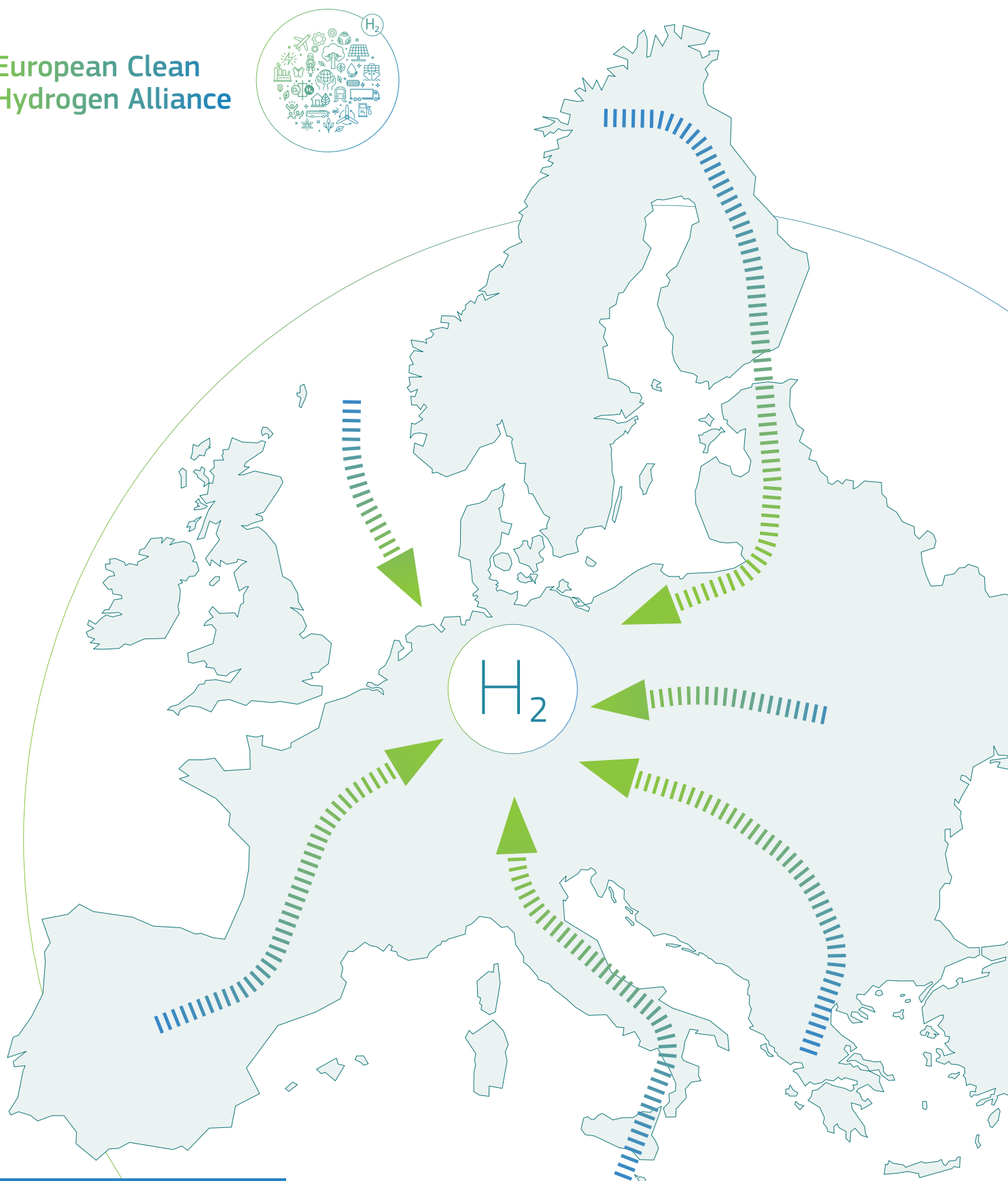


LEARNBOOK ON HYDROGEN SUPPLY CORRIDORS

Clean Hydrogen Alliance
Transmission and
Distribution Roundtable

European Clean
Hydrogen Alliance



March 2023

1 INTRODUCTION

The European Clean Hydrogen Alliance (ECH2A) Roundtable on Clean Hydrogen Transmission and Distribution brings together public and private companies, research institutes, civil society and policy makers/regional authorities working in the transport and distribution of hydrogen (renewable and/or low-carbon) from renewable and low-carbon hydrogen production sites to consumer/demand centers, especially those sectors with hard-to-abate emissions.

The scope of the Roundtable is on the following four Archetypes: 1. Transmission and distribution pipelines for local, regional, national, and international transport and storage facilities; 2. Marine storage and handling terminals in ports covering both existing as well as new terminals,

3. Shipping covering deep sea and short-distance maritime routes, 4. Inland distribution modes of transport including trucks, rail, barges, hubs and operational storage (such as bullets, tanks, containers, etc.).



Figure 1: Potential H₂ supply corridors, European Commission, RePowerEU Communication Action Plan, May 2022.

On 29 September 2022, the CEOs of the Roundtable gave the Sherpas the mandate to prepare a report on 'H₂ supply corridors', as outlined in European Commission's RePowerEU Action Plan. REPowerEU outlined the need to accelerate development of hydrogen infrastructure for producing, importing, and transporting 20 million tonnes of hydrogen by 2030. The European Commission outlined three potential H₂ import corridors via the Mediterranean, the North Sea area and, as soon as conditions allow, with Ukraine. Visually these corridors were split into seven different routes as seen in Figure 1.

The 'Learnbook on H₂ Supply Corridors' aims to build on this framework, providing industry expertise and knowledge on three key areas: i) identify the potential and specificities of each corridor; ii) provide visual representation of each corridor with a list of planned H₂ transmission, distribution, storage, terminal and production/demand projects; iii) identify region specific bottlenecks and provide recommendations to mitigate them.

The scope of the 'Learnbook' is based on the RePowerEU's schematic representation of the H₂ corridors and will include:

1. South Central H₂ corridor
2. Iberian H₂ corridor
3. North Sea H₂ corridor
4. Nordic Baltic H₂ corridor
5. Eastern H₂ corridor
6. South-eastern H₂ corridor

It was agreed that projects in the 'North-African H₂ corridor' would be allocated to either the South Central (named as Adriatic in the RePowerEU1) or Iberian corridors depending on their geographical scope. In addition, there would be a further grouping of projects focusing on Germany as a key arrival and convergence point for all corridors.

The projects included in the 'Learnbook' reflect the best available information submitted by project promoters by March 2023, and are in no way exhaustive, as some promoters may still work outside of the reach of the Alliance. The list of projects outlines the projects visualised in the Hydrogen Infrastructure Map, which includes projects from various collection exercises: TYNDP, PCI, DG GROW survey, and projects from partner associations (GIE, Eurogas, CE-DEC, GD4S, GEODE) and was lastly updated on 31 March 2023.

Through curation of data and input for the 'Learnbook' it became clear that although each corridor has its individual and unique characteristics, there are several cross-cutting themes which are common amongst all. Reflecting this, the final section of the document delineates these Union-wide bottlenecks and the corresponding Union-wide regulatory and policy measures that could help ease them.

Disclaimer:

"Joining the ECH2A, NGOs agree to engage and contribute to the deployment of renewable hydrogen in terms of supply, demand and distribution as we promote the rapid phase-out of the use and production of all fossil fuels in order to reach the objectives of the Paris Agreement. Thus we do not consider fossil fuel based hydrogen as a short- or long-term solution. We see our role in contributing to targeting the use of renewable hydrogen specifically to those sectors and industrial processes which are hard to decarbonise (steel, cement and basic chemicals, aviation, shipping and heavy good vehicles)."

1 The South Central H₂ Corridor refers to the Adriatic H₂ Corridor, as named in the REPowerEU Plan. This renaming better reflects the geographical area interested by this Corridor initiatives and avoids potential confusions with PCI definitions.

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2 SOUTH CENTRAL H₂ SUPPLY CORRIDOR (NAMED AS ADRIATIC IN THE REPOWEREU)

2.1 POTENTIAL OF THE H₂ CORRIDOR

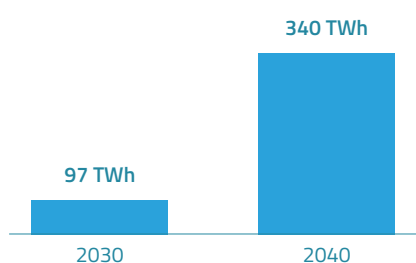
Major driver of development of the South Central Corridor is the need to meet hydrogen demand from industry, transport and power in Italy, Central Europe, and Germany with a large-scale production at lower cost in North-Africa. The countries along the route in Central and Eastern Europe – such as Austria, Slovenia, Croatia, and Switzerland will also benefit from competitive H₂ imports. Key opportunities include the high repurposing potential of gas pipelines from Italy to Central Europe via Austria, Slovakia and the Czech Republic, and pipeline interconnections with Algeria and Tunisia – the main anticipated suppliers for this corridor.

The South Central Corridor represents a fundamental energy bridge for Europe between Mediterranean shores, making available to the Union abundant, cost-competitive hydrogen resources from North Africa and exploiting for the most part existing infrastructure. Indeed, the North Africa-Europe link is a key component to progressive decarbonisation at the international level in support of the energy transition. Finally, the corridor would constitute a strategic link guaranteeing to Europe greater energy diversification and security while, at the same time, contributing to the stabilisation of a key Region, in the context of the European neighborhood policy.

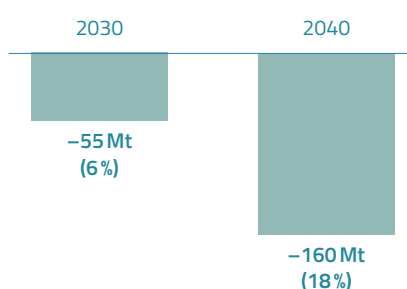


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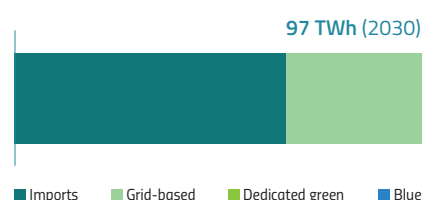
H₂ supply potential
(TWh/y)



Emissions reductions
(MtCO₂/y vs. 2019)



In 2030 hydrogen supply is ~100 TWh, of which more than 70% is imports. Hydrogen supply increases significantly 2040, reaching 340 TWh.



Source: Five hydrogen supply corridors for Europe in 2030, [European Hydrogen Backbone](#), May 2022

2.2. PROJECTS SNAPSHOT

HYDROGEN INFRASTRUCTURE MAP 2030



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- ◆ New
- ◆ New and conversion
- ◆ Conversion of existing infrastructure

Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2040



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- ◆ New
- ◆ New and conversion
- ◆ Conversion of existing infrastructure

Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2050



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports









- New
- New and conversion
- Conversion of existing infrastructure

Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

Project name	Category	Commissioning year	Capacity	Link
Italian H ₂ Backbone (part of Sunshyne corridor)	Transmission	2030	Import from N. Africa: 448 GWh/d Export to N. EU: 201 GWh/d	
Puglia Green Hydrogen Valley – Cerignola	Production	2026	80 MW	
Puglia Green Hydrogen Valley – Taranto	Production	2026	80 MW	
Puglia Green Hydrogen Valley – Brindisi	Production	2026	60 MW	
SLOH2 backbone	Transmission	2035	6 GWh/d	
SLOP2G(electrolyser)	Production	2028	10 MW	
Central European Hydrogen corridor project, CEHC SK part Baumgarten and Lanžhot (part of Sunshyne corridor)	Transmission	2030	144 GWh/d	
Central European Hydrogen corridor project, CEHC, CZ part (Lanžhot-Waidhaus) (part of Sunshyne corridor)	Transmission	2030	144 GWh/d	
OGE H2ercules Network South (part of Sunshyne corridor)	Transmission	2030	144 GWh/d	
H ₂ Readiness of the TAG Pipeline System (part of Sunshyne corridor)	Transmission	2030	168 GWh/day IT/AT 142 GWh/d to WAG and/or SK	
H ₂ Backbone WAG + Penta West	Transmission	2030	55 TWh	
H2EU+STORE	Transmission & Storage	2030	2030: 2.5 TWh 2040: 40 TWh 2050: 80 TWh	
Underground Sun Storage 2030	Storage	2023	Storage working volume: 4.5 GWh H ₂ (assuming one cycle per year) Injection capacity: 0.031 GWh H ₂ /d Withdrawal capacity: 0.048 GWh H ₂ /d	
Underground Sun Storage Scale-Up	Storage	2030	150 GWh H ₂ assuming one cycle per year – project running as of 2030	
HyPipe Bavaria – The Hydrogen Hub	Transmission	2027–2030	2030: 150 GW/d	
H ₂ Kollektor	Distribution	2026		
H ₂ Campus WN	Production	2023	3 MW	
LogHyn	Production	2026	4 000 t/y	

The table includes some of the hydrogen projects displayed on the Hydrogen Infrastructure Map, last updated on 30 March 2023.

2.3 SPECIFIC BOTTLENECKS

The peculiarity of the regions involved and the strong dependance on extra-EU countries for large-scale production at lower costs needs to be considered.

- In North Africa there is currently a lack of dedicated H₂ infrastructure assets and a clear development process for H₂ infrastructures while natural gas pipelines connecting North Africa to Europe through Italy are already in place and suitable for repurposing.

- Energy demand is strongly condensed in North Italy/ Austria/Germany while the potential for the most cost-effective production of hydrogen is in the south of Europe/ North Africa. Taking advantage of higher RES availability and producibility, as well as extended land availability, green hydrogen production in Southern regions is the most cost-efficient solution, also adding the transport costs from North Africa to Europe.

2.4 SPECIFIC RECOMMENDATIONS

- To address the issue with lack of infrastructure as mentioned above, in January 2023 Italy and Algeria signed a cooperation agreement to develop energy infrastructures, including H₂ pipes. The cooperation agreement involves various industrial players, including upstream and infrastructure operators in order to define a strategic collaboration to support the development of the hydrogen corridor.

- To tackle the need for interconnection between the North and South a coordinated development of the full corridor, including progressive enhancements of the H₂ Italian backbone and their interconnections with Austrian, Slovak, Czech and German grids, should be ensured.
- Intensify existing and establish new strategic energy/ H₂ partnerships between EU and promising exporting countries (for example by signing collaboration documents on strategic projects for large scale and cost-efficient hydrogen production). One example of cooperation that could be used as basis for the MoU with North Africa is the signed MoU EU-Ukraine "on a Strategic Partnership on Renewable Gases."

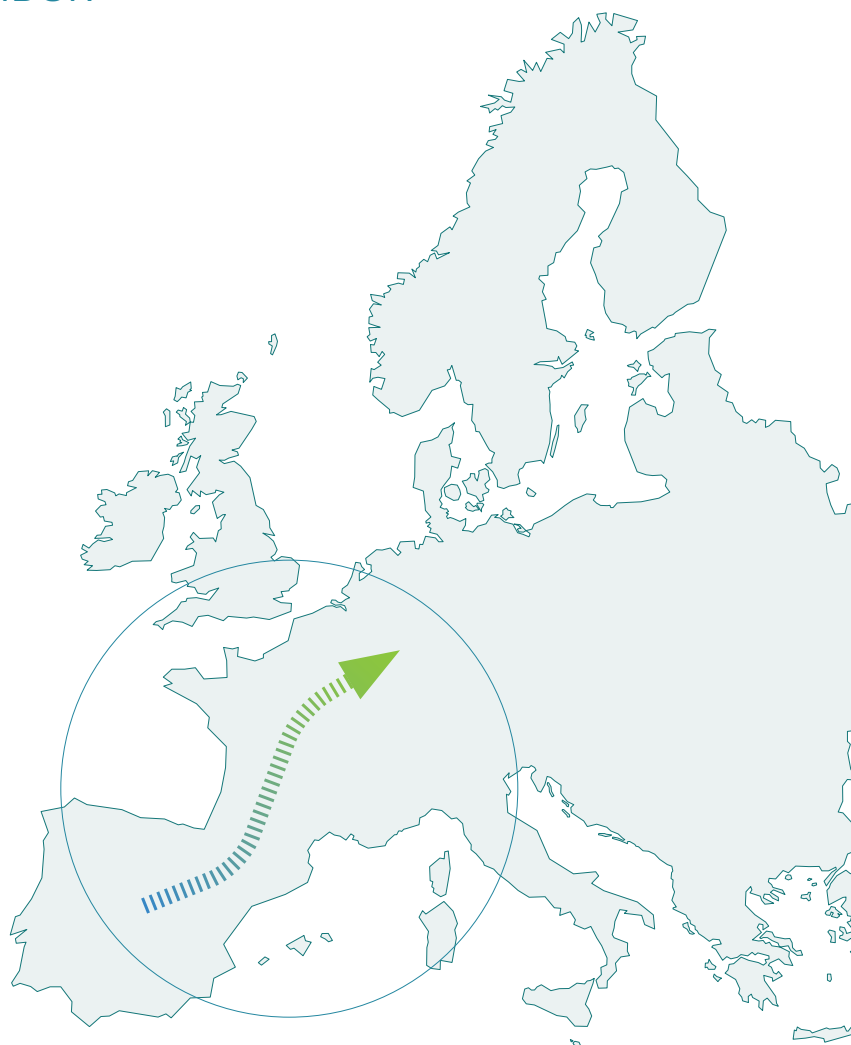


3 IBERIAN H₂ SUPPLY CORRIDOR

3.1 POTENTIAL OF THE H₂ CORRIDOR

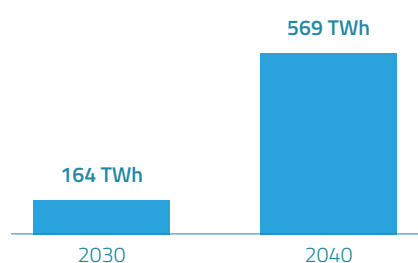
Major driver for the development is to connect high-production potential regions in the south (ES, PT, MO, DZ) with off-taker regions in North-Western Europe (DE, BE, NL, FR). New interconnections between Portugal and Spain, and between the Iberian Peninsula and France are key for the development of the corridor. As it would help provide reliable H₂ supply for off takers in the region and allow all three countries to benefit from the low-cost, high-volume Spanish and Portuguese hydrogen production and underground storage sites located in France and in the Iberian Peninsula. This corridor, which would stretch all the way to Germany, can play an important role in decarbonising regional industrial and transport ecosystems in Portugal, Spain, and France, and deliver hydrogen at low cost to demand centres in Germany and neighbouring countries.

