Ports project will be reflected. This project will be explained in depth in the following section.

As mentioned in the previous section, Spain stands out considerably compared to other European countries in terms of environmental certification, but not all port authorities have the same degree of involvement in the implementation of environmental management systems; there are some that do not yet have ISO14001 certification, which is one of the first steps in terms of commitment to the environment. The image below (figure 6) shows the status of ISO and EMAS certification implementation in the 28 Spanish port authorities.

Figure 6. Level of implementation of ISO 14001 and EMAS environmental management systems in port authorities.



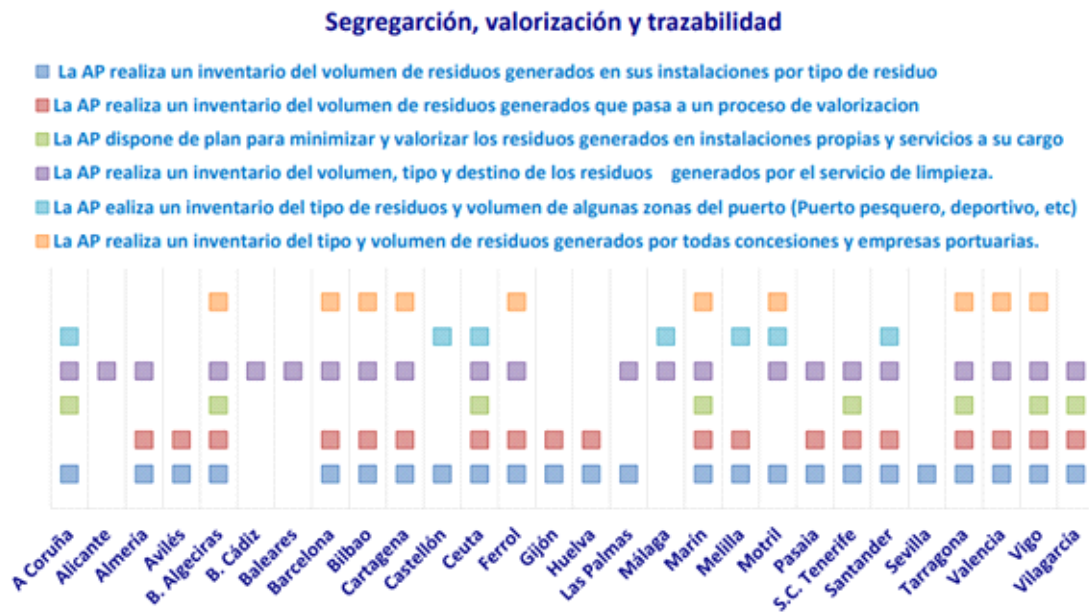
Source: Sustainability Area - Planning Department - State Ports (2020).

Of the 28 port authorities, only 7 have EMAS certification. It should be recalled that this certification goes beyond ISO 14001 and is a driver for the performance of actions aimed at the circular economy. This results in a proportion of 25%, which is very low. ISO 14001 certification, being the most basic and least demanding certification in terms of requirements, is held by 15 port authorities and is being implemented in 6 port authorities.

Waste management is considered the first basic action in terms of sustainability, a fundamental action that can lead to other measures. Port authorities carry out this management, but they differ from each other, some port authorities are more involved in this process than others. For example, one port authority may only carry out inventories by type of waste, while others may do so, in addition to subsequent traceability.

Another key element of the circular economy is the reuse of waste as a resource for other activities and actions. Port authorities are obliged to have in their waste management plan within their port management obligations. Below (figure 7), we show and analyze the degree of involvement with this action within each port authority.

