Autoridad Portuaria
Santa Cruz de Tenerife

iaph
international association
of ports and harbors

WPSP
WORLD PORTS SUSTAINABILITY PROGRAM

Tenerife Port ZERO

Index

1. Introduction

The Port Authority of Santa Cruz de Tenerife is one of the 28 members of the state port system of Spain and currently manages under its jurisdiction the ports of Santa Cruz de Tenerife, Santa Cruz de La Palma, Los Cristianos, San Sebastián de La Gomera, Granadilla and La Estaca.

As an environmentally responsible entity, it has a profound commitment to sustainable development and wants to present in this document the "Tenerife Port ZERO" project. This innovative endeavor represents the resolute pursuit of facilitating the energy transition within ports, with the overarching goal of creating CO_2-neutral ports that actively contribute to achieving global climate objectives.

As we all know, the urgent need to address climate change has brought the maritime industry into the spotlight as a significant contributor to greenhouse gas emissions. Ports, as vital hubs of international trade and logistics, have a crucial role to play in mitigating these emissions and transitioning towards a sustainable future. This project aims to spearhead this transformation by implementing comprehensive strategies that reduce, offset, and eliminate CO_2 emissions generated within port operations.

To embark on this transformative journey, we recognize the importance of accurately measuring and understanding our current carbon footprint. As the saying goes, "What gets measured gets managed." Hence, our first step towards achieving a CO_2-neutral port was to conduct a thorough assessment of our carbon emissions to ascertain the baseline from which we commence our sustainability efforts. This action has provided us with invaluable insights into the various emission sources, enabling us to develop targeted and effective mitigation strategies.

By quantifying our carbon footprint, we have gained a comprehensive understanding of the challenges that lie ahead. It has served as a compass, guiding our decisions and empowering us to adopt innovative measures that align with global climate goals. Moreover, the data obtained will facilitate transparent reporting, allowing stakeholders to witness our progress and fostering collaborative partnerships to drive sustainable change.

It is important to acknowledge that prior to the initiation of the "Tenerife Port ZERO" project, several decarbonization and sustainability initiatives were already underway within our ports. However, it was the year 2017 that we recognized the need for a comprehensive assessment of our carbon footprint as a starting point and benchmark for the subsequent initiatives that form an integral part of our project.

Building upon the foundation of our past efforts, the measured carbon footprint acts as a catalyst, spurring us to intensify our commitment to decarbonization and sustainable practices. It serves as a reference point for quantifying the positive impact of the comprehensive reduction plan we have devised, fostering a culture of continuous improvement and innovation.

In summary, while previous sustainability initiatives were already in place, the measurement of our carbon footprint since 2017 serves as a pivotal starting point and a basis of comparison for the array of initiatives encompassed within the "ZERO Emissions Port" project. By leveraging this data-driven approach, we are empowered to drive meaningful change, accelerate our progress, and inspire others to follow suit in the pursuit of a greener, more sustainable maritime industry.

2.Objective

The "Tenerife Port ZERO" project is firmly aligned with the focus area of the IAPH Sustainability Awards: "Facilitation of energy transition in ports: striving towards CO_2-neutral ports to help achieve global climate goals." With this in mind, our project is guided by the following objectives:

- Quantify and Understand: Our primary objective is to accurately measure and comprehensively understand the carbon footprint generated by our port operations. By conducting a thorough assessment, starting from 2017 onwards, we establish a baseline that serves as a reference point for evaluating our progress in reducing emissions.

- Reduction and Mitigation: Building upon the measured carbon footprint, we have developed a comprehensive reduction plan that encompasses a range of innovative strategies. Our aim is to significantly reduce CO_2 emissions within our port, employing measures such as the adoption of renewable energy sources, energy efficiency optimization, green transportation systems, and the promotion of sustainable practices among port users and stakeholders.

- Collaboration and Partnerships: We recognize that achieving CO_2-neutral ports and contributing to global climate goals requires collective action. Thus, we actively seek partnerships with industry players, local communities, governmental bodies, and international organizations to foster collaboration and knowledge exchange. By working together, we can amplify our impact and accelerate the energy transition in ports worldwide.

- Transparency and Accountability: We are committed to transparency and accountability throughout our journey towards a sustainable port. We will regularly report on our progress, sharing the results of our carbon footprint measurements, showcasing the effectiveness of our reduction strategies, and highlighting the

positive environmental outcomes achieved. By doing so, we aim to inspire others and encourage the wider adoption of sustainable practices in the maritime industry.

- Leadership and Inspiration: As a port authority, we aspire to lead by example and inspire others to embrace sustainable practices. Through our efforts to achieve CO_2-neutral port operations, we aim to be at the forefront of the energy transition in ports. By demonstrating the feasibility and benefits of sustainable measures, we seek to motivate and empower other ports to embark on similar journeys towards a greener and more climate-resilient future.
- Innovation and Research: Another crucial objective of the project is to leverage the port environment as a platform for research and development (R&D) activities focused on marine energy production, including wave and offshore wind power. We aim to harness the potential of the marine environment within the port to explore and implement innovative technologies that generate clean, renewable energy.
- Alternative Fuels and Hydrogen Generation: As part of our commitment to energy transition, we aspire to explore and develop alternative fuels that can replace traditional fossil fuels in port operations. This includes researching and implementing solutions for the production and use of sustainable fuels, such as biofuels and synthetic fuels. Additionally, we seek to leverage the port's infrastructure and resources to explore the generation and utilization of hydrogen as a clean energy source, with the potential to power various port activities.

3.Carbon footprint and GHGs Reduction Plan

Carbon footprint

As pointed out in the introduction, our pursuit of a CO_2-neutral port, the first step was to measure our carbon footprint for the 2017-2020 period following the "Methodological Guide for Carbon Footprint Calculation in Ports"[1] developed by the State Ports of Spain. This comprehensive guide, based on international best practices, ensures consistency and accuracy in our calculations. By adhering to this methodological framework, we establish a reliable baseline for evaluating our sustainability efforts and contribute to the collective knowledge of carbon footprint measurement in the maritime industry. Shown in the table below are the results obtained in the measurement of the carbon footprint in the Port Authority of Santa Cruz de Tenerife, onwards PAT.

