

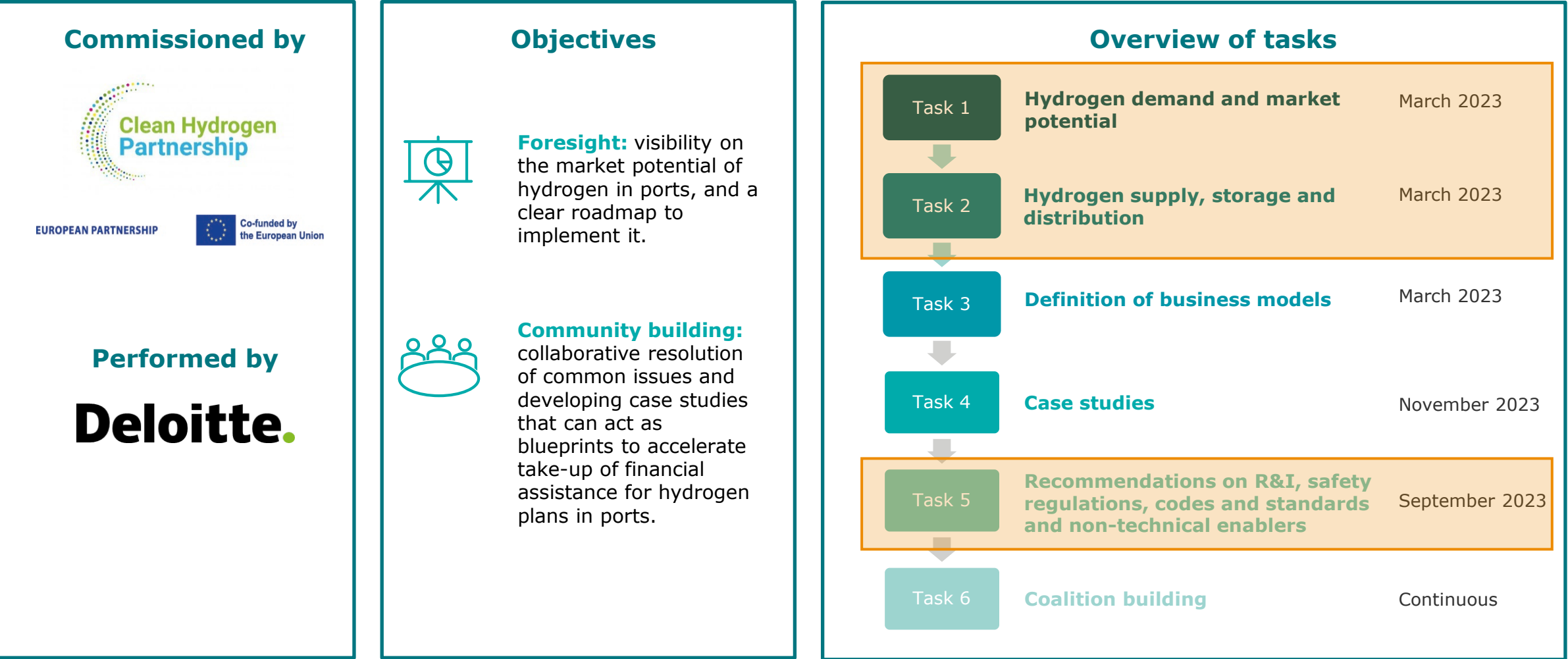


Study on hydrogen in ports and industrial coastal areas

e4ports-Symposium

November 2023

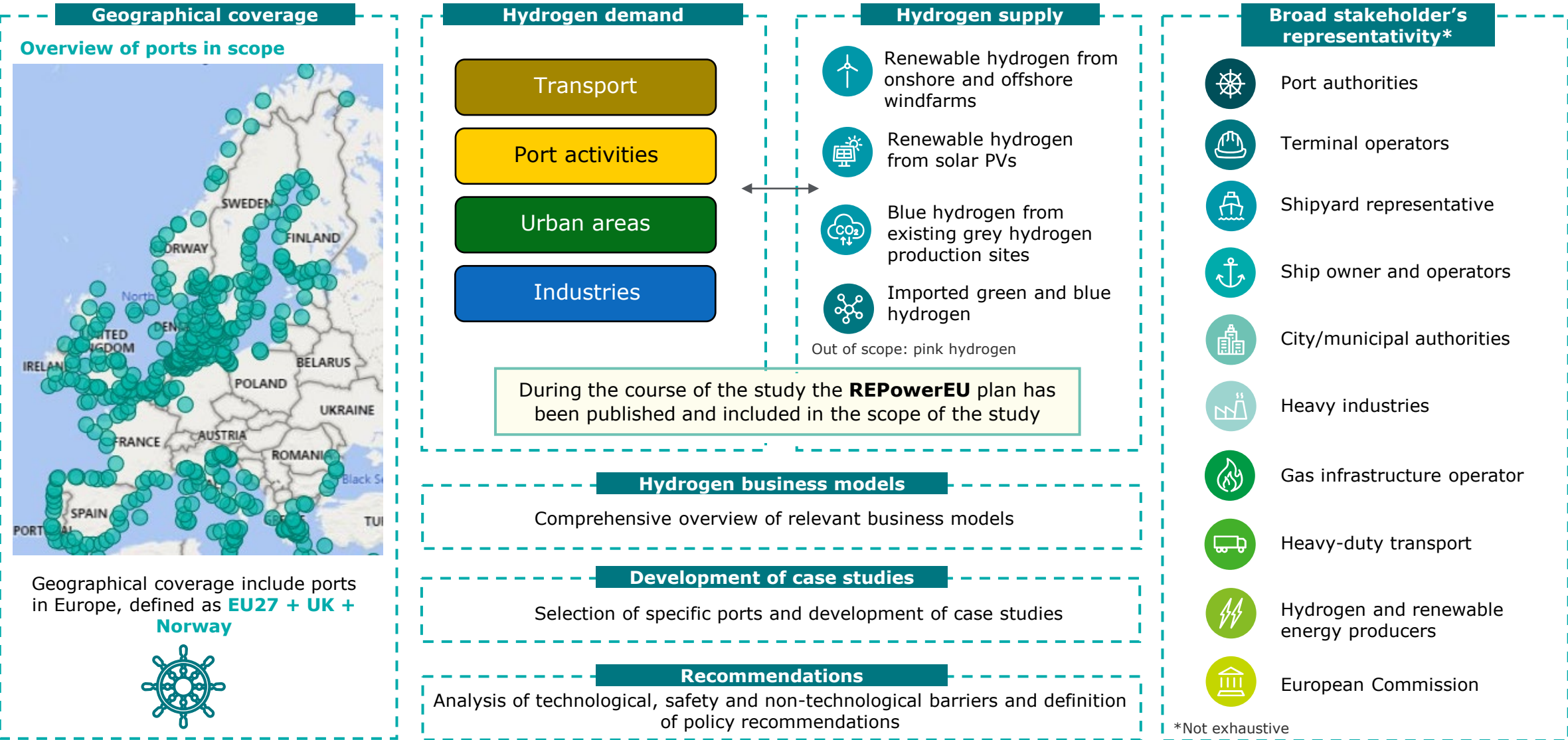
Objectives and tasks of study on hydrogen in ports and industrial coastal areas



The study feeds into the work of the **Global Hydrogen Ports Coalition**, launched at the latest Clean Energy Ministerial (CEM12). This important international initiative brings together ports from around the world to work together on hydrogen technologies.

* Dates refer to delivery date of final reports

Study on hydrogen in ports and industrial coastal areas: overview of the general approach

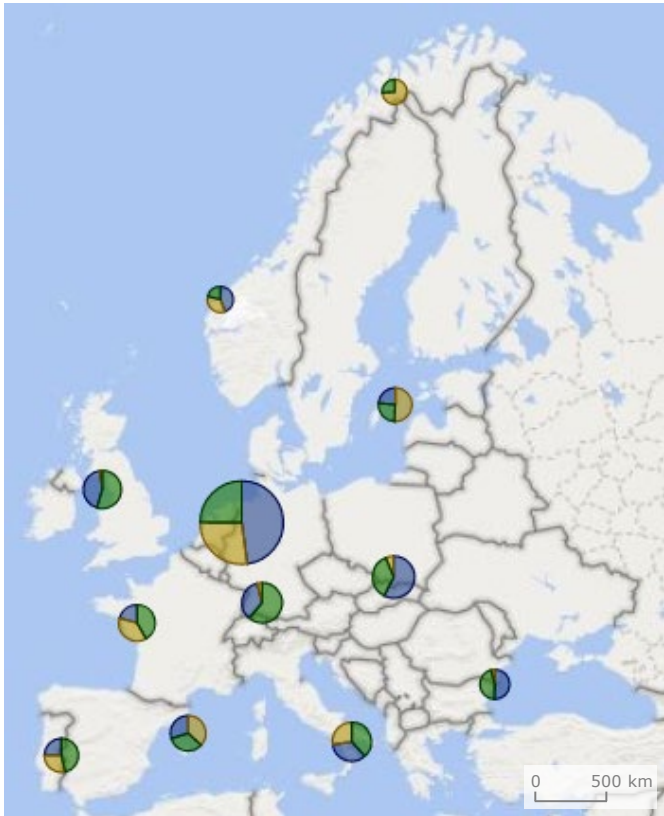


Hydrogen demand

high-level results

Overview of hydrogen demand projections until 2050 in Europe across all demand subcategories