This project corresponds to the announcement made on the 20 of October 2022 in Brussels by three leaders from France, Spain and Portugal to develop a maritime pipeline connecting Barcelona with Marseille as the most direct and efficient option to connect the Iberian Peninsula to Central Europe. In Alicante on 9 of December 2022, they confirmed the launching of this Green Energy corridor, newly called H2Med. In the longer term the corridor can also provide access to hydrogen imports from Morocco and Algeria.

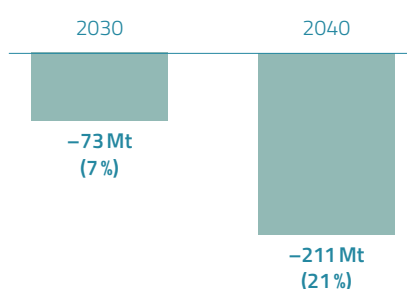


ACCORDING TO THE EHB 2022 REPORT ANALYSIS:

H₂ supply potential
(TWh/y)

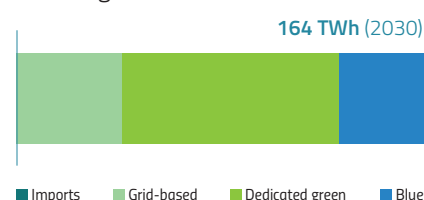


Emissions reductions
(MtCO₂/y vs. 2019)



In 2030 hydrogen supply is

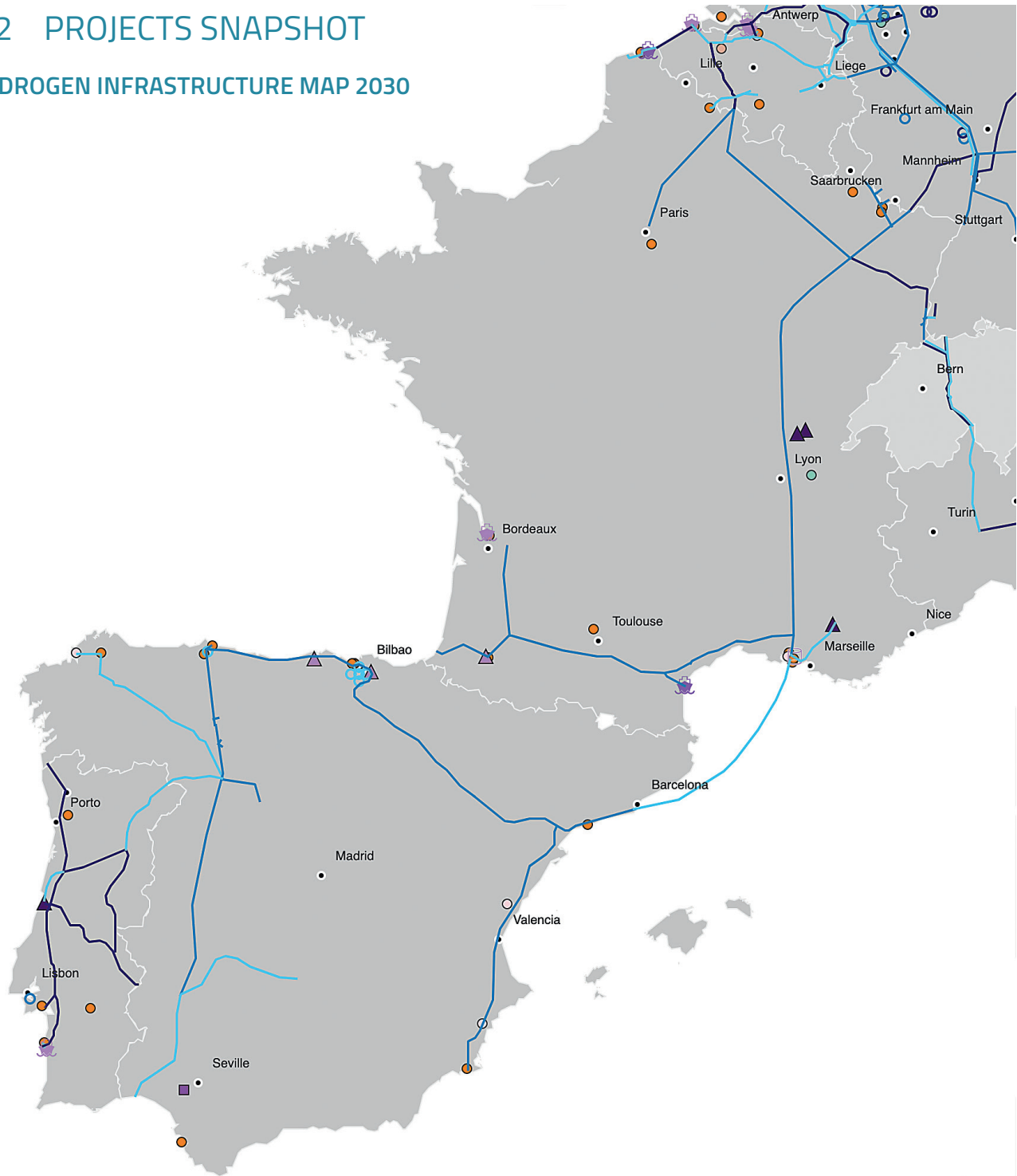
~160 TWh, of which 65% is from dedicated green hydrogen. Hydrogen supply increases significantly 2040, reaching 570 TWh.



Source: Five hydrogen supply corridors for Europe in 2030, [European Hydrogen Backbone](#), May 2022

3.2 PROJECTS SNAPSHOT

HYDROGEN INFRASTRUCTURE MAP 2030



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- ◆ New
- ◆ New and conversion
- ◆ Conversion of existing infrastructure

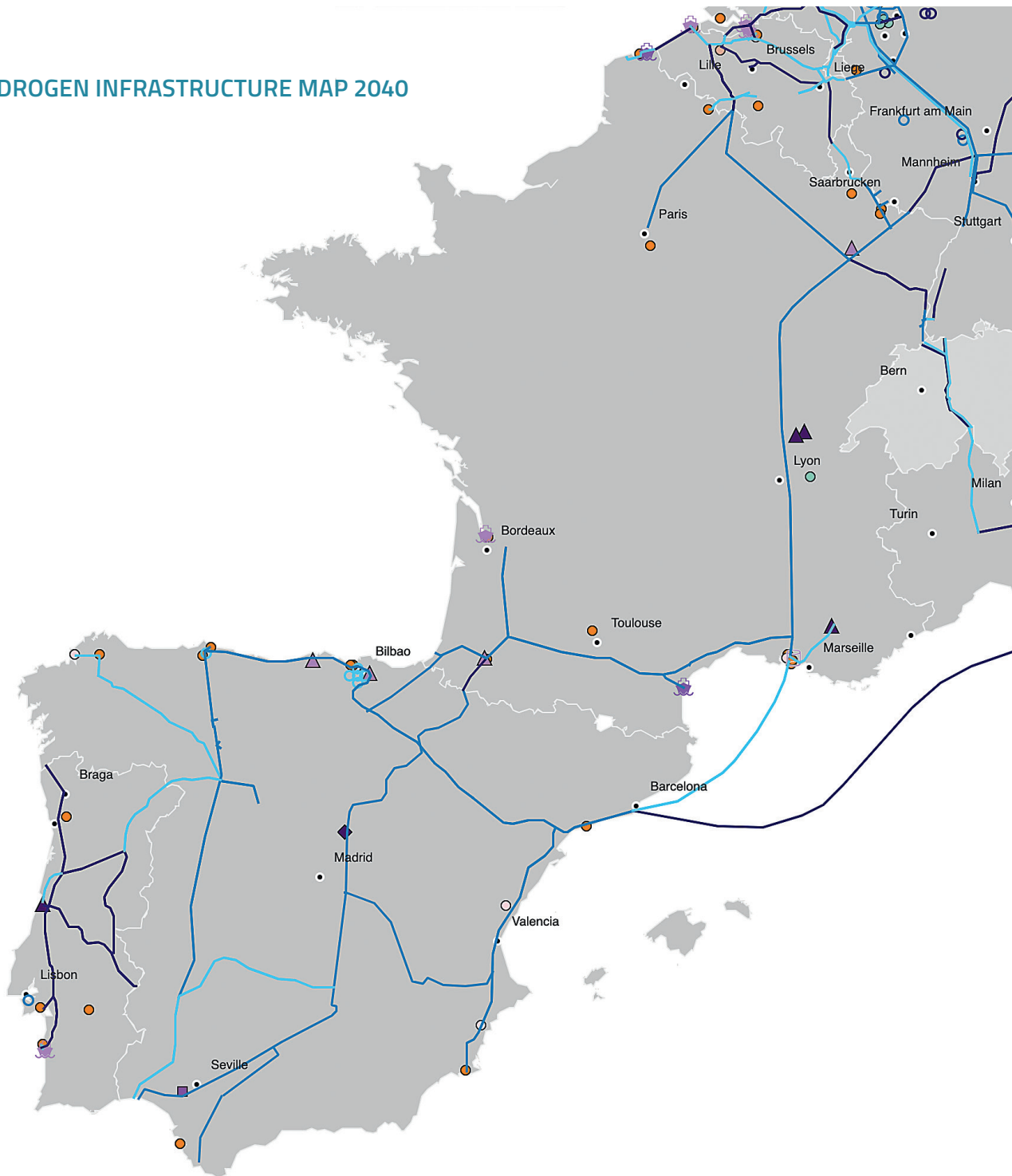
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2040



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
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- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- ◆ New
- ◆ New and conversion
- ◆ Conversion of existing infrastructure

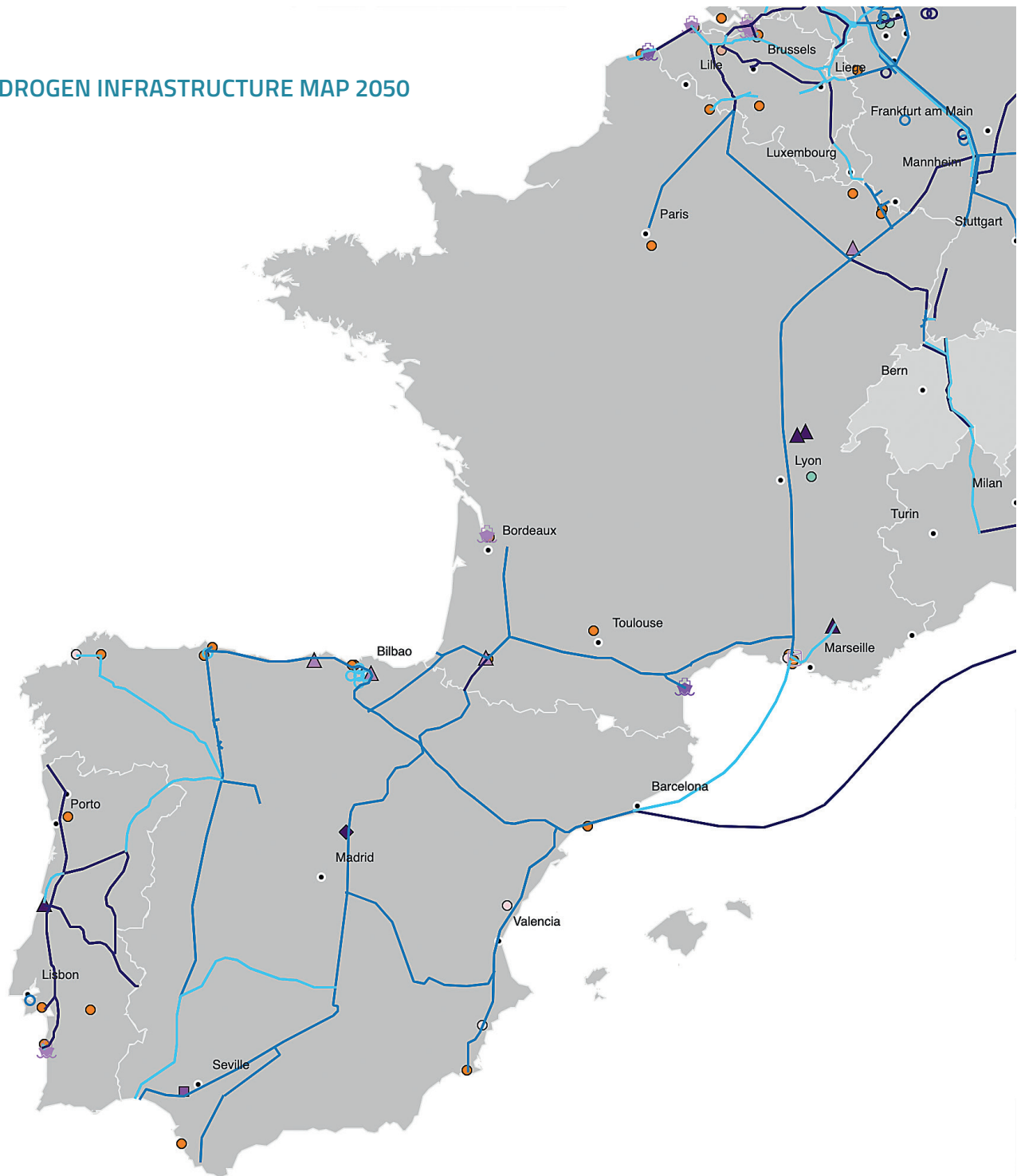
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2050



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
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- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports


- ◆ New
- ◆ New and conversion
- ◆ Conversion of existing infrastructure














Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

Project name	Category	Commissioning year	Capacity	Link
H2Med-CelZa	Transmission	2030	0.75 MTPA H ₂ (81 GWh/d HHV)	
H2Med-BarMar	Transmission	2030	2 MTPA H ₂ (216 GWh/d HHV)	
Spanish hydrogen backbone 2030 (6th list PCI candidate)	Transmission	2028–2030	1.3 Mt of national demand, 2 Mt of exports through BarMar, 0.75 Mt of imports through CelZa and 0.45 Mt of exports through carriers (maritime transmission)	
Spanish hydrogen backbone (including repurposing of existing gas connections with France and Morocco)	Transmission	~ 2040		
ES-IT Offshore Interconnector (new H ₂ -ready gas pipeline to be repurposed)	Transmission	2040	320 GWh/d HHV	
H ₂ storage North-1 (Spain)	Storage	2030	Working Gas Volume by 2030: 335 GWh (Full WGV to reach 1,110 GWh before 2040 at a later stage of development)	
H ₂ storage North-2 (Spain)	Storage	2030	Working Gas Volume by 2030: 240 GWh (Full WGV to reach 812 GWh before 2040 at a later stage of development)	
Yela	Storage	2040	Working Gas Volume: 1,700 GWh	
HySoW (Hydrogen Southwest corridor of France)	Transmission & Storage	2030	44 GWh/d HHV (transport part to connect the storage) Storage saline capacities: 500 GWh (WGV HHV)	
H2Med-CelZa (Celorico da Beira - Vale de Frades pipeline)	Transmission	2030	81 GWh/d HHV	
Portuguese hydrogen backbone first stage (Includes: new Figueira da Foz Cantanhede pipeline, and repurposed pipelines Cantanhede Mangualde, Mangualde Celorico da Beira, and Monforte Celorico da Beira)	Transmission	2030	Portuguese hydrogen back- bone will accommodate the H ₂ production and consumption in Portugal and allow for an export of up to 0.75 Mt via CelZa to Spain.	
Portuguese hydrogen backbone 2040	Transmission	2040	Portuguese hydrogen back- bone will accommodate the H ₂ production and consumption in Portugal and allow for an export of up to 0.75 Mt via CelZa to Spain	
MosaHYc	Transmission	2027	5,5 GWh/d	
RHYn	Transmission	2028	20 GWh/d	