[1]https://www.puertos.es/es-es/medioambiente/Documents/Guia%20Huella%20de%20Carbono%20-%20Puertos%20del%20Estado%20-%20Web.pdf

Table 1. 2017-2020 carbon footprint measurement results

Port Authority of Santa Cruz de Tenerife	2017	2018	2019	2020
Scope 1 [kg CO_2eq]	**130.588**	**166.851**	**169.275**	**118.899**
Scope 2 [kg CO_2eq]	**1.139.723**	**1.991.954**	**1.279.432**	**0**
Scope 3 [kg CO_2eq]	**109.864.766**	**98.545.887**	**94.819.665**	**140.299.162**
Other organizations operating in the PAT	64.773	2.433.410	2.531.006	1.954.738
Maritime traffic in the PAT	108.338.630	94.614.633	90.795.620	137.098.573
Traffic of vehicles in passage regime in the PAT	245.541	266.676	293.908	209.572
Transport of goods by truck within the PAT	1.215.821	1.231.168	1.199.130	1.036.279
Carbon footprint [kg CO_2eq]	**111.135.077**	**100.704.693**	**96.268.372**	**140.418.061**

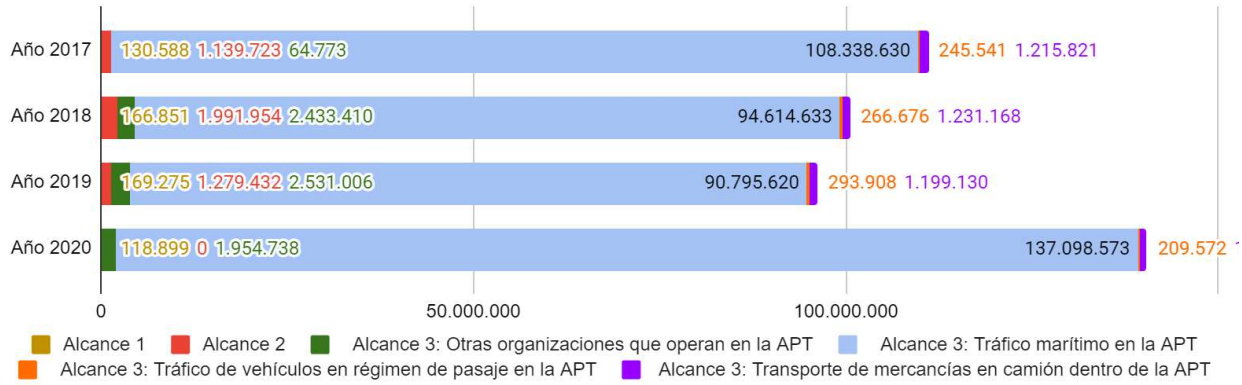

Figure 1. 2017-2020 carbon footprint measurement results

From this study the main insight is that **more than 95% of the emissions are related with the maritime traffic** in Zone I waters and calls.

The other important insight related with **scopes 1 and 2** is that by that time, **fuel consumption was reducing** and **emissions related with electricity** consumption were **0 kgCO_2eq/kWh by 2020** as the electricity supplier provided 100% renewable electricity with guarantee of origin (GdO).

The carbon footprint of the PAT has been officially registered with the Ministry for Ecological Transition and Demographic Challenge (MITECO). This recognition demonstrates our commitment to transparency and accountability in our sustainability efforts,

obtaining the carbon footprint certification, symbolized by the label next to this text.

GHGs Reduction Plan

The measurement of our carbon footprint has laid the foundation for our comprehensive reduction plan aimed at achieving our goal of a CO_2-neutral port. Building upon the data obtained from the carbon footprint assessment, we developed a strategic roadmap outlined in the table below.

Table 2. 2030 GHGs Reduction Plan Targets

Actuations	Related to	2022	2023	2024	2025	2030
Environmental Management System, according to the UNE-EN ISO 14001:2015 standard.	Environmental Protection	Maintain 100% port certification	Maintain 100% port certification	Maintain 100% port certification	Maintain 100% port certification	EMAS Certification
Measurement of GHG emissions from major stakeholders within the APT.	Environmental Awareness	40%	50%	60%	70%	100%
Employees trained (as a percentage of total employees).	Environmental Awareness		>60%	62%	64%	>70%
Investment in port-ship electric connection (cumulative total investment).	Air Quality	-	-	7,63 M€	23 M€	47 M€
Zero-emission electric vehicles (percentage of zero-emission vehicles in the fleet).	Air Quality	40%	40%	50%	60%	100%
100% renewable electricity usage.	Air Quality	-	Renewable supply for all ports	Renewable supply for all ports	Renewable supply for all ports	Renewable supply for all ports
Electric charging points.	Energy Efficiency		10 points	14 double points	14 double points	28 double points
Supply of LNG to cruise ships.	Air Quality	Santa Cruz de Tenerife port	Santa Cruz de Tenerife port	Santa Cruz de Tenerife port	All ports	All ports
Electric consumption.	Electric Consumption	-	0% emissions	0% emissions	0% emissions	0% emissions
Fuel consumption.	Fuel Consumption	25% reduction in annual emissions ratio	30% reduction in annual emissions ratio	35% reduction in annual emissions ratio	40% reduction in annual emissions ratio	100% reduction in annual

		compared to 2019	compared to 2019	compared to 2019	compared to 2019	emissions ratio compared to 2019
GHG reduction Scopes 1+2 [%].	General	20% reduction compared to 2019	30% reduction compared to 2019	40% reduction compared to 2019	70% reduction compared to 2019	100% reduction compared to 2019
GHG reduction Scopes 1+2 and 3 [%].	General	5% reduction compared to 2019	10% reduction compared to 2019	20% reduction compared to 2019	30% reduction compared to 2019	70% reduction compared to 2019

This plan encompasses various targets across different aspects, including environmental management, awareness, air quality, energy efficiency, and consumption. By implementing the initiatives of the project, we aim to significantly reduce greenhouse gas emissions, promote renewable energy usage, enhance environmental protection, and foster a culture of sustainability within our port community. Through the collective efforts outlined in the reduction plan, we are committed to making tangible progress towards our vision of a zero-emissions port, aligned with global climate goals.

4. Topics

4.1. Setting ambitious carbon reduction/neutrality targets

In the context of setting ambitious carbon reduction/neutrality targets, it is noteworthy that the PAT has established more ambitious reduction goals than the strategic framework outlined by the State Ports for 2030[2].

Table 3. Carbon reduction targets of the PAT against State Ports.

Actuations	Strategic framework for 2030 (State Ports)	Objectives of PAT for 2030
GHG reduction Scopes 1+2 [%].	70% reduction compared to 2019	100% reduction compared to 2019
GHG reduction Scopes 1+2 and 3 [%].	50% reduction compared to 2019	70% reduction compared to 2019

Furthermore, **the Port Authority aims to achieve carbon neutrality by 2035 through the implementation of a forthcoming protocol.** This protocol is currently being developed and will incorporate energy communities and offsetting projects, which are still being defined. One of the offsetting projects could be the restoration and expansion of seagrass meadows,

[2] https://www.puertos.es/es-es/MarcoEstrategico/Documents/PdE_Marco_Estrategico_2022.pdf

commonly known as "sebadales." Seagrass meadows are highly effective in capturing and storing carbon dioxide from the atmosphere, making them valuable natural carbon sinks. By undertaking projects to plant and protect seagrass meadows within the port area or nearby coastal regions, the Port Authority can contribute to offsetting its carbon emissions and enhancing the marine ecosystem's resilience.

