AURORA
ENERGY RESEARCH

Το μέλλον του πράσινου υδρογόνου και άλλων εναλλακτικών καυσίμων στην Ευρώπη: Προσφορά, ζήτηση και υποδομές

Hydrogen & green gases forum

Ιούνιους 2025

While current H_2 demand is met by grey H_2, growing production, demand in new sectors, and infrastructure will eventually drive the renewable H_2 market

AURORA

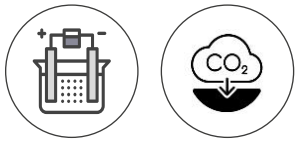
Widespread evolution of the hydrogen market from today's fossil-heavy to future low-carbon will occur from multiple fronts

	Short-term (2025-2027)	Medium-term (2028-2035)	Long-term (2036-2060)
Supply	Fossil-based hydrogen continues to remain the dominant source of supply.	Electrolytic hydrogen[1] gradually scales up while grey hydrogen production is reduced.	Domestically produced electrolytic hydrogen and later imports become the dominant source of supply.
Demand	Total European hydrogen demand of 7Mt H_2 is mostly coming from industry.	Low-carbon hydrogen demand starts to increase in certain sectors such as ammonia, refineries, steel, aviation, and maritime.	Increased hydrogen demand in industry, transportation, and power generation.
Infrastructure	Limited infrastructure to utilise, transport, or store hydrogen due to volumes uncertainty.	Ramp up of hydrogen import facilities for derivatives, and more pipelines for pure H_2.	Better connected regions via pipelines, including regions from outside Europe.
Policy and market	High-level targets are set, but policy and regulatory frameworks are still being built.	Developed policy and regulatory frameworks, but projects require subsidies to varying extents to be viable.	Electrolytic hydrogen production costs are competitive with blue and grey hydrogen in many regions.
Financing and pricing	Electrolyser projects are typically heavily subsidised, generally on-site, and small-scale.	HPAs[2] with firm offtakers become increasingly important for securing financing, while subsidies remain crucial.	Liquid trading in the 2040s may allow for the financing of merchant projects.

1) Renewable/RFNBO hydrogen or low-carbon hydrogen; 2) HPA: Hydrogen purchase agreement;

Source: Aurora Energy Research

To build a low carbon and renewable hydrogen market, financial support is needed across the hydrogen value chain from governments

	 **Production** *Supply support*	 **Offtake** *Demand support*	 **Infrastructure** *Supply and demand support*
	Subsidies or funding to produce low-carbon/ renewable H_2, including support for electrolysis, CCS[1] and other production methods.	Subsidies or funding to stimulate offtake demand for low-carbon/renewable hydrogen.	Investment in infrastructure such as hydrogen refuelling stations, pipelines, and import and storage facilities.
Support types	▪ Non-bidding selection ▪ General incentives ▪ Competitive bidding	▪ Non-bidding selection ▪ General incentives ▪ Competitive bidding	▪ Non-bidding selection
How support is offered	▪ National auctions ▪ Innovation Fund ▪ IPCEI[2] ▪ Recovery and Resilience Facility ▪ Net Zero Innovation Portfolio ▪ Net Zero Hydrogen Fund ▪ UK Research and Innovation	▪ IPCEI ▪ Recovery and Resilience Facility ▪ Innovation Fund projects ▪ Renewable fuel quotas ▪ Carbon Contracts for Difference	▪ Connecting Europe Facility – Energy and Transport ▪ IPCEI ▪ Clean hydrogen partnerships ▪ Horizon Europe ▪ European Regional Development Fund ▪ Innovation Fund

1) CCS: Carbon capture and storage; 2) IPCEI: Important project of common European Interest;