Project name	Category	Commissioning year	Capacity	Link
WHHYN	Transmission	2026	24 GWh/d	
DHUNE	Transmission	2027	24 GWh/d	
French-Belgian corridor	Transmission			
HYnframed	Transmission	2028	25 GWh/d	
Hy-Fen	Transmission	2030	200 GWh/d	
French Hydrogen Backbone 2040	Transmission	2040	NA	
HyWest Larrau and Biriadou	Transmission	2035–2040	Biriadou: 85 GWh/d (HHV) Larrau: 47 GWh/d (HHV)	
H2ercules Network South	Transmission	2030	192 GWh/d	
Hypster (First phase)	Storage	2023	Storage Working volume: 0.12 GWh	
Hypster (Second phase)	Storage	2026	Storage Working volume: 1.7 GWh	
GeoH2	Storage	2030	Storage Working volume: 250 GWh	
Tarragona Hydrogen Network (T-HYNET) (Electrolyser)	Production	2025	150 MW	
Valle andaluz del hidrogeno verde (Electrolyser)	Production	2027	2 GW	
Hyperion H ₂ Alter (Electrolyser)	Production	2025	9.22 MW	
H2Sines.Rdam	Terminal & Port	2026		
H2Sines.RDAM electrolyser	Production	2028	400 MW	
BH2C (Phase I, II, III, IV)	Distribution	2023–2026		
Asturias H ₂ Valley	Distribution	2025		

The table includes some of the hydrogen projects displayed on the Hydrogen Infrastructure Map, last updated on 30 March 2023.

3.3. SPECIFIC BOTTLENECKS

- There is no adequate and timely development of storage assets at this stage in the Iberian corridor, which provides a problem for efficient use and development of transport infrastructure. There are regulatory, administrative and financial issues which are not sufficiently addressed at present.
- There is currently lack of dedicated H₂ assets and development process for hydrogen in North Africa. At this stage no substantial flows from North Africa are assumed in 2030 via the Iberian corridor.

3.4. SPECIFIC RECOMMENDATIONS

The storage and transport infrastructure should be developed consistently in a timely manner along the corridor:

- Timely development of the storage projects across the corridor is important to provide the needed market integration and security of supply. This is of particular interest for the Iberian corridor, supplying demand to Germany with wind and solar renewable based hydrogen produced in Spain.
- Need to get as soon as possible clarity on availability of funds to finance first the studies and then the works to comply with the 2030 commissioning objectives. Waiting for the CEF fund related to the PCI status would threaten the availability of the corridor in due time. CBA and CBCA conducted needs to capture all the costs and benefits for all projects and countries included in the Iberian corridor.
- To tackle the need for interconnection between the North and South a coordinated development along the entire corridor, including progressive enhancements of the H₂ Spanish and Portuguese backbone and their interconnections with French and German backbones, should be ensured.

Support for development of import from North Africa:

- Energy demand is strongly condensed in Germany while the potential for the most cost-effective production of hydrogen is in the south of Europe/North Africa. Taking advantage of higher RES availability and producibility, as well as extended land availability, green hydrogen production in Southern regions is the most cost-efficient solution.
- Energy partnerships with third countries like Morocco and Algeria have to be intensified to ensure H₂ imports from these regions with promising renewable potentials. Current initiatives like the one between Germany, the country towards which the corridor is transporting hydrogen, and Morocco and Algeria should be intensified and extended. These partnerships should involve governments and industrial players for good coordination across the corridor. The questions around guarantee of origin certification should also be part of these partnerships. There is a need for reinforced coordination between EU, EU member states and North African countries.

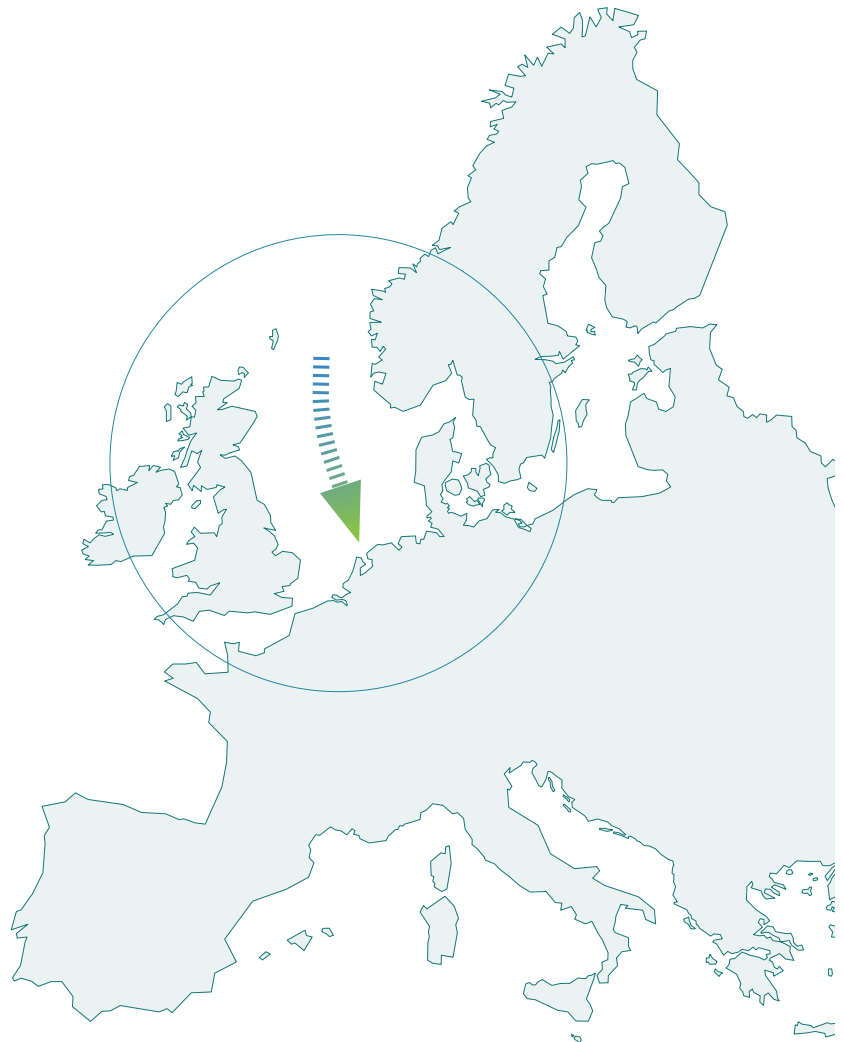


4 NORTH SEA H₂ SUPPLY CORRIDOR

4.1 POTENTIAL OF THE H₂ CORRIDOR

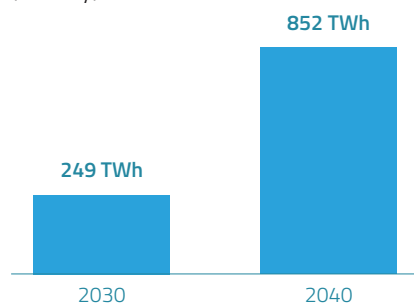
The corridor will combine several types of infrastructure assets to establish itself as a hub for (i) liquid imports of hydrogen and derivatives, (ii) pipeline imports and wider transmission, (iii) storage, (iv) production, and (v) end-use. To build up this full ecosystem the corridor leverages existing infrastructure of the seaports in Antwerp, Rotterdam, Zeebrugge, Amsterdam, Gent, Terneuzen, Vlissingen, which will form the start of an energy import and transport corridor. As well as leverage on the extensive offshore renewable capacity in the North Sea with import capacity and connection to the national and regional H₂ backbones in the Netherlands and Belgium to the hinterland in Germany.

Hydrogen derivatives as such are well-known products in this region as they are already widely used in the chemical clusters close to ports as well as in the German hinterland. Hence, there is existing infrastructure to import and use hydrogen/hydrogen derivatives as well as other assets such as know-how and expertise on safety of handling these molecules. Based on EHB Initiative analysis, the corridor covers 12,000 km of large-scale hydrogen pipelines in 2030, of which 70% would be repurposed.

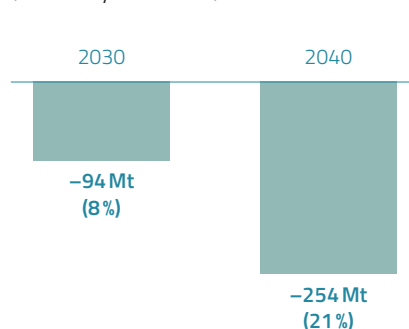


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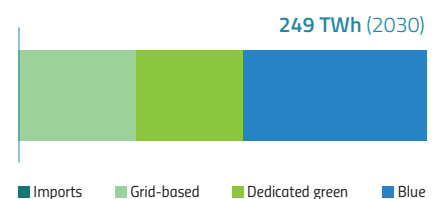
H₂ supply potential
(TWh/y)



Emissions reductions
(MtCO₂/y vs. 2019)



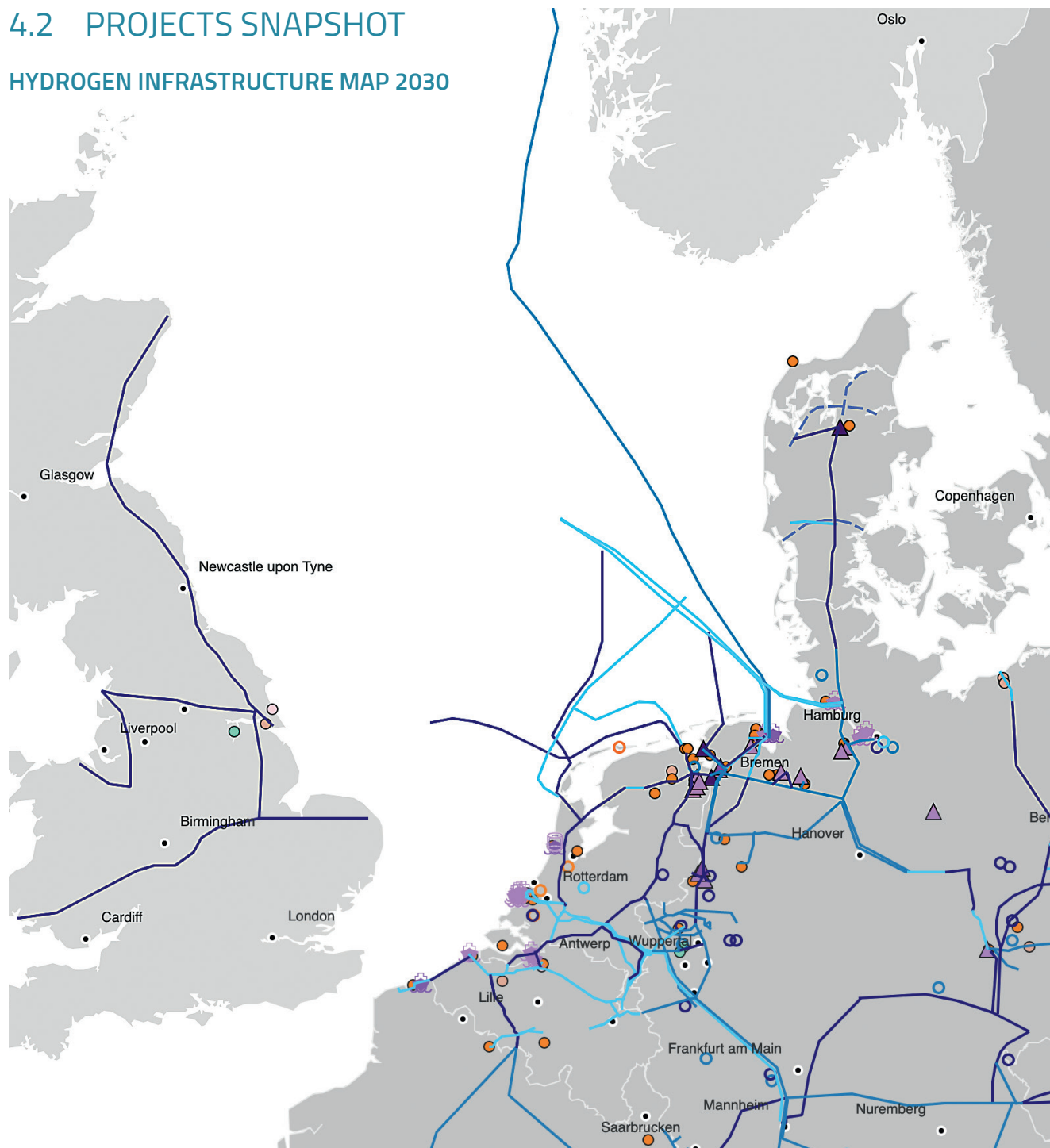
In 2030 hydrogen supply is ~250 TWh, of which over 40% is blue hydrogen. Hydrogen supply increases significantly 2040, reaching 570 TWh.



Source: Five hydrogen supply corridors for Europe in 2030, [European Hydrogen Backbone](#), May 2022

4.2 PROJECTS SNAPSHOT

HYDROGEN INFRASTRUCTURE MAP 2030



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- ▢ New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

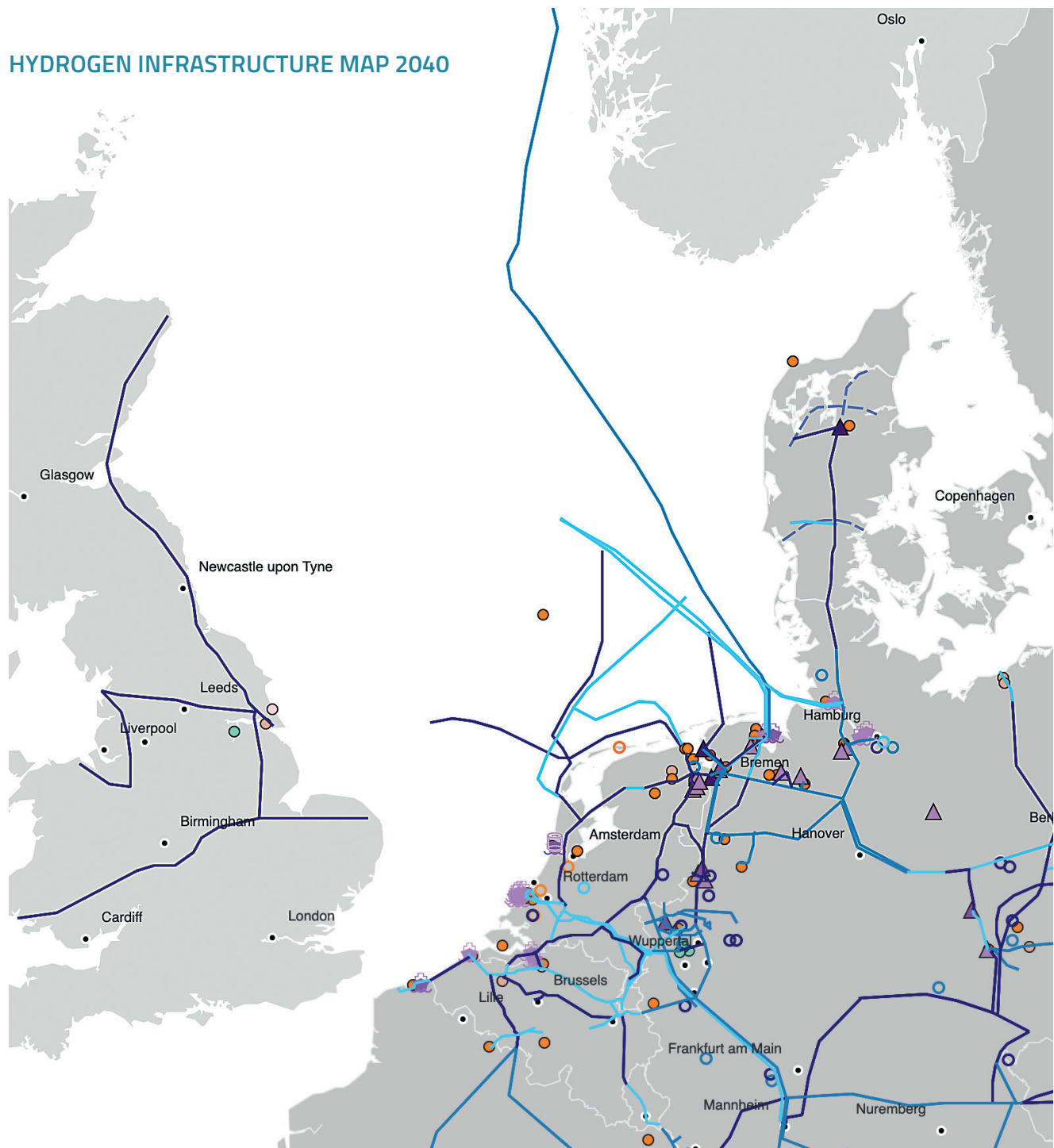
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2040



