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Blue Paper

Commercial supply chain and hydrogen strategy roadmap for Europe - Germany, UK & Norway

Part-15 (Global demand clusters, international trade and development hydrogen strategy roadmaps for different geographies)

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Europe

The German government predicts a hydrogen demand of about 90 to 110 TWh by 2030 and in order to accommodate this demand, electrolysers with a total capacity of up to 5 GW are to be built in Germany by 2020.

GERMANY

Germany has committed itself together with the other European member states to achieve the green house gas (GHG) neutrality by 2050. Apart from phasing out coal fired power for which Germany has already taken the relevant actions, this means preventing emissions which are particularly hard to reduce such as process related GHG emissions from the industrial sector. For the energy transition to be successful, security of supply, affordability and environmental compatibility need to be combined with innovative and smart climate action. This means that the fossil fuels we are currently using need to be replaced by alternative options.

This applies in particular to gaseous and liquid energy sources, which will continue to be an integral part of Germany's energy supply. Against this backdrop, hydrogen will play a key role in enhancing and completing the energy transition.

The German industry currently uses about 1.7 Million Tons (55TWh) of hydrogen per year and the government expects this to get double by 2030 as the strategy sparks new demand. However 95% of the hydrogen currently in use is the "gray hydrogen", which is produced from fossil fuels, mainly natural gas and emits CO2 into the atmosphere during the production process. In order to reduce CO2 emissions associated with hydrogen production , the government plans to accelerate the expansion of the production capacity of green hydrogen which is produced using electricity derived from renewable energy sources.

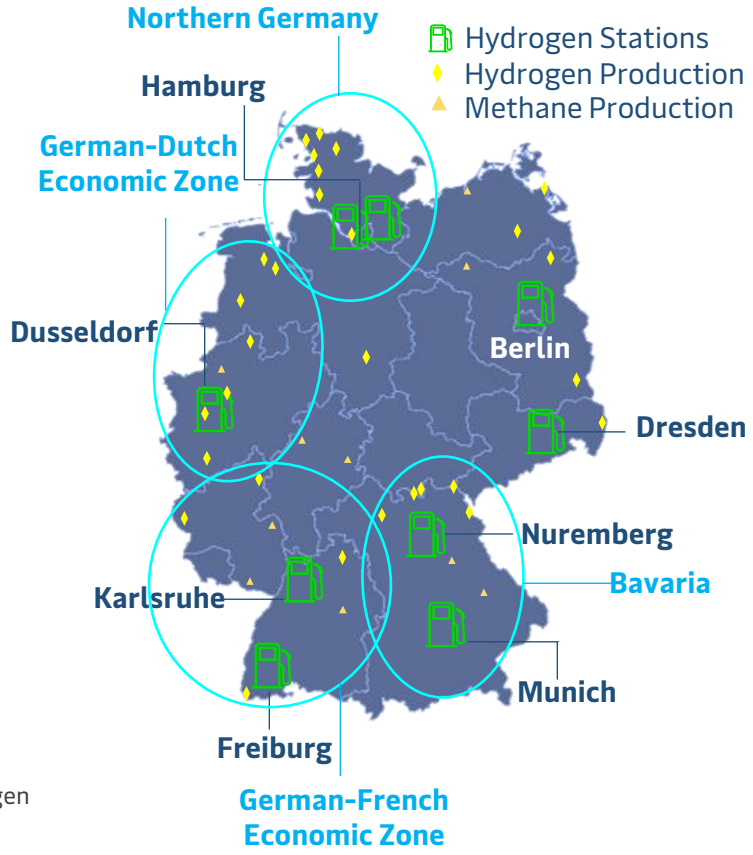
> The government will invest 12.36 Billion Euros by 2026 (9 Billion Euros) from the coronavirus economic stimulus package
>
> _ The German Government

Germany is one the most active EU member states in expanding the use of hydrogen. The hydrogen strategy covers the entire value chain, from related technologies to production, storage, infrastructure, and utilization, including logistics, quality assurance, and consumer protection.

