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Short-term hydrogen demand: Who is buying renewable hydrogen?

Public Webinar

26 March 2025

Today's presenters and other key information

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Source: Aurora Energy Research

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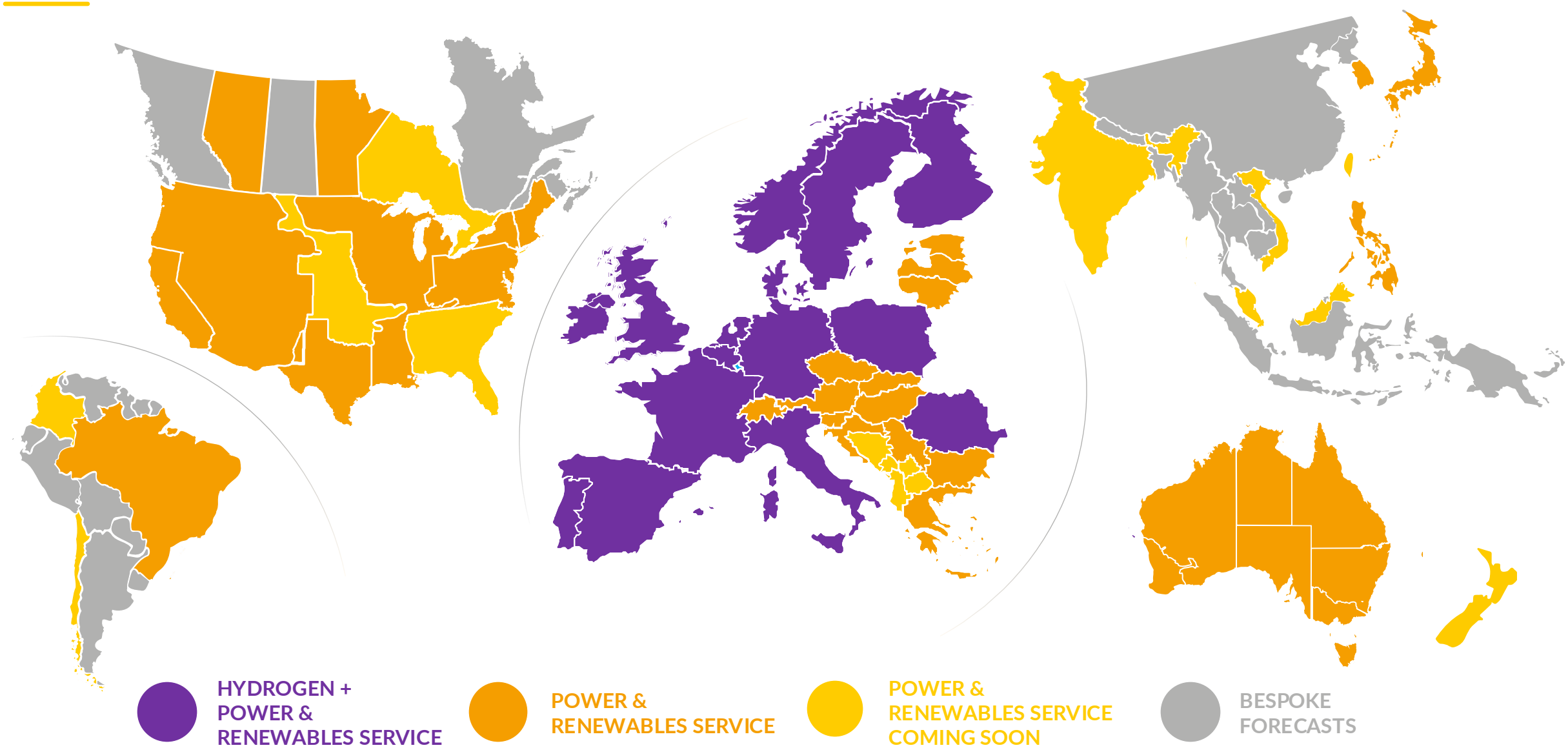

Discover the major players across the value chain utilising Aurora's hydrogen market analytics

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Source: Aurora Energy Research

Our European Hydrogen Market Service keeps you up-to-date with regular insights, policy & market updates, and roundtable discussions

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Strategic Insights

- Designing for value: innovative power procurement strategies and upsides for electrolyser business models
- Closing the gap: offtakers' willingness to pay for low-carbon hydrogen
- Hype to HPA: crafting offtake strategies and purchase agreements
- Seas of opportunity: economics of hydrogen from offshore co-location
- A traded hydrogen market in Europe: what will prices and market structures look like?
- The economics of hydrogen imports: Better to stay local?
- Financing electrolysers: Overview of market trends in Europe

Country deep-dives

- The "13k mechanism" in Germany – price formation and its impact on hydrogen production
- Hydrogen in the NLD: From natural gas to green hydrogen hub
- The role of green hydrogen in the I-SEM
- Policies, regulation, and economics of green hydrogen in France
- The role of green hydrogen in Iberia
- Hydrogen for a Net Zero Great Britain
- Low carbon hydrogen in the Nordics
- Net Zero and the role of hydrogen for the Italian power system

Major deliverables of European Hydrogen Service in 2025

1) Existing reports are available in our EOS platform under the European Hydrogen Product

Source: Aurora Energy Research

Our updated European Hydrogen Market report is coming soon!

- HyMar, is a bi-annual update of the overview of attractiveness of the hydrogen market
- Scan the QR code or go to: https://auroraer.com/sector/hydrogen/hymar/ to sign up for the redacted slides

Full report available to subscribers on 11th April.

Agenda

I. Setting the scene: Hydrogen applications today and beyond

II. Policy incentives for demand

III. Short-term hydrogen demand outlook

IV. Long-term hydrogen market outlook

V. Key takeaways

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In Europe, current hydrogen demand is mostly driven by feedstock in refineries, ammonia, and methanol and is fulfilled by grey hydrogen