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

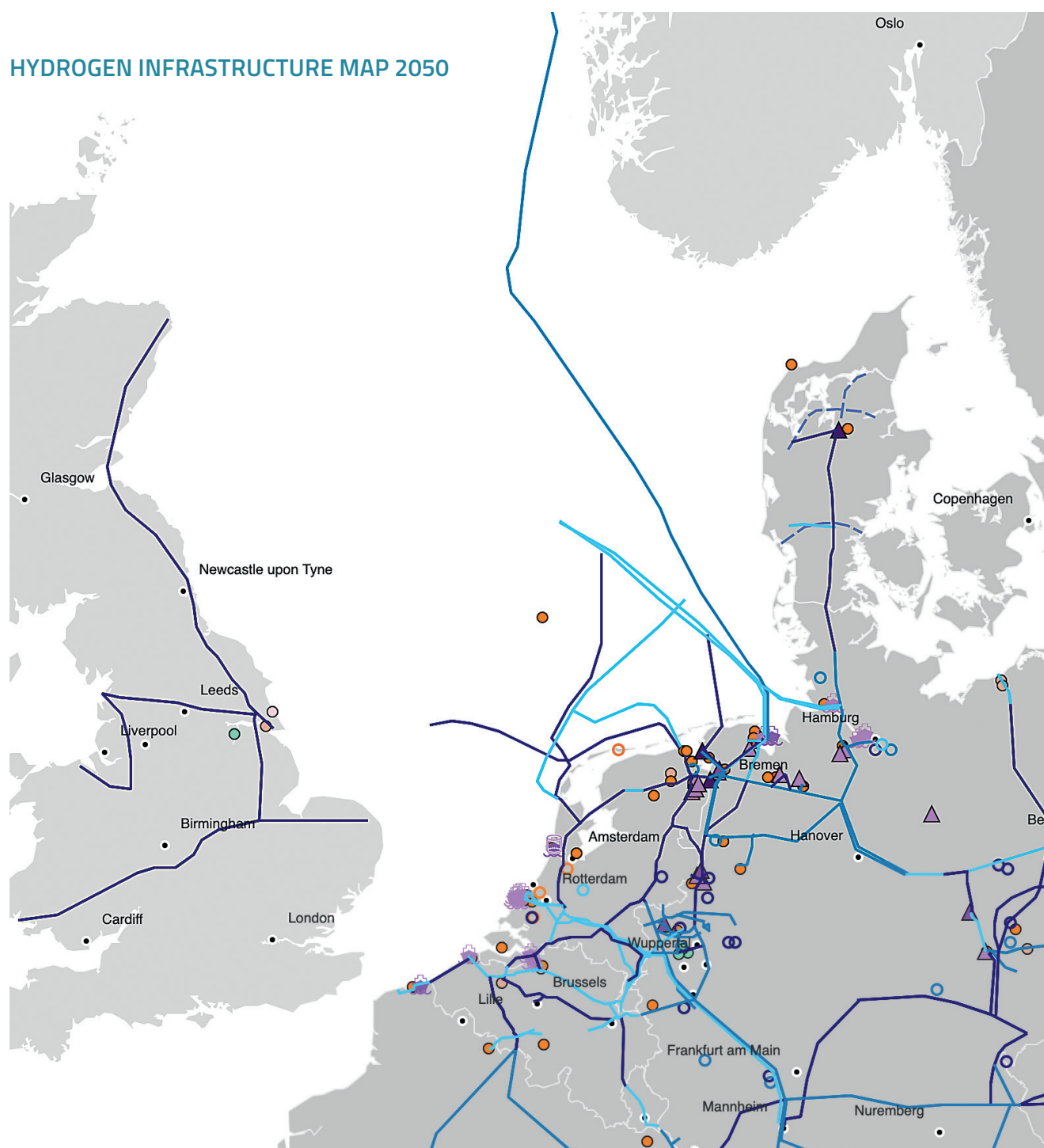
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2050



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports







- ◆ New
- ◆ New and conversion
- ◆ Conversion of existing infrastructure

Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

Project name	Category	Commissioning year	Capacity	Link
DK Hydrogen Pipeline, West DK Hydrogen System	Transmission	2028	60 GWh/d	
DK Hydrogen Storage	Storage	2030	Working Gas Volume: 3,500 t H ₂ (116 GWh), Injection: 3.16 GWh/d Withdrawal: 9.5 GWh/d	
Delta H ₂ Corridor	Transmission	2027	131,5 GWh/d	
National H ₂ Backbone by Gasunie (NL)	Transmission	2027	Capacity: 10–15 GW by 2030 Interconnection capacities: NL-BE 2026 1,5 GW NL-BE 2030 2 GW NL-BE 2040 3 GW NL-DE 2026 0,5 GW NL-DE 2030 10,2 GW NL-DE 2040 15,8 GW	
Belgian Hydrogen Backbone (BE)	Transmission	2026 2027 2030 2040	BE-NL: +36 GWh/d BE-FR: +24 GWh/d Import: +16.2 GWh/d BE-NL: +12 GWh/d BE-FR: +84 GWh/d BE-DE: +91 GWh/d Import: +48 GWh/d BE-NL: +12 GWh/d	
Zeebrugge New Molecules development (import)	Terminal & port	2030	- 3 NH ₃ tanks of 100,000 m ³ each - Connection to H ₂ grid of Fluxys - 3×3000 t/d cracking of NH ₃ to H ₂ (1250 t H ₂ /d) equal to 450,000 t/y - 17.7 TWh/y HHV - 48 GWh/d = 2 GWh/h	
Dunkerque New Molecules development (import)	Terminal & port	2030	- 3 NH ₃ tanks of 100,000 m ³ each - Connection to H ₂ grid of GRTgaz - 3×3000 t/d cracking of NH ₃ to H ₂ (1250 t H ₂ /d) equal to 450,000 t/y - 17.7 TWh/y HHV - 48 GWh/d = 2 GWh/h	
Antwerp NH ₃ Import Terminal (Antwerp)	Terminal & port	2027	- 2 NH ₃ tanks of 100,000 m ³ each - Connection to H ₂ grid of Fluxys - Cracking of NH ₃ to H ₂ : 3000 t/d - 3000 t/d NH ₃ is equal to 411 t/H ₂ / day - 150,000 t/H ₂ per year - 5.9 TWh/y HHV - 16.2 GWh/d = 0.67 GWh/h HHV	
H2BE (large-scale low-carbon H ₂ production in North Sea port (Ghent)	Production	2028	1 GW	
HyStock hydrogen storage	Storage	2027	Working gas volume: 833 GWh Injection capacity: 75.5 GWh/d Withdrawal capacity: 75.5 GWh/d	
SeaH2land (electrolyser in North Sea Port Vlissingen)	Production	2030	1 GW	

Project name	Category	Commissioning year	Capacity	Link
Project Helios	Terminal & port	2026		
Amplifhy Rotterdam	Terminal & port	2026	Daily Send-out capacity: 45 GWh	
Amplifhy Antwerp	Terminal & port	2026	Daily Send-out capacity: 45 GWh	
CHYMIA (Cluster HYdrogen for Mobility and Industry in Antwerp)	Production	2025	100 MW	
NorthH2	Production	2030	4 GW	
Djewels (electrolyser)	Production	2025	20 MW	
ACE terminal in Rotterdam	Terminal & port	2026	6,240 GWh/y	
AquaDuctus	Transmission	2029	Transport capacity of up to 10 GW of green hydrogen production	
HyOffwind (Zeebrugge)	Production	2024	25 MW	
Power to Methanol	Production	2023	8,000 t/methanol	
H2ermes (electrolyser)	Production	2025	100 MW	
H2era	Production	2026	500 MW	
HyNetherlands	Production	2025	100 MW	
H2morrow	Production	2028	1 GW	
HH1 Loading Facility	Production	2025	200 MW	
H2-Fifty (electrolysers)	Production	2025	250 MW	
Green Hydrogen Hub Zuidwending	Storage	2026	Storage working volume: 400 GWh Injection capacity: 4.5936 GWh/d Withdrawal capacity: 9.216 GWh/d	
Green Hydrogen Hub Drenthe	Storage	2028	Storage working volume: 400 GWh Injection capacity: 4.5936 GWh/d Withdrawal capacity: 9.216 GWh/d	
H2ercules Network North	Transmission	2028	IP Oude: 52.8 GWh/d IP Dornum / Wilhelmshaven: 642 GWh/d	
H2ercules Network West	Transmission	2030	IP Eynatten: 91.2 GWh/d	
H2ercules Network North-West	Transmission	2030	IP Elten: 76.8 GWh/d	
Stad Aardgasvrij - Hydrogen City	Distribution	2025		
WaterstofWijk Wagenborgen	Distribution	2023		

The table includes some of the hydrogen projects displayed on the Hydrogen Infrastructure Map, last updated on 30 March 2023.

4.3 SPECIFIC BOTTLENECKS

- Missing open-access hydrogen backbone connected to industrial regions in German hinterland (e.g. parts of Bavaria and Baden-Wuerttemberg).
- Lack of adequate regulatory, as well as R&I framework as to transportation of hydrogen and hydrogen carriers from landing point to place of consumption.
- The local renewable electricity-to-hydrogen production capacity will not be able to meet high demands in this highly industrialised region and the hinterland it is serving, this imbalance will need to be addressed by imports from third countries.

4.4 SPECIFIC RECOMMENDATIONS

- Capitalise on existing infrastructure to import and use hydrogen and hydrogen derivatives, as well as on the existing expertise as a solid basis to build upon.
 - Support large scale imports by the creation of a well-functioning international market for hydrogen/hydrogen carriers by a.o. guarantee of origin/certification system, operational support mechanisms, rapid permitting procedures for the development of infrastructures, international partnerships, etc.
 - Address regulatory challenges linked to transportation of hydrogen and hydrogen carriers from the landing ports to the hinterland destinations by different transport modes, such as by barges, rail, seagoing vessels.
- E.g. to see the uptake of the construction of hydrogen and hydrogen carrier seaborne tankers, certain regulatory challenges linked to safety issues and lack of international standards, as well as lack of sufficient and coordinated investments, need to be addressed;
- e.g. to facilitate transport by barges and rail there is a need for clear and harmonised safety regulations and permitting procedures for LH₂ and CH₄ transportation in inland shipping and rail.



5 NORDIC BALTIC H₂ SUPPLY CORRIDOR

5.1 POTENTIAL OF THE H₂ CORRIDOR

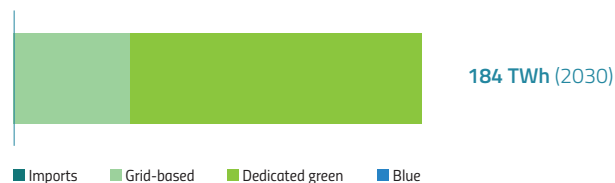
Major driver for the development of the Nordic Baltic H₂ supply corridor is the major potential onshore and offshore wind potential in the Nordics, and the Baltic Sea, along with grid-based green hydrogen, leveraging the vast, low-cost hydropower potential of the Nordics. The Baltic Sea is a large area with dense population and a relatively small amount of consumption. Hydrogen will be supplied to steel, ammonia, paper and pulp industry located in the North (need of 100 TWh of H₂) as well as to the continent. Pipeline and terminal routes with first green exports from the region to continental Europe planned in 2028.

The Nordic route will build on new hydrogen infrastructure based on development of 1,000 km of dedicated green H₂ pipeline in the Bothnian Bay operational by 2028. There is also a plan for 3,000 km long pipeline based on a joint project to connect six states – Finland, Estonia, Latvia, Lithuania, Poland and Germany. This corridor offers also connection to Central and Eastern Europe and South Germany via pipelines in the project “FLOW – Making Hydrogen Happen” and the “Czech-German Hydrogen Interconnector”.



ACCORDING TO THE EHB 2022 REPORT ANALYSIS:

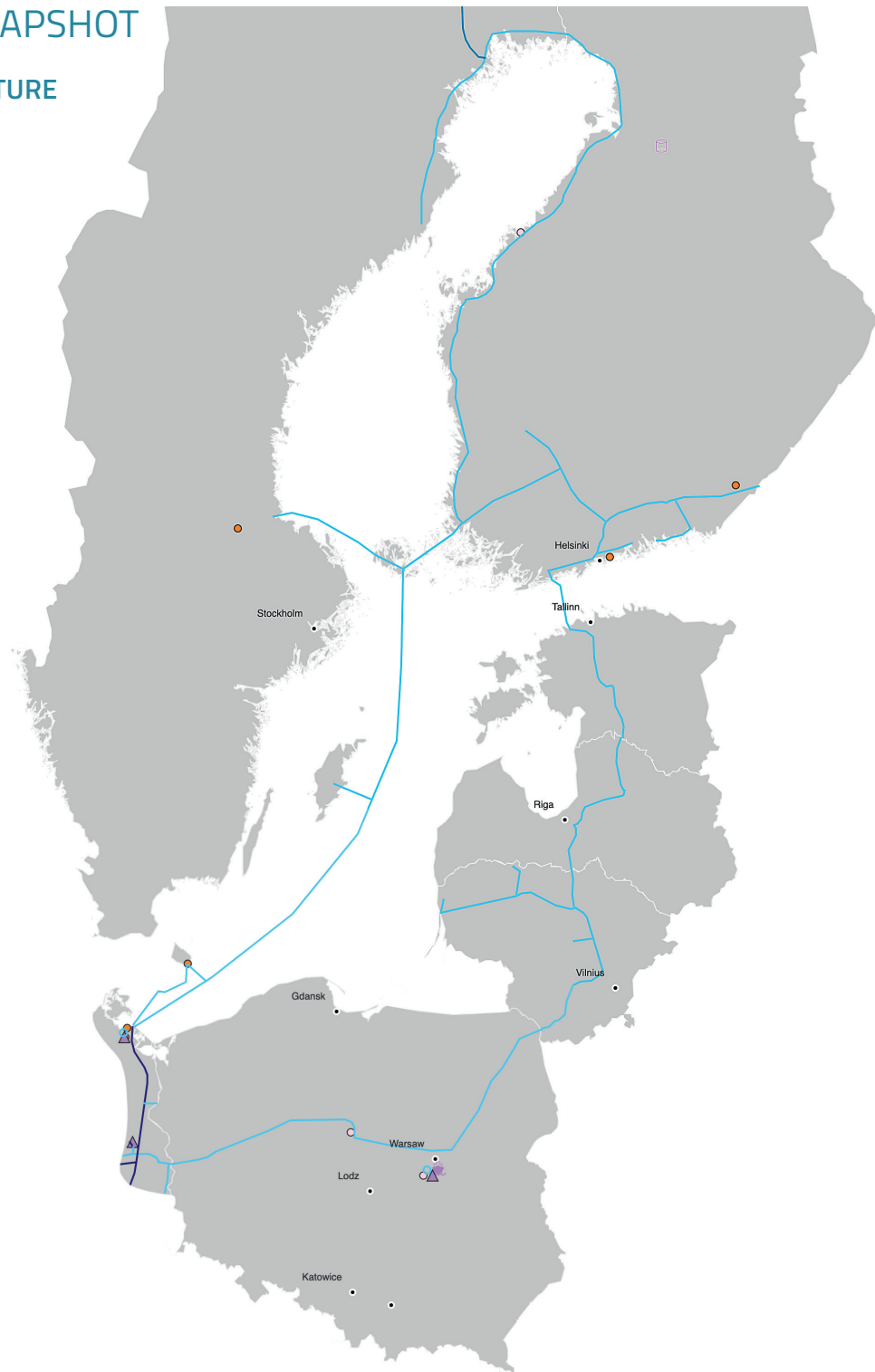
In 2030 hydrogen supply is ~185 TWh, of which nearly 70% is green hydrogen. Hydrogen supply increases significantly 2040, reaching 500 TWh.



