Federal Ministry
for Economic Affairs
and Climate Action

GERMAN-NORWEGIAN
ENERGY AND INDUSTRIAL PARTNERSHIP

Roadmap on expected hydrogen off-take in Germany in the German-Norwegian Context

The effects of Russia's illegal war of aggression against Ukraine clearly demonstrated that Germany was excessively dependent on energy imports from individual countries for its energy security. Against this background, the goals in the Updated German National Hydrogen Strategy (NHS) have become increasingly important, not only for combatting climate change, but also for ensuring national security. The stated goals seek to ensure a high level of security of supply by developing competitive intra-European hydrogen production, as well as by diversifying and securing international imports.

Based on an analysis of current scenarios, the German Federal Government estimates that total hydrogen demand will be 95 to 130 TWh in 2030. Of this, around 50% to 70% (45 to 90 TWh) will have to be covered by imports (in the form of hydrogen and hydrogen derivatives), as the potential of domestic hydrogen production in Germany is limited. The share of imports needed to cover German hydrogen demand is expected to increase further in the years beyond 2030. Moreover, meeting German demand solely through domestic supply would neither be technically nor economically viable, nor would it serve the broader energy transition process. For this reason, the NHS not only focuses on the domestic production of hydrogen, but will also be supplemented by an import strategy for hydrogen and hydrogen derivatives.

The German government is pursuing the development of import infrastructures based on both pipeline and ship transport. Given the cost advantages and better scalability, it assumes that a large proportion of the demand for elemental hydrogen will be covered by pipelines. One of the German government's most important goals is to integrate Germany's core hydrogen network with the emerging hydrogen networks of the EU Member States and neighbouring countries. The infrastructure projects under the IPCEI Hydrogen Hy2Infra wave (approved by the European Commission in February 2024) represent an initial step in these efforts and will be implemented promptly based on national decisions. In addition, the German government intends to promote and strengthen import and infrastructure projects along specific hydrogen import corridors that are emerging based on cross-border EU infrastructure projects, known as Projects of Common Interest (PCI) as well as on projects involving non-EU-countries, i.e. Projects of Mutual Interest (PMI). In particular, it is seeking to support project initiatives that can provide large volumes of hydrogen at an early stage of the hydrogen market ramp-up in order to speed up the transformation of German industry. The large-scale production of low-carbon hydrogen based on natural gas from Norway offers a key opportunity for both countries.

German-Norwegian joint feasibility study and political task force

In January 2023, Norway and Germany confirmed their close partnership on energy, climate policy and industrial transformation. They agreed to explore the technical and economic feasibility of solutions based on a step-by-step approach, particularly focusing on a large-scale pipeline. A joint feasibility study has been commissioned to evaluate