For the promotion of the practical use of the hydrogen technology , the German Federal Ministry of Economic Affairs and Energy is primarily advancing the following three programs (1) The Hy Experts program forms concepts for the green hydrogen utilization with high potential for practical use. (2) The HyPerformer program supports the implementation of specific green hydrogen projects. In addition, (3) the Reallabor (Real-World Laboratories) program goes one step further and is working on large-scale hydrogen utilization experiments and their industrialization through industry-government-academia collaboration. In particular, large water electrolysers, PtL equipment, heat pumps, smart grids, and district heating are targeted, and 600 million euros has been set aside for this program for 2020-2023.

In the future, the government plans to expand the number of commercialization sites for each program throughout the country. Meanwhile, such sites have already begun to gather in four priority regions. The northern part of Germany, with its extensive low-lying areas, is expected to have the largest number of hydrogen production sites due to the high concentration of wind farms. Second to this is the German-Dutch economic zone, which includes the Ruhr area, the largest industrial cluster. In addition, the southwest part of Germany, which is adjacent to France, and the southern state of Bavaria, are also notable for the number of projects utilizing hydrogen technology, and are likely to become important locations for the hydrogen industry from now on.

Key regions & sites in Germany for hydrogen development



Source: Eninrac research & analysis, Hydrogen Roadmap- Germany, Channel Checks

In Germany, the pipeline network that reaches as far as 130 km is expected to begin transporting hydrogen by the end of 2022

Hydrogen gas can be transported and stored using natural gas pipelines. In January 2020, FNB Gas, the association of German transmission system operators, announced plans for partially repurposing more than 90% of existing natural gas pipelines for hydrogen transportation and storage network. Under the target of a stable supply to all of Germany, FNB aims to complete the plan by 2030. The operational policy also promises not to discriminate hydrogen based on its production location, and to handle not only green hydrogen from north-eastern Germany, but also hydrogen imported via liquefied hydrogen carriers and pipelines. As an initial step in the plan, the power generator RWE Generation, transmission company Nowega, and energy and chemical giants OGE, Evonik, and BP began to develop a pipeline network (GET H2 Nukleus) in March 2020.

This network will transport green hydrogen produced at RWE's 100 MW water electrolysis plant in the northern city of Lingen to BP's chemical plant in the Ruhr industrial zone near Essen and Evonik's chemical plant in the city of Marl, among other locations. The pipeline network that reaches out as far as 130 km is expected to begin transporting hydrogen by the end of 2022.

Because the domestic production capacity for green hydrogen is limited, the German government expects that a large part of the future demand will be met by imports. To this end, it has recognized the expansion of international collaboration and cooperation as an important issue and has positioned the Netherlands and France as promising supply partners within the EU. Also, outside the EU, there are high expectations for the procurement potential of countries such as Morocco, Ukraine, and Russia.

> Germany has begun to work on green hydrogen production in collaboration with the Netherlands and France. North Africa, Ukraine, and Russia are also seen as potential suppliers, and Germany intends to make the most of the existing natural gas pipeline network inside and outside the EU for hydrogen distribution.
>
> _ Germany Hydrogen Strategy

Hydrogen strategy roadmap and targets for Germany – A landscape view for investments

