Clean Hydrogen Partnership

Hydrogen for maritime and ports applications

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EUROPEAN PARTNERSHIP

Clean Hydrogen Partnership

Clean Hydrogen Joint Undertaking

EU Institutional Public-Private Partnership (IPPP) **2021-2027**

Hydrogen Europe

Industry incl SMEs
More than 500 members

European Commission

Hydrogen Europe Research

Research community
More than 150 members

1 billion EURO from Horizon Europe* to implement R&I activities and facilitate the transition to a greener EU society through the development of hydrogen technologies

**** additional 200 million EURO for Hydrogen valleys (under REPowerEU)***

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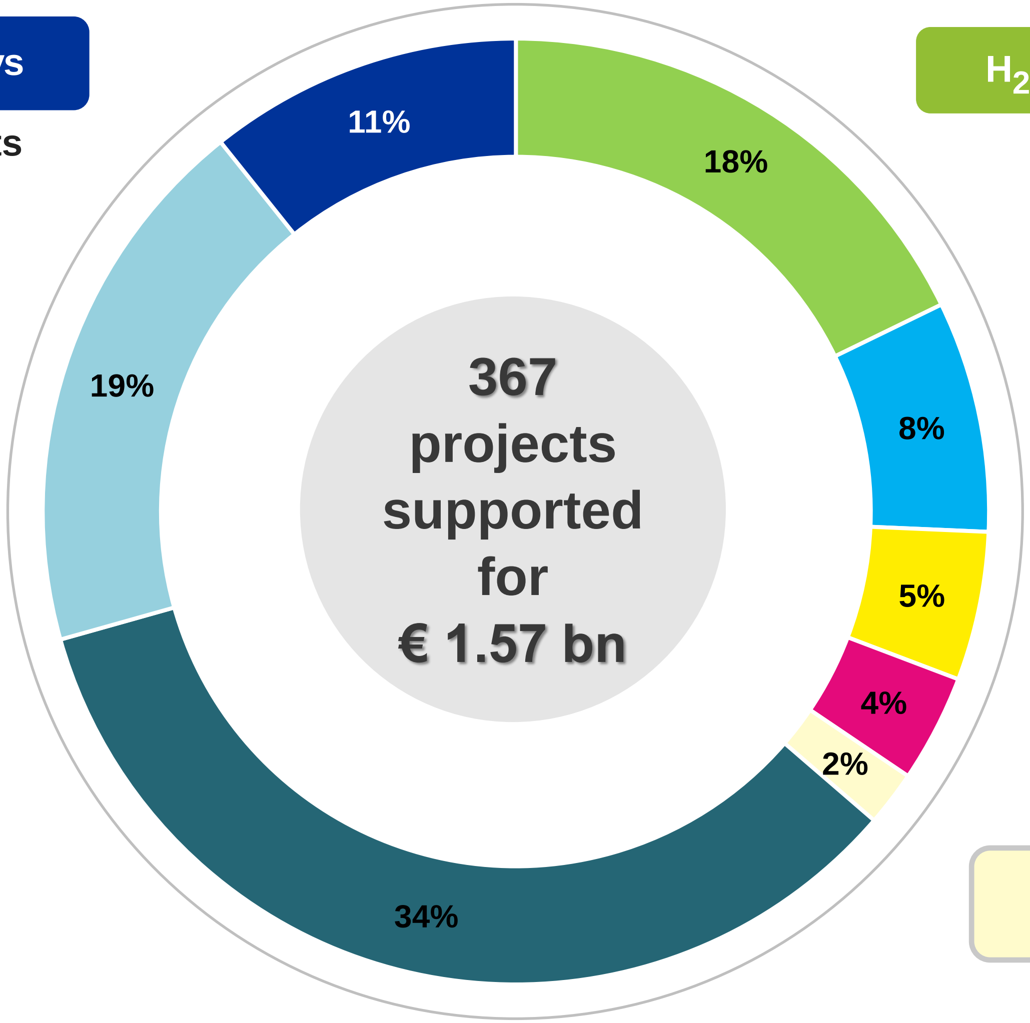
Clean Hydrogen JU Programme (incl FCH JU legacy)



