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GERMANY

The H_2 Handbook

Legal, Regulatory, Policy, and Commercial Issues Impacting the Future of Hydrogen

HYDROGEN IN GERMANY – NEW POLITICS, MANY PUBLIC FUNDING PROGRAMS, AN EMERGING MARKET

On 10 June 2020, the German government announced its "**National Hydrogen Strategy**" outlining a broad package of measures and public funds to be made available for furthering the development of a national hydrogen industry in Germany.

On 1 July 2020, Germany took over the presidency of the Council of the European Union (EU Council). The EU Council presidency is limited to six months and rotates in a fixed order from one EU member state to the next. The member state chairing the EU Council is expected to coordinate and organize the broad political strategy of the European Union for the respective period. Member states commonly use this position to add certain of their own high-priority topics to the EU agenda or put them into focus. In the weeks before the change of the EU Council presidency, it had become apparent that hydrogen would be one of the core topics of the German presidency. On 16 July 2020, Federal Minister of Economics Peter Altmaier (Christian Democratic Union of Germany, or CDU) explicitly confirmed this priority, which is also demonstrated by the federal government's program for the German EU Council presidency published on 30 June 2020.

Even though the National Hydrogen Strategy focuses primarily on measures to support hydrogen projects and develop a domestic hydrogen market in Germany, the federal government in Germany explicitly acknowledges that some of the challenges in furthering and promoting hydrogen as an innovative energy source can only be resolved in the European Union context. German Development Minister Gerd Müller (CDU) also sees significant development potential beyond Europe. Following the federal government's decision on the National Hydrogen Strategy, he declared that green hydrogen can become the clean oil of tomorrow ("[…] grüner Wasserstoff kann so zum sauberen Öl von morgen werden.").

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PART I - GERMANY IN (ENERGY) TRANSITION

Environmental awareness among the German population has increased in recent decades. Climate change has become one of the greatest concerns, in particular for young Germans involved in the "Fridays for Future" movement, demonstrating their willingness to change climate policy. There seems to be a growing interest among German citizens to consider new sustainable technology solutions in order to protect nature, the climate, and the planet.

German politics mirror these societal views. Chancellor Angela Merkel pushed Germany's withdrawal from nuclear energy after the incident in Fukushima, Japan, in 2011, thereby reversing her prior outspoken support of nuclear energy. This tragic event marked the beginning of the "energy transition" in Germany. Based on a long-term plan, nuclear (until the end of 2022) and coal-fired (by 2038 at the latest) power plants will be shut down and fossil fuels will be replaced by renewables to reduce carbon emissions and slow climate change. This "decarbonization" represents a goal to which Germany has also committed itself within the framework of the Paris Climate Protection Agreement. The new National Hydrogen Strategy clearly states that hydrogen will be an indispensable component in reaching the ambitious goals of climate neutrality and carbon neutrality.

Even though there are still many development needs regarding hydrogen production, storage, and use, hydrogen is seen as having advantages over pure electrical energy, in particular with regard to shortage of raw materials for and disposal of batteries, but also with regard to transportation. Hydrogen, which stores the energy obtained in gaseous form, can be easily transported, and Germany already has an extensive natural gas pipeline network. Additional advantages of hydrogen usually mentioned in the German discussion include conservation

of resources, security of supply, and environmental and climate protection. However, the economic viability and the associated broader acceptance by the population still remain to be achieved.

To reach Germany's sustainability goals, several new pieces of legislation have already been implemented to create incentives for green energy production and consumption by way of public funding. For example, the federal government introduced a more favorable tax treatment for electric than for traditional company cars, as well as grants for the private purchase of electric cars and for the construction of charging stations. With the new National Hydrogen Strategy, the German government is now pushing forward a broad initiative supporting hydrogen production and use in Germany and establishing it as a competitive alternative energy source and decarbonization tool.

PART II - THE FEDERAL POLITICS REGARDING HYDROGEN IN GERMANY

The German government has been providing substantial hydrogen funding since 2007, when it launched its "**National Hydrogen and Fuel Cell Technology Innovation Programme**."

In June 2020, this focus was reconfirmed and substantially deepened and broadened with the new German National Hydrogen Strategy presented by the federal government right before the start of the German EU Council presidency. With the National Hydrogen Strategy, the German government is looking to secure German leadership in innovation with regard to climate protection technologies and to develop those technologies into a German hallmark.