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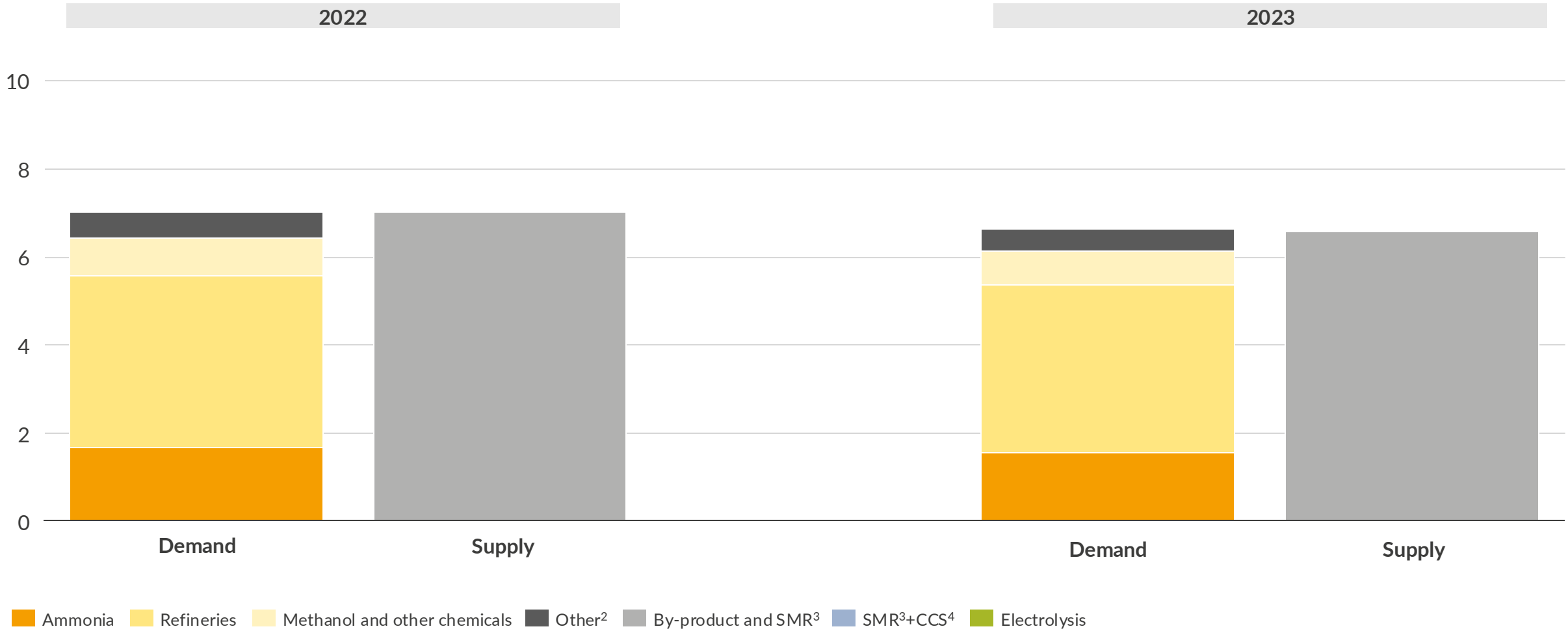
Historic hydrogen demand and supply-mix in Europe[1], with breakdown by sector and technology
million tonnes of H_2



1) Europe includes all countries covered in our Hydrogen Market Report (HyMaR) available on EOS; 2) Other includes other industry, mobility, heat, and gas blending; 3) SMR: Steam Methane Reforming; 4) CCS: Carbon Capture and Storage;

Sources: Aurora Energy Research, European Hydrogen Observatory

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

Widespread evolution of the hydrogen market from todays 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	Low carbon hydrogen ramps up while grey hydrogen is phased out gradually	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. Subsidies required in some regions	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[1] are increasingly used to secure financing, while subsidies remain crucial in many regions	Liquid trading in the 2040s allows financing of merchant projects

1) HPA: Hydrogen purchase agreement;

Source: Aurora Energy Research

In the near-term, renewable H_2 is expected to play a role in sectors with limited decarbonisation options, strong policy incentives and financial support

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Sector	Drivers	Bottlenecks	Alternatives[3]	Policy incentives	Financial support[4]
Feedstock	▪ Existing infrastructure and demand for H_2 ▪ Mandates, targets, and financial support	▪ Cost	▪ Grey H_2		
E-fuels[1]	▪ Strong mandates encourage switch to e-fuels in certain sectors	▪ Cost	▪ Biofuels		
Steel	▪ H_2 needed to decarbonise primary steel	▪ Costly upfront charges for producers to switch ▪ Secondary steel has cheaper alternatives	▪ Electrification ▪ Natural gas + CCS		
Industrial process heat	▪ H_2 is a promising option for high-grade heat decarbonisation, despite the development of electrification technologies	▪ Cost ▪ Low, mid industrial heat has cheaper alternatives	▪ Electrification ▪ Biofuels		
H_2 in power	▪ Key policy drivers are progressing, though recent setbacks have occurred	▪ Cost ▪ Lower efficiency ▪ Lack of infrastructure	▪ Batteries ▪ Pumped hydro storage ▪ Other power[2]		
Space heating	▪ Little-to-no industry-wide driver in near-term	▪ Cost ▪ Lower efficiency ▪ Lack of infrastructure	▪ Electrification ▪ Biofuels		
Rail transport			▪ Electrification		
Road transport			▪ Electrification		

Report focus

Hydrogen will play a role in sectors with limited or costly decarbonisation options. However, renewable / low-carbon hydrogen remains expensive compared to current methods, making mandates, subsidies, and penalties essential to closing the cost gap and driving demand.

No direct H_2 policy policies · Policy incentive exist in few EU +/ GBR countr · Targets exist without penal s · Mandates with pe ties · Direct s port · Partial pport · No support

1) E-fuels include e-ammonia, e-kerosene, e-methanol, e-methane, etc., and are used in the maritime and aviation sectors; 2) This includes, but is not limited to, RES, nuclear, biofuels, fossil fuels, etc.; 3) Fossil fuel alternatives are not considered except for carbon capture storage application and grey hydrogen in the feedstock sector; 4) For feedstock and e-fuels we assume financial support comes from a myriad of support, including support from European H_2 Bank auction, CCfDs, IPCEI projects, etc.;
Source: Aurora Energy Research

In the near-term, renewable / low carbon H_2 demand will hinge on whether the funding gap between the LCOH and willingness to pay can be closed

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The "missing money" problem for renewable / low carbon hydrogen

