

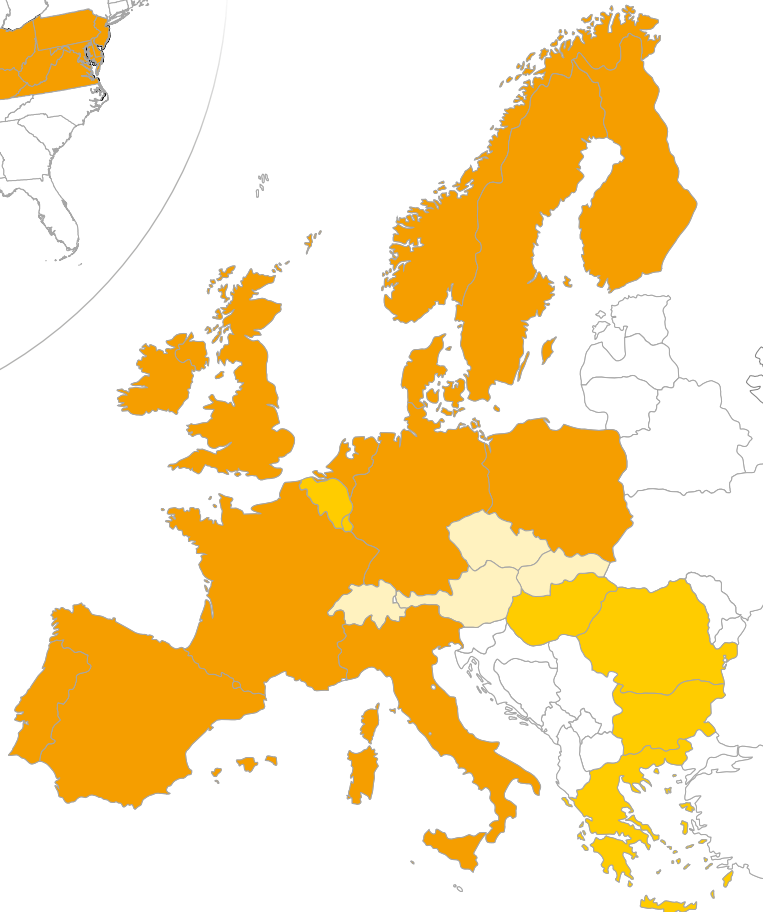
UK Hydrogen Strategy Policy Note

Summary slides for non-subscribers

17 August 2021



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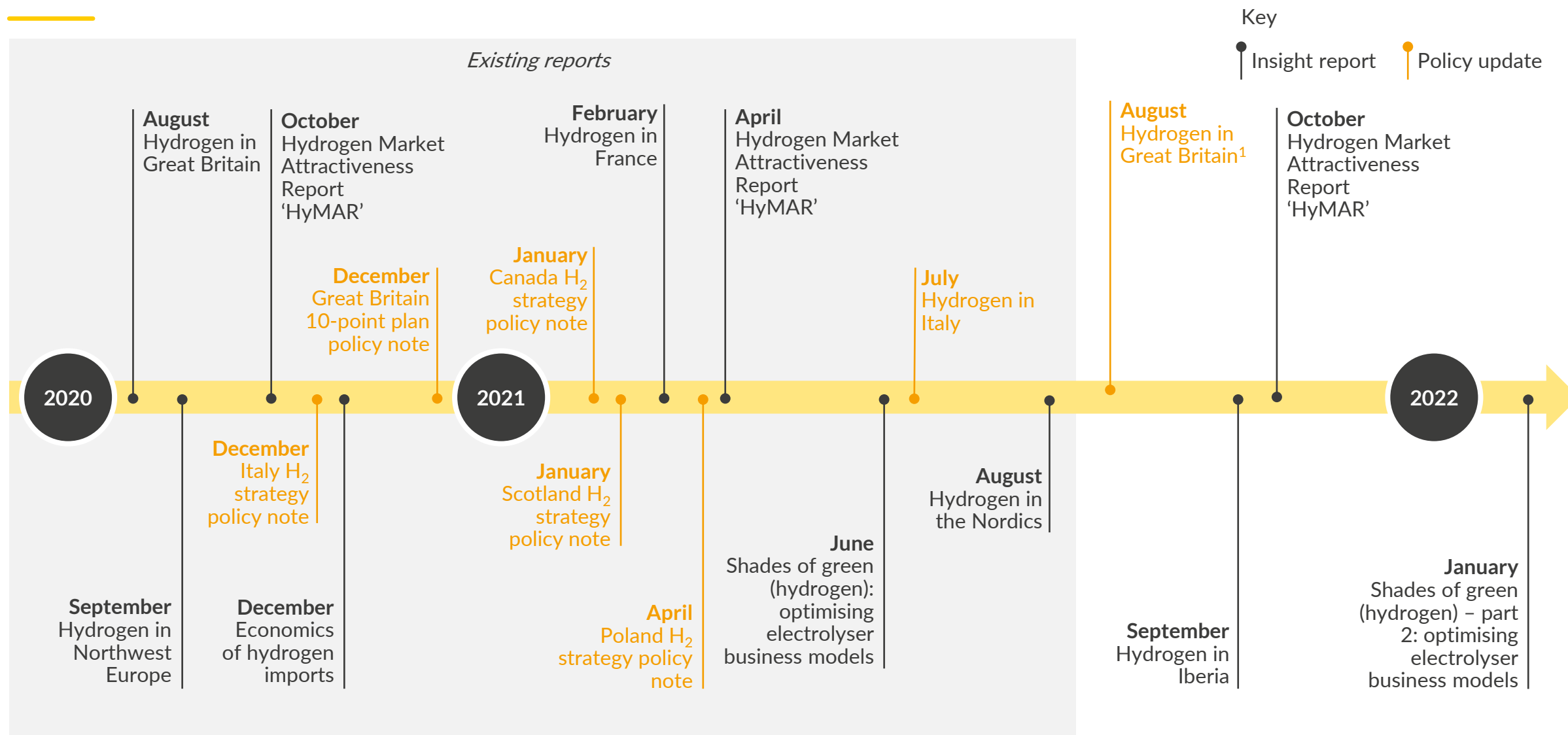
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Timeline of strategic insight reports and policy updates



All reports are available to subscribers of Aurora's European Hydrogen Service. 1) Subscribers will receive an in-depth version of this report

