valenciaport
Autoridad Portuaria de Valencia

Project Port Authority of Valencia strategy towards Zero Emissions by 2030

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Contents

Part I: Basic information

The Port Authority of Valencia (PAV), under the commercial name of Valenciaport, is the public body responsible for the management of three state-owned ports located along 80 kilometers on the eastern edge of the Spanish Mediterranean: Valencia, Sagunto and Gandía. PAV, like the other Port Authorities, depends on the Ministry of Transport, Mobility and Urban Agenda and is governed by Royal Legislative Decree 2/2011 of 5 September approving the Consolidated Text of the Law on State Ports and the Merchant Navy. This law establishes the role that APV must play in fulfilling the functions entrusted to it and its organizational structure.

The Port Authority of Valencia, aligned with the policies established by the European Green Deal, has established a strategy that aims to reduce drastically GHG emissions from port activity through the implementation of the results obtained from various innovation projects related to energy efficiency, climate impact reduction, circular economy and energy transition from clean fuels and renewable sources. To this end, a collaboration network has been established with about 45 companies from both the Valencia port cluster and other European countries, of which approximately 50% are SMEs and knowledge centres. This conglomerate of companies led by the Port Authority of Valencia will be responsible for the implementation of a series of initiatives included in the APV Strategy towards zero emissions in 2030. In geographical terms, the project has extensive coverage as it includes companies based in 7 Spanish regions, as well as other countries in the vicinity.

On the other hand, the PAV's Strategic Plan sets out its mission and the strategic objectives to be achieved in the coming years. Valenciaport is the leading Spanish port in the Mediterranean in terms of commercial traffic, mainly containerised goods, thanks to a dynamic area of influence and an extensive network of connections with the world's main ports. It is characterised by a cohesive Port Community, through innovative elements such as the Marca de Garantía or the technological platform valenciaportpcs.net and made up of all the public and private agents that provide their services through the ports of Valencia, Sagunto and Gandía. It is not only a key element in the external projection of the Valencian Region, but also the maritime gateway for production and consumption of the entire Iberian Peninsula.

Title and Project tipology	
Project title	Port Authority of Valencia Strategy towards Zero Emissions by 2030
Project tipology	R&D project, technological innovation and first deployments in digitalisation solutions, renewable energies and new fuels to reduce emissions in the Port of Valencia and the modes of transport linked to it and to develop technologies that can be extended to the Spanish port sector.

Value Chain	
Main value chain impacted by the project	Ports and transportation

Location	
Production sites where the project will be carried out	In Spain: Valencia, Madrid, Aragon, Canary Islands, Catalonia, Basque Country, Andalusia In Europe: France, Italy, Greece, Israel, The Netherlands

Planning	
Estimated completion time	2030

Part II: Technical proposal

1) Project objectives

Final objective

The **Valenciaport cluster** has set itself the ambitious goal of making Valencia a **zero net emissions port by 2030.** The aim of the project presented here is to implement the strategy that will enable the decarbonisation of the port of Valencia, which is not only the largest port in terms of commercial traffic in Spain, but also the one that serves the territory in which 55% of the Spanish working population lives and in which 51% of the Spanish GDP is generated.

The project is articulated around **six blocks** of intervention on the value chain of the port sector in which the necessary initiatives are framed to make a port zero emissions (going even further than decarbonisation by also aiming to reduce PM and other pollutants harmful to health). In this sense, in order for a port to achieve zero emissions, it is essential that it has its own renewable energy generation capacity and that it has its own intelligent systems for managing this energy to distribute it, correcting the imbalances between the times when energy is generated with renewable sources and when demand is produced and optimising the management of the port's energy network. This strategy takes into account the climatological conditions of the port of Valencia and avoids interference in any port operations, the first block (Renewable energy) includes an optimal mix of renewable energy development to cover the needs in the 2030 horizon, taking advantage of wind, photovoltaic and wave energy, as well as applying intelligent management systems.

The own generation of renewable energies will also be a guarantee that the hydrogen produced will be 100% green. There is general consensus on the importance of green hydrogen as an energy vector for the decarbonisation of the European economy and, in fact, Spain has already included it in its national plans in this area, with the publication of the Renewable Hydrogen Roadmap in Spain.

This strategy includes quantitative objectives for 2030 regarding the implementation of hydrogen as a fuel in ports, something that the port of Valencia is working on, being the first port in the system to implement hydrogen pilots in port operations in 2021. However, these developments are still very immature in each of the segments of the value chain and, therefore, the second block (Hydrogen technologies) includes the hydrogen production, storage and distribution initiatives that have been considered to cover these gaps.

On the other hand, it is important not to forget the core business of ports, which involves channelling freight and passenger traffic, as large multimodal hubs, and which has a significant impact on the environment. This impact is increased by the existence of certain inefficiencies in the traffic management aspects which, although they are being reduced over time, still persist and make it essential to work along the lines of the activities included in block three (Intelligent energy and freight and passenger traffic management systems) and to fully optimise the management systems of the different dimensions of port traffic. Similarly, another basic role of the ports in an advanced landlord governance model is the provision and maintenance of infrastructures to be operated by the private sector. In this function of the ports there is a niche for improving their carbon footprint by introducing circularity in the works or by proposing eco-efficient infrastructures which are dealt with in block four (decarbonisation of port operations) of decarbonisation of maritime transport, port machinery, works and buildings in port. In this block, not only the infrastructures part has been included but also an analysis of port operations, their environmental impact and the solutions that could best minimise it have been proposed, either as a pilot test (such as the hydrogen pilot boat or the different OPS systems for ships), building supply points and also through hydrogen and electric developments for terminal machinery that today consumes diesel and therefore causes most of the emissions of the terminals.

The fifth block (road transport decarbonisation) is related to the decarbonisation of road transport as the port is, by definition, a modal interchange point in which road has a clearly preponderant share compared to rail and, therefore, its real impact does not end in the port area. This block consists of the deployment of an initial fleet of zero emission lorries which, completed with the supply facilities which will also be put into operation, will facilitate the extension of the decarbonisation objective to the hinterland of Valenciaport.

Lastly, the sixth block (improvement of rail transport) contains initiatives related to improve the usage of the rail transport in ports.

Project description

This project is part of a global strategy of digitalisation and decarbonisation of the Spanish port system. Once the strategy has been implemented in Valenciaport, the activities foreseen in the project can be extended to other Port Authorities, Administrations, the science-technology-business system and companies in the logistics sector at both national and European level.

Project Motivation

The importance of ports as key nodes in logistics and transport chains is indisputable, since 80% of international trade uses maritime transport (according to data from the United Nations Conference on Trade and Development, UNCTAD), while in the case of the European Union, 75% of exports and imports are carried out by sea. For Spain, the maritime mode is used for 60% of exports and 85% of imports, which represents 53% of Spanish foreign trade with the European Union and 96% with third countries. En términos de impacto económico y según datos de Puertos del Estado, la actividad del sistema portuario estatal aporta cerca del 20% del PIB del sector del transporte, lo que representa el 1,1% del PIB español. Asimismo, genera un empleo directo de más de 35.000 puestos de trabajo y de unos 110.000 de forma indirecta.

The context in which this global project is being developed is marked by Valenciaport's clear commitment in relation to the European Green Pact that "transport must be infinitely less polluting", highlighting the urgent need to reduce greenhouse gas (GHG) emissions from the aviation and maritime transport sectors. The need for urgent action in this sector is also marked by the sheer volume by which the sector's emissions would have to be reduced in order to achieve climate neutrality, as a 90% reduction is required. In addition, the maritime and port sector is attracting the attention of the European institutions because its GHG emissions are not covered by the United Nations Framework Convention on Climate Change (UNFCCC).