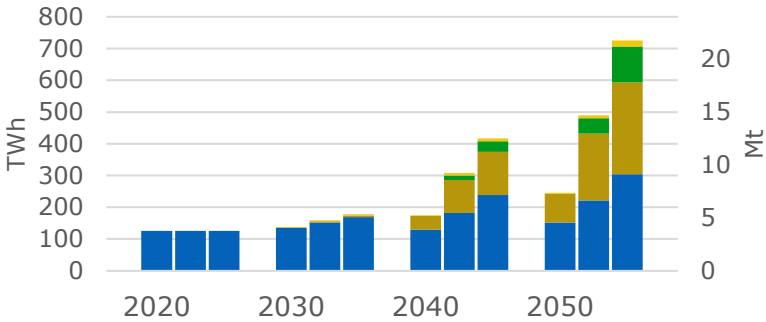
Hydrogen demand per demand cluster per category – ambitious scenario in 2050



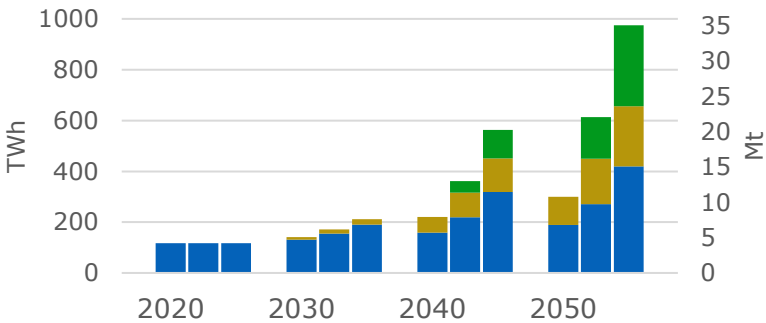
The circles on the map are located in the center of the relevant cluster

● Industry ● Transport ● Urban areas ● Port activities

Hydrogen demand in ports



Hydrogen demand outside of ports

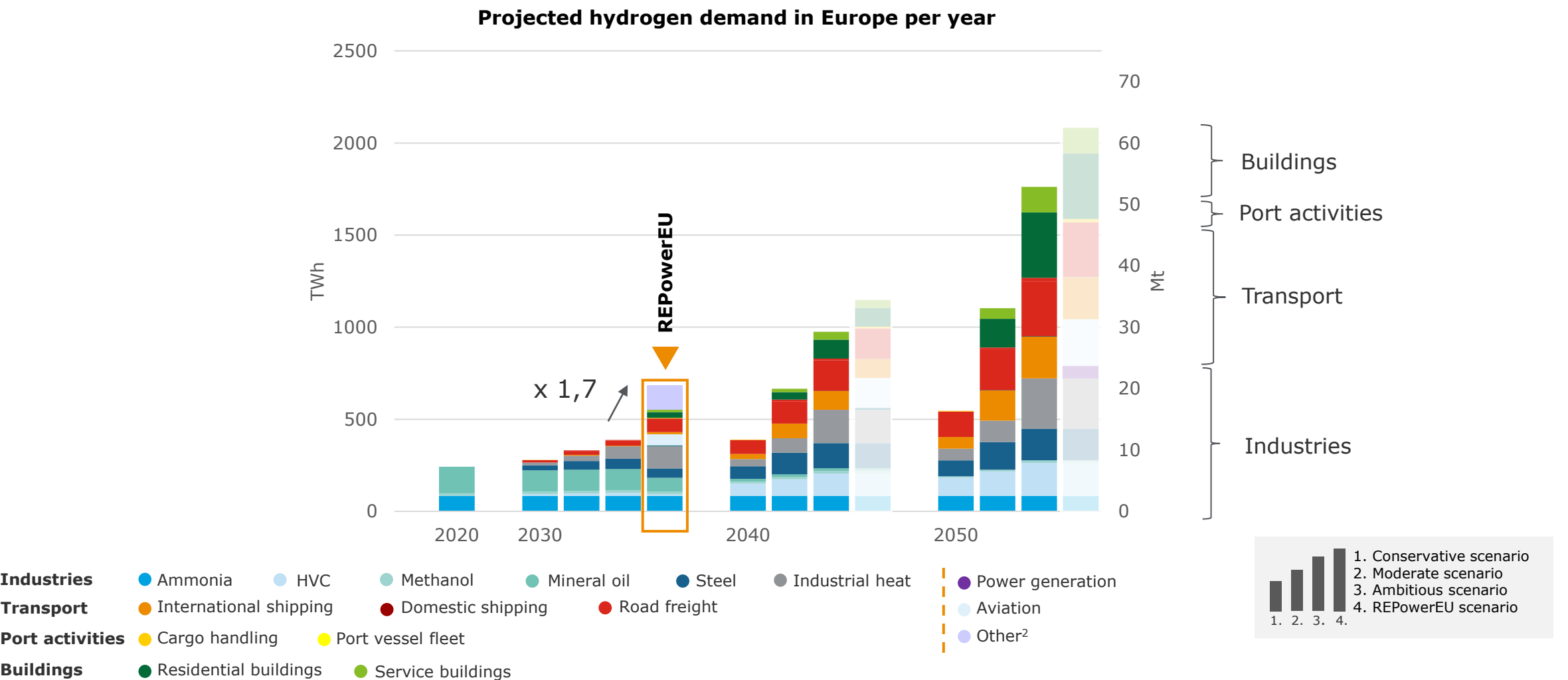


1. Conservative scenario
2. Moderate scenario
3. Ambitious scenario

Key messages:

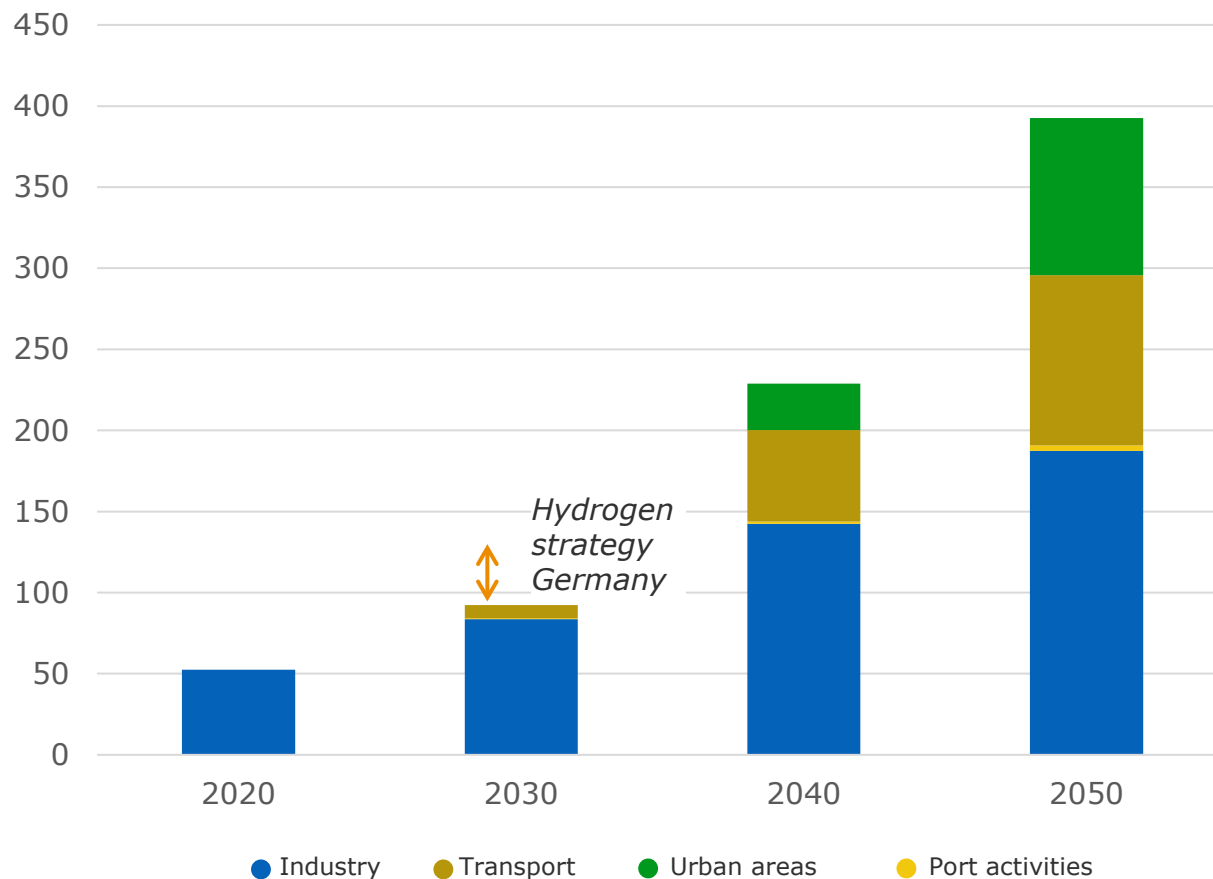
- Hydrogen demand projections:
 - 2030: between 283 and 389 TWh
 - 2050, between 545 and 1764 TWh
- Mainly driven by industries and the international shipping sector demand for clean hydrogen in the vicinity of **European ports** could reach 730 TWh, or **42% of total hydrogen demand in the EU expected in 2050**. This would represent a six-fold increase compared to the current demand for hydrogen near European ports (126 TWh).
- Clean hydrogen consumption in port areas has the potential to lead to up to 360 Mt of CO₂-eq abatement in 2050 (or **8% of total European GHG emissions** in 2019) as well as additional environmental benefits (e.g., reduction of toxic atmospheric emissions, water pollutants, solid waste, and noise emissions).