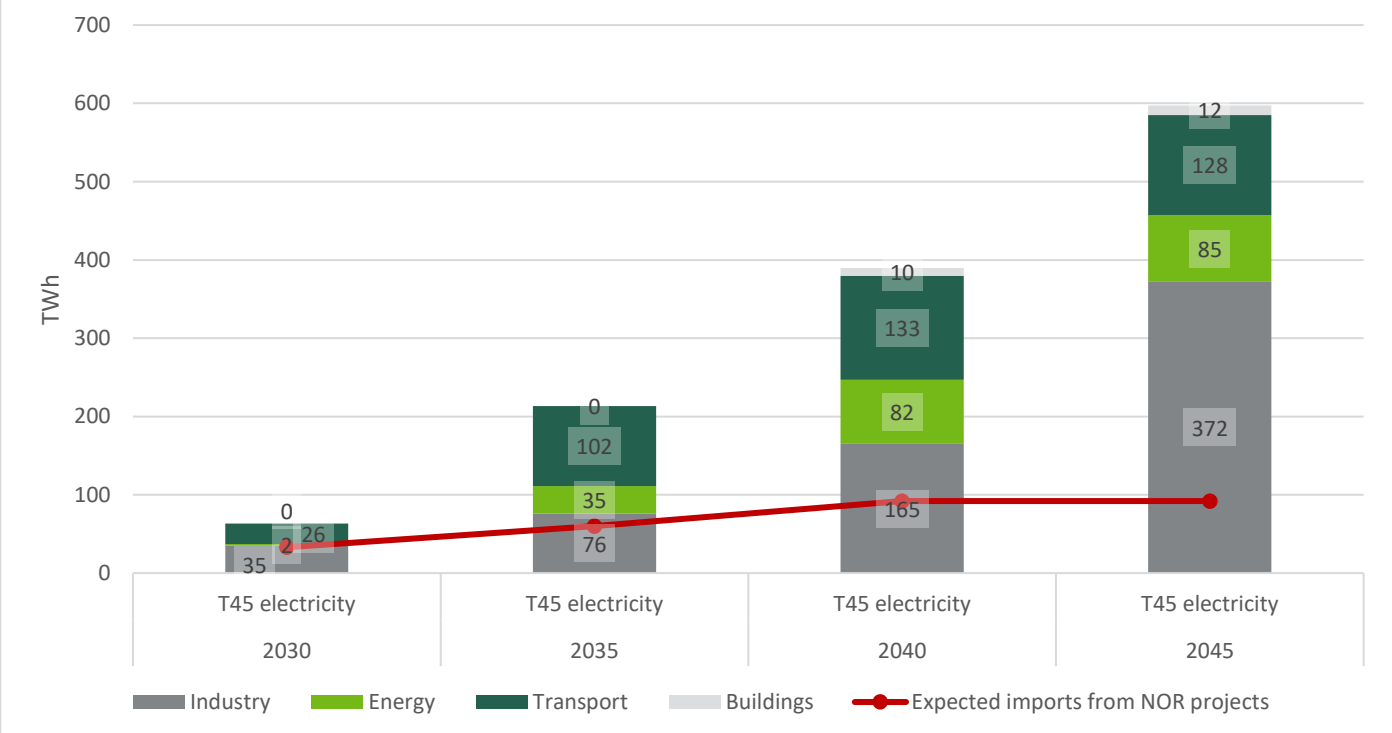
the transportation of hydrogen from Norway to Germany and of CO_2 from Germany to Norway. The results were presented by Gassco and dena in a joint report in November 2023.

The infrastructural, regulatory and economic aspects have been jointly elaborated in the established German-Norwegian task force and associated working groups. All parties involved agree that establishing fixed off-take volumes for German customers is essential in order to provide a secure business case along the entire value chain.

The German government's expectations for the development of hydrogen demand in Germany

Germany's system development strategy sets out a cross-sectoral vision and a robust strategy for the transformation of the German energy system, which can be used as a basis for various subsequent processes. These processes include infrastructure planning, e.g. the electricity and gas/hydrogen network development plan as well as sectoral and energy source-specific strategies and programmes. Based on the *long-term scenarios for the transformation of the energy system in Germany* (the official energy scenarios developed on behalf of the German Federal Ministry for Economic Affairs and Climate Action (BMWK)), the system development strategy concludes that **demand for hydrogen will increase to 360 to 500 TWh by 2045**. Additionally, 200 TWh of hydrogen derivatives such as ammonia and synthetic fuels will be needed, which leads to a total demand in the range of the T45-Electricity scenario in figure 1. This means that German hydrogen demand in 2045 will be up to nine times higher than current hydrogen demand. This is mainly the result of the new fields of application. According to the scenarios, the **share of imports will remain significantly above 70%** of total demand (up to 85%).

Figure 1: Total hydrogen demand in Germany per sector and expected imports from Norway based on project announcements (based on BMWK's long-term T45 electricity scenario)



By 2030, the main use of hydrogen and its derivatives will be primarily in the industrial sector, e.g. in the chemical and steel industries, as well as in the transport sector. In the power sector, electrolysers will chiefly be used on the consumption side as variable system-serving stabilisers or flexible loads. On the generation side, it is also possible for hydrogen to be converted back into electricity in times of high electricity demand and low power generation using renewable energy sources. Sufficient quantities of hydrogen will also be required by 2030 in order to enable the market ramp-up of hydrogen-based power plants. In addition, any new gas-fired power plants to be built are also to be designed as "convertible to hydrogen or its derivatives" (H_2-ready). The direct reduction process in the steel industry

alone will require up to 22-24 TWh of hydrogen by 2030, unless natural gas is also used as a reducing agent during a transitional period. Other new demands, for example in the chemical industry, will be added. Existing fossil hydrogen consumption, which currently ranges between 55 to 60 TWh/year and is generated mostly in refineries, will be at least partially replaced by carbon-neutral hydrogen by 2030.