4.2. Provision of port emission reduction equipment and services to ships, inland barges and trucks

OPS

The provision of port emission reduction equipment and services to ships is a critical aspect of sustainable port operations. As part of the OPS Master Plan for Spanish Ports, a project aimed at drafting a Master Plan for the supply of electric power to ships at berth in Spanish Ports, each port within the Port Authority has developed an OPS (Onshore Power Supply) Master Plan. This comprehensive plan contributes to the reduction of emissions and the promotion of alternative fuels in the transportation sector, particularly in the PAT as more than 95% of its emissions comes from vessel calls.

The OPS Master Plan for Spanish Ports project aligns with the National Action Framework for the development of alternative fuel infrastructures in compliance with Directive 2014/94/EU. With a budget of 4,399,564 Euros, the project received co-financing of 1,280,413 Euros from the Connecting Europe Facility – CEF program, dedicated to the construction of the Trans-European Transport Networks (TEN-T).

The project successfully achieved its objectives by identifying the benefits of OPS and addressing the main barriers that hinder the full development of this technological solution. Measures were implemented to overcome these barriers, and three new OPS facilities have been constructed in the ports of Santa Cruz de Tenerife, Palma de Mallorca, and Las Palmas as pilot projects. Additionally, a comprehensive list of 20 new OPS facilities, integrating the OPS Master Plan, has been prepared for execution between 2022 and 2024, taking into account viability, environmental considerations, and technical studies.

The OPS Master Plan will be further updated in 2024 to align with future obligations outlined in the forthcoming Regulation on alternative fuel infrastructure. These obligations will require ports to have OPS facilities capable of providing OPS to 90% of calls from specific fleets, including ferries, container ships, and cruisers, by 2030.

By implementing the OPS Master Plan and expanding the availability of onshore power supply, the Port Authority aims to significantly reduce emissions and foster a more sustainable and environmentally friendly maritime transportation sector in the PAT ports.

To promote the adoption of OPS among different shipping companies as soon as possible, the Port Authority of Santa Cruz de Tenerife will incentivize the implementation of this system by offering a 50% reduction in the berthing fees for any vessel utilizing onshore power supply. This financial incentive aims to encourage and reward shipowners and operators who choose to prioritize sustainable practices and reduce emissions by connecting to OPS facilities while berthed at the port. By providing this significant discount, the Port Authority demonstrates its commitment to supporting environmentally friendly initiatives and fostering the widespread use of OPS technology within the maritime industry.

By May 2023, the Port Authority of Santa Cruz de Tenerife has already electrified the berths for interisland ferry traffic in the ports of Santa Cruz de Tenerife, La Palma, and La Gomera, where vessels are already regularly connected, thus avoiding harmful emissions to the environment and the public.

Image 1. Vessel connected to the OPS in La Gomera port.

Currently, a plan is being prepared for the electrification of all ports, including container terminals and cruise ships:

Table 4. OPS to be executed in the PAT ports until 2030.

Port	Vessel types	Projected Power	Investment	Year
S/C Tenerife	Ro-Ro, Cruise, Container	44,5 MW	22,50 M€	2025
Los Cristianos	Ro-Pax			
S/S La Gomera	Fast Ferry			
La Estaca	Ro-Pax			
Granadilla	Platform			
S/S La Gomera	Ro-Pax	30,9 MW	13,2 M€	2028
S/C La Palma	Cruise			
La Estaca	Cruise			
Granadilla	Platform			
S/C Tenerife	Container	12 MW	11,47 M€	2030
S/C La Palma	Container			
TOTAL		**88,3 MW**	**47,17 M€**	

By implementing the projected OPS systems and ensuring their efficient operation, a significant amount of emissions will be avoided. Specifically, the calculated emissions from various pollutants amount to 64,556.92 tons of CO_2 equivalents per year.

This represents a reduction of approximately 71% compared to the maritime traffic emissions in 2019. This substantial reduction demonstrates the positive impact of implementing OPS, contributing to a more sustainable and environmentally-friendly maritime industry. The successful implementation of these systems showcases our commitment to reducing carbon emissions and promoting a greener future for the industry.

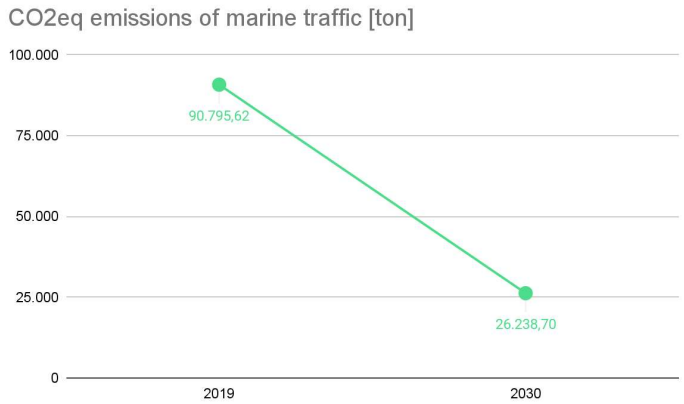

Figure 2. OPS impact on the carbon footprint 2019-2030

4.3. Increasing energy efficiency of port operations

It is noteworthy that the Port of Santa Cruz de Tenerife ranks 72nd globally in the World Bank's 2022 Container Port Performance Index[3], which assesses port performance based on vessel turnaround time. The port's ability to minimize vessel stay time contributes to improved energy efficiency in operations. In this year's edition, the Port of Santa Cruz de Tenerife has climbed 16 positions compared to the previous year's indicator, securing the 72nd spot in the global ranking, surpassed only by the national ports of Algeciras and Barcelona.

The terminals have achieved this improvement through automated and paperless truck access, simultaneous unloading of two 20-foot containers, excellent crane maintenance, ongoing worker training, and a strict policy of zero accidents and zero errors.