The goal is to become a leading global supplier of modern hydrogen technology. However, the German government's goals extend beyond the national goal of further expanding it's already prominent position regarding hydrogen research and development (R&D) (based on research and investment in the field of hydrogen in the last decade) and upscaling the "home market" for hydrogen production and storage. It intends to motivate the rest of the European Union and the world to use hydrogen as the oil of the 21st century.

To achieve its goal of establishing hydrogen as a competitive option for decarbonization, the federal government envisions the implementation of numerous support programs and legislative initiatives in coordination with the various federal ministries responsible for innovation, industry, climate, and energy policy. One of the main drivers behind the National Hydrogen Strategy is, of course, to counter the effects of climate change; green hydrogen in particular enables carbon-neutral energy production. The main focus of the strategy is now to make hydrogen marketable through various measures and to foster the production of and industry for green hydrogen in Germany. However, Germany will still have to import hydrogen to meet its needs (at least for the foreseeable future), which is why the strategy also pursues international collaboration projects. The German government projects that national hydrogen demand will be approximately 90 to 110 terawatt hours (TWh) until 2030. In order to cover at least a part of this demand in Germany, hydrogen generation plants with a total capacity

of up to 5 gigawatts, including the necessary offshore and onshore facilities, will be built in Germany by 2030. This corresponds to green hydrogen production of up to 14 TWh and required renewable electricity of up to 20 TWh.

According to the strategy, other secondary products such as ammonia, methanol, and methane should also be produced from hydrogen. Assuming green hydrogen is used, the strategy describes these products as Power-to-X (PtX) and, in the case of gaseous derivatives and liquids derivatives, they are described as Power-to-Gas (PtG) and Power-to-Liquid, respectively. Hydrogen can provide a valuable storage method for superfluous power (e.g., produced by wind farms), as it can be stored in highly pressurized tanks and be converted back into power when needed (PtG).

The new National Hydrogen Strategy is not only a necessary step towards the German energy transition, but it recently also has been described as a means to reduce the economic consequences of the COVID-19 pandemic. The Federal Minister for the Environment, Svenja Schulze (Social Democratic Party of Germany, or SPD), hopes that the new National Hydrogen Strategy will provide a "double thrust," not only for climate protection but also for the sustainable recovery of the economy from the COVID-19 crisis.

On 3 June 2020, the German government adopted an economic stimulus package to overcome the consequences of the COVID-19 crisis that provides for €9 billion to be made available for the construction of hydrogen plants. Of this amount, €7 billion is to be used domestically for the purpose of establishing climate-neutral, green hydrogen in Germany. The remaining €2 billion is to be used for international partnerships, including the production and import of blue hydrogen, which is hydrogen produced from natural gas that includes carbon capture and sequestration (CCS).

In addition to this mega-package for hydrogen promotion, numerous other federal funds are available within the framework of the National Hydrogen and Fuel Cell Technology Innovation Programme already mentioned. In addition, the individual German federal states also have launched funding programs (supplementing the federal funding or stand-alone). These federal state subsidies are not discussed in detail here, as they differ substantially and generally require that the (subsidized) investments be made in the respective state and, as such, are of interest mainly to companies looking to invest in the respective member state. There are a couple of developments worth highlighting, however. Specifically, the northern German states have ambitious plans regarding hydrogen and provide corresponding subsidies, which are likely due primarily to the local availability of wind energy in sufficient quantities for the energy-intensive production of green hydrogen. In particular, the city of Hamburg has shown big ambitions to present a lighthouse project soon—press reports have mentioned plans to build a sizable hydrogen production plant (electrolyser) in the Hamburg harbor. The project still seems to be in development, though, and investors are still needed.

Among numerous other measures, the new National Hydrogen Strategy also provides for the establishment of a 25-member National Hydrogen Council, which will advise the federal government on the hydrogen industry and technology. This council has a very diverse structure and consists of representatives from both industry and science appointed by the federal government. The council is chaired by Katherina Reiche, a former top politician from Chancellor Merkel's CDU, who moved to the private sector five years ago. Reiche's involvement and position send a clear signal that the National Hydrogen Council is to take on its role as an interface between politics and industry. While in the last decade hydrogen funding has been promoted primarily for research projects, the focus is now shifting to establishing hydrogen as an economically viable and competitive alternative energy source, storage means, PtX component, and basic material for industrial uses. The goal is to ramp up the German market and promote a competitive German hydrogen industry with a steady demand and supply of hydrogen.

