AURORA ENERGY RESEARCH

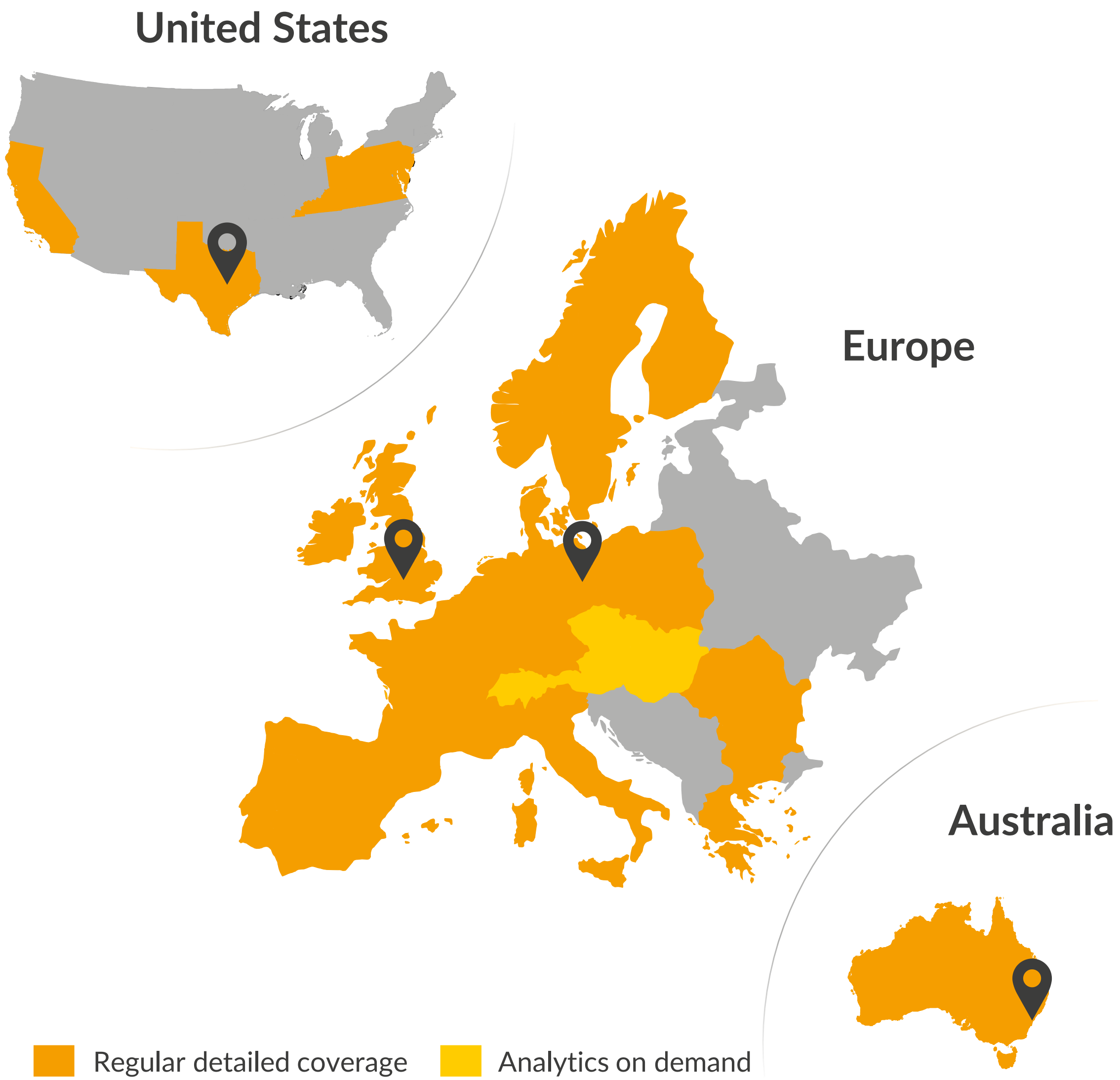
Hydrogen Market Attractiveness Report

Free report

2nd November 2021

Aurora provides data-driven intelligence for the global energy transformation

- Power markets
- Renewables
- Storage
- Electric vehicles
- Hydrogen (H_2)
- Carbon (CO_2)
- Natural gas



4 Offices
Oxford | Berlin | Sydney | Austin

180+
market experts

350+
subscribing companies

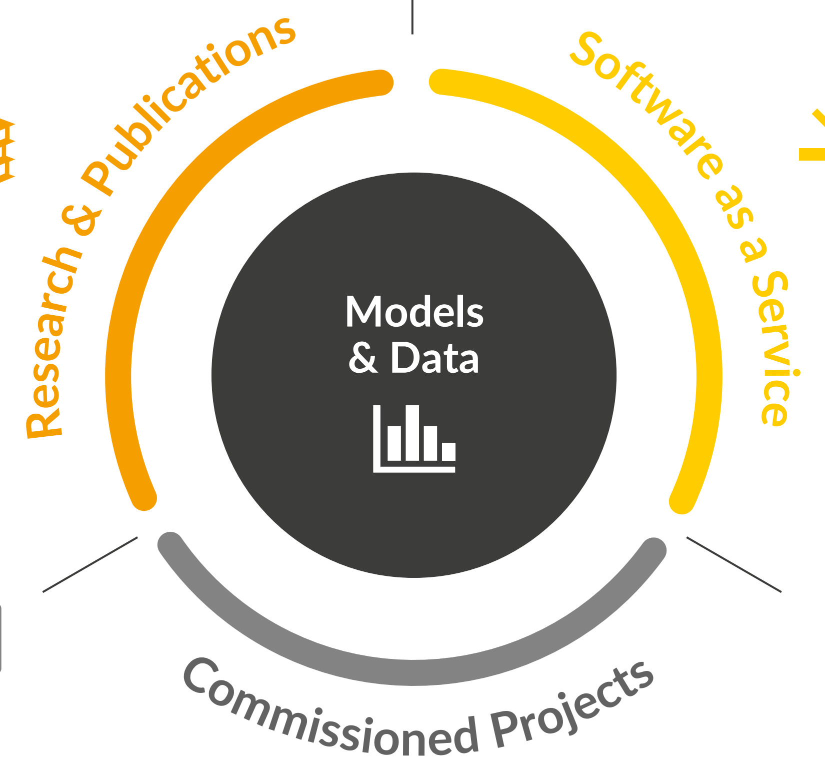
100+
transactions supported in 2020

Source: Aurora Energy Research

Aurora brings a sophisticated approach to the provision of analysis and insight to the energy industry

Research & Publications

- Industry-standard market outlook reports and price forecasts for power, gas, carbon and hydrogen markets
- Strategic insights into major policy questions and new business models
- Read and constantly challenged by 350+ subscribers from all industry sectors



Software as a Service

- Cloud-based tools for quick, accurate, asset- and site-specific valuations using Aurora's trusted forecasts
  - First-of-a-kind wind valuation tool launched in 2019 and already widely adopted in GB, Germany, Ireland, France, Iberia, Poland and Australia

Commissioned Projects

- Bespoke analysis, drawing upon our models and data
- Trusted advice for all major market participants proven in 400+ projects: transaction support, valuations, strategy & policy engagement

Models & Data

- Market-leading long-term models for power, gas, hydrogen carbon, oil and coal markets
- Continuous model improvements through client feedback

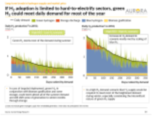
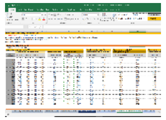
Source: Aurora Energy Research

Our European Hydrogen Market service offers regular insights, policy/market updates & roundtable discussions

Hydrogen Market Attractiveness Report (HyMAR)

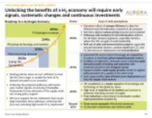

- Summary of policy developments and incentives across Europe
- Global electrolyser project database
- Hydrogen market sizing: demand scenarios by country and sector
- Analysis of demand and supply drivers

Strategic Insight Reports

- Regular insight reports on topical issues in the evolving European hydrogen market covering country, policy and technology deep dives
- Upcoming reports on next slide

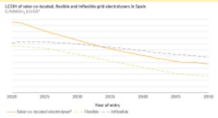
Policy updates & thought leadership




- Regular updates on European Hydrogen policies and incentives across power, heat, transport and industry
- Thought leadership on required policies and incentives to grow hydrogen sector

Access anytime via EOS online platform

Investment case analysis



- Hydrogen production economics based on Aurora's in-house power, gas and carbon price forecasts
- Granular electrolyser business cases, including optimised grid-connected and renewables co-located models
- For use in strategy formulation, transactions and JV negotiations

Group Meetings

- Presentation of Market Attractiveness reports and Strategic Insight reports
- Networking opportunity with developers, investors and Governments – the 'go-to' roundtable to discuss hydrogen developments in Europe

Workshops and analyst support


- Bilateral workshops to discuss Aurora's analysis and specific implications
- Ongoing analyst support to answer questions about our research

For more information, please contact
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+44 (0) 07425 647505

