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Atlantic Area



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Boosting the hydrogen transition
in the Atlantic Area ports

Deliverable D 4.1.1

**Map of Initiatives for Hydrogen Growth in
the Atlantic Area**

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EXECUTIVE SUMMARY

The objective of this Deliverable **D4.1.1 Mapping of Initiatives for Hydrogen Growth in the Atlantic Area** is to identify initiatives in the field of hydrogen in ports. Up to now, there is no repository offering this information, and it would be useful for practitioners and the general public to have a repository where they can locate up-to-date information on this topic.

An in-depth literature research was conducted from trustworthy sources in order to identify key initiatives related to Hydrogen (H₂) in European seaports, particularly those of the Atlantic Area (AA). In order to obtain as much information as possible per initiative, multiple sources were verified and cross-validated, and direct contacts were established with initiative partners/promoters. Extensive press coverage, journal papers and communications exist regarding this subject. However, not all of them pertain to consolidated initiatives, as a portion of them merely serve as promotional campaigns and/or unreliable sources.

To identify the main initiatives, this Deliverable establishes an information search methodology with a scope of the Atlantic Area and an information presentation model. There are different sources consulted such as digital press, web pages of associations, and project repositories (CORDIS, funding and tenders' portal, Interreg, Horizons Europe, etc.).

In accordance with the original project proposal, this Deliverable incorporates a Map of Initiatives containing information on the main initiatives related to Hydrogen and other pertinent energy carriers, such as Methanol and Ammonia, in present and planned ports in the AA regions. It serves to locate the main projects, their main characteristics, and the partners that compose them, among other complementary information. The content is structured in the form of an initiative file, with numerous main contents: Project Name, Location, Objective Summary, Main Partners, Duration/Timeline, Energy Carrier Production Technology, Energy Carrier Typology, Investment/Funding, Source of Funding, Brief Description, Energy Carrier Production, Capacity and/or Consumption, Final Uses, Contacts and Useful Links. To have complete information on each initiative, it was necessary to contact the promoters of the initiatives since some of the information is not published. As a result, Deliverable D4.1.1 is an encompassing document that provides an overview of H₂ trends in European seaports, which will be edited and updated throughout the implementation of the project.

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ABBREVIATIONS AND ACRONYMS

AA	- Atlantic Area
CCS	- Carbon Capture and Storage
ETS	- Emissions Trading System
EU	- European Union
FC	- Fuel Cell
NE	- Northern Europe
NS	- North Sea
PEM	- Proton Exchange Membrane
RES	- Renewable Energy Source

SYMBOLS

H ₂	- Hydrogen
CO ₂	- Carbon dioxide
CH ₄	- Methane
NO _x	- Nitrogen oxides
SO _x	- Sulfur dioxide

1 INTRODUCTION

Seeking to be a leader in the ongoing “green” energy transition, the European Union (EU) has set forth a sizeable number of initiatives towards implementing a renewable energy source (RES)-based economy. These initiatives fall within the scope of various directives and programs, from REPowerEU to the Green Deal. The multi-billion-euro funding sources call upon both private companies and public institutions to undertake strategic projects towards meeting the EU’s ambitious goals for energy transition in the upcoming years and decades.

One of the main goals regards energy storage. The share of RES in Europe’s energy market has increased significantly, with some countries reaching over 80% of RES integration into their national grids by early 2024. However, RES raises challenges regarding resource intermittency (*e.g.*, daylight cycles for solar and rainfall deficit for hydropower), which, in turn, promotes another issue related to synchronization between energy supply by RES and energy demand for anthropogenic activities. As often there is a temporal discrepancy in this supply-and-demand chain, there is a need for storage. While batteries (*e.g.*, Lithium-ion) have received increasing interest, other energy carriers have also been considered. A key option comes in the form of Hydrogen, which not only entices the prospect of energy storage but can also be used for other industrial purposes.

Being responsible for over 70% of the global trade network, maritime shipping and seaport activities play a pivotal role in the EU’s economy. However, this has come at the expense of significant pollutant emissions over the years. To tackle them, the EU has set increasingly tougher regulations upon emissions of CO₂, SO_x, NO_x, CH₄ and other pollutants, posing a challenge that port authorities must meet in order to accommodate the new restrictions. Hydrogen and its related energy carriers, such as Methanol and Ammonia, provide a high potential alternative to standard fossil-fuel-based energy sources, thus opening the path towards effective decarbonization and electrification of seaport infrastructure and marine mobility. In support of the EU’s 2050 net-zero target, the EU has established a swiftly evolving policy context that has generated momentum for the development of a European hydrogen economy. This context includes:

- The 2020 EU Hydrogen Strategy with an objective to establish a vision for the development of a European hydrogen ecosystem that spans from research and innovation to the expansion of production and infrastructure to an international scale [1]. The following milestones are included in this objective:
 - 2020 - 2024: Implementation of a minimum of 6 GW of electrolyzer capacity with the ability to generate up to 1 Mt or 33 TWh of renewable H₂. The primary objective is to reduce carbon emissions in the existing H₂ production methods and promote the utilization of H₂ in industrial operations and for long-distance transportation of heavy-duty vehicles.
 - 2025 - 2030: The objective is to install a minimum of 40 GW of electrolyzer capacity, which can generate up to 10 Mt or 333 TWh of renewable H₂. An extensive infrastructure of H₂ refueling stations and storage facilities will need to be developed. An essential step towards establishing a comprehensive H₂ network across the EU involves strategically

repurposing some components of the current gas infrastructure. The objective is to install 40 GW of electrolyzer capacity in nations that are in close proximity to the EU.

- 2030 - 2050: Hydrogen technology for the generation and utilization of environmentally friendly H₂ must attain full development and penetrate all sectors that are challenging to decarbonize, including aviation, maritime transport, and industrial facilities.
- 2021 onwards - “Fit for 55” package aims to establish the legislative and policy framework necessary to facilitate the prompt development of H₂ production, transportation, and end-use infrastructures until 2030 [2].
- 2022 onwards - REPowerEU Plan’s goal is to initiate the H₂ Accelerator program with the objective of achieving a domestic renewable hydrogen production of 10 Mt and importing 10 Mt of renewable H₂ by 2030. This includes importing 4 Mt in the form of ammonia [3].

Nevertheless, this implies large investments, logistical problems inherent to adapting and retrofitting the existing infrastructure and vessels to accommodate the new “green” energy carriers, and the establishment of H₂ valleys, hubs, and/or corridors that link various entities (public and private) from different countries of the EU. Therefore, part of the EU investments in the “green” energy transition are directed towards European initiatives towards the implementation of H₂ in seaports and marine mobility.

Under this framework, the HYDEA project seeks to identify the key initiatives and investments being made within the European landscape, in order to perceive the main market trends and understand what opportunities and challenges may be expected for the particular case of the Atlantic Area (AA) ports, given their unique features and necessities. This is the underlying premise of WP4.1, which is hereafter presented in the form of Deliverable 4.1.1., and which will serve as a follow-up not only for the remaining tasks of WP4 but also as a complement to other project activities, such as the establishment of the HYDEA community in WP3. The culmination of this Deliverable is the creation of a “Map of initiatives for Hydrogen growth in the Atlantic Area”. This map will contain information on the main initiatives related to H₂ in present and planned ports in the Atlantic Area regions. This map will serve to locate the main projects, their key characteristics, and the partners that compose them. It will offer a complete vision of the role that ports are taking in the hydrogen economy and a vision of the project models that are being carried out. The information on this map is completed with partner searches and direct contacts with initiative promoters, but also with information coming from promoters who want to make their respective projects more visible.

To initiate this research, ports were designated according to the volume of dominant activity in their archetype, as not every port within the scope of consideration is anticipated to have a substantial impact on the H₂ economy. Space constraints may significantly impede local production, storage, and bunkering operations, among other things. By employing H₂ port archotyping, one can structure the discussion on hydrogen demand, supply, and market potential of H₂, as well as facilitate the formulation of feasible business models. The primary H₂ activity drivers of each port establish a connection between it and one or more H₂ port archetypes. According to axes pertinent to the study conducted in [4], 4 H₂ port archetypes have been established: Logistics and transport (a large amount of liquid bulk, dry bulk, containers, cargo, and passengers in the port), urban (large urban areas in proximity to the port), industrial (high industrial activity in proximity to the port), and bunkering

(considerable number of bunkering fuels in the port). To ascertain the ranking of each port according to the archetypes it is linked to, data from many sources was collected for each archetype:

- Logistics and transport - The total amount of various types of cargo, measured in Mt, and the number of passengers traveling to and from the port, were collected from the Deloitte port database (based on data ESTAT);
- Urban - The population residing within a radius of 21 km from the port was derived from the Opendatasoft data hub;
- Industrial - Emissions of ETS installations within a 21 km radius of the port [CO₂-eq.], obtained from the EU ETS database;
- Bunkering - Volume of bunkering fuels [t], obtained from Deloitte port database (based on data ESTAT).

After the collection of data, the normalization method is applied across all ports to scale down the data to a range of 0 to 1. In other words, within the context of 1 H₂ activity driver, the port with the highest activity is assigned a value of 1, while the port with the lowest activity is assigned a value of 0. Every other port is proportionally adjusted within this range, according to the H₂ activity driver.

The list of ports based on the volume of dominant activity in their archetype is presented in [Table 1](#) which belongs to 'Tier 1' (the leading group of ports that maintained regular feedback interactions during the development of [4]). A port with a significant level of engagement in the corresponding activity is denoted by a dark color (*e.g.*, dark blue), while a port with a relatively minor level of involvement is denoted by a light color (*e.g.*, light blue). The level of industrial activity in Europe is most pronounced at the ports of Duisburg and Rotterdam, which are determined by the quantity of carbon dioxide (CO₂) emissions from industrial installations close to each port. Logistics and transport operations at individual ports are determined by passenger volume and port traffic. Rotterdam and Antwerp exhibit the highest passenger traffic and total number of ports, respectively. Helsinki has the highest passenger activity and Rotterdam has the highest cargo activity. The quantity of bunkering fuels sold in each port determines the bunkering activity; Rotterdam and Antwerp have the highest bunkering activity, respectively. Port urban activity is determined by the population density of neighboring cities; Barcelona and Hamburg have the most urban activity.

Lastly, the partners carried out follow-up research divided by region (*e.g.*, Portuguese partners searched Portuguese initiatives) to complement and detail the case studies inherent to AA ports. While some initiatives were already identified in the initial general screening, others were only found after this second-stage screening. As such, this stage enabled the final setup of the Map of Initiatives, which is embedded on the project's website. Multiple endeavors were made to generate the map utilizing various applications, sources, and libraries including QGIS, WordPress, ESRI, Leaflet, and Plotly. These tools include distinct functionalities, and some of them (WordPress and ESRI) necessitate registration and subscription costs. These fees must be renewed annually, even after the project has been completed, to maintain the data on the website. Consequently, this aspect of the tools posed a disadvantage for this project. Initially, QGIS was used to create an interactive map of the H₂ initiatives. However, QGIS proved to have limitations in this aspect. The goal was to pinpoint all the initiatives in the AA ports and allow users to interact with the map by clicking on markers representing the port

locations involved in the H₂ project and project information would be displayed. Therefore, it was determined that in order to minimize expenses, ArcGIS (online) will be used to generate an interactive map since the University of Porto has an annual subscription to it.

Table 1 - List of ports from 'Tier 1' involved in the corresponding activity.

PORTS	COUNTRY	INDUSTRIAL	LOGISTICS AND TRANSPORT	BUNKERING	URBAN
Rotterdam	Netherlands	●	●	●	
Amsterdam	Netherlands	●	●	●	●
Antwerp-Bruges	Belgium	●	●	●	
Calais	France		●		
Marseille	France	●		●	
Helsinki	Finland		●		
Piraeus	Greece		●		●
Hamburg	Germany		●	●	●
Duisburg	Germany	●			
Düsseldorf	Germany	●			
Stavanger	Norway	●			
Barcelona	Spain				●
Algeciras	Spain			●	
Napoli	Italy				●
Stockholm	Sweden				●
Constanta	Romania		●		
Klaipėda	Lithuania		●		

2 METHODOLOGY

In order to establish the Map of Initiatives, it was essential to conduct a comprehensive overview of European ports, in general, and establish the foundation for the research of the AA ports, in particular. With the intention of facilitating the identification of the most prospective initiatives and the main market trends, literature research was conducted in the initial months of the activities associated with WP4.1. This involved the following steps which are also summarized in [Figure 1](#):

- Definition of research keywords such as “hydrogen”, “methanol”, “ammonia”, “renewable fuels”, “energy carriers”, “maritime shipping”, “electrification”, “decarbonization”, “cold ironing”, “Power-to-X”, “seaports”, “harbors”, “marine renewable energy sources”, etc.;
- Identification, evaluation, and summary of literature sources of interest towards identifying European Hydrogen-related initiatives in ports. The sources include peer-reviewed journals (*e.g.*, Elsevier, MDPI, Springer, etc.) and databases (*e.g.*, Scopus, Web of Science, etc.), as well as European Commission databases and associated initiatives and institutions (*e.g.*, Clean Hydrogen Partnership, Horizons Europe, etc.) and trustworthy media (*e.g.*, Offshore Energy,

which disseminates official press releases made by port authorities, companies and public institutions related to offshore industries, including H₂ and other energy carriers);

- Follow a “branch” approach to obtain additional information. In other words, from the previous step, it was possible to identify major stakeholders involved in the principal initiatives and consult their websites and online platforms. This, in turn, enabled the identification of additional initiatives in which they are involved through dedicated topic sub-pages that re-direct to said initiatives. These were then also evaluated, and the process was repeated upon the identification of other partners;
- The collected data was cross-validated by the partners involved in WP4.1 and also by other information sources (*e.g.*, consult different project sub-pages from company websites of stakeholders involved in said projects, to ensure that the provided information is consistent). In most identified initiatives, the information was found to be reliable and complete across the distinct information sources, but punctual gaps were detected and considered, particularly in terms of project duration and funding. As a result, over 90 European initiatives worthy of note were identified and summarized;
- Based on the collected data for each European initiative, the partners established and agreed upon a multi-parameter summary of the information. This encompasses the following fields: Project Name, Location, Objective Summary, Main Partners, Duration/Timeline, Energy Carrier Production Technology, Energy Carrier Typology, Investment/Funding, Source of Funding, Brief Description, Energy Carrier Production, Capacity and/or Consumption, Final Uses, Contacts and Useful Links. By summarizing them in this manner through a Table format, it became feasible to handle the huge amount of data and identify recurrent patterns/trends, from partners to applications for the energy carriers, a matter to be further developed in WP4.2.