H_2 Valleys
14 Projects
€ 169 mill

H_2 End Use: Clean Heat and Power
85 Projects
€ 293.6 mill

H_2 End Use: Transport
78 Projects
€ 540.5 mill

H_2 Production
78 Projects
€ 280.3 mill

H_2 Storage & Distribution
37 Projects
€ 124.4 mill

Cross-cutting
54 Projects
€ 80.1 mill

Supply Chain
18 Projects
€ 58 mill

Strategic Research Challenge
3 Projects
€ 29.6 mill

**It excludes some call 2023 grants – still under preparation*

Ships: towards larger vessels testing different fuels and FC

Building the pilots and experiments to speed up standards for waterborne applications

Maritime

R&D vessel
CH_2 PEM

MARANDA / 0,16 MW

Platform vessel
NH_3 SOFC

SHIPFC / 2 MW

Ro-Ro vessel
LH_2 PEM

HyShip / 3 MW

2017 — 2018 — 2019 — 2020 — 2022

Fluvial

FLAGSHIPS > 1 MW

2 cargo vessels
CH_2 PEM

HEAVENN / 0,38 MW

Barge vessel
CH_2 PEM

RH2IWER / 7.5MW

6 inland vessels
CH_2 PEM

e-SHyIPS ON THE WAVE OF HYDROGEN

Pre-Normative Research

Hydrogen for passenger vessels

- Experimental data
- Guidelines for safe design for the new IGF chapter on hydrogen

IMO INTERNATIONAL MARITIME ORGANIZATION

CESNI

Synergies

WATERBORNE

Challenges

- Delayed implementation
- H_2 supply issues
- Supply chain issues for large SOFC
- Lenghty authorisation process

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Ports as hydrogen «coastal hubs»

Pilots for clean port operations in container and ferry terminals

Heat and on-shore power for ferry terminals

- Port of Palma = 100kW
- Port of Orkney = 75 kW
- Port of Tenerife = 100kW
- Port of Helsinki = 600kW

GREEN HYSLAND
BIGHIT
EVERY WH$_2$ERE
BalticSeaH2

Heavy machinery for container handling



- Port of Valencia

H2PORTS

Integrated H2 ecosystem = port of Hirtshals

- H2 production and end-uses
- Aquaculture, industry and logistics (trucks)

Studies and pilots on:

- Infrastructure for H_2/NH_3 bunkering
- NH_3 and synthetic fuels for maritime
- Retrofit of port vessels fleet
- Passenger ferries

BalticSeaH2

Ports as hydrogen « coastal hubs »

- Creating / Serving H_2 demand locally for energy intensive industry (steel, chemicals, refineries, etc)
- Integration of renewable electricity
- International trading routes for H_2
- Multimodal transport node

Study on hydrogen in ports and industrial coastal areas

- European Hydrogen Ports Network
- Report 1: Hydrogen demand & supply, business models
- Report 2: R&I, safety and governance gaps
- Report 3: case studies with techno-economic feasibility

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Study on hydrogen in ports and industrial coastal areas

100+

Stakeholders

representing the European hydrogen port community have been involved throughout the course of the study

3

Reports

were published, providing

- an assessment of the hydrogen demand, supply and associated infrastructure in ports and industrial coastal areas;
- new guidance for R&I, safety codes and standards, and policy and regulation;
- new case studies and project concepts

60-80

Members

of the European hydrogen port community participated in each of the three European Hydrogen Port Network events

18

Advisory Board members

who oversaw and guided the delivery of the study, providing detailed feedback for each workstream