Source: Aurora Energy Research

Timeline of strategic insight reports and policy updates

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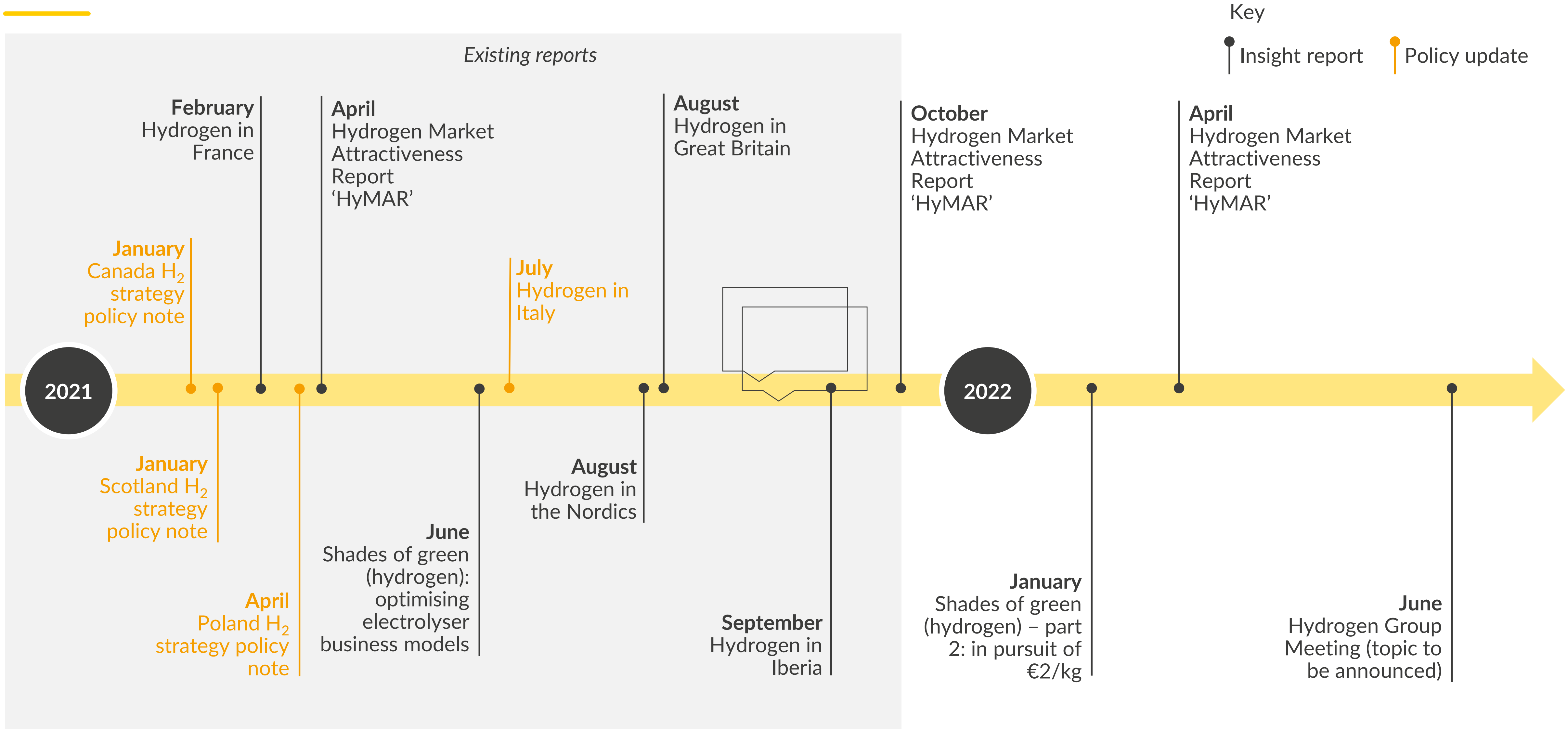

All reports are available to subscribers of Aurora's European Hydrogen Service

Source: Aurora Energy Research

Aurora is already providing hydrogen market analysis to major players across the value chain

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Utilities & Renewables

- EDF Energy
- RWE
- e.on
- uniper
- CEZ GROUP
- sse
- steag
- Trianel
- eew Energy from Waste
- ONYX POWER
- TRITON POWER
- eregio
- VIRIDI
- NICE SOLAR ENERGY
- axpo
- Ørsted
- BSR Energy
- amp
- rhenag EnergieBündel. Seit 1872.
- fortum
- edp
- octopus energy
- SWH. Stadtwerke Halle
- SCOTTISHPOWER
- centrica

Supply Chain

- BASF We create chemistry
- BOC Member of The Linde Group
- urenco The Energy to Succeed
- ITM POWER Energy Storage | Clean Fuel
- SIEMENS
- SALZGITTER AG Stahl und Technologie
- MITSUBISHI POWER
- Port of Rotterdam

Financiers

- PJT Partners
- 丸紅株式会社 Marubeni
- KOMMUNAL KREDIT
- BlackRock
- BlueWaterEnergy
- SEB
- BARCLAYS
- meridiam INVESTING FOR THE COMMUNITY
- low carbon powering tomorrow

Government & regulation

- Schweizerische Eidgenossenschaft / Confédération suisse / Confederazione Svizzera / Confederaziun svizra
- Ministerie van Economische Zaken en Klimaat
- JETRO JAPAN EXTERNAL TRADE ORGANIZATION
- Department for Business, Energy & Industrial Strategy
- Bundesnetzagentur
- CREG
- Committee on Climate Change
- Department for Transport
- National Infrastructure Commission

Upstream gas and networks

- Shell
- equinor
- Naturgy
- OGE
- nationalgrid
- Thyssengas
- Vitol
- fluxys

Source: Aurora Energy Research

Contents

Source: Aurora Energy Research

Germany, Netherlands and the UK remain the most attractive to invest in for low-carbon hydrogen; Sweden and Norway improve in this update

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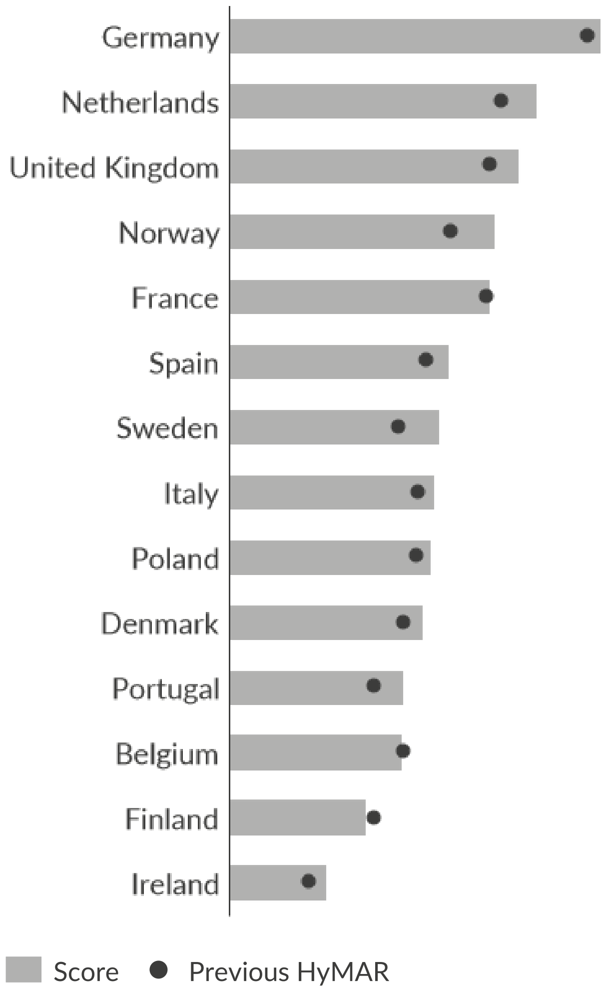
Country	Rank		Previous Rank	Comments
Germany	1	=	1	
Netherlands	2	=	2	
United Kingdom	3	=	3	
Norway	4=	▲	5	Considered cheaper than France for hydrogen production
France	4=	=	4	Now equal fourth with Norway
Spain	6	=	6	
Denmark	7	▲	10	Extremely low cost renewable electricity for H_2 production
Sweden	8	▲	11	Consideration of blue hydrogen in policy category benefits Sweden
Italy	9	▼	7	Displaced by Sweden and Denmark
Poland	10	▼	8	
Portugal	11	▲	12	Low cost hydrogen production via solar modelled by Aurora
Belgium	12	▼	9	Displaced by Sweden and Portugal
Finland	13	=	13	
Ireland	14	=	14	

Overall Scores[1] and changes since April 2021 (out of 100)



1) Full score breakdown is available to subscribers of our European Hydrogen Service

Source: Aurora Energy Research

Aurora's Hydrogen Market Attractiveness Rating (HyMAR) combines indicators to derive an overall attractiveness score

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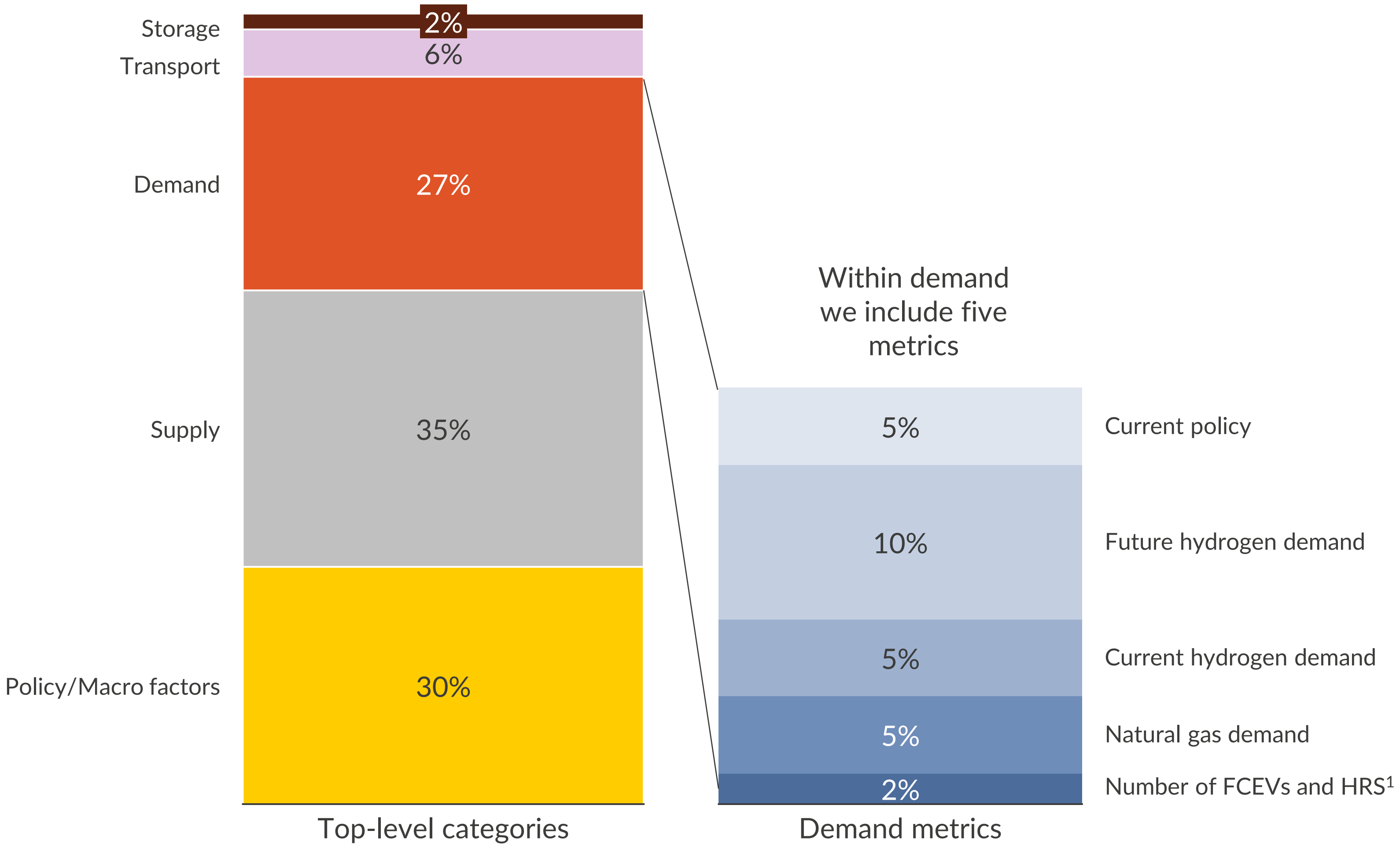
How we score countries



We collected data on 23 metrics on which to compare countries for their attractiveness for hydrogen

These metrics ranged between policy, regulatory and macroeconomic factors, drivers for supply and demand, and potential to transport and store hydrogen

1) Fuel Cell Electric Vehicles and Hydrogen Refueling Stations

Source: Aurora Energy Research

Contents

Source: Aurora Energy Research

Four major policy announcements are investigated in detail in our HyMAR report for October

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Timeline of previous hydrogen policy announcements

June
Germany defines green hydrogen in its "Renewable Energy Sources Ordinance (EEV)". According to the ordinance, green hydrogen is produced electrochemically by using renewable energy sources. Electrolysers can be waived from the EEG levy up to 5,000 hours of operation, beyond that they should pay the levy even if powered by renewables.