Figure 7. Segregation, valorization and traceability of generated waste



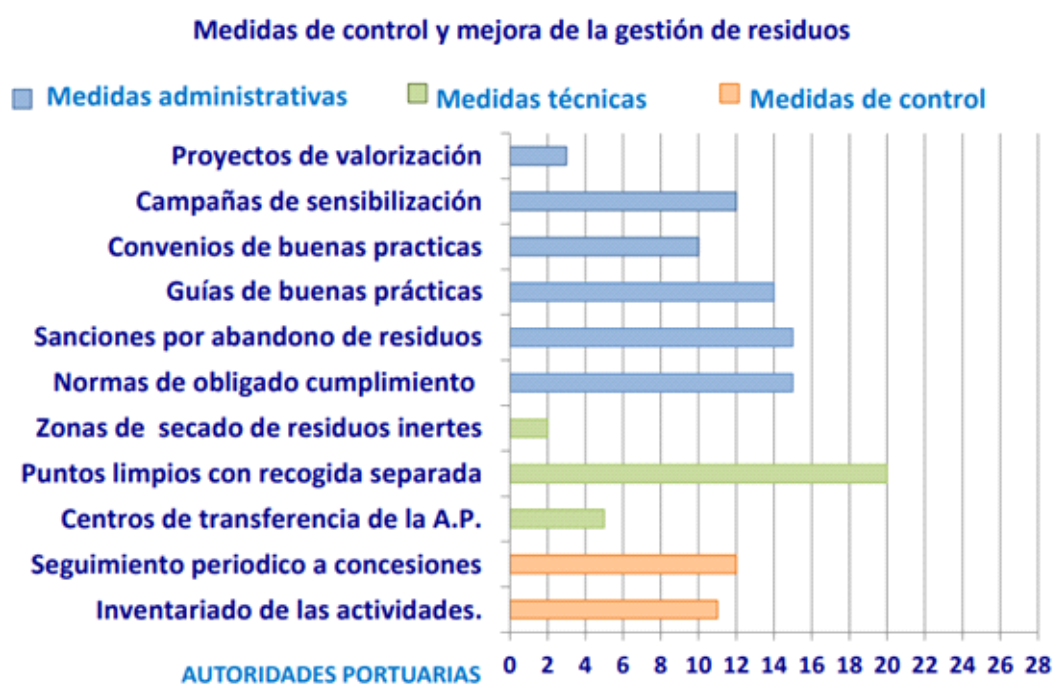
Source: Sustainability Area - Planning Department - State Ports (2020).

After analyzing the data, these are the main results that we can observe:

- Within the 28 state port authorities, the action of keeping an inventory of the volume of waste generated by type of waste is carried out in 24 of them, while the port authorities of Alicante, Cadiz, Baleares and Malaga do not carry out this type of inventory.
- The waste recovery process is carried out by 19 port authorities.
- Only 8 of the 28 port authorities have a plan to minimize and recover waste generated in their own facilities and services.
- Inventories of the volume, type and destination of waste generated by the cleaning service are present in 22 out of the 28 port authorities.
- The low figures are due to the fact that not all port authorities are responsible for the management of sports and passenger areas.
- The highest level of involvement in this process would be that in which segregation, valorization and traceability of waste is carried out, being the inventory monitoring of the type and volume of waste generated by all port concessions and companies, is carried out by 10 port authorities.

Finally, the following image (figure 8) shows the control and improvement measures implemented by the Spanish port authorities in terms of circular economy strategies.

Figure 8. Waste management control and improvement measures



Source: Sustainability Area - Planning Department - State Ports (2020).

As we can see in the image above, as far as administrative measures are concerned, they are carried out by an average of 11.5 ports, with recovery projects being the least carried out (only 3 port authorities). This reflects a lack of commitment to circular economy measures, as it is important to plan what to do with the waste generated in order to reuse or recycle it in an appropriate way that ensures the lowest possible environmental impact.

In relation to technical measures, there is a large difference between the 3 evaluated, with inert waste drying areas (2 port authorities) and port authority transfer centers (5 port authorities) being the lowest, compared to clean points with separate collection present in 20 of the 28 ports evaluated.

Finally, the control measures evaluated, periodic monitoring of concessions and inventory of activities, are present in less than half of the port authorities, 12 and 11, respectively.