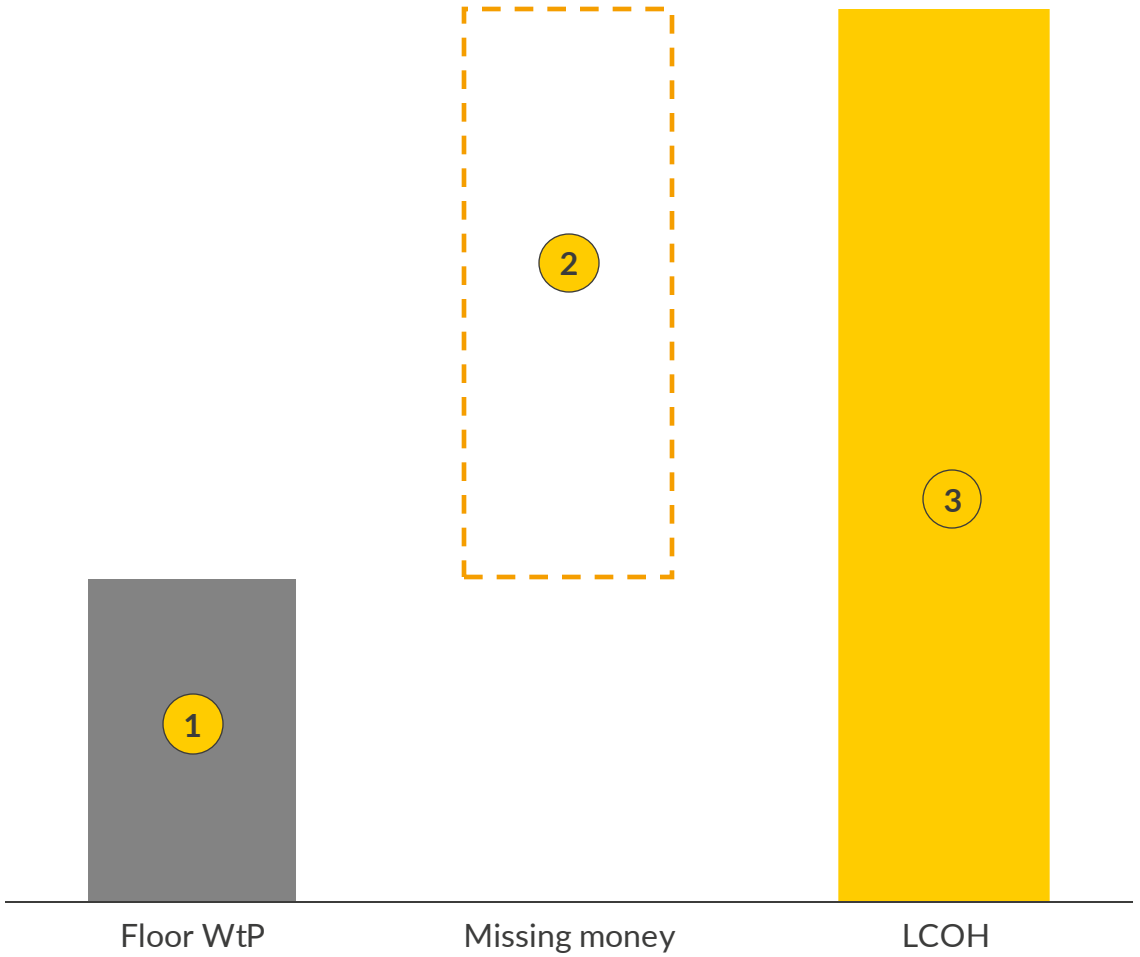
1. The "floor" willingness to pay (WtP) is the minimum price hydrogen must reach to match the cost of the competing reference technology.
   - From a techno-economic perspective, offtakers adopt low-carbon H_2 only if its production costs are equal to or lower than the reference technology.
2. Assuming cost parity, the difference in non-H_2 costs represents the amount offtakers are willing to pay for H_2, which defines the "floor" WtP.
   - Additional costs beyond WtP for renewable / low-carbon hydrogen can be offset through green premiums, subsidies, or avoided penalties to fill the "missing money" gap.

3 Levelised cost of hydrogen (LCOH) components

Renewable / low carbon hydrogen LCOHs include:

- **Electrolyser:** Electrolyser CAPEX
- **Power procurement:** RES asset's CAPEX and OPEX or cost of power purchase agreement and grid charges
- **Storage (offtaker and electrolyser business model dependent):** Used to address the mismatch between production and offtake profiles
- **Other :** Grid connection costs and fixed operating and maintenance costs for the electrolyser

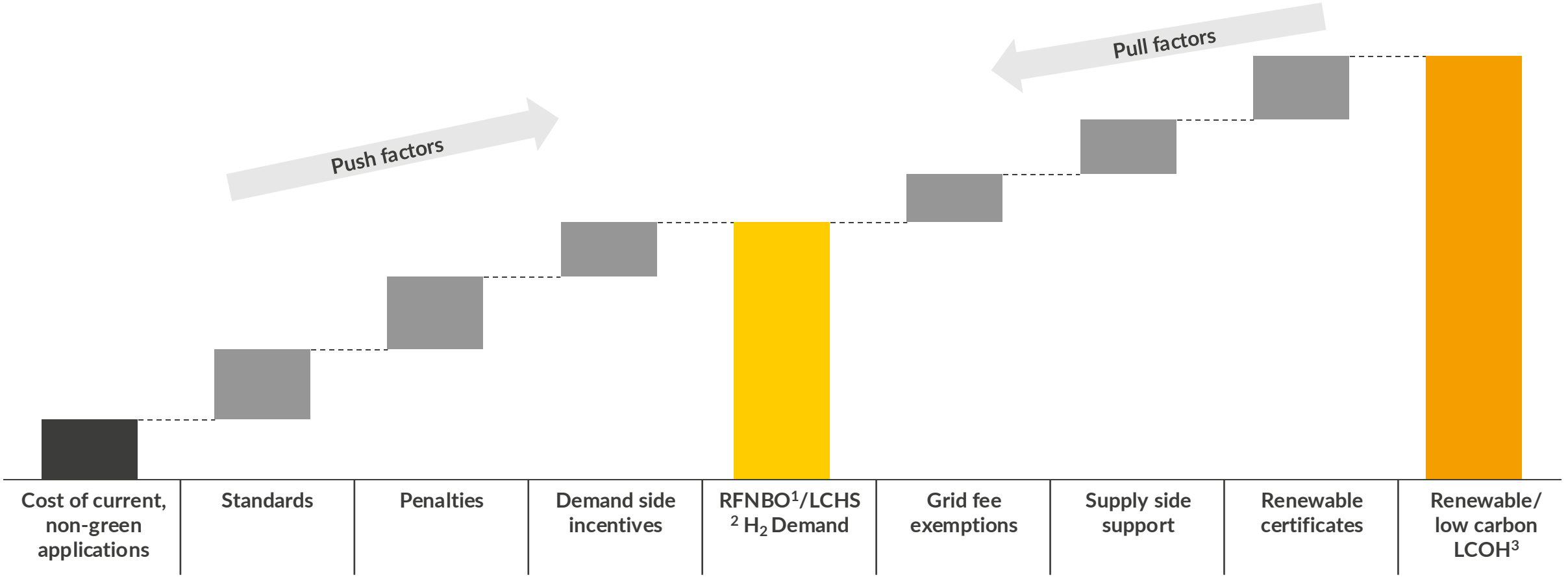
Illustrative graph for determining WtP for renewable / low carbon H_2



Source: Aurora Energy Research

The “missing money” needed to increase renewable hydrogen demand can be bridged with the help of multiple, complimentary policy frameworks

Building a renewable/low carbon hydrogen economy requires complementary policy frameworks. Push factors, like penalties, drive demand by enforcing adoption, while pull factors, such as supply-side support, lower costs and boost market uptake. Together, they form the hydrogen demand in Europe, by bridging the gap between the renewable / low carbon levelised cost of hydrogen (LCOH) and willingness to pay (WtP).



1) RFNBO: Renewable Fuels of Non-Biological Origin; 2) LCHS: Low Carbon Hydrogen Standard; 3) LCOH: Levelised cost of hydrogen;