Source: Five hydrogen supply corridors for Europe in 2030, [European Hydrogen Backbone](#), May 2022

5.2 PROJECTS SNAPSHOT

HYDROGEN INFRASTRUCTURE MAP 2030



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

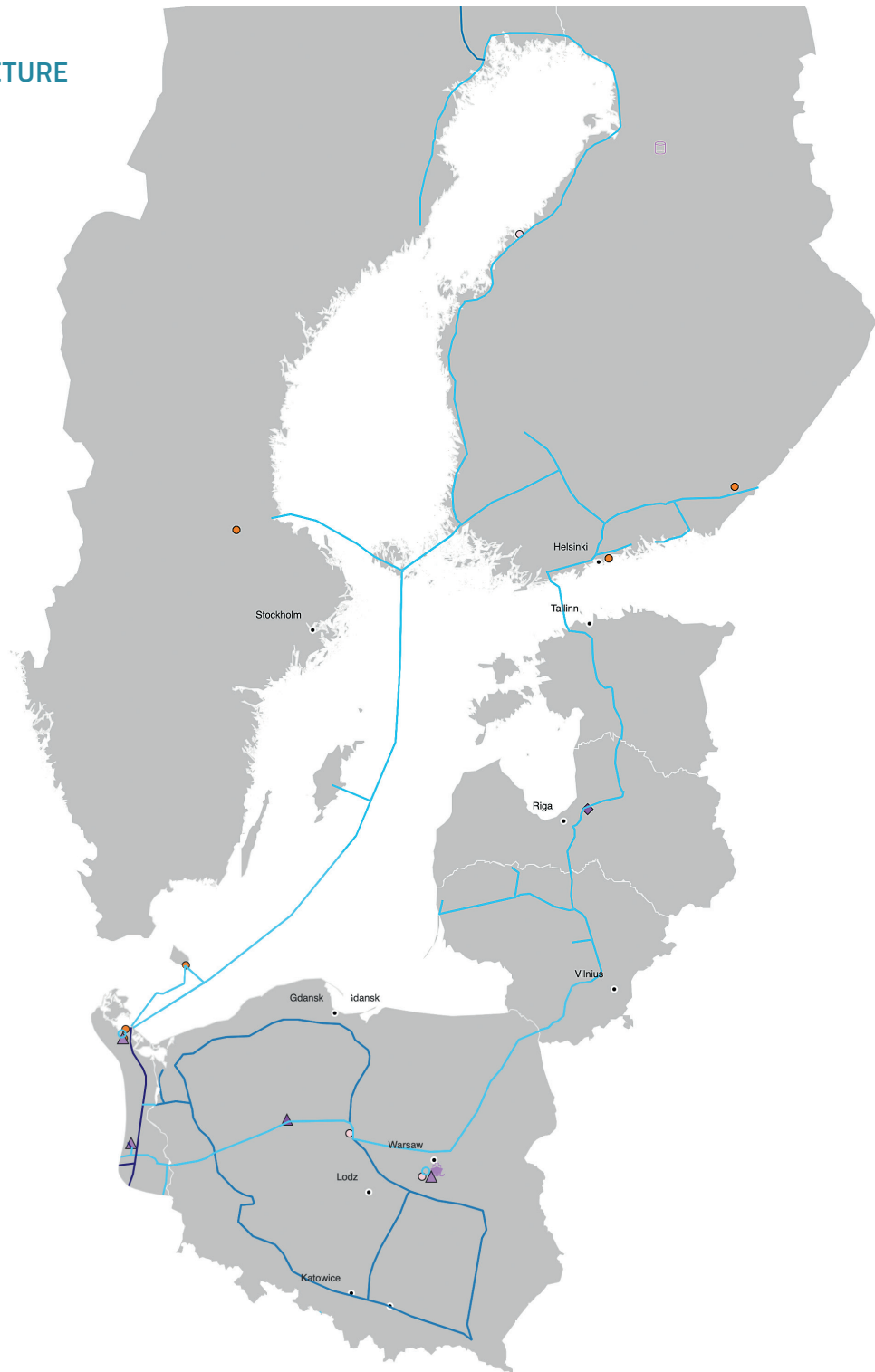
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2040



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

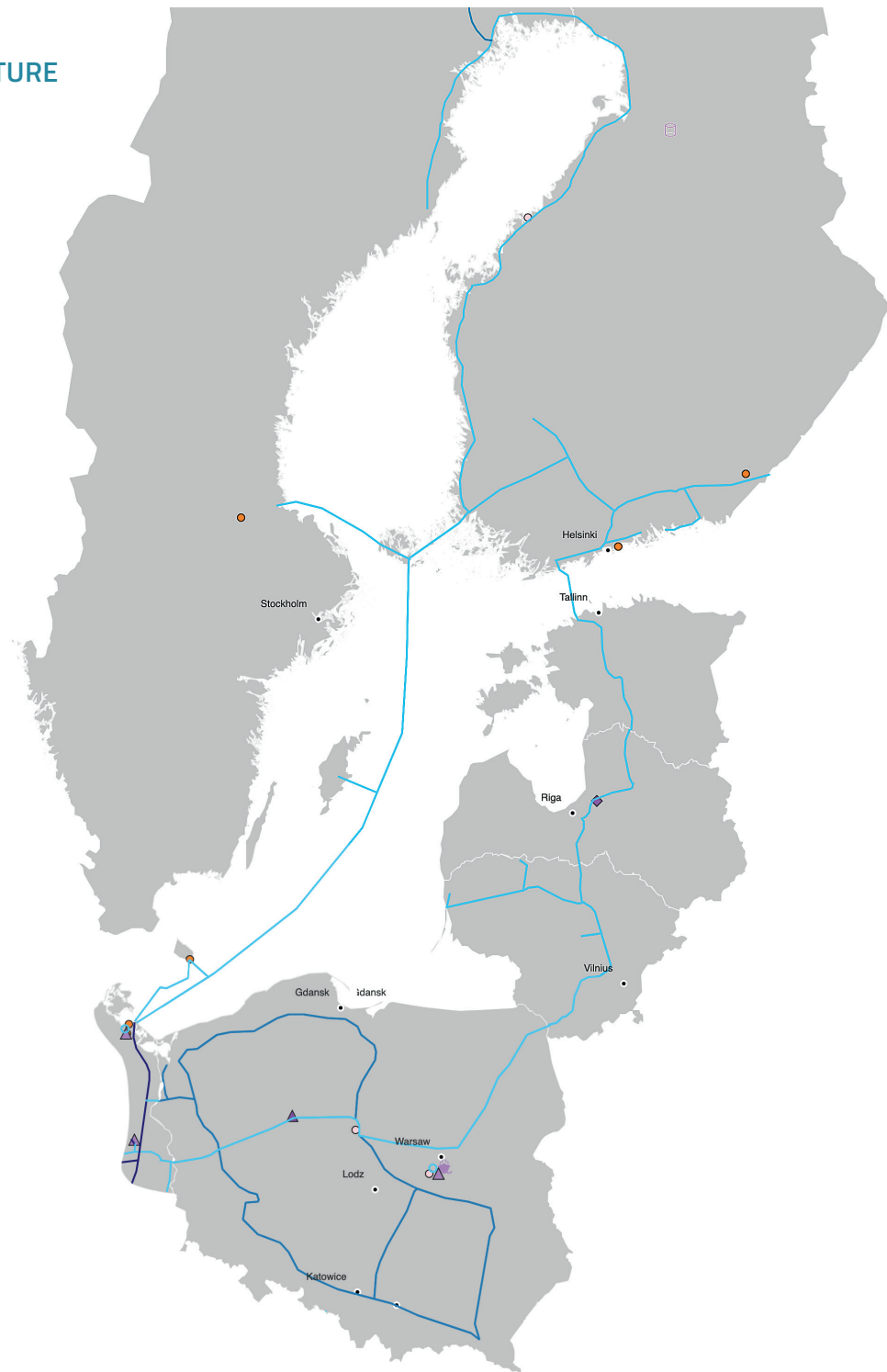
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2050



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- ◆ New
- ◆ New and conversion
- ◆ Conversion of existing infrastructure

Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

Project name	Category	Commissioning year	Capacity	Link
Nordic Hydrogen Route – Bothnian Bay – Swedish part	Transmission	2029	406 GWh/d	
Nordic-Baltic Hydrogen Corridor – FI section	Transmission	2029	200 GWh/d	
3H2 – Helsinki Hydrogen Hub	Production	2024	2 MW	
UPM Lappeenranta Biorefinery Green H ₂	Production	2025	20 MW	
Hycamite Customer Sample Facility	Production	2023	7.85 MW	
Hydrogen step 1 in Hofors	Production	2023	20 MW	
IPCEI Northern Green Crane	Terminal & port	2026	Expected yearly volume: 292 GW/y	
Nordic-Baltic Hydrogen Corridor – EE section	Transmission	2029	200 GWh/d	
Nordic-Baltic Hydrogen Corridor – LT section	Transmission	2029	200 GWh/d	
Nordic Baltic Hydrogen Corridor – LV section	Transmission	2029	200 GWh/d	
Hydrogen seasonal storage in Latvia	Storage	2040		
Nordic-Baltic Hydrogen Corridor – PL section	Transmission	2029	200 GWh/d	
Polish Hydrogen Backbone Infrastructure	Transmission	2039		
Damastawek Hydrogen Storage project	Storage	2035	Storage working volume: up to 4.3 TWh	
Green Falcon	Production	2021	515 MW	
H ₂ Interconnector Bornholm–Lubmin	Transmission	2027	2027: 36 GWh/d 2030: 91.2 GWh/d 2035: 240 GWh/d	
Flow– Making Hydrogen happen (VIP Brandov) (part of Hydrogen Interconnector)	Transmission	2030–2035	240 GWh/d	
Czech German Hydrogen Interconnector, Czech Part Brandov – Waidhaus (part of Czech–German Hydrogen Interconnector)	Transmission	2030	144 GWh/d	
OGE H2ercules Network South (part of Czech–German Hydrogen Interconnector)	Transmission	2030	IP Waidhaus: 144 GWh/d	

The included data on capacities is subject to change based on future feasibility study results.

The table includes some of the hydrogen projects displayed on the Hydrogen Infrastructure Map, last updated on 30 March 2023.

5.3 SPECIFIC BOTTLENECKS

- Need for tailored engagement to drive public acceptance, especially with local indigenous communities in the North area.
- Limited parallel lines between the clusters/valleys and regionally defined production sites.
- Limited understanding of the relevant timescale for cross-border planning for the switch from gas to hydrogen. Need to define exact number of interconnections and infrastructure to be dedicated for H₂.

5.4 SPECIFIC RECOMMENDATIONS

- Understand the maturity of the hydrogen valleys and production plans in the region.
- Prepare a joint regional approach plan with specific recommendation for the dedicated Members States and European Commission towards fulfilling REpowerEU.
- Preparation of the special plan for the connecting especially northern part of the region production side towards further connection with Baltic states towards west of Europe.
- Plan for the potential re-routing towards Ukraine to utilise the huge potential of the green H₂ production from the East.



6 EASTERN H₂ SUPPLY CORRIDOR

6.1 POTENTIAL OF THE H₂ CORRIDOR

Major driver for the development of the Eastern corridor is to utilise the potential of renewable hydrogen production in Ukraine. Ukraine is a very promising future major supplier of renewable hydrogen with excellent conditions for large-scale, green hydrogen production development. The estimated technical potential is ~500–800 GW of renewable energy capacity, while the supply potential ranges between ~1,000–1,500 TWh.

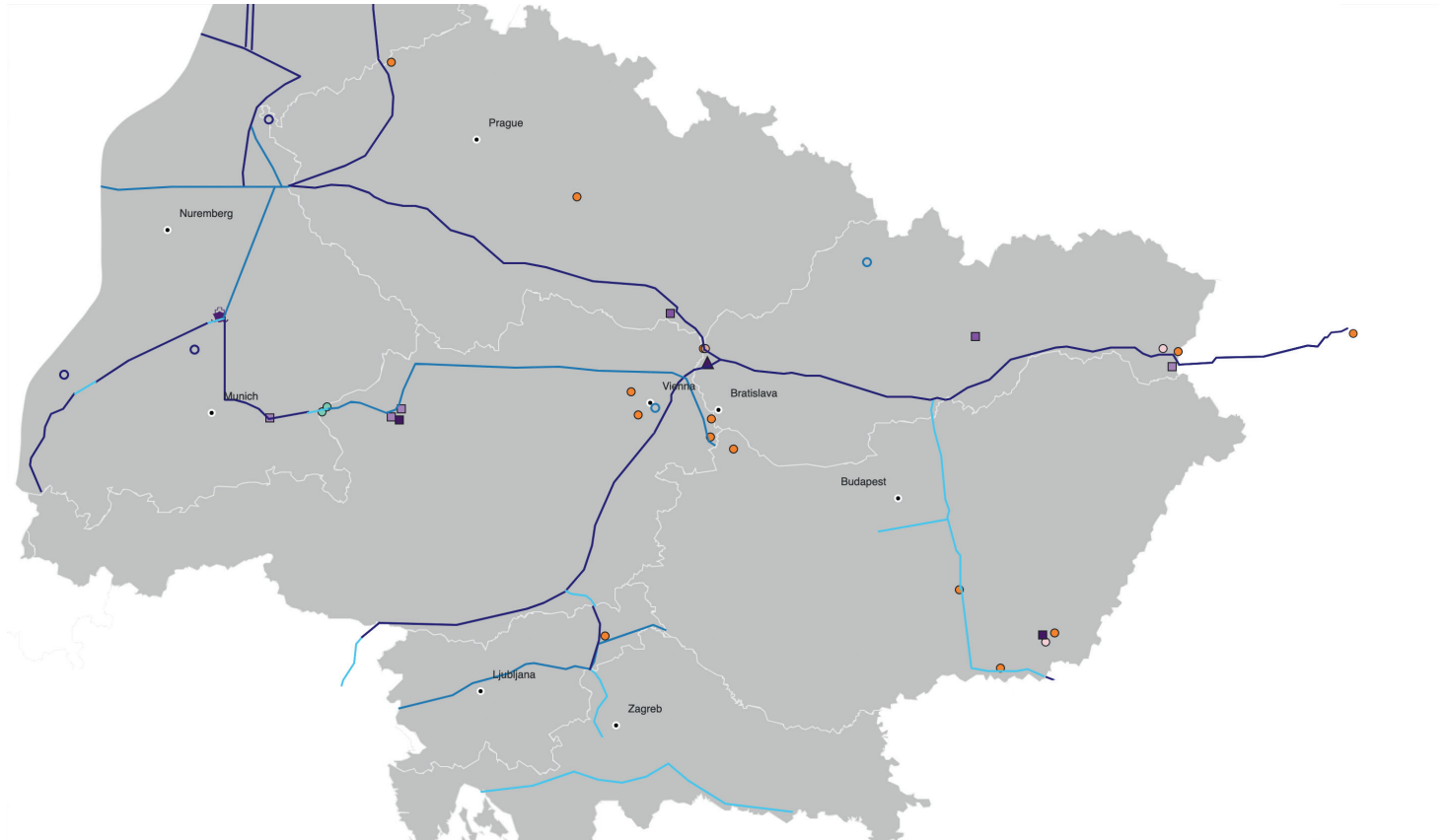
Ukraine has well-developed ammonia and steel production industries which could prove suitable offtakers. Ukraine is well connected to Europe by its large natural gas pipeline system that can be repurposed to transport hydrogen and also features a significant number of large-scale underground gas storages.

Parallel pipelines along the planned project “Central European Hydrogen Corridor (CEHC)” allow for fast and cost-efficient repurposing of dedicated pipelines without any negative effect on the security of the regional supply of natural gas. Repurposed pipelines in the Czech Republic and Slovakia will be combined with targeted investments in new dedicated H₂ pipelines in Austria and compressor stations in Slovakia. The Hydrogen storage facilities of RAG Austria in the regions of Salzburg and Upper Austria and NAFTA in Slovakia (IPCEI) will be used to secure and structure the (seasonal) demand of the hydrogen consumers. The corridor can connect high H₂ supply potential in Ukraine with off takers in Central Europe and southern Germany by 2030. On the corridor additional countries can be connected, i.e. Hungary, Slovenia and Croatia. Besides pipeline transport, the Danube river could be used for the transport of hydrogen derivatives from Eastern Europe via ships.