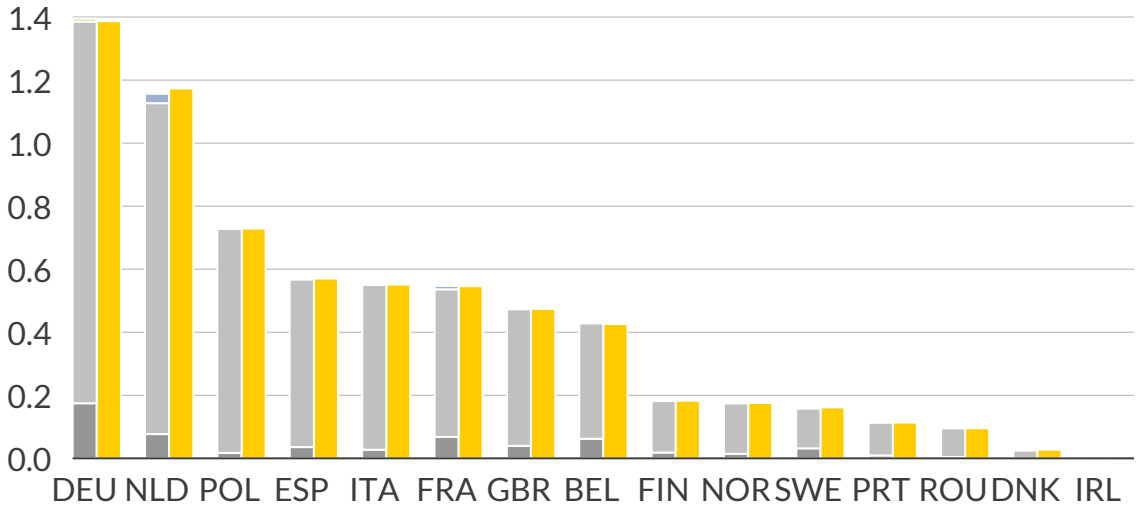
Source: Aurora Energy Research

Current hydrogen supply is dominated by grey hydrogen, with low-carbon hydrogen remaining marginal

AURORA

Grey hydrogen production and demand in Europe[1] in 2023[2]

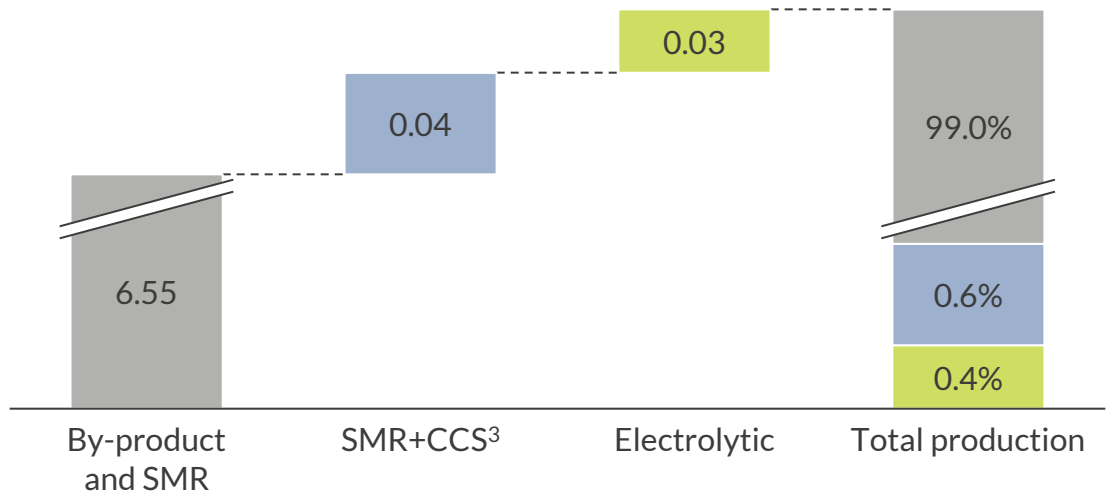
Mt H_2



- Around 99% of hydrogen in Europe is produced from the steam methane reforming (SMR) process or derived as a by-product of chemical industries, usually referred to as grey hydrogen.
- SMR facilities are usually located in proximity to refining and fertiliser plants, the major offtakers of hydrogen.
- By-product hydrogen is produced via the chlor-alkali process or the production of ethylene or styrene in the petrochemical industry.

European[1] hydrogen production by technology in 2023[2]

Mt H_2



- Production of low-carbon hydrogen (produced through electrolysis or CCS-coupled SMR) is compared to conventional hydrogen.
- In 2023, the largest producer of electrolytic hydrogen in Europe was Germany, having produced 9000t, or 0.7% of its total production.
- The Netherlands is the largest producer of hydrogen produced by SMR+CCS[3], or 'blue hydrogen' producing 30,970t, 2.7% of its total production.
- Most low-carbon hydrogen produced is consumed by the mobility and refining sectors.