Source: Aurora Energy Research

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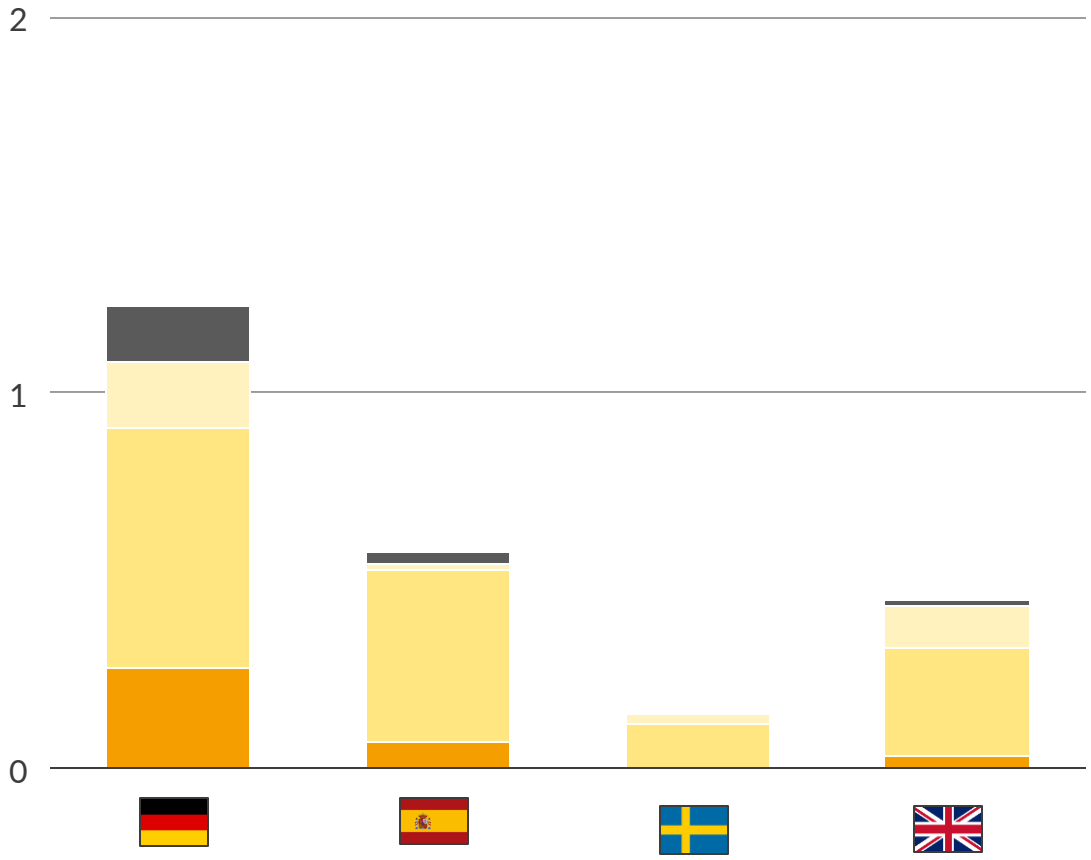
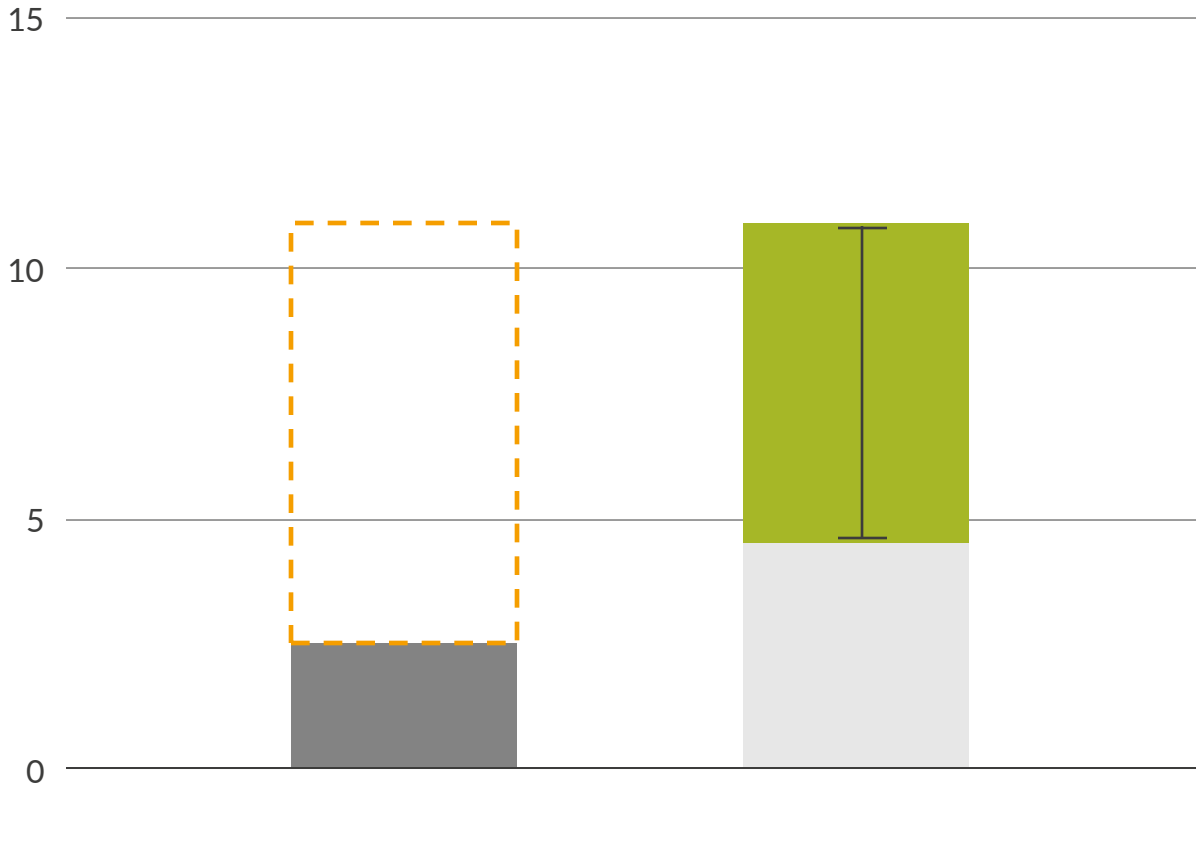
Current H_2 applications could be early adopters of low-carbon / renewable H_2 due to available mandates and high, pre-existing demand volumes

Current grey hydrogen demand for feedstock in key European countries
million tonnes of H_2



Illustrative chart: Levelised cost of H_2 (LCOH) for grey vs. RFNBO[1] H_2, in 2030
€/kg H_2



Ammonia | Refinery | Methanol and other chemicals | Other[2] | Grey LCOH | RFNBO LCOH range for all four countries | Missing money

1) RFNBO: Renewable Fuels of Non-Biological Origin; 2) Other includes other industry, mobility, heat, and gas blending;