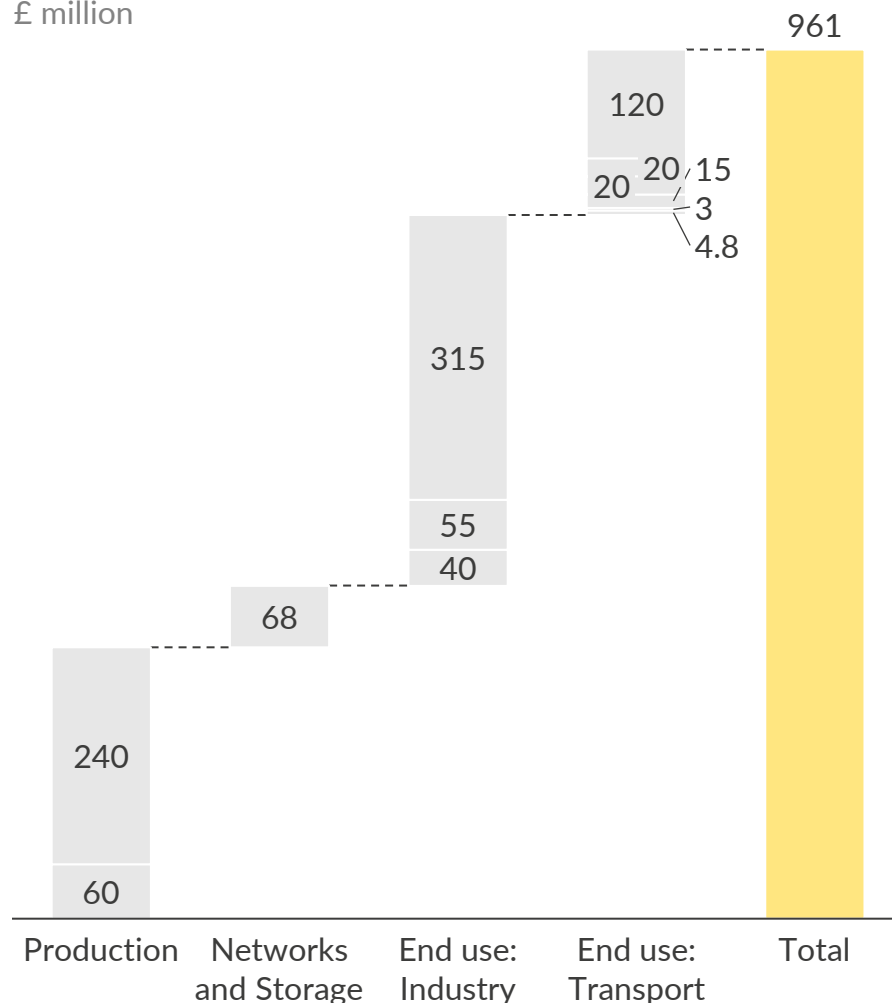
Executive Summary

On 17th August the UK Department for Business, Energy & Industrial Strategy published the government's UK Hydrogen Strategy. Aurora provides a summary and its assessment in this policy note

- The UK government published its long-awaited hydrogen strategy on 17th August 2021. This follows from the Ten Point Plan for a Green Industrial Revolution released in November 2020 and Scotland's hydrogen strategy published in December
- 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
- The government opened a public consultation into hydrogen production business models, which could be modelled on renewable power contracts for difference (CfDs). Launch of the scheme is due in 2023
- The UK government expects a more than doubling in hydrogen demand by 2030, roughly in line with Aurora's central scenario. This growth is due to come from industry followed by power and transport. By 2050 the government is more ambitious, expecting a near 20-fold increase in demand, which is 25% higher than Aurora's High scenario
- The UK re-iterates its target for 5 GW of installed hydrogen production capacity. According to Aurora's electrolyser database, the United Kingdom pipeline of electrolyser projects by 2030 is close to its 5 GW target, at 4.06 GW
- The strategy includes a table of assumed levelised costs for hydrogen (LCOH) production for a few business models, and the government's assumed LCOH for grey hydrogen in 2050 hints at its strongly bullish view on carbon costs
- 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
- Next steps: the hydrogen strategy sets out many ambitious milestones over the next four years, most notably its 2022 low carbon hydrogen standard and 2023 launch of its hydrogen production subsidy scheme

Nearly £1 billion is committed to hydrogen-specific uses by the UK strategy

Funding committed by the strategy, by category
£ million



The UK strategy makes reference to large funds which may be deployed to support hydrogen businesses and technologies, totalling **£961m**.

Production

- The government has opened a public consultation into hydrogen production business models in order to design a support scheme to bridge the cost gap between low-carbon hydrogen and high-carbon fuels. This will be modelled similarly to existing offshore wind carbon contracts for difference (CfDs) where operators receive payments per MWh for 15 years. The payment amount is determined in a competitive auction. Indicative 'Heads of Terms' on the hydrogen subsidy scheme are due in Q1 2022
- £300m total funding is split between the £240m Net Zero Hydrogen Fund, which will co-invest in early hydrogen projects, and the Low Carbon Hydrogen Supply 2 competition, which will aim to develop novel solutions. *Note: this £60m fund can also be awarded to storage projects*