6.2 PROJECTS SNAPSHOT

HYDROGEN INFRASTRUCTURE MAP 2030



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

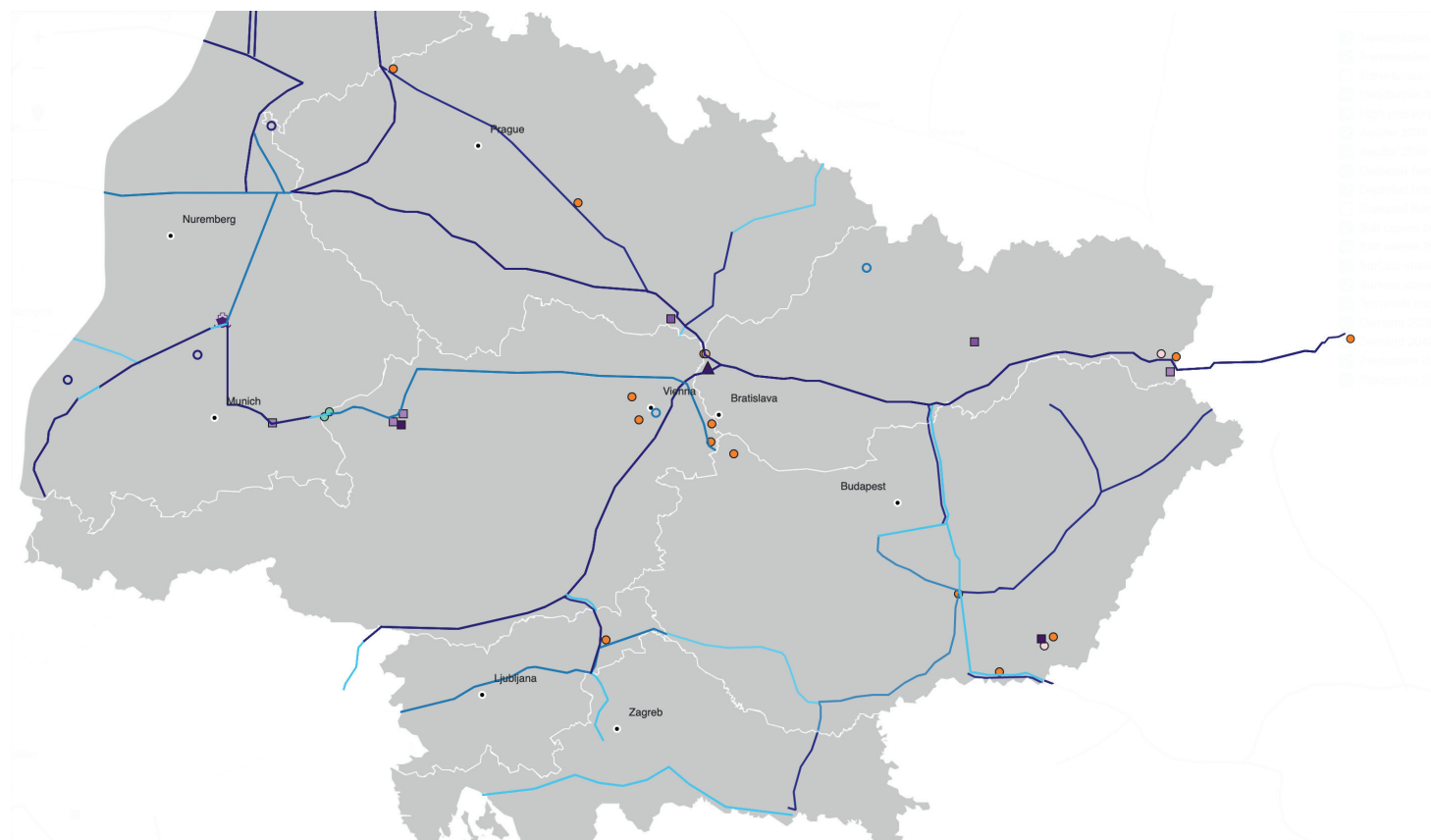
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2040



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

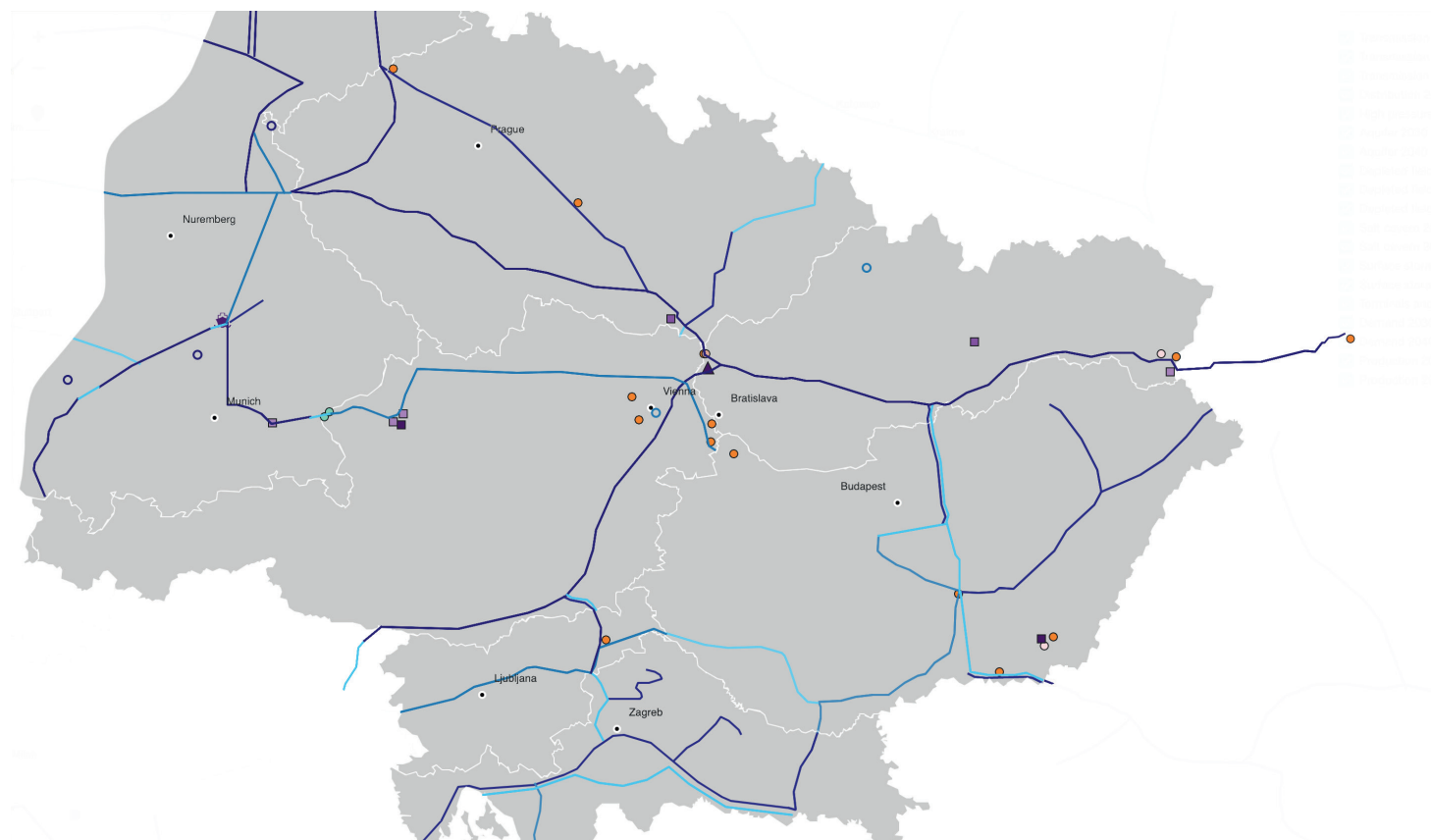
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2050



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports








- New
- New and conversion
- Conversion of existing infrastructure






Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

Project name	Category	Commissioning year	Capacity	Link
H2EU+STORE	Transmission & Storage	2030	2030: 2.5 TWh 2040: 40 TWh 2050: 80 TWh	
Underground Sun Storage 2030	Storage	2023	Storage working volume: 4.5 GWh H ₂ (assuming one cycle per year) Injection capacity: 0.031 GWh H ₂ /d Withdrawal capacity: 0.048 GWh H ₂ /d	
Underground Sun Storage Scale-Up	Storage	2030	150 GWh H ₂ , assuming one cycle per year – Project running as of 2030	
Central European Hydrogen Corridor (UKR part)	Transmission	2030	2030: IP Veľké Kapušany 240 GWh/d	
Central European Hydrogen Corridor (SK part)	Transmission	2030	2030: IP Veľké Kapušany 240 GWh/d 2030: IP Baumgarten 144 GWh/d	
Central European Hydrogen Corridor (CZ part)	Transmission	2030	2030: 144 GWh/d	
OGE H2ercules Network South (part of Central European Hydrogen Corridor)	Transmission	2030	IP Medelsheim: 192 GWh/d IP Waidhaus: 144 GWh/d	
H2I-S&D storage	Storage	2023		
UGS Lab – H ₂ storage	Storage	2024	Injection capacity: 2.6 GWh H ₂ /d Withdrawal capacity: 4.84 GWh H ₂ /d	
Underground Gas Storage Velke Kapusany	Storage	2025	Storage working volume: 3,122.83 GWh mix of H ₂ and natural gas Injection capacity: 34.2184 GWh H ₂ /d Withdrawal capacity: 34.2184 GWh H ₂ /d	
P2G Velke Kapusany electrolyser	Production	2024	7.2 GWh/y	
H ₂ Infrastructure-Distribution	Distribution	2030		
H ₂ Kollektor	Distribution	2026		
G2F – Gas To Future (Electrolyser)	Production	2024	2.9 GWh/y	
H ₂ Backbone WAG+Penta West	Transmission	2030	2030: 55 TWh	

Project name	Category	Commissioning year	Capacity	Link
SLOH2 backbone	Transmission	2035	6 GWh/d	
SLOP2G Electrolyser	Production	2028	10 MW	
Green Hydrogen @ Blue Danube	Terminal & port	2024	220 t/d	
Flow – Making Hydrogen happen (VIP Brandov)	Transmission	2030–2035	240 GWh/d	
HyPipe Bavaria – The Hydrogen Hub	Transmission	2027–2030	2030: 150 GW/d	

The table includes some of the hydrogen projects displayed on the Hydrogen Infrastructure Map, last updated on 30 March 2023.

6.3 SPECIFIC BOTTLENECKS

- Many uncertainties relate to the ongoing war in Ukraine. Specific issues include the operational state of Ukraine's natural gas infrastructure, the speed of economic recovery and infrastructure investment and the development of a hydrogen market and related supply chains in Ukraine.
- High share of nuclear power generation in the energy mix in the region, and as such very dependent on how nuclear is treated in terms of Taxonomy Regulation.

6.4 SPECIFIC RECOMMENDATIONS

- Intensify energy partnerships with exporting countries, like Ukraine.
- The Hydrogen Bank should consider creating a specific funding window for hydrogen production/infrastructure development in Ukraine (this also fits well with the idea of reconstruction after war).



7 SOUTHEASTERN H₂ CORRIDOR

7.1 POTENTIAL OF THE H₂ CORRIDOR

The major driver behind the development of this hydrogen corridor is the need to decarbonise industry, transport and power across Eastern and South-Eastern Europe. This is specifically relevant for new green steel projects and existing industry in Greece, Bulgaria, Romania, Hungary, Slovakia, Croatia, Slovenia, Austria, Czechia towards Germany.

Due to the vicinity to North Africa and Middle East, the corridor could in the future facilitate hydrogen imports from the neighboring countries via shipping or subsea pipeline transportation. The area offers abundant renewables potential, due to land availability and high-capacity factors for solar and onshore wind. Depleted gas fields in Greece, Czechia, Slovakia, Austria, and salt caverns Germany will be used to provide a cost-effective hydrogen storage solution.

H₂ SUPPLY AND DEMAND DATA:

Demand data per year

- 2030: 53 TWh
- 2040: 179 TWh
- 2050: 260 TWh

Supply data per year

- 2030: 22.1 TWh
- 2040: 151 TWh
- 2050: 183 TWh



7.2 PROJECTS SNAPSHOT

HYDROGEN INFRASTRUCTURE MAP 2030



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2040



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2050



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- ◆ New
- ◆ New and conversion
- ◆ Conversion of existing infrastructure





Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

Project name	Category	Commissioning year	Capacity	Link
Dedicated H ₂ Pipeline (Bulgaria to Greece)	Transmission	2030	70 GWh/d	
Dedicated H ₂ Pipeline (Greece to Bulgaria)	Transmission	2030	70 GWh/d	
Retrofitting of existing Greek Transmission System (Bulgaria to Greece)	Transmission	2025	9.967 GWh/d	
Retrofitting of existing Greek Transmission System (Greece to Bulgaria)	Transmission	2025	5.5 GWh/d	
South Kavala Underground Gas Storage facility	Storage	2029	Injection capacity: 35 GWh/d Withdrawal capacity: 35 GWh/d	
Maritsa East hydrogen ready pipeline	Transmission	2026	70 GWh/d	
H ₂ transmission system in Bulgaria. Pipeline from the Bulgarian-Greek border (Kulata) and Sofia region in Bulgaria.	Transmission	2029	70 GWh/d	
H ₂ transmission system in Bulgaria with 2 branches to Romania -near Ruse and Kozloduy	Transmission	2040	To be defined and aligned jointly with the Romanian operator.	
H ₂ transmission system in Bulgaria. Pipeline from the Sofia region to Romania, Oltenia region	Transmission	2040	To be defined and aligned jointly with the Romanian operator.	
Giurgiu – Nodlac corridor modernisation for hydrogen transmission	Transmission	2029	76,8 GWh/d	
Central European Hydrogen Corridor project, CEHC SK part	Transmission	2030	Veľké Kapušany IP: 240 GWh/d Lanžhot IP: 144 GWh/d	
H2I-S&D storage	Storage	2023		
UGS Lab – H ₂ storage	Storage	2024	Injection capacity: 2.6 GWh H ₂ /d Withdrawal capacity: 4.84 GWh H ₂ /d	
Underground Gas Storage Velke Kapusany	Storage	2025	Storage working volume: 3,122.83 GWh mix of H ₂ and natural gas Injection capacity: 34.218 GWh H ₂ /d Withdrawal capacity: 34.218 GWh H ₂ /d	
P2G Velke Kapusany electrolyser	Production	2024	7.2 GWh/y	
Central European Hydrogen Corridor project, CEHC, CZ part (Lanžhot-Waidhaus)	Transmission	2030	144 GWh/d (6 GWh/h)	

Project name	Category	Commissioning year	Capacity	Link
SK-HU H ₂ corridor	Transmission	2030	100 GWh/d	
Hydrogen production for fuel gas at Varosfold CS	Production	2028	1 MW	
H2EU+STORE	Transmission & Storage	2030	2030: 2.5 TWh 2040: 40 TWh 2050: 80 TWh	
Underground Sun Storage 2030	Storage	2023	Storage working volume: 4.5 GWh H ₂ (assuming one cycle per year) Injection capacity: 0.031 GWh H ₂ /d Withdrawal capacity: 0.048 GWh H ₂ /d	
Underground Sun Storage Scale-Up	Storage	2030	150 GWh H ₂ (assuming one cycle per year)	
Adjustment of existing EUS pipeline SK-HU	Transmission	2040	100 GWh/d	
H ₂ Backbone Murfeld	Transmission	2035	12 TWh	
HyPipe Bavaria – The Hydrogen Hub	Transmission	2027–2030	2030: 150 GW/d	
H2ercules Network South	Transmission	2030	Waidhaus IP: 144 GWh/d	

The table includes some of the hydrogen projects displayed on the Hydrogen Infrastructure Map, last updated on 30 March 2023.

7.3 SPECIFIC BOTTLENECKS

- The absence of national hydrogen strategies in many of the countries of the corridor can delay the progress of the hydrogen market developments in the region.
- The lack of parallel networks could also delay the development of the required infrastructure, since the construction of new, dedicated H₂ pipelines will take more time and most likely they will be more expensive relative to repurposed pipelines elsewhere in Europe.

7.4 SPECIFIC RECOMMENDATIONS

- Facilitate integrated energy system planning of hydrogen, natural gas, and electricity infrastructure supporting the accelerated deployment and integration of renewable energy resources.
- Integrate import considerations in hydrogen infrastructure planning, including port facilities for accepting and handling hydrogen carriers.
- Establish strategic hydrogen partnerships between EU and potential exporting countries in North Africa and the Middle East.
- Develop support mechanism for international hydrogen projects and transparent certification mechanisms.