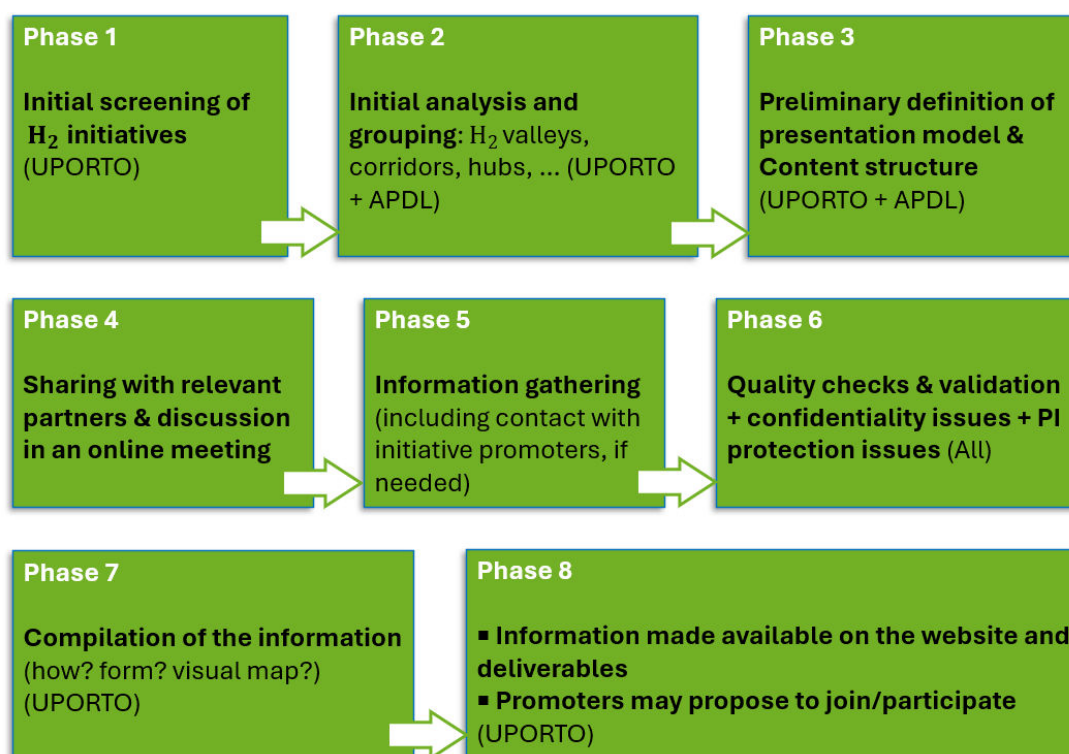


Figure 1 - Scheme of the procedural framework.

The outcomes of this “branched” research are provided in Section 3 of this Deliverable, including a brief description of the 29 most pertinent initiatives being undertaken mostly in the Atlantic area and the North Sea (NS) regions.

3 DETAILED MAPPING OF HYDROGEN INITIATIVES

3.1 INTRODUCTION

In accordance with the Deliverable's scope, a decision was made to prioritize H₂ initiatives situated in the AA ports in the detailed description or mapping process. Furthermore, it became pertinent to incorporate additional initiatives from the 4 participating countries (France, Ireland, Portugal, and Spain) into this study, regardless of their locations in non-AA regions; however, it is important to emphasize that only H₂ projects related to seaports were considered. Moreover, in light of some promising H₂ initiatives in other European countries, it was decided to include some of them in this document, especially those in partnership with the ports in [Table 1](#). A total of 158 H₂ projects were identified from various reliable sources. However, since some of these projects were not in collaboration with ports, the list was narrowed down to approximately 90 projects, considering the specific objectives of this Deliverable. There were a few exceptions for projects located outside of the 4 countries. As mentioned, priority was given to initiatives in the AA ports. As a result, [Figure 2](#) presents the condensed mapping of ports (not all ports are presented on the map because there were some uncertainties about whether some of them still function. Some were represented by one location since they were close to each other) in 4 countries located in the AA with those involved in the H₂ projects. The main objective was to highlight big ports that may have an impact on the hydrogen market in the future.

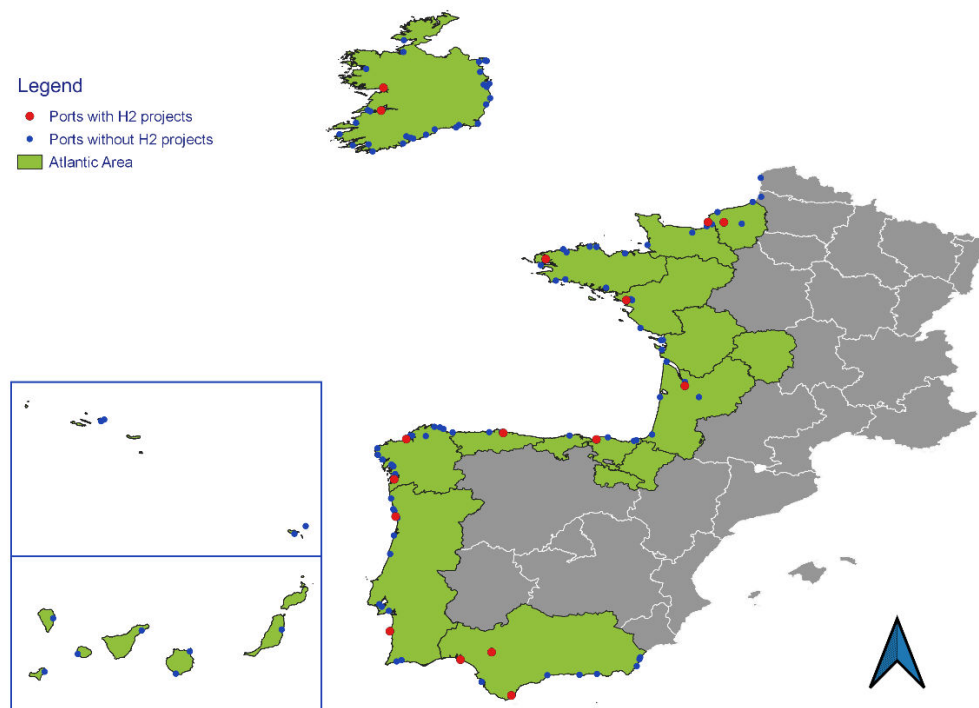


Figure 2 - Mapping of ports involved in H₂ projects (red marker) and ports not involved in H₂ projects (blue marker) located in the AA.

3.2 DETAILED MAPPING OF H₂ INITIATIVES IN PORTS

This section has 29 initiatives selected from the previously indicated list of about 90 projects. The initial 23 projects are situated within the aforementioned 4 countries, while the remaining 6 are located in other European nations. The purpose of this section was to analyze and select a limited number of initiatives from the list and provide a comprehensive description of them. The selection process considered factors such as the level of complexity, scale, investment, and geographical location of the projects. However, due to the limited number of projects in some countries or regions within the AA, it was decided to include all initiatives from such regions to fulfill the scope of the Deliverable, even if they did not fully meet the selection criteria. Consequently, these projects were given priority in the analysis. The comprehensive description also encompasses projects in the non-AA regions that were selected based on the criteria, with a focus on those situated in Northern Europe (NE), particularly those listed in [Table 1](#) given that NE has very important ongoing projects that may dictate market trends. These projects involve substantial investments and stakeholders, which are expected to have a significant impact on the prevailing trends in the hydrogen market.

An Interactive Map was also created, which can be found on the [HYDEA](#) project website. It is important to highlight that the Interactive Map may not give a detailed description of the initiatives as it is presented in this Deliverable, due to some limitations encountered during the development of the map (e.g., the limited size of the pop-up box). Nevertheless, the map incorporates an important additional parameter that denotes the status of each initiative. This parameter is exclusively included on the map due to its ease of modification, both during and after the development of the HYDEA project.

Project 1 - GREENH2ATLANTIC

Location:	Portugal
Objective Summary:	The objective is to encourage the reduction of carbon emissions in the Sines fossil fuel industrial hub by effectively integrating a 100 MW alkaline electrolyzer with solar and wind energy sources. This will demonstrate the most cost-effective production of green hydrogen.
Main Partners:	Axelera, Bondalti, CEA, DLR, EDP, Efacec, Engie, Galp, Vestas, INESC TEC, ISQ, McPhy, Martifer, and Port of Sines.
Duration/Timeline:	2021-2027
Energy Carrier Production Technology:	100 MW alkaline electrolyzer (16-MW modules)
Energy Carrier Typology:	Green Hydrogen
Investment/Funding:	76.614M
Source of Funding:	EU contribution: 30M
Brief Description:	GreenH2Atlantic will convert a previously coal-fired power station into a cutting-edge facility for producing renewable hydrogen. This project is in line with Europe's plans for reducing carbon emissions and transitioning to cleaner energy sources.

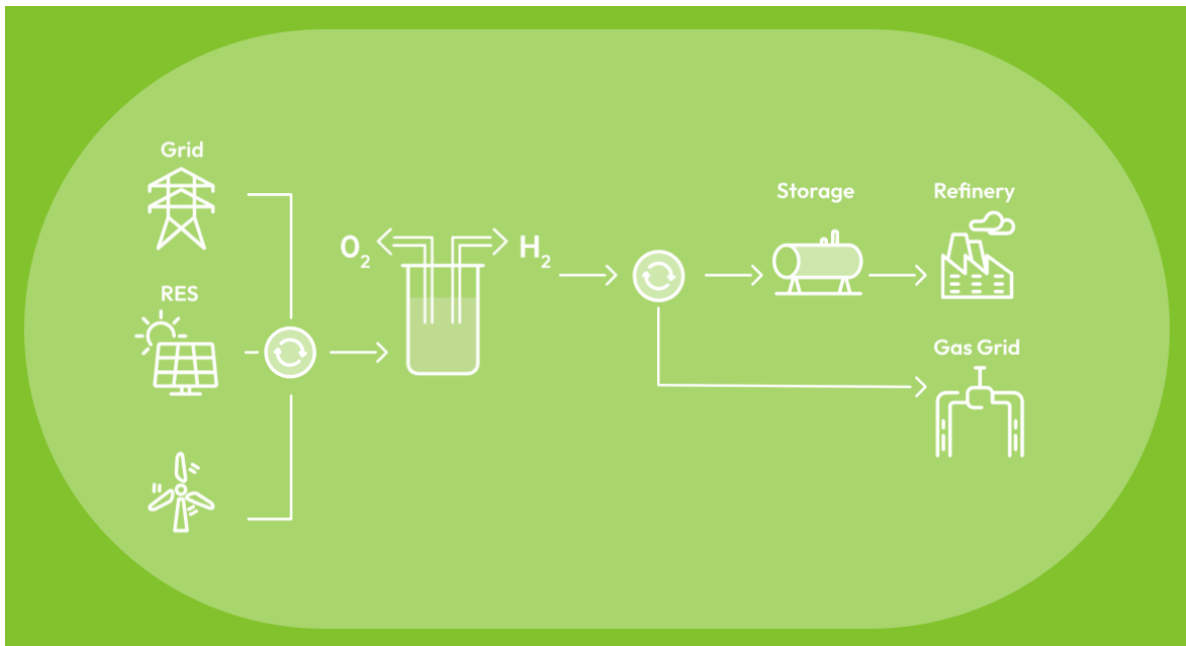


Figure 3 - The process used to produce, store, and transport H₂.

Energy Carrier Production, Capacity and/or Consumption:

10,000 tons.

Final Uses:

Repurpose of shutdown coal power plant, Industry, and Storage.

Contacts:

<https://www.greenh2atlantic.com/contact>

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Useful Links:

[\[A\]](#) [\[B\]](#)

Project 2 - MadoquaPower2X

Location:

Portugal

Objective Summary:

The objective of the initiative is to decrease annual CO₂ emissions by generating green hydrogen and renewable ammonia.

Main Partners:

Madoqua, Power2X, and Copenhagen Infrastructure Partners.

Duration/Timeline:

2022-2027

Energy Carrier Production Technology:

1 GW of electrolysis capacity (alkaline water) and the production of green ammonia (Haber-Bosch process).

Energy Carrier Typology:

Green Hydrogen and Ammonia

Investment/Funding:

> 2.8B

Source of Funding:

Consortium investment

Brief Description:

This project will be the first installation in the forthcoming energy and technical center in Sines, operating on a large industrial scale. The activity will stimulate economic growth by adhering to the newest EU Taxonomy's classification of

sustainability. Additionally, it plays a crucial role in ensuring a self-sufficient electricity infrastructure.



Figure 4 - The infrastructure required, and the process used to produce green Hydrogen and Ammonia.

Energy Carrier Production, Capacity and/or Consumption:

150,000 tons of green H₂ and 300,000 tons of green ammonia per year, CO₂ emissions avoided by 1,200,000 tons/yr.

Final Uses: Storage, Port-to-port transport, Industrial, Agricultural, and Distribution.

Contacts: <https://madoquapower2x.com/contact/>

Useful Links: <https://madoquapower2x.com/>

Project 3 - Galp H2 Park

Location: Portugal

Objective Summary: To construct a 100 MW industrial electrolysis plant dedicated to the generation and storage of green hydrogen gas.

Main Partners: Galp and Port of Sines

Duration/Timeline: 2023-2030

Energy Carrier Production Technology:

100 MW (up to 600 MW, long-term) of proton exchange membrane (PEM) electrolyzers + recycled wastewater from Águas de Santo André (feedwater).

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 240M

Source of Funding: PRR and Next Generation EU

Brief Description: Implement a partial substitution of the existing grey hydrogen utilized in the operations of the Sines refinery, resulting in a decrease in greenhouse gas

emissions. Therefore, it helps achieve decarbonization goals at the European, national, and company levels by increasing the variety of energy sources and promoting the local economy. Additionally, it plays a role in establishing Sines as a hub for clean and sustainable energy.



Figure 5 - The location of the new Hydrogen infrastructure.

Energy Carrier Production, Capacity and/or Consumption:

15,000 tons of green H₂ per year, 110,000 tons of CO₂ emissions are reduced per year.

Final Uses: Storage, Non-marine mobility, Industrial, Infrastructure electrification, and Distribution.

Contacts: galph2park@galp.com, Tel 800 200 200
geral@apambiente.pt, Phone: 214 719 074

Useful Links: [\[A\]](#) [\[B\]](#)

Project 4 - NeoGreen’s flagship Power-to-X project

Location: Portugal

Objective Summary: The objective is to generate green hydrogen and e-methanol in order to support the reduction of carbon emissions in the maritime and petrochemical industries, specifically in Iberia and North-Western Europe.

Main Partners: NeoGreen Hydrogen and Port of Sines.

Duration/Timeline: 2022-2027

Energy Carrier Production Technology:

330 MW Electrolyzers (800+MW of RES installed for electricity supply).

Energy Carrier Typology:

Green Hydrogen and Methanol

Investment/Funding: > 1B

Source of Funding: Consortium investment

Brief Description: A 330 MW electrolyzer and methanol synthesis complex will be constructed on a 10.8 ha site in the Sines Industrial and Logistics Zone, which is situated near the port. The generated H₂ will thereafter be introduced into the gas grid to reduce carbon emissions in the local network. E-MeOH is utilized as a marine fuel and transported to reduce carbon emissions in the chemical industry.

Energy Carrier Production, Capacity and/or Consumption:

40,000 tons of green hydrogen, capable of delivering 230,000+ tons of e-methanol per year.