In this context, ports play a key role, both as interconnection points in transport networks and as important multimodal nodes, logistics hubs and commercial locations. As such, ports have great potential to immediately contribute to the transition towards low-carbon port operations, more eco-efficient land connections and carbon-neutral maritime transport and multimodal mobility. In addition, it should be noted that the port environment allows for testing technologies in a relevant environment and in real operation in a situation of balance between supply and demand thanks to the participation of end users of the port cluster.

Another clear priority for the port sector, understood as a logistics-maritime-port cluster, is digital transformation. In this field, the context is marked by the introduction of a set of emerging digital technologies that are leading innovation in products, services, processes, marketing, sales and business in the logistics, transport, security, environment, energy, trade and public services sectors. Logistics chains and ports as one of their main nodes have proven to be essential for a country's competitiveness, sourcing and foreign sales of its companies. Therefore, the digital transformation of the state port system, making it one of the most modern, efficient and sustainable in the world, is a clear competitive advantage for Spain, not only to guarantee domestic supply, but also to attract foreign investment and boost Spain's export activity, whose contribution to the Spanish GDP is increasingly important for the country's economic development.

The proposed project includes R&D initiatives and first industrial deployments whose final objective is to contribute to the double green and digital transition of the Spanish port system, following the strategic objectives defined by the European Commission.

The projects will be carried out in a cooperative manner between the knowledge centres involved, manufacturers and technologists and user companies of the innovative solutions in the Spanish port clusters, coordinated by the Port Authority of Valencia, thus involving all the links in the value chain of the logistics-port sector, with the intention of showing the backbone of the territory.

The initiatives that will be integrated in the global project will be developed between 2021 and 2030 for the most part, although some of the initiatives are already underway since 2018, and will contribute significantly to increasing the competitiveness of the Spanish port system as a whole, including increases in the productivity of manufacturers and technologists linked to this relevant sector of the Spanish economy, with the capacity for sectoral transformation and a broad impact on employment and the territory.

Specific Objectives of the PAV Strategy Towards Zero Emissions by 2030

- Promote the decarbonisation of the Spanish port system, including the incorporation of the circular economy in port construction projects and port operations.
- Promote the digital transformation of the Spanish port system.

Carry-over effect

The benefits to be obtained from the project will not be limited to the hundreds of companies participating in this project, of which more than 40% will be SMEs, but will generate positive knock-on effects on multiple additional sectors such as the production of components and equipment for renewable energy generation plants (wind, solar and wave power, among others), the construction sector, the software development industry and technological solutions applicable to numerous other fields, to name just three of the major sectors that will feel the knock-on effect of this global project to a greater extent.

The companies participating in this global project are committed to disseminating the new knowledge in an open manner, participating in numerous communication events that will be addressed to all interested companies and individuals, going beyond their only customers and suppliers.

In addition to contributing to the achievement of the direct objectives of decarbonisation and digital transformation of Spanish ports, the actions foreseen in the global project have an impact on:

- Employment, knowledge and research, as specialised employment is required for its execution, boosting the growing demand for employment in the logistics and distribution sector and configuring the project as an engine for attracting talent, knowledge, research and innovation,
- Territorial cohesion, through projects that will promote the integration of the port with the transport networks, which in turn will encourage greater use of rail transport,
- Care for people and social inclusion, through actions aimed at increasing industrial and occupational safety within the port facilities.
- Regional governance and efficient administration, by allowing the sharing of information in real time with all the administrations involved in port activities through the introduction of a data-based economy and management and the creation of a digital ecosystem made up of all the digital platforms with which the port is related, both in the public and private sector.

2) Líneas of action

Within the scope of the project PAV Strategy Towards Zero Emissions by 2030, the lines of action include:

I. First block - Renewable energy generation:

Includes an optimal mix of renewable energy development to cover the needs in the 2030 horizon, taking advantage of wind, photovoltaic and wave energy, as well as applying intelligent management systems.

II. Second block - H2 Production, storage and distribution:

The own generation of renewable energies will also be a guarantee that the hydrogen produced will be 100% green. There is general consensus on the importance of green hydrogen as an energy vector for the decarbonisation of the European economy and, in fact, Spain has already included it in its national plans in this area, with the publication of the Renewable Hydrogen Roadmap in Spain.

This strategy includes quantitative objectives for 2030 regarding the implementation of hydrogen as a fuel in ports, something that the port of Valencia is working on, being the first port in the system to implement hydrogen pilots in port operations in 2021. However, these developments are still very immature in each of the segments of the value chain and, therefore, this block includes the hydrogen production, storage and distribution initiatives that have been considered to cover these gaps.

III. Third block – Intelligent energy and freight and passenger traffic management systems

Ports have a significant impact on the environment. This impact is increased by the existence of certain inefficiencies in the traffic management aspects which, although they are being reduced over time, still persist and make it essential to work along the lines of the activities included in block three and to fully optimise the management systems of the different dimensions of port traffic.

IV. Fourth block - Shipping, port handling machinery, ports' works and buildings decarbonisation:

In this block, not only the infrastructures part has been included but also an analysis of port operations, their environmental impact and the solutions that could best minimise it have been proposed, either as a pilot test (such as the hydrogen pilot boat or the different OPS systems for ships), building supply points and also through hydrogen and electric developments for terminal machinery that today consumes diesel and therefore causes most of the emissions of the terminals.

V. Fifth block - Incorporation of zero-emission hydrogen-based technologies for road transport

This block consists of the deployment of an initial fleet of zero emission lorries which, completed with the supply facilities which will also be put into operation, will facilitate the extension of the decarbonisation objective to the hinterland of Valenciaport.

VI. Sixth block - Improvement of the railway network within the port for a better and more efficient utilisation

This block contains initiatives related to improve the usage of the rail transport in ports.

3) Overall Project summary

As mentioned above, and focusing on the Zero Net Emissions by 2030 project in Valenciaport, it is important to highlight that the clear commitment of the European Green Deal is that "transport must be infinitely cleaner", highlighting the urgent need to reduce greenhouse gas (GHG) emissions from the aviation and maritime transport sectors. According to rigorous estimates and taking into account intra-regional trade, approximately 80% of world trade moves through ports and maritime transport accounts for 13% of EU transport GHG emissions, a share that is growing steadily year on year. The need for urgent action in this sector is also marked by the sheer volume by which the sector's emissions would have to be reduced to achieve climate neutrality, as a 90% reduction is required. In addition, the maritime and port sector is attracting the attention of European institutions because its GHG emissions are not covered by the United Nations Framework Convention on Climate Change (UNFCCC).

Considering the potential of ports to contribute to the ecological transition, the Valenciaport cluster has set itself the ambitious goal of making Valencia a zero net emissions port by 2030. The aim of the project presented here is to develop the action plan that will enable the decarbonisation of the port of Valencia, which is not only the largest port in terms of commercial traffic in Spain, but also the one that serves the territory in which 55% of the Spanish working population lives and in which 51% of the Spanish GDP is generated.

30 actions or projects have been selected considering the previously listed work to achieve the objective of this PAV Towards Zero Emissions in 2030 project. Some of them have already started to be implemented and others will be implemented from 2021 with a 2030 horizon.

I. Energy generation from renewable sources:

a. 2.1 MW Photovoltaic plants:

The project consists of the installation of two photovoltaic plants for the generation of energy for self-consumption by Valenciaport at the Valencia and Gandía facilities. The total estimated energy to be installed is 700 kWp in the port of Gandía and 1,460 kWp in the port of Valencia.

In addition, various technologies will be tested that are already on the market or are very close to coming onto the market that will maximise energy production in maritime-port environments with the least maintenance required. These technologies will include the type of solar panels to be installed, as well as the structures that support them.

b. 15 MW wind power plant for the production of renewable energy for self-consumption in the port of Valencia.

The project consists of the installation of wind turbines with a minimum installed power of 15 MW, which will seek to maximise energy production in the area around its location. The location will be on land, next to the northern extension of the port of Valencia and its use will be for the self-consumption of the services and installations of the port of Valencia.