20+

European seaports and inland ports

Actively took part in the study through interviews and the case studies

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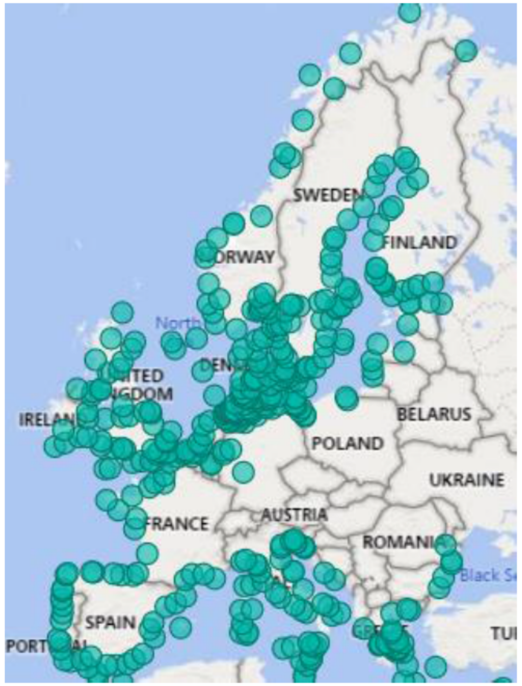
Overview of the general study approach and tasks

Geographical coverage

Overview of ports in scope



Geographical coverage include ports in Europe, defined as **EU27 + UK + Norway**

Hydrogen demand

- Transport
- Port activities
- Urban areas
- Industries

Hydrogen supply

- Renewable hydrogen from onshore and offshore windfarms
- Renewable hydrogen from solar PVs
- Blue hydrogen from existing grey Hydrogen production sites
- Imported green and blue hydrogen

Out of scope: pink hydrogen

During the course of the study the **REPowerEU** plan has been published and included in the scope of the study

Hydrogen business models

Comprehensive overview of relevant business models

Development of case studies

Selection of specific ports and development of case studies

Recommendations

Recommendations on the areas of priority for R&I projects, safety regulations, codes and standards and non-technical enablers

Broad stakeholder's representativity*

- Port authorities
- Terminal operators
- Shipyard representative
- Ship owner and operators
- City/municipal authorities
- Heavy industries
- Gas infrastructure operator
- Heavy-duty transport
- Hydrogen and renewable energy producers
- European Commission

*Not exhaustive

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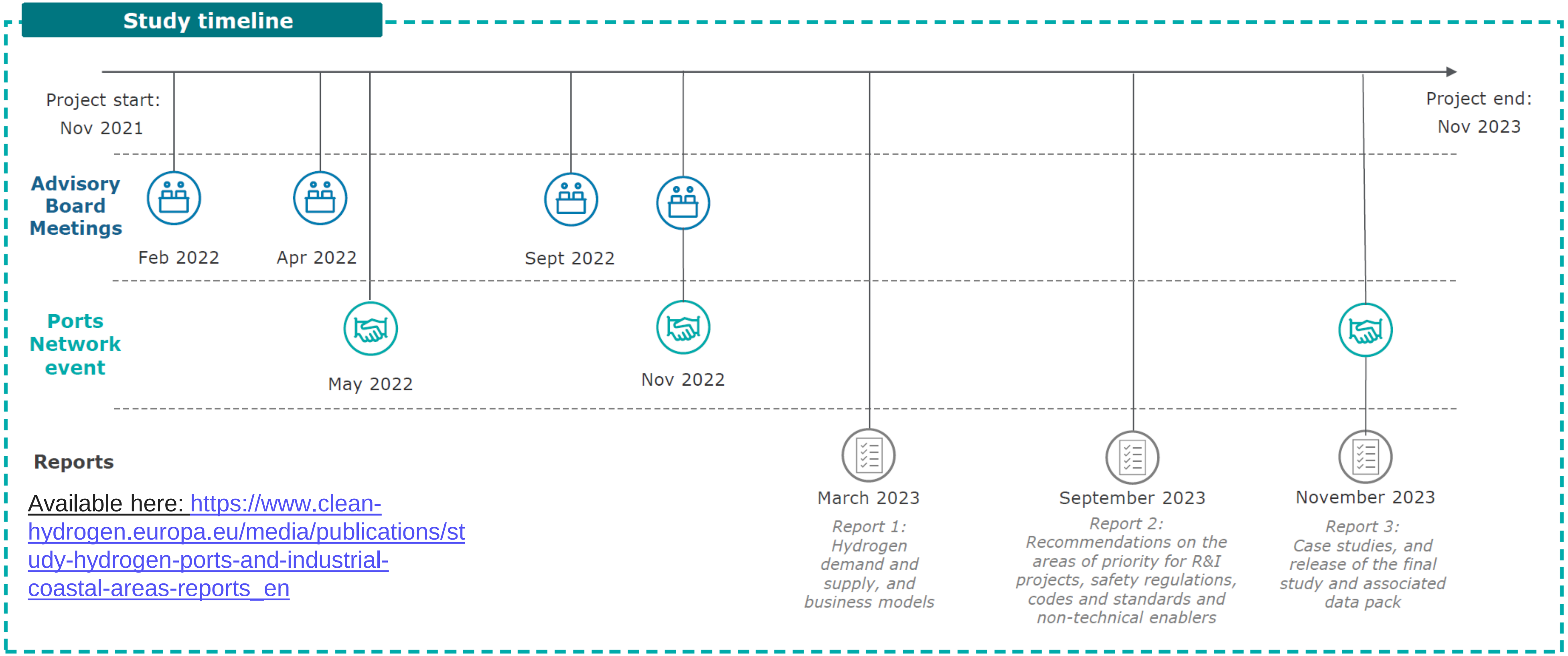
Broad consultation and 3 public reports