Hydrogen demand in Europe per demand subcategory and scenario for 2020, 2030, 2040 and 2050



Overview of hydrogen demand projections until 2050 in Germany

Hydrogen demand in Germany for the ambitious scenario



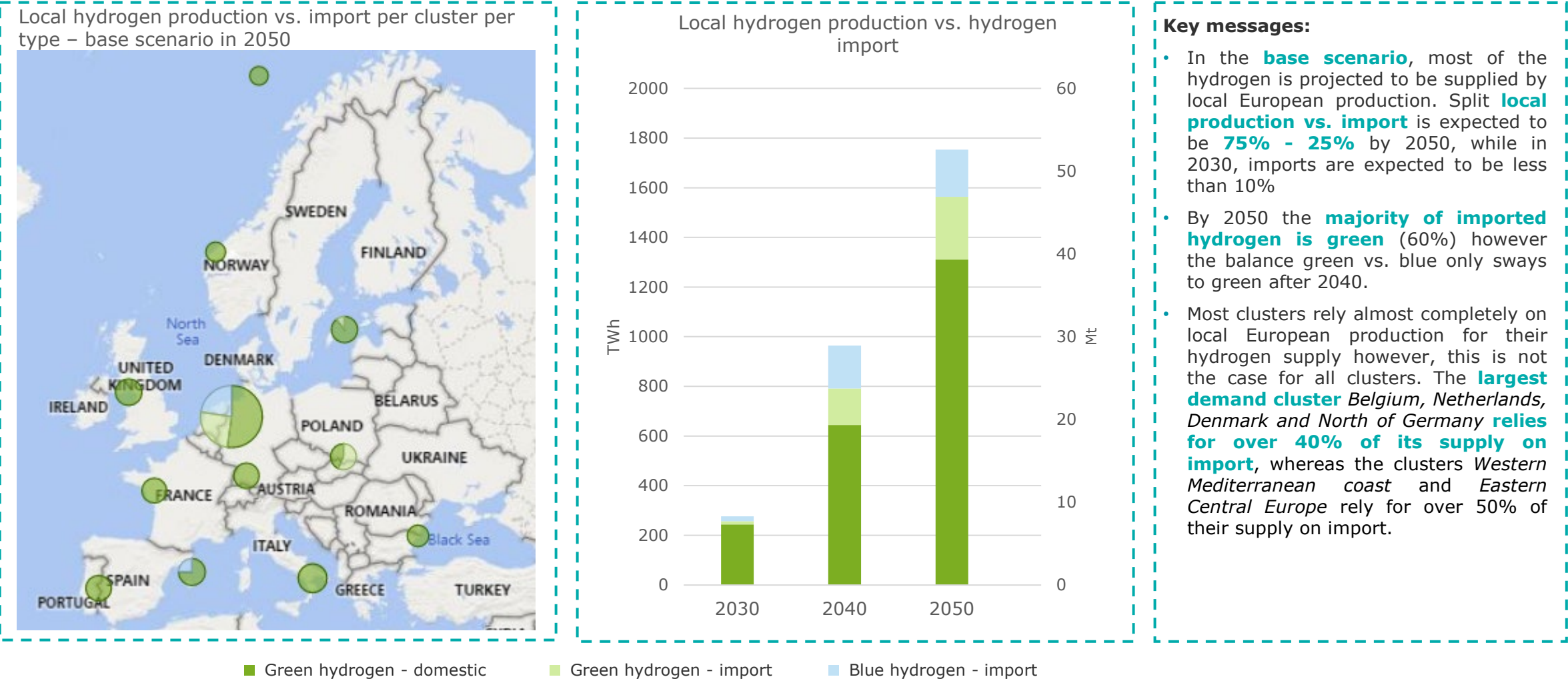
Key messages:

- In **2030**, total hydrogen demand is projected to be up to **~ 92 TWh** (about 2.8 Mt)
- In 2050, total hydrogen demand is projected to be up to ~ 392 TWh (about 12 Mt)
- By 2050, the **industry** (mainly HVC, industrial heat and steel) **will likely be the largest demand sector** for renewable and low-carbon hydrogen, followed by transport sector, potentially urban areas and finally port activities.
- REFERENCE: Projected hydrogen demand in Germany's national hydrogen strategy (BMW's):
 - **2030: 95-130 TWh**
 - 2045: 290-440 TWh industry, conversion sector 80-100 TWh & a role in transport and potentially buildings

Hydrogen supply

high-level results

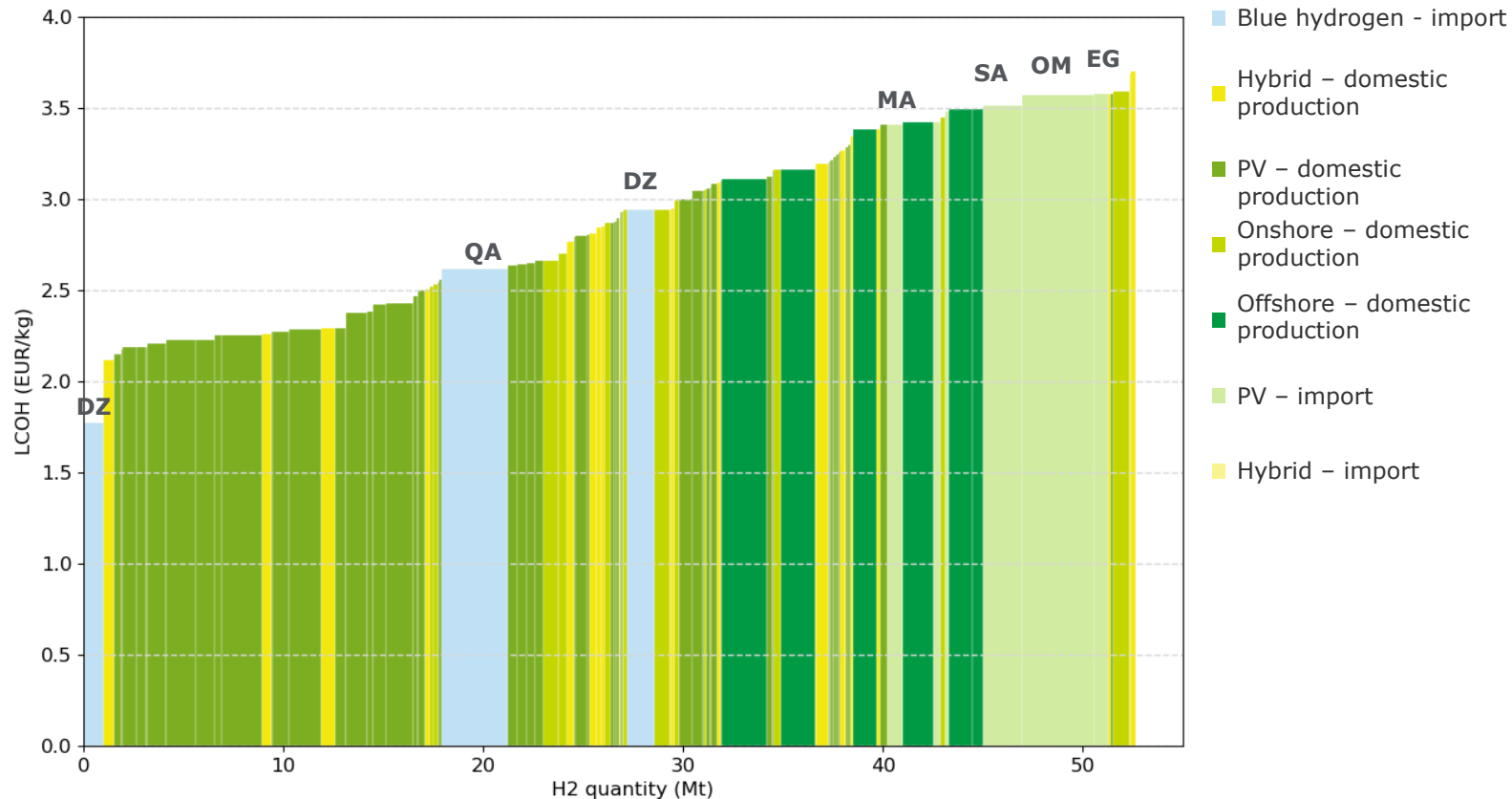
The base scenario¹ evolves to a 75% - 25% split of local production vs. import of hydrogen by 2050, with important variation between clusters...



Note: (1) The ambitious scenario is the default demand scenario for which supply is matched, unless stated otherwise. (2) Turquoise hydrogen via pyrolysis was also considered an option in the model, however, LCOH was higher than for GHR and thus not an outcome of the model.