October
Germany announces modelling of hydrogen gas networks along with legislative framework for pricing models – along with plans to auction off new parcels of economic exclusion zone and subsidies for hydrogen production.

April

October

July
The UK extends support for hydrogen as a transport fuel – by adding subsidies for producers of maritime, rail, and other non-road hydrogen fuel.

August
The UK publishes its Hydrogen Strategy – confirming nearly a billion pounds of incentives.

Sources: Aurora Energy Research

The UK's Hydrogen strategy is comprehensive, but some European countries are already ahead in developing their plans and incentives

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- The UK government published its hydrogen strategy on 17th August 2021
  - The UK joins other major economies including Germany, France, Canada, and the Netherlands, who had already published strategies in 2020
- The UK government plans to reduce the market risk of low-carbon hydrogen for producers by introducing a **CfD-like variable premium**, which will remain in place until a liquid hydrogen market is formed
  - The consultation opened in August and closed on the 25th of October– other countries have already enacted similar policies like the SDE++ in the Netherlands, which completed its first round on June 8th
- The strategy outlines up to **£961 million of funding for hydrogen-related projects**, of which one-third is for hydrogen production projects and one-third for end-users in the industrial sector
  - While this is impressive, Norway has committed to spending nearly EUR1 billion on a single project. Other countries such as Germany and France have both committed 7 billion euro, but not necessarily as structured as the UK's commitment
- **The UK re-iterates its target for 5 GW of installed low carbon hydrogen production capacity**. According to Aurora's electrolyser database, the United Kingdom pipeline of electrolyser projects alone by 2030 is close to its 5 GW target, at over 4 GW[2] which suggests its target could be increased further
  - Only France has made a larger pledge than this
- **The United Kingdom will introduce its own standard for low-carbon hydrogen in 2022**. Aurora expects this standard will be less stringent than the EU Taxonomy, in order to include blue hydrogen
  - Hydrogen exports from the UK will need to meet the carbon intensity thresholds set by the importing countries. It is unclear whether the UK's standard will differ from other incoming hydrogen standards
- The UK's Heat and Buildings strategy, released on October 19th, reiterates that a **final strategic decision will be made on hydrogen heating in the UK after the completion of the hydrogen neighbourhood and village trials in 2026.** This was first announced in the hydrogen strategy.
  - In the short term, incentives will be offered to those installing heat pumps, lowering the potential share of heating hydrogen can fulfil in the future if uptake is significant

1) Full report and analysis of the UK hydrogen strategy is available to subscribers of our European Hydrogen Service 2) Does not include blue hydrogen projects

Source: Aurora Energy Research

Contents

Source: Aurora Energy Research

Aurora's global electrolyser database identifies 342.9 GW of planned projects globally, an increase of 91.4 GW since April 2021

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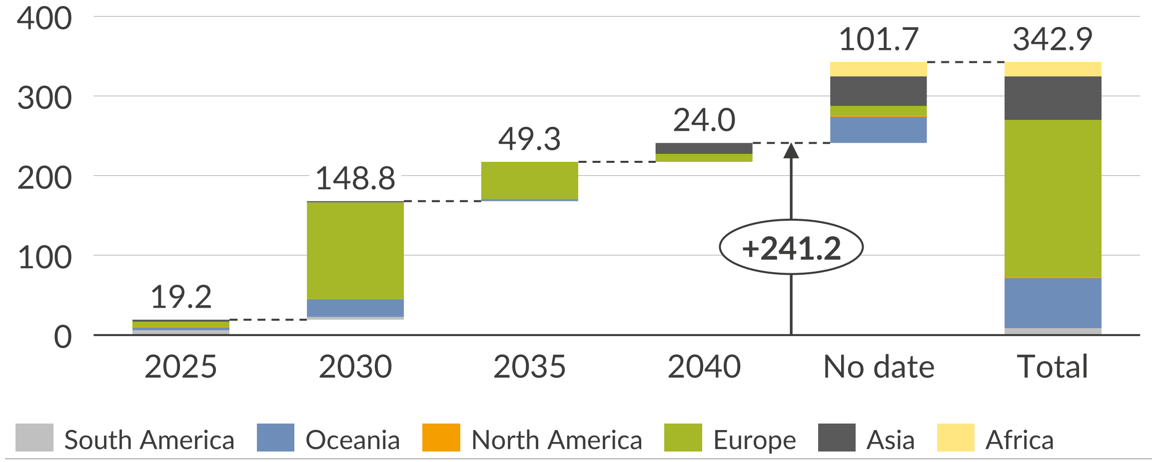
The electrolyser project pipeline is ramping up in number and size of projects

- Aurora's electrolyser database aggregates information on actual and planned projects from industry announcements and academic sources. It identifies 342.9 GW of planned projects globally, with 200.7 GW planned for deployment in Europe
- 67 new electrolyser projects have been added to our database since HyMAR April 2021, representing 91.4 GW (+36%) of additional electrolyser capacity
- 3 particularly large giga-scale projects have been announced in the last 6 months: Kazakhstan (30 GW), Western Green Energy Hub in Australia (28 GW), and Aman in Mauritania (18 GW)
- Globally, Gasunie, ENGIE, Endesa are named partners on the most projects, each on more than 10 projects

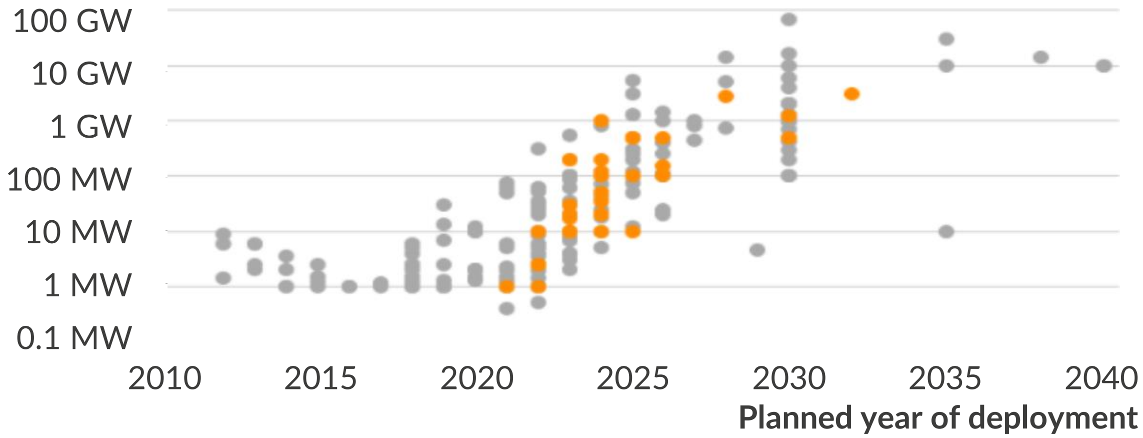
Global cumulative electrolyser project capacities by continent

GW

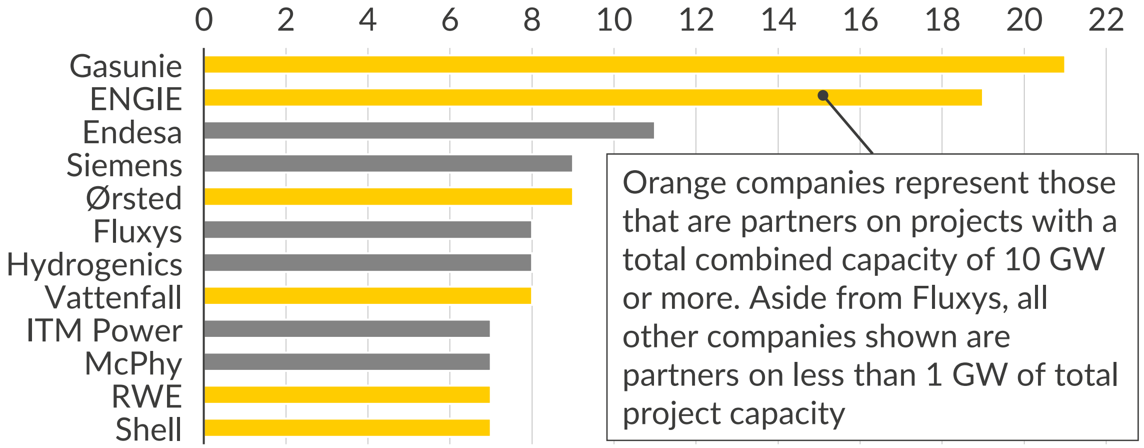


Planned H_2 electrolyser installations (by year)

MW/GW



Number of projects by company globally



1) Aurora's Global Electrolyser Database is available to subscribers of our European Hydrogen Service