Therefore, one of the causes that generates these barriers to change is the lack of knowledge of what the circular economy is. The LOOP - Ports project identifies that there is a need for training in this area in Spanish ports. Training is essential, as sustainability is sometimes not a clear concept, it can encompass new concepts (blue lines, blue economy, green port...) which makes it unclear what the circular economy is.

There is also a lack of maturity to see the wide range of possibilities offered by the circular economy. It has to be a common goal, all those ports with a very cohesive, structured and collaborative port cluster are ideal places to implement and promote these actions that in the long term are seen as actions that can give results that generate fewer emissions and are more environmentally friendly.

The different governance schemes have a great impact on the form of organization and management of environmental actions in the port, therefore, in the ports of Spain it is more complicated to implement these measures, as they are governed by the national port law that does not allow to have a common structure that allows an industrial symbiosis with its environment, and that in turn prevents a port-city relationship with common objectives, the implementation is complicated, so in Spain is at a disadvantage to get the most out of this concept.

Another fundamental cause that hinders the implementation of the circular economy is Spain's legislation in the area of sustainability in port areas. Any company or entity follows the law, if it is not clear or does not require specific aspects, only minimum requirements will be met. The adoption of the circular economy is fundamentally structural, it is up to the company to adopt it or not, for example, in its corporate social responsibility. Spain is not explicitly pushed by legislation as it only regulates basic aspects such as pollution and waste management. It is necessary to have a clear legislation to go ahead and set goals. If there is not something that pushes and motivates to carry out actions, it is difficult for this change to take place.

4.3 LOOP project as a catalyst for the implementation of CE in Spanish ports

As a final part of the results section, we describe the LOOP-Project, an international initiative that we find can be a driver and booster of circular transition in port industry.

This type of projects favors the transition towards a circular economy by bringing the necessary training to those in charge of port management. Through the training and information they provide, they raise awareness of the importance of caring for the environment. In addition, they can offer support for the needs that may arise at the time of implementing the measures in each specific port, facilitating this process, studying each case in a particular way.

The LOOP-Ports Project, "is a project created by EIT (European Institute of Innovation & Technology) under the Climate-KIC initiative to achieve a real switch to a circular economy in EU ports. Its main objective is to facilitate the transition to a more circular economy in the port sector, where products, materials and resources are kept in the economy as long as possible, minimizing waste generation". The mission of this project is therefore to bring knowledge and other tools to the ports, to facilitate their approach to the adoption of measures and actions for sustainability and environmental care. To this end, they offer training and specific case studies, which make it possible to think of solutions adapted to each specific port. It also allows the exchange of knowledge and best practices between ports with different degrees of implementation of circular economy measures.

This project includes 13 partners from the European Union (Spain, Italy, France, Germany, Denmark and the Netherlands) and has been in operation for about two years, ending in November 2020, since in this time the necessary information was collected, and today, you can contact them in case you want to request information or training. During the time the project has been in operation, a database of European ports has been established, many examples of European ports in which the circular economy is implemented have been collected, as well as other examples of good practices from the rest of the world, the main drivers have been analyzed to formulate specific recommendations to develop the circular economy, specific training material has been developed, a web tool providing information about circular economy has been created, a network of European ports focused on circular economy activities has been created, and business models based on real cases have been developed and analyzed for replicability in other ports.

The project has collected data and information from the main 480 European ports. These are broken down into the following categories and number of ports (table 7):