Table 5. Santa Cruz de Tenerife rank in the World Bank's 2022 Container Port Performance Index

Port Name	2022 Rank	Index Points	2021 Rank	Change
Sohar	65	28.832647	47	-18
Colon	66	28.737558	64	-2
Aqaba	67	28.660159	32	-35
Rio De Janeiro	68	26.736563	83	15
Kattupalli	69	25.480878	95	26
Boston (USA)	70	25.129463	115	45
Jawaharlal Nehru Port	71	24.52839	50	-21
Santa Cruz De Tenerife	72	24.384752	88	16
Keelung	73	24.140515	77	4
Savona-Vado	74	24.02082	111	37
Kamarajar	75	23.869578	71	-4

[3]https://openknowledge.worldbank.org/entities/publication/6a51b12c-77cd-4236-be5b-13e468fe0cca

4.4. Use and production of renewable energy in the port

The generation and utilization of renewable energy within the port has always been a top priority for our Port Authority. In 2016, we embarked on the e-island project, which was presented to the IAPH World Ports Sustainability Awards 2016, which involved, among other actions, the installation of solar panels and small-scale wind turbines. This initiative marked the beginning of our journey towards harnessing clean energy sources and reducing our reliance on conventional power systems.

In line with our commitment to sustainability and innovation, we are currently executing a groundbreaking project in the port of Granadilla. This project, called Primavera, focuses on the development of offshore wind energy, and it serves as a testament to our dedication to explore new frontiers in renewable energy. The aim is to make the Canary Islands a hub for this type of technology in Europe and globally. Furthermore, the port of Granadilla will be utilized as a testing ground and a laboratory for the installation of a wave energy generation system, which harnesses the power of ocean waves to generate electricity. This system aims to demonstrate its feasibility, scalability, and durability in marine environments, paving the way for large-scale implementation of wave energy as a viable renewable energy source.

e-Island: Genera

Image 2. Photovoltaic installation of Fish Market

Consisted in installation of self-consumption facilities, in order to cover the energy needs required at various points, within the correspondence of the Port Authority. From photovoltaic and wind installations, clean energy is obtained, following the fundamental objectives of the e-island project. The actuations were:

Table 6. Power, Budgets and State of self-supply installations

Location of self-supply installations	Type of Installation	Budgets	Grants	State
Headquarters Building of the Port Authority	Photovoltaic (90kW)	212.494 €	180.620 €	Executed
Building of Fishermen's Association	Photovoltaic (30kW)	75.563 €	64.228 €	Executed
Fish Market	Photovoltaic (55kW)	119.827 €	101.852 €	Executed
Ribera's Tunnel	Photovoltaic (65kW)	104.760 €	89.046 €	Executed
Port of La Estaca	Mini-Wind (50kW)	111.998 €	95.198 €	In progress
Port of La Gomera	Mini-Wind (50kW)	150.000 €	127.500 €	In progress
	TOTAL AMOUNT	774.642 €	658.445 €	

The installation of photovoltaic and wind energy systems has resulted in significant energy savings and a notable reduction in CO_2 emissions, thereby promoting a greener and more environmentally friendly port environment.

Table 7. Energy saving and CO2 emissions of Self-supply installations

	Energy saving	Emissions without installations	Emissions with installations
Building of Port Authority	30%	184.569 kg CO2/year	129.934 kg CO2/year
Fishermen's brotherhood	60%	31.952 kg CO2/year	12.682 kg CO2/year
Fish Market	64%	53.550 kg CO2/year	19.507 kg CO2/year
Ribera's Tunnel	85%	49.266 kg CO2/year	7.367 kg CO2/year
Port of La Gomera	49%	54.479 kg CO2/year	27.857 kg CO2/year
Port of La Estaca	68%	58.120 kg CO2/year	18.115 kg CO2/year
	TOTAL AMOUNT:	431.936 kg CO2/year	215.462 kg CO2/year

Off-shore wind

Primavera Offshore Wind S.L., a company created by Enerocean, is executing the Primavera project, which involves the engineering, installation, operation, maintenance, and dismantling of a unique floating wind energy facility for the generation of renewable electricity in the marine environment of the Port of Granadilla. This project utilizes the innovative W2Power technology and it was awarded with the best project in marine renewable energy in the Atlantic Project Awards 2020.

Enerocean is a leading Spanish company in offshore wind and other renewable technologies in the marine environment. It achieved the world's first successful testing of a multi-turbine platform in open sea conditions (at the PLOCAN test area in June 2019). The groundbreaking W2Power solution integrates patented features and key technological elements.

Featuring two wind turbines mounted on the same floating structure, constantly oriented towards the prevailing wind, W2Power offers one of the highest power-to-weight ratios and the lowest cost of energy among all floating wind technologies. The conceptual design of W2Power has already received approval from Bureau Veritas, and the global certification

process for the design to be used in the Primavera project is well underway, following successful sea trials.

The objective of the Primavera project is to install a full-scale floating wind platform utilizing the W2Power technology. It consists of two 5,5 MW wind turbines, resulting in a total nominal power of 11 MW, along with auxiliary installations and complementary equipment for electricity production within Zone II of the Port of Granadilla. This installation will have the **capacity to cover** the average electricity consumption of **approximately 19.000 households in Tenerife**.

The W2Power technology comprises two wind turbines, each supported by an inclined tower, which is assembled onto a floating base consisting of four steel columns. The bow column will be connected to the mooring system, ensuring the continuous alignment of the platform (and hence the wind turbines) with the prevailing wind direction, thus harnessing the wind resource in the designated concession area.

Image 3. Off-shore wind turbines of the Primavera project in Granadilla port waters.

Commercial Off-shore wind Farm

Blue Float and Capital Energy have entered into an agreement to develop a commercial offshore wind farm in the port area of Granadilla. The project entails a significant investment of 125 million euros. They have currently applied for the concession of public port domain and are in the process of obtaining the necessary environmental approvals.

The project will utilize the innovative telescopic monopile technology known as Elisa, developed by ESTEYCO. This technology offers enhanced efficiency and cost-effectiveness in the installation of offshore wind turbines. By harnessing the power of offshore wind, the

project aims to contribute to the transition to clean and renewable energy sources while reducing reliance on fossil fuels.

The offshore wind farm project in Granadilla will consist of a **50 MW capacity**, comprising **five wind turbines**, each with a power output of 10 MW. These turbines, towering at a height of 230 meters each, will harness the strong and consistent winds of the region to generate clean and sustainable electricity. The construction and installation of the wind farm are expected to be completed within a timeline of three years.

With its strategic location in the port area, the offshore wind farm will not only generate clean electricity but also provide opportunities for local economic growth and job creation. The project demonstrates a commitment to sustainable energy development and serves as an important milestone in advancing the renewable energy sector.

Image 4. Commercial off-shore wind farm to be installed in Granadilla

Wave Energy Converter (WEC)

This project R&D consists in the development of a wave energy generation system that aims to produce electricity on a large scale and ensure high durability in the marine environment. The system harnesses the power of ocean waves and stores hydraulic energy within its structure, eliminating the need for energy conversion. A WEC (Wave Energy Converter) plant will be installed in the Port of Granadilla after the first test in Santa Cruz de Tenerife port.