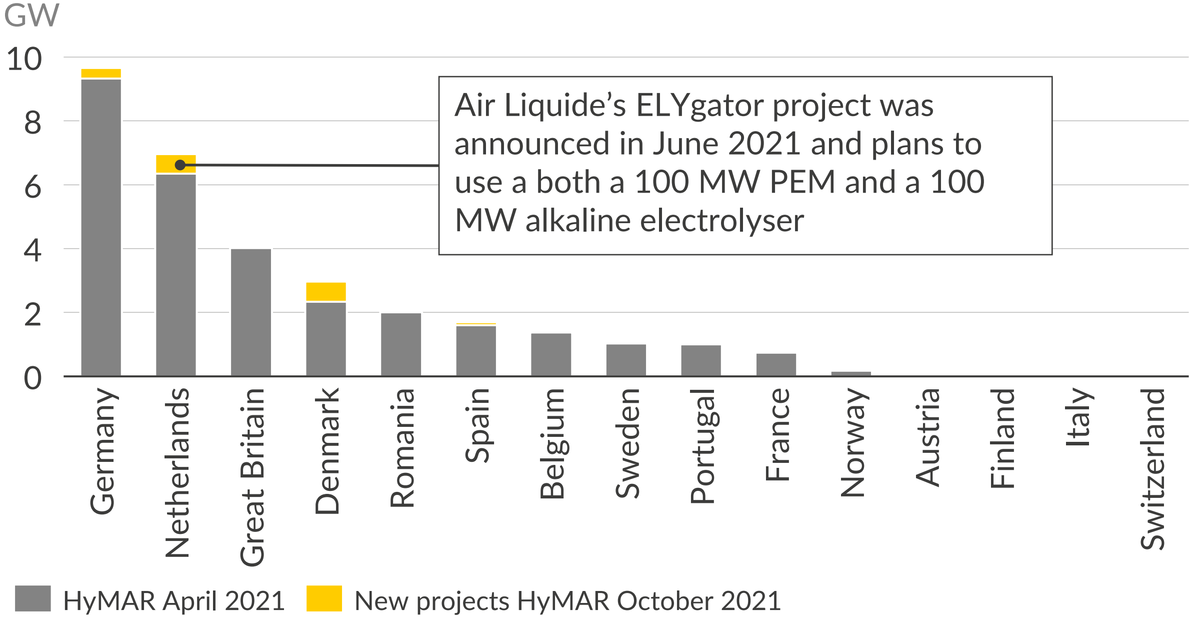
Source: Aurora Energy Research

New green hydrogen projects since April 2021 have been concentrated in Germany, the Netherlands and Denmark

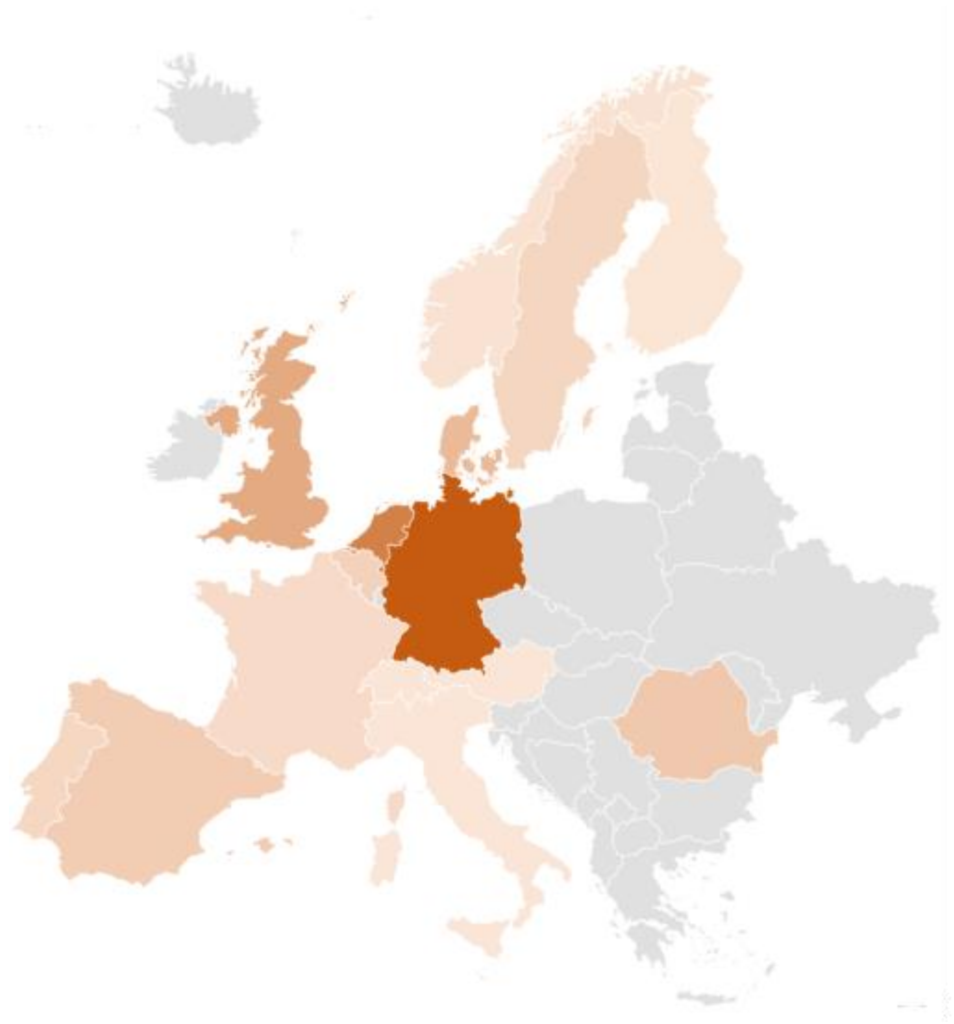
Denmark has announced the most new electrolyser capacity, followed by the Netherlands then Germany

- The countries with the largest pipeline of electrolyser projects – Germany, Netherlands, Denmark, Spain – continue to announce the largest new green hydrogen projects
- The Netherlands has announced six projects with an average size of 111 MW (ranging from 10 MW – 200 MW) in the last 6 months
- Since April HyMAR, the total pipeline of projects planned to commission by 2040 in Europe has increased from 187 GW to 201 GW

European cumulative electrolyser project capacities



Electrolyser project pipeline by 2030 (early stage projects excluded)



Aurora's global electrolyser database identifies a pipeline more than triple the size of the EU's 40 GW pledge for 2030

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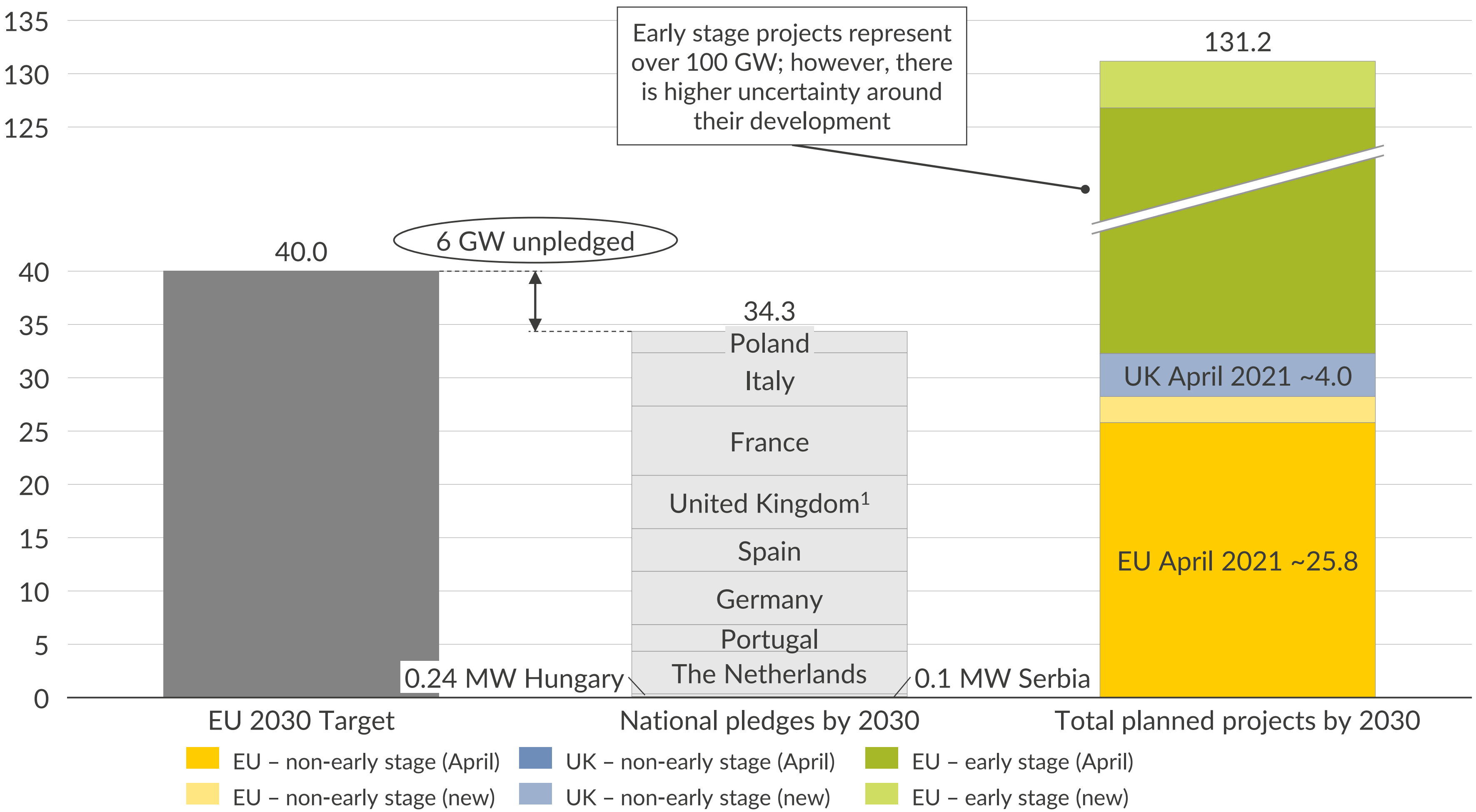
Current H_2 electrolyser capacity pledges and actual planned construction by 2030
GW



- In its strategy, the EU aims for at least 40 GW of electrolyser capacity across Europe by 2030
- 34 GW of electrolyser capacity across Europe has already been pledged by eight countries towards the 2030 target
- ~32 GW of projects across Europe are in more advanced planning phases with target commissioning dates by 2030
- Since April HyMAR, ~2.4 GW of planned electrolyser capacity has been added in EU countries and 36 MW added for the UK
- The largest single announcement was the "Green fuels for Denmark" hydrogen project at 1.3 GW
- Early-stage projects have the potential to add over 100 GW additional capacity (but timing is less certain)