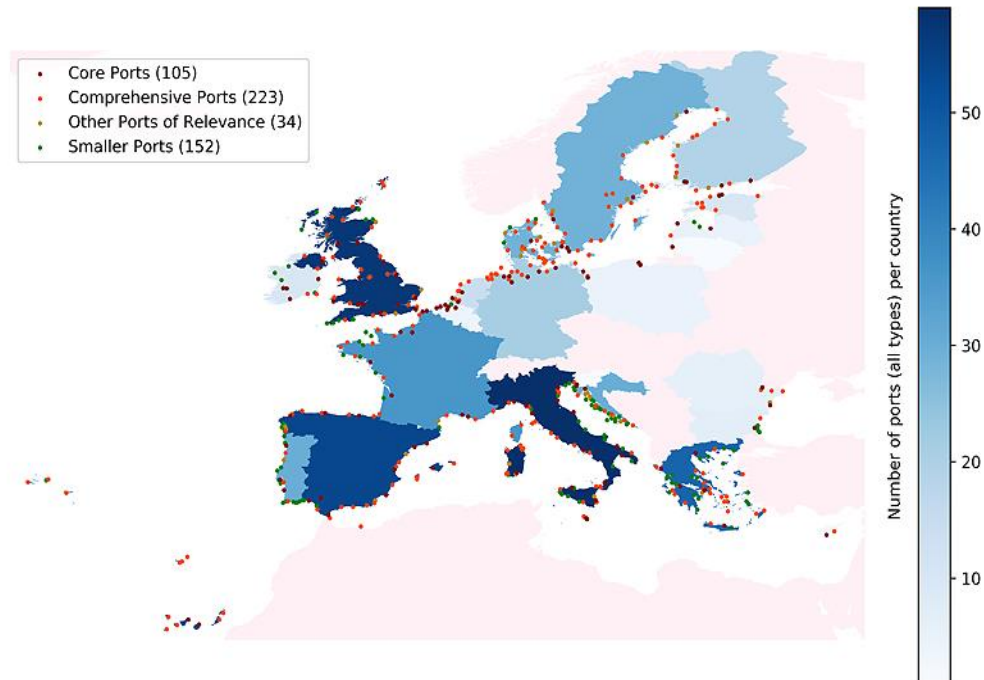
Table 7. Number & type of ports per country

Core Ports	Comprehensive Ports	Other Ports of Relevance	Smaller Ports
105	223	34	152

Source: Adapted from LOOP-Ports project (2021).

The following image (figure 9) shows the distribution of the ports as shown above:

Figure 9. Number & type of ports per country



Source: LOOP-Ports project (2021).

The category of core port and comprehensive port is a division carried out by the European Commission. According to López-Bermúdez et al. (2020) "Core ports are basic or primary ports, while comprehensive ports are for ensuring the accessibility and connectivity of all regions in the European Union, including the remote, insular, and outermost regions, as also pursued by the Integrated Maritime Policy established by Regulation (EU) No 1255/2011 of the European Parliament and the Council".

The categories Other Ports of Relevance and Smaller Ports have been established by the LOOP-Ports project. Other Ports of Relevance are those ports that operate with an annual traffic exceeding one million gross tons or more than one million passengers per year. Smaller Ports are those ports that do not fall into the category of Core Port, Comprehensive Port and Other ports of Relevance.

For the case study, these data will be used to determine the level of implementation of the circular economy in Spain and Europe. Specifically, within Spain there are 13 core ports, 23 Comprehensive ports, 4 Other ports of Relevance and 4 Smaller Ports.

The ultimate goal of this project, therefore, is the implementation of measures that enable a more efficient use of resources, controlling waste and extending the useful life of materials, in order to contribute to more environmentally friendly practices at the end of the process.

As mentioned, there is still a long way to go for Spanish ports to integrate the concept of circular economy into their port management philosophy. There are initiatives such as LOOP-Ports, which offers specific training on the subject. The professionals involved in this project offer, in addition to training, the possibility of establishing contact to hold meetings to establish a more continuous relationship of support for any doubts that may arise during the implementation of the circular economy in the port. In addition, they analyze which actions are the most suitable based on the specific characteristics of each port.

The LOOP-Ports initiative uses different indicators from different sources and information from the seaports' own websites to obtain 4 specific indexes based on material use and reuse: metal, plastic, cement and biomaterial) and one general sustainability index.