Report 1: Hydrogen demand & supply, business models

Report 2: R&I, safety and governance gaps

Report 3: case studies with techno-economic feasibility

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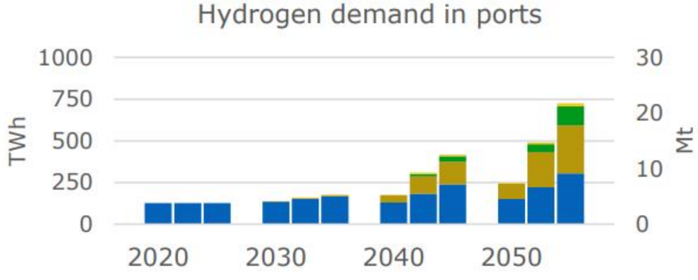
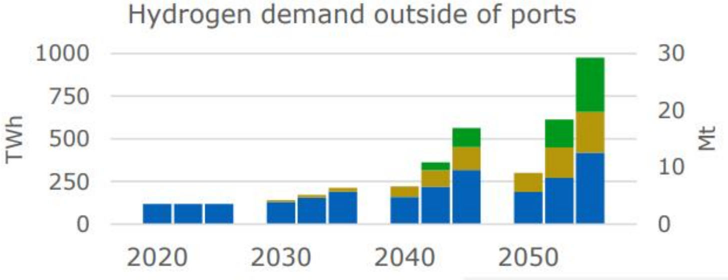
Hydrogen demand and market potential in Europe

Sectoral scope of the hydrogen demand assessment

- Hydrogenation of mineral oil in refineries
- Production of ammonia for fertilizers
- Production of methanol for current uses
- Production of primary steel
- Production of High Value Chemicals
- Generation of heat for industrial processes
- Domestic shipping
- International shipping
- Heavy-duty vehicles
- Heating of residential buildings
- Heating of service buildings
- Cold ironing
- Cargo handling
- Port vessel fleet

High-level results across all demand segments*





Industry Transport Urban areas Port activities

Estimated hydrogen demand per cluster and per demand segments (Ambitious scenario in 2050)

The circles on the map are located in the center of the relevant cluster

Overview of the main findings

- Overall, hydrogen demand for new uses is expected to first take off in the **late 2020s** for **industrial applications** (mainly for primary steelmaking and high temperature process heat). From **2030 onwards**, in parallel with a strong increase in hydrogen demand in all industries, hydrogen demand is expected to accelerate in the **transport sector**, as shipping and heavy-road transport activities move towards decarbonization. Hydrogen demand for low-heat temperature applications in **urban areas** is uncertain and might start in the late 2030s to potentially increase from **2040 onwards**. Altogether, the incremental demand for hydrogen, both inside and outside the vicinity of ports, is foreseen to expand steadily in the 2030s, reaching up to **1764 TWh (53 Mt) in 2050**.
- Hydrogen demand in the vicinity of ports is expected **to be very substantial**, mainly **driven by industrial demand** and further **supplemented by hydrogen demand in the shipping sector** from the 2030s. When only considering hydrogen demand related to industrial and transport activity, the projected **hydrogen demand in port areas is about 50% of the overall hydrogen demand**.