By-product SMR SMR+CCS Electrolytic Demand

1) Only covers 15 countries (DEU, NLD, POL, ESP, ITA, GBR, FRA, BEL, FIN, SWE, NOR, ROU, PRT, DNK, and IRL); 2) Latest available historic data from European Hydrogen Observatory; 3) CCS: Carbon capture storage;

Sources: Aurora Energy Research, European Hydrogen Observatory

Among various supply support mechanisms, auctions are the most popular in Europe, with over 13bn € committed to initial rounds

AURORA

Supply-side support is needed to ease the burden on project developers and kickstart the low-carbon/renewable hydrogen value chain. Such incentives and support schemes are common across Europe and beyond, they can be broken down into three broad categories:

	Non-bidding selection	General incentives	Competitive bidding
Selection	Project-related criteria	Eligibility/qualification criteria[1]	▪ Financial bid ▪ Project-related and eligibility/qualification criteria[2]

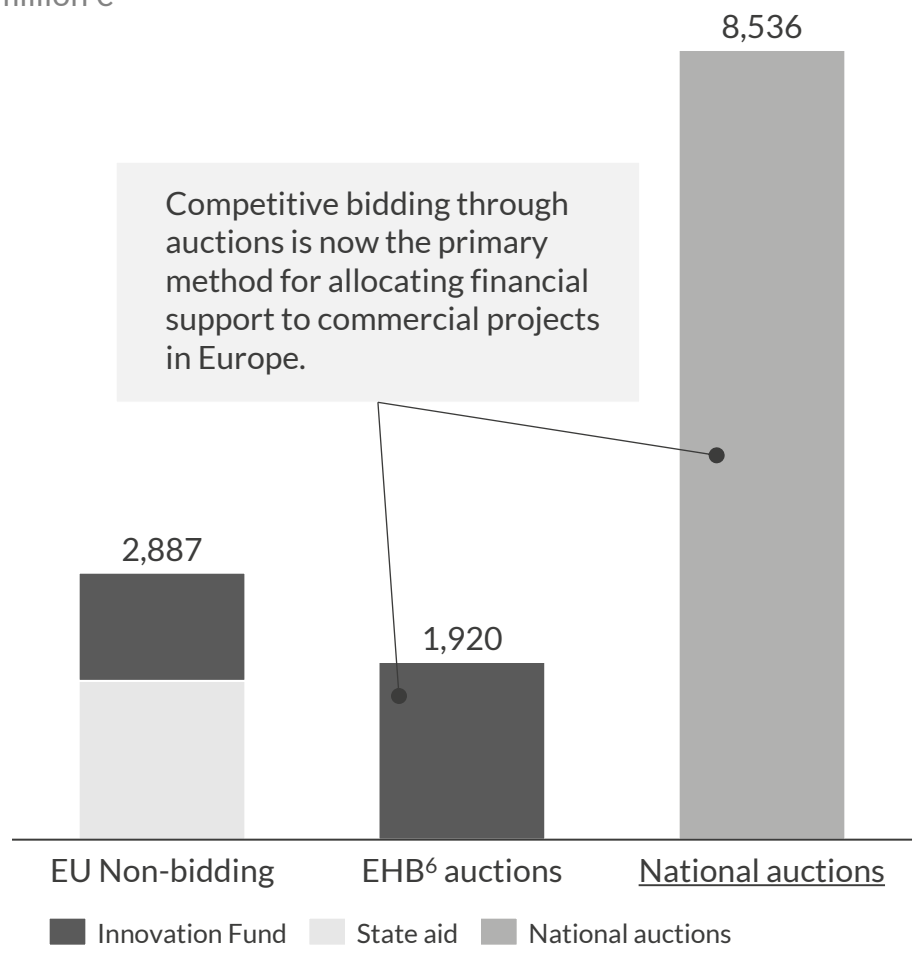
Examples	▪ Innovation Fund call for proposals
	▪ State aid
	  ▪ IPCEI[3] (EU)
	  ▪ RRF[4]
		▪ Grid charge reduction (DEU, ITA, NOR)
		▪ Tax credit (USA)
		▪ Free allowance allocation[5]
			▪ EHB[6] pilot auction (EU)
			▪ National auctions