The variables taken to build a database and elaborate these 5 indexes were the following:

- Overall characteristics: country, port, latitude, longitude, geographical area, type of port.
- Industrial sector: Fishing traffic, enlargement expectation, general cargo traffic, containerized traffic, etc.
- Statistics: number of port calls, annual gross tonnage handled, number of terminals, etc.
- Environment: ISO 14001 certifications, ESPO members, WPCI members, etc.
- Port management: government model, ownership and management organism.
- Circular economy: local, national, weblink and regional.
- Additional information: port websites and comments.

These five indexes help the platform to calculate and compare the degree of suitability of implementation of circular economy initiatives in ports, as shown in the following table (table 8).

Table 8. Port suitability indexes to circular economy initiatives developed in LOOP-Ports

Index	Parameters
General index	General index that compiles the following parameters: generic parameters, number of shipyards, port extensions, port statistics and environmental parameters.
Plastic index	Index that calculates the plastic generation potential based on the following parameters: generic parameters, total number of annual containers, number of stopovers, number of fishing actions, number of passengers and environmental parameters.
Metal index	Index that calculates the metal generation potential based on the following parameters: generic parameters, port size, general cargo calls, total number of annual containers, number of shipyards and environmental parameters.
Cement index	Index that calculates the cement generation potential based on the following parameters: generic parameters, type of traffics, number of enlargements and environmental parameters.
Biomaterial index	Index that calculates the biomaterial generation potential based on the following parameters: generic parameters, number of port calls, number of fishing actions, number of passengers and environmental parameters.

Source: Adapted from LOOP-Ports project (2021).

The ports in Europe with the best indexes are shown below (table 9):

Table 9. Ports with best score in LOOP-Ports indicators

Country	Port
Estonia	Tallin
Finland	Helsinki, Turku
France	Nantes St. Nazaire, Calais, Fort de France
Germany	Bremerhaven, Hamburg
Greece	Piraeus, Igoumenitsa
Italy	Messina
Netherlands	Rotterdam, Amsterdam
Portugal	Setubal, Aveiro
Slovenia	Khoper
Spain	Valencia, Vigo, Algeciras, Cartagena, Sagunto, Bilbao
Sweden	Stockholm, Gothenburg
United Kingdom	Dover/Folkestone

Source: Adapted from LOOP-Ports (2020).

As we can observe from previous data, in Spain, six ports (Valencia, Vigo, Algeciras, Cartagena, Sagunto and Bilbao) have the ideal conditions for establishing a circular economy in port management. It should be noted that, of the ports classified, three of them are the most important in Spain (Valencia, Algeciras and Bilbao).

In general, Spain shows good results in the indicators with respect to other European countries, standing out above all as a country with more environmental certifications and with more ports that present sustainability reports. It is true that this does not necessarily mean that the circular economy is more integrated at the national level, since, for example, the northern countries are pioneers in the integration of the circular economy in their work philosophy and have few ports with certification and with the presentation of sustainability reports, so, as mentioned above, having these certifications does not ensure the implementation of the circular economy. With regard to membership in organizations with environmental objectives, other European countries stand out in this aspect, such as the United Kingdom, France and Norway. Spain could do more to motivate ports to join green strategy organizations and initiatives such as ECOPORTS, which would help ports to better understand the concept and integration of the circular economy.

A clear example of the impact of this initiative in the Spanish context, was the training workshop on circular economy carried out with the companies of the cluster (group of interrelated companies that work in the same industrial sector) and the port of Valencia itself. In this workshop, the needs of the port were identified and thanks to the project, the port clustered companies established circular economy objectives to be met. These objectives were integrated into the sustainability report that they prepare and present each year, resulting in a major milestone for the project. It has also served at an informative level to train the port clustered companies, in two ways, the first being through the project itself that has achieved that companies have a better awareness of the concept of circular economy and the second through the course that was carried out, where 30 of the most important companies of the Valencia Port were present. In addition, a post-workshop questionnaire was carried out and it was observed that the concept of circular economy was better understood by the clustered companies and solutions in line with the circular economy transition were starting to be thought and applied.