Networks and Storage

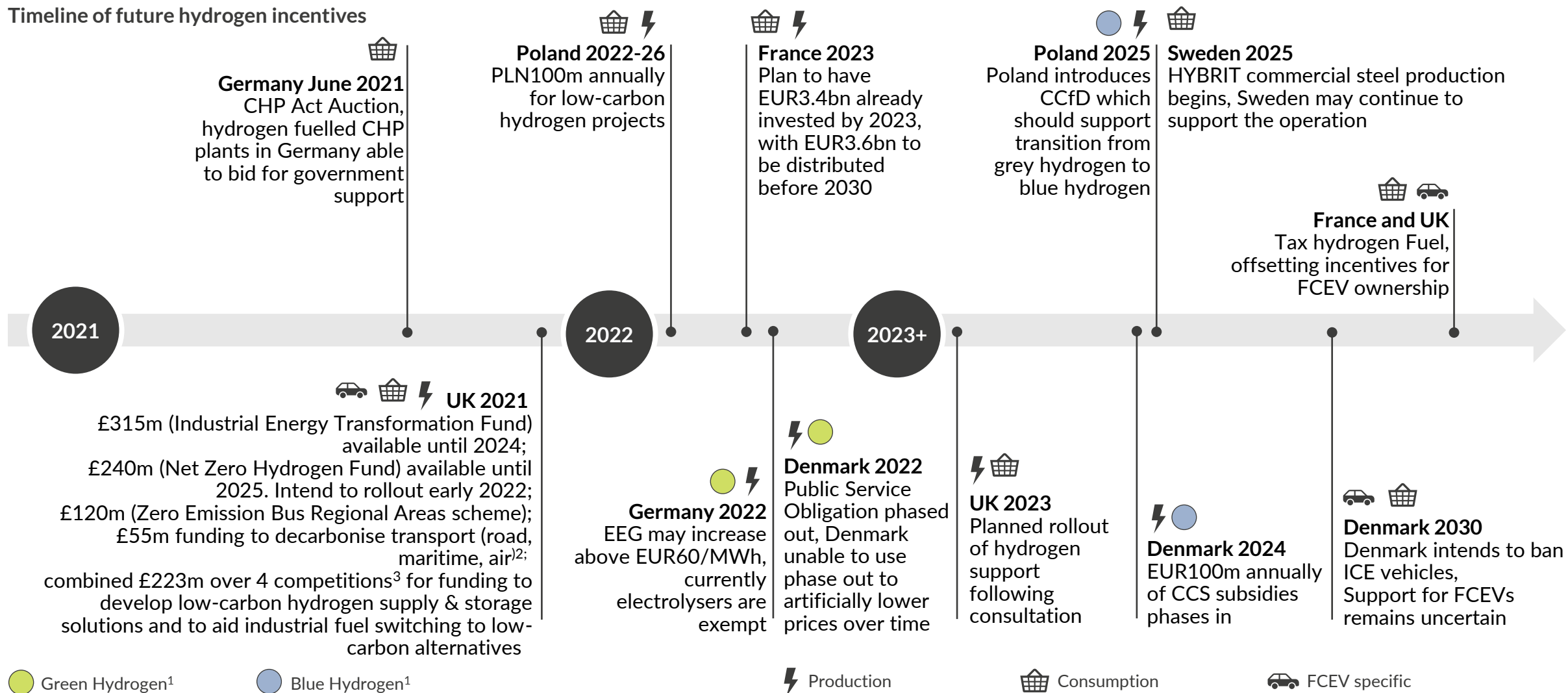
The only dedicated network and storage funding is the £68m Longer Duration Energy Storage Demonstration competition, which also considers storing hydrogen produced from excess electricity.

End Use

- The biggest fund by far is the Industrial Energy Transformation fund, which focusses on supporting fuel switching technologies. Smaller funds are for separate fuel switching competitions, including one dedicated to replacement of red diesel
- Despite ambitious demand forecasts, hydrogen transport is not particularly well funded in Aurora's view. Specific funds are allocated to develop hydrogen bus, HGV and maritime fleets, along with sustainable aviation fuel. Two regional transport hubs will also be funded