Assuming that by 2045, a higher proportion of steel production than previously will be accounted for by secondary steel, around 50-70 TWh of hydrogen will be required in steel production by 2045, depending on production levels. Overall, assuming a largely unchanged structure, the industrial sector will require around 300 to 400 TWh of hydrogen by 2045. In the transport sector, a relatively high proportion of fuel-cell trucks in heavy goods transport could result in a hydrogen demand of up to 50 TWh. Depending on flexibility options in the future energy system, hydrogen-based power plants will have a capacity of 40-70 GW by 2045. As the German government expects the import requirements for hydrogen derivatives to be covered by ship imports, this roadmap does not address these.

German instruments for securing the off-take of hydrogen

The German government recognises that hydrogen will be more expensive than fossil alternatives even in the long term. It wants to provide massive support for the transformation to facilitate the switch to hydrogen in the various sectors. The German government has already launched extensive programmes for many of these sectors, which will support the transformation and use of climate-neutral energy sources. Many of the instruments enable the use of low-carbon hydrogen, which is based on natural gas. Under updated National Hydrogen Strategy, willingness to promote the use of low-carbon hydrogen has increased further. The German Government believes that natural gas-based, low-carbon hydrogen will eventually pave the way into a future which will be dominated by renewable hydrogen. This is based on the assumptions that natural gas-based, low-carbon hydrogen will be significantly cheaper than renewable hydrogen for the foreseeable future and that it will be available in large quantities starting in the early 2030s. This will enable industry to make the necessary investment decisions. However, given the goal of climate neutrality, the scope for using fossil-based energy sources will further diminish in the long-term future. During the transition phase to a fully renewable energy system, fossil-based energy sources must also meet the strictest possible carbon intensity limits.

To increase the willingness to pay in energy-intensive industry, Germany has launched Carbon Contracts for Difference (CCfD), which are intended to close the gap between prices.

Info box 1: **Carbon contracts for Difference - CCfD**

Design and scope	CCfD offer companies financial planning security with regard to certain price developments (e.g. for energy carriers such as hydrogen) and thus hedge against risks that still stand in the way of investing in climate-friendly production processes. As soon as transformative production can be carried out more cheaply than conventional production, the payment relationship established by the CCfD is reversed: additional revenues from the subsidised companies then flow back to the state, which on balance ensures that state subsidies are in line with demand.
Total funding volume	Up to €4 billion in the first round The maximum total funding is expected to be in the double-digit billion range
Admissibility of low-carbon hydrogen	Yes. The use of low-carbon hydrogen is included, according to the calculation of GHG savings defined in the Delegated Act on Art. 28(5) REDII ((EU) 2023/1185). Renewable hydrogen will however receive a higher subsidy.

To ensure security of supply in Germany's overall energy system whilst also supporting power plant operators with the transformation, the German government has developed a power plant strategy which is currently being elaborated further. In addition to the tenders for hydrogen-ready power plants, a capacity mechanism is currently being established that could create additional demand for hydrogen in the future.

Info box 2: **Power Plant Strategy**

Design and scope	New gas-fired power plants will only be operated with natural gas for a transitional period. Tenders for up to four 2.5 GW, H2-ready, gas-fired power plants are planned. From 2035-2040, they are to switch from natural gas to hydrogen. The exact conversion dates are to be set in 2032. The nature of the funding still needs to be clarified. The German government plans to reach an agreement by summer 2024 on the design of a capacity mechanism and on what funding is available for the construction and operation of the power plants.
Total funding volume	Approx. €15-20 billion
Admissibility of low-carbon hydrogen	Yes. Power plants are to run on "all colours of hydrogen and green hydrogen wherever possible."

The auctions under the H2Global mechanism, which also closes the gap between prices, are aimed specifically at covering import requirements.