One of the most important company categories who play an important role in this context, the companies that manage waste in the port (private companies authorized by the port authority itself), were also invited to attend the project meetings, which was an achievement even for the port itself, since it was possible to broaden the debate and discussion with these entities that had not participated until now.

Apart from the case of the Valencia workshop, even the official organization “Puertos del Estado” has shared information, collaborated and attended the meetings carried out by the LOOP-Ports project. To have gained the attention and interest of an official state

organization such as Puertos del Estado, is a key milestone since it produces as a tractor force which is a very important factor in the adoption and implementation of the circular economy. In best case scenario “Puertos del Estado” can apply these initiatives in the 28 official port authorities of the state.

The project coordinator, Mr. Jorge Lara, representing the Loop-Ports project, is wishing to work with all Spanish ports who aims to adopt the circular economy. According with his opinion and is very motivated to see more and more ports developing actions and integrating sustainability and care for the environment into their work philosophy. He is very positive in this point while hi is conscious of the work missing.

5. CONCLUSIONS

As we have seen so far, there is a growing awareness of environmental care. This is the reason why new paradigms such as the circular economy are becoming more and more present in society and more precisely in economic activities such as port industry. Even so, it is clear that there is a need to continue to raise awareness among all sectors of the population and to promote training in this area, especially in sectors such as the object of this work, the port sector. As we have seen, this capital infrastructures present many potentially polluting sources as well as resources consumption or wastes generation (fossil fuels, generation and disposal of waste produced by ships, water pollution, air pollution due to bulk goods (feldspar, red clay, ...) among others).

As we have shown in this work, Spain is moving towards a circular transition. According to the official indicators of the level of involvement with the circular economy of the Eurostat, Spain is in a worse position than the European average both in the production of waste and in the recycling and reuse ratios, however, it shows a favorable progress and transition towards circular economy in competitiveness and innovation indicators, such as, for example, in the number of patents and jobs in the field of sustainability. Although these Eurostat indicators do not show the degree of implementation of the circular economy within the port industry, they show us the country's national involvement, which in turn this national involvement gives us an indication of the actions of the industries at country level. To study the involvement and implementation of the circular ideology in the port industry, it is necessary to make use of more specific indicators for this area and this has been one of the aims of this work.

In this work we have proposed a series of indicators to monitor the transition to circular economy specifically in the port industry. These indicators have been developed by the

private initiative LOOP Project and in our opinion reflect in a proper way the key point of circular economy.

The analysis of these indicators makes us to conclude that, Spain shows better results, standing out over the rest of European countries in indicators such as environmental certifications and presentation of sustainability reports. On the other hand, Spain is surpassed in other aspects such as membership in environmental organizations by countries such as France, Norway and the United Kingdom. These indicators at the port industry level offer us a better analysis of the situation and view of the involvement of the port sector with the ideology of the circular economy.

The analysis of the 28 port authorities of Spain shows us that the Spanish port industry does not have a significant integration of the circular economy in its management ideology. In this work we have stress to the fact that not all port authorities in Spain are facing circular transition in the same way, factors such as different management, traceability, and recovery of waste, level of implementation of environmental management systems and control measures and improvement of waste management can be described as some of the cause of this difference.

For all these reasons, it is of vital importance to close circular economy perspective to port industry and to offer new strategies regarding resources management and waste reduction. This proposal focus on the circular economy transition, should be adapted to the characteristics of each port, based on the one hand on technical aspects such as the polluting sources or in relation to the reuse of waste generated; but on the other hand, in organizational aspects such as the property and relationship about public and private coexistence in ports. The transition can be streamlined with the support of the Puertos del Estado organization that governs the different Spanish port authorities by implementing changes that facilitate the adoption of this circular ideology, at organizational level as in the port management system itself.

Although the port is made up of private companies that manage the operational activities (stowage, mooring, transport ...) at the end of the process, the port authorities are responsible for planning and managing the port. The responsibility for the actions carried out by private companies should fall on the port authority to favor a control that allows a transition towards a circular economy in this industry.