Support	Investment, Construction, Operation	Operation	Investment, Operation

Investment · Construction · Operation · Lump sum support · Production-based support

Financial support to H_2 production projects by initiative and funding source

million €



1) Prerequisite for different initiatives include lifecycle GHG emission intensity and specific production technologies; 2) Including but not limited to innovation, maturity, replicability, lifecycle emission, cost efficiency, hydrogen production process constraints; 3) IPCEI: Important Projects of Common European Interest; 4) RRF: Recovery and Resilience Facility; 5) See a deep dive on the free allowance allocation in our June 2024 report, page 7; 6) EHB: European Hydrogen Bank;

Sources: Aurora Energy Research; European Commission

H_2 demand is driven by bridging the cost gap with existing technologies via policy, regulation, and technological advances, especially for new applications

AURORA

Drivers of renewable/low carbon H_2 demand in Europe

- **Hydrogen costs**: The biggest driver, as lower costs make hydrogen more competitive and widely adopted.
- **Access to infrastructure**: Without a distribution network, hydrogen adoption remains limited.
- **Pace of total decarbonisation**: The urgency of net zero targets will determine hydrogen's role.
- **Carbon Border Adjustment Mechanism (CBAM)**: Strong border mechanisms can prevent offshoring and maintain industrial H_2 demand.
- **Technology readiness level of alternatives:** If alternatives to hydrogen mature quickly, demand could be reduced.
- **Industrial growth and geopolitics:** Europe's ability to maintain industries like steel and ammonia affects hydrogen demand.
- **Supply chains/skills:** Uninterrupted supply chains and skilled workers are needed, but less of a driver than cost, policy, and infrastructure.

Sector	Description of hydrogen use	Role of H_2
Feedstock	Used in chemical industry such as ammonia, refineries	●
E-fuels[1]	Synthesis of fuels e.g. e-ammonia and e-SAF	◕
Steel	Essential input in the DRI-EAF[2] process	◕
Industrial heat	Combustion of H_2 in furnaces for energetic purposes	◑
H_2 in power	Use in H_2 CCGTs/OCGTs to replace traditional thermal assets	◑
Road transport	Use in H2 ICEs[3]/fuel cells in HGVs/other road vehicles	◔
Rail transport	Use of H_2 to power trains in regions with limited electrification	◔
Space heating	Direct use of hydrogen in boilers for residential space heating	○

Uncertainties / risks which could affect H_2 demand:

- It is possible that some industries e.g. steel may offshore to cheaper locations, reducing H_2 demand in Europe.
- Uncertainty of the H_2 infrastructure timeline, such as the European backbone could lead to supply chain shortage.
- The role of blue and other low-carbon hydrogen options (including electrolytic business models), with cost and deployment changes potentially impacting demand.

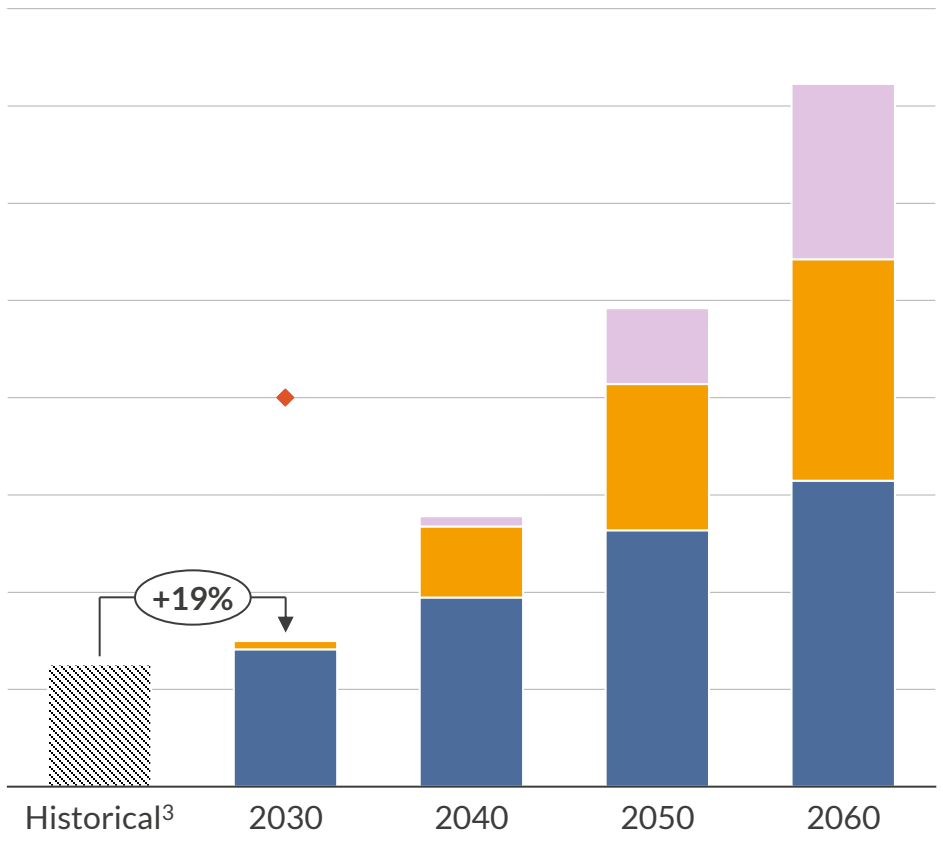
1) E-fuels include e-ammonia, e-kerosene, e-methanol, e-methane, etc., and are used in the maritime and aviation sectors; 2) DRI-EAF: Direct reduced iron–electric arc furnace; 3) ICE: Internal Combustion Engine;