... for which the cheaper local production and blue imports are complemented with more expensive local production and green imports

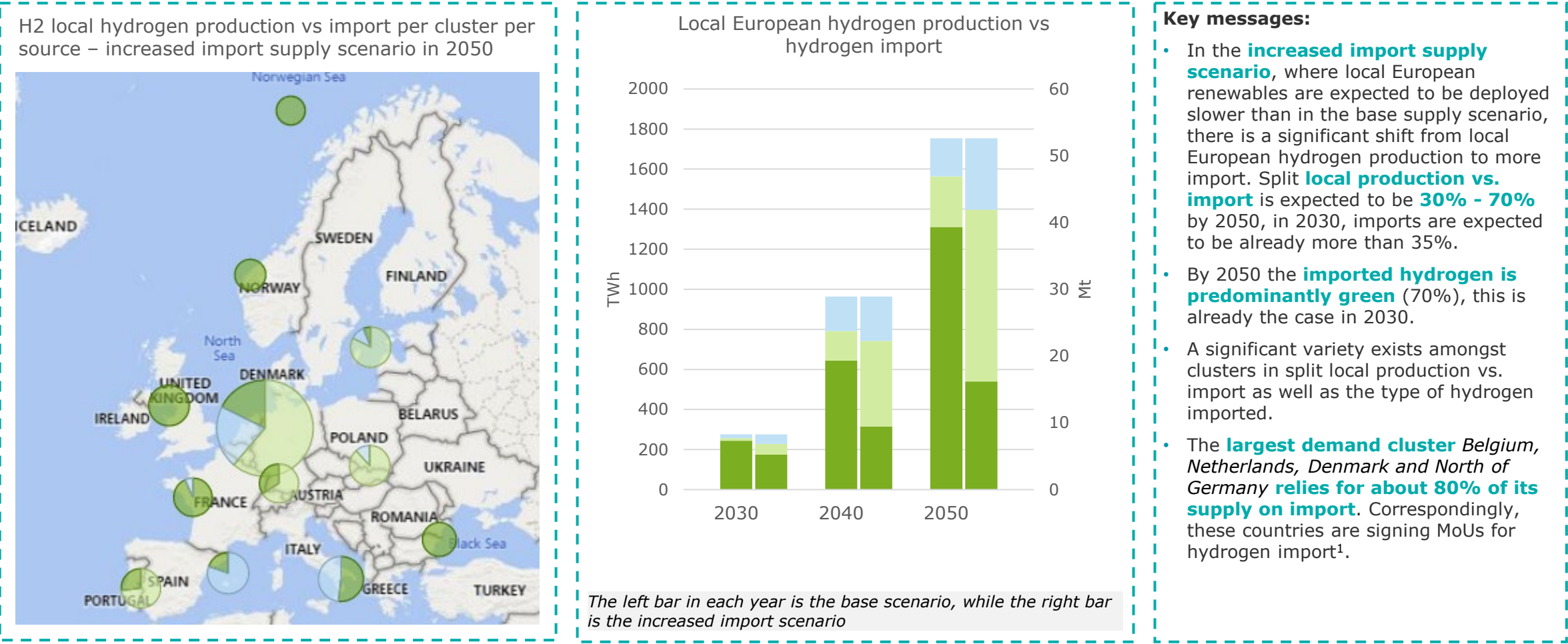
Merit order curve hydrogen supply – base scenario in 2050



Key messages:

- **Local PV and hybrid systems** are the most cost-effective hydrogen sources and have the possibility to provide **at least 15 Mt of hydrogen** at a **cost lower than 2,5 EUR/kg**
- Further, local hydrogen supply is based on other onshore wind, PV and hybrid systems at a cost between 2,1 and 3,3 EUR/kg and **offshore wind** at a cost between **3 and 3,5 EUR/kg**
- **Blue hydrogen imports** are expected from Algeria and Qatar at a **cost below 3 EUR/kg**
- **Green hydrogen imports** are expected from Morocco, Oman, Saudi Arabia and Egypt at around **3,5 EUR/kg**. The hydrogen supply model assumes consumption of hydrogen, however in many cases the carrier used for transport, such as **ammonia**, can be used directly **without conversion to hydrogen**. Avoiding this conversion step makes the **import case significantly more competitive** (cost reduction of 0,4² to 0,8³ EUR/kg) for sectors where direct offtake of these carriers is expected (e.g. shipping). We refer to ongoing initiatives such as [HyPort Dugm](#) or [HyEx](#) where ammonia will be imported from Oman and Chili, respectively.

In the increased import supply scenario, with constrained EU renewables deployment, there is a significant shift to 70% hydrogen imports



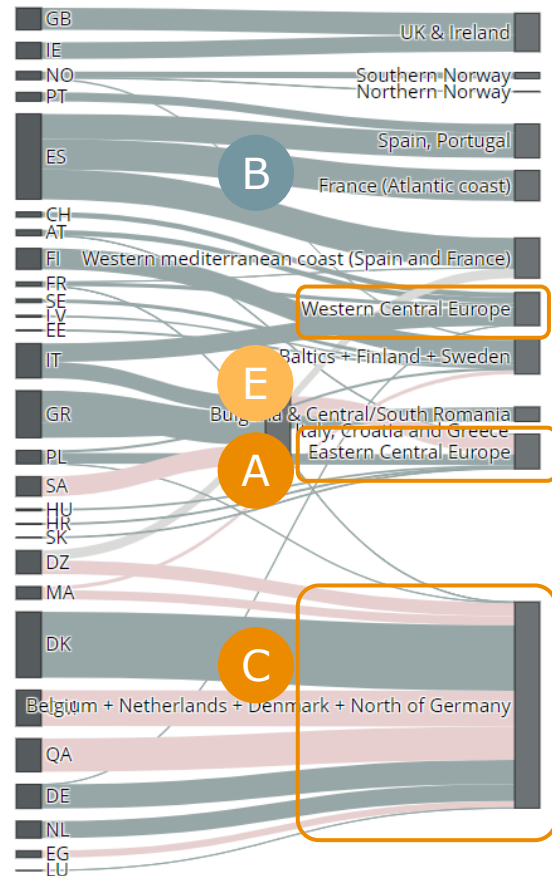
■ Green hydrogen - domestic ■ Green hydrogen - import ■ Blue hydrogen - import

Note: (1) E.g. Belgium (or Belgian ports) are signing memorandums of understanding (MoUs) with Oman, Namibia and Chili; the Netherlands (or ports in the Netherlands) with the United Arab Emirates (Africa-focused); Germany with Australia
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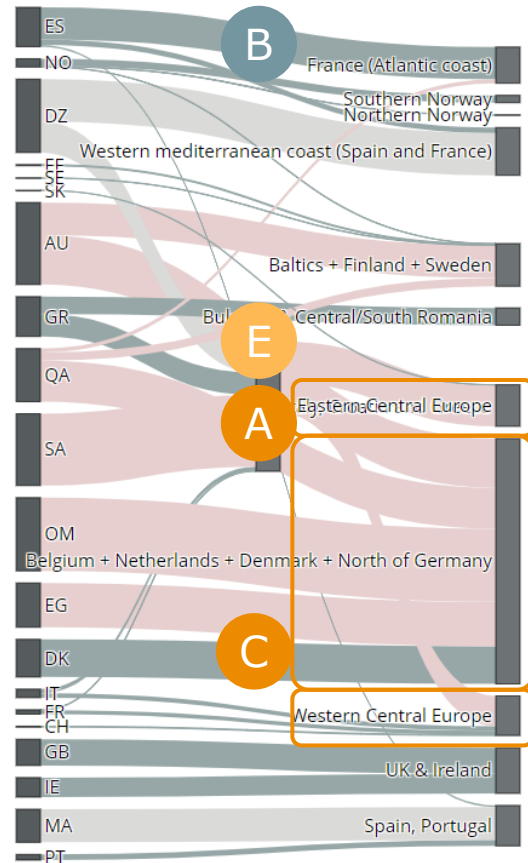
Hydrogen in ports and industrial coastal areas11

The projected need for specific corridors largely aligns with the communicated corridors in European Hydrogen Backbone vision

Base supply scenario in 2050



Increased import supply scenario in 2050



■ Maritime import ■ Pipeline import ■ Intra European transport

Comparison to identified corridors in European Hydrogen Backbone vision¹

- To deliver the hydrogen demand and supply targets set by the REPowerEU plan, five large-scale pipeline corridors are envisaged by European Hydrogen Backbone initiative:

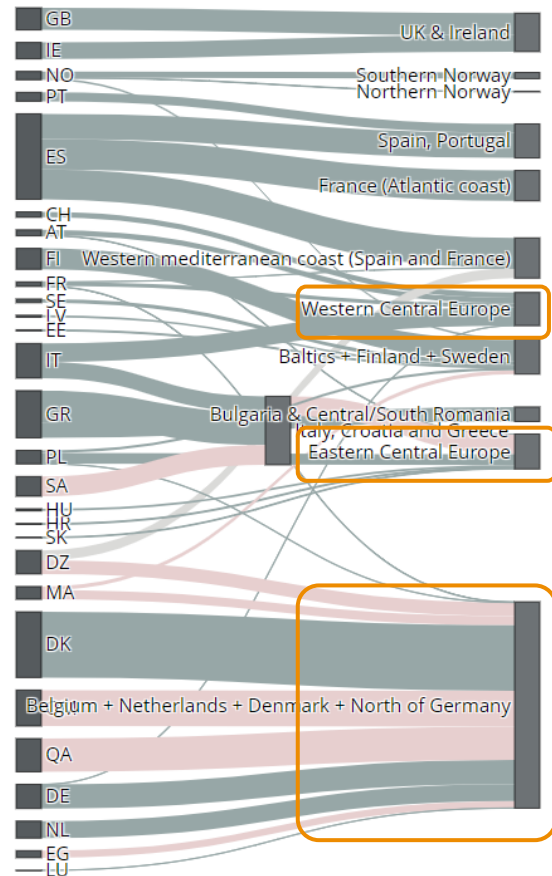
- Corridor A: North Africa and Southern Europe (from Algeria through Italy to Central Europe)
- Corridor B: Southwest Europe and North Europe
- Corridor C: North Sea
- Corridor D: Nordic and Baltic regions
- Corridor E: East and South-East Europe



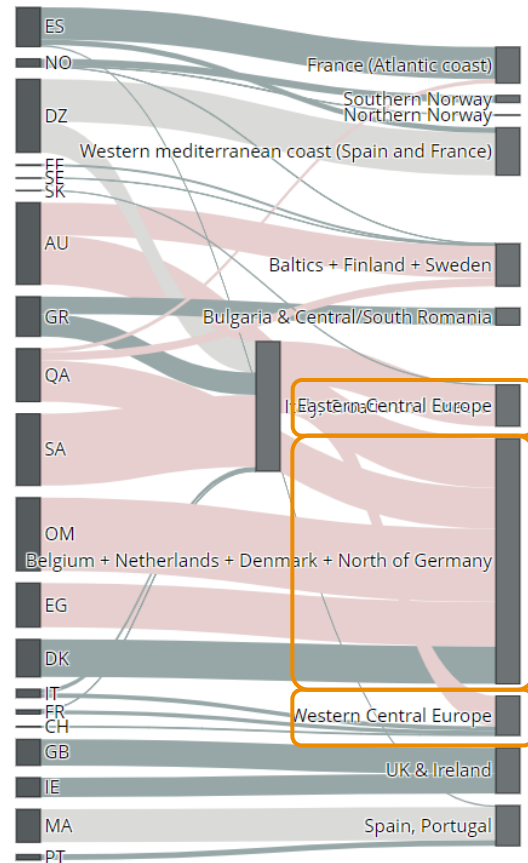
- From our economical analysis, it can be concluded that there is indeed a **projected need for corridor A, B, C and E**. It should be noted that our analysis is an economic optimization and does not take into account other factors such as policy initiatives.