Investment Targets

A. Budgets

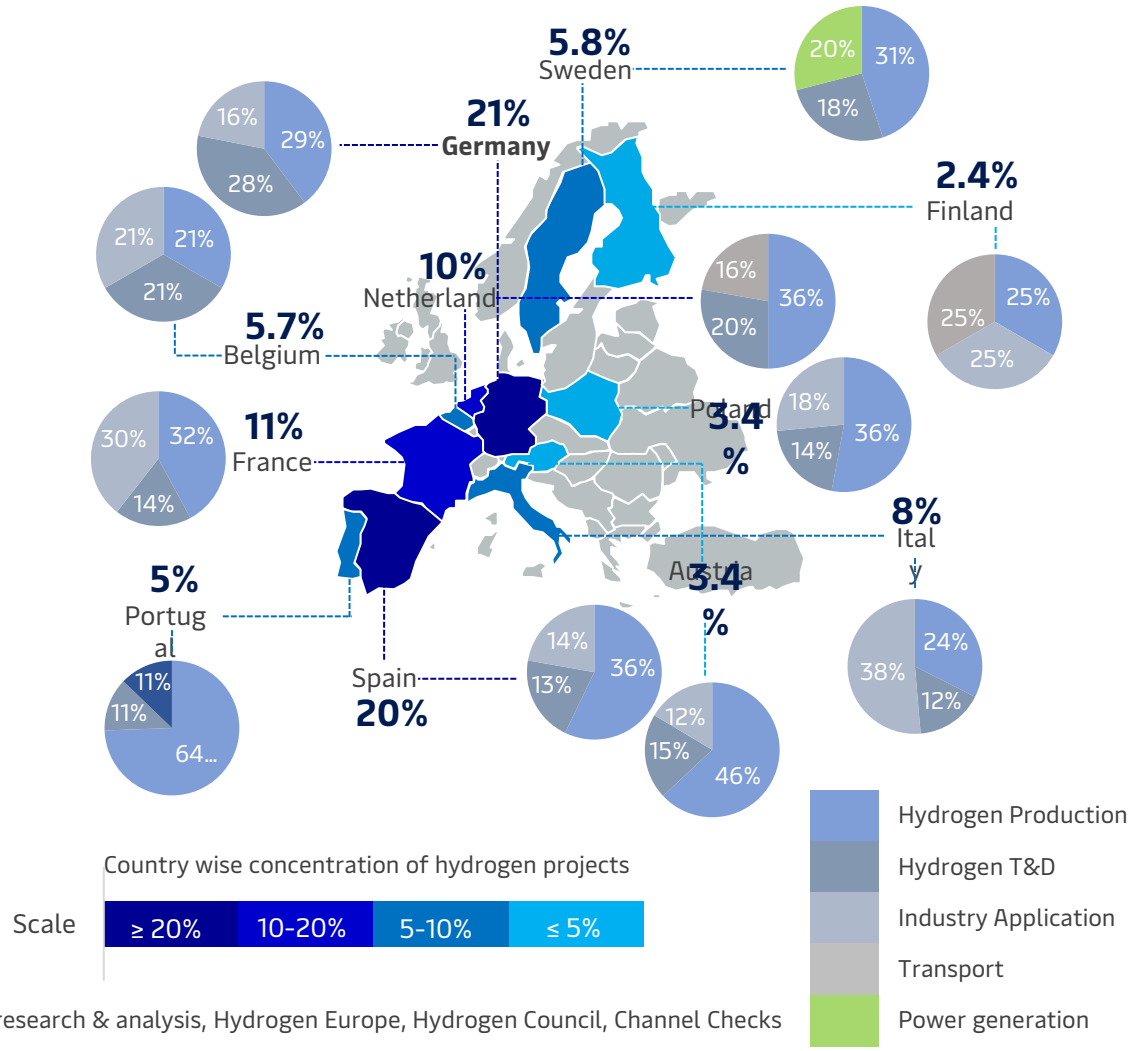
Targets Budget (Billion Euro)	Details	Target Year
3.6	Support for conversion to fuel cells for automobiles, trains, and coastal and inland water transportation vessels	2023
3.4	Support for development of hydrogen refuelling and recharging infrastructure	2023
1.91	Support for hydrogen technology research (e.g., NIP II, a program for innovation in hydrogen and fuel cell technology)	2026
1.1	Support for PtL facilities that convert electricity to liquid fuel	2023
1	Investment in new technologies and large-scale facilities	2024
0.7	Support for the introduction of fuel cell heaters	2023
0.6	Support for hydrogen research and industrialization through the Real-World Laboratories program	2023
0.05	Support for research on the practical application of fuel cell powered airplanes and ships	2024

Brief overview of project archetypes in key European countries

Europe is a leading global market for electrolyser capacity deployment with 40% of global installed capacity. It is significant to note that close to 70 MW of electrolysis became operational in 2020, making the total installed capacity to almost 300 MW. Europe's alone contribution hovers around 120 MW.