The implementation of this wave energy generation system will serve as a platform for conducting research and development activities, allowing for the verification of its technical and commercial viability. This will serve as an opportunity to gather valuable data, analyze the system's feasibility, and refine its design and operation. Ultimately, this initiative aims to advance the field of wave energy technology and pave the way for its future integration into the market as a sustainable and commercially viable renewable energy solution.

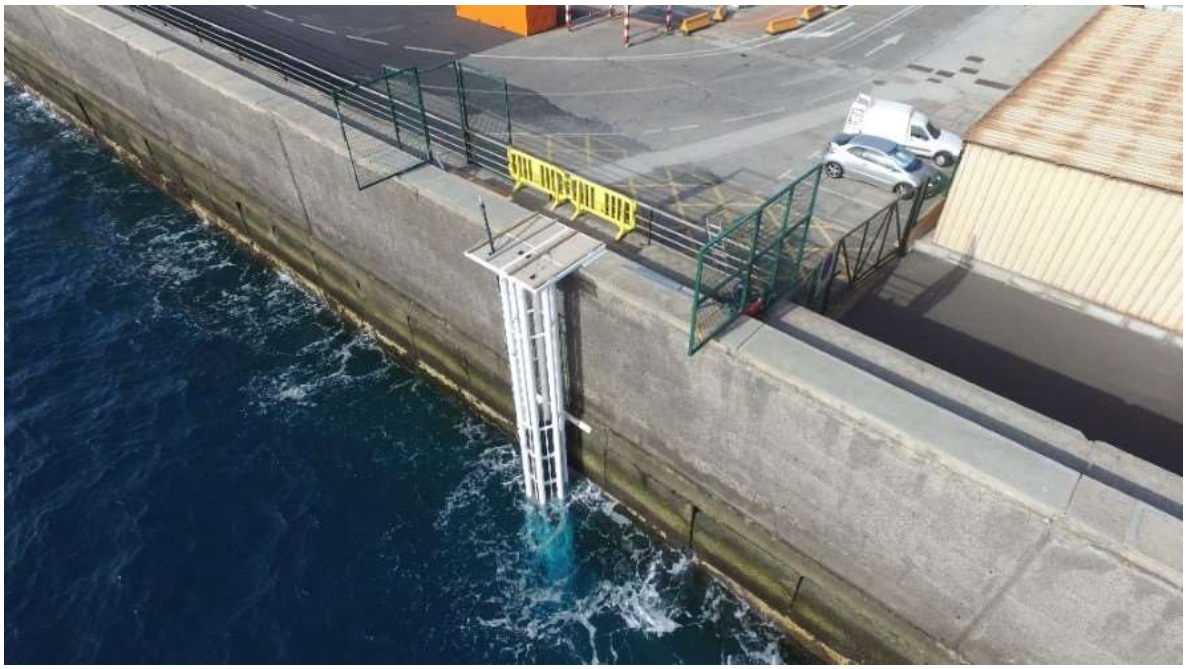

Image 5. WEC R&D system installed.

Technically, the WEC (Wave Energy Converter) is a system that harnesses the kinetic energy of waves along our coastline and stores the hydraulic energy within its structure, without the need for energy format conversion. This energy is directed towards a Pelton turbine, which includes a nozzle or injector that propels a jet of water onto a wheel equipped with spoon-shaped blades. The water interacts with the blades, exchanging energy with the wheel due to the change in its momentum, resulting in the generation of a significant amount of electrical energy. This energy can be utilized for consumption within port infrastructure, by port clients, peripheral businesses near the port area, or fed into the grid.

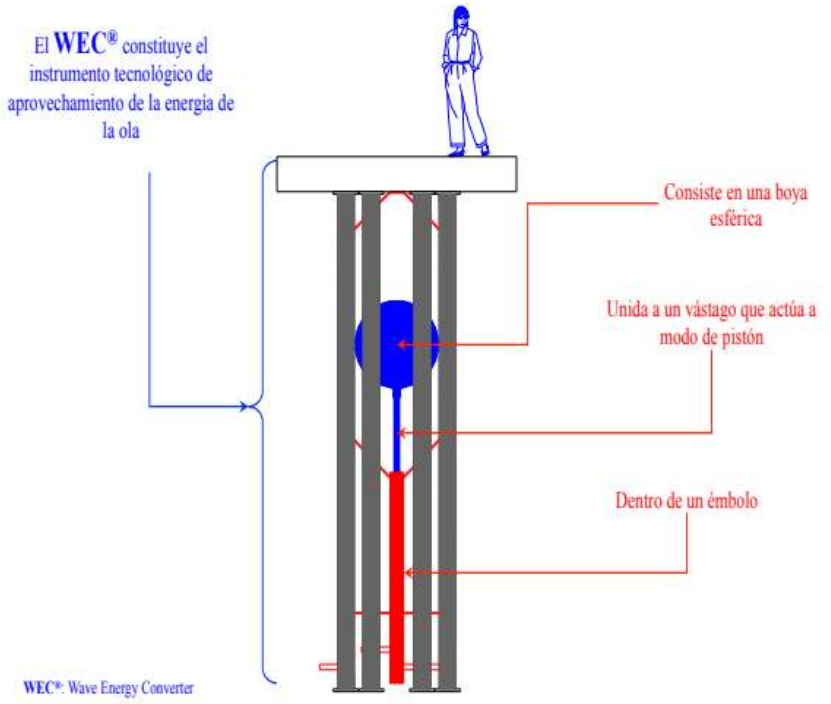

Image 6. Principle of operation.

Fast charging points

The PAT, within its program of continuous improvement of the facilities of services, have installed charging points for electric vehicles in the different ports of the islands of La Palma, El Hierro, La Gomera and Tenerife.

This comes under the Sustainable Electric Mobility Plan e-Island, carried out in order to implement electric vehicles in the Canary Islands and sensitize the population to the use of these new technologies.

With all this, it is intended to develop an optimal recharging network in the ports of the province of Santa Cruz of Tenerife, and likewise, provide charging points for electric vehicles that move within the dock (Port Police, Port Authority Vehicles), in addition for the users of the ships, who make trips between islands. In the table below is indicated the number of charging points installed in each port.

Table 8. Fast charging points for EV installed in the PAT ports.

Fast charging points	N. º of Units
Port of S/C of Tenerife	7
Port of Los Cristianos	2
Port of S/C of La Palma	2
Port of La Gomera	2
Port of La Estaca	1
Total amount:	14

This initiative highlights the commitment of the Port Authority to promote sustainable transportation solutions and facilitate the adoption of electric vehicles within the port areas.