The projected need for specific corridors largely aligns with the communicated corridors in European Hydrogen Backbone vision

Base supply scenario in 2050



Increased import supply scenario in 2050



Key messages:

- Germany's hydrogen demand is projected to be supplied partially by **local production** for a small part (~13% in 2030, corresponding to **12 TWh**, corresponding 5.7 GW electrolysis capacity and ~20% in 2050), or not at all in the increased import scenario
- It is projected that Germany will **import**:
 - Via pipeline, from amongst others, directly, **Denmark** or transited via **Belgium, the Netherlands, Italy**, coming from outside of Europe (pipeline/ship: **Algeria, Morocco**, ship, cf. below)
 - Via ship from countries outside of Europe, mostly countries in the **North of Africa or Middle East**. However, also other options such as **Australia** are possible
- LCOH range: 2030: 2.9 – 5 EUR/kg**, 2050: 2.6 – 3.5 EUR/kg
- REFERENCE**: Germany's national hydrogen strategy:
- Local production: 25 TWh**, 10 GW electrolysis capacity
- Import strategy** (to be released): pipeline: Norway, the Netherlands, Belgium, Denmark, France, Morocco, Algeria, Tunisia, the United Kingdom and Ukraine, ship: Australia, Saudi Arabia, the United Arab Emirates, South Africa, Namibia and Chile