Source: Aurora Energy Research

As policy support, infrastructure, and decarbonisation efforts expand, H_2 demand will increase across existing and new sectors in the near and mid-term

AURORA

Total demand for H_2 and derivatives[1] in Europe[2]
Mt H_2



Current-market

- Current hydrogen demand is primarily driven by sectors where there are no viable alternatives, such as ammonia production and refineries.
- Nearly all this demand (>99%) is met by grey hydrogen however there are signs the industry is shifting to favour renewable resources.
- Germany, the Netherlands, and Poland are Europe's top consumers, accounting for 17%, 15%, and 9% of total demand, respectively.

Near-term (2027-2040)

- Aurora forecasts a 19% increase in H_2 demand from current levels, driven primarily by new applications and continued industrial demand.
- However, the forecasted demand in 2030 is less than half of the RePowerEU target due to market delays, slow regulatory progress, and postponed FIDs.
- In the near-term, most of the demand for transport is coming from e-fuel applications in maritime and aviation driven by mandates, e.g. ReFuelEU.

Long-term (2040-2060)

- Increased intermittency of renewables in power markets drives the use of hydrogen in power for balancing in several countries.
- We see increased growth in the transport sector driven by infrastructure build-out, decreased production costs, and strict mandates.

1) Hydrogen derivatives considered in this analysis cover ammonia, methanol, synthetic diesel, and synthetic kerosene; 2) Fifteen EU countries; 3) Historic data from European Hydrogen Observatory; 4) RePowerEU targets covers EU-27. Aurora's forecast covers a subset of EU-27, Norway, and the United Kingdom;
Sources: Aurora Energy Research, European Hydrogen Observatory

In the near-term, sustainable[1] hydrogen growth hinges on closing the cost gap with existing technology or alternatives

Addressing the "missing money" problem for sustainable[1] hydrogen is a key challenge hindering market growth

The "floor" willingness to pay (WtP) represents the minimum price hydrogen must achieve to compete with existing technologies.