Info box 3: **H2Global**

Design and scope	Hydrogen Intermediary Company GmbH (HINT.CO) concludes long-term purchase contracts (HPA of 10 years) based, on the supply side, on the lowest bidder and short-term sales contracts (e.g. 1 year), Hydrogen Service Agreements (HSA), and based, on the demand side, on the highest bidder within the EU. Priority is given to PtX products as logistics for transport (shipping, rail and road haulage) are more mature, long-distance hydrogen pipelines still to be built. In May 2023, H2Global announced collaboration with the European Hydrogen Bank. H2Global will work on a joint European auction open to all EU countries.
Total funding volume	The German government is providing €900 million in funding over a ten-year period from 2024-2033. This sum is allocated within the first three tenders on green ammonia, green methanol and e-SAF. The tender deadline was February 2023. According to the federal budget for 2023, the funding will be raised to provide an extra €3.5 billion for new tenders with contract periods up to 2036.
Admissibility of low-carbon hydrogen	Support for low-carbon hydrogen production is not intended under H2Global.

As part of the IPCEI Hydrogen, which started in 2021, end-user projects could also be selected for funding. Particularly the German steel industry projects that have now been approved on the basis of CEEAG State aid are generating a significant demand for low-carbon hydrogen.

Info box 4: **Important Projects of Common European Interest – IPCEI Hydrogen**

Design and scope	IPCEI are designed to bring together expertise, financial resources and economic actors across the EU. The IPCEI Hydrogen waves Hy2Tech and Hy2Use have been approved. Hy2Tech relates to technologies for renewable hydrogen production. Hy2Use is concerned with technologies for hydrogen off-take in the industry. Hy2Infra deals with hydrogen-related infrastructure and has also been approved. Hy2Move will focus on mobility and is expected to be approved in 2024.
Admissibility of low-carbon hydrogen	Yes. Member States agreed that the "full clean hydrogen value chain" should be covered, meaning low-carbon and renewable hydrogen.
European projects with funding (pre-)approval	Hy2Tech: €5.4 billion Hy2Use: €5.2 billion Hy2Infra: €6.9 billion

Info box 5: **Climate Energy and Environmental Aid Guidelines - CEEAG**

Design and scope	CEEAG provides important framework conditions for State aid in the field of climate, environment and energy in the EU. Some IPCEI Hydrogen steel projects were transferred to be notified under CEEAG.
Admissibility of low-carbon hydrogen	Yes, but restricted in share.
German projects funding (pre-)approval	Funding granted for hydrogen use in DRI/steel production in 2023: €5.6 bn (Salzgitter €1 bn, Thyssenkrupp €2 bn, Stahl-Holding-Saar €2.6 bn) + in process: Arcelor-Mittal

Given the emission-reducing effect of hydrogen and thus its contribution to meeting Germany's emission reduction targets, the emission reduction targets and respective measures jointly agreed at European level promote the off-take of hydrogen in different ways.

The EU Emission Trading System (ETS) incentivises the reduction of greenhouse gas emissions in the EU and EEA-EFTA countries. It works on the basis that polluters pay for their emissions. The revenue is then used to support domestic investments in renewable energy, low-carbon technologies, and energy efficiency. Currently, the EU ETS covers around 40% of EU emissions, including installations in the energy sector. Operating on a "cap and trade" system, the EU ETS cap limits the volume of emissions that may be emitted by specific installations. The cap is expressed in allowances, whereby one allowance equals one tonne of CO_2eq. Companies must surrender allowances for their emissions each year and can trade allowances with others. As the cap decreases annually, emitting CO_2 becomes increasingly expensive. This will further drive the demand for renewable and low-carbon energies such as hydrogen as it increasingly becomes cost-competitive, not only in Germany, but also across the EU and EEA-EFTA countries.