The aim is to install turbines that can withstand maritime atmospheric conditions but will be located on land, so innovative development will be needed to integrate them into the port infrastructure itself in a way that makes the intended use of the infrastructure compatible with the highest possible energy production from the turbines.

c. 3 MW hybrid wave/solar power generation system

The project consists of the development and installation of a 3 MW wave energy project with innovative technology for the generation of clean electricity from the ocean and sea waves in the Port of Valencia.

d. Photovoltaic pilot plants with heterojunction technology

The project deals with the optimisation of production by means of innovative photovoltaic systems adapted to a port environment with a dual functionality to:

1. generate integrated renewable energy in specific areas suitable for this purpose but not used for operations (e.g. along breakwaters, on the roofs of buildings and in covered parking areas, creating an acoustic barrier between the port operations areas and the city, among other areas).

2. Enable a multi-function of the photovoltaic module: lighting, noise barrier, signal, visual

e. Port-linked off-shore wind turbine with integrated hydrogen production

The pilot consists of the installation of an offshore wind turbine generator (WTG) with a nominal power of 3 MW outside the harbour breakwater. The exact location, which will have to be defined exactly during the preparation of the final tender and especially in the first design phase, is assumed to be in a water depth of 20 to 30 metres. For the installation of the wind turbine, and considering the water depth in the installation area, an innovative system will be tested which, if validated, would allow in later phases to reach an industrial process in the manufacture and installation of these elements for this water depth.
The wind turbine will be used to generate the energy needed to power an alkaline electrolyser, which produces hydrogen from water as an energy source for port facilities or equipment.

II. H2 production, storage and distribution of clean fuels:

a. 1 MW electrolyser in the port of Valencia

Development, construction and operation of an electrolyser of around 1MW in the Port of Valencia to supply renewable hydrogen to the various innovative pilots to be carried out within the port. Based on the results of a study of the technical requirements for hydrogen production, a state-of-the-art electrolyser will be procured from the market to produce the required renewable hydrogen. It will be able to produce more than 420 kg of H2 per day, with an annual total of 54,000 kg (3,000h of operation). The source of the renewable energy will be the photovoltaic plants to be installed by the Port Authority of Valencia in the port of Valencia, totalling 7.5 MW.

b. Mobile hydrogen supply station

Taking into account that it will be necessary to upgrade the hydrogen plant that is being developed within the framework of the H2Ports project (https://h2ports.eu/) and which will operate in the Port of Valencia from mid-2021. It will have a fixed part which includes reception, storage of H2 at low pressure and compression, and a mobile part with high pressure storage at two pressure levels (300 and 450 bar) and the dispenser. Given the increase in consumption compared to that planned for H2Ports, it will be necessary to double the fixed part, so that it will be possible to supply up to 200 kg of hydrogen for equipment with hydrogen storage at 350 bar.

Action started in 2019.

c. LNG and hydrogen supply station for trucks in the port of Valencia

A hydrogen and LNG refuelling station project for trucks is proposed, with the following criteria:

- Low-maintenance, oil-free hydrogen compressor, including water cooling system. Capacity approx. 800 kg/day from 40 bar to 900 bar, with intermediate pressure inlet, including cooling system and weather insulation.
- Storage system in metal tanks type I, with a total capacity of 1000 kg divided (approximately) into 400 kg high pressure (900 bar) and 600 kg medium pressure (500 bar).
- High-speed dispenser for trucks, according to standard, with 700 bar and 350 bar nozzle, with precision mass flow meter.
- Cooling system (chiller) to guarantee dispensing accuracy.
- Valve equipment
- Safety systems
- Control system for preventive maintenance and incident detection, with telematic sending of signals to centralised system (SCADA).

d. Methanol synthesis plants with green hydrogen and CO2 from capture processes

The ambition of this pilot is to demonstrate at scale the production of green methanol using renewable electricity, CO2 capture in the air and co-electrolysis of water-CO2.

e. Bateries for storage of clean energy

The objective of this innovation is to test and validate the concept of an energy self-sufficient grid in an industrial port which will be tested in the port of Valencia managed by the Port Authority of Valencia. The integration of energy storage units and the use of innovative tools related to synchronised control systems will optimise the photovoltaic, wind and wave energy self-consumption system, smoothing high peak demand and facilitating the management of renewable generation.

III. Intelligent energy and freight and passenger traffic management systems:

a. Intelligent energy management system with digital twin and optimisation, training and simulation modules.

An Intelligent Digital Energy Management System for Green Ports will be developed, comprising a Digital Energy Twin based on machine learning algorithms and advanced modelling and simulation tools, focused on demonstrating the integration of low emission hybrid energy use and generation providing support in the planning, management, monitoring and control of the different energy resources (consumption, renewable energy generation, storage systems...) with the final objective of demonstrating the success of the integration of sustainable energy supply and production in ports and supporting the decision making of the Port Authority.

b. Intelligent freight traffic management system

This action aims to introduce new elements of automation and artificial intelligence and machine learning systems based on data collected in real time on port operations to add greater intelligence to the different services and operations carried out in terminals and other logistics facilities located in the port.

Action started in 2020.

c. Intelligent traffic management system for light vehicles and cruise passengers

The Project aims at:

1) Solving the mobility problems arised from a Cruise Terminal, by:

- Giving the needed information to all transport-service-chain agents involved (turists, taxi, bus,
- terminal managers, etc).
- Giving to the terminal managers the proper tolos to accomodate properly the supply and demand of transportation services.

2) Measuring the environmental impact of the vehicles running at the terminal

3) Analysing the mobility of the turists landing to the most visited places of the city

4) Improving the port cargo logistic chain efficiency

The solution proposes a "Global Smart Ports" IT platform that would integrate:

- A global sensorisation system (IOT) in port in charge of collecting the necessary information to enable better decision making throughout the value chain.
- An ecosystem of "Smart Mobility Ports" applications in charge of managing the mobility information associated with all terminals (passengers and goods).
- A "Logistic Supply Chain Ports" application ecosystem in charge of managing the information associated with the movement of goods within the port

d. Intelligent maritime traffic management system

The project aims to optimise port call processes through the digital transformation of these, managing large volumes of structured information in real time and usable by the different port stakeholders involved, the ships and the shipping companies themselves for collaborative decision-making.

IV. Decarbonisation of maritime transport, port machinery, works and port buildings:

a. H2 powered port pilots' craft

In this project, the existing facilities of the H2PORTS project will be used, where there will be a semi-portable hydrogen refuelling infrastructure, which is of great value, as it allows the project costs to be optimised and, on the other hand, European funds will be used more intensively by giving continuity to the infrastructure. Once the craft has been designed, built and approved to operate in real conditions, she will be tested in real conditions, where the necessary data will be taken and analysed, looking for optimisations to be implemented in future vessels.

b. On-shore energy supply facility based on hydrogen and methanol

The technical solution consists of a methanol reformer capable of producing high-purity hydrogen in a single reforming and separation unit. The hydrogen is then used directly in a fuel cell to produce electricity. The ambition is to demonstrate that renewable methanol is a safe, cost-effective and alternative fuel for on-shore power generation.

c. On-shore power supply facility for ferries

The project aims at the promotion, construction and subsequent operation of the infrastructure necessary to supply electricity to the ships.