1) The UK left the EU on January 31, 2020, and the target is for 5 GW of low carbon hydrogen production, not limited to electrolysers. 2) The Global Electrolyser Project Database is available to subscribers of our European Hydrogen Market Service

Sources: Aurora Energy Research, LBST International Hydrogen Strategies, National Hydrogen Strategies

Wind and hybrid solar-plus-wind projects power 95% of the planned electrolyser capacity for projects in Europe

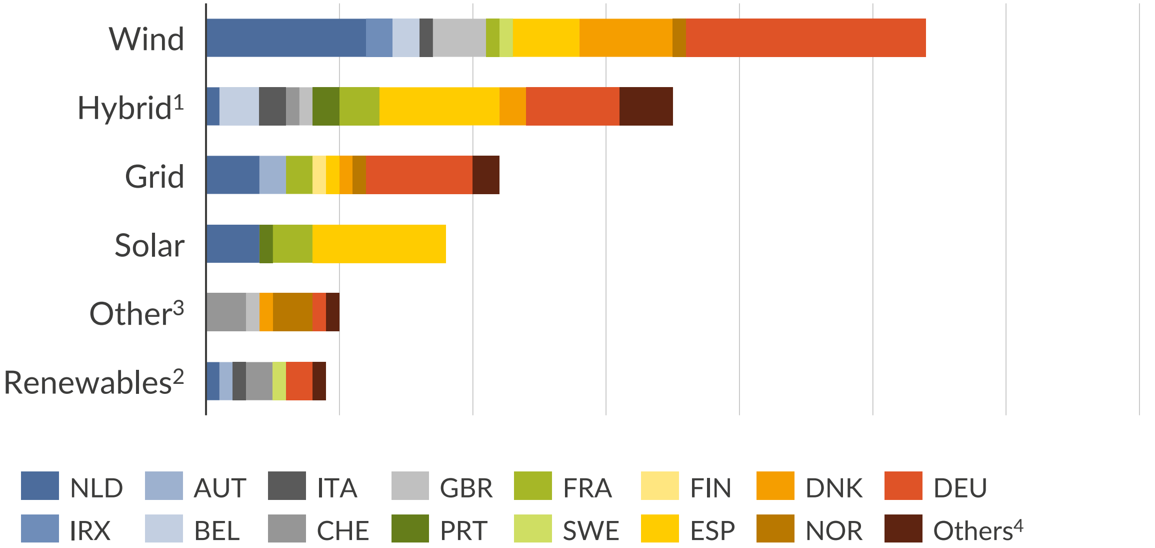
Wind has been the most popular power source for projects announced in the last six months

- **Globally**, 208 projects out of 308 indicate a power source; however, only 46% of the European projects indicate the power source
- Since HyMAR April 2021, **wind was the most frequently chosen power source,** adding eight new projects. This was followed by **Solar**, **Other and Renewables** all adding three new projects
- Aurora's modelling suggests electrolysers co-located with renewables consistently have lower LCOH than grid connected electrolysers

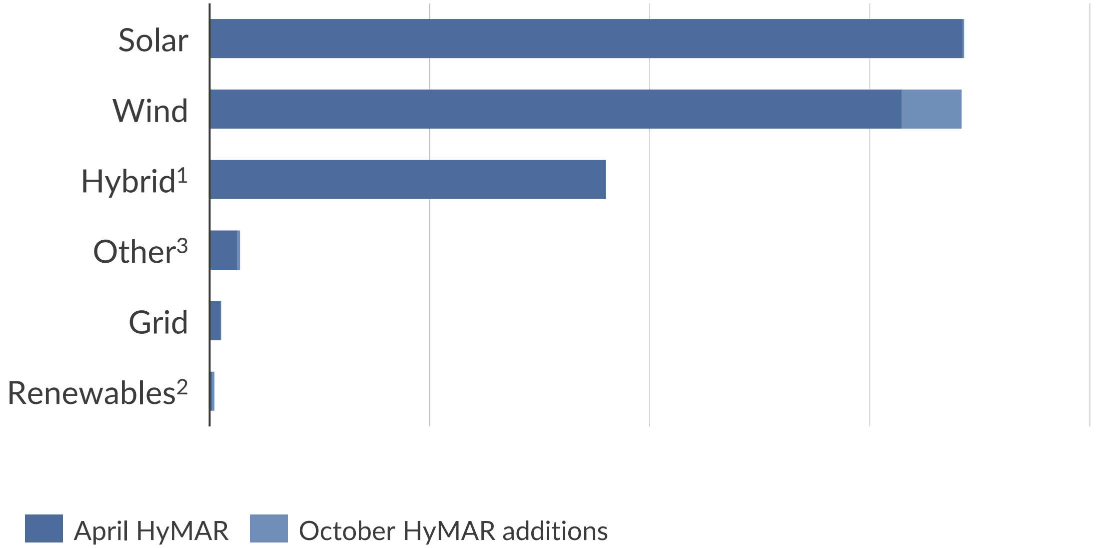
Solar, wind or a combination of the two (hybrid) are the favoured power source for the vast majority of planned project capacity in Europe

- **Hybrid** solar-plus-wind was the power source of choice in 14 countries in Europe, trailed by **wind** energy in 11 countries and **grid** connected in 10
- **Solar** was only specified as a power source in four countries: Spain, Portugal, France and the Netherlands
- Projects with solar, wind or hybrid power sources represent the majority of the planned project capacity for projects with a power source specified
- Wind-powered projects added 5.4 GW of capacity since April

Number of projects by power source for European countries



Capacity of projects by power source in Europe, GW



1) "Hybrid" projects are those that are powered by both solar and wind 2) "Renewables" projects are those that only indicate the power comes from renewables. **Renewables** projects were vaguely defined but have the potential to be grid connected projects supplied by a PPA. This category does not overlap with any of the other categories 3) "Other" power sources includes hydropower, energy from waste and geothermal 4) "Others" includes CZE, GRC, ISL, SVK, PRT, HUN

Source: Aurora Energy Research

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Source: Aurora Energy Research

Aurora has analysed four distinct electrolyser business models – one of which is currently included in the HyMAR rating

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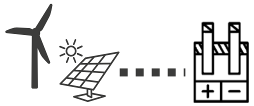

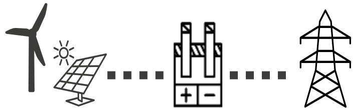

	Inflexible Electrolyser	Flexible Electrolyser	Co-located (Island)	Co-located (Grid)
Description	▪ Grid electricity **only** and runs at **95%** load factor	▪ Grid electricity **only** and ability to choose operating hours to minimise LCOH[2]	▪ Electrolyser connected to renewable asset only (no grid connection)	▪ Electrolyser connected to grid plus direct connection to RES asset
Key drivers	▪ Can **decouple electrolyser location from RES location** to be closer to demand ▪ Possible to 'green' power via GoOs/PPAs[1] ▪ High load factor achievable ▪ Produces regular output of hydrogen	▪ **'Smart' operation** avoids periods of high power prices and high grid charges, accessing lower LCOH ▪ Can **decouple electrolyser location from RES[3] location** to be closer to demand ▪ Possible to 'green' power via GoOs/PPAs	▪ Availability of **zero carbon, low marginal cost renewable energy** ▪ Benefits from decreasing renewable LCOEs ▪ Can optimise capacity ratio of electrolyser:RES in order to minimise LCOH	▪ Combines the benefits of grid connected and co-located business models ▪ Availability of **zero-carbon, low marginal cost renewable energy** ▪ Option to 'top up' electrolyser with grid electricity, or to sell renewable energy to the grid to increase revenues
Constraints	▪ Access to power grid ▪ Capital cost of grid connection ▪ Electrolyser subject to costly **grid charges** ▪ Uncertain **carbon intensity** of hydrogen output	▪ Lower average load factor results in less hydrogen production ▪ Due to smart operation, hydrogen production is less regular	▪ **Intermittency of RES** results in inconsistent hydrogen production ▪ **Lower average electrolyser load factors** ▪ Often located away from demand ▪ Optimal electrolyser:RES size can result in significant spilled power	▪ Electrolyser subject to grid charges ▪ Carbon intensity of grid electricity ▪ Capital cost of grid connection ▪ Must be located near to RES - often far from demand
HyMAR metric?	▪ No (analysis available for selected countries only)[4]	▪ No (analysis available for selected countries only)[4]	▪ Yes	▪ No[4], preview of modelling of this business model in appendix

1) GoO: Guarantees of origin, PPA: Power purchase agreement 2) LCOH: Levelised cost of hydrogen 3) RES: Renewable energy systems 4) Not all HyMAR countries have been modelled to date for these business models.