In November 2021, the European Clean Hydrogen Alliance announced a pipeline of projects that European industry is undertaking to roll out the European hydrogen economy on a large scale. Featuring over 750 projects , the pipeline is a testimony to the size and dynamism of the European hydrogen industry. The project archetypes range from clean hydrogen production to its use in industry, mobility, energy and buildings.

Concentration of upcoming hydrogen projects across few countries in the EU and their industry archetypes



Source: Eninrac research & analysis, Hydrogen Europe, Hydrogen Council, Channel Checks

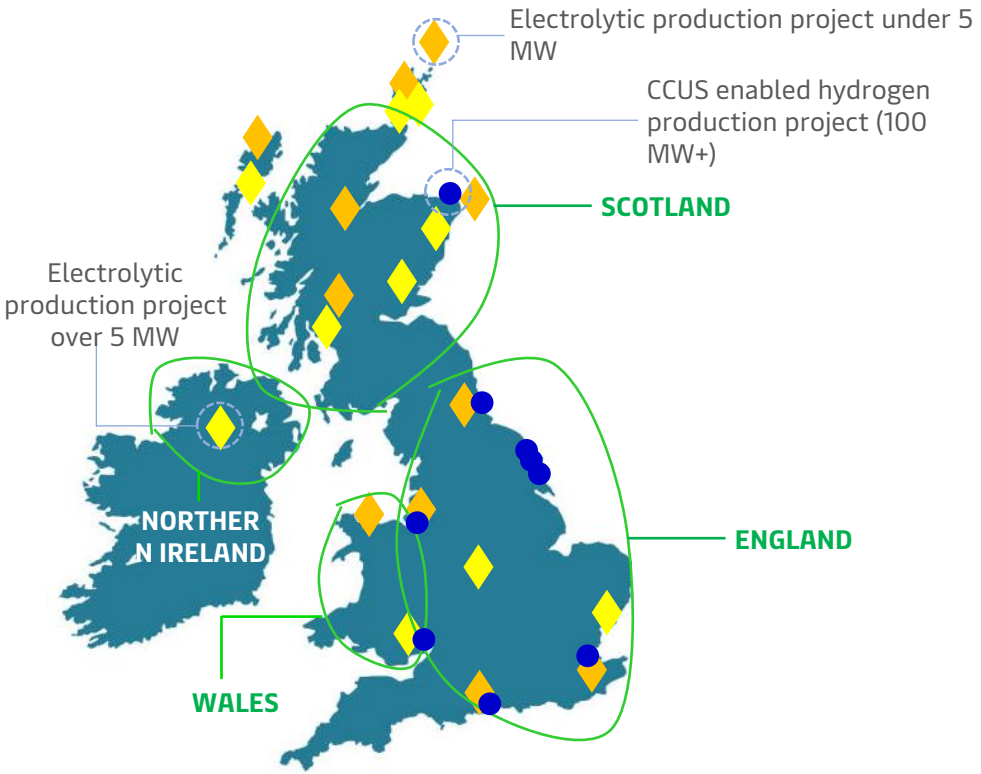
Hydrogen soon be blended with natural gas and shall be supplied safely to over 650 homes as part of a trial in Winlaton in the north east of England

UK

Courtesy its geography, geology , infrastructure and capabilities , the UK has an important opportunity to demonstrate global leadership in low carbon hydrogen and to secure competitive advantage. UK has decades of experience in production, distribution, storage, use and regulation of gas. The widespread use of natural gas for power generation and for heat in industry & homes means that we have potential supply routes and numerous potential use cases for hydrogen gas.

The government of UK recognize the importance of a clear goal alongside long term policy frameworks in bringing forward low carbon technologies. Our ambition for 5GW of low carbon hydrogen production capacity by 2030 is a signal of the government's firm commitment to work with industry to develop a strong and enduring UK hydrogen economy.