- This will require a connection to the distribution network, which will be more or less complex depending on the network's capacity to absorb the power demanded.
- Then, depending on the ships to be supplied, frequency variation equipment will be needed (there are ships whose frequency is 60 HZ when the frequency of the distribution network in Europe is 50 HZ).
- Once the frequency has been transformed, it will be lowered from the distribution voltage to the ship's supply voltage (6 kV or 400 V).
- And finally, the necessary elements for a correct connection of the conductors from the quay to the ship (cranes, supports, connectors, etc...) must be developed.

d. Ships' retrofitting to become OPS ready

One of the main shipping companies working at the port of Valencia Will overcome the retrofitting of four (4) vessels of their fleet to become OPS ready.

e. On-shore power supply pilot for a containership

This Project will test an innovative OPS system in a port container terminal in Valencia. Once the viability of the prototype has been demonstrated, the aim is not only to continue providing the electricity supply service at the MSCTV terminal, but also to extend the concept developed to the other two container terminals, which operate in the Port of Valencia with similar quay characteristics.

Action started in 2021.

f. Hydrogen fuelled Terminal tractor and reach stacker

Action started in 2019 within the H2Ports project framework and it consists of testing new machinery within normal working condition in two terminals at the port of Valencia.

g. Autonomous truck for closed-loop goods transport

The Smart Port concept requires the use of technologies to transform logistics services into interactive, point-to-point services that are more efficient, transparent and aimed at providing added value to the end customer, as well as pursuing an environmental commitment to be a sustainable port.

The aim of the project would be to advance in the provision of strategic technologies that bring us closer to the port of the future (Smart Port) as the only way to meet the growing demands of efficiency, economy, safety and environmental compatibility according to the "Industry 4.0" concept and with the highest levels of automation, such as those required in scenarios that integrate different automated land transport vehicles (GVs) in port operations.

h. Oxy-combustion

This pilot develops an advanced propulsion system (APS) based on a reciprocating internal combustion engine (RICE) that produces its own O2, separating it from atmospheric air by means of a thermally integrated membrane module based on a mixed ionic-electronic conductor (MIEC), to operate with oxy-fuel combustion.

i. Communication and data exchange of a hydrogen truck according to ICT 4.0 semantics.

It will include an equipment communication and data exchange system according to ICT 4.0 semantics, thus being the first CVH and the first TTCH to use these semantics to communicate via a peripheral device. These semantics will be established for a completely new, decarbonised driving installation, which is a new content and addition to the current ICT 4.0 semantics. Alongside communication, the innovation will also provide a platform for the refuelling strategy. Based on truck performance and energy consumption over time, an efficient refuelling strategy can be calculated, based on the customer's available refuelling/charging systems.

j. Use of hydrogen generators to provide clean energy for port Works

These H2 generators will be used to consume hydrogen to provide electrical energy for machinery, temporary office cabins, bathrooms and rest rooms for site personnel on two major construction sites in the port of Valencia: the construction of the northern extension and the international zero-emission passenger terminal.

k. Eco-efficient passenger terminal (including photovoltaic glass, mini-wind turbines, electrolyser, batteries...)

A 100% self-sufficient international passenger terminal project will be implemented, with generation and storage of renewable energy in the terminal itself. Energy is generated with photovoltaic and mini wind power production, using lithium battery storage and in the form of hydrogen, in order to be able to obtain energy for 100% of the demand at any time the Terminal needs it.

The Terminal's photovoltaic generation will have surplus production during peak photovoltaic production hours, accumulating part of this energy in the lithium batteries, and the surplus will be used for hydrogen production, which will be compressed and stored in high-pressure cylinders to be used in the 20 kW fuel cell, which will recharge the system's lithium storage, in order to use this energy for the Terminal itself.

l. Eco-design and circular economy pilots on construction sites

The main objective is the development and validation of technologies that allow the introduction of concepts of circularity in the construction of port infrastructures, through the use of approaches linked to the procurement of secondary raw materials derived from models of industrial symbiosis with the port as the central axis and the eco-design of these infrastructures considering the complete life cycle of the same. In addition, it will be validated through the construction of a demonstrator of these technologies in a port environment by means of the execution of a section of road within the port and of an eco-designed construction relating to concrete port infrastructures.

m. Acoustic panels with PM capture

The overall objective of this initiative is the development of an innovative solution to substantially reduce two environmental problems related to the development of activities in the logistics area of the substantially reduce two environmental problems related to the development of activities in the logistics area of ports, namely port logistics area, atmospheric pollution and noise levels.

To this end, a system based on the technology known as "sound crystals" is proposed to create a permeable acoustic barrier with the capacity to capture atmospheric pollutants that are very harmful to health, suspended particles of PM 10, PM 2.5 and smaller diameters.

n. Reefer power consumption monitoring system.

Energy consumption from reefers is currently the primary source of energy consumption in a container terminal, which can lead to serious power supply problems for the terminal. This project proposes the development of a system for monitoring the electrical consumption of refrigerated containers, in order to provide a better service to its shipping customers, who will soon be demanding it anyway. This system could be replicated in other terminals.

V. Incorporation of zero-emission hydrogen-based technologies for road transport:

a. Hydrogen and fuel cell pilot project in road transport

Although the development of the technological part is outside the scope of this project, the main innovation of the project is the testing and initial deployment of a technology that will be used for the first time in the road transport sector working in the port of Valencia.

VI. Improvement of the railway network within the port for a better and more efficient utilisation:

a. Improvement of the railway network in the ports of Valencia and Sagunto.

Construction of a new railway line, elimination of level crossings and reorganisation of the road network in the ports of Valencia and Sagunto.

4) Expected results

The expected results of the project include the development and implementation of each of the initiatives included:

I. Market

a. Situation of the national market in which the project takes place

The **main value chain** on which the project has an impact is that of transport and ports. The description of the Global Project has already mentioned the undeniable importance of maritime transport for international trade and of ports in particular as nodes of modal exchange and interconnection of transport networks. This condition as a chain at the service of a country's productive sector makes ports a priority axis with a knock-on effect for improving a country's productive efficiency.

Spain is a country with a large coastal area, where the state-owned port system is located, with 46 ports managed by 28 port authorities. Reviewing data included above, in 2019 (the last year with closed statistics) the port system moved more than 564 million tonnes, 17.5 million TEUs and handled 170,000 calls of merchant ships and 4,236 cruise ships. If we compare these figures with those of the previous decade, in 2019 total port traffic reached 413 million tonnes and 113,000 merchant ship calls were recorded, while, with regard to container traffic, 2009 closed with a figure of 11.8 million TEUs, all these figures showing considerable growth in the last decade, marked by the financial crisis and the subsequent recovery.

Likewise, from a financial point of view, during the last year, the port system achieved a turnover of more than 1,150 million euros, with a pre-tax result of 276 million euros and an EBITDA of 646 million euros. In terms of economic impact, when analysing the effect of port activity on the rest of the economy, and according to data from Puertos del Estado, the activity of the state port system contributes close to 20% of the GDP of the transport sector, which represents 1.1% of the Spanish GDP. It also generates more than 35,000 jobs directly and 110,000 indirectly.

In the specific case of the port of Valencia, which will be the pivotal point of this project, it should be noted that it is the leader in container traffic in the Western Mediterranean, reaching a record of 5.4 million TEUs channelled through its facilities in 2019, with a more than remarkable growth in the system over the last two decades, serving a large hinterland that includes more than 50% of the Spanish working population. In terms of connectivity, the Port of Valencia is also a leader in Spain, as shown in the ranking drawn up by UNCTAD on the basis of the results of the Port Connectivity Index, where it occupies 21st position worldwide.

In financial terms, Economic Sustainability is key to fulfilling the Mission of the Port Authority of Valencia, which is why the main objective has been set as the optimisation of income, costs and investments to ensure self-financing in the short and long term. In order to ensure economic sustainability, the APV has established in its Strategic Plan the challenge of improving profitability and revenue (above traffic growth and inflation), as well as modulating investments and costs to ensure economic self-sufficiency and the availability of infrastructures and services that make it possible to increase revenue.

Specifically, in 2019 the net consolidated turnover of the Port Authority of Valencia reached 139.7 million euros, with the result for the year being 24.4 million euros.