Within the analysis of each port, it is necessary to be able to evaluate the long-term effects and benefits of these measures, not only at the port level, but on a larger scale. This type of thinking is associated with the level of social and cultural awareness. In European ports in the northern area, such as Rotterdam, we can see how circular

economy is at the basis of all actions carried out, being the backbone of all management. In Spain, there is no commitment at this level, so there is still a lot of work to be done.

In order to make the implementation of the circular economy in a sector such as the port sector possible, a detailed study of each port must be carried out. It does not consist of the application of general measures that are applicable to all ports because each port has its own characteristics in relation to infrastructure or availability of resources, for example, there are ports that do not have a sustainability department. In our opinion, a distinction must be made, for instance, between ports that have a sustainability department and those that do not. While the first ones will be able to carry out actions and measures towards a circular economy paradigm (such as a reuse of waste, traceability of waste, green purchasing, etc.), those that do not have the resources or a strong infrastructure to have a sustainability department cannot promote specific circular economy actions or measures. In this case they are strictly limited to the actions required by law: waste control, noise pollution, air pollution and obtaining basic certifications.

Maybe for these second type of ports, projects such as LOOP-Ports are capital help as it can offer support, providing information and guidance when implementing circular economy measures. These initiatives are positive since, as we have seen, they have obtained positive results, as for example in the port of Valencia. In conclusion, these projects can be very good drivers of circular economy transition. Therefore, we suggest the need to help from a public perspective to these private initiatives if public institutions want to foster the circular transition.

Parallel to the aspect of the importance of developing sustainability strategies, the role of government authorities in promoting issues such as the circular economy is considered important. They are promoting measures such as the European Union's Green Pact aim to reduce emissions by decarbonizing the maritime sector to 90%, making the European Union climate neutral by 2050. This plan encourages the adoption of sustainable management measures by offering financial support and technical assistance to help companies and organizations make the transition to a green economy. These measures, together with the application of sanctions to those ports that do not comply with the indications given, can serve to encourage greater involvement of companies in caring for the environment, implementing changes towards more respectful and sustainable behavior, reducing waste and reusing materials and extending their useful life. In conclusion, the transition to a real circular economy in these important economic infrastructures.

But the role of institutions may be is not enough to carry out this important change, the companies who are operating within the port, must take the initiative and promote themselves measures and actions that shift towards a more sustainable behavior. This commitment must be integrated into the organization's own philosophy and values without the need to apply measures such as sanctions by external agents. Only with combination of public and private initiatives, the change towards a greener economy will be possible in a shorter period.

In the case of Spanish ports, the companies operating within the port area are private, so the port authority cannot force them to assume commitments beyond those established by Spanish legislation on sustainability. On the contrary, in other European countries, such as those in the north, ports are part of the city, they are an extension of it, and are managed by the city council. This model of port management can facilitate the implementation of common measures to be followed regarding circular economy. In these cases, the city council sees the port as its own, which it has to take care of, it is a responsibility that falls on all citizens, as opposed to the Spanish management model in which the management of the port falls on a few people, those who make up the port authority.

As we showed in this work, Spanish ports have barriers compared to other European ports in terms of lack of information, lack of knowledge regarding the concept of circular economy, lack of legislation to promote these measures and port management independent of the locality where they are located.

However, despite these barriers, Spanish ports are on the way to implementing the necessary measures to have a more sustainable and environmentally friendly port system through the inclusion of circular economy measures.

In conclusion, it is necessary that state policies move forward, in order to motivate port authorities to focus on circular transition as well as to promote interesting international and specialized projects such as LOOP-Ports. These types of projects favor the transition towards a circular economy by bringing the necessary training to those in charge of port management. Through the training and information they offer, awareness is being generated regarding the importance of caring for the environment. In addition, they can offer support to the needs that may arise at the time of implementing the measures in each specific port, facilitating this process, studying each case in a particular way.