Key regions & sites in UK for hydrogen development

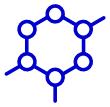


Source: Eninrac research & analysis, Hydrogen Roadmap- UK, Channel Checks

Hydrogen strategy roadmap and targets for UK – A landscape view till 2030

Hydrogen Production Objective

A. Production

Objective		**Production – 1 GW of low carbon hydrogen production capacity by 2025 5 GW of low carbon hydrogen production capacity by 2030**
		**Private investment to meet the production target – 4 Billion Pounds by 2030**
		**Carbon, Capture, Utilization & Storage (CCUS) clusters- 4 CCUS clusters by 2030 2 CCUS clusters by 2025**
		**Setting up of 40 GW of offshore wind capacity & integrating with hydrogen**

B. Production Cost (Technology Wise)

Objective	Steam Methane Method (SMR) without carbon capture	**Steam Methane Method (SMR) of 300 MW without carbon capture- £ 130/MWh by 2050**
	Steam Methane Method (SMR)/ Autothermal reformation (ATR) with carbon capture	**Steam Methane Method (SMR) of 300 MW with carbon capture – £ 65/MWh by 2050**
	PEM	**Grid electrolysis or PEM of 10 MW – £ 155/MWh by 2050**
	Renewable electrolysis	**PEM of 10 MW (with dedicated offshore wind) £ 71/MWh by 2050**

Hydrogen development across UK

1. SCOTLAND

21-126 TWh
Hydrogen production per year by 2045

96 TWh
Hydrogen for export to Europe & rest of UK

£ 65 Million
Portfolio of renewable hydrogen projects


25 Hydrogen double decker buses


60 Hydrogen fuelled vehicles for many shapes and sizes


300 Homes with new hydrogen boilers

2. WALES

100-300 MW
Commercial hydrogen wind farm to be established

£ 4.8 Million
Hydrogen production & fuelling hub

In January 2020, ASKO started using world's first hydrogen powered trucks which have a range of 500 kms with a gross weight of 26 tonnes

NORWAY

Norway is to become a low emission society by 2050. The government has a target for greenhouse gas emissions in 2050 to be reduced between 90 and 95 percent compared to 1990 levels. Norway has many years of industrial experience across the entire hydrogen value chain and conditions for the production and use of clean hydrogen are ideal. Many Norwegian companies & technology communities are already developing and supplying equipment and services for the production , distribution, storage and use of hydrogen for various sectors. Further, Norway also has large and the potential to increase energy production from renewable energy. Converting natural gas to clean hydrogen requires the capture and storage of CO2. The Norwegian continental shelf could potentially act as a CO2 storage.

The country also has competitive knowledge and technology communities and a maritime industry that includes large segments of the maritime value chain. The industry already has experience in developing and implementing new high-technology solutions in maritime transport, including the use of batteries and liquefied natural gas (LNG). Several projects in the industry are already looking closely at hydrogen or ammonia as energy carriers.

> The government of Norway is supporting broad array of zero emission solutions in the transport sector including hydrogen
>
> _ Norway Hydrogen Strategy

Hydrogen strategy roadmap and targets for Norway – A landscape view till 2030

Hydrogen Usage Objective

A. Mobility

Target Figures for Zero Emission Vehicles

Targets till 2025 –

- New cars & light vans must be zero emission vehicles by 2025
- New urban buses must be zero emission vehicles or use biogas by 2025

Targets till 2030 –

- By 2030, new large vans, 75 per cent of new long-distance buses and 50 per cent of new trucks must be zero emission vehicles
- By 2030 , good distribution in the biggest urban centers must be virtually zero emission
- Public agencies must use biofuel , low and zero emission technology as much as possible in their own and leased vehicles and vessels

Targets till 2050 –

- By 2050, transport must be virtually zero emission or climate neutral

B. Production

	Technology Type	Electrolysis Efficiency in percentage by 2030	System cost (USD/KW) By 2030
Objective	Alkaline Electrolysis	65-70%	850
	PEM Electrolysis	63-68%	1500

Hydrogen mobility scenario by the end of 2019 and early 2020

Number of hydrogen vehicles registered in Norway -

149 Hydrogen cars
01 Light van
05 Hydrogen buses
01 Hydrogen truck

70
Hydrogen trucks have been ordered by ASKO from American company Nikola motor, which are to be delivered by 2023

Source: Eninrac research & analysis, Hydrogen Roadmap- Norway, Channel Checks

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