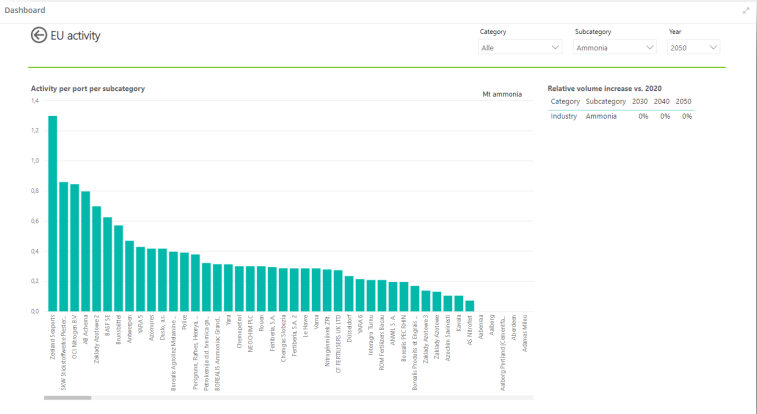
Detailed insights via dashboards

main functionalities

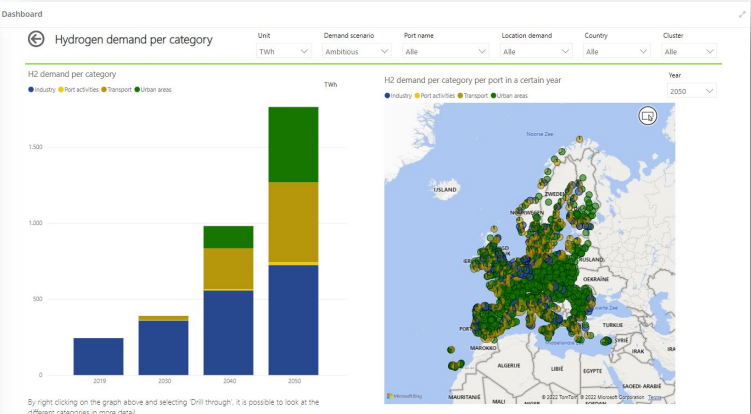


Overall perspective: hydrogen demand and related CO₂ abatement

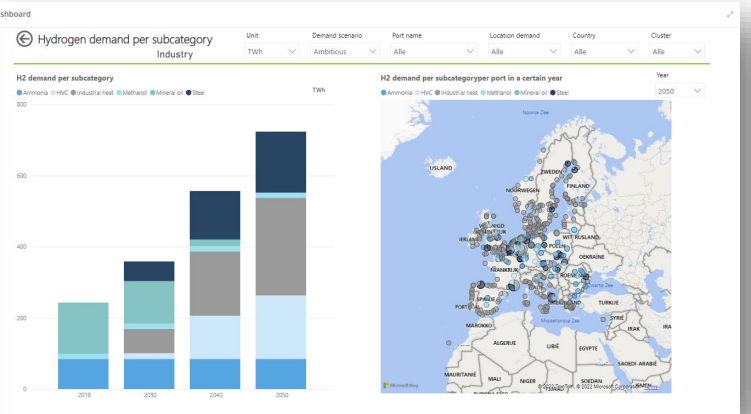
EU activity



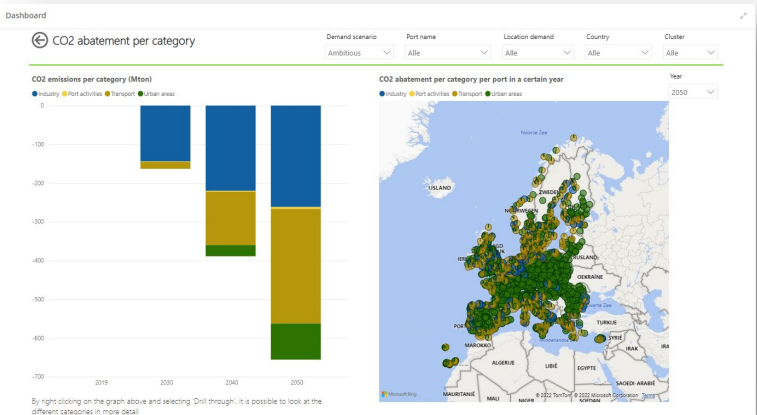
Hydrogen demand per category



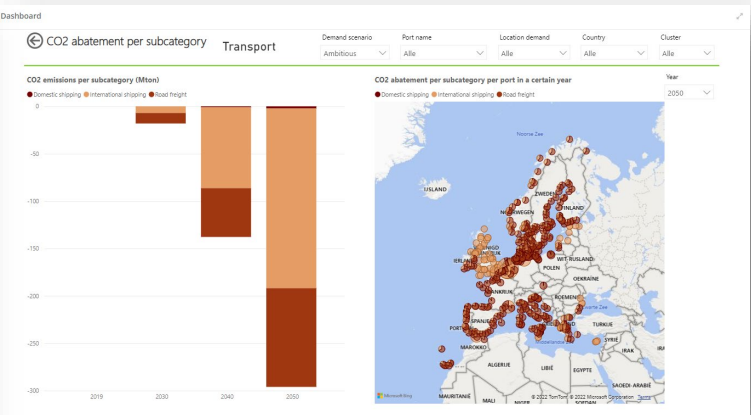
Hydrogen demand per subcategory



CO₂ abatement potential per category

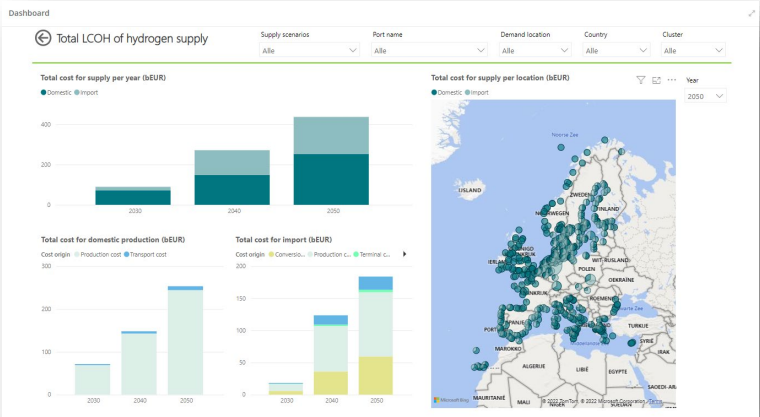


CO₂ abatement potential per subcategory

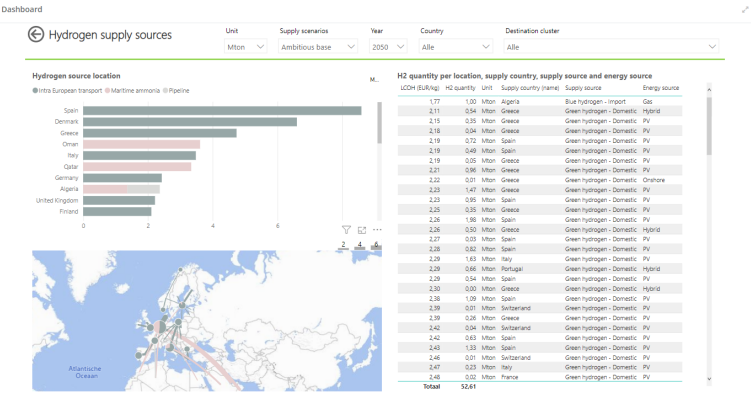


Overall perspective: hydrogen supply and required infrastructure

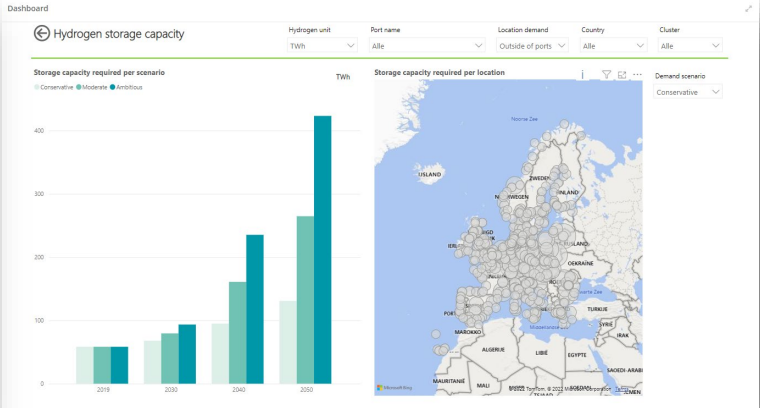
LCOH supply



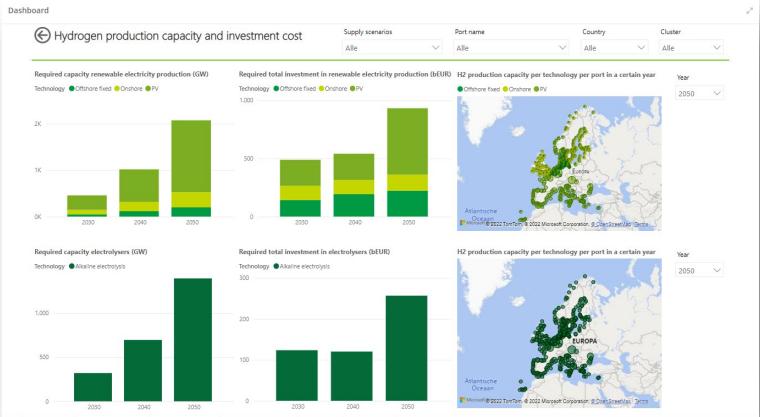
Supply sources



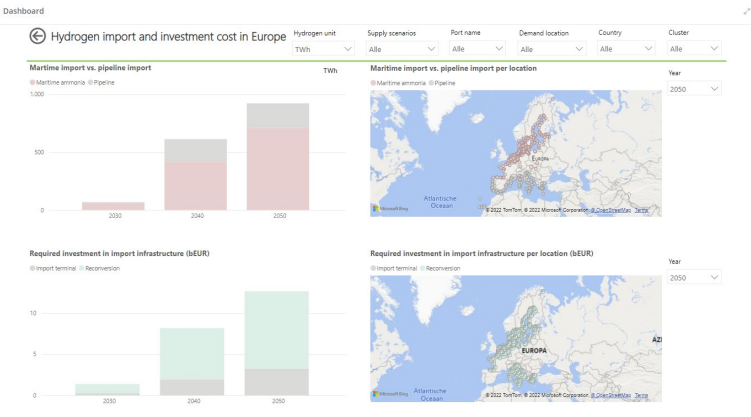
Storage capacity



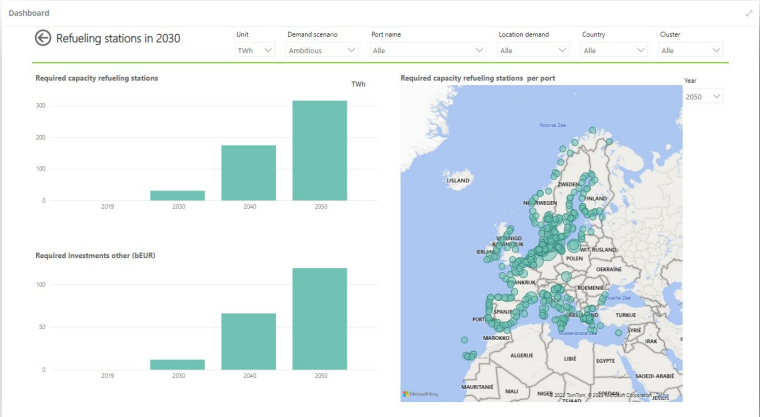
Production capacity and investments



Import capacity and investments



Refueling stations capacity



Policy recommendations

high-level results

This study provides a three-level analysis for each of the hydrogen-related activities and infrastructure expected to be developed in port areas

R&I challenges

Assessment of current **technological challenges**, identification of **areas of priority for R&I** projects and **recommendations on R&I objectives** and milestones (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.

Key recommendations to **port authorities and other port stakeholders**

Key recommendations to **EU Member States (national governments)**

Key recommendations to **the European Union**

Bunkering of hydrogen and hydrogen derivatives



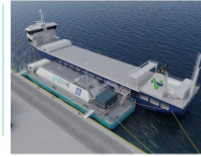
Introduction: Ports will need to timely develop hydrogen and/or hydrogen carrier bunkering infrastructures for maritime and inland shipping

Description of the activity: Bunkering of hydrogen/hydrogen carriers (i.e., ammonia, methanol) for use as fuel by ships, including shore-to-ship (fuel bunkered directly from a storage tank or pipelines), ship-to-ship (fuel bunkered from cargo tanks of a refueling vessel)¹ and truck-to-ship (fuel bunkered from a truck connected to the ship on the quayside)², but also floating ammonia bunkering systems and swappable compressed hydrogen (GH2) containers.

- With the upcoming adoption of the FuelEU Maritime Regulation⁵ and already adopted IMO targets⁶ and Act of Mannheim⁷ (inland EU shipping), the maritime sector is under increasing pressure to accelerate emissions reductions, notably through the **gradual replacement of fossil-fuel powered vessels with low-carbon alternative fuels**. In this context, while the uptake of specific low-carbon alternative maritime fuels is largely driven by shipping companies, **sea and inland ports can play a catalytic role in offering, promoting and using alternative maritime fuels**. Indeed:

- Firstly, while numerous alternative maritime fuels are being touted as the future of ships (i.e., compressed or liquid hydrogen, methanol, ammonia, synthetic fuels) and there is no clear answer as to which fuel or combination of fuels will be the most suitable, **we have no choice but to act in order to ensure that we will be in the position to provide the right fuels in sufficient quantities and in a timely manner**, while meeting the diverse and complex safety and handling requirements associated with these fuels.
 - Secondly, **ports can also play a user role by using these alternative fuels to decarbonize their own port vessels** (i.e., tugboats, ferries, etc.).
 - Thirdly, **ports can act as a promoter of alternative maritime fuels, notably by raising awareness within the port community and wider public in order to push progress and direction of alternative fuel use and adoption in the maritime sector**.
- In this context, **ports will eventually need storage facilities from which bunkering infrastructures (i.e.,**

vessels) will be able to source alternative fuels and supply them to ships that need them. In the case of small vessels based in ports, bunkering from a fixed barge may be another option'.



Ammonia bunkering infrastructure prototype
by AZANE Fuel Solutions (Source: [link](#))

Hydrogen in ports and industrial coastal areas

R&I challenges and associated recommendations for the development of hydrogen derivatives (ammonia and LOHC) bunkering systems*

Description of the R&I challenge: Ammonia and LOHC bunkering can be done using ship-to-ship, truck-to-ship and (floating) bunker stations. Loading and unloading of ammonia from terminal to ammonia-carrying ships is currently handled safely in ammonia bulk transfers². LOHC can utilize existing bunkering infrastructure for diesel due to similarities in intrinsic qualities.

Objective: Demonstration and qual

- Target for 2030: $> 20 \text{ tH}_{2,\text{equiv}}/\text{h}^*$
- Cost target in 2030: NA
- Research Timeline: 2023-2028

Where are we today: Feasibility study to establish green ammonia ship-to-ship bunkering at the Port of Singapore¹. The SABRE consortium has received approval in principle (AIP) from the US classification society ABS for an ammonia bunkering vessel design². The Ship-aH2oy project has received €15m to demonstrate the operation of LOHC/SOFC system on the Edda Wind vessel³.

Technical R&I aspects: Ammonia can be stored under pressure or refrigerated. Different arrangements of fuel tank and supply tank have specific bunkering equipment requirements. Pressurized fuel tanks can be bunkered both by pressurized and refrigerated tanks². For the bunkering of ammonia, toxicity is the main risk³.

- > A qualification program for ammonia equipment.
- > Infrastructure deployment for facilities to store, handle, and distribute ammonia to ships, as well as equipment for transferring the fuel from the shore to the ship.
- > Numerical and experimental work to quantify the probability and occurrence and effects of incidents.
- > Demonstrate LOHC bunkering with existing bunkering infrastructure.

Note: (*) This is

Notes: (*) This analysis focuses on ammonia and LOHC as the main hydrogen carriers, other carbon-based fuels and solid carriers are relevant but outside the scope of this analysis; (**) Data taken from [Strategic Energy and Innovation Agency](#) (page 164) equivalent amount for NH₃ and LOHC to provide same energy content

Sources: (1) [Morsk to offer ammonia bunkering in Singapore - Maritime Gateway](#); (2) [DNV GL Ammonia as a marine fuel](#); (3) [DNV GL: Use of liquid ammonia bunkering](#); (4) [Ship-to-Ship first-of-its-kind maritime LOHC](#); (5) [Maritime Executive](#), 2022

*Ammonia* bunker vessel⁵

Hydrogen in ports and industrial coastal areas

Description of the safety challenge: The handling and bunkering of all hydrogen-based maritime fuels (like gaseous hydrogen, (cryo)compressed hydrogen, liquid hydrogen, ammonia, methanol, liquid organic hydrogen carriers, metal hydrides) in a port environment are associated with potential safety hazards (explosion, fire, toxicity) that can have an immediate impact on the physical safety of people, building structures and equipment in the direct proximity.