Final Uses: Storage, Marine mobility, Industry, Distribution, and Grid electricity.

Contacts: <https://neogreenhydrogen.com/home>

Useful Links: <https://neogreenhydrogen.com/sines>

Project 5 - H2tALENT

Location: Portugal

Objective Summary: H2tALENT's objective is to establish a prominent Hydrogen Valley that will strengthen investment in the area and promote the development of hydrogen ecosystems in Alentejo. This will be achieved by implementing innovative green hydrogen initiatives along the entire value chain.

Main Partners: <https://www.pact.pt/site/project/h2talent/>

Duration/Timeline: 2024-2029

Energy Carrier Production Technology:

Electrolyzers

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 9.948M

Source of Funding: EU contribution: 8.828M

Brief Description: H2tALENT aims to attract, nurture, and improve individuals, initiatives, and goods related to hydrogen in the Alentejo region, positioning it as a prominent and acknowledged hub for green hydrogen. Technology assessment and effect modelling are used to enable the appropriate integration of the energy system, so contributing to the energy transition in Portugal. The use of Digital Twinning enables efficient planning and operation by supporting the expansion and duplication of processes. Additionally, workforce development and public perception efforts enhance the capabilities of employees and contribute to social advantages.

Energy Carrier Production, Capacity and/or Consumption:

As a consequence of this project, in the next 5 years 2.1 GW of electrolyzers, 180K tons/year of green H₂, 2 billion euros of investments and 5,000 jobs are planned in Alentejo.

Final Uses: Distribution, Industrial, and Non-marine mobility.

Contacts: <https://www.pact.pt/site/fale-connosco/>
Useful Links: [\[A\]](#) [\[B\]](#)

Project 6 - Green Flamingo

Location: Portugal and Netherlands

Objective Summary: The objective is to construct a solar-powered green hydrogen production facility, which would rank among the largest planned plants globally, with a capacity of 1 GW. The aim is to transport the initial batch of liquid hydrogen from Sines to Rotterdam by 2027.

Main Partners: EDP, Galp, Martifer, REN, Vestas, Port of Sines, Shell, ENGIE, Anthony Veder and Vopak.

Duration/Timeline: 2023-2030

Energy Carrier Production Technology:

Electrolyzers

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 5B

Source of Funding: EU contribution (IPCEI)

Brief Description: The plant plays a crucial role in Portugal's efforts to address the economic downturn resulting from the Covid-19 pandemic. The group plans to generate hydrogen through the process of electrolysis, using renewable power sources, within the industrial zone of the Sines port. Subsequently, the hydrogen undergoes liquefaction and is transported by a liquid hydrogen carrier to the port of Rotterdam for the purpose of distribution and commercialization.



Figure 6 - The solar panels used to power green hydrogen production plants.

Energy Carrier Production, Capacity and/or Consumption:

1 GW hydrogen production plant through electrolyzer. They will initially assess the potential of producing, transporting, and storing around 100 tons per day,

with the potential to scale this up over time. The project starts with a 10 MW pilot electrolysis installation. Full capacity is expected by 2030.

Final Uses: Storage, Non-marine mobility, Marine mobility, Port-to-port transport, Industry, Infrastructure electrification, and Distribution.

Contacts: <https://www.portofrotterdam.com/en/contact>

Useful Links: [\[A\]](#) [\[B\]](#) [\[C\]](#) [\[D\]](#)

Project 7 - MAGPIE

Location: Portugal, Netherlands, France and Germany

Objective Summary: The project aims to showcase technological, operational, and procedural energy supply solutions that will promote environmentally friendly, smart, and integrated multimodal transportation. It will ensure the successful implementation of these solutions through the European Green Ports of the Future Master Plan.

Main Partners: <https://www.magpie-ports.eu/consortium>

Duration/Timeline: 2021-2026

Energy Carrier Production Technology:

On-site BioLNG production; Smart Energy Systems; Shore power peak shaving; Port digital twin (GHG tooling and energy matching); Ammonia bunkering; Offshore charging buoy; Autonomous e-barge and transshipment; Green energy container for inland shipping; Hybrid shunting locomotive; Green connected trucking; Spreading of road traffic; non-technological innovations to increase the use of green energy.



Figure 7 - Project map showing green energy infrastructure.

Energy Carrier Typology:

Hydrogen, Ammonia and Methanol

Investment/Funding: 30.764M

Source of Funding: EU contribution: 24.964M

Brief Description: The MAGPIE project will undertake 12 pilot activities in three main domains: alternative energy sources, smart technology implemented in power operations, and links between rivers and railways and the surrounding area. MAGPIE aims to integrate the rapid implementation of green energy sources with the optimization of logistics in ports using automation and autonomous operations.

Energy Carrier Production, Capacity and/or Consumption:

12 pilot activities in 3 key areas: alternative energy sources; smart technologies applied to power operations; and river and rail connections with the hinterland.

Final Uses: Port-to-port transportation, Storage, Non-marine and marine mobility, and Industrial.

Contacts: <https://www.magpie-ports.eu/contact/>

Useful Links: [\[A\]](#) [\[B\]](#)

Project 8 - SH2AMROCK

Location: Ireland

Objective Summary: The project aims to establish Ireland's first multi-modal hydrogen transport hub. Its primary objectives are to enhance domestic confidence, expertise, and knowledge to achieve decarbonization in challenging sectors, facilitate greater cross-border energy cooperation with Northern Ireland, and capitalize on the island's potential as a long-term energy exporter.

Main Partners: <https://www.sh2amrock.eu/>

Duration/Timeline: 2024-2029

Energy Carrier Production Technology:
Electrolyzers

Energy Carrier Typology:
Green Hydrogen

Investment/Funding: 54M

Source of Funding: Local government, national government, and EU

Brief Description: SH2AMROCK will serve as the initial phase in the implementation of Ireland's long-term goals for hydrogen and energy. It plans to implement green hydrogen technology in crucial industries that are difficult to decarbonize throughout the island of Ireland. This includes developing essential infrastructure to support the generation, distribution, and utilization of green hydrogen.

Energy Carrier Production, Capacity and/or Consumption:

500 tons of Hydrogen per year.

Final Uses: Industrial, Distribution, Storage, and Non-marine mobility.

Contacts: <https://www.sh2amrock.eu/>

Useful Links: [\[A\]](#) [\[B\]](#)

Project 9 - Green fuels supply chain corridor (MoU)

Location: Ireland and Netherlands

Objective Summary: The objective is to establish a supply-chain corridor for exporting environmentally friendly fuels to Europe, which will be generated from the abundant wind resources in the western region of Ireland.

Main Partners: Ports of Rotterdam and Shannon Foynes.

Duration/Timeline: 2024-2030

Energy Carrier Production Technology:

N/A

Energy Carrier Typology:

Green Hydrogen, Ammonia and Methanol

Investment/Funding: N/A

Source of Funding: N/A

Brief Description: The two ports may collaborate on market growth in this emerging market and collectively identify end-users for the supply from Ireland. The project's agreement will primarily concentrate on the market and trade expansion of large quantities of green hydrogen and its by-products generated at the proposed worldwide green energy hub on the Shannon Estuary.

Energy Carrier Production, Capacity and/or Consumption:

N/A

Final Uses: Port-to-port transport, Industry, Marine mobility, Agriculture, Non-marine mobility, and Storage.



Figure 8 - The port of Rotterdam.

Contacts: <https://www.portofrotterdam.com/en/contact>

<https://www.sfpc.ie/contact/>

Useful Links: [\[A\]](#) [\[B\]](#)

Project 10 - Green hydrogen production site, Sealhyfe project

Location: France

Objective Summary: To construct an industrial facility capable of producing up to 85 tons per day of environmentally friendly and sustainable hydrogen.

Main Partners: Nantes Saint-Nazaire Port and Lhyfe.

Duration/Timeline: 2022-2028

Energy Carrier Production Technology:

Industrial-scale Electrolysis

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: N/A

Source of Funding: N/A

Brief Description: This project is anticipated to make a significant contribution to the decarbonization of the industrial port complex and maritime transit. Furthermore, it aligns with the action program aimed at developing a "Low Carbon Industrial Zone" (ZIBaC).

Energy Carrier Production, Capacity and/or Consumption:

85 tons/day of green and renewable hydrogen (with an installed electrolysis capacity of 210 MW).



Figure 9 - The Sealhyfe offshore green hydrogen production platform.

Final Uses: Industry, Distribution, and Marine mobility.

Contacts: <https://www.nantes.port.fr/fr>

Useful Links: [A] [B]

Project 11 - Cryocap

Location: France

Objective Summary: Participate in and make a valuable contribution to the project of reducing carbon emissions in various industrial processes at the Port-Jérôme location.

Main Partners: Air Liquide, Armines, CEA, and Port of Jerome.

Duration/Timeline: 2015-2020

Energy Carrier Production Technology:

Production via SMR using biomethane

Energy Carrier Typology:

Blue Hydrogen

Investment/Funding: 35M

Source of Funding: 5.1M from public funding

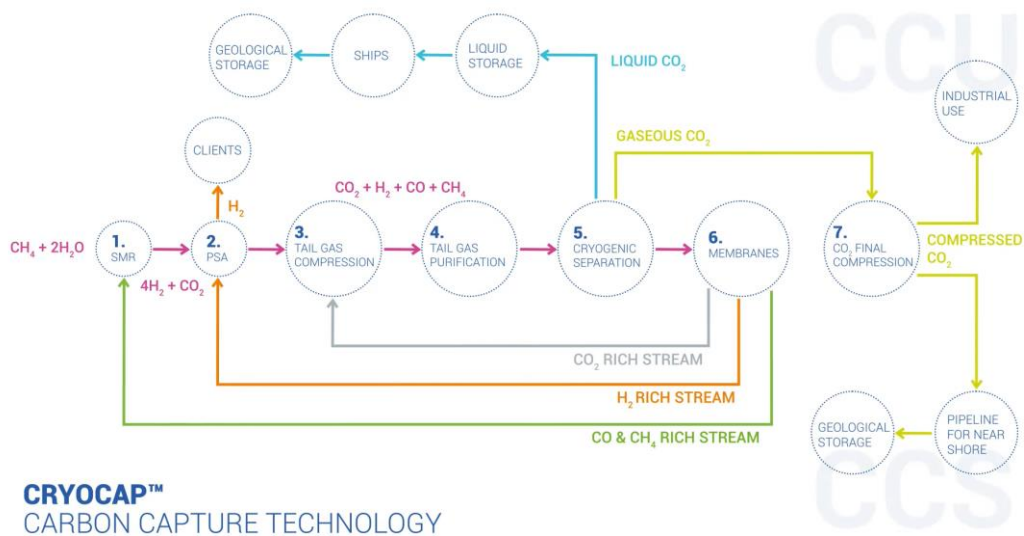
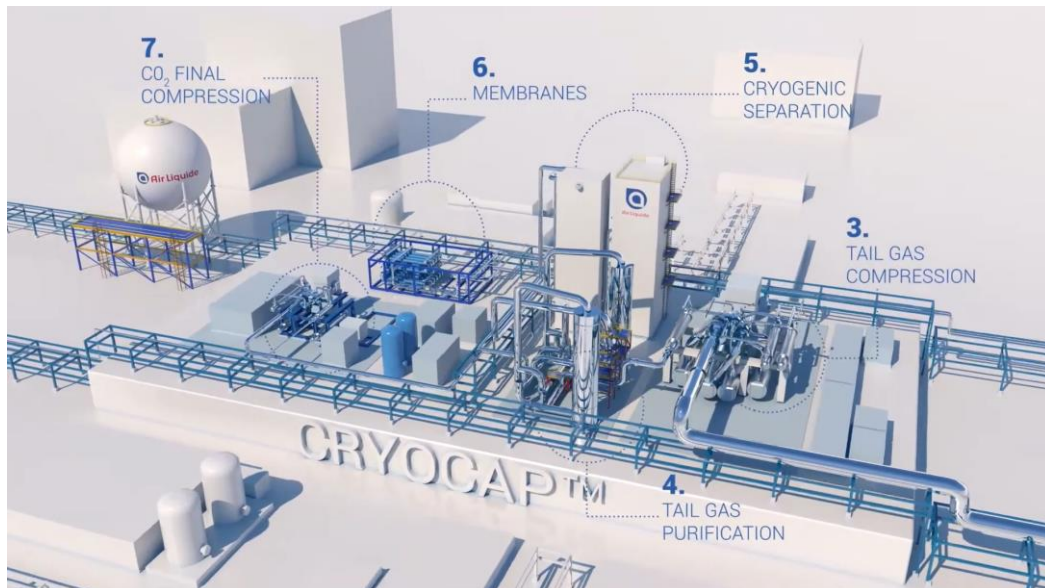


Figure 10 - The process of carbon capture technology.

Brief Description: The technique involves capturing the CO₂ released during the production of H₂ using a cryogenic method that converts the gas into a liquid state. Once purified, this CO₂ can be utilized to fulfill the requirements of nearby industrial markets for various purposes, including agro-food and water treatment, among others.

Energy Carrier Production, Capacity and/or Consumption:

4,500 kg/day of hydrogen produced via steam methane reforming coupled with CCS. Biomethane is used as feed gas. Hydrogen is then used in the refining industry, while CO₂ is used for the food industry, water treatment pH control, and greenhouses.

Final Uses: Industry and Distribution.

Contacts: <https://www.airliquide.com/contact>

Useful Links: [\[A\]](#) [\[B\]](#)

Project 12 - New low-carbon hydrogen facility

Location: France

Objective Summary: The project is anticipated to enhance and enlarge the local industrial ecology. According to the interested parties, it will aid in the process of reducing carbon emissions in industrial sites within the port region, as well as in the maritime and aviation sectors. The need for sustainable fuels in these sectors is experiencing substantial growth.

Main Partners: Haropa Port and Verso Energy.

Duration/Timeline: 2023-2029

Energy Carrier Production Technology:

Electrolysis (350 MW) and other for captured CO₂ (CCS).

Energy Carrier Typology:

Blue Hydrogen

Investment/Funding: 500M

Source of Funding: N/A

Brief Description: A production facility will be established on a piece of land owned by Haropa Port/Rouen in the municipality of Grand-Quevilly, located at the administrative border with Petit-Couronne. The estimated timeline for its launch is 2029. The project aims to generate hydrogen using the process of water electrolysis. Additionally, a facility will be established to produce synthetic fuels by utilizing captured and recycled CO₂. This project is expected to create approximately 150 direct and 250 indirect jobs.

Energy Carrier Production, Capacity and/or Consumption:

350 MW, corresponding to an annual volume of more than 50,000 tons of hydrogen.

Final Uses: Industrial, Non-marine, and marine mobility.

Contacts: <https://www.haropaport.com/en/contact>

<https://verso.energy/en/contact-us/>

+33(2) 79 18 05 00

Useful Links: [\[A\]](#) [\[B\]](#)

Project 13 - H2Bordeaux

Location: France

Objective Summary: The project's objective is to examine hydrogen as a substitute fuel for transportation to reduce carbon emissions in the Core Port of Bordeaux. This will be achieved by utilizing the hydrogen generated by a factory located in the metropolitan area of Bordeaux.