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Hydrogen supply

Hydrogen supply sources in scope

- Local European production of green hydrogen from onshore and offshore windfarms
- Local European production of green hydrogen from solar PVs
- Imported green and blue hydrogen (incl. from Norway and UK)
- Local European production of blue hydrogen*

Two supply scenarios

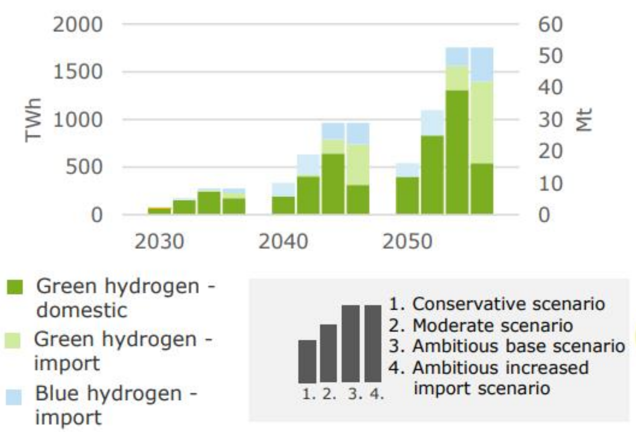
Economic model strives for overall cost minimization and is based on LCOH modelling taking into account all costs of the hydrogen supply chain.

Base supply scenario: set of three hydrogen supply scenarios matching respectively the forecasted hydrogen demand in the three demand scenarios.

Increased import supply scenario: additional hydrogen supply scenario matching only the hydrogen demand foreseen in the ambitious demand scenario and incorporating a predefined constraint in the rate of deployment (5%) of European renewable energy sources for hydrogen until 2050.

Overview of the main conclusions – hydrogen source of supply

Local European hydrogen production vs hydrogen import



Ports are expected to play a key role in facilitating the **hydrogen supply to the wider port community or even the hinterland in their role as energy hub**. We refer to the separately developed dashboards to understand hydrogen supply implications (and corresponding investments) on port level.

Base supply scenario:

- **Local European green hydrogen production:** It is projected that by 2050 around **75% of hydrogen demand could be met by European green hydrogen production** (400 TWh - 1,300 TWh). Solar PV is expected to be the most economically competitive renewable energy source to produce hydrogen (at a **levelized cost of hydrogen of around 2.2 EUR/kg**). The projected **local production is highly diversified between European countries** and is largest in **Spain, Denmark, Greece and Italy.**
- **Hydrogen imports:** Local European hydrogen production is expected to be supplemented by green and blue hydrogen imports, representing 25% of total hydrogen supply. North of Africa and the Middle East are expected to be the main suppliers of hydrogen to Europe by 2050 (at **LCOH of around 3.5 EUR/kg**).

Increased import supply scenario:

- **Local European green hydrogen production:** Setting a **constraint on the local deployment rate of renewables**, results in a shift to hydrogen being supplied by mainly green hydrogen imports. In this scenario, **only 30% of future hydrogen demand in Europe is expected to be supplied by local European production in 2050** (540 TWh).
- **Hydrogen imports:** Since the largest part of hydrogen will be supplied by import, Europe will need to significantly tap into more foreign sources, i.e., **increased import from North Africa and the Middle East** but also further distanced countries.