Sources: Aurora Energy Research, European Commission, UK government

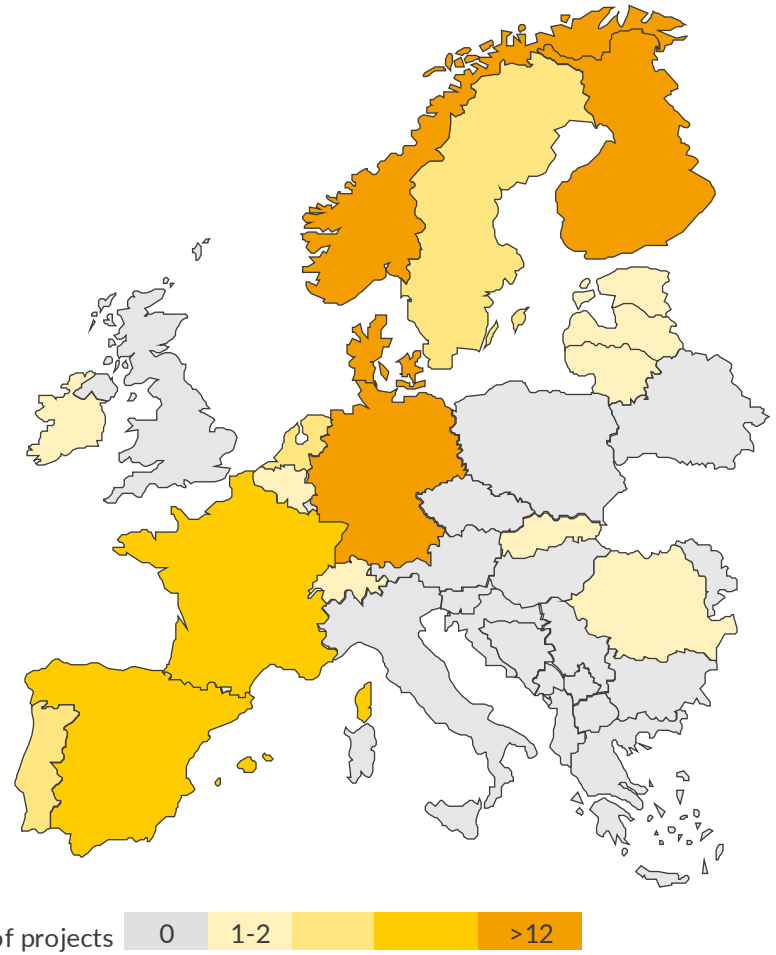
Mandates and support for maritime and aviation are expected to drive near-term demand for renewable / low carbon hydrogen

E-fuels in the transport sector compete with other decarbonisation alternatives

E-fuel	Transport applications	Production maturity[1]	Possible key alternatives
E-ammonia	▪ Shipping	High	▪ Fossil fuels + CCS ▪ Bio-fuels
E-kerosene	▪ Aviation	Low	▪ Bio-fuels
E-methanol	▪ Shipping	High	▪ Fossil fuels + CCS ▪ Bio-fuels
E-methane	▪ Shipping ▪ Road vehicles	Medium	▪ Hydrogen ▪ Bio-fuels ▪ Electrification ▪ Fossil fuels + CCS

Distribution of hydrogen projects[2] with a focus on e-fuel production in Europe[3]

of projects



Low Medium High

1) Based on current status of system integration and process technology, existing plants, and novelty; 2) Commercial projects with at least 1MW electrolyser capacity, including early-stage projects; 3) Taken from the electrolyser database available on Aurora's EOS platform here;

Sources: Aurora Energy Research, European Commission, UK government

Renewable hydrogen will be needed to decarbonise primary steel, with subsidies needed to help bridge the cost gap in production

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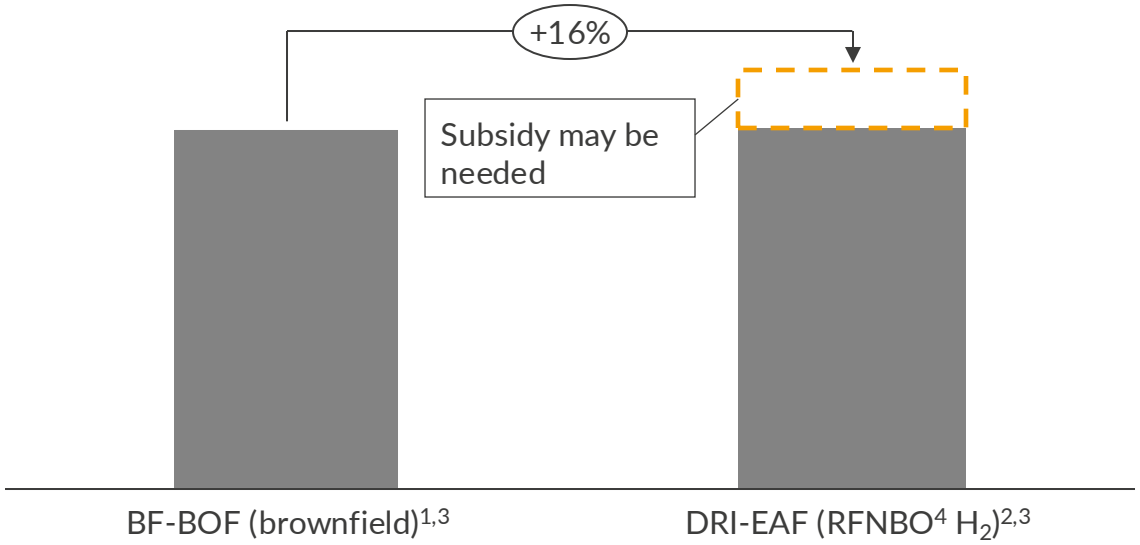
Types of steel

Report focus

	Primary steel	Secondary steel
Raw materials	Iron ore and reducing agent	Recycled steel (hot metal, metal scraps, sponge iron)
Process	Uses a blast furnace (BF) or direct reduced iron (DRI)	Electric arc furnace (EAF) or induction furnace
Energy usage	●	◑
Cost	●	◑
Decarbonisation	H_2	Electrification via RES

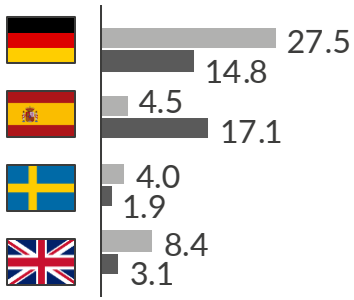
Illustrative chart: cost of primary steel in Germany (2030) via varying processes

€/tonne crude steel



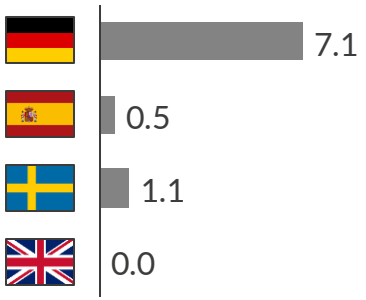
Total steel production capacity in the focus countries, 2021

Mt



Total current H_2 subsidies in the focus countries for primary steel

€ billion



Primary steel Secondary steel ● High ◑ Medium

Gas-hydrogen blending

Steel plants will start with a natural gas-hydrogen mix, transitioning fully to hydrogen as availability and affordability improve.