Main Partners: Storengy (Engie), Port of Bordeaux, and HENSOLDT NEXEYA FRANCE.

Duration/Timeline: 2020-2022

Energy Carrier Production Technology:

Electrolyzers

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 750K

Source of Funding: EU contribution: 375K

Brief Description: The task of this project will necessitate assessing the complete hydrogen value chain, encompassing the processes of recovery, treatment, storage, transportation, and valorization. The Action specifically targets a particular section of the value chain, which is the infrastructure required to effectively utilize the recovered hydrogen in the harbor region of Bordeaux.

Energy Carrier Production, Capacity and/or Consumption:

This solution would reduce CO₂ emissions by about 400 t/year for a container ship making 1 24-hour stopover per week. Reduce CO₂ emissions by more than 100 t/year per vessel.

Final Uses: Industrial and Infrastructure electrification, Non-marine and marine mobility.

Contacts: h2.bordeaux@nexeya.com

t-guillon@bordeaux-port.fr

contact@storengy.com

Useful Links: [\[A\]](#) [\[B\]](#)

Project 14 - REDII Interreg North Sea

Location: France

Objective Summary: Expediting the implementation and utilization of green hydrogen-based technologies in an integrated way with marine and other sustainable energy in ports located in the Atlantic Area.

Main Partners: Ports of Skagen, Moss, Brussels, Hamburg (Marketingà), Trelleborg, Zwolle, Korsoer, Brest (Brittany Region and Bretagne Development), Eigersund municipality, MCS (container terminal), MEP (Maritime Equity Partners), and VIVES university.

Duration/Timeline: 2023-2026

Energy Carrier Production Technology:

Several options to be compared

Energy Carrier Typology:

Methanol, Blue and Green Hydrogen

Investment/Funding: Interreg North Sea / Focal in Brest port for France

Source of Funding: N/A

Brief Description: Analyzing the potential of H₂ and ammonia in the port of Brest (pilot port) to set out feasibility and decarbonization road maps.

Energy Carrier Production, Capacity and/or Consumption:

N/A

Final Uses: Industrial Storage, Distribution, Infrastructure electrification and Port-to-port transportation, Non-marine, and marine mobility.

Contacts: Maximilien Le Menn maximilien.lemenn@bretagne.bzh

Useful Links: <https://www.interregnorthsea.eu/redii-ports>

Project 15 - H2SHIPS

Location: France, Netherlands, UK, Belgium and Germany

Objective Summary: The project H2ships aims to explore the technological and economic feasibility of utilizing hydrogen as a fuel source in the shipping industry. Two primary factors will be taken into account: The utilization of H₂ as a source of fuel for propelling ships and the process of bunkering H₂ in ports to ensure the refueling of vessels. The H₂ ships project will also explore the factors that can encourage the use of H₂ technologies in the maritime industry.

Main Partners: Hynamics, University of Birmingham, Delft University of Technology, Navalu, SYCTOM, Amsterdam Port Authority, HAROPA – Ports of Paris, Port Oostende, Steinbeis 2i GmbH, HYDROGEN EUROPE, Transport & Environment, and Tata Steel Europe.

Duration/Timeline: 2019-2023

Energy Carrier Production Technology:

Electrolyzers

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 6.33M

Source of Funding: EU contribution (ERDF): 3.47M

Brief Description: This project will examine the structure and arrangement of the supply chain for H₂ used in water transportation. The primary concern is to determine the necessary circumstances for establishing and expanding this supply chain. Facilitate the adoption of H₂ as a fuel in the Northwest-Europe region by sharing the findings with influential decision-makers and stakeholders in the marine and inland transport industry.

Energy Carrier Production, Capacity and/or Consumption:

Pilot 1 will be a 20 m-long vessel operating in both urban and seaport areas between Amsterdam and IJmuiden. The vessel will be powered by a hybrid fuel cell-battery propulsion system.

Final Uses: Port-to-port transportation and Marine mobility.

Contacts: berthon@eifer.org

Useful Links: [\[A\]](#) [\[B\]](#) [\[C\]](#)

Project 16 - North Sea H2 Valley Ports

Location: France, Netherlands, Denmark, Belgium, and Germany

Objective Summary: The objective of the project is to create Hydrogen Valley Master Plans in a minimum of 4 ports: Bremen, Brest, Esbjerg, and den Helder.

Main Partners: New Energy Coalition, Ports of Bremen, Brest, Esbjerg and den Helder, Free Hanseatic City of Bremen, Institute of Shipping Economics and Logistics (Bremen) Ballard Power Systems, University of Cean – Normandy, Ontwikkelingsbedrijf Noord-Holland Noord en Laholm Municipality.

Duration/Timeline: 2024-2026

Energy Carrier Production Technology:

Review of all technologies

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 1.5M (Studies/coordination activities).

Source of Funding: This project receives subsidies from the European subsidy program InterReg.

Brief Description: The consortium members of the NS H₂ Valley Ports project will create detailed plans for H₂ assets in 4 NS ports. These plans will optimize the production, utilization, storage, and transport of H₂. The goal is to improve the governance of maritime port ecosystems in the NS region and help stakeholders overcome existing barriers in the development and deployment of maritime H₂Valleys.

Energy Carrier Production, Capacity and/or Consumption:

N/A

Final Uses: Port-to-port transport, Non-marine and marine mobility, Storage, and Distribution.

Contacts: <https://www.brest.port.bzh/fr/contacts>

Jon Jordan at jon@18.170.5.111 or phone +44 1259 781404

<https://www.newenergycoalition.org/en/contact/>

Useful Links: [\[A\]](#) [\[B\]](#)

Project 17 - N/A

Location: Spain

Objective Summary: This project aims to reduce carbon emissions in industrial operations and power generation. It also seeks to promote the use of green H₂ in transport, including

cars and truck fleets associated with port activity, such as public transport, municipal services, and trains.

Main Partners: Port of Algeciras, Fistera Energy, Enagás, and White Summit Capital.

Duration/Timeline: N/A

Energy Carrier Production Technology:

Electrolyzers

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 300M

Source of Funding: N/A

Brief Description: The initiative enables Andalusia to assess the worth of renewable resources that can be utilized for the production of green H₂. Andalusia, being strategically positioned, can effectively utilize the renewable resources at its disposal to produce green H₂ and facilitate the decarbonization of sectors that cannot be electrified. The green H₂ generating project in the Bay of Algeciras aims to efficiently incorporate renewable energy resources into the region.



Figure 11 - 3D design of Hydrogen production facility.

Energy Carrier Production, Capacity and/or Consumption:

Green H₂ production plant in the Bay of Algeciras of up to 237 MW. This facility will supply green H₂ to the local industry. Planned to transport 4.5 Mtons of green H₂ by 2030.

Final Uses: Industrial

Contacts: <https://fuelcellsworks.com/contact/>

Useful Links: [A] [B]

Project 18 - Jules Verne

Location:	Spain
Objective Summary:	The production and distribution of green H ₂ for use in port logistical operations, industrial consumption, land transportation, maritime mobility, and 'zero emissions' Cold Ironing in the Port of Vigo area.
Main Partners:	Port Authority of Vigo, Univergy, Quantum Group, Soltec Ingenieros, Anfaco Cecopesca Technology Center, Aclunaga, CTAG, ENERGYLAB, Neuwalme, Exportrends, Botamavi and Aister + up to 15 other companies.
Duration/Timeline:	2022-2024
Energy Carrier Production Technology:	1.4 MW Electrolyzer (PEM or Alkaline), initially at 300 kW (lung at 30 bar) + electrical transformer, purified water generation unit (<1 μs), and H ₂ separating, drying, and purifying unit.
Energy Carrier Typology:	Green Hydrogen
Investment/Funding:	6M (initial investment)
Source of Funding:	2.4M from the call “Proyectos Pioneros y Singulares de hidrógeno renovable”
Brief Description:	The Port of Vigo has initiated the process of designing and establishing a consortium of companies to develop the green H ₂ value chain in Vigo and Galicia. This project aims to create high-quality jobs, promote the establishment and diversification of companies utilizing green H ₂ technologies, and foster research, development, and innovation through the utilization of advanced technology centers in the region.
Energy Carrier Production, Capacity and/or Consumption:	570 kg of hydrogen/day (213 mt/year), enough to supply an equivalent fleet of between 35 and 45 heavy vehicles + one or two small ships. Reducing CO ₂ emissions by more than 2,800 tons/year.
Final Uses:	Non-marine mobility, Distribution, Marine mobility, and industrial.
Contacts:	https://www.apvigo.es/en/paginas/contacto
Useful Links:	[A] [B] [C]

Project 19 - Green methanol hub

Location:	Spain
Objective Summary:	The objective is to construct and manage a methanol production facility in the Port of Huelva, establishing Andalusia as a leader in the global production of renewable energy for challenging industries like maritime and air transport, as well as the chemical industry.
Main Partners:	Cepsa, C2X, and Port of Huelva.
Duration/Timeline:	2025-2028
Energy Carrier Production Technology:	Green methanol plant.

Energy Carrier Typology:

Green Methanol

Investment/Funding: 1B

Source of Funding: Cepsa y C2X private funding

Brief Description: The project aims to generate green methanol from renewable sources, positioning it as one of the top five largest green methanol facilities globally. The project will generate a total of 2,500 jobs, both directly and indirectly, while also contributing to the reduction of emissions and providing a boost to the economy. The purpose of this energy source is to provide sustainable power for industries such as shipping, air transport, and the chemical industry, which are difficult to transition to more environmentally friendly alternatives.

Energy Carrier Production, Capacity and/or Consumption:

300,000 tons/year (up to 380,000), avoiding the emission of up to 1 million tons of CO₂, 2 GWs by 2030.

Final Uses: Non-marine and Marine mobility, Industrial and Storage.

Contacts: <https://www.cepsa.com/en/footer/contact-us>

Useful Links: [A] [B]

Project 20 - Green Bay

Location: Spain

Objective Summary: The primary goal of the project is to electrify maritime transport in the Vigo estuary by developing and implementing technologies for electric propulsion systems and battery energy storage. This will help to reduce emissions in the maritime sector operating inside the estuary.

Main Partners: Naturgy, Mainsolutions, Movelco, Nodosa, Grupo Botamavi, Xunta de Galicia, Benza Energy Solutions, Ctag, Arvi, Aimen, Portos de Galicia, Port Authority of Vigo, etc.

Duration/Timeline: 2020-2024

Energy Carrier Production Technology:

Hybrid propulsion boats (diesel and batteries) and pure electric with batteries. hydrogen vehicles for goods transport and vessels with hydrogen fuel cells.

Energy Carrier Typology:

Hydrogen

Investment/Funding: 40M

Source of Funding: Next Generation EU funds

Brief Description: The project will be executed in five distinct phases: requirement definition, research and development, prototype development and port infrastructure, pilot testing, and a final step encompassing findings, optimization, and scalability. Hydrogen technologies will be utilized to develop and implement sustainable solutions to decarbonize land transport and the maritime sector. This will involve the creation and storage of hydrogen, as well as the

development of H₂ vehicles for transporting commodities and vessels equipped with H₂ fuel cells.

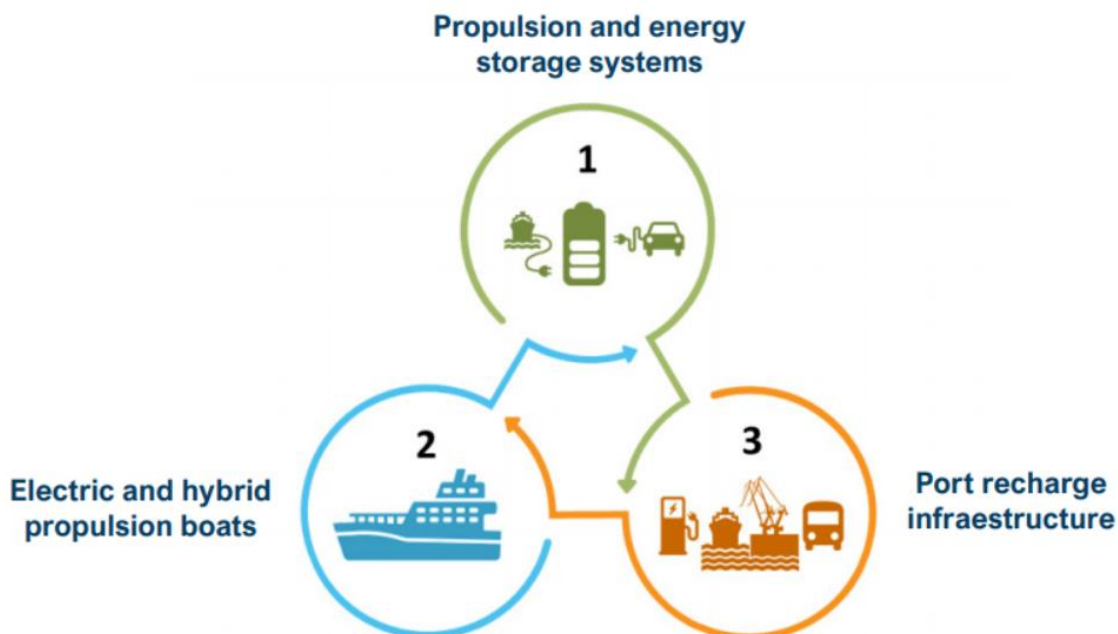


Figure 12 - Final uses of H₂.

Energy Carrier Production, Capacity and/or Consumption:

Hybrid propulsion boats (diesel and batteries) and pure electric with batteries; Advanced shipbuilding technologies for small shipyards to obtain efficient ships to reduce energy needs; A prototype of a hybrid and pure electric propulsion package to reduce gas emissions in the port.

Final Uses: Non-marine and marine mobility, Storage, and Infrastructure electrification.

Contacts: <http://bluegrowthvigo.eu/en/contact>

Useful Links: [\[A\]](#) [\[B\]](#)

Project 21 - H₂ Puerto de Sevilla-H₂ Green City

Location: Spain

Objective Summary: The objective is to establish an H₂ plant at the Port of Seville to facilitate industrial processes and mobility.

Main Partners: Alaner and Port Authority of Seville.

Duration/Timeline: 2022- N/A

Energy Carrier Production Technology:

1 MW PEM, 2 MW PV capacity

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 26M

Source of Funding: 9,5M from the Spanish government

Brief Description: Alener, an energy company, plans to construct a plant in the Port of Seville for the production and storage of renewable H₂. This gas will be supplied and distributed inside the city of Seville as part of Alener's H₂ Green City concept. This initiative positions Seville as a trailblazer in the implementation of this technology in urban areas. The model utilizes H₂ in the residential, industrial, tertiary, and mobility sectors. Approximately 50 employment opportunities will be created during the development of the facilities.



Figure 13 - Port of Seville.

Energy Carrier Production, Capacity and/or Consumption:

170 tons of H₂ production per year, and 5,000 tons of CO₂ avoided per year.

Final Uses: Non-maritime and maritime mobility, Industrial and Storage.