In terms of economic impact, the latest study available analyses the impact of the activity linked directly and exclusively to the goods moved in 2016, omitting passenger, fishing and sporting activities, with the following results, which highlight the social and economic dimension of the port.

- The total economic impact of the Port Community of Valenciaport is estimated at a GVA that follows a growing trend, exceeding 2,499 million euros in 2016, representing around 2.39% of the Valencian Community. This figure represents the 683 million euros generated by the initial activity of Valenciaport and by the economic impact that its activity generates in the companies of the port community, which amounts to 1,817 million euros, considering the direct effect, the indirect effect and the induced effect.
- The Direct Effect is the most relevant impact with an employment volume of 16,367 workers in 2016, representing 1.67% more than in 2015. The sum of the workers of these infrastructures together with their total economic impact amounted to 866 jobs, representing around 2.10% of total employment in the VC.
- The tertiary sector accounts for almost 61% of the total impact of these infrastructures as a whole, with "Trade and repairs", "Transport and communications" and "Real estate and business services" standing out.

This project is perfectly in line with the mission of the Port Authority of Valencia, which is to "Sustainably promote the mobility of people and goods and the external competitiveness of the business fabric of its area of influence through a competitive offer in terms of quality and price of port, maritime, intermodal and logistics infrastructures and services". This sustainability has several aspects:

- Economically sustainable: optimising income, costs and investments to ensure the APV's short and long-term self-financing.
- Socially sustainable: favouring territorial integration and coexistence with the different members of the society it serves.
- Environmentally sustainable: making efficient use of resources, minimising and balancing negative impacts on the territory and the environment.
- Aligned with European transport policies: promoting intermodality, digitalisation, decarbonisation, innovation, safety and employment.

The **secondary value chain** affected by the project is the construction sector. The construction sector in Europe and, in particular in Spain, has a significant impact, both in terms of macroeconomic figures and in terms of its potential impact, due to the amount of natural resources it mobilises. With regard to the first element, although the sector has lost importance in the last ten years and according to INE data, in 2006 its contribution to Spanish GDP was 10.8%. At the end of 2018, this figure stood at 5.6%, after remaining stagnant at 5.2% in 2014 and 2015.

In terms of its impact in terms of resources and just as an example, it is known that the construction and use of buildings in the European Union represents

- 40% of final energy consumption
- 35% of greenhouse gas emissions
- 50% of all materials extracted
- 30% of water consumption
- 35% of the total waste generated
- 54% of demolition materials are sent to landfill, while in some countries only 6% of demolition materials are sent to landfill.
- Building produces 71% of the construction and demolition waste produced compared to 29% for civil works influence through a competitive offer in terms of quality and price of port, maritime, intermodal and logistics infrastructures and services". This sustainability has several aspects:

- Economically sustainable: optimising income, costs and investments to ensure the APV's short and long-term self-financing.
- Socially sustainable: favouring territorial integration and coexistence with the different members of the society it serves.
- Environmentally sustainable: making efficient use of resources, minimising and balancing negative impacts on the territory and the environment.
- Aligned with European transport policies: promoting intermodality, digitalisation, decarbonisation, innovation, safety and employment.

As can be seen, the construction sector is one of the key sectors of our economy, which mobilises more natural resources, especially non-renewable ones, which is why its conversion to a circular economy is key, given that its optimisation and reduced use of resources will help to generate a less dependent, more competitive and resilient economic system in the face of economic and environmental crises.
The conversion to a circular economy is key, given that its optimisation and reduced use of resources will help to generate an economic system that is less dependent, more competitive and resilient in the face of economic and environmental crises. Although there is no system of indicators to assess the circularity of this sector, which will be one of the aspects of debate reflected in this document, by way of example, it can be seen that currently only 40.9% of the declared CDW waste is recovered in some way, when the target set at EU level for 2020 is 70%. The transition of the construction sector towards a circular economy will not only imply a significant reduction of natural resources and environmental impact, but will also mean an economic opportunity derived from the competitive advantage, as well as a better restitution and regeneration of natural capital, if the necessary restoration processes are developed.

After the brief context that defines the value chains on which the project has an impact, it is considered that the initiatives included in this project are framed in three markets with a direct impact on the transport chain, namely the **market for energy generation with renewable sources, the market for H2 production, storage and distribution of clean fuels and the market for intelligent management systems**.

Market for energy generation with renewable sources

Renewable energies are defined as energy sources that are generated continuously or, at least, in time scales comparable to human life, as opposed to fossil fuels. They are known as clean energies as they are based on the use of natural energy resources, representing an inexhaustible source of energy with little environmental impact. For all these reasons, the development of renewable energies is a fundamental tool in the fight against climate change and, thanks to their indigenous nature, they contribute to the serious problem of energy dependence and favour the development of new technologies and job creation.

By virtue of these advantages, clean technologies are being promoted by the European Union (EU), which ratified the Paris Agreement in 2016 to provide an international and coordinated response to the challenge of the climate crisis. That same year, the European Commission presented the so-called "winter package" ("Clean Energy for all Europeans") whose main binding targets are a 32% share of renewables in total gross final energy consumption by 2030 and a 40% reduction in greenhouse gas (GHG) emissions compared to 1990. Here it is worth noting the recent announcement that EU member states are increasing their GHG emission reduction commitment to at least 55%, which implies greater ambition in energy efficiency and renewable.

In line with the Paris Agreement, on 28 November 2018 the European Commission presented its long-term strategic vision ("A clean planet for all") committing to a climate-neutral economy by 2050. Along these lines, the European Green New Deal was announced at COP25 in Madrid, where renewables are a key element for the creation of jobs and wealth. For all these reasons, the Spanish renewable energy sector enjoys an unstoppable projection supported at national level by the Climate Change and Energy Transition Law, the National Integrated Energy and Climate Plan (PNIEC) 2021-2030 and the Just Transition Strategy.

Achieving climate targets requires decarbonising the energy system, which is responsible for three out of every four tonnes of GHGs emitted into the atmosphere. This requires a transition from fossil fuels to efficiency and renewable, while at the same time electrifying a considerable part of thermal and transport demand.

The target set by the PNIEC for 2030 is for 74% of electricity generation in the electricity mix to be of renewable origin. Royal Decree 960/2020, of 3 November, which regulates the economic regime for renewable energies for electricity production facilities, establishes that the awarding of the economic regime for renewable energies will be carried out by means of auctions, the first of which is planned for the end of January 2021.

Looking back over the last ten years, it should be noted that, despite the good moment currently being experienced by the Spanish renewable energy market, which is currently a fundamental part of economic growth, reaching 1% of Spain's GDP last year, this has not always been the case in the last decade.
decade. Unfortunately, the sector suffered a hard blow at the beginning of 2012 with a renewable energy standstill that led to the installation of only 27 MW and 43 MW in 2015 and 2016, respectively. This paralysis in generation with renewable energy sources led to an energy dependence on imported fossil fuels, which reached an all-time high in 2008 when it reached 81.3%, a value much higher than the EU average, which has remained stable over the last few years.

Despite this paralysis, the sector has been recovering since 2016 and 2017, when photovoltaic and wind auctions were launched. In this sense, CO2 emission-free technologies (renewables and nuclear) accounted for 54.8% of total national production in 2010 and closed the decade with 59.6% of the total.

On the external side, the renewables sector has become a relevant player in the national economy, specifically in its contribution to Spain's trade balance, where the positive export balance amounted to 1,186 million euros, with 4,273 million euros of exports of goods and services. The sector is consolidating its position as an engine of economic recovery with a large market that can lead if renewable development is linked to national industrial regeneration. However, the renewable sector alone cannot compensate for the large energy deficit (-23,242 million), which accounts for 72.6% of the entire Spanish trade deficit (-31,980 million).