Description of the safety challenge: The handling and bunkering of all hydrogen-based maritime fuels (like gaseous hydrogen, (cryo)compressed hydrogen, liquid hydrogen, ammonia, methanol, liquid organic hydrogen carriers, metal hydrides) in a port environment are associated with potential safety hazards (explosion, fire, toxicity) that can have an immediate impact on the physical safety of people, building structures and equipment in the direct proximity.

Where are we today: Bunkering guidelines, procedures, standards and checklists for bunkering of hydrogen-based fuels do not exist². CEN/CENELEC are in the early stages for developing standards for bunkering hydrogen³; some generic inputs can be retrieved from Norwegian standard FOR-2009-06-602 (does not cover hydrogen)³. Experience with the loading and unloading of sea going vessels carrying methanol and ammonia is available. Although different from bunkering, overlap in lessons learned are to be considered⁴.

Safety projects should focus on:

- Assessment of the cyclic thermal effects on durability and integrity of storage tanks and hoses during direct gaseous hydrogen fueling; design considerations and integrity of hoisted (swappable) fuel containers to survive unintentional drops from the swapping cranes.
- Ventilation considerations in terms of position of vent pipes relative to living quarters and height above deck; installation of gas detectors in fresh air ventilation to accommodation and working spaces.
- Fire-fighting systems appropriate for hydrogen carrier used and fire loads anticipated; fire integrity of the fuel tank; fire detection systems and their measurement locations.
- The location of the bunkering infrastructure in relation to the safety distance required; distances differ per phenomenon - toxicity (ammonia), overpressure (explosion) and heat radiation (explosion/fire); Determination of scale of the operations in light of the more stringent guidelines of SEVESO III (5 tonnes limit).

<p>The EU should encourage the ISO and IEC/CENELEC to develop bunkering guidelines/standards; make use of existing and corresponding documents for the bunkering of LNG. Basic principles will be similar, and the operational and safety requirements will differ.</p> <p>The EU should encourage the International Association of Classification Societies (IACS) and Society for Gas as a Marine Fuel (SGMF) to provide a more specific and practical bunkering guidelines for the implementation of the international guidelines.</p> <p>The EU should encourage bunker operators to develop bunker procedures with support from the classification societies.</p> <p>The EU should encourage the International Association of Ports and Harbors (IAPH) to develop harmonized bunker checklists.</p> <p>The EU should develop a roadmap to harmonize maritime regulations with EU onshore regulations, national regulations and Port Authorities prescriptions to support the definition of practical solutions.</p>	<p>1. The EU should encourage the ISO and IEC/CENELEC to develop bunkering guidelines/standards; make use of existing and corresponding documents for the bunkering of LNG. Basic principles will be similar, and the operational and safety requirements will differ.</p> <p>2. The EU should encourage the International Association of Classification Societies (IACS) and Society for Gas as a Marine Fuel (SGMF) to provide a more specific and practical bunkering guidelines for the implementation of the international guidelines.</p> <p>3. The EU should encourage bunker operators to develop bunker procedures with support from the classification societies.</p> <p>4. The EU should encourage the International Association of Ports and Harbors (IAPH) to develop harmonized bunker checklists.</p> <p>5. The EU should develop a roadmap to harmonize maritime regulations with EU onshore regulations, national regulations and Port Authorities prescriptions to support the definition of practical solutions.</p>
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Hydrogen in ports and industrial coastal areas 7

Non-technical barriers hindering the efficient, rapid and large-scale development of alternative fuels bunkering infrastructures for maritime and inland shipping.

1. Lack of **port-specific roadmaps/planning** developed by port authorities in collaboration with future hydrogen (derivatives) bunkering fuel companies, alternative fuel storage owners, terminal operators and shipping companies **to precisely define governance, as well as key milestones and**

1. Lack of **port-specific rosnaps/planning** developed by port authorities in collaboration with future hydrogen (derivatives) bunkering fuel companies, alternative fuel storage owners, terminal operators and shipping companies to **precisely define governance, as well as key milestones and conditions for the development of alternative fuel bunkering activities in ports** (i.e., timing, quantities, end-users, required infrastructures, investment needs, etc.).
2. Lack of **consensus on what will be the future fuels mix of choice in the maritime sector** (e.g., ammonia, methanol, e-LH₂, GH₂), preventing hydrogen and hydrogen carrier bunkering infrastructures from moving from the R&D phase to wide adoption.
3. With the likely expansion of several alternative maritime fuels in the coming years, various bunkering options with different technological requirements will be needed¹. This situation may lead to **increased pressure in ports that are already facing land scarcity, as separate bunkering installations require more and different berthing points, and large safety zone requirements may be needed** for at least some of these alternative fuels (e.g., ammonia)^{2(a)}.
4. Lack of **sufficient demand and supply** (availability of alternative maritime fuels in ports in sufficient quantities) **certainities for hydrogen/hydrogen carriers-based bunkering fuels** to incentivize seaports (i.e., terminals, bunker operators and/or other third parties) to invest in dedicated bunkering infrastructures (e.g., filling points and bunker barges).
5. Lack of **EU-wide harmonized technical and safety protocols**, as well as **regulatory framework** (including clear guidelines to Member States on administrative practices and permitting procedures) for the construction and safe operation of hydrogen and hydrogen carriers bunkering infrastructures in the shipping sector.
6. Lack of **harmonized operational practices between Member States for ship bunkering**, resulting in the need to design and build several types of bunkering infrastructure for each (alternative) maritime fuel, adapted to the bunkering specificities of the Member States.
7. Lack of **innovation breakthroughs** to further improve the efficiency and safety in handling and bunkering alternative fuels.

Note: (1) For instance, while LH2 requires highly insulated containers with cryogenic hoses for bunkering, ammonia is corrosive and toxic and need specialized equipment to eliminate any potential for leakage. Even though battery-electric propulsion seems to display great viability for inland vessels or port support vessels, innovative bunkering solutions such as concentrated fuel tanks for GH2 enables simplified bunkering and can mitigate the use of hydrogen in inland shipping; (2) While an adequate dedicated area for fuel handling and bunkering would be required for all alternative maritime fuels, the bunkering of ammonia is expected to be more complex than for hydrogen, as it is more corrosive and toxic. However, given that density of alternative maritime fuels are substantially less per volume than traditional fossil fuels, more space is required on top of the additional space needed to adhere to safety distances.

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Hydrogen in ports and industrial coastal areas

 Responsible authority(ies): **Port authorities and other port stakeholders**

As the adoption of alternative marine fuels becomes more widespread, all port authorities with bunkering operations in their ports need to consider how best to develop bunkering infrastructure for alternative fuels, either by taking on this responsibility themselves or by using third-party bunkering services in their port. To do so, under the leadership of port authorities, port areas (terminal operators, alternative fuel storage owners, fuel/bunker production company

As the adoption of alternative marine fuels becomes more widespread, **all port authorities with bunkering operations in their ports need to consider how best to develop bunkering infrastructure for alternative fuels**, either by taking on this responsibility themselves or by using third-party bunkering services in their port. To do so, under the leadership of port authorities, **port areas** (terminal operators, alternative fuel storage owners, fuel/bunker production company and shipping companies) **should define a framework** (e.g., governance, timing, quantities, end-users, required infrastructures, investment needs, space availability etc.) **for the development of alternative maritime fuels bunkering infrastructures** that promotes and drive supply and demand dynamics of these fuels.

- Should port authorities not directly responsible for the development and operation of alternative fuel bunkering infrastructures, they should **actively contribute to encouraging, stimulating, or compelling** (depending on port governance and regulatory powers) **private fuel bunkering operators** to timely develop and operate alternative fuel bunkering infrastructures. For instance, this incentivization can be done by:
- **Altering regulatory frameworks, providing guidance** (i.e., in coordination with relevant societies and associations), or **including specific provisions** in tender specifications or terminal concession contracts.
 - **Investing in specific flagship demonstration projects** to prove the technical and economic feasibility of safely handling and bunkering alternative fuels.
 - **Providing support to identify and secure access** to European and/or national **public funding** programmes.
 - **Providing training support** for personnel of bunkering operators on the safety operation and maintenance of alternative fuel bunkering infrastructures.































3 Pending the development of IMO and ISO technical regulatory standards, **relevant stakeholders** (e.g., classification societies), **could align themselves to establish harmonized technical and safety standards** for bunkering of alternative maritime fuels as well as **technological standards for building alternative maritime fuel bunkering infrastructures and equipment** used in Member States.

- Due to the spatial requirements of building and operating the various bunkering infrastructures associated with the likely expansion of several alternative maritime fuels, sea and inland ports **with space limitations** may be able to bypass their own alternative bunkering requirements by **contracting with larger ports or nearby alternative fuel providers for bunkering of specific fuels**. In turns, **ports could also consider to specialize in specific alternative maritime fuels** that will also supply other ports in the same coastal area.