Source: Aurora Energy Research

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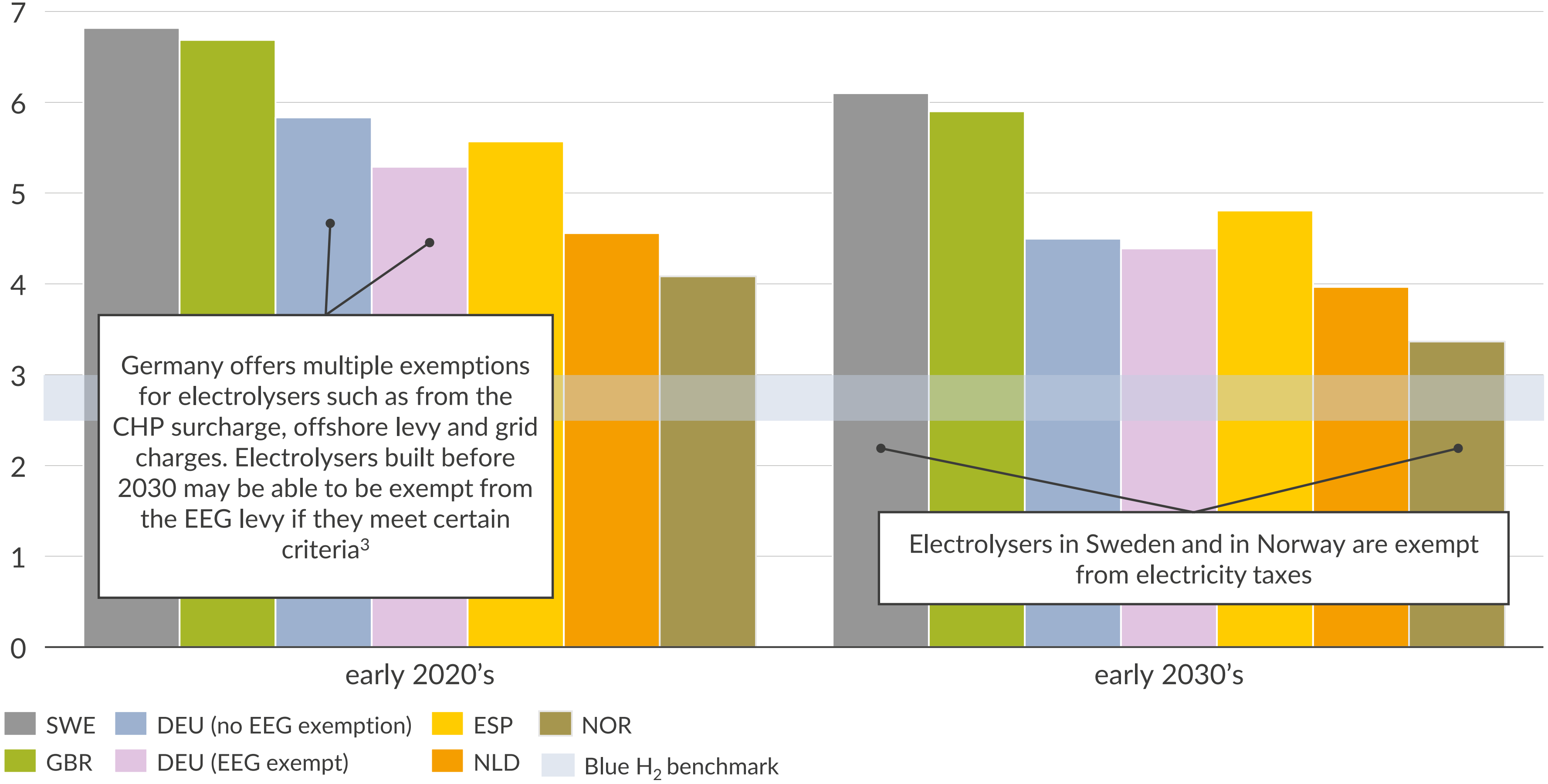
Norway's cheap electricity and renewables make it the most attractive country when electrolysers are operated inflexibly

1 Inflexible

Inflexible LCOH for different countries – PEM electrolyser

EUR/kg H_2



- Aurora has conducted detailed research into the hourly non-wholesale power costs that would apply to an electrolyser, taking into consideration any exemptions or compensations they would likely receive
- The exemptions and compensations offered by the UK reduce the average non-wholesale power costs paid by an electrolyser in 2030 by 52%, from £75.8/MWh to £36.6/MWh
- Norway's cheap electricity and renewables mean hydrogen produced from an inflexibly operated grid connected electrolyser could compete with blue hydrogen by early 2040s. However, most other countries are unlikely to be competitive

1) GBR represents the average LCOH from 3 price zones; C, N and B 2) average LCOH from every price zone in country **3) Full breakdown of EEG exemption requirements available to our subscribers of our European Hydrogen service**

Sources: Aurora Energy Research, Eurostat

Norway can produce the cheapest hydrogen for the co-located (island) business case using onshore wind

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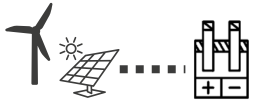
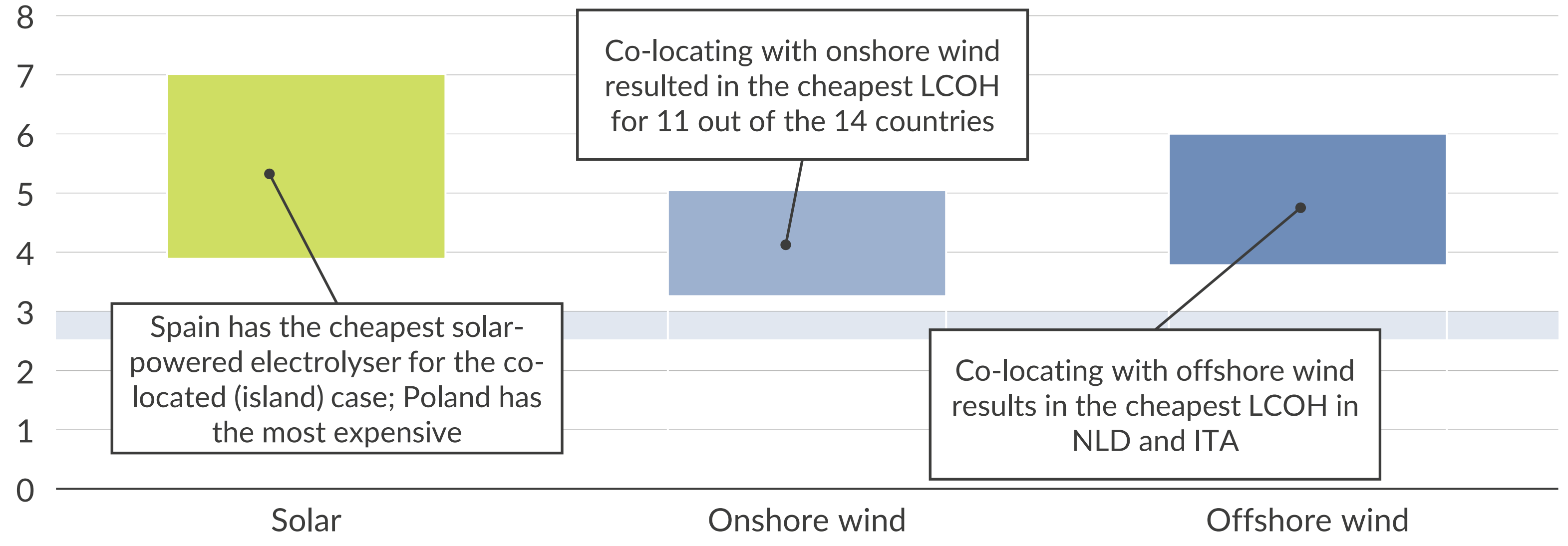
3 Co-located (island)



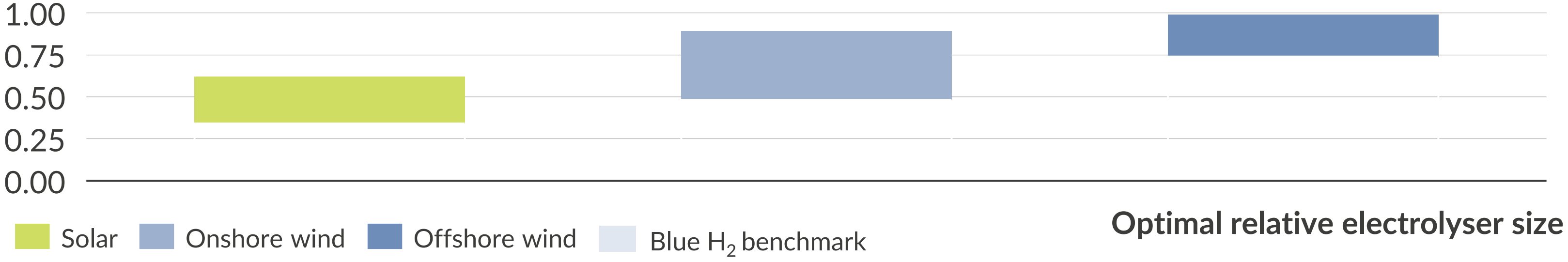
LCOH for optimally sized[1] co-located electrolyser built in 2030, range across Europe[2]

EUR/kg H_2



Optimal electrolyser size ratio for electrolyser built in 2030, range across Europe[2]

MW(electrolyser)/MW(RES)



- The co-located (island) business case describes an electrolyser co-located with a RES asset with no grid connection, hence it operates as an island
- There is an optimum electrolyser to RES capacity ratio where the electrolyser load factor is maximised whilst not spilling too much RES power
- The LCOH from this **co-located (island) business model are those that inform the HyMAR score**
- Onshore wind co-located electrolysers have the lowest LCOH at 3-5 EUR/kg H_2 in 2030. Norway produces the cheapest hydrogen using this model, with a cost in 2030 approaching parity with **blue hydrogen at ~2.5-3.0 EUR/kg H_2**
- Electrolysers co-located with solar can compete with wind-based schemes in sunnier parts of Europe such as Spain, Portugal and France. In more northerly locations, the lower average load factor and greater seasonality result in more RES curtailment and lower electrolyser load factors, both increasing LCOH
- Countries capable of producing the lowest LCOH from renewable sources typically also have the highest RES load factors.

1) See appendix for details of how this business model is modelled 2) LCOH and optimal size ratio figures are available to subscribers of our European Hydrogen Service

Source: Aurora Energy Research

Adding a grid connection to a co-located electrolyser can increase its load factor in periods of low RES output and increase revenues

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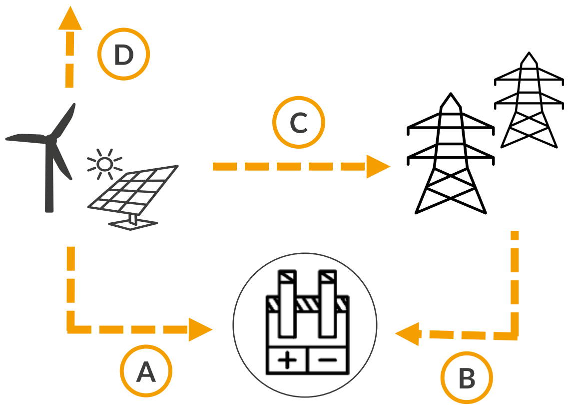
4 Co-located (grid)

Schematic of co-located electrolyser and renewables with grid connection

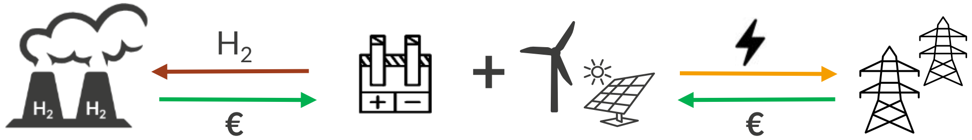


Key:

- A Electrolyser imports power from RES
- B Electrolyser imports power from grid
- C RES exports power to grid
- D RES spills power