Thanks to the incorporation of clean energies, the import of 20,732,240 tonnes of oil equivalent (toe) of fossil fuels was avoided in 2018, which generated an equivalent economic saving of
8,547 million euros. As a result, atmospheric emissions of 56,659,226 tonnes of CO2 were avoided, saving 899 million euros in emission allowances.

Currently, the Spanish renewable energy sector, where wind, hydro and photovoltaic energy stand out, is going through a good moment with a growth of 10.7% in 2018 and 15.6% in 2019, the highest growth rates since 2012, contributing 12,540 million euros to GDP and employing 95,089 people both directly and in jobs induced in other sectors of activity.

In this regard, 2019 has been a very significant year, with two milestones: the publication of the PNIEC, whose maximum investment item (38%) is for renewable energies, and the record renewable installation of 7,051 MW in both large grid-connected plants and distributed self-consumption facilities. According to provisional data from the Ministry for Ecological Transition and the Demographic Challenge, 18.1% of final consumption from renewables was reached in 2019, bringing us closer to the target of 20% by the end of 2020.

The latest data, according to REE's press release forecasting the end of 2020, the national electricity mix is made up of nuclear (22.2%), wind (21.7%), combined cycle (17.8%), hydro (11.9%), cogeneration (10.8%), solar photovoltaic (6.1%) and coal (2%). In summary, renewable energies accounted for 43.6% of all electricity in Spain, 6.1% more than in 2019, contributing to reducing CO2 equivalent by 27.3% compared to the previous year. The clean energy with the greatest presence has been wind power, although solar photovoltaic also stands out for increasing its generation by 65.9% compared to 2019. In contrast, coal has cut its production by 60% compared to 2019 due to the closure of seven thermal power plants, reaching the lowest share in the national generation structure since records have been kept.

In conclusion, these figures show how Spain is advancing in the energy transition and the projection of the renewable sector so that 74% of all Spanish electricity generation in 2030 will be of renewable origin.

The growing competitiveness of photovoltaic solar energy drives its installed capacity to exceed that of wind power by 2025, hydroelectric power by around 2030 and coal by 2040. In fact, in the baseline scenario (NPS), renewables and coal change places in the electricity mix: the share of generation from renewables rises from 25% today to around 40% between 2018 and 2040, while coal follows the opposite path.

Focusing on solar photovoltaic technology, it has proven to be highly cost-competitive as an energy production technology worldwide, demonstrating costs below $40/MWh. Several hundred MW plants are in the process of being installed or have already been installed demonstrating the competitiveness of the technology for large plants. Bifacial technology started to be implemented only 2-3 years ago, and currently more than 50% of plants are designed bifacial thanks to an increase of the generated energy (depending on the albedo) up to 10% of the frontal production depending on the technology. Heterojunction cell technology is the technology that today demonstrates both the highest frontal efficiency (exceeding 25%) and high bifaciality (>90%). These properties are leading to a take-off in the production of this technology, which is expected to exceed 5-10GW in the next 5 years.

Port PV installations are few (and small) and unmonitored and it is a test bed to see degradation phenomena linked to the saline environment and also to prepare the knowledge for marine PV technology. The interest of the project is also to demonstrate its installation without losing useful land use for the port by looking at the design of smart structures and implementations.

From a technology point of view, all the renewable sources present in the national energy mix are the following: biofuels, biomass, wind, geothermal, marine, mini-wind, mini-hydro, solar photovoltaic, solar thermal and solar thermoelectric. Overall, renewables contributed 15.1% of primary energy in Spain, with thermal renewables contributing 6.9% of final energy. In terms of electricity production, renewables contributed 37% of consumption in 2019. For example, in the electricity system, the power installed in 2019 in the peninsula is 104,936 MW, of which 38%, 39,607 MW, are renewable.

According to IRENA figures, 72% of the world's installed capacity in 2019 was renewable, of which 90% was wind and solar photovoltaic. The large-scale international development of renewables over the last decade has led to a substantial reduction in their relative costs to the point where cheaper electricity is generated mainly by wind and solar in new capacity. Specifically, in the period 2009-2020, photovoltaic technology has reduced its costs in terms of generation by 90%, and wind and solar have reduced their costs in terms of generation by 90%.
generation by 90% and wind has achieved cost reductions, in terms of electricity generated, of 71%.

At the same time, the cost of battery storage continues to fall rapidly and is increasingly competing with natural gas-based combined cycle peaking plants to manage short-term fluctuations in supply and demand.

Market for production, storage and distribution of clean fuels

With respect to the second key market, renewable hydrogen, as discussed in previous sections of this document, it is set to become one of the main energy carriers in the long term, due to its climate-neutral production and consumption. However, in the current situation, at EU level, 95% of the hydrogen consumed is known as grey hydrogen, i.e., that which is generally obtained from hydrocarbons using catalytic methane reforming (Steam Methane Reforming). In Spain, annual hydrogen consumption comes mainly from refineries (70%) and the chemical industry (255), amounting to 500,000 tonnes, practically all of which is grey hydrogen, with its consequent impact in terms of emissions. Specifically, the European Hydrogen Strategy includes net emissions of 9 kgCO2eq/kgH2 from the source to the door of reforming with natural gas vapour and practically zero emissions for hydrogen produced by electrolysis, using IEA data.

For its part, the port of Valencia will be the first in Europe to incorporate hydrogen energy to reduce the environmental impact of its operations thanks to the European H2Ports project, coordinated by the Valenciaport Foundation. The action proposes the realisation of different pilots until 2023 to bridge the gap between prototypes and pre-commercial products:

- The first prototype will consist of a hydrogen-powered reach stacker vehicle tested in a real test, in a port container terminal.
- The second prototype will consist of a 4x4 tractor unit (terminal tractor) equipped with fuel cells for testing in the loading/unloading operations of a Ro-Ro terminal.
- The third prototype will consist of a mobile hydrogen supply station, which will provide the necessary fuel in the right conditions and quantity to ensure the continuous working cycles of the above mentioned equipment.

The H2Ports project also has the transversal objective of carrying out feasibility studies for the development of a sustainable hydrogen supply chain in the port, coordinating all the actors involved: clients, hydrogen producers, suppliers, etc.

The small size of the renewable hydrogen market in Spain, and Europe, is explained by its lack of cost competitiveness with the current state of technology, so it is vitally important to start up R&D&I projects that enable the development and deployment of the technology in all the links of the hydrogen chain, i.e., production, storage, distribution and consumption. This is the only way to achieve the objectives set out in the Hydrogen Roadmap drawn up by the Spanish government, which aims to achieve an installed capacity of 4 GW of electrolysers by 2030, with an intermediate milestone of between 300 and 600 MW by 2024. The objectives are not only limited to energy production, but the Hydrogen Roadmap also includes goals in industrial matters, establishing that 25% of industrial hydrogen consumption will be of renewable origin, or in the field of mobility, setting the objective of creating a fleet of at least 150 buses; 5,000 light and heavy vehicles; and 2 lines of commercial trains powered by renewable hydrogen. In the port sector, the implementation of hydrogen-powered port machinery is expected in the five main Spanish ports.

In short, green hydrogen is one of the main levers for decarbonisation of the energy sector both at national level, where Spain's geographical and climatic characteristics make it the country with the greatest hydrogen production potential in Europe, with a potential of over 3,000 TWh/year, and at European level. Although a promising expansion and penetration is predicted for the coming decades, the involvement of all the players in the value chain will be necessary to guarantee its promotion and competitiveness: public administrations to establish policies and aid along these lines, the private sector for investment in large-scale start-up projects, and end consumers to guarantee demand.

Market for intelligent management systems

A Smart Port is a concept linked to Industry 4.0 or Fourth Industrial Revolution in which the port uses emerging technologies, such as the Internet of Things, Big Data, blockchain or Distributed Ledger

Technologies (blockchain), machine learning and artificial intelligence techniques (machine learning, artificial intelligence) and other methods, to improve the economic competitiveness and efficiency of the port, the social, environmental and energy sustainability of the operations, as well as the safety and security of the facilities. In a smart port, the port value chain is transformed into an open and interconnected ecosystem in all areas.