Natural gas RFNBO[4] hydrogen

1) BF-BOF: Blast furnace-basic oxygen furnace, this is the traditional process with coal as feedstock; 2) EAF: Electric arc furnace; 3) Traditional process assumes 15% scrap recycling while the DRI-based processes assume 50%; 4) RFNBO: Renewable Fuels of Non-Biological Origin;

Sources: Aurora Energy Research, EUROFER

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The uptake of renewable H_2 in Europe will be influenced by several factors, with cost being one of the most significant drivers

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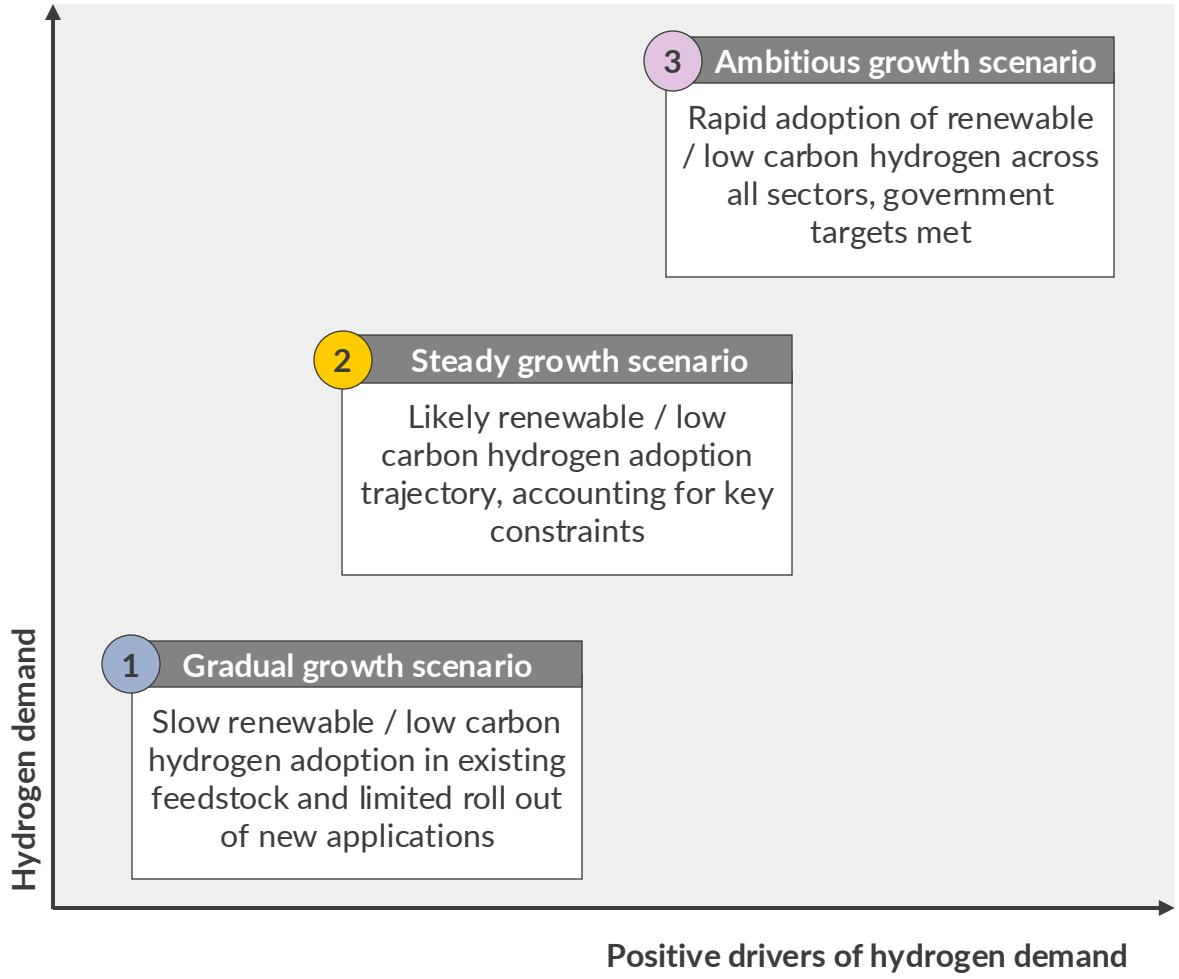
Drivers of renewable / low carbon H_2 demand in Europe

- **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 affects hydrogen demand.
- **Supply chains/skills:** Uninterrupted supply chain and skilled workers are needed, but less of a driver than cost, policy, and infrastructure.

The interaction of these drivers shapes the demand for renewable and low-carbon hydrogen, leading to different scenarios in our demand forecast.

Aurora has designed and assessed three demand scenarios that capture uncertainty in the renewable / low carbon hydrogen market



Source: Aurora Energy Research

We analysed the H_2 market uncertainties across three scenarios, forecasting demand based on project delays, fast sector adoption, and policy support

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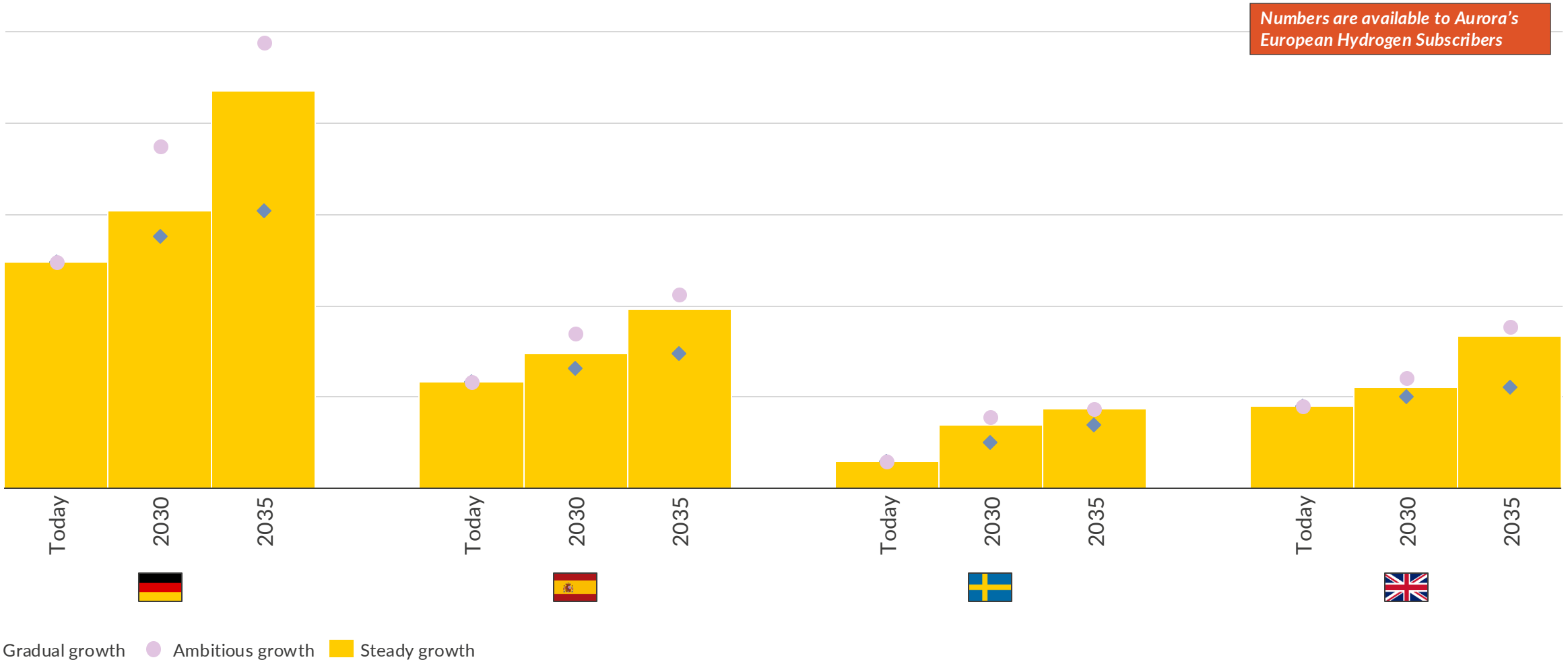
Total H_2 demand for all key countries across all scenarios
million tonnes of H_2