However, the indicators proposed by initiatives such as LOOP-Ports are not entirely decisive in judging which ports are better or worse in this area, for example, the port of

Rotterdam is a pioneer in taking circular economy actions and the Netherlands does not stand out in the indicators analyzed. This is in our opinion one of the limitations of our work. We think, it is necessary to carry out a more in-depth and concrete investigation to know the situation of the Spanish port sector in order to know the existing implementation of circular economy actions.

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ANNEXES

Annex I: Mr. Jorge Miguel Lara López interview questionnaire.

Block 1: LOOP-Ports Project

- How did the LOOP-Ports project come about? What is the purpose of the project? What motivated it to start?
- At what point did the need for this project arise?
- Who was the "initiator"? How long did it take to start the project? What resources were needed? What has been the most difficult to obtain to carry out the project? How long did it take and what did it require to start the project?
- Is the project meeting expectations? Is there anything unexpected that is not working as expected? What is going wrong? How do you plan to solve it?

Profile

- No. of employees? Departments?
- Where are your headquarters? Offices?
- Who is in charge of the project?
- No. of participants in the project? How are they involved? How is the project financed?

Block 2: The process of the implementation of the initiative in the european ports

- How does this collaboration come about, i.e., does the port contact you or do you contact the port? ---- what is your role, i.e., how and in what way do you help the port? (What is your job, what do you do?) What is your level of involvement? Who bears the costs?
- How is this process initiated in a port? How do you analyze and find out what practices can be implemented? Who is responsible for this process of need / change / improvement detection?
- How complex is this process? How long does it usually take from analysis to implementation?
- Who is responsible for implementation? Who sets the objectives and indicators? What is the starting point for setting objectives? Who monitors the results and indicators?
- Is there an audit to check that the established good practices are being complied with?
- Is the responsibility for best practices fully assumed by the port or do other stakeholders play a role in this action?
- What are the most common obstacles encountered, what are they due to, how are they usually solved?
- Once the action is implemented, is the benefit seen? in what forms? economic margin? reputation? pollution and emission levels? results are usually seen in what time frame? short/medium/long?

Block 3: LOOP-Ports project in Spanish ports and results

- What is your general assessment of Spanish ports in the field of circular economy? Are they better or worse positioned than other European ports? Do you think that Spanish ports have enough initiative towards change or do they need more motivation from external agents?
- Do you think Spanish ports have enough initiative towards change or do they need more motivation from external agents?
- Are there any impediments to the implementation of circular economy actions in Spanish ports, such as economic, regulatory, lack of willingness, etc. Is the implementation of this initiative on national territory long and complex?
- In what basic general aspects should most of them be improved? Is there any action or actions that you would like to see implemented in all Spanish ports?
- Which are the national ports with which you have worked? What actions were carried out?
- Who was responsible for the implementation and costs?
- What were the established objectives, what results are being achieved, are they as expected and are these practices still being maintained today?
- Which is the most advanced Spanish port in terms of circular economy, and why?
- What is your most ambitious action at national level? Which is the next one?
- Which ports are you planning to work with in the future? why? what do you intend to achieve? when can the opportunity for collaboration arise?
- What are the factors that a Spanish port is conditioned to when implementing circular economy actions (size, resources, geographical position)? (size, resources, geographical position)
- From the implementation, what benefits is the port expected to gain, does it get any kind of social recognition or awards? How do you know that it pays you back for the action? How long does it take to appreciate the benefits of the action?

Assessment

- At an overall level do the Spanish ports you have worked with achieve good results? (Check if good results are being obtained) Do they meet the objectives, is it as expected (worse, same, better)?
- Do they achieve better results compared to other European ports? What is wrong? What could be done to improve the results?
- Sources or means to consult the results and performance indicators of Spanish ports.

Annex II: Ms. Inés López Arias interview questionnaire.

- What are your functions within the port of Castellón?
- How is sustainability managed within the port?
- What concrete actions in sustainability are currently being carried out?
- How does the implementation of these actions work? Who assimilates the costs and the provision of resources?
- What is the port of Castellon's sustainability goals for the future?
- Have you consulted with any organization specialized in the application of circular economy in ports?