Contacts: solar@alener.es
puertodesevilla@apsevilla.com

Useful Links: [\[A\]](#) [\[B\]](#)

Project 22 - Bay of Biscay Hydrogen

Location: Spain

Objective Summary: The objective is to establish a 100 MW renewable H₂ production facility in the vicinity of the Port of Bilbao, the Left Bank, and surrounding districts. This plant will be responsible for reducing carbon emissions from major industrial consumers in the region.

Main Partners: Repsol, Petronor and Port Authority of Bilbao.

Duration/Timeline: 2022- N/A

Energy Carrier Production Technology:

100 MW of electrolysis capacity, 385 MW PV capacity, 190 MW wind capacity and 73 MW battery.

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: 200M

Source of Funding: European funds (IPCEI)

Energy Carrier Production, Capacity and/or Consumption:
N/A



Figure 14 - Port of Bilbao.

Brief Description: The project is planned to commence production in the latter part of 2024. The electrolyzer will generate renewable hydrogen to be used in decarbonization applications for transport, specifically in mobility and heavy transport. The infrastructure required for this purpose will be installed at the Energy Intelligence Centre of the Ezkerraldea-Meatzaldea Technology Park and will be directly linked to the production plant. The project has a significant influence on production and the overall development of the value chain to seize the economic and industrial growth potential presented by renewable hydrogen in the energy transition.

Final Uses: Industrial, Non-marine, and marine mobility.

Contacts: <https://petronor.eus/es/contacto/>

Useful Links: [\[A\]](#) [\[B\]](#)

Project 23 - GRASSHOPPER

Location: Spain and Netherlands

Objective Summary: The GRASSHOPPER (GRid ASSisting Modular HydrOgen Pem Power Plant) project seeks to develop an advanced hydrogen FC technology that is both cost-

effective and appealing to customers and markets. Additionally, it wants to produce a power plant that is capable of variable power production in the MW size.

Main Partners: Coxabengoa, INEA, JMFC, Nedstack, Politecnico di Milano, “Zentrum für BrennstoffzellenTechnik” (ZBT GmbH), GoFlex, Nouryon Industrial Chemicals, SWW StadtWerke Wunsiedel, Tennet, and Port of Seville.

Duration/Timeline: 2018-2021

Energy Carrier Production Technology:

Demonstration PEM MW Fuel Cell Power Plant (FCPP).

Energy Carrier Typology:

Green Hydrogen and Ammonia

Investment/Funding: 4.4M

Source of Funding: Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 779430 and European Union’s Horizon 2020 research and innovation program.

Brief Description: The GRASSHOPPER power plant aims to showcase emission-free power generation inside an actual industrial setting by utilizing the surplus hydrogen generated by the Nouryon facility. The MW-scale FC Power Plant (FCPP) will be constructed using knowledge gained from a 100-kW pilot plant blueprint, incorporating recently developed stacks and Membrane Electrode Assemblies (MEAs). This pilot plant is sufficient in size to achieve cost reductions and verify its capacity to adapt to different operational requirements and stabilize the power grid by responding quickly.

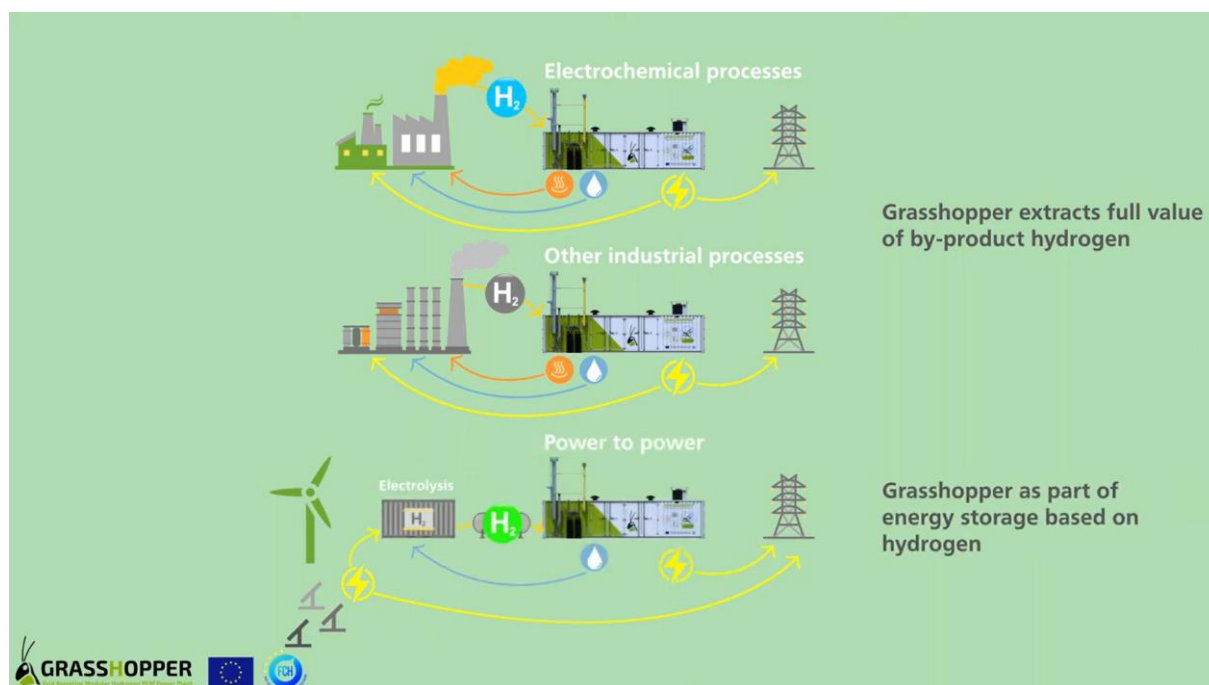


Figure 15 - Illustration of different processes to produce Hydrogen.

Energy Carrier Production, Capacity and/or Consumption:

CAPEX < 1,500 €/kWe, yearly production of 25 Mwe (100 kW pilot plant).

Final Uses:

Non-marine mobility and Industrial.

Contacts: <https://www.grasshopperproject.eu/contact/>
Useful Links: [A] [B]

Additional list of some interesting initiatives in ports not located in the AA

Project 24 - Hyport

Location: Belgium

Objective Summary: The objective is to establish a functioning plant in the port vicinity of Ostend by 2025, which will generate green hydrogen.

Main Partners: Port of Oostende, DEME Concessions and PMV.

Duration/Timeline: N/A -2025

Energy Carrier Production Technology:
Electrolyzer

Energy Carrier Typology:
Green Hydrogen

Investment/Funding: N/A

Source of Funding: N/A

Brief Description: The final product, green H₂, will be used as an energy source for electricity, transportation, heating, and fuel, as well as a raw material for industrial applications.

Energy Carrier Production, Capacity and/or Consumption:
The port plans to install 399 wind turbines for a total installed capacity of 2.26 GW, with a possibility to further increase it by up to 4 GW. To reduce CO₂ emissions in Flanders by around 500,000 to 1,000,000 tons per year.

Final Uses: Infrastructure electrification and Industrial.

Contacts: <https://www.portofoostende.be/en/contact>

Useful Links: <https://www.portofoostende.be/en/news/hyportr-green-hydrogen-plant-in-ostend>

Project 25 - NorthH2

Location: Netherlands

Objective Summary: To significantly contribute to the attainment of the established climate objectives in Europe, the Netherlands, and Germany. It seeks to expedite the growth of a global H₂ market by implementing large-scale production, storage, and transportation of green H₂. The primary focus is on supplying industrial sectors that are challenging or unfeasible to electrify.

Main Partners: RWE, Shell, Equinor, Eneco, Gasunie and Groningen Seaports.

Duration/Timeline: 2020-2040

Energy Carrier Production Technology:
Large-scale Seawater Electrolysis

Energy Carrier Typology:
Green Hydrogen

Investment/Funding: N/A

Source of Funding: N/A

Brief Description: The consortium has recently been conducting the initial part of a feasibility study focused on the period leading up to 2030. According to the study, NorthH2's comprehensive strategy can result in a 20% decrease in societal expenses compared to a more limited approach. The collaboration aims to accomplish cost reduction by implementing the complete chain of offshore wind farms, production, storage, distribution, and utilization of green hydrogen on a big scale. The commencement of the second part of the feasibility study, which focuses on the period following 2030, has now commenced.

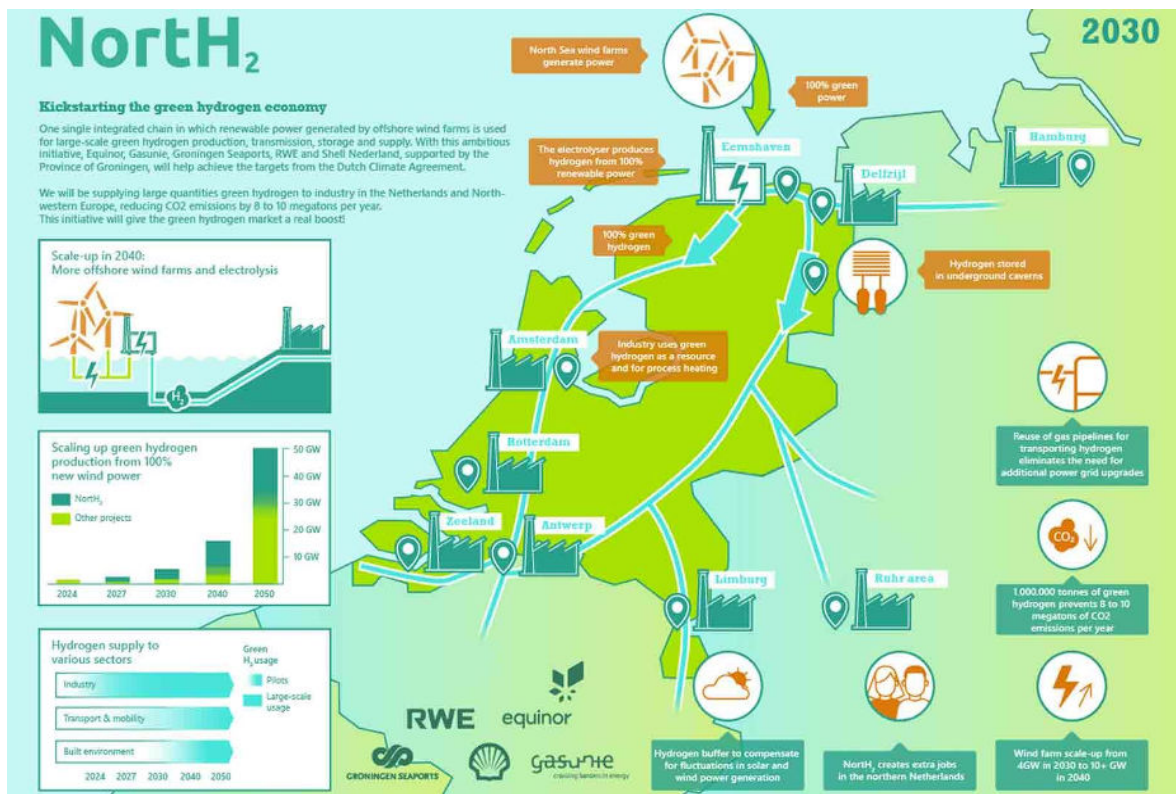


Figure 16 - The H₂ chain from a large-scale offshore wind farm and production to storage, distribution, and ultimately, final use.

Energy Carrier Production, Capacity and/or Consumption:

2 to 4 GW (2030), 10 GW (2040), 750,000 tons/year of green H₂, save 8 to 10 Mtons/year of CO₂.

Final Uses:

Storage and Port-to-port transportation, Industrial, Distribution, Infrastructure electrification, and Marine mobility.

Contacts:

<https://www.north2.eu/contact/>
<https://www.linkedin.com/company/72505529/admin/info@north2.eu>

Useful Links:

[A] [B] [C] [D]

Project 26 - H2Ports

Location: Spain

Objective Summary: To test, assess, and showcase novel FC technologies designed to enhance energy efficiency, decarbonization, and safety in port terminals. The pilots selected for testing in this project will mark the initial implementation of H₂ technology in port handling equipment in Europe.

Main Partners: Port of Valencia, Ballard, CNH, MSC, HY, Grimaldi group, ATENA, enagas and CM.

Duration/Timeline: 2019-2024

Energy Carrier Production Technology:
Fuel Cell Technologies

Energy Carrier Typology:
Green Hydrogen

Investment/Funding: 4.117M

Source of Funding: Co-funded by the EU and SOCIETAL CHALLENGES - Smart, Green and Integrated Transport.

Brief Description: The MSC Terminal Valencia has chosen to test a Reach Stacker, while Valencia Terminal Europa (part of Grimaldi's company) has selected a Terminal Tractor. These specific machines have been expressly adapted for the usage of FC in port facilities. The project aims to conduct daily operating activities for 2 years, during which the equipment will be utilized. The project will focus on analyzing methods to enhance energy efficiency, performance, and safety of operations involving FC port equipment.



Figure 17 - Port equipment and their location of operation.

Energy Carrier Production, Capacity and/or Consumption:

Fuelling 2 new types of equipment in the port sector (Reach Stacker and Terminal Tractor) for a period of 2 years.

Final Uses: Marine mobility (Port activities).

Contacts: www.fundacion.valenciaport.com
<https://h2ports.eu/contact/>

+34 96 393 94 00

Useful Links: [\[A\]](#) [\[B\]](#)

Project 27 - H2A

Location: Netherlands

Objective Summary: To evaluate the viability of establishing a specialized supply chain for delivering Masdar-produced H₂ in its liquefied green form to the port of Amsterdam. The Port of Amsterdam is facilitating the importation of green H₂ through its infrastructure and is also establishing a supply chain for liquefied green H₂ at the port.

Main Partners: Masdar, Port of Amsterdam, SkyNRG, Evos Amsterdam, and Zenith Energy Terminals.