Estimated hydrogen supply per cluster and per type (Ambitious base scenario in 2050)

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The potential roles of ports in the future hydrogen economy

Landlord

Providing land for hydrogen economy

Examples:* Port of Antwerp Bruges, North Sea Port, Port de Barcelona

Key investments for ports to consider

- **Provide land and/or make land available** to foster hydrogen activities across the value chain production facilities (MAKE), import terminals (BUY), pipelines, bunkering facilities, fuel stations etc. (BUY and MAKE)
- **Partner with companies** willing to place their facilities/assets/infrastructure on the available lands (BUY and MAKE)

Community builder and enabler

Bringing the right parties together locally and globally

Examples:* valenciaport (Autoridad Portuaria de Valencia), Port of Rotterdam, Port of Hamburg, constantza port, Port of Antwerp Bruges, North Sea Port

Key investments for ports to consider

- **Taking part in regional and global alliances and networks** (BUY and MAKE)
- For larger port with larger capacity, **forming a local platform** with actors to discuss hydrogen projects (BUY and MAKE) for the port itself
- **Developing solid relationships with the whole ecosystem** (industry actors, policy makers, government, investors, etc.) (BUY and MAKE)
- **Promoting hydrogen** as a sustainable energy carrier (BUY and MAKE)

Investor

Investing in infrastructure/equipment/etc. enabling the hydrogen economy

Examples:* Port of Antwerp Bruges, Port of Gothenburg

Key investments for ports to consider

- **Investing financial resources** to build production infrastructure (MAKE), import terminals (BUY), hydrogen pipelines (BUY and MAKE) and hydrogen fuel stations (BUY and MAKE)
- **Investing financial resources** in adjacent domains (e.g., windmills park) (MAKE and BUY)
- **Investing financial resources** in port infrastructure to welcome hydrogen infrastructure (MAKE and BUY)
- **Partnering with skilled actors** to set up the right infrastructures & activities (MAKE and BUY)
- **Financing** the transition as leverage for technological innovations & demo-facilities

The choice of positioning and associated investments is likely to be largely influenced by several factors, including: **the port archetype** (industrial, bunkering, logistics and transport, urban), **the size of the port** (smaller versus larger ports) and their **individual strategy**, often driven by their respective municipal and national strategy.

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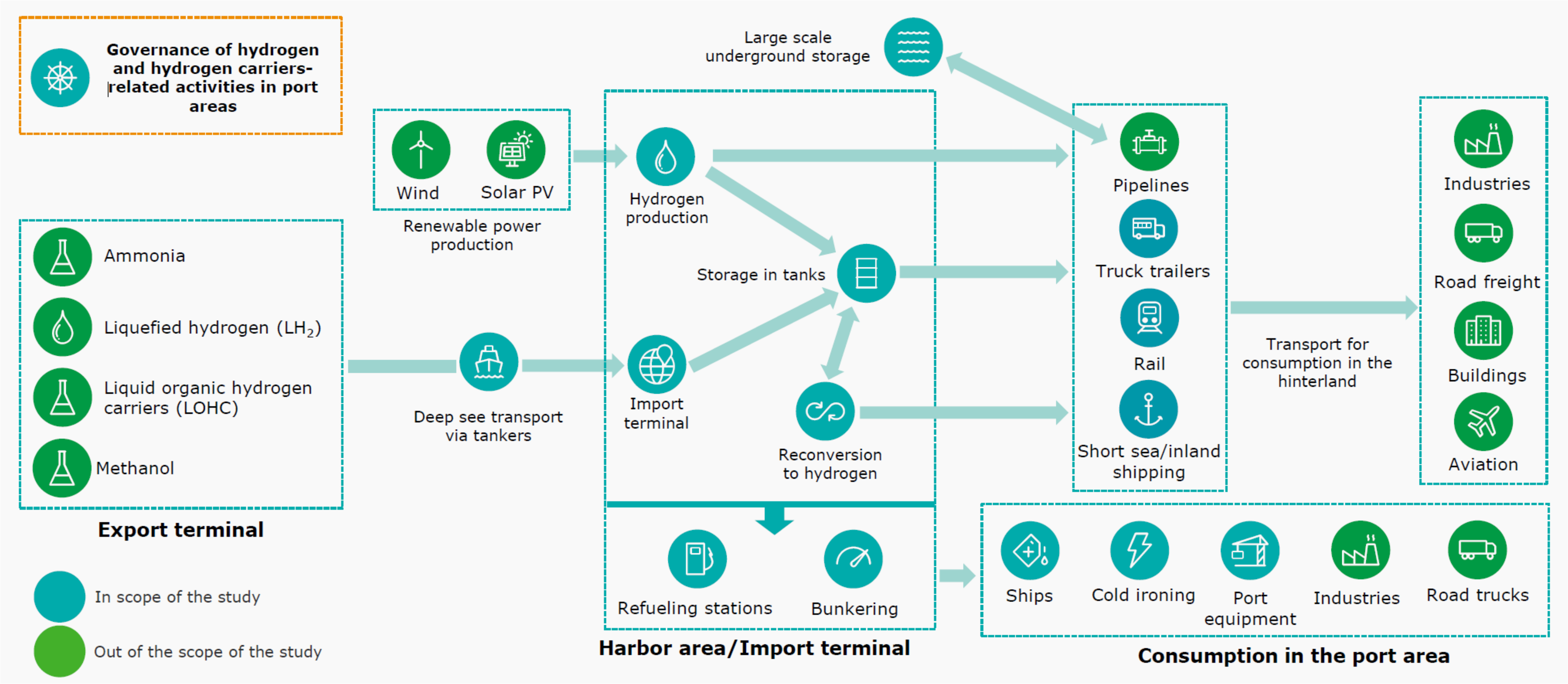
Hydrogen value chain impact on activities and infrastructures in EU ports