- Heat in buildings, along with power, do not have dedicated funds allocated in the strategy

Multiple incentives to support green and blue hydrogen, as well as demand for hydrogen, are due to be introduced this year

Timeline of future hydrogen incentives



1) No colour specific symbol where incentive is production methodology agnostic 2) £20m for low-carbon transport trials, GPB20m for the Clean Maritime Demonstration Competition, £15m for the 'Green Fuels, Green Skies' Competition 3) £60m Low Carbon Hydrogen Supply 2 Competition, £68m for the Longer Duration Energy Storage Demonstration Competition, £55m Industrial Fuel Switching 2 Competition, £40m Red Diesel Replacement Competition

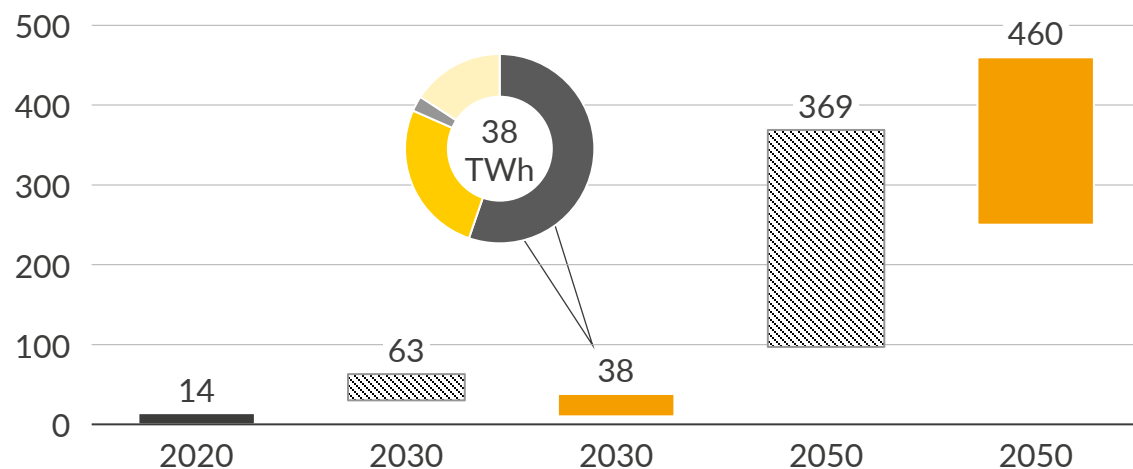
The British government expects at least a 20-fold increase in hydrogen demand by 2050, and even higher in the high scenario