Duration/Timeline: N/A

Energy Carrier Production Technology:

N/A

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: N/A

Source of Funding: N/A

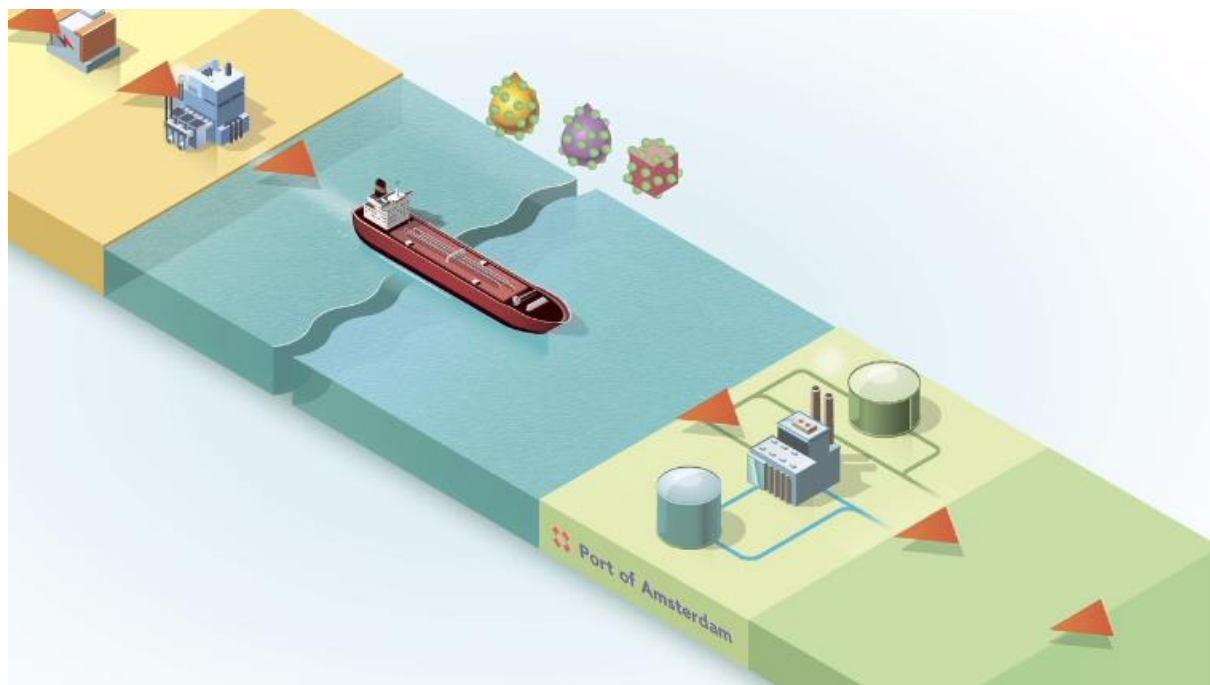


Figure 18 - Exportation and importation of H₂ from international partners to the Port of Amsterdam.

Brief Description: The port of Amsterdam is currently engaged in the importation, manufacturing, and use of H₂. In collaboration with its partners, it is also actively developing the necessary infrastructure to supply H₂ to various industries, the surrounding

region, and the city itself. The objective is to only utilize green H₂, which is produced from renewable energy sources like wind or solar power.

Energy Carrier Production, Capacity and/or Consumption:

To set up a 100% green value chain by importing 1 million tons of green H₂ per year.

Final Uses: Storage and Port-to-port transportation, Industrial and Infrastructure electrification.

Contacts: <https://masdar.ae/en/contact-us>; Tel.: +971 2 653 3333
<https://www.portofamsterdam.com/en/contact>
<https://skynrg.com/contact/>
info@skynrg.com; +31 20 470 70 20
<https://www.zenithterminals.com/contact>

Useful Links: [\[A\]](#) [\[B\]](#) [\[C\]](#) [\[D\]](#)

Project 28 - H2ermes

Location: Netherlands

Objective Summary: To assist in the establishment of a new, circular economy and the development of new H₂ infrastructure in the region.

Main Partners: Port of Amsterdam, Tata Steel and HyCC.

Duration/Timeline: N/A

Energy Carrier Production Technology:

Electrolysis

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: N/A

Source of Funding: N/A

Brief Description: The port of Amsterdam is currently engaged in the importation, manufacturing, and use of H₂. In collaboration with its partners, it is also actively developing infrastructure to supply H₂ to various industries, the surrounding region, and the city itself. The objective is to only utilize green H₂, which is produced using renewable energy sources like wind or solar power.

Energy Carrier Production, Capacity and/or Consumption:

Project H₂ermes is a planned 100 MW green H₂ factory. Using renewable electricity, this plant can make up to 15,000 tons of green H₂ per year.

Final Uses: Storage and Port-to-port transportation, Industrial and Infrastructure electrification.

Contacts: <https://h2ermes.nl/contact-en/>

Useful Links: [\[A\]](#) [\[B\]](#)

Project 29 - H2era

Location: Netherlands

Objective Summary: To commence operations at the newly established factory in the port of Amsterdam by the year 2027.

Main Partners: Port of Amsterdam and HyCC.

Duration/Timeline: N/A

Energy Carrier Production Technology:

Electrolyzer

Energy Carrier Typology:

Green Hydrogen

Investment/Funding: N/A

Source of Funding: N/A

Brief Description: H2era will utilize electrolysis, powered by renewable electricity, to separate water into its constituent elements of hydrogen and oxygen. The plant will be linked to offshore wind power through TenneT's high-voltage grid, thereby avoiding strain on the local grid. The hydrogen will be utilized to enhance the sustainability of current companies in the NS Canal Area and can also be employed for eco-friendly transportation. In the future, the plant can be linked to the national hydrogen network to facilitate the interchange of resources between industrial clusters.

Energy Carrier Production, Capacity and/or Consumption:

500 MW green hydrogen plant in the port.

Final Uses: Storage and Port-to-port transportation, Industrial and Infrastructure electrification.

Contacts: <https://www.portofamsterdam.com/en/contact>

Useful Links: [\[A\]](#) [\[B\]](#)

4 LIST OF HYDROGEN INITIATIVES

This section provides a list of the ports that were identified as being involved in the H₂ initiatives (including those that are not located in the AA). It is crucial to emphasize that there are numerous H₂ initiatives in Europe, and it is possible that some of them were not included in this document. This is because the primary emphasis was solely on AA ports. It is also possible that not all of these initiatives are presented in [Table 2](#), as some have been cancelled or are just beginning to be announced during the development of this document. Nevertheless, those that were successfully identified are presented in [Table 2](#). Due to the constraints imposed by the page size, an exhaustive coverage of the initiatives could not be accommodated. Consequently, readers are advised to access the websites of the respective projects and the news outlets via the hyperlinks provided for additional information.

Table 2 - List of H₂ initiatives present and planned in AA ports.

PROJECT NAME & PORTS	LOCATION	TECHNOLOGY	RENEWABLE GAS	PRODUCTION/CONSUMPTION	LINKS
Hydrotug 1 - Port of Antwerp-Bruges and Port of Ostend	Belgium	BeHydro V12 dual fuel medium speed engines – each providing 2 megawatts	Green Hydrogen and Traditional fuel	An overall reduction of 65% of traditional fuel consumption and associated emissions in the tugboat's overall cycle. The Hydrotug 1 can store 415 kg of compressed hydrogen in 6 stillages installed on deck and eliminates the emission's equivalent of 350 cars per year.	1 2 3
Call for Expansion and re-shaping of the terminal in Zeebrugge	Belgium	N/A	Hydrogen	To provide direct access from the sea for large ships to ensure the supply of not only LNG but also hydrogen and hydrogen derivatives	1 2 3
Hypport - Port of Oostende	Belgium	Electrolyzer	Green Hydrogen	The port plans to install 399 wind turbines for a total installed capacity of 2.26 GW, with a possibility to further increase it by up to 4 GW. To reduce CO ₂ emissions in Flanders by around 500,000 to 1,000,000 tons per year	1
ISHY - Port of Oostende	Belgium	N/A	N/A	Concrete actions that will take place: (i) retrofit of a Crew Transfer Vessel; (ii) retrofit of an inland barge with H ₂ hybrid propulsion system; (iii) newly-built of electric river cruise vessels	1 2 3
Hydroville - Port of Antwerp-Bruges	Belgium	N/A	N/A	H ₂ fuelled passenger ferry. 2x hydrogen ICE with total shaft power 441 kW; 12 H ₂ tanks (205 l @200 bar) and 2 diesel fuel tanks (2x265 l) as pilot/backup fuel.	1 2
Hydrotug - Port of Antwerp-Bruges	Belgium	N/A	N/A	2 BeHydro V12 dual-fuel medium-speed engines, length of 30.17 m, a width of 12.5 m, a weight of 678.8 tons and a bollard pulling power of 65 tons. can store 415 kg of compressed hydrogen in 54 gas cylinders	1 2
Hyoffwind - Port of Antwerp-Bruges	Belgium	Electrolyzer	Green Hydrogen	Electrolyzer: 25 MW (100 MW in the second phase), H ₂ produced from wind energy and then injected in the NG grid	1 2 3
CCU-hub Ghent, North Sea Port Cluster. Port of Ghent.	Belgium	Electrolyzer	Green Hydrogen	Renewable energy – North Sea wind farms – 300 MW – 1,300 GWh/y, electrolysis – hydrogen (H ₂) 41,500 tons/y- oxygen (O ₂) 330,000 tons/y. carbon dioxide capture – 120,000 tons/year.	1 2

HRS CMB and H ₂ hub - Port of Antwerp-Bruges	Belgium	1.2 MW PEM electrolyzer		212.8 Nm ³ /h hydrogen.	1 2
Green fuels on Bornholm Energy Island - Port of Roenne A/S.	Denmark	Power-to-X	Methanol and Ammonia	At least 2 GW (2030) of offshore wind energy.	1 2 3
New low-carbon hydrogen facility - Haropa Port	France	Electrolysis (350 MW) and other for captured CO ₂ (CCS)	Low CO ₂ H ₂	350 MW, corresponding to an annual volume of more than 50,000 tons of hydrogen.	1 2
Green hydrogen production site, Sealhyfe project - Nantes Saint-Nazaire Port and Lhyfe	France	Industrial-scale Electrolysis (1 MW demonstrator, scaled up to 210 MW in a future unit)	Green and Renewable Hydrogen	85 tons/day of green and renewable hydrogen (~31000 t/yr).	1 2
Reuze project – Infinium and Engie / Port of Dunkirk	France	Electrolysis and Infinium electro-fuels process	Synthetic fuel (eFuels) and Naphtha	Convert more than 300,000 tons/year of harmful CO ₂ into more than 100,000 tons per year of clean-burning electro-fuels and naphtha.	1
H2Bordeaux - Port of Bordeaux	France	Electrolyzers	Green hydrogen	This solution would reduce CO ₂ emissions by about 400 t/year for a container ship making 1 24-hour stopover per week.	1 2
GH2 Ambès	France	Electrolysis (100 MW), 300 MWe electrolyzer capacity	Green and blue hydrogen and ammonia	H ₂ production (15 kt/year), NH ₃ production (90 kt/year), and more than 15,000 tH ₂ /year. The project will enable the avoidance of up to 4 million tons of CO ₂ eq. emission over its lifetime.	1 2 3
Cryocap - Port of Jerome	France	Production via SMR using bi-omethane	Hydrogen	4500 kg/day of H ₂ produced via steam methane reforming coupled with CCS. Biomethane is used as feed gas. Hydrogen is then used in the refining industry, while CO ₂ is used for the food industry, water treatment pH control, and greenhouses.	1 2
HyAMMED - Port of Marseille	France	N/A	Hydrogen	It will allow up to 20 daily refueling of low-carbon H ₂ trucks for long-distance journeys, with a range of up to 800 km. The project will reduce CO ₂ emissions by more than 1,500 tons per year, the equivalent of more than 2 million km traveled by truck. Will mainly supply low-carbon H ₂ to the first European fleet of eight 44-ton trucks specially designed for the project.	1
REDII Interreg North Sea - Port of Brest	France	Several options to be compared	Blue and Green Hydrogen, Methanol	N/A	1

Green Mobile energy for reefer containers - Port of Marseille	France	N/A	Hydrogen	CMA CGM (reefer operator) and the Héliion (fuel cells) have developed a solution to power reefer containers through a containerized hydrogen-powered generator. The generator can power up to about 32 containers.	1
WasH2Emden - Port of Emden	Germany	N/A	Green Hydrogen	To create emission reductions for the shoreside port operation, in logistics, but also for ships moored in the port, by utilizing regeneratively produced H ₂ . This could potentially guarantee a H ₂ production of 850 tons/year.	1 2
ArcelorMittal - climate neutral steel - Port of Hamburg	Germany	50MW Electrolyzer	Green Hydrogen	ArcelorMittal wants to produce 1 million tons of carbon-neutral steel per year in Hamburg by 2030 to save 800,000 tons of CO ₂ each year the plant would enable the production of 100,000 tons of DRI for steelmaking with green H ₂ by 2025.	1
GreenPlug H2 push boat (H2SB) - Port of Hamburg	Germany	N/A	Hydrogen	With 750 kilos of high-pressure compressed H ₂ on board and a battery capacity of about 2,500 kW hours, the push boat has a range of about 215 nautical miles when pushing its companion barge, the Ursus.	1 2
H2LOAD - Port of Hamburg	Germany	N/A	N/A	Plan to put over 100 hydrogen-powered vehicles into operation (introduce hydrogen fuel cells powered straddle carriers, trucks, tractor trucks, forklifts, masted container handlers, reach stackers, and shunting locomotives).	1
H2HADAG - Port of Hamburg	Germany	N/A	Hydrogen	Retrofit of 3 diesel-hybrid passenger vessels to hydrogen hybrid vessels and new-built of 2 hydrogen hybrid vessels.	1
RH2INE - Port of Duisburg and Port of Dusseldorf	Germany	Electrolyzer	N/A	Development of an H ₂ distribution network for supplying 10 ships through 3 HRS. will stimulate a targeted structural demand for H ₂ in the mobility sector, aligned with a sustainable hydrogen supply network.	1 2 3
N/A - Copenhagen	Denmark	1.3 GW Electrolyzer by 2030	Green Hydrogen	Delivery of 250,000 tons of sustainable fuel, reduction of annual carbon emissions by 850,000 tons.	1 2
Green Hydrogen for Bremerhaven - (BREMEN ports Bremerhaven)	Germany	2 MW Electrolyzer	Green Hydrogen	The preparation of 8 test pads for a total electrolysis capacity of about 10 MW.	1 2 3

Galway Hydrogen Hub - GH2 Port of Galway	Ireland	Trimms Lane 38kV grid sub-station, 4+10MW Electrolysis Units) + water storage and treatment, approximately 56 m ³ of water/day during peak production (public water source)	Green Hydrogen	Peak production of 1,450 tons of H ₂ for 3,534 Taxis, 200 Buses, and 109 Heavy Duty Trucks.	<u>1</u> <u>2</u> <u>3</u>
Kestrel Project – Cork Harbour?	Ireland	Electrolyzers	Green Hydrogen	N/A	<u>1</u>
Port of Livorno. The North Tyrrhenian Port Network Authority (Port of Livorno, Piombino and Portoferraio)	Italy	Retrofitted ships, refuelling station and storage tanks	Green Hydrogen and Ammonia	172,500 MW and 862.5 tons of H ₂ /year needs (39,000 in 2050), ferry 23 tons/year (H ₂), container ship 16,906 tons/year (NH ₃), refuelling station 144 tons/year (H ₂), 4.226 tons/year (NH ₃).	<u>1</u> <u>2</u>
PORTS8 - Port of Venice	Italy	N/A	Hydrogen	Development of a hydrogen production centre and a roadside refuelling station in the port area of Porto Marghera (Venice).	<u>1</u> <u>2</u>
SUNSHINH3 - Port of Venice	Italy	N/A	Green ammonia	The development of a green ammonia distribution system to supply green hydrogen, reducing carbon dioxide emissions to zero.	<u>1</u>
Locomotives - Port of Trieste	Italy	N/A	Hydrogen	Development of 2 locomotives powered by H ₂ . Carry out a test with a locomotive manufacturer, for a vehicle powered by a H ₂ engine.	<u>1</u> <u>2</u>
Agnes - Port of Ravenna	Italy	Electrolyzer	Green Hydrogen	Offshore wind and solar power plants. Use local RES for hydrogen production via electrolysis.	<u>1</u> <u>2</u>
Port of Klaipeda	Lithuania	1.2 MW containerized PEM electrolyzer cell	Green Hydrogen	193 tons/year (6 700 needed by 2050), avoid approximately 56 703 tons of CO ₂ emissions by 2050.	<u>1</u> <u>2</u>
NorthH2: Groningen Sea-ports	Netherlands	Large-scale Seawater Electrolysis	Green Hydrogen	2 to 4 GW (2030), 10 GW (2040), 750 000 tons/year of green hydrogen, save 8 to 10 megatons/year of CO ₂	<u>1</u> <u>2</u>
Energy Terminal (LNG to Hydrogen) at Vlissingen port, Floating Storage Regasification Unit (FSRU)	Netherlands	FSRU and Energy Terminal	Blue Hydrogen	The facility will have an annual throughput capacity of up to 7.5 billion m ³ , corresponding to around 25% of the current total average gas consumption in the Netherlands (source: central bureau of statistics NL – 2022).	<u>1</u> <u>2</u>