Sources: Aurora Energy Research

The subsidy gap could reach up to ~6 €/kg H_2 depending on the sector, with the highest gap seen for high-grade industrial process heat

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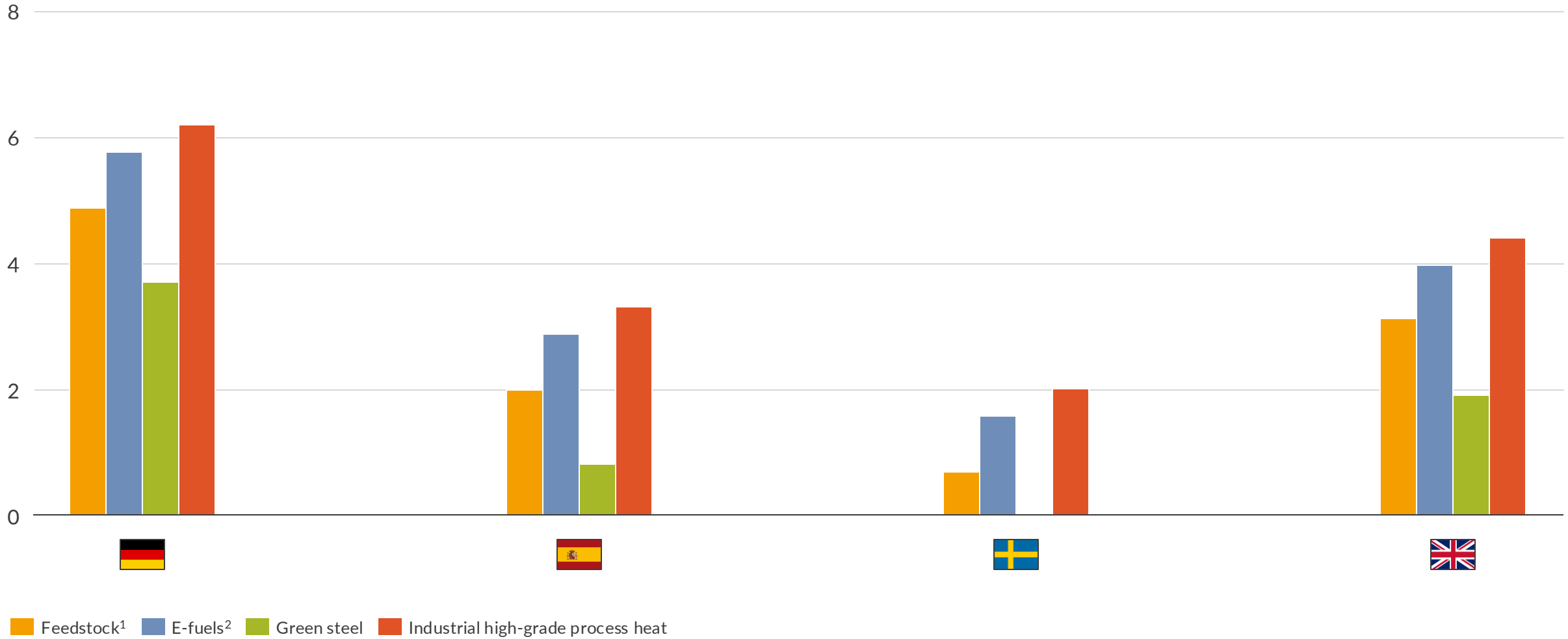
Missing money needed to close the gap between the willingness to pay (WtP) and levelised cost of renewable / low carbon H_2 (2030, steady growth scenario)

€/kg H_2



1) Feedstock includes refinery, ammonia, methanol, and other chemicals; 2) This has been calculated using the willingness to pay for e-kerosene;

Sources: Aurora Energy Research, Climate Change Committee

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Analysing the long-term European hydrogen market is subject to a wide range of uncertainties

Key uncertainties	Level of uncertainty	Impact
Electrolyser deployment	Medium	▪ Faster-than-expected electrolyser deployment may cause regional oversupply, lowering hydrogen prices by reducing reliance on costly imports. ▪ Bilateral HPAs[1] are still expected to be needed in the near-term which should balance supply/demand.
Blue H_2 deployment	High	▪ Blue H_2 has lower running costs than electrolytic hydrogen or imports in the near-term. ▪ Higher capacity than anticipated could put downward pressure on prices, but this is dependent on the evolution of commodity prices and efficiency improvements for this technology.
Phase out of grey H_2	Low	▪ Ambitious targets and mandates make it likely that grey hydrogen will be phased out within 1-2 decades. ▪ The impact on supply mix and prices is mostly limited to the 2020s where grey hydrogen still has a dominant role.
Demand for H_2 and e-fuels	Medium	▪ While there is a consensus that H_2 will be required to fully decarbonise certain sectors of the European economies, there is a high degree of uncertainty regarding its contribution in each individual sector.
Build out of hydrogen infrastructure	Medium	▪ Aurora believes pipelines such as the European Hydrogen Backbone are key for market efficient hydrogen transport across Europe. ▪ We assume Europe will be fully interconnected via pipelines by the 2040s; otherwise, regional price gaps may widen, and some hydrogen demand could go unmet.
Availability of cheaper H_2 imports from outside Europe	Medium	▪ Europe is engaging with high-potential hydrogen-exporting countries through initiatives like H2Global. While more countries may join, it remains uncertain if the necessary supply chains will materialize.
Security of supply restrictions for domestic H_2 production	Medium	▪ Current REPowerEU strategy targets to supply half of EU's demand through domestic production and half through imports. ▪ While in the future imports from outside could be cheaper than domestic production, it is likely that Europe ensures that a certain amount of production remains within the region.
Industrial offshoring of green steel	Medium	▪ Lower hydrogen prices and accessible materials could boost green steel competitiveness outside Europe, even with CBAM. ▪ This may result in green steel projects moving abroad and reduced domestic hydrogen demand.

Low uncertainty Medium uncertainty High uncertainty

1) HPA: Hydrogen purchase agreement

Source: Aurora Energy Research, European Union, European Commission

Hydrogen demand across Europe is expected to increase six-fold by 2060, ~30% will be met with domestic electrolytic production