A smart port should not be seen as a mere application of digital technology. The intelligence of a port is also based on its ability to develop a collaborative approach. A port authority must act as a conductor whose musicians are shipping companies, logistics facilities and port terminals, carriers and logistics operators, as well as in the relationship with the city and local communities where the port is developed. The port authority or port infrastructure manager must co-produce and combine technical and technological issues. The challenge is to create ecosystems, communities of interest and practices that make the whole system smarter.

Not all ports are the same, have the same needs or problems, are in the same environment, have the same activities, have the same traffic or handle the same volumes. Therefore, the vision of digital strategy may also be different. However, it is possible to identify trends, examples and patterns that have already been implemented in other sectors and in other ports that will facilitate the definition of the particular vision of the smart port.

In February 2018, Puertos del Estado (Spain) participated in a Smart Ports conference where the vision of this entity was set out in which the new Industry 4.0 requires moving "from electronic ports to interconnected ports, which will produce changes in the port governance model and not because it is preferred that ports are more public or more private, but because the way of competing and being efficient will be different and it is necessary to adapt the management". Within this vision of becoming "interconnected ports", the capacity to manage and administer data to generate "predictive models" that allow decisions to be taken to "be more efficient" will be key. Everything will have to be interconnected, which will require important cultural changes and changes in governance models. The "synchro-modality" and the fact that the "loss of strength of intermediation in the logistics sector" is foreseeable, with the intermediation links becoming "secondary agents", are gaining weight. In addition to innovation and the energy revolution, they highlight the importance of the internet of things, big data and blockchain. Sharing digital platforms is a key objective, even going beyond the strict limits of the logistics chain to, for example, connect port platforms to city platforms. The transformative role of automation also stands out, with the port sector being one of the most sensitive, with a major impact on port terminals and having a strong impact on employment and training.

II. Expected Project impact

The objective of this project, as previously stated, involves the conversion of the port of Valencia into a zero net emissions port by 2030. In addition to the direct impact that the project will have in terms of emissions and improving the sustainability of the transport system in the Valenciaport area, the potential for replicability in the rest of the Spanish ports of the technologies to be developed in the project is considerable and, thus, it can be expected that the impact will have a multiplier effect in the medium term as other ports move towards the same objective.

a. Impact on the value chain

Main value chain and segments of the value chain that will be impacted by the project

This project affects the energy generation, consumption and distribution component insofar as, thanks to the initiatives included in the first block, it will enable the Port of Valencia to use renewable energies in its energy mix, which is essential to achieve the objective set out here. Complementarily, it also acts on the part of the energy management systems to maximise the impact of the other initiatives, as well as on the other systems which optimise the Port Authority's own traffic management with the aim of increasing the efficiency of the activity.

Finally, port authorities in Spain, under an advanced landlord governance system, are providers of infrastructures for management by private operators. In its role as provider and responsible for the maintenance of these infrastructures, the project raises the possibility of developing and maintaining them in an eco-efficient way, improving this function of the Port Authority.

These initiatives involve both the Port Authority of Valencia and other key players in the transport chain such as shipping companies, terminals, technical-nautical services, road transport, as well as energy suppliers, infrastructures and engineering and consultancy companies, thus covering the entire value chain, both in terms of activities and in terms of the agents involved.

Secondary value chain and segments of it on which the project will have any impact

The secondary value chain is concerned with improving energy efficiency in port infrastructure development.

b. Impact on employment

It is important to note that, due to the nature of the project, the jobs generated both in the shorter term and in the longer horizon will be mostly of high technological content and added value, and, moreover, with a huge potential for the coming decades. For example, in the case of renewable energies, the total employment of the technologies analysed is expected to increase significantly, from 456,000 jobs in 2014 to 658,000 jobs in 2050. These results suggest that renewables can be an important driver of employment in Europe in the medium term. This employment growth will be driven mainly by solar photovoltaics. Onshore wind energy will keep its employment levels in 2050 similar to those of 2011. In relative terms, offshore wind energy will experience the greatest growth in the period analysed, although its share in absolute terms will still be modest at the end of the period.

In terms of the different activities along the value chain, between 2014 and 2050, most employment will be created in operation and maintenance activities (133,000 jobs), followed by installation activities (54,000 jobs). The Spanish National Federation of Installations (FENIE) recently announced that it considers it essential to take urgent measures in view of the lack of qualified personnel in qualified installation companies. Equipment manufacturing will be the activity with the lowest employment growth over the period analysed. In 2050, total employment will be concentrated in Germany, Spain, Italy, the United Kingdom, France and Denmark. On the other hand, job creation in the period 2014-2050 is concentrated in the UK, France, Italy, the Netherlands and Spain, mainly due to PV deployment.

In the case of hydrogen, in the most optimistic scenarios at European level in terms of emission reductions with a significant use of hydrogen, it would imply the development of a leading industry in Europe that could generate up to five million highly skilled jobs by 2050, according to Hydrogen Europe. It is therefore an industry with huge development potential, whose quantitative impact in the short term may be minor, but which is undoubtedly a long-term commitment.

Given the positive effect of the Valenciaport cluster on the rest of the Valencian and Spanish economy, and the high number of jobs generated by this sector, we believe that it is advisable to invest in innovation projects such as the one presented here, which will lead to an improvement in the competitiveness of the sector and a consequent increase in the creation of quality employment. The actions foreseen in the project will require specialised employment for their execution, thus boosting the growing demand for employment in the maritime-logistics-port sector and configuring the project as an engine for attracting talent, knowledge, research and innovation in clean energies for the transport infrastructure and services sector.

In quantifying the impact on employment that the project would have three years after its completion, when it has been possible due to the development of each of the initiatives, some of which are still in an incipient phase, the calculation has been made taking into account the preliminary demand estimates handled by the promoters of the different alternatives, the estimated costs and margins and the employment needs.

If we consider the employment generated by the project in the three years following its completion, it is 4,014 jobs, although in the ten years that follow it is foreseeable that many of these initiatives will be extended to more ports in the state-owned port system and in other European countries in which the companies participating in the consortium are present, without including the indirect employment that could be generated. As already mentioned, most of the employment generated here will be highly qualified specialised employment, allowing the project to make a qualitative leap in the productive structure of the country.

c. Impact on industrial property

A number of patents will be generated through the development of some projects.

It is interesting to highlight the fact that many of the existing patents for the technologies are held by the Spanish project partners themselves. This is particularly relevant in the last block of decarbonisation of maritime transport, port machinery, works and port buildings.

As in other sections, the industrial property rights will be detailed in greater depth as the design of the projects is completed over the coming months.

d. Impact on markets

It is worth mentioning once again that this project is part of the Global Project for the digitalisation and decarbonisation of the Spanish port system and, therefore, many of the initiatives included here can be applied in other ports, making the impact of the project transcend the specific case of the port of Valencia.

Entering into the specific figures estimated by the consortium in terms of the activity generated in the years following the completion of the project, the turnover generated around the initiatives included in the project would exceed 2,400 million euros, multiplying by 15 the investment foreseen in the budget proposed for the development of the project. It should be remembered that the objectives of decarbonisation and digitalisation are among the priorities of the majority of European ports; however, due to their size or financial capacity, only a small group can lead actions that include the R&D necessary to develop, test and optimise the products, services and other elements to achieve these objectives. For this reason, the technologies developed here have a clear target market and it is more than likely that their acceptance in the medium term will be even greater. Moreover, as production and development of the solutions increases, costs will be reduced, reaching more competitive prices that will be accessible to a larger segment of customers.