The EU taxonomy defines whether economic activities are sustainable. The aim is to channel investments into economic activities that are needed for the energy transition. In the EU taxonomy, the threshold value for greenhouse gas emission savings for hydrogen production are set at 73.4% and at 70% for hydrogen-based synthetic

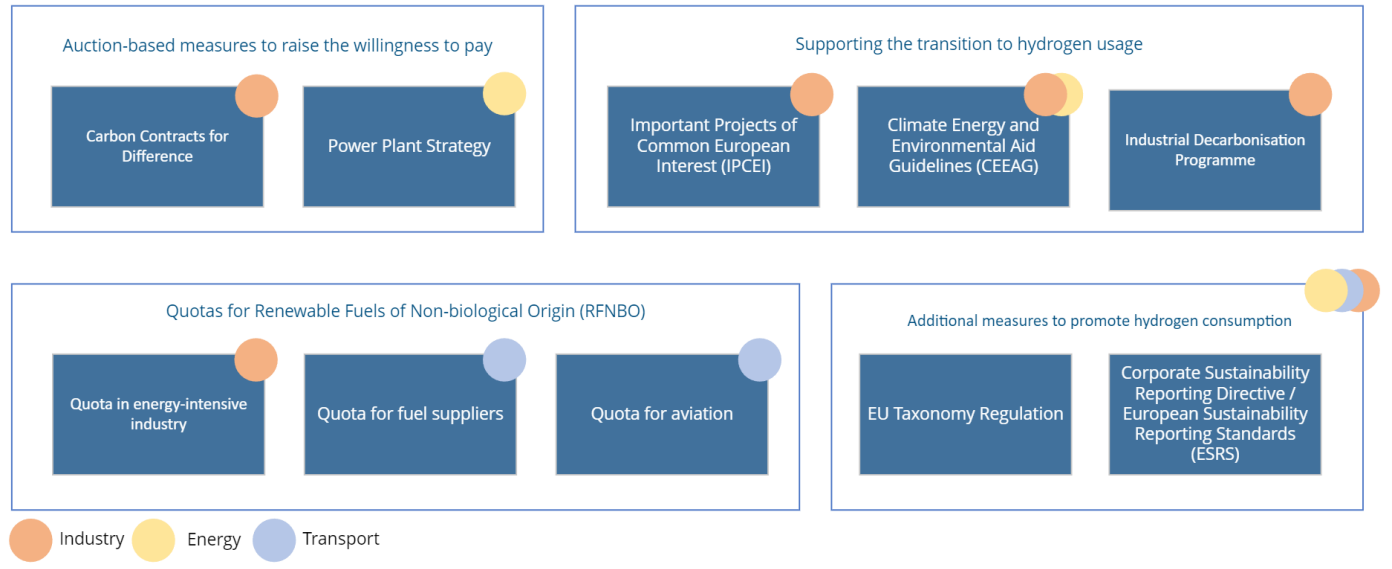
fuels. The Corporate Sustainability Reporting Directive (CSRD) obligates companies to report on their sustainability performance compared with the EU taxonomy, i.e. the threshold values above. Companies must fulfil these reporting obligations and taxonomy limits in order to make investments bankable. One possible solution is the use of low-carbon or renewable hydrogen.

The Renewable Energy Directive III (RED III) defines renewable fuels of non-biogenic origin (RFNBOs) and the minimum GHG savings through the use of RFNBOs. EU Member States have to ensure that RFNBOs used for final energy and non-energy purposes account for at least 42% of hydrogen used in the industrial sector by 2030, and at least 60% by 2035 (in accordance with Art. 22a). Reducing the emissions of these companies is a top priority for the German government. At the moment, there are no plans to allocate this quota to specific companies. Companies will therefore have the option of using natural gas-based, low-carbon hydrogen.

Suppliers of gasoline and diesel need to reduce the CO_2 emissions of the fuels they place on the market by a legally defined percentage (GHG quota). The fulfilment options are defined in Section 37a(5) Federal Immission Control Act (BImSchG), including the possibility of using RFNBOs or biofuels. Aviation fuel suppliers are also required to ensure that a minimum share of the fuel that is replacing fossil aviation fuel is sourced from RFNBOs. The percentage of this share is specified in Section 37a (4a) BImSchG.

Figure 2 provides an overview of the instruments discussed, which are continually evaluated and will be supplemented with additional instruments in the future. The instruments presented here only represent a selection within the funding framework in Germany.

Figure 2: Overview of hydrogen off-take instruments



There are additional support options for smaller project initiatives such as hydrogen fuelling stations. As it is currently assumed that contracts with Norwegian producers are concluded with major customers or intermediaries, they will not be explained further in this roadmap.