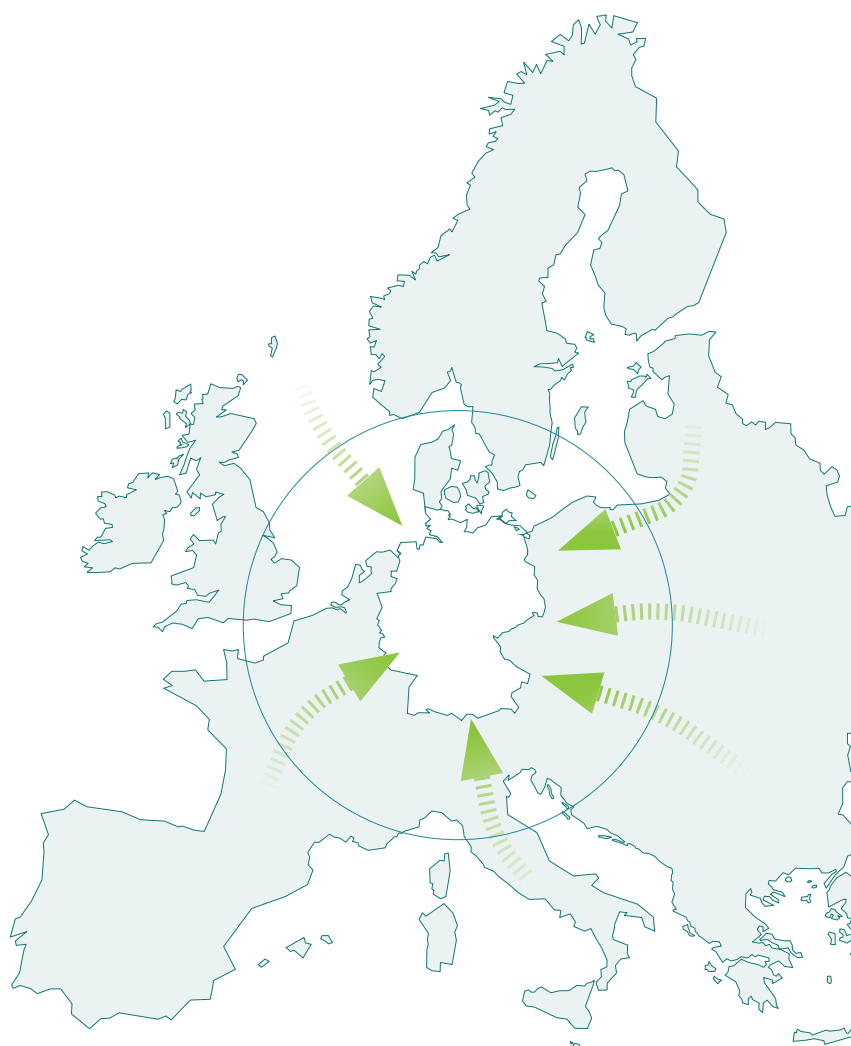
8 GERMANY – DEMAND DRIVING ROLE FOR ALL CORRIDORS

8.1 POTENTIAL OF GERMANY AS CENTRAL DEMAND CENTRE

Germany plays a central role in the development of a European hydrogen economy as all six outlined corridors are connected directly or indirectly to German demand centres. The development of the German domestic hydrogen market has therefore significant effects on the overall realisation and speed of the corridors.

Germany's natural gas system is complex with 16 gas TSOs and 700 DSOs, but it is well organised and can build on very well-developed gas infrastructure both on the level of distribution (550,000 km) as well as transmission (25,000 km) that can be repurposed to transport hydrogen easily to a great variety of customers.¹ Germany has a long experience in gas conversion processes from town gas to natural gas and more recently ongoing conversion from Dutch L-Gas to H-Gas.

In 2030 Germany expects a hydrogen demand between 95–130 TWh across all sectors. In addition, current grey hydrogen demand of 55 TWh needs to be decarbonised. Should prices for fossil energy carriers remain high, and hydrogen production costs further decrease, hydrogen demand could rise quicker and in greater quantity than currently envisaged. In addition, Germany has the largest gas storage capacity in the EU and the fourth in the world, after United States, Russia and Ukraine. This storage capacity can be gradually repurposed to provide much-needed hydrogen storage capacity. In addition, several sites for new salt caverns are available adjacent to existing storage sites. Flexibility can be further increased in the future by repurposing LNG import terminals that are currently being set up in Germany for hydrogen and its derivatives imports beyond 2030. At the DSO level a national project [GTP - Gas distribution Transformation Plan](#) was set up.

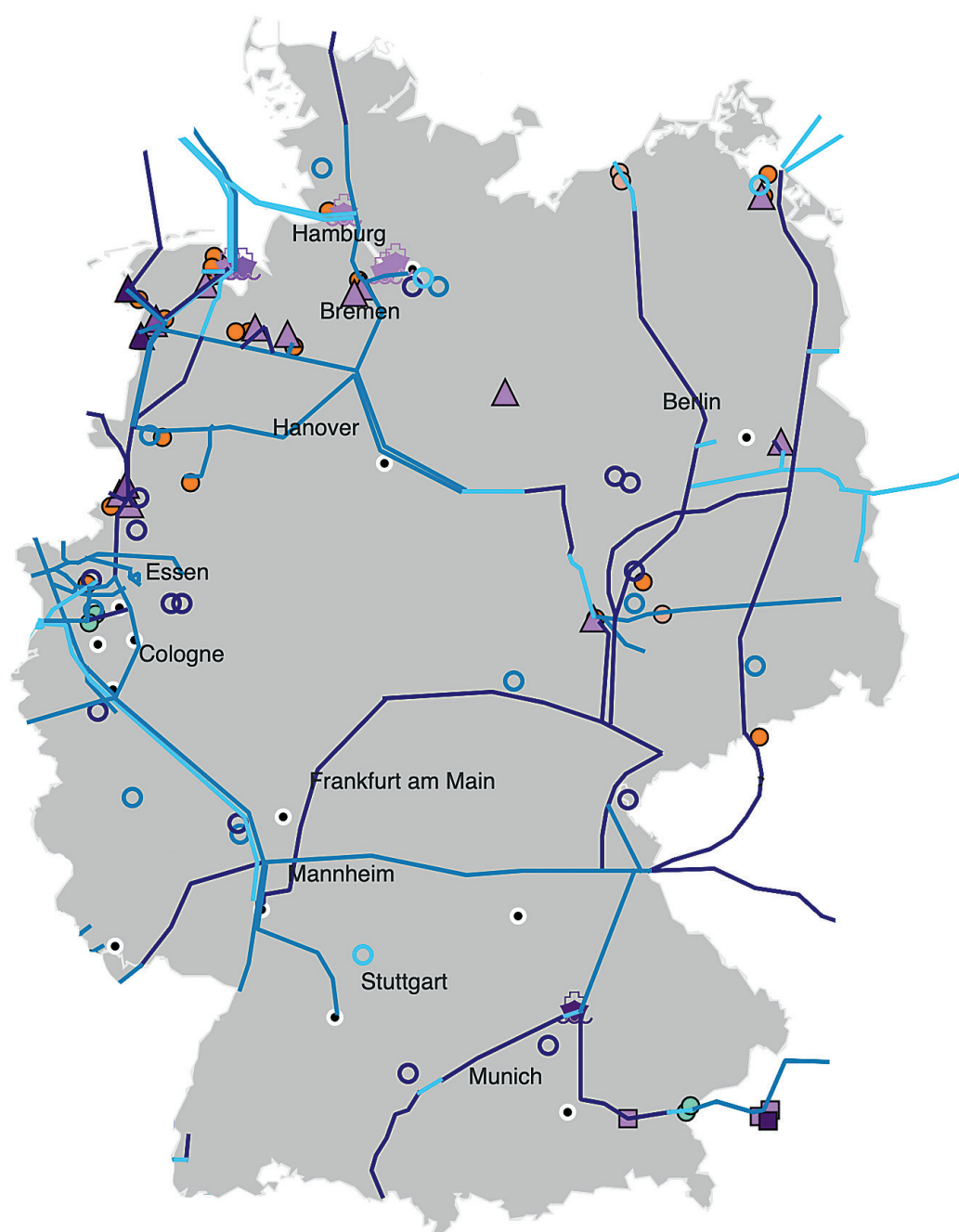


As part of the analysis conducted by European Hydrogen Backbone initiative, demand in the middle of Europe (Germany, Benelux, Czechia, Poland, and Austria) will in 2040 exceed supply potential of the region by 440 TWh. This underlines the necessity for the region for well-established import routes and large-volume (underground) hydrogen storage sites.

¹ [FNB-Gas Wasserstoffbericht.pdf](#)

8.2 PROJECTS SNAPSHOT

HYDROGEN INFRASTRUCTURE MAP 2030



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

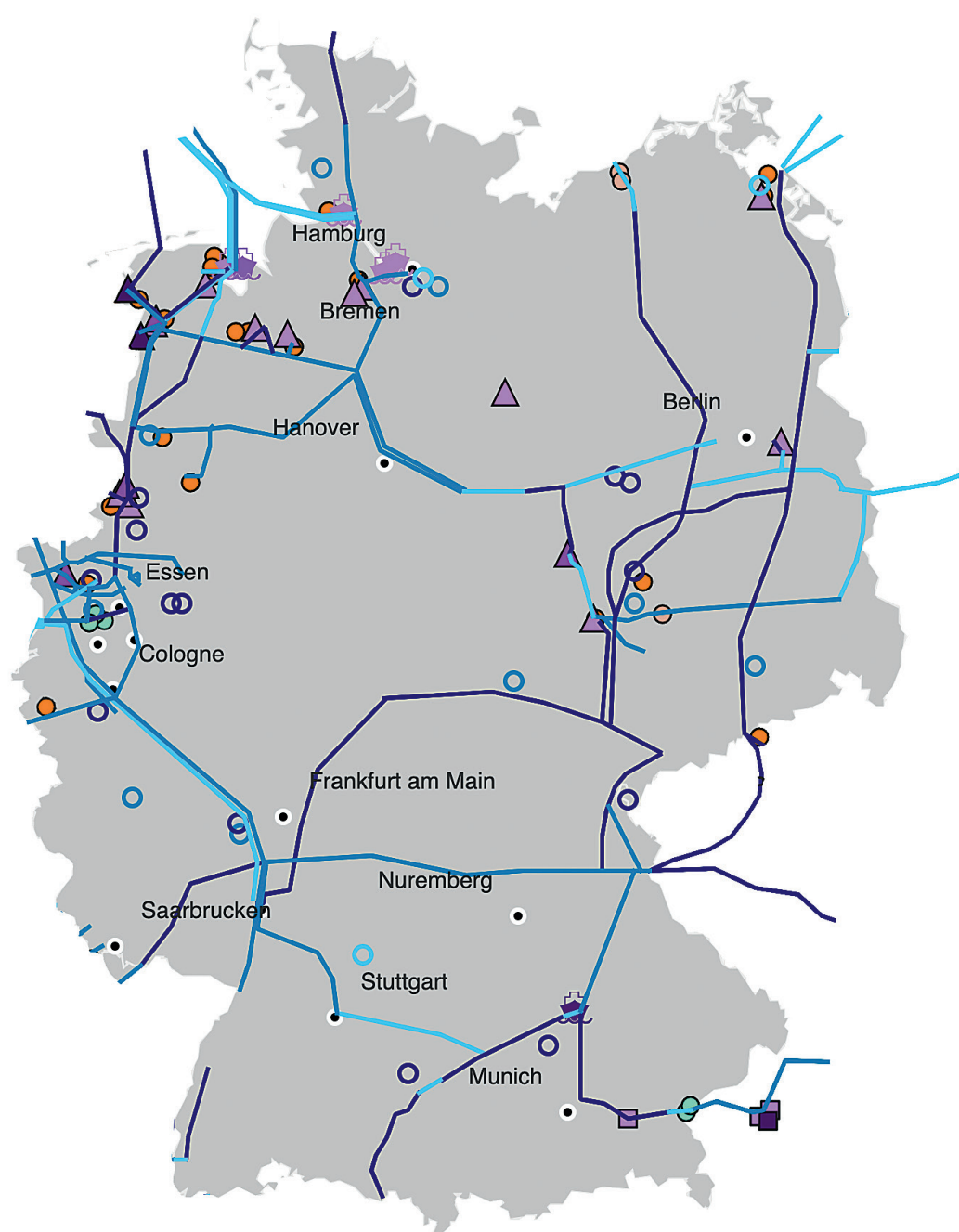
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2040



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports

- New
- New and conversion
- Conversion of existing infrastructure

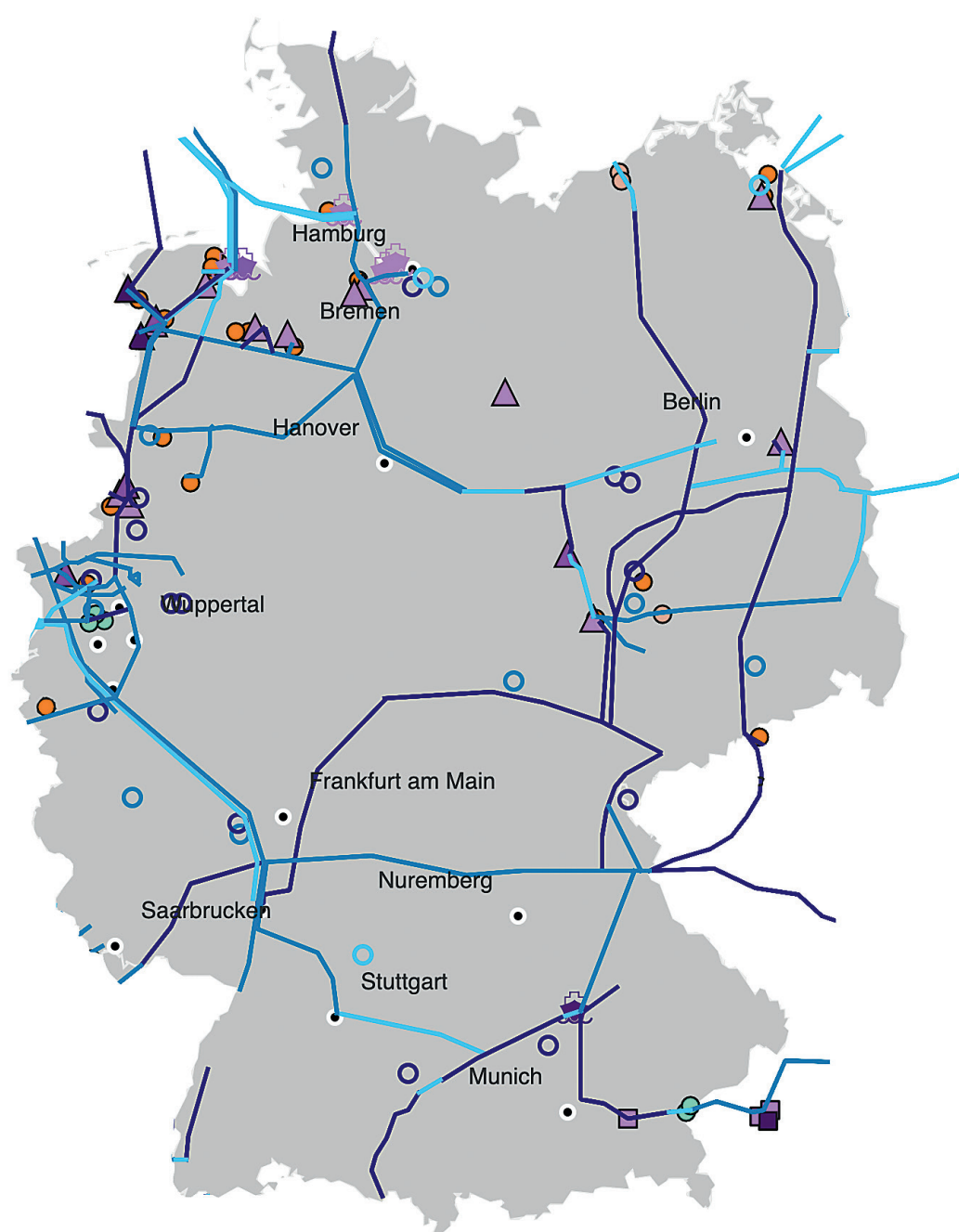
Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

HYDROGEN INFRASTRUCTURE MAP 2050



LEGEND

Transmission

- New
- New and conversion
- Conversion of existing infrastructure

Distribution

- New
- New and conversion
- Conversion of existing infrastructure
- Completed
- High pressure distribution