- A "co-located (grid)" business model expands on the island co-located electrolyser model, providing an additional grid connection which allows for greater flexibility in hydrogen production
- With a grid connection, the electrolyser can choose to purchase grid electricity to top up its production when the renewables generation is insufficient and it is still economically viable to produce hydrogen. The system can also sell any excess renewable generation, minimising spill
- However, any power purchased from the grid will have associated grid charges, which vary by time of use, voltage level, and carries an associated carbon intensity
- The hydrogen produced can be sold to an offtaker or injected into the grid[1]

Under this business model, revenues come from two sources:



1 Hydrogen exports

- The electrolyser produces hydrogen with power from the RES assets or the grid
- Produced hydrogen is sold to offtakers e.g. in industry

2 Electricity exports

- The RES assets generate electricity and sell to the grid at wholesale prices
- Or it supplies power to the electrolyser if hydrogen is more valuable

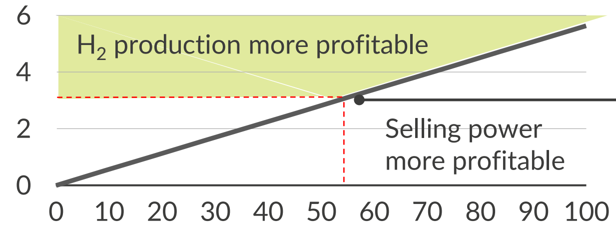
Revenue optimisation

To maximise its revenues, the asset will need to optimise its operations based on the profits from both sources, which is dictated by:

i. Hourly power prices – we use Aurora Central scenario for the analysis

ii. Hydrogen price – we assume a fixed purchase price by industrial offtakers

Hydrogen price, EUR/kg H_2



Power price, €/MWh

*At a power price of 55 €/MWh, a hydrogen offtake price of at least **3 €/kg H_2** would be required to incentivise hydrogen production over power generation*

1) Additional transport costs to the consumption centre are not included in this analysis.

Source: Aurora Energy Research

Key benefits of adding a grid connection include higher project profitability, operational flexibility and lower project risk

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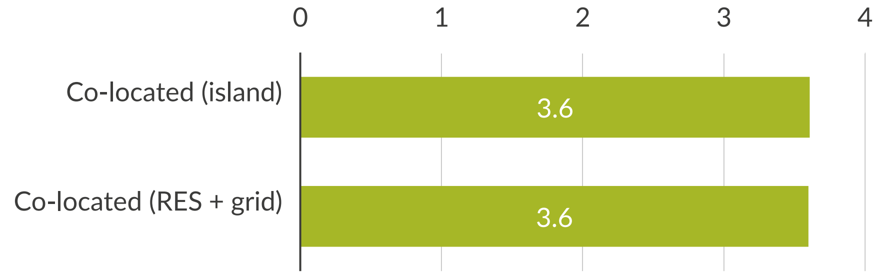
The results presented on this slide are based on the following assumptions:

1. H_2 offtake price is 4 EUR/kgH_2; Electrolyser size optimised between 10-100 MW
2. RES capacity is 50 MW solar + 50 MW onshore wind (100 MW total RES capacity);

1 Both island and grid co-located models can achieve a comparable LCOH…

Levelised cost of electrolyser H_2 production in 2025

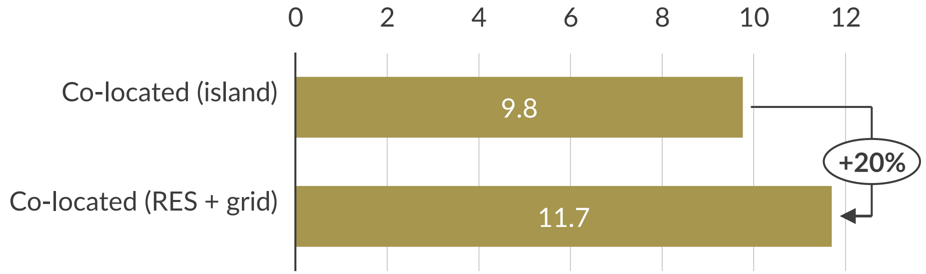
EUR/kg H_2



2 …but grid co-located models can achieve higher IRRs due to power exports

Project profitability (H_2 + RES)

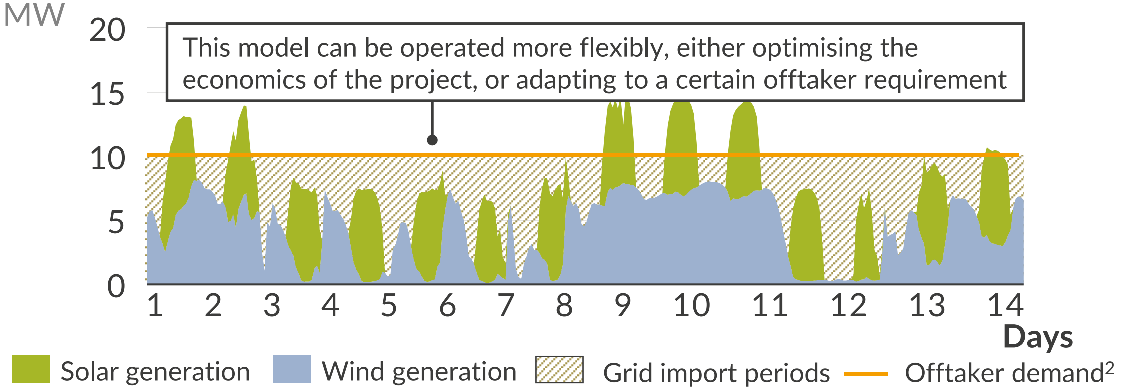
IRR (unlevered, pre-tax), %



3 A grid connection can provide higher operational flexibility…

Example electricity generation profiles for a co-located grid park[1]

MW



4 …and access to multiple revenue streams, reducing investment risks

- The availability of two different sources of revenue mitigates the risk of the business model and provides higher optionality due to exposure to both hydrogen and electricity markets
- The optimal arrangement found for this model has a small electrolyser capacity which further de-risks the project as the majority of the revenues come from the power market, which is a more mature market
- Further, both Spain and Portugal are likely to make available the participation of electrolysers in ancillary services, opening an additional source of revenue
- Exposure to multiple markets reduces counterparty and regulatory risks

1) Assuming a 10 MW solar asset combined with a 10 MW onshore wind asset, plus a 10 MW electrolyser and 10 MW grid connection. 2) This illustrative example assumes a baseload demand profile from the offtaker.

Source: Aurora Energy Research

Contents

Source: Aurora Energy Research

Our modelling approach to hydrogen demand estimates sector size, potential hydrogen penetration, and fuel or feedstock conversion rate

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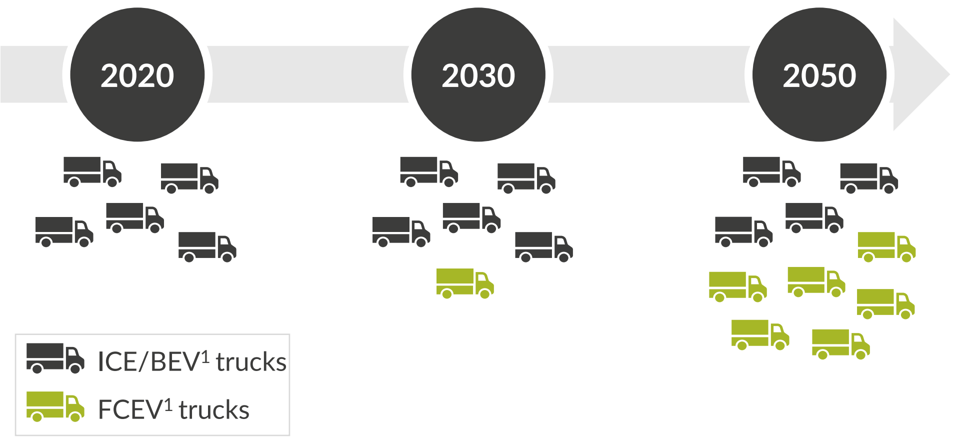
To describe the methodology, we illustrate a hypothetical hydrogen demand in heavy-duty vehicles for 2020, 2030 and 2050



Total demand if everything was converted into hydrogen now

Annual market size × Fuel consumption × Sectoral growth × H_2 penetration

Total demand if everything was converted into hydrogen in future

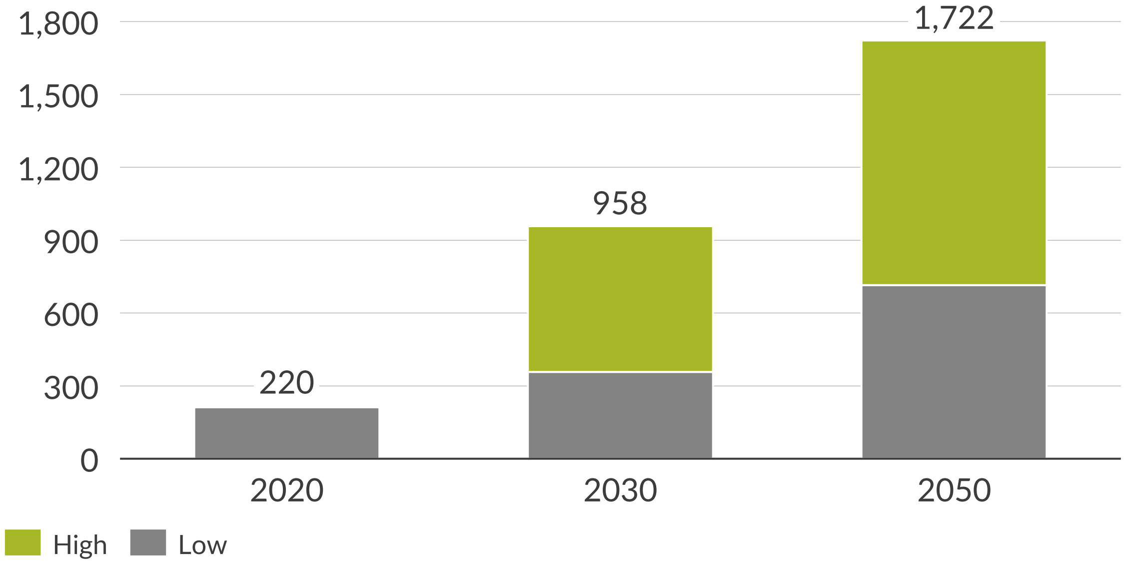
There is a high degree of uncertainty around technological, financial and logistic feasibility of hydrogen applications in many sectors

Aurora's High Hydrogen scenario is based on government strategies being fully implemented, with targets being met or exceeded. Support for hydrogen in this scenario is assumed to remain constant or increase.