Liquefied green hydrogen supply chain - Port of Amsterdam	Netherlands	Electrolyzers	Green Hydrogen	N/A	1 2 3
H2era project - Port of Amsterdam	Netherlands	Electrolyzers	Green Hydrogen	100 MW H ₂ plant in IJmuiden, on the Tata Steel site to produce 15,000 tons/year. 500 MW green hydrogen from the project of H2era (ready by 2027).	1 2
H2Maasvlakte - Port of Rotterdam	Netherlands	100 MW to 500 MW Electrolyzer capacity	Green Hydrogen	100 MW to 500 MW hydrogen production.	1 2
CCS + Hydrogen plant - Port of Rotterdam	Netherlands	Cryogenic process	Blue Hydrogen	This will enable to reduce emissions by 2.5 million tons of CO ₂ per year, which is equivalent to around 10% of the current Rotterdam industry CO ₂ emissions.	1 2 3
Djewels, Groningen Sea-ports	Netherlands	20 MW Electrolyzer (Djewels 1)	Green methanol and hydrogen	Green hydrogen will be employed for the production of green methanol (20MW) and green kerosene at SkyNRG (50-60 MW). 3000 tons of green hydrogen per year.	1
Hydrogen for shore power, Groningen Sea-ports	Netherlands	N/A	Green Hydrogen	Scaling up the production of green hydrogen by offering space and facilities for test centres, start-ups, scale-ups, pilot and demo plants.	1
HydroPorts - Port of Den Helder, Groningen Sea-ports and Port of Amsterdam	Netherlands	CCS (CO ₂)	Green Hydrogen and blue hydrogen	100 MW hydrogen plant with Nouryon and Tata Steel. This could produce 15,000 tons of green hydrogen per year.	1 2
H2SHIPS - System-Based Solutions for H ₂ -Fuelled Water Transport in North-West Europe	Netherlands	N/A	N/A	Hydrogen bunkering and propulsion for shipping and will identify the conditions for successful market entry for the technology. A new hydrogen-powered port vessel will be built.	1
H2ermes - Port of Amsterdam	Netherlands	Electrolyzer	Green Hydrogen	Building a 100 MW Hydrogen Plant in Amsterdam for TaTa Steel. Deployment of hydrogen delivered by a 100 MW electrolysis plant. This enables H2ermes to produce up to 15,000 tons of green hydrogen and large amounts of oxygen each year.	1
Hy4Am - Port of Amsterdam	Netherlands	Electrolyzer	Green Hydrogen	To supply approximately 200 kg/h of green hydrogen to mobility and industry in the Amsterdam region from 2024	1

H-vision - Port of Rotterdam	Netherlands	CCS (CO ₂)	Grey Hydrogen	Over 700 ktons/year – equivalent to some 3,200 MW. Savings will increase from 2.2 million tons in 2026 up to 4.3 million tons in 2031.	1 2 3
Porthos - Port of Rotterdam	Netherlands	CCS (CO ₂)	Grey Hydrogen	To store around 37 Mton CO ₂ , approximately 2.5 Mton CO ₂ per year for 15 years.	1
Terberg H2 tractors - Port of Rotterdam	Netherlands	N/A		Pilot H ₂ -powered terminal tractor in operation since February 2021 at the United Waalhaven Terminals in Rotterdam. The tractor (HYT203-H2) is equipped with 4+1 150 l hydrogen cylinders @350 bar, each containing 14.4 kg.	1
BP refinery green H2 Plant - Port of Rotterdam	Netherlands	50 MW Electrolyzer	Green Hydrogen	45,000 tons of H ₂ per year using renewable energy.	1
Shell green H2 plant - Port of Rotterdam	Netherlands	Electrolyzer	Green Hydrogen	200 MW electrolyzer for the production of about 50,000 kg H ₂ /day. This saves a minimum of 200,000 tons of CO ₂ per year.	1
Uniper electrolyzer in Maasvlakte - Port of Rotterdam	Netherlands	Electrolyzer	Green Hydrogen	H ₂ plant with a capacity of 100 MW on the Uniper site by 2025 and eventually expand that capacity to 500 MW.	1
CurHyl - Port of Rotterdam	Netherlands	RES	Green Hydrogen	10 MW electrolyzer for converting electricity from the Slufterdam wind farm into green hydrogen, In a next phase, the installation may be expanded to 100 MW with electricity from the Hollandse Kust Zuid wind farm.	1
H2-Fifty - Port of Rotterdam	Netherlands	250 MW Electrolysis Plant and RES	Green Hydrogen	20,000 to 30,000 tons of green hydrogen and save up to 270,000 tons of CO ₂ per year.	1
Hydrogen for shore power - Ports of Den Helder, Harlingen and Delfzijl	Netherlands	N/A	Hydrogen	Hydrogen-based mobile fuel cell generator will be designed and tested to supply shore power.	1
VoltH2 - North Sea Port Cluster	Netherlands	Electrolyzer	Green Hydrogen	The project will be designed to be scalable in phases, up to a target of 100 MW by 2030.	1 2
Hydrohub GW - North Sea Port Cluster	Netherlands	Electrolyzer	Green Hydrogen	Conceptual design fit for implementation of 1 GW electrolyzer plant ready by 2030 to deliver hydrogen at a viable cost.	1

HYDEA - Ports of Brest, Leixões, Viana do Castelo, Seville and Vigo	Portugal	CCS (CO ₂) and innovative membrane system (Hydrogen)	Blue and Green Hydrogen, Methanol	N/A	1
GREENH2ATLANTIC - Port of Sines	Portugal	100 MW alkaline Electrolyzer (16-MW modules)	Green Hydrogen	10,000 tons.	1 2
NeoGreen's flagship Power-to-X project - Port of Sines	Portugal	330 MW Electrolyzers (800+MW of RES installed for electricity supply) and methanol synthesis complex.	Green Hydrogen and Methanol	40,000 tons of green hydrogen, capable of delivering 230,000+ tons of e-methanol per year.	1 2
Galp H2 Park Project - Port of Sines	Portugal	100 MW (up to 600MW, long-term) (PEM) electrolyzers + recycled wastewater from Águas de Santo André (feed-water)	Green Hydrogen	15,000 tons of green H ₂ per year, 110 tons of CO ₂ emissions reduced per year.	1 2 3
MadoquaPower2X (Zona Industrial e Logística de Sines, ZILS)	Portugal	1 GW of electrolysis capacity (alkaline-water) and the production of green ammonia (Haber-Bosch process)	Green Hydrogen and Ammonia	150,000 tons of green H ₂ and 300,000 tons of green ammonia per year, CO ₂ emissions avoided by 120,000 tons/year.	1
Green Bay - Portos de Galicia, and Port Authority of Vigo	Spain	Hybrid propulsion boats (diesel and batteries) and pure electric with batteries.	Hydrogen	Hybrid propulsion boats (diesel and batteries) and pure electric with batteries; Advanced shipbuilding technologies for small shipyards to obtain efficient ships to reduce energy needs; A prototype of a hybrid and pure electric propulsion package to reduce gas emissions in the port.	1 2
H2Ports project – Implementing FC and hydrogen Technologies in Ports Valenciaport	Spain	Fuel Cell Technologies	Hydrogen	Fuelling 2 new types of equipment in the port sector (Reach Stacker and Terminal Tractor) for 2 years.	1 2
Jules Verne investment project - Port Authority of Vigo	Spain	1.4 MW Electrolyzer (PEM or Alkaline), initially at 300 kW (lung at 30 bar) + electrical transformer, purified water generation unit (<1 μs) and	Green Hydrogen	570 kg of hydrogen/day (213 Mt/year), enough to supply an equivalent fleet of between 35 and 45 heavy vehicles + one or two small ships.	1 2

		Hydrogen separating, drying and purifying unit			
N/A - Port of Algeciras	Spain	Electrolyzer	Green Hydrogen	Green H ₂ production plant in the Bay of Algeciras of up to 237 MW. This facility will supply green hydrogen to local industry. Planned to transport 4.5 million tons of green H ₂ by 2030.	<u>1</u> <u>2</u> <u>3</u>
H2Ports - Port of Valencia	Spain	Fuel Cell technologies	Hydrogen	The design and development of 3 pilots: a yard tractor, a mobile refueling station, and a reach stacker (as of 2021 the reach stacker is in full development at Hyster). The HRS includes a 300-bar compressed H ₂ storage and a 450-bar compressed H ₂ storage.	<u>1</u> <u>2</u>
GREEN HYSLAND - Ports de Balears	Spain	7.5MW of electrolysis capacity connected to local PV plants and 6 FCH end-user applications	Green Hydrogen	2 CHP applications at commercial buildings, electricity supply at the port and injection of H ₂ into the local gas grid	<u>1</u>
H2 Puerto de Sevilla-H2 Green City	Spain	1 MW PEM, 2 MW PV capacity	Green Hydrogen	170 tons of H ₂ production per year, 5,000 tons of CO ₂ avoided per year	<u>1</u>
Musel GreenMet - Port Authority of Gijón	Spain	50 MW PEM	Green Hydrogen	N/A	<u>2</u>
Bay of Biscay Hydrogen - Port Authority of Bilbao	Spain	100 MW of electrolysis capacity, 385 MW PV capacity, 190 MW wind capacity and 73 MW battery	Green Hydrogen	N/A	<u>1</u> <u>2</u> <u>3</u>
N/A - Port of Gothenburg	Sweden	4 MW electrolyzer	Green Hydrogen	2 tons of H ₂ /day. A hydrogen bay for heavy goods traffic refueling with a hydrogen capacity of 270 kg (15 heavy trucks/day).	<u>1</u> <u>2</u> <u>3</u>
New terminal at Immingham port to support import of green ammonia Associated British Ports (ABP)	UK	Bulk liquid green energy terminal (Green Ammonia import to Green Hydrogen) and CCS (CO ₂)	Green Hydrogen and Ammonia	To produce fuel for heavy transport, such as buses and lorries, helping reduce the dependency of UK mobility and freight on fossil fuels. It will save up to 580,000 tons of CO ₂ a year.	<u>1</u> <u>2</u>
H2Sines.Rdam - Port of Sines, Port of Rotterdam	Portugal Netherlands	400 MW Electrolyzer, PEM fuel cells	Liquid Hydrogen	Cargo capacity 10 times larger than the state of the art, 100 tons/day.	<u>1</u> <u>2</u>

Port of Antwerp-Bruges and Port of Duisburg	Belgium Germany	ICE Hydrogen or fuel cells	Green Hydrogen	0.8 to 2.7 million tons (2030 to 2050).	1 2
H2-Fifty, RH2INE (has several sub-projects), Ports of Pecém and Rotterdam	Brazil Netherlands	250 MW Alkaline and/or PEM electrolyzer by 2025 (Rotterdam), 2 GW park	Green Hydrogen and Ammonia	Rotterdam: 20 Mt of H ₂ by 2050, 2 Mt locally (4 Mt import, 1 from Pecém in 2030), 20,000 to 30,000 tons/year (H2-Fifty), reduced 26 Mton of CO ₂ equivalent emissions in 2030	1 2
GRASSHOPPER project - Green H2 and ammonia plants in the port of Seville	Spain Netherlands	Demonstration of PEM MW Fuel Cell Power Plant (FCPP)	Green Hydrogen and Ammonia	CAPEX < 1 500 €/kWe, yearly production of 25 Mwe (100 kW pilot plant).	1 2
Green methanol hub Cepsa, C2X, and Port of Huelva	Spain	Green methanol plant	Green Methanol	300,000 tons/year (up to 380,000), avoiding the emission of up to 1 million tons of CO ₂ , 2 GWs by 2030.	1 2
Green fuels supply chain corridor (MoU) – ports of Shannon Foynes and Rotterdam	Netherlands Ireland	N/A	Green Hydrogen, Ammonia and Methanol	N/A	1 2
Green corridor for short-sea shipping - Ports of Rotterdam and Oslo	Netherlands Norway	3.2 MW hydrogen fuel cell	Green Hydrogen	Short-sea vessels capable of carrying around 365 45-foot long high cube containers, they will operate weekly loops between Rotterdam and ports in the Oslofjord by 2040. Each vessel will avoid 25,000 tons of CO ₂ emissions a year	1 2 3
Port of Wilhelmshaven EnergyHub, World Energy GH2	Germany Canada	1,000 MW Wind farm (164 wind turbines) and infrastructure for hydrogen and ammonia export	Green Hydrogen and Ammonia	1,2 Mtons of green ammonia, with a starting production estimate of 400,000 tons for export.	1 2 3
Green Flamingo - Ports of Sines and Rotterdam	Portugal Netherlands	Full capacity is expected by 2030. 1 GW solar plant by 2025.	Green Hydrogen	465,000 tons of hydrogen per year by 2030, 18.6 MT/year of CO ₂ emissions avoided.	1 2 3
sMArt Green Ports as Integrated Efficient multi-modal hubs (MAGPIE) - Ports of Rotterdam, Sines, Delta, and Haropa	Netherlands Portugal France Germany	On-site BioLNG production; Smart Energy Systems; Shore power peak shaving; Port digital twin (GHG tooling and energy matching); Ammonia	N/A	12 pilot activities in 3 key areas: alternative energy sources; smart technologies applied to power operations; and river and rail connections with the hinterland.	1 2

		bunkering; Offshore charging buoy; Autonomous e-barge and transshipment; Green energy container for inland shipping; Hybrid shunting locomotive; Green connected trucking; Spreading of road traffic; Non-technological innovations to increase the use of green energy.			
North Sea H2 Valley Ports (InterReg North Sea Project) Ports of Bremen, Brest, Esbjerg, and den Helder	Netherlands Denmark Belgium Germany France	Review of all technologies	Green hydrogen	To be defined.	1 2
H2SHIPS - Ports of Amsterdam, Haropa, and Ostend	Belgium Netherlands France UK Germany	Electrolyzer	N/A	Pilot 1 will be a 20 m-long vessel operating in both urban and seaport areas between Amsterdam and IJmuiden. The vessel will be powered by a hybrid fuel cell-battery propulsion system.	1 2 3
Hy-trucks - Ports of Antwerp-Bruges Rotterdam and Duisburg	Netherlands Germany Belgium	N/A	N/A	1,000 hydrogen-powered trucks and adequate infrastructure by 2025. To reduce CO ₂ emissions by more than 100,000 tons/year. Establish a network of 25 high-capacity H ₂ stations connecting Antwerp, Rotterdam, and Duisberg.	1
SeaH2Land - North Sea Port Cluster	Belgium Netherlands	1 GW electrolyzer, 2 GW of new offshore wind	Green Hydrogen	45 km of regional H ₂ pipelines between Belgium and the Netherlands.	1
Hydrogen Delta - North Sea Port Cluster	Belgium Netherlands	Electrolyzer	Green Hydrogen	Several green hydrogen plants (100-200 MW scale) by 2025. Scaling up the electrolyzers to a GW scale by 2030.	1

5 DISCUSSION

This section outlines the principal characteristics and/or trends identified during the collection and analysis of the AA initiatives. It is important to note that the figures in this deliverable might change in the future due to the announcement of new H₂ projects and the cancellation of some existing ones.