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Hydrogen in ports and industrial coastal areas

























Prioritization of R&I challenges for the development of hydrogen and hydrogen carriers-related activities and infrastructure in port areas

In the port		
	Import terminals of hydrogen in EU ports	
	Import terminals of hydrogen carriers in EU ports	
	Bunkering of hydrogen and hydrogen derivatives	
	Use of hydrogen and hydrogen-based fuels in the maritime sector	
	Use of hydrogen and hydrogen carriers in cold ironing	
	Use of hydrogen and hydrogen carriers in port equipment	
In the vicinity of the port		
	Renewable hydrogen production	
	Surface hydrogen storage solutions	
	Surface hydrogen derivatives storage solutions	
	Conversion of imported hydrogen carriers into hydrogen	
	Multimodal land-based hydrogen refueling stations	
	Transport of hydrogen and derivatives from ports to users	
In the wider setting of the port area		
	Deep sea transport of hydrogen via tankers	
	Deep sea transport of hydrogen carriers via tankers	
	Hydrogen storage in underground geological formations	

Prioritization of challenges:
















Prioritization of **safety challenges** for the development of hydrogen and hydrogen carriers-related activities and infrastructure in port areas

In the port			In the vicinity of the port			In the wider setting of the port area		
	Import terminals of hydrogen and hydrogen carriers in EU ports			Renewable hydrogen production			Deep sea transport of hydrogen and hydrogen carriers via tankers	
	Bunkering of hydrogen and hydrogen derivatives			Surface hydrogen and derivatives storage solutions			Hydrogen storage in underground geological formations	
	Use of hydrogen and hydrogen-based fuels in the maritime sector			Conversion of imported hydrogen carriers into hydrogen				
	Use of hydrogen and hydrogen carriers in cold ironing			Multimodal land-based hydrogen refueling stations				
	Use of hydrogen and hydrogen carriers in port equipment			Transport of hydrogen and derivatives from ports to users				

Prioritization of challenges:



Prioritization non-technical challenges (policy, regulatory, governance, strategic) for the development of hydrogen and hydrogen carriers-related activities and infrastructure in port areas

<div>  Governance of hydrogen and hydrogen carrier-related activities and infrastructure in port areas <div></div> </div>		
In the port	In the vicinity of the port	In the wider setting of the port area
<div>  Import terminals of hydrogen and hydrogen carriers in EU ports <div></div> </div>	<div>  Renewable hydrogen production <div></div> </div>	<div>  Deep sea transport of hydrogen and hydrogen carriers via tankers <div></div> </div>
<div>  Bunkering of hydrogen and hydrogen derivatives <div></div> </div>	<div>  Surface hydrogen and derivatives storage solutions <div></div> </div>	<div>  Hydrogen storage in underground geological formations <div></div> </div>
<div>  Use of hydrogen and hydrogen-based fuels in the maritime sector <div></div> </div>	<div>  Conversion of imported hydrogen carriers into hydrogen <div></div> </div>	
<div>  Use of hydrogen and hydrogen carriers in cold ironing <div></div> </div>	<div>  Multimodal land-based hydrogen refueling stations <div></div> </div>	
<div>  Use of hydrogen and hydrogen carriers in port equipment <div></div> </div>	<div>  Transport of hydrogen and derivatives from ports to users <div></div> </div>	

Prioritization of challenges:



Key recommendations to port authorities and other port stakeholders

Step 1: Assess and formulate a strategy

- 1 **Assess** the **societal relevance** and the **techno-economic rationale**
- 2 **Acquire** a comprehensive understanding of the **power and interest of all stakeholders**
- 3 **Set up** a multi-stakeholder hydrogen **working group**
- 4 **Develop** a clear **roadmap** with key milestones, conditions and organizational structure

Step 2: Engage with stakeholders

- 5 **Engage** with the competent **regulatory authorities**
- 6 **Build partnerships** between the port authority, key other relevant port-related stakeholders and neighboring connecting ports.
(Assist national governments in establishing strong and resilient strategic partnerships with exporting countries)

Step 3: Invest and incentivize

- 8 **(Co-)invest** in specific flagship demonstration projects
- 9 **Incentivize** relevant port-related stakeholders to timely develop and/or operate hydrogen (carrier)-related activities and infrastructure.

Key recommendations to EU Member States (national governments)

Providing the enabling environment

- 1 **Specify the role of ports in the national H2 strategy** (including short-, medium- and long-term timelines, quantitative milestones, required infrastructure and investment needs).
- 2 **Work** towards the development of **integrated cross-border hydrogen valleys involving several maritime and inland ports**.
- 3 **Mitigate** the risk of delays in developing infrastructures due to a potential **lack of social and public acceptance**.
- 4 Mandate that all under construction or planned **LNG terminals and large-scale storage tanks** are **designed considering later conversion** to LH2 or hydrogen carriers (e.g., ammonia).

- 5 Define an appropriate **policy and regulatory framework** for the **design and operation** of hydrogen and hydrogen carriers infrastructures **in port areas**.
- 6 **Address** the growing **concern** over the **lack of availability of freshwater** supplies needed by electrolysis facilities.

Investing and incentivizing

- 1 **Maximize support for EU companies** in the design, construction and retrofitting of zero-emission ships, hydrogen and hydrogen carrier tankers and associated maritime equipment.
- 2 Allocate **public funding** to pioneers in the EU port areas that are **launching investments in R&I and also in market-ready projects** at all steps of the hydrogen value chain in a port environment.

Key recommendations to the institutions of the European Union

Providing the enabling environment

Encourage the **IMO to adapt existing** and **develop regulations** and **technical** and **safety standards** for

- the sea-based transportation of hydrogen;
- import terminals of hydrogen and LOHC;
- the bunkering of hydrogen and hydrogen-based fuels;
- the utilization of hydrogen and hydrogen-based fuels in deep-sea and short-sea applications.

Encourage the ISO to adapt existing and **develop new standards and protocols** (e.g., on LNG to liquified hydrogen and compressed/refrigerated ammonia; vehicle on-board hydrogen storage, tank characteristics, port equipment vehicles, etc.).

Work with the relevant regulatory and standardization authorities (e.g., CCNR and CESNI & CEN and CENELEC) to develop harmonized EU-wide regulations, clear guidelines to Member States on administrative practices and permitting procedures, as well as technical and safety standards.

Support the development of testing and certification protocols for various processes and activities involving hydrogen

Investing and incentivizing

Maximize support for EU companies in the design, construction and retrofitting of zero-emission ships, hydrogen and hydrogen carrier tankers and associated maritime equipment.

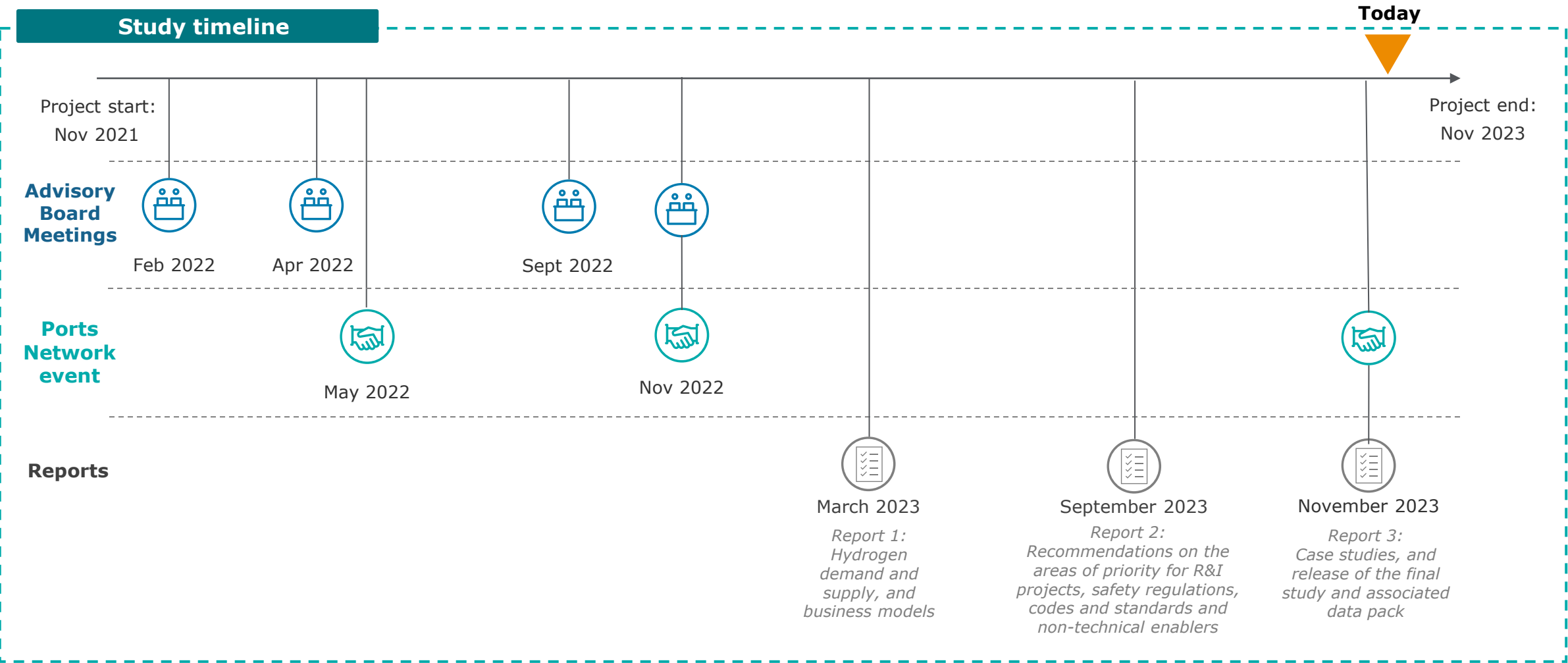
Complementary to national funding programs, **allocate public funding to R&I and market-ready projects** aiming at demonstrating or decreasing the cost of import, production, storage, conversion, refueling and end-use of hydrogen (carriers) in a port environment.

Support in **clarifying** whether (and if so, under what specific conditions) it is technically and economically **feasible to convert existing LNG** terminals into **LH2, ammonia** and **LOHC** terminals.

Next steps and Q&A

Framework for the study

Project timeline



Questions

Access our reports



Q&A

Registration link to last European
Hydrogen Ports Network event,
21 November 2023 in Brussels



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