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Report 2 analyses a priority scale of challenges

4 dimensions of challenges

Space & land-use trade-off	New energy facilities	New hydrogen infrastructure	Transportation to consumption clusters
• **Land availability** in the port area • Spatial development & **planning** • **Transition** from the current setup • **Safety** zone requirements • **Modal shift** in transport	• New maritime fuel **bunker** facilities • Multimodal hydrogen **refueling stations** • Land-based **cargo handling** and **terminal equipment** • Port **vessels** • **Onshore power supply** (cold ironing)	• Dedicated **terminals** and quays • New on-/off **loading facilities** • **Landing** of offshore produced **power** • **Electrolysis plants** • **Storage** in tanks • **Conversion** infrastructure	• **Connection via pipelines** to nearby industrial clusters • **Multimodal transportation to the hinterland** via truck trailers, trains and inland ships • Hydrogen **storage** in **offshore** underground geological formations

3 levels analysis of the challenges

R&I challenges

Assessment of current **technological challenges,** identification of **areas of priority for R&I** projects and **recommendations on R&I objectives** and millstones (e.g., cost target, research timeline)

Safety challenges

Identification of **gaps** in **safety regulations, codes** and **standards** and **recommendations** on safety regulations, codes and standards to update or develop.

Non-technical (policy, regulatory, strategic, etc.) challenges

Identification of **non-technical (policy, regulatory, strategic, etc.)** and **recommendations** on these non-technical challenges.

Prioritization:

High · Medium · Low

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Diversity of ports involvement on hydrogen: 4 cases studies

Case study 4

Key characteristics

- **Port(s) involved**: Port of Pecém, Port of Rotterdam
- **Country**: Brazil, the Netherlands
- **Topic**: Hydrogen import
- **Role of port in the project**: Landlord and enabler

Case study 2

Key characteristics

- **Port(s) involved**: Port of Antwerp-Bruges & Port of Duisburg
- **Country**: Belgium, Germany
- **Topic**: Decarbonization of port equipment
- **Role of port in the project**: Landlord, enabler and investor

Case study 1

Key characteristics

- **Port(s) involved**: Port of Klaipeda
- **Country**: Lithuania
- **Topic**: Hydrogen production
- **Role of port in the project**: Enabler and investor

Case study 3

Key characteristics

- **Port(s) involved**: The North Tyrrhenian Port Network Authority (Port of Livorno, Piombino and Portoferraio)
- **Country**: Italy
- **Topic**: Hydrogen consumption (shipping)
- **Role of port in the project**: Landlord and enabler

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Thank you

For further information
https://www.clean-hydrogen.europa.eu/