The most used technologies in the AA initiatives:

The electrolyzer technology is the most frequently employed (see [Figure 19](#)) due to the abundant supply of water and the absence of pollution. In numerous H₂ production initiatives, alkaline and PEM electrolyzers with capacities ranging from 1 MW to 1 GW are frequently employed. This could be because PEM offers several advantages, such as preventing the leakage issue experienced by other types of electrolyzers. However, the Ohmic loss reduction leads to a high current density and high pressure due to the electrolyte's solidity [5], nevertheless, they are more efficient and tolerant to intermitted power supply. On the other hand, alkaline electrolysis has a relatively high Ohmic loss and only provides a slow current density and the charge load, resulting in a decline in efficiency. The primary disadvantage of an alkaline electrolyzer is the leakage issue associated with its electrolyte liquid [6], however, it is the most mature technology. This is elaborated upon in [Deliverable 4.2.1](#).

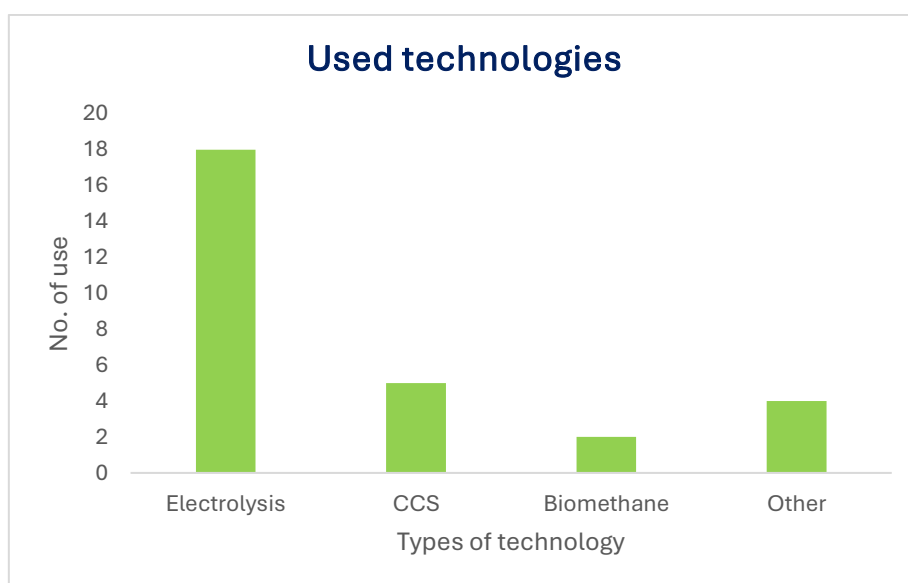


Figure 19 - The most used technologies in AA H₂ initiatives.

Green hydrogen end uses and applications:

Some common applications of H₂ include the hydrogenation of mineral oil in refineries, the production of ammonia for fertilizers, and the production of methanol for various purposes (see [Deliverable 4.2.1](#)). Many H₂ projects involve the industrial sector as the end user of H₂, encompassing industries such as steel, iron, chemical, and plastic. The uses of H₂ are categorized as "Industry" in this Deliverable. "IE" refers to industry electrification, whereby H₂ is used to provide heat for industrial processes. This is followed by non-marine mobility or "NMM" (inland transportation modes, fuel/electricity, and houses) and marine mobility or "MM" (ships, tugboats, vessels, etc.). There are fewer projects focused on port-

to-port transport or “P-PT” (energy carrier transfer/transportation, bunkering, shipping, valleys, and corridors) in AA ports compared to the projects in the Netherlands and Belgium. Figure 20 presents the figures for the final uses of H₂.

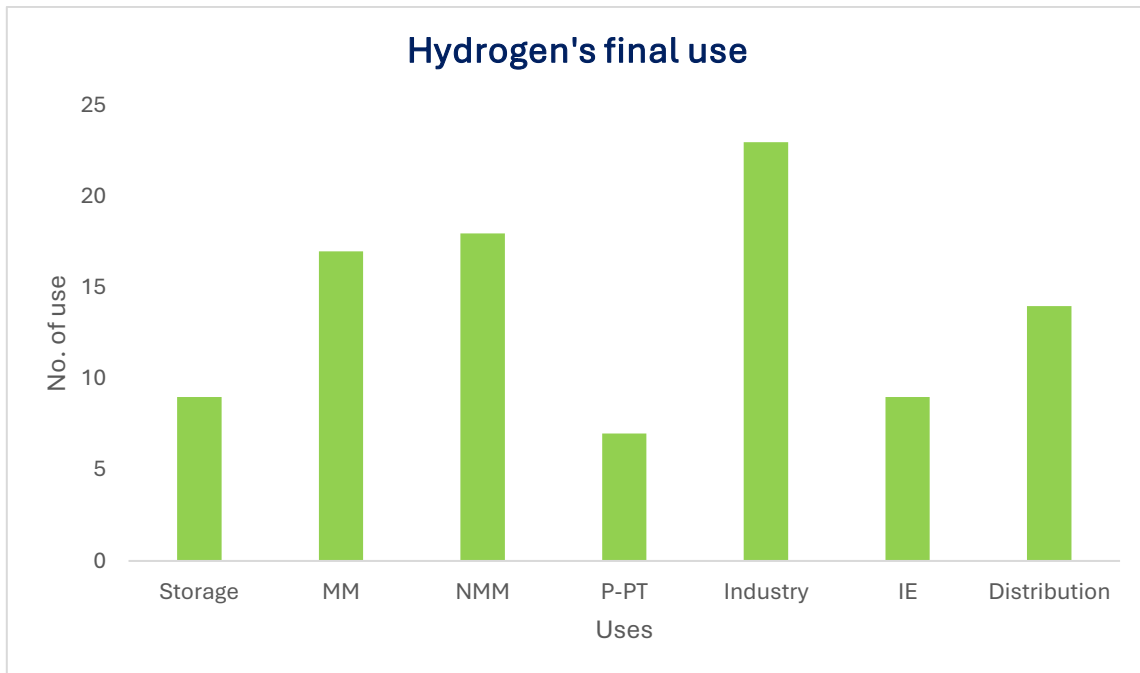


Figure 20 - Final uses of H₂.

Source of energy for the AA H₂ initiatives:

In order to comply with the EU regulations and policies, and to preserve "green solutions", RES such as wind and solar (both onshore and offshore) are used as the primary energy sources in numerous initiatives (Figure 21), although wind turbines exhibit certain drawbacks associated with their construction process [7].

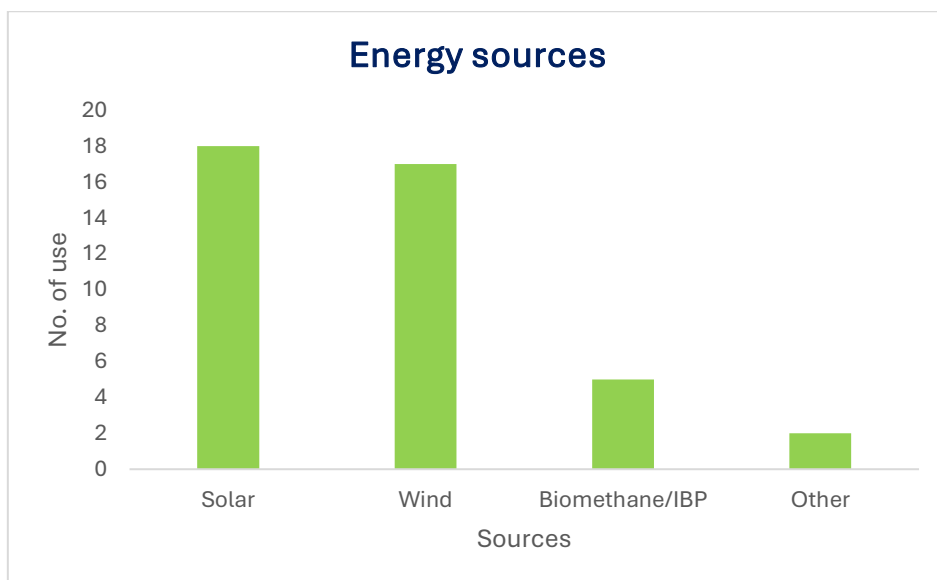


Figure 21 - Energy sources used in most AA initiatives to produce H₂.

Energy carriers produced in AA ports:

The primary focus is on green H₂ as illustrated in [Figure 22](#), which is more logical in light of the drawbacks associated with other types of H₂. Despite the theoretical potential of blue H₂ production to decarbonize current H₂ uses and new industrial and non-industrial H₂ applications, the deployment of new blue H₂ projects will probably face increasing competition from green H₂ (domestic and imported) as the latter becomes more widely available at a lower cost beyond 2035. Additionally, the EU has consistently stated that institutional endeavors to establish a hydrogen economy by 2030 and beyond will be directed towards green hydrogen, as emphasized in the "Fit for 55" policy proposal package (2021) [2] and endorsed in the REPowerEU Communication (2022) [3]. The majority of initiatives are producing green H₂ instead of other types of H₂, as a result of the numerous political, regulatory, economic, and technological barriers (*e.g.*, regulatory and political acceptance constraints, high natural gas and carbon prices, uncertainties in the capture rate of CCS, little or no public subsidies, risks of methane leakage from natural gas during exploration and transportation) and the strong political impetus at the EU level. This will be further addressed in [Deliverable 4.3.1](#).

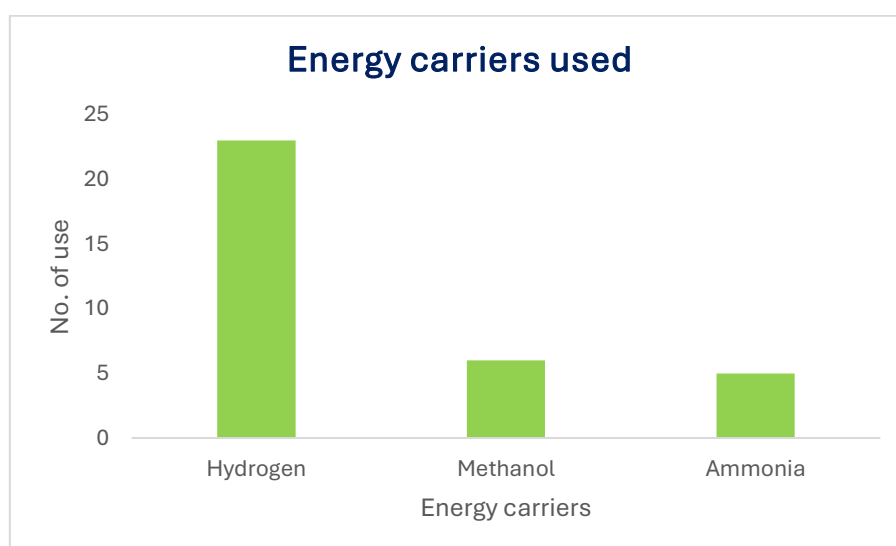


Figure 22 - Energy carriers used in AA H₂ projects in ports.

Leading AA ports in 4 countries in terms of H₂ projects:

According to the current information, the following is a compilation of AA ports in each country that are leading in the number of projects:

- France: Ports of Haropa and Brest with 3 initiatives in each port;
- Ireland: Ports of Galway and Shannon Foynes with 1 initiative in each port;
- Portugal: Port of Sines with 7 initiatives;
- Spain: Ports of Vigo and Seville with 2 initiatives in each port.

Main benefits of the AA H₂ initiatives:

The majority of the initiatives integrate technologies based on green H₂ to contribute to broader strategies and policies dedicated to the decarbonization of industrial port complexes, port operations, and maritime transport. They are assisting in decarbonizing their operations and the transition from

fossil fuels to ensure the security of the energy supply, thereby bolstering the local economy through market and trade development.

6 CONCLUSION

This Deliverable aimed to identify initiatives in the field of H₂ in ports. This task was carried out by conducting in-depth literature research from different trustworthy sources to identify key initiatives related to H₂ in European seaports, particularly those of the Atlantic Area (AA). A total of 158 H₂ initiatives were identified from various reliable sources. Some of these projects were not in collaboration with ports, therefore, the list was narrowed down to approximately 90 initiatives, considering the main goal of this Deliverable. There were a few exceptions for projects located in other European countries given their magnitude in terms of investment fund and complexity.

The information gathered indicates that few ports in the AA have initiated or are currently involved in the H₂ project for energy transitioning. Nevertheless, it is observed that the main ports are at the forefront of this transition, with the Port of Sines leading the way with H₂ projects in Portugal, followed by the ports of Vigo, Valencia, and Galicia, among others, from Spain. Ports of Brest, Marseille, and Haropa from France are also engaged in these projects, and finally, Ireland's ports (Galway and Shannon Foynes). At a broader European level, northern countries are clearly in the lead in these initiatives, as shown in Tables 1 and 2. For instance, the Netherlands, with its ports of Rotterdam and Amsterdam, is the main host of H₂ initiatives and is involved in several energy transition projects, including those involving partners from Europe and beyond. Belgium, with its port of Antwerp-Bruges, follows suit. This is because the ports of Antwerp-Bruges and Rotterdam have sufficient space and investment capability to accommodate H₂ initiatives and continue to be the preeminent ports for industrial, bunkering, logistics, and transportation archetypes, respectively. As shown in [Figure 2](#), the ports in the Portuguese and Spanish islands have not yet participated in these initiatives. Nevertheless, some initiatives have been undertaken, albeit not in collaboration with ports, such as the SEAWORTHY project. It is important to emphasize that this document solely outlines the initiatives that the authors successfully identified during a specified period in order to develop this Deliverable. While numerous other initiatives could have been incorporated, they were omitted so as not to overlook the primary focus of the Deliverable.

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