Storage

- ◆ New and converted aquifer
- ◆ Conversion of existing aquifer
- New depleted field
- New and converted depleted field
- Conversion of existing depleted field
- ▲ New salt cavern
- ▲ New and converted salt cavern
- ▲ Conversion of existing depleted salt cavern
- New surface storage

Terminals and ports














- New
- New and conversion
- Conversion of existing infrastructure








Demand

- Demand

Production

- Electrolyser
- Methane Reforming (SMR/ATR)
- Other/no data available

Project name	Promoter	Project Type	Category	Capacity	Link
Green Octopus Mitteldeutschland	ONTRAS Gastransport GmbH and VNG Gasspeicher GmbH	Mix: new + conversion of existing infrastructure	Transmission and storage	Entry/exit capacity of 84 GWh/d	
Nordic-Baltic Hydrogen Corridor – DE section	ONTRAS Gastransport GmbH	Newly-built infrastructure	Transmission	ONTRAS entry: 200 GWh/d ONTRAS exit: 100 GWh/d	
doing hydrogen	ONTRAS Gastransport GmbH	Mix: new + conversion of existing infrastructure	Transmission	Entry/exit capacity of 84 GWh/d	
HyPipe Bavaria – The Hydrogen Hub	bayernets	Conversion of existing infrastructure	Transmission	150 GW	
RHYN Interco	terranetsBW	Conversion of existing infrastructure	Transmission and distribution	12 GWh/d	
H2EU+STORE	RAG Austria, Bayerngas, bayernets, Gas Connect Austria, Eco-Optima, eustream, Nafta, Open Grid Europe, Gas Transmission System Operator of Ukraine, Storage System Operator of Ukraine (Ukrtransgaz JSC) and MND	Mix: new + conversion of existing infrastructure	Integrated infrastructure project	2030: 2.5 TWh 2040: 40 TWh 2050: 80 TWh	
AquaDuctus	GASCADE	New	Transmission	10 GW	
FLOW - making hydrogen happen	GASCADE	Mix: new + conversion of existing infrastructure	Transmission	Up to 20 GW	
H ₂ Interconnector Bornholm–Lubmin (IBL)	GASCADE	New	Transmission	Up to 10 GW	
HyPerLink I/II	Gasunie Energy Development GmbH	Mix: new + conversion of existing infrastructure	Transmission	4.080 GW	
HyPerLink V	Gasunie Energy Development GmbH + Thyssengas		Transmission	3.84 GW	
HyPerLink III:	Gasunie Energy Development GmbH		Transmission	8.6 GW	
HyPerLink IV	Gasunie Energy Development GmbH		Transmission	10 GW	
H ₂ CAST Etzel	Gasunie Energy Development GmbH + project partners (STORAG ETZEL, GASUNIE, DEEPKBB, DLR, HARTMANN Valves, SOCON, Clausthal University of Technology)	Storage	Storage		
GET H ₂	Nowega, OGE, Thyssengas	Conversion of existing infrastructure/newly built pipeline	Transmission		

Project name	Promoter	Project Type	Category	Capacity	Link
H2ercules	OGE	Conversion of existing infrastructure	Transmission		
Xanten – Vörde – Oberhausen	Thyssengas	Conversion of existing infrastructure/newly built pipeline	Transmission		
Leverkusen – Köln	Thyssengas	Conversion of existing infrastructure/new-built pipeline	Transmission		
East-West Connection	Thyssengas	Conversion of existing infrastructure/new-built pipeline	Transmission		
Vlieghuis – Ochtrup	Thyssengas	Conversion of existing infrastructure	Transmission	2027: 600 MW 2029: 800 MW 2031: 1,300 MW	
Clean Hydrogen to Europe (CHE)	Equinor	Mix of new and conversion	Transmission	4 mt/y	
H2.Ruhr	EON, Enel and Iberdrola		Distribution	80,000 t/y of green H ₂ & green ammonia	
Ammonia Import Terminal Brunsbüttel	RWE Supply & Trading GmbH	New	Terminal & port	300,000 t/y of green NH ₃	
bp Wilhelmshaven Green Hydrogen Hub	BP Europa SE	Mix	Terminal & port	54.8 GW/h daily send-out capacity	
H2-20 in Schoppsdorf	Avacon Netz GmbH	Conversion of existing infrastructure	Distribution		
Hamburg Hydrogen Industry Grid (HH-WIN)	Gasnetz Hamburg GmbH	New	Distribution	2 GW	
WESTKuSTE100 - Teilprojekt Gruner Heizen	Thuga AG/Stadtwerke Heide GmbH	Mix of new and conversion	Distribution		
H2-Sauerland	Westnetz GmbH	Conversion of existing infrastructure	Distribution		
H2-Netz Hanshagen	E-ON	New	Distribution		

The table includes some of the hydrogen projects displayed on the Hydrogen Infrastructure Map, last updated on 30 March 2023.

8.3 SPECIFIC BOTTLENECKS

- Overhaul of the energy system in Germany: The German energy system is currently undergoing major changes due to the Russian war against Ukraine with Russian natural gas supplies to Germany having declined sharply. Thus, a change of import and supply routes occurred on the gas market. In addition to the diversification of fossil energy sources, the rapid conversion to climate-friendly energy sources is the focus of German and European energy policy. The ramp-up of a national and European hydrogen market based on a well-connected onshore and offshore hydrogen infrastructure plays a central role. As 99% of the industrial consumers, power plants and CHP plants and most of the decentralised hydrogen production are connected to the DSO level it is important that the conversion of the TSO and DSO go hand-in-hand and are supported by politics. Many industrial end-users are in the south and south-west of Germany where the timing of the backbone might not meet their needs.
- Uncertainty at national level on H₂ planning and tariff framework: Lack of clarity for many investments at the grid level regarding the future tariff design. The proposal by DENA – very similar to the inter-temporal Cost allocation mechanism that has been proposed by the European Parliament in its position would allow grid operators to go ahead with their investment.
- Regulatory uncertainty at EU level on unbundling to delay investments in Germany: The Hydrogen and Gas decarbonisation package proposed by the European Commission in December 2021 has added further uncertainty in the German infrastructure market due to its restrictive unbundling provisions for hydrogen. As numerous countries in Europe, Germany has very successfully applied the Independent Transmission Operator (ITO) model in its gas and electricity market. The suggested phase-out by the European Commission of the ITO model in the hydrogen sector after 2030 and the immediate ownership unbundling even for one meter of hydrogen grid at the DSO sector has therefore triggered severe uncertainties and is delaying much needed final investment decisions by infrastructure operators.

8.4 SPECIFIC RECOMMENDATIONS

The legal and regulatory conditions need to be set as quickly as possible to allow current infrastructure operators to start repurposing their assets to hydrogen.

Set-up of an adequate overall regulatory framework, considering the German specificity of fully privately-owned network operators:

- Providing coherent rules for hydrogen network operators to ensure hydrogen for public supply.
- Allocating risks fairly to address investors' and customers' concerns in the hydrogen scale-up phase.
- Ensuring the refinancing for network operators in an adequate manner and providing for cost-competitive network fees in the initial scale up phase. The proposal of the DENA for the temporal cost allocation method that has been included in the European parliament's position provides could be one option.
- Applying pragmatic unbundling rules for the hydrogen sector. At the TSO level the ITO unbundling model has worked very successfully in Germany in the past in electricity and gas and should also be applied in the hydrogen sector. The DSO unbundling rules have been implemented very strictly by the regulator and have enabled intense competition across the country even in every smallest grids.

- The potential of current infrastructure operators for hydrogen can be unleashed by not imposing any legal separation obligations (horizontal unbundling).

- Distinction between distribution and transmission needed. Germany has clear rules on tasks and contracts of each infrastructure level and without the separation DSO will be bound by the European network codes and not anymore by the German rules.

Set-up a coherent network and storage development framework at national level

- Introducing a legally binding integrated network development planning process for all gases (hydrogen and methane).
- Giving the TSOs and the SSOs the mandate to build and operate a start backbone-network for hydrogen, referred to the analysis of strategic production and demand centres within Germany without further delay.
- Introducing instruments to optimise the localisation of power-to-gas facilities as well as hydrogen-fired power plants by providing an adequate incentive regime.
- Integration of Gas distribution Transformation Plan into the hydrogen planning.
- Implement the local heating and cooling plans as a basis of the investment decisions in the cities and regions.

9 GENERAL BOTTLENECKS AND RECOMMENDATIONS

During the discussion with the stakeholders several bottlenecks and recommendations were identified that had a horizontal character, influencing the development of all the respective H₂ supply corridors identified. To provide a holistic picture, these general bottlenecks and recommendations are addressed in this dedicated chapter.

9.1 GENERAL BOTTLENECKS

- Missing clear regulatory framework:
 - » Gas/H₂ Decarbonisation Package to be finalised,
 - » Missing H₂ standards which could delay the H₂ production development and the H₂ infrastructure deployment,
 - » Concerns regarding proposed TPA rules for import terminals under the Gas Package proposal,
 - » Missing certification scheme for Hydrogen imports,
 - » Overcomplicated permit granting procedure,
 - » Unbundling rules - Unbundling rules should facilitate the efficient conversion by the TSO to foster development of new and repurposed hydrogen infrastructure.
- Missing leadership for the purchasing of hydrogen abroad (EU level or member state level).
- Missing Technology openness: All types of CO₂ neutral and green hydrogen (water electrolysis, methane electrolysis/pyrolysis, SMR+CCUS etc.) will be needed for the energy transition and should be considered in production, infrastructure planning and funding.
- Concerns over societal acceptance for new energy carriers' projects.
- Missing incentives for off-takers – lack of clear targets and financial support (funding).
- Missing availability of workforce.
- Overview of full value chain for every commercial party is difficult.
- Missing clear and coordinated action at EU level and national governments on infrastructure planning & development.
- Missing alignment at Member State level on the hydrogen market organisation target, which risks not seeing a deep and secure liquid market emerge by 2030, and instead seeing national or even territorial H₂ islands. There is a lack of funding opportunities and financing for infrastructure. Short-term financing capacity of private actors is not up to the ambitions of REPowerEU by 2050.
- The technical elements of transporting hydrogen might be also considered as potential bottlenecks if not properly addressed.

9.2 GENERAL RECOMMENDATIONS

- The development of production, transmission and storage infrastructure must take place simultaneously. Especially large volume underground H₂ storage helps market participants to purchase in larger volumes, more flexibly and cheaper. Here, an infrastructure development must therefore be advanced quickly.
- Need for clear and stable EU legislation needed for investor certainty:
 - » Need for light regime and long-term security, with easy and applicable regulation as well as possible transition period
 - » Ensure a regulatory regime for DSOs which ensures the most efficient transition of gas infrastructures with the same unbundling rules for hydrogen than for the natural gas networks
 - » Simplify, shorten and accelerate planning and permitting procedures for the full value chain of renewable energies and hydrogen infrastructure projects to meet 2030 ambitions.
 - » Establish integrated energy system planning of hydrogen and natural gas infrastructure, based on shared energy scenarios covering also the electricity sector
 - » Implement a robust hydrogen certification scheme for hydrogen imports operational by the end of 2023 the latest to provide clarity for exporting countries
 - » Support and facilitate the import of blending/pure hydrogen from third countries
- Simultaneous planning and implementation of H₂ storages along the H₂ import corridors. H₂ storages will be needed to enhance SoS by providing seasonal balancing as well as more short-term flexibility services. Both in the transition period and in a fully CO₂-neutral world, there will be a need for both H₂ production and H₂ customer storages.
- Leadership required for the purchasing of hydrogen abroad (EU level or member state level), specifically need for EU to aggregate offtake and enter into bilateral agreements with third countries
- Unlock EU and national financing:
 - » To fast-track hydrogen infrastructure corridors deployment (e.g. ring-fencing specific funds for H₂ corridors in EU funding programmes; aligning IPCEI process with the H₂ corridors, etc.)
 - » Need for early financing which gives the possibility to design the necessary network in the right size from the beginning, not based on current production/needs but what we foresee in 2030, 2040 and 2050
- Intensify energy partnerships with exporting countries providing financing support to reduce the cost of capital in export countries, need for public-private & private-private partnerships on concrete projects
- Give space for innovation and competition for market players (avoid overregulation)
- Societal acceptance for new energy carriers is key. (EU and in export countries)
- Incentives for off-takers with technology open approach
- Different options and technologies to import and exchange hydrogen and derivatives
- Insert specific references of GO importance for H₂ development, including blending, and the key role of a GO framework harmonised across Member States as well as their key partners in the identified corridors (North Africa, Ukraine, non-EU Northern countries such as UK and Norway).

10 CONCLUSION

This 'Learnbook' has attempted to bring some concreteness, specificity, and tangibility to the conceptual framework of hydrogen corridors outlined by the European Commission in its' REPowerEU Action Plan. The final product represents the combined efforts of all those involved in the Roundtable, with the project data being provided by the Members of the Roundtable, and the co-chairs and facilitating organisation having synthesised it into a useable amalgamated form.

It is clear from the data presented herein that there is a significant established and growing momentum for delivering on the European Commission's vision for the transmission, distribution and storage of hydrogen within the EU and the wider neighbourhood regions. Most projects presented in the document are quite mature, with a relatively well elaborated set of corridors to be commissioned already before 2030. This is very positive news for the sector, and the signals of intent and willingness are clear.

Nevertheless, the data and input collection process for this Learnbook also clarified structural issues with the buildout of the corridors that are fundamentally at odds with the scale and timeline envisaged. The Learnbook delineates specific barriers corresponding to given corridors, but the most consistently voiced concerns pertained to three cross-cutting issues. (i) Prolonged regulatory uncertainty and complexity, (ii) financing limitations and complexity relative to global competitors, and (iii) administrative timelines that are incompatible with strategic timelines. Overcoming these sticking points is key to creating the critical mass required to realise the ambitions of an initiative of this nature.

Individual corridors have inherent regional and national nuances associated with their physical geography, but the international collaboration of parties required to deliver pan-European network infrastructure has invariably encouraged promoters to call for a pan-European harmonisation of the approach to governance and support. This is needed as pertains to funds and regulation that have a pan-European or cross-border scope (e.g. IPCEI or interoperability issues), but there are also consistent calls to leverage cooperation for strategic ends, for example joint purchasing or the signature of partnerships with third countries.

The Transmission and Distribution Roundtable has proven a valuable base for collaboration amongst actors involved in the build out of value chains for connecting renewable and low-carbon hydrogen production with demand centres. Hopefully the Learnbook can be a useful evolving reference point for the realisation of Europe's hydrogen corridors moving forward, a crucial precursor to a European hydrogen economy.

ABBREVIATIONS

BE – Belgium	ITO – Independent Transmission Operator
CBA – Cost Benefit Analysis	L-Gas – Low calorific gas
CBCA – Cross Border Cost Allocation	H-Gas – High calorific gas
CEDEC – European Federation of Local and Regional Energy Companies	LH ₂ – Liquid Hydrogen
CEF – Connecting Europe Facility	LNG – Liquefied Natural Gas
CHP – Combined heat and power	MO – Morocco
CH ₂ – Methylene	MoU – Memorandum of Understanding
CO ₂ – Carbon Dioxide	Mt – Megatonne
DE – Germany	Mt/y – Megatonne per year
DENA – German Energy Agency	MTPA H ₂ – Million Tonnes per annum
DG GROW – The Directorate General for Internal Market, Industry, Entrepreneurship and SMEs	MW – Megawatt
DZ – Algeria	NGO – Non-governmental organisation
DSO – Distribution System Operator	NH ₃ – Ammonia
ECH2A – The European Clean Hydrogen Alliance	NL – The Netherlands
EHB – European Hydrogen Backbone	OGE – Open Grid Europe
ES – Spain	PCI – Projects of Common Interest
FR – France	PT – Portugal
GD4S – Gas Distributors for Sustainability	R&I – Research & Innovation
GIE – Gas Infrastructure Europe	RES – Renewable Energy Sources
GWh – Gigawatt hours	SMR/ATR – Steam methane reforming/ Autothermal Reforming
GWh/d – Gigawatt hours per day	t/d – Tonnes per day
GWh/y – Gigawatt hours per year	t/y – Tonnes per year
GO – Guarantee of Origin	TWh – Terawatt-hour
H ₂ – Hydrogen	TWh/y – Terawatt-hours per year
HVH – Higher Heating Value	TPA – Third Party Access
IPCEI – Important Projects of Common European Interest	TSO – Transmission System Operator
	TYNDP – Ten-Year Network Development Plan

IMPRINT

PUBLISHER

European Clean Hydrogen Alliance - Roundtable
for Hydrogen Transmission and Distribution

SUPPORTED

by the European Commission
Directorate-General for Internal Market,
Industry, Entrepreneurship and SMEs

DESIGN

DreiDreizehn GmbH, Berlin | www.313.de

PICTURES

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