The hydrogen strategy published by the United Kingdom foresees high demand scenario by 2050, amounting to 460 TWh by 2050

- Current hydrogen demand, which is currently not low-carbon as it is produced by fossil fuels, is just 14 TWh in 2020
- The strategy acknowledges a barrier to demand growth is the lack of infrastructure; thus, low-carbon demand will emerge first in existing industrial demand. In 2030, industry will constitute more than half of hydrogen demand
- The strategy expects heating demand will pick up in mid-2030s from a low base. More plans for hydrogen in heating are due by the government in 2026

Comparison of hydrogen demand forecasts¹

TWh/a



■ Current ■ Aurora Energy Research ■ UK hydrogen strategy ■ Industry ■ Power ■ Heat ■ Transport

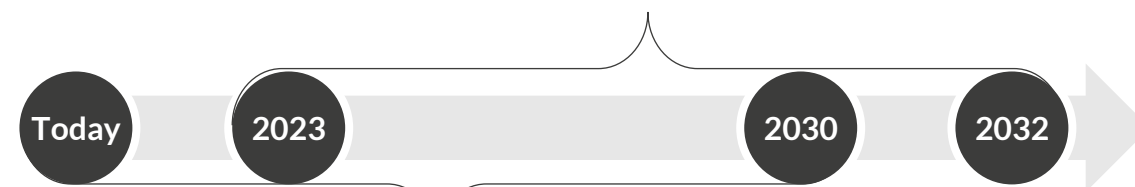
1) Bottom and top of the bars represent low and high demand forecasts in the respective year

Use of low-carbon hydrogen has significant positive impacts on the system



41 MtCO₂e is equivalent to carbon captured by 700 million trees over the same period

5 GW of low-carbon hydrogen would avoid ~41 MtCO₂e between 2023 and 2032



Specifically in industry, switching to low-carbon hydrogen would result in a decrease of ~3 MtCO₂e by 2030.