Intelligent Public Lighting

Since the beginning of 2013, the PAT, under the Sustainable Electric Mobility Plan e-Island has carried out a multitude of projects to change the lighting of sodium vapor (400W-250W) to LED lighting (250W-150W), with the aim of making considerable energy savings.

Since the project was launched, a series of Smart Public Lighting installations have been carried out on the islands, which has considerably reduced the total power consumed by the company's public lighting in the ports and the costs of it.

Table 9. Evolution of electric consumption related to lighting.

Lighting provinces S/C of Tenerife	Consumed Power (Kwh)	Costs in the Invoice
2012	2.088.188	279.240 €
2013	1.751.940	243.429 €
2014	1.559.395	200.125 €
2015	1.546.558	200.106 €
2016	1.478.418	196.000 €
2017	1.166.093	155.166 €

4.5. Testing and piloting new fuels and technologies

Regarding testing and piloting new fuels, the Port Authority is actively involved in driving innovation and sustainability in the maritime industry. As a member of the Renewable Hydrogen Hub Cluster Canary Islands, an initiative that promotes the development and implementation of hydrogen technologies, the Port Authority is committed to exploring and piloting new fuels and technologies that can contribute to a greener and more efficient port ecosystem. The Port Authority is also a partner of the Interreg Europe project SEAfuel.

Additionally, the Port Authority is collaborating with various companies to explore alternative fuel generation from plastic waste. By leveraging innovative processes and technologies, they aim to transform plastic waste into a valuable resource, ultimately reducing plastic pollution and creating a sustainable fuel source. These collaborative efforts emphasize the Port Authority's dedication to fostering a circular economy and exploring innovative solutions to address environmental challenges.

Regarding the topic testing and piloting new technologies, there is the eH2 RTG project focused on decarbonizing the logistical operations of Port Terminals by implementing highly efficient ULPHE-PEM fuel cell power generation systems in port cranes, utilizing hydrogen as a clean energy source.

Green Hydrogen

The Renewable Hydrogen Cluster of the Canary Island aims to establish a sustainable energy system that transitions from a heavy reliance on external sources and fossil fuels to one powered by renewable energy generated within the islands. This transformation will ensure the energy security and supply of the archipelago while promoting the production and consumption of green hydrogen as a means to decarbonize various sectors and drive regional economic growth.

To meet the criteria for "renewable hydrogen," the project involves the construction of new renewable electricity generation plants. The centralized production of hydrogen will be distributed according to local and island-specific needs, as exemplified in the case of Tenerife, where the production site will be located in the Granadilla port area, taking advantage of available land, proximity to energy infrastructure, access to desalinated water, and logistical transport capabilities.

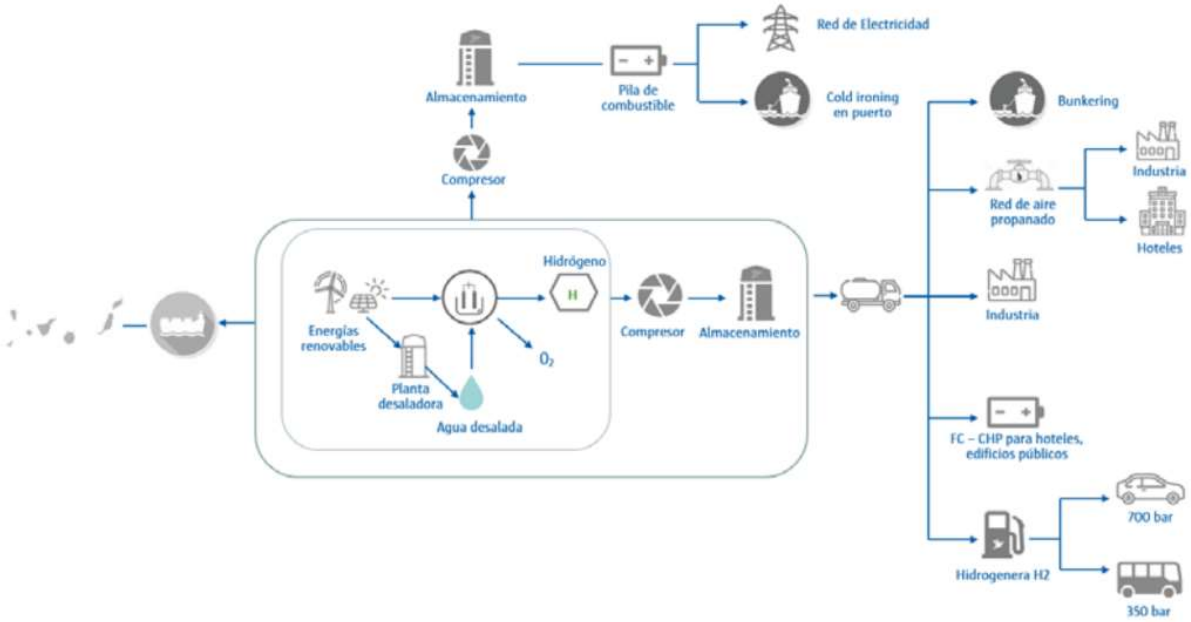

Figure 3. Green H2 generation and supply in Tenerife. The Renewable Hydrogen Cluster of the Canary Island.

In Tenerife, as illustrated in image above, the green hydrogen produced will be utilized in various applications, including:

- Internal usage in the Granadilla port for cold ironing, port supply, and consumption by port facilities.
- Powering a crane, a tugboat, a fuel cell for cold ironing, port supply, and consumption by port facilities in the Santa Cruz de Tenerife port.
- Supplying a fleet of 10 buses in Santa Cruz de Tenerife.
- Providing energy to five hotels, either through hydrogen fuel cells using 100% hydrogen or a blend of hydrogen (10%) with propane air.
- Fueling a fleet of 10 rental cars.
- Supplying a fleet of 10 delivery vans.

In total, the project aims to generate 954 tons of hydrogen per year which means **avoiding the emission of 10.402 tons of CO_2 per year.**

Related to this, the Port Authority is a partner in the SEAfuel project, which is a research and development project aimed at promoting the production and use of renewable hydrogen in insular and remote regions of Europe. The project aims to harness local renewable energy resources such as wind and solar power to produce green hydrogen through water electrolysis.

One of the main objectives of the SEAfuel project is to demonstrate the technical and economic viability of renewable hydrogen as a sustainable alternative to fossil fuels in insular and remote regions. The project focuses on implementing hydrogen production and storage systems, developing supply infrastructures, and integrating hydrogen-powered vehicles and vessels into the local transport fleet.