Aurora's Low Hydrogen scenario represents a business as usual case, where hydrogen penetration is limited to the most economically viable and competitive applications – we assume government support for hydrogen in this scenario is limited with a conservative hydrogen penetration

Aurora's hydrogen demand forecast for HyMAR countries

TWh H_2/y



1) ICE: Internal combustion engine; BEV: Battery electric vehicle; FCEV: Fuel cell electric vehicle

Germany’s current need for process heat drives high hydrogen demand when decarbonising industry

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H_2 demand in industry covers feedstock and process heat

- Iron and steel and petrochemicals make up the bulk of Germany’s industrial heat demand, and both require high grade heat which cannot be electrified and requires either hydrogen or biogas to decarbonise
- Germany has established ammonia and methanol industries, providing a baseline of industrial demand which Aurora forecasts to remain steady between now and 2050

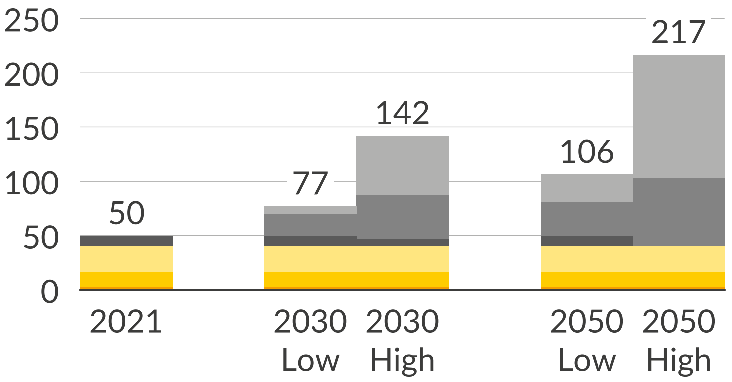
H_2 demand in the transport sector covers passenger vehicles, busses, rail and maritime

- Germany’s rail is currently 75% electrified, and new rail routes planned are to be exclusively electric – Aurora therefore forecasts minimal penetration in rail transport when compared to the rest of Europe
- Germany’s enthusiasm for hydrogen refuelling stations[1], combined with a modest planned bus fleet, mean our assumptions for transport penetrations are typically higher than the European average

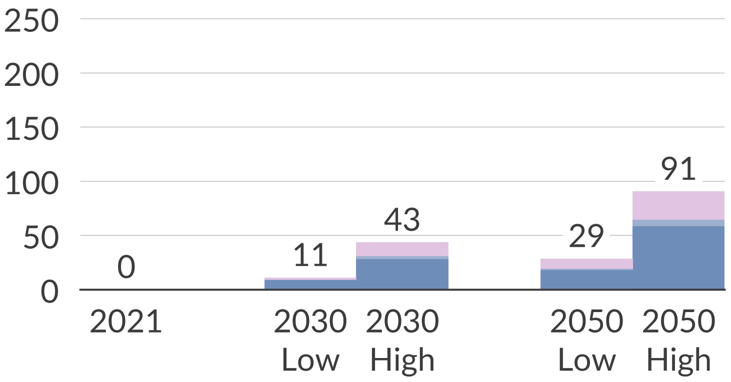
H_2 demand in space heating covers all use in the heating of buildings

- Aurora assumes the majority of space heating will be decarbonised by heat pumps
- Households and commercial space heating amount to more than 800 TWh of heating demand – modest penetration into district heating has been assumed as coal CHP plants are removed from the heating system and potentially replaced with hydrogen-fuelled CHPs

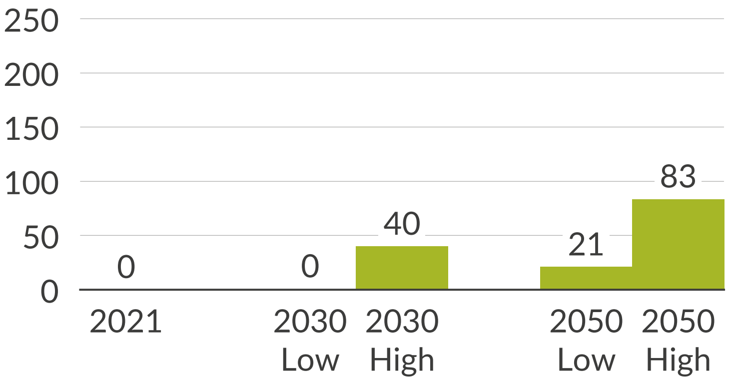
Industrial demand for hydrogen in Germany
TWh H_2 (HHV) per year



Transport demand for hydrogen in Germany
TWh H_2 (HHV) per year



Heating demand for hydrogen in Germany
TWh H_2 (HHV) per year



Process Heat | Steel | Refinery | Ammonia | Methanol | Other Chemicals | Syn-fuels | Maritime | Rail | Road Freight | Bus | Car | Heating

1) Germany contains more than 50% of the hydrogen refuelling stations among all HyMAR countries 2) Detailed breakdowns and commentary on all HyMAR countries are available to subscribers of our European Hydrogen Service

Sources: Aurora Energy Research, The National Hydrogen Strategy (Germany)

Takeaways

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Germany, the Netherlands, and the UK remain the most attractive markets for investment in hydrogen in Europe, with France and Norway close behind in joint fourth place.

Since the last edition of HyMAR, the UK has announced its long awaited hydrogen strategy. The strategy commits funding approaching £1billion and commits to implementation of a CfD like mechanism and hydrogen carbon intensity standard. As ambitious as this strategy is, some other European countries are either more ambitious or further ahead in implementing hydrogen incentives.

Aurora's global electrolyser database shows 343 GW of electrolyser capacity is under development globally – a 90 GW or 36% increase in the pipeline over the last 6 months. 57% of this planned capacity is located in Europe, meaning that Europe will remain a leading producer and distributor of hydrogen in the near term – although a series of mega-schemes announced in Australia, Asia, and Africa have also put these regions on the hydrogen map.

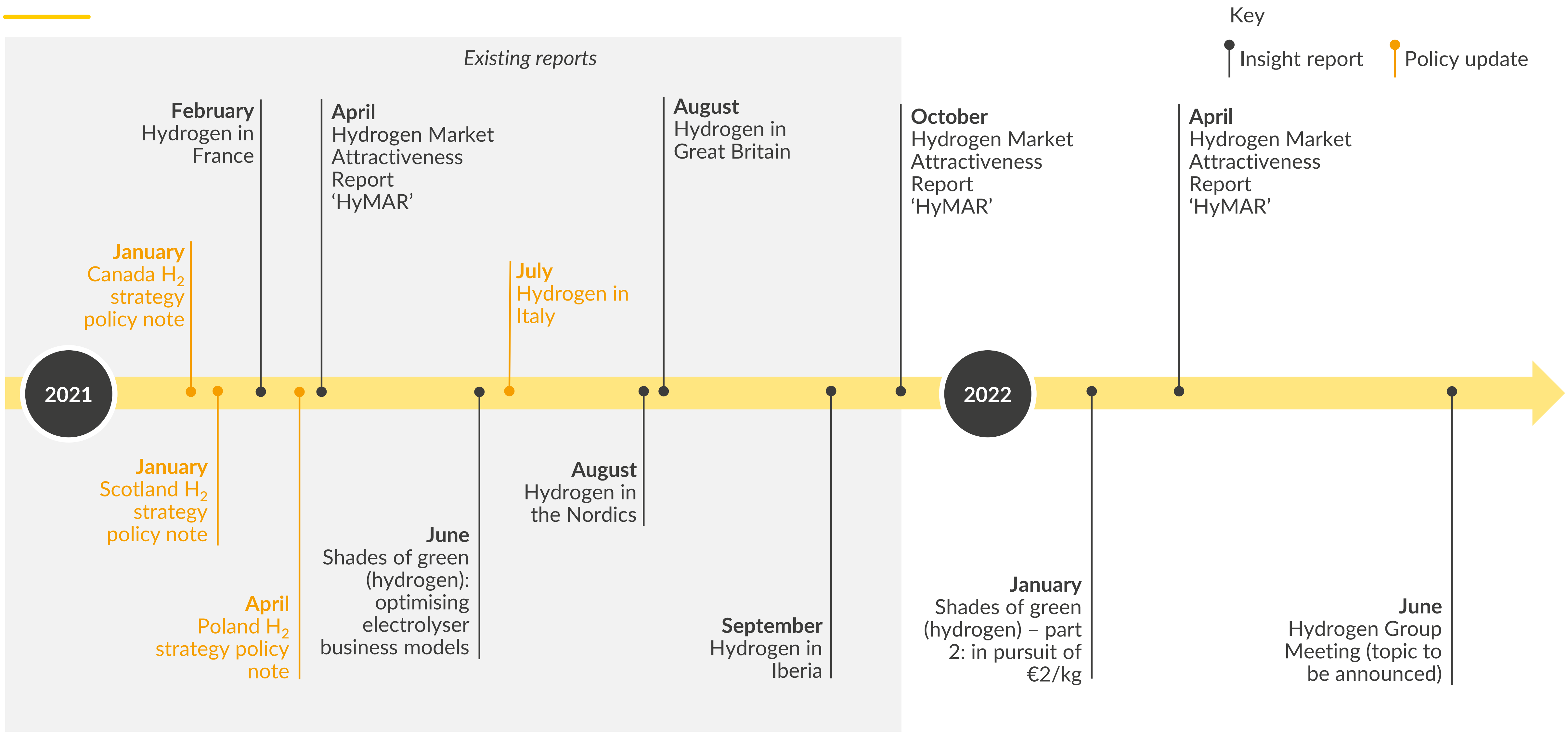
€

Hydrogen production via electrolysis remains more expensive than blue or grey hydrogen, but Aurora's modelling suggests that green hydrogen can reach cost parity in some cases around 2030. The main driver for this is cost of electricity, with Norway able to offer both the cheapest grid supplied electricity, and the lowest cost renewables within Europe.

Source: Aurora Energy Research

Timeline of strategic insight reports and policy updates

AURORA



All reports are available to subscribers of Aurora's European Hydrogen Service

Source: Aurora Energy Research

Details and disclaimer

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