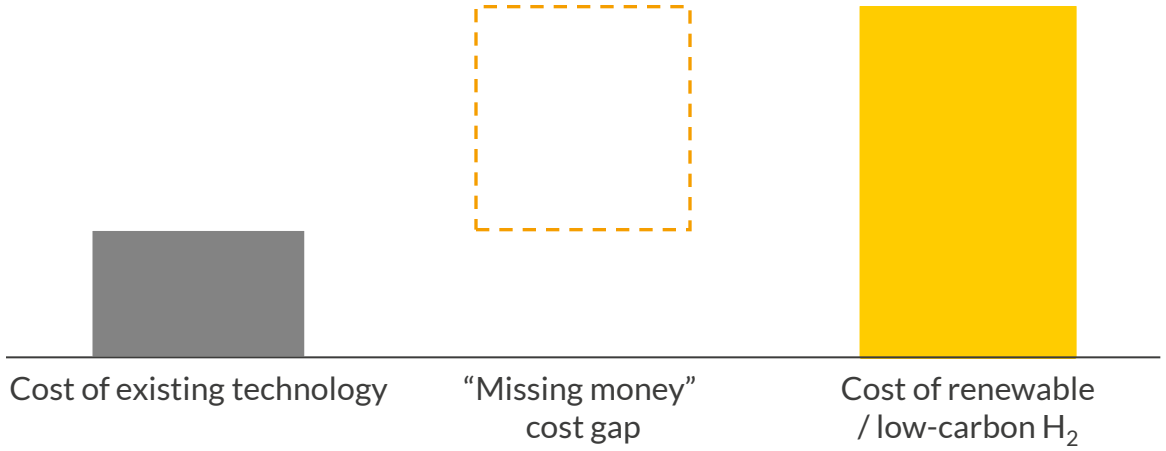
From a techno-economic standpoint, offtakers will only adopt low-carbon hydrogen if its production costs are on par with or lower than those of competing technologies.

Assuming cost parity, the difference in non-hydrogen costs defines the "floor" WtP—essentially the amount offtakers are willing to pay for H_2.

Additional costs above this floor can be mitigated through green premiums, subsidies, or avoided penalties, helping to close the "missing money" gap.

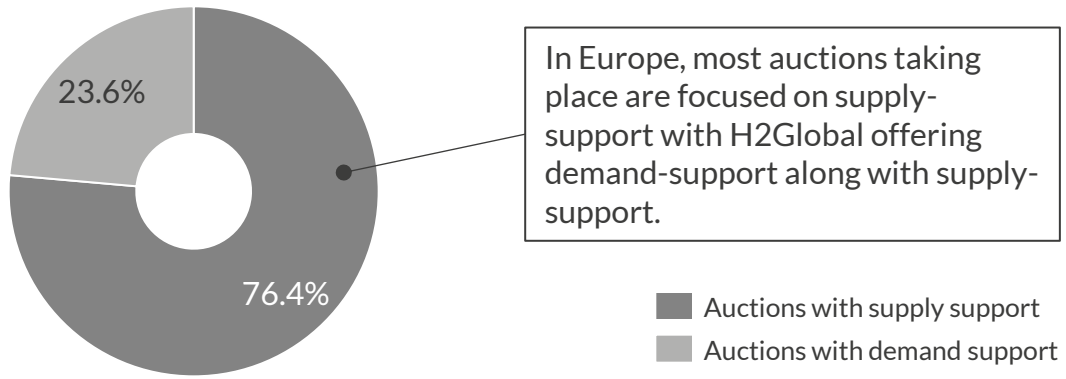
There are several demand support mechanisms available; however, most auction-based support focuses on supply.

Illustrative graph displaying the "missing money" cost gap for sustainable[1] H_2



Number of auctions in Europe with financial supply and demand support

%



1) In this case "sustainable hydrogen" includes non-grey hydrogen, this includes, blue, renewable, low-carbon, etc.

Source: Aurora Energy Research

Several infrastructure projects are planned across Europe, with many targeting completion in the 2030s

AURORA

Overview of key hydrogen network initiatives and projects across Europe

Initiative	Region /Country	Description
European Hydrogen Backbone	Europe	A plan to create a pan-European hydrogen pipeline network, connecting hydrogen supply and demand across Europe.
Hydrogen and Natural Gas Ten-Year Network Development Plan	Europe	A roadmap by ENTSOG to integrate hydrogen into the existing gas network across Europe.
German Core Hydrogen Network (*Wasserstoff-Kernnetz*)	Germany	A national network focused on hydrogen infrastructure that will connect key industrial hubs via a 9,666km infrastructure, with 60% converted lines and phased implementation through the 2030s.
Nordic-Baltic Hydrogen Corridor	Finland, Estonia, Latvia, Lithuania, Poland, and Germany	A transnational initiative by six TSOs across the participating region to develop hydrogen infrastructure and meet the RePowerEU 2030 targets.
Nordic Hydrogen Corridor	Finland, Norway, and Sweden	A project establishing a hydrogen refuelling network for heavy-duty vehicles in Sweden, Norway, and Denmark.
H2Med	Spain, France, and Portugal	A planned pipeline project to interconnect hydrogen networks in the Iberian peninsula to Northwest Europe, to supply Europe with renewable hydrogen by 2030. There will be additional 703km of pipeline built to expand the network.
SoutH2 Corridor	North Africa, Italy, Austria, and Germany	3,300km hydrogen pipeline connecting participating regions and led by TSOs who each submitted PCI[1] submissions to the EC[2]. It aims to supply renewable hydrogen to European demand clusters.
Baltic Sea Hydrogen Collector (BHC)	Finland, Sweden, Germany, and potentially Denmark	The BHC plans to build a 1,250km pipeline system which will connect participating countries via offshore pipelines capitalising off offshore wind.
Project Union	UK	A project that will repurpose existing gas pipelines and build new ones to create a 1,500-mile hydrogen backbone in the UK.