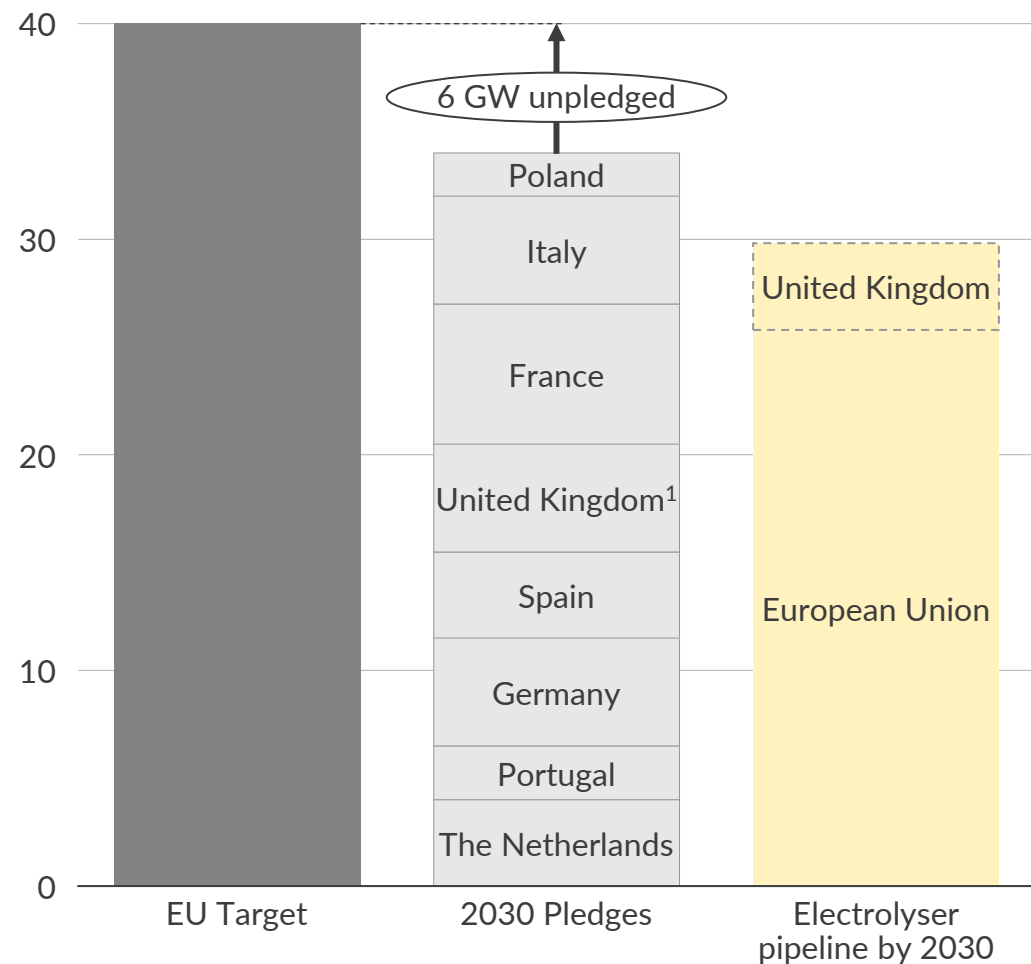


3 MtCO₂e is equivalent to removal of 1.4 million cars from the road

	2030	2050
Jobs created	9,000	100,000
GVA	£900 million	£13 billion

According to Aurora's electrolyser database, the United Kingdom pipeline of electrolyser projects by 2030 is close to its 5GW target

Current H₂ electrolyser capacity pledges and actual planned construction
GW



Aurora's global electrolyser database tracks electrolyser projects that are in discussion, planned, under construction and existing



Large scale electrolyser projects in the United Kingdom are scattered around the country. According to Aurora's electrolyser database, the largest electrolyser project in the United Kingdom is located in Aberdeen, and the project is planned to be commissioned by 2030s.

Remaining large scale projects, with a planned capacity of 100 MW each, are located in Liverpool and Hornsea.