Through collaboration among partners from different European regions, SEAfuel seeks to facilitate the exchange of knowledge and best practices in renewable hydrogen production and utilization. Furthermore, it aims to drive the transition towards a low-carbon economy and contribute to the reduction of greenhouse gas emissions in the participating regions.

Synthetic fuels from plastic waste

The Port Authority, in another line of work, is in conversation with a partner to install a production plant to transform non-recycled plastic into valuable petrochemicals. Through a chemical process, plastic waste is converted into second-life fuels, including methane and hydrogen.

This breakthrough technology offers a promising solution to tackle the 84% of plastic that is currently not recycled worldwide. Through the proprietary pyrolysis process this plastic waste is turned into gas, liquid and solid fractions, producing synthetic fuels and gas for the Oil&Gas and transport industries. The process is registered under industrial secrecy in addition to two published patents.

Image 7. Images of the industrial process to convert plastic waste into petrochemicals.

eH2 RTG

The objective of this project is to decarbonize the logistical operations of Port Terminals by utilizing hydrogen as a fuel source. This will be achieved through the implementation of highly efficient ULPHE-PEM fuel cell power generation systems in port cranes. By adopting this innovative technology, the aim is to significantly reduce the carbon footprint associated with port operations. The use of hydrogen as a clean energy source will result in zero emissions of CO2, greenhouse gasses (GHGs), and harmful particulate matter, ensuring a more sustainable and environmentally friendly approach to logistics in Port Terminals.

Image 8. Port crane powered by a hydrogen fuel cell.

The e-H2 RTG project includes the design, validation and demonstration in a national terminal of a pre-commercial prototype of an RTG crane , manufactured by Paceco, with an electrical generation system (Hycogen-HFCT), based on the innovative Ulphe-Pem fuel cell technology developed by Jalvasub Engineering.

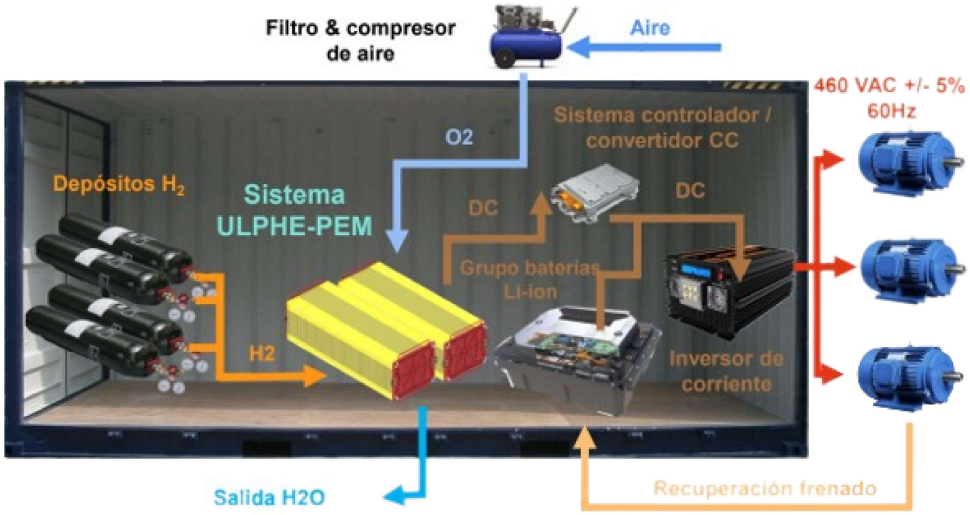

Image 9. Operating scheme of a port crane powered by a hydrogen fuel cell.

RTG cranes are one of the main producers of CO_2 emissions in container terminals,meaning 40-50% of the total energy consumption of the terminal. For this reason, Paceco Momentum and Jalvasub Engineering have come together to invest joint efforts in R&D with the aim of introducing the disruptive technology of high-efficiency Ulphe-Pem fuel cells in the load handling sector. The common objective is that, for the first time, this type of machinery is propelled in a totally ecological way and with zero CO_2 emissions, GHG gasses and polluting particles.

The implementation of this project will make it possible to establish the bases for the implementation of a green culture based on hydrogen in container terminals. This would mean nothing less than the elimination of a substantial part of the CO_2 emissions into the atmosphere. The objective is to serve to position Spain as a benchmark for this green technology at a European and world level and to contribute to the development of the introduction of hydrogen in society. Additionally, further development is already underway to use ammonia as fuel.

The project is part of the first call in the Pre-commercial category of the Ports 4.0 Fund. which represents the innovation model adopted by State Ports and the Spanish Port Authorities to attract, support and facilitate the application of talent and entrepreneurship to the Spanish public and private logistics-port sector in the context of the 4th Industrial Revolution.

PORTS 4.0
Ports of Spain Tradetech Fund

4.6. Provision of clean ship incentives

Electrification of a harbor pilot vessel

The Mobile Electric Platform for Training in Marine Technologies and Support in Sustainable R&D, PLEaMAR, is a new infrastructure under the supervision of the University of La Laguna (ULL) and linked to the new Laboratory for Development and Training in Marine Technologies, LDF-TECNOMAR. Its purpose is to provide support to research teams operating in the field of marine sciences and technologies in the Canary Islands region and its surrounding areas, as well as to offer training to students pursuing degrees and postgraduate studies related to maritime, electronic engineering, and mechanical engineering.

PLEaMAR is based on the electrification of the vessel Añaza P, which was donated by the Harbor Pilots Corporation of the Port of Santa Cruz de Tenerife. The project involves replacing its current power system with a fully electric propulsion train of approximately 150 kW and a 100 kWh battery, as well as modernizing its instrumentation and facilities. The vessel, which has been docked at the port platform linked to the Section of Nautical, Machinery and Naval Radioelectronics since March 2021, has already undergone dismantling, cleaning, repair, and hull painting works.

The research team responsible for this exciting project aims to have the electric propulsion system, battery system, and basic navigation instrumentation installed by June 2023. As part of the project's objectives, the research team is collaborating with two international consortia in the proposal of two Horizon projects, both currently awaiting evaluation by the European Commission: the "Atlantic Maritime Research Centre (AMRC) - The Excellence HUB of the Ultra-peripheral regions of the Atlantic" and the "Autonomous All-Electric Waterborne Feeder Loop System and Service" projects.