1) PCI: Projects of Common Interest; 2) EC: European Commission;

Sources: Aurora Energy Research, European Hydrogen Backbone, Entsog, Elering, Nordic hydrogen corridor, H2Med, SoutH2 Corridor, Baltic Sea Hydrogen Collector, National Gas

The European Hydrogen Backbone proposes four[1] major hydrogen supply corridors by 2030, with over 70% of pipelines repurposed from gas

AURORA

A North Africa & Southern Europe

- Algeria set up a hydrogen task force with Germany in February 2024. +
- Relies on repurposing intensively-used Trans-Mediterranean gas pipeline. −

B Southwest Europe & North Africa

- Iberia is connected to the network with high export potential. +
- New connection will be needed between Spain and France. −

C Nordic and Baltic regions

- Enables connection to Poland with high potential demand. +
- A large number of new hydrogen pipelines are required. −

D East and South-East Europe

- Unlocks potential of hydrogen production in west Asia. +
- Uncertainty of Ukraine interconnection considering Russian invasion. −

Five supply corridors proposed by the European Hydrogen Backbone

X → Proposed supply corridors

\+ Positive factors

− Potential uncertainties

Countries included in the European Hydrogen Backbone

1) The fifth proposed corridor - the North Sea corridor, was recently cancelled in September 2024 citing lack of funding and demand;

Sources: Aurora Energy Research, European Hydrogen Backbone

Pipeline development has been slow due to volume and revenue uncertainties, along with technical and regulatory challenges

AURORA

Risk elements	Description	Evidence from on-the-ground projects
Volume uncertainty	Uncertainty around long-term demand creates policy uncertainty, which delays investment in pipeline infrastructure, as these are typically regulated assets that depend on clear policy signals.	Equinor cancels Norway to Germany offshore pipeline citing insufficient demand.
TSO's business model	Clear guidance on network operators' revenue streams is essential, particularly in the short-term when pipeline networks may be underutilised.	Germany is one of the few countries that has progressed with its approved *Kernnetz*[1] establishing a clear revenue model for TSOs, whereas most other EU countries still lack clarity.
Permitting complexity	The permitting process across Europe is often lengthy, with uncertain approval timelines due to the involvement of numerous stakeholders.	Fluxys'[2] 35km pipeline in Belgium could be delayed more than a year due to suspension of environmental permitting.
Technical challenges	While repurposed gas pipelines are significantly cheaper than new-build, not all can be repurposed due to the original construction materials used.	The Dutch H_2 network (HyNetwork), saw costs increase from 1.5bn € to 3.8bn € due to reduced ability to reuse existing gas pipelines, thereby relying on expensive new-build pipelines.[3]
Cross border regulation	Although the Hydrogen and Decarbonised Gas Market Package has been adopted at the EU level, setting rules on access, and tariffs, further alignment between Member States remains necessary.	Denmark to Germany pipeline was delayed by three years citing regulatory challenges, among others.
Safety	Hydrogen's physical properties necessitate stricter safety design and longer testing/approval periods.	The H21 Leeds City Gate project in Great Britain raised concerns about household safety in the event of a switch from methane to hydrogen.

1) German Hydrogen Core Network; 2) Belgium's gas network TSO and hydrogen network operator; 3) The increase in investment costs was communicated to the Dutch House of Representatives during the consultation on the HyNetwork rollout plan in December last year. The increase was attributed to the need for additional new pipelines, higher material and labor costs, and the need to meet additional sustainability requirements, such as those related to nitrogen and water management;
Sources: Aurora Energy Research, Argus Media, HyNetwork