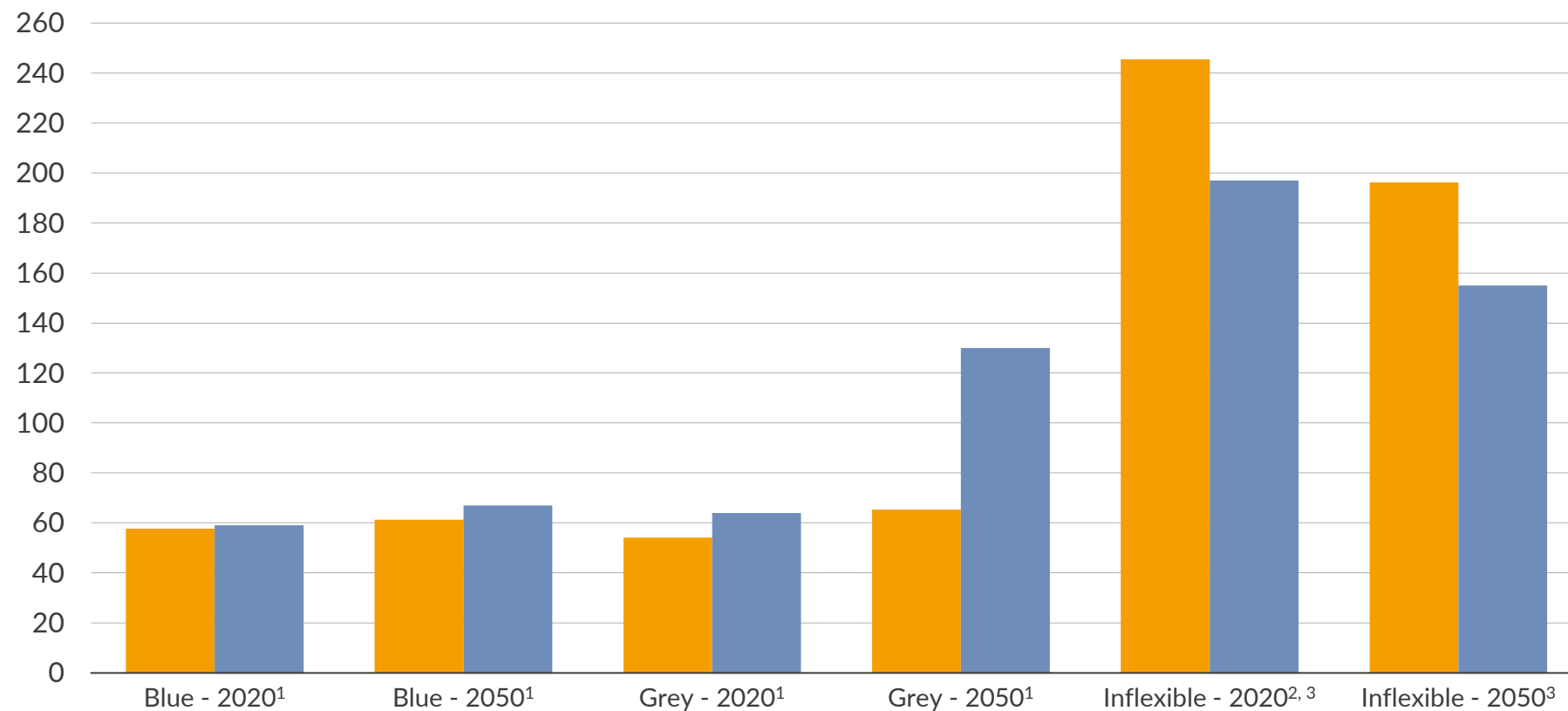
Recap: Pledges by Scotland and the United Kingdom

- In December 2020, the Scottish government released its hydrogen strategy, which indicated clear ambition on green hydrogen. It pledged 5 GW of electrolyser capacity by 2030
- The hydrogen strategy released by the United Kingdom in August 2021 pledges 5 GW of **low-carbon** hydrogen capacity, which covers both electrolyser and blue hydrogen. What overlap there is with the Scottish strategy is unclear

1) The UK target is for 5 GW of low-carbon hydrogen production and is not limited to electrolyzers.

The strategy includes numbers on levelised cost of hydrogen, and are similar to Aurora's view with a few notable exceptions

Levelised cost of hydrogen (LCOH)
£/MWh H₂ real 2020



 Aurora Energy Research  BEIS hydrogen strategy

1) AER LCOH include carbon taxes 2) AER value is from 2021 3) AER inflexible LCOH includes VAT. 4) Co-location offshore wind values, as well as LCOH for several other UK business models are available to subscribers

Sources: Aurora Energy Research, BEIS

Costs for blue, grey and green co-location with wind are similar

- The hydrogen strategy includes a table of assumed levelised costs for hydrogen production for a few business models
- The LCOH for both blue and co-location with dedicated offshore wind⁴ reported in the strategy are similar to Aurora's forecasts
- In contrast, the hydrogen strategy's grey LCOH in 2050 is double that assumed by Aurora, which is likely due to the UK government's expectations for high carbon costs
- Aurora assumes a higher inflexible LCOH than the government. We assume this is because Aurora models additional non-wholesale power costs

The United Kingdom will introduce its own standard for low-carbon hydrogen in 2022