The PLEaMAR project is funded by the Canary Islands Agency for Research, Innovation, and Information Society (ACIISI) and receives support from ULL, its Nautical Section, and the collaboration of the Santa Cruz de Tenerife Harbor Pilots Corporation. It also benefits from the involvement of the Santa Cruz de Tenerife Port Authority, which is committed to promoting the use of sustainable and innovative energy sources in the port area as part of its Corporate Social Responsibility Plan. This objective aligns with the goals of the International Maritime Organization (IMO) to reduce greenhouse gas and nitrogen oxide emissions, as well as other pollutant emissions associated with the use of fossil fuels. In line with the emission reduction efforts, studies conducted by the research team indicate that PLEaMAR will serve as a demonstrator that many services performed in the inner waters of the port can be carried out using vessels equipped with 100% electric propulsion systems.

Image 10. Añaza P vessel.

Regarding fuel consumption, its economic cost, and the emissions generated by the pilotage activity during the analyzed period, it was concluded that, on average, this piloting service consumes between 100.000 and 130.000 liters of fuel annually, with an approximate cost of 82.000 euros. If the pilots' corporation were to generate its own renewable energy at the port facilities, this economic cost could be significantly reduced, improving the company's economic sustainability and competitiveness. The emissions produced by the pilotage

service due to the use of fossil fuels, measured in CO_2 equivalent, range between 300 and 350 tons annually.

H2 - OPS

OPS Master Plan Project Collaborates with EVERYWH2RE project for Innovative Ship Electrification Pilot. The project is aimed at developing a groundbreaking pilot for supplying ships with electric power generated from renewable sources while berthed. This pioneering initiative involves the utilization of a 100 kW hydrogen-based fuel cell assembly.

Building upon the successful implementation of hydrogen fuel in various port machinery and equipment at the Port of Valencia, the Port Authority of Tenerife has eagerly volunteered to materialize this pilot project, which has gained the recognition and support of State Ports. This noteworthy endeavor adds to the recent achievements of the pilot shore power supply installations in Santa Cruz de La Palma, San Sebastián de la Gomera, and Santa Cruz de Tenerife, already mentioned.

Image 11. Punta Salinas vessel.

The pilot project entails the reception, installation, and utilization of a fuel cell (FC) provided by the EVERYWH2RE project. This FC will utilize hydrogen (H_2) procured by the PAT to supply electric power to the search and rescue vessel, Punta Salinas, operated by SASEMAR. The vessel has a maximum installed power of 80 kW while berthed. The FC, along with nine bottles are housed in a standard ISO container - 'the unit'.

The unit has a capacity to deliver 100 kW, which is expected to meet the vessel's average power demand of approximately 50-75 kW. The operating mode of the unit will allow the general grid to act as a backup for the installation. This arrangement ensures a seamless and reliable power supply to the vessel, further enhancing its operational efficiency and environmental performance.

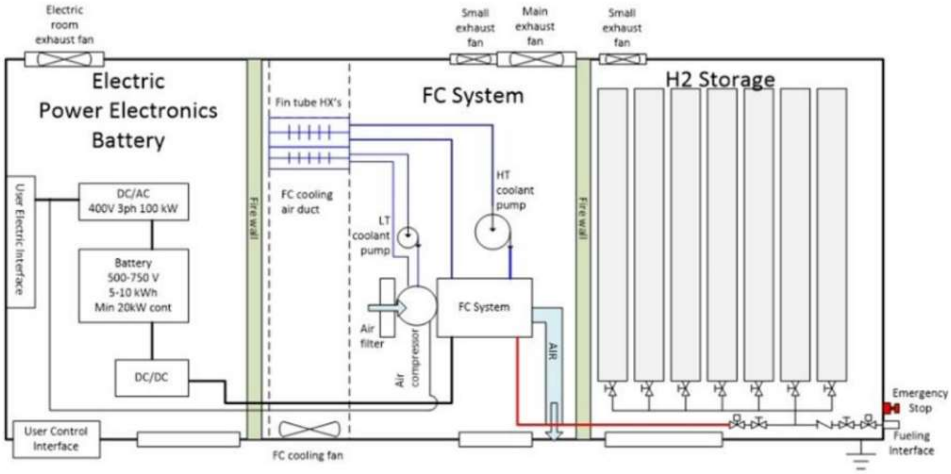

Image 12. Port authorities inspecting the unit (above).
Operating scheme of the unit (below).

As an active participant in the OPS Master Plan Project, alongside two other port authorities, the Port Authority of Tenerife, as previously mentioned, is fully committed to promoting the electrification of ships at berth. With the installation of shore power connections to the general electric grid, this project has spearheaded a series of impactful measures to foster the widespread adoption of this innovative and sustainable solution.

By submitting this outstanding endeavor for consideration, PAT hopes to inspire and contribute to the broader implementation of hydrogen-based solutions, while striving to set new industry standards and elevate sustainability practices across the maritime sector.

5. Conclusion

The collective efforts showcased in the Tenerife Port ZERO project represents a comprehensive endeavor aimed at transforming the Port Authority into a net-zero emissions entity by the year 2035. Through the implementation of innovative initiatives and the ongoing pursuit of new solutions, our vision of a sustainable and environmentally conscious port authority is becoming a reality.

By embracing technologies such as onshore power supply, hydrogen fuel cells, and synthetic fuels from plastic waste, we are actively reducing our carbon footprint and paving the way for a greener future. These projects, along with those on the horizon, demonstrate our unwavering commitment to sustainable practices and position us as pioneers in the industry.

With a clear trajectory towards achieving our emissions goals, we are confident that our endeavors will not only make a significant impact locally but will also serve as an inspiration and blueprint for other port authorities worldwide.

Last but not least, the Tenerife Port ZERO project aligns with several Sustainable Development Goals (SDGs) established by the UN:

By implementing technologies such as onshore power supply and hydrogen fuel cells, it promotes the use of clean and renewable energy sources, contributing to the transition towards affordable and sustainable energy solutions.

The project incorporates innovative technologies and practices, such as synthetic fuels from plastic waste and fuel cell power generation systems, fostering advancements in industry and infrastructure while promoting sustainable development.

Its focus on reducing emissions and adopting environmentally friendly practices contributes to creating sustainable and resilient cities and communities by mitigating the environmental impact of port operations.

Through the transformation of non-recycled plastic waste into valuable petrochemicals and the utilization of clean energy sources, the project promotes responsible consumption and production patterns while reducing waste generation and resource depletion.

The project's objective of achieving net-zero emissions aligns directly with SDG 13, as it addresses the urgent need to combat climate change and its impacts by implementing measures to reduce greenhouse gas emissions.

By reducing emissions and implementing sustainable practices, the project indirectly contributes to the preservation and conservation of marine ecosystems, promoting the health and sustainability of marine life.

It involves collaborations between various stakeholders, including port authorities, engineering companies, and research institutions, fostering partnerships and synergies to achieve sustainable development objectives.