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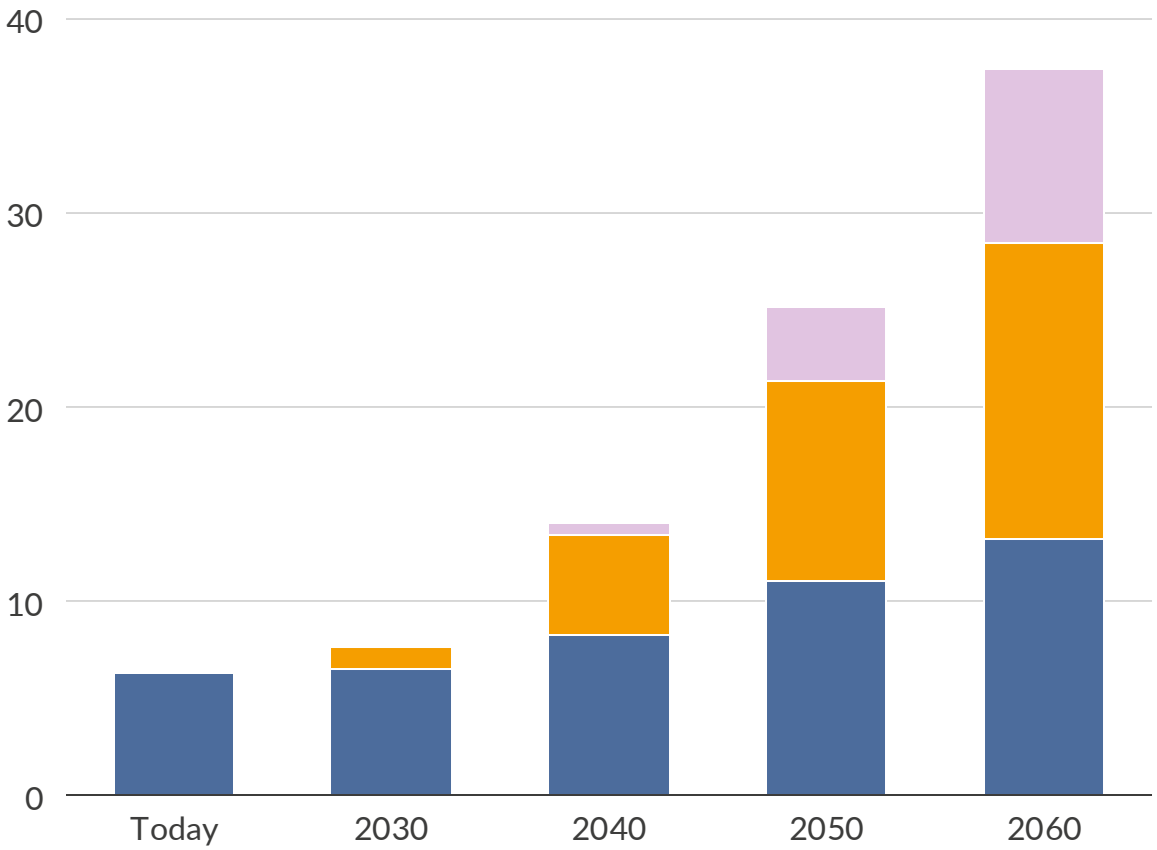
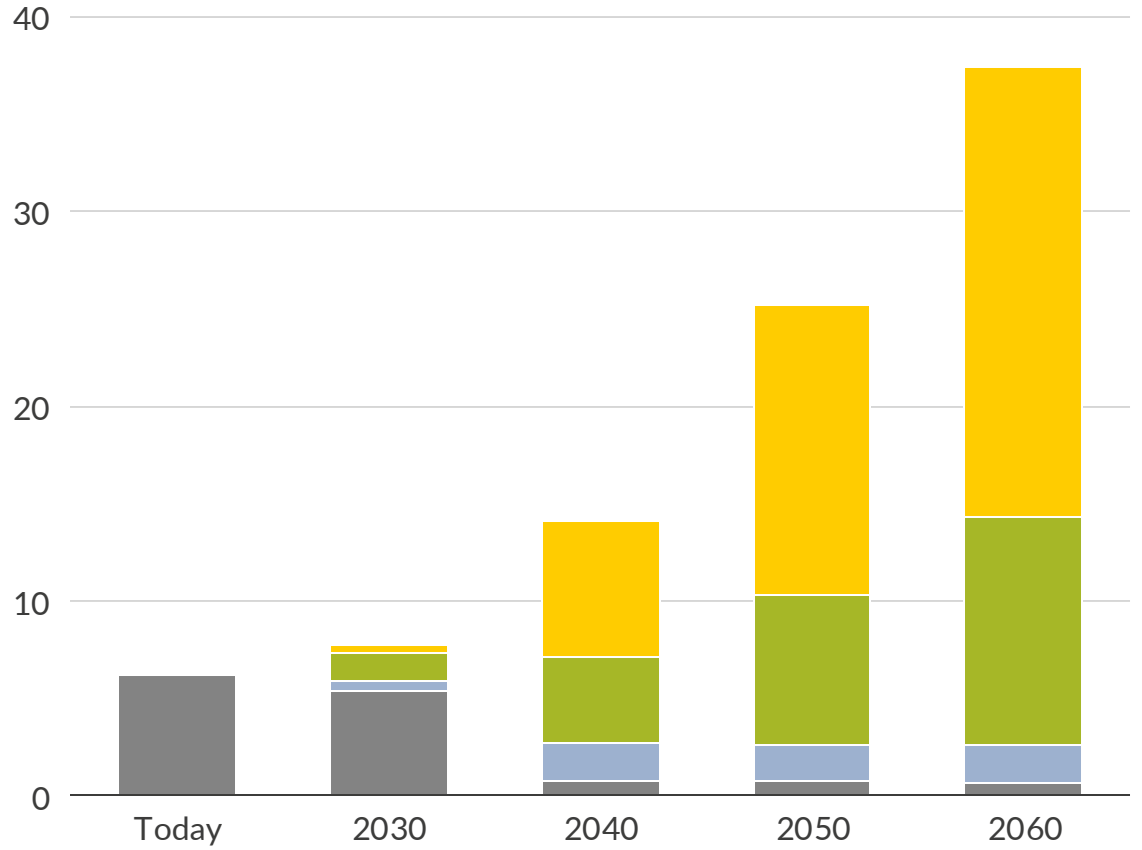
Demand assumptions for H_2 and derivatives[1] in Europe[2]
million tonnes of H_2, final energy consumption



Supply mix of H_2 and derivatives in Europe
million tonnes of H_2, final energy consumption



1) Hydrogen derivatives considered in this analysis cover ammonia, methanol, synthetic diesel, and synthetic kerosene; 2) European countries include BEL, DNK, DEU, ESP, FIN, FRA, GBR, IRL, ITA, NLD, NOR, POL, PRT, and SWE;

Sources: Aurora Energy Research, European Hydrogen Observatory

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Key takeaways

In Europe, hydrogen demand is currently met by grey hydrogen, used mainly in refineries, ammonia, and methanol production. Transitioning to renewable hydrogen will require policy support to close the cost gap between renewable and grey hydrogen. Key early adopters of renewable hydrogen include feedstocks (ammonia, refineries, methanol), e-fuels in aviation and maritime, and green steel.

Aurora analysed three hydrogen demand scenarios—Gradual Growth, Steady Growth, and Ambitious Growth—across Germany, Spain, Sweden, and Great Britain, accounting for market uncertainties. Aviation and maritime sectors are expected to adopt hydrogen due to strict mandates and heavy penalties. Feedstocks will likely transition to renewable/low-carbon hydrogen with mandates and financial support, while steel adoption will primarily rely on subsidies due to limited targets and mandates.

By 2035, hydrogen demand is expected to grow significantly across our four key countries. Achieving this demand will require additional funding to transition from today's fossil fuel-dependent hydrogen industry to more sustainable, low carbon alternatives.

Long-term hydrogen demand is highly uncertain, influenced by various market factors.

Source: Aurora Energy Research

Details and disclaimer

Publication
Short-term hydrogen demand: Who is buying renewable hydrogen?

Date
26th March 2025

Prepared by
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