The UK will introduce its own standard for low-carbon hydrogen, but next year

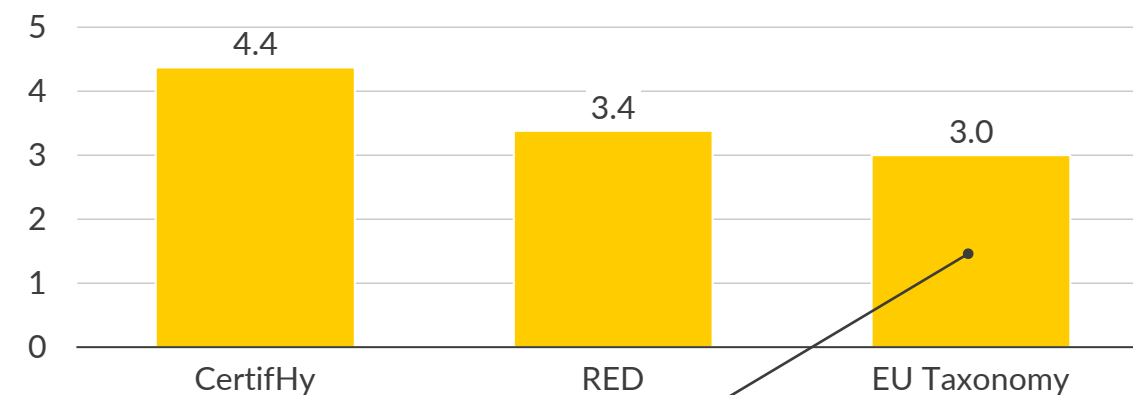
- The UK's hydrogen strategy stipulates that its low-carbon hydrogen standard will be finalised and published in 2022
- Given the strategy's 'twin-track' approach favouring both blue and green hydrogen, Aurora expects this standard will set a carbon intensity threshold higher than the EU's Delegated Act. Aurora expects the EU threshold is stringent enough to exclude blue hydrogen and even some green hydrogen
- Alongside the strategy – the government have called for consultation on their low-carbon hydrogen standard implementation

Setting a low-carbon standard is essential for developing a hydrogen economy

- A standard is essential for indicating to producers and consumers that the hydrogen being consumed is eligible for subsidies and grants
- Hydrogen exports from the UK will need to meet carbon intensity thresholds set by the importing countries. Aligning thresholds internationally will aid this - the Scottish hydrogen strategy released in December indicated its goal to export hydrogen
- Nearly all hydrogen produced globally today is made from methane via steam methane or autothermal reformation (SMR or ATR). While cost effective, these production methods have a high carbon intensity (see chart).
- There are several ways of making low-carbon hydrogen, all with different lifetime carbon intensities¹. Lifetime carbon emissions are important, since they account for both direct emissions (during hydrogen production) and indirect emissions (e.g. manufacture and transport of equipment), which can be significant for certain renewable technologies

Proposed carbon threshold for renewable hydrogen

kgCO₂/kgH₂ (lifecycle)



In June 2021, the EU finalised the Delegated Act for Sustainable Finance Taxonomy, setting a carbon intensity limit of **3 tCO₂/tH₂** for sustainable hydrogen

Importantly, this **limit includes lifecycle emissions**, which could exclude some blue hydrogen, and possibly even some green hydrogen from solar, from the definition

The limit is lower than stipulated in the EU's Renewable Energy Directive for hydrogen used in transport, and lower than CertifHy's proposed limit of 4.37 tCO₂/tH₂ that would form the basis of a proposed trading system for low-carbon Guarantees of Origin

1) When calculating lifetime emissions, all emissions are counted, including those during manufacturing, transportation and production; 2) EU Renewable Energy Directive

The hydrogen strategy sets out many ambitious milestones over the next four years which will enable the UK's hydrogen economy

Timeline of upcoming policy and regulation

Year	Milestone	Significance
2022	Launch of £240m "Net Zero Hydrogen Fund"	This fund is intended to co-invest in early stage hydrogen projects
	Launch of UK low carbon hydrogen standard	Publishing of this standard will allow producers and consumers certainty that their product is aligned with the UK's Net Zero goals
	Update of hydrogen network review	Interim findings published on whether incentives, regulation or other future-proofing are needed to insure resilience of the hydrogen and wider network
	Hydrogen Sector Development Action Plan	This plan will focus on the monitoring of competitiveness of UK hydrogen businesses and potentially act to level the playing field
2023	First contracts allocated of the Hydrogen Business Model	Following consultation called for alongside the hydrogen strategy, the first funds are expected to be deployed in 2023, helping producers of low-carbon hydrogen overcome cost challenges
	Grid blending decision	Final decision on whether or not to proceed with blending of 20% hydrogen into natural gas grid. Dependent on safety and economics assessments
	Hydrogen heat trials (neighbourhood)	Launch of a study aiming to determine the feasibility of replacing natural gas with hydrogen for heating
2025	Hydrogen heat trials (village)	Continuation of neighbourhood heating trial with larger trial area and customer base
2026	Decision on the future of hydrogen in heating	Strategic decisions on hydrogen in heating, and whether to proceed to the "hydrogen town"

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