The most immediate potential for business generation is to be found in the block that includes initiatives aimed at decarbonising maritime transport, port machinery, works and port buildings, which represents 89% of the total. This block, in addition to being the most numerous in terms of initiatives, also includes large-scale projects and others relating to mobile assets (such as transport equipment or port machinery) whose replicability is almost immediate and which do not require a large investment per unit.

The second of the blocks with the greatest impact in terms of sales volume up to 2030 is renewable energy generation, where it would reach 91 million euros, followed by block 2, related to hydrogen generation, where this figure would be 74 million euros. It is important to point out that these technologies will probably require a longer maturation period for their generalised implementation, due in many cases to their investment costs, but that they will end up being present in a large part of the European ports. The companies that make up the consortium, as pioneers in many of the proposed initiatives, are called upon to play a key role in this implementation.

On another level, the fact that this project also results in the operational improvement of port activity and, therefore, in the improvement of the competitiveness of the productive fabric, is once again highlighted. Insofar as these measures translate into cost advantages, both for the Spanish ports and for the Spanish exporting sector, it can be seen that this project can also lead to an operational improvement in port activity and, therefore, to an improvement in the competitiveness of the productive process.
for the Spanish export sector, they can facilitate an increase in the market share of the companies, increasing the volume of activity and, therefore, the turnover.

e. Impact on economy and society

As mentioned in previous sections, the initiatives included in this project will have a significant impact on employment and the market in the short term, which will have a multiplying effect when the implementation of the Global Project seeking the decarbonisation and digitalisation of the state-owned port system is completed.

In general, energy efficiency measures and the improvement of digital systems ultimately result in a reduction of transport costs and, consequently, in an improvement of the export potential of Spanish companies and of the accessibility to the international market for national consumers. The benefit also reaches the port authorities and, for example, the improvement of maritime traffic management contributes to reducing the average time spent in port and the idle and unproductive times of the vessels themselves and of the agents involved. This would make ports more competitive and attractive in the eyes of shipping companies and allow them to handle a greater number of annual calls, with the consequent increase in turnover at a general level and a reduction in the unit costs of the agents by providing them with the basis for being more efficient in the provision of their services.

f. Contribution to digital transformation

A clear priority for the port sector, understood as a logistics-maritime-port cluster, is digital transformation. In this field, the context is marked by the introduction of a set of emerging digital technologies that are leading innovation in products, services, processes, marketing, sales and business in the logistics, transport, security, environment, energy, trade and public services sectors. Logistics chains and ports as one of their main nodes have proven to be essential for a country's competitiveness, sourcing and foreign sales of its companies. Therefore, the digital transformation of the state port system, making it one of the most modern, efficient and sustainable in the world, is a clear competitive advantage for Spain, not only to guarantee domestic supply, but also to attract foreign investment and boost Spain's export activity, whose contribution to the Spanish GDP is increasingly important for the country's economic development.

The project proposes the development of new products and solutions that contribute to the 4.0 Economy with a high innovative component. These initiatives will allow the transformation of Spanish ports thanks to the application of a large number of new technologies that will facilitate the development of digital registers and integrations.

Among the most visible results of this digital transformation process are the development of different technological systems for the management of port infrastructures and their operations, proposing a common data and communications model between systems, starting from the basis of the asset itself and presenting this effective integration of technologies and data through innovative digital twins for ports and container terminals based on virtual and augmented reality technologies. These digital twins will access the objects and assets spatially in three dimensions and the information of these assets in real time and in simulation mode from access to BIM and territory models, being able to access the technical and operational information associated with port assets and infrastructures, through integrated agile dashboards, in a very simple way.

g. Contribution to ecological transition

Pollution prevention: prevention measures that will be achieved as a result of the project.

The principle of prevention, which aims to prevent pollution at source before it is necessary to minimise its effects or restore affected resources, and the polluter pays maxim, are taken as the basis for preventing, reducing and, as far as possible, eliminating pollution from industrial activities in the port.

European regulations will soon require a strict and integrated control of pollutant emissions and energy consumption in European ports. An important part of the results of this project includes the real quantification of consumption savings and the measurement and/or calculation of the reduction of equivalent CO_2 emissions that each of the initiatives will entail in order to subsequently design a series of Best Practices in terms of pollution control and prevention.

These control and prevention measures will also help Spanish ports to be better prepared to obtain permits for industrial processes, which will include emission limit values based on the best available techniques, determined by working groups made up of experts from industry and national administrations.

Other measures consist of preventive maintenance of technologies, machinery and infrastructures, as well as prevention training of the workers in charge for their proper use.

Climate change mitigation: estimated reduction of tonnes of CO_2 as a result of the project and justification of this quantification.

This global decarbonisation project in the port of Valencia brings together a series of initiatives that affect the various sectors of the port-logistics environment transversally, which to a greater or lesser extent have an environmental impact. Below is a description of the annual reduction of CO_2 emissions classified in the five blocks defined in the global project, taking the first year after completion of the projects as the standard year.

The calculations have been carried out on the basis of the estimates provided by the different entities of each initiative described, although it should be remembered that, at this preliminary stage of the project, the data may not be definitive and should therefore be understood as the best approximation at this time. As described earlier in this impact section, as work continues on the design of the initiatives, the analysis of climate mitigation will be completed.

Overall, it is estimated that this decarbonisation tractor project will have an impact on climate change mitigation by initially reducing over 100,000 tonnes per year in the port of Valencia, this figure being linked to the first phase of the Zero Net Emissions Plan in Valenciaport in 2030. Emission reductions are estimated to be significantly higher between 2027 and 2030 (in the second phase of the plan, the implementation phase) when many of the pilots included in the first phase are implemented in the port machinery fleets, in a high % of the lorry fleet serving the port of Valencia and shore-side electricity is supplied to ships at many of the port's quays.

As indicated at the beginning of this impact section, the potential for scalability of this type of project given its degree of innovation is very high, both within the port of Valencia and throughout the Spanish and European port system, with the result that the environmental impact in the following years will be much greater than that estimated here.

Climate change adaptation: justification of climate change adaptation measures to be adopted as a result of the project.

The climate change adaptation strategy is complementary to the mitigation strategy as they are closely linked, and consists of different measures that focus on limiting impacts, reducing vulnerabilities and increasing the resilience of human and natural systems, including industry, to climate change.

Climate change impacts include increased flooding due to rising seas, increased erosion, loss of important ecosystems as a result of warming seawater, and increased intensity and frequency of coastal storms.

In particular, projects related to the infrastructure development part will incorporate a number of climate change adaptation measures related to some of the points in the previous paragraph in their design, although specific details cannot yet be given at this stage of development.

Transition to the circular economy: transition measures to the circular economy to be adopted as a result of the project.

The results of the eco-design and circular economy project could reduce 13,932 tonnes of CO_2 per year, considering a CO_2 reduction of 20% by the substitution of virgin material by secondary raw material. The specific environmental footprint analysis to be carried out in the project will assess the impact of the project from the point of view of climate change.

Although Europe's economy has shown continuous improvements in resource productivity, it remains under-dimensioned as a way to improve the competitiveness of European industry. This is demonstrated by new evidence that the implementation of the circular economy, both in production and in the waste recovery sector, could increase resource productivity by up to 3% per year. This would translate into an increase in GDP of up to 7 percentage points compared to the current development scenario.

Activities related to the incorporation of circular economy concepts in the construction of port infrastructures contribute to the adoption of sustainable waste management solutions in the circular economy and industrial symbiosis, which will contribute to the improvement of the market for secondary raw materials, as well as an improvement in the efficiency of the processes for the generation of secondary raw materials.

The new circular economy model involves increasing reuse, recycling and recovery of waste. Europe loses around 600 million tonnes of material in the form of waste every year, which could potentially be reused, recovered or recycled. Turning waste into resources is an essential challenge to increase competitiveness and move towards a more circular economy.