PART III - THE (PREEXISTING) NATIONAL HYDROGEN AND FUEL CELL TECHNOLOGY INNOVATION PROGRAMME

The first National Hydrogen and Fuel Cell Technology Innovation Programme (NIP I) was introduced by the federal government in 2006 and is managed by the Federal Ministry of Transport and Infrastructure. It was first set until 2016. The successor program (NIP II) also runs for 10 years until 2026.

The federal government (in charge: the Ministry of Transportation) has commissioned Forschungszentrum Jülich (Project Management Jülich), in cooperation with the National Organisation for Hydrogen and Fuel Cell Technology (NOW GmbH), to implement the National Hydrogen and Fuel Cell Technology Innovation Programme. NOW GmbH (100 percent held by the Federal Republic of Germany) has been coordinating and steering the National Hydrogen and Fuel Cell Technology Innovation Programme since 2008. Project Management Jülich (also 100 percent owned by the German state) conducts research in the field of hydrogen and uses its findings to advise German policymakers.

From 2007 to 2016, NIP I supported projects with a funding of €700 million and was intended to prepare for the establishment of a German hydrogen industry sector through stable framework conditions and funding opportunities. However, from 2016 to 2026, NIP II (with a total funding of €1.4 billion) aims to ensure the market launch of fuel cell products, to establish a hydrogen infrastructure for transportation, and to make hydrogen technology competitive in the energy market.

The subsidies are distributed by way of online calls for specific funded measures published by NOW GmbH with application deadlines. Interested parties can apply to receive support for the respective hydrogen projects. Potential interested parties can also register with the **e-mail service** to keep up to date on funding opportunities.

One important project under the NIP II is "HyLand," through which 25 municipalities and regions have been identified as particularly important for the success of the implementation of the traffic transition in Germany. Under HyLand, these municipalities and regions will be supported financially in their endeavors to push towards low-emission public transportation, heat and electricity generation, and electricity storage. Several funding initiatives are gradually being launched and are sometimes repeated at certain intervals. Examples of the programs over the last several years include:

- Funding for fuel cell passenger cars in company or public fleets;
- Funding for fleets of industrial trucks with fuel cell drive;
- Funding for publicly accessible hydrogen filling stations in road traffic (2018 and 2019);
- Funding for fuel cell vehicles in public transportation and fleets (2017 and 2018);
- Funding for fuel cell systems for self-sufficient energy supply of critical or off-grid infrastructures; and
- Funding for trains and ships with fuel cell drive.

To date, a total of 212 projects have been completed through the National Hydrogen and Fuel Cell Technology Innovation Program, 22 of which are ongoing. The projects cover the areas of transportation, shipping, special markets, cross-sectional issues, and electricity-based fuel.

PART IV - THE NEW GERMAN NATIONAL HYDROGEN STRATEGY 2020

The new German National Hydrogen Strategy aims to make carbon-free hydrogen economically viable, which will only be possible if a "home market" for hydrogen technologies is successfully developed.

The idea is to incentivize green hydrogen production in Germany to help ensure that German hydrogen will be attractive throughout the European Union and internationally. Under the strategy, carbon-free hydrogen will be established as an alternative energy carrier and fuel in transportation. Sustainably produced hydrogen will be used as the basis for synthetic fuels, particularly in air and heavy-duty transport. Hydrogen will be made sustainable as a basic material for industrial uses. The transportation and distribution infrastructure will be further developed. Science will be further promoted, and skilled workers will be trained to create global market opportunities for German companies. International markets and global cooperation for hydrogen will be established to realize the full potential of hydrogen solutions. In order to achieve these goals, the strategy envisages 38 concrete measures in six fields of action, namely:

- Production
- Primary focus application areas (especially transportation, industry, and heating)
- Supply infrastructure
- Research, education, and innovation
- The European need for action
- The international hydrogen market (including necessary imports of hydrogen into Germany)

The new National Hydrogen Strategy[1] provides clear examples of the focus points of future hydrogen policy in Germany.

Hydrogen Production

"The introduction of **CO2 pricing for fossil fuels used in transport and the heating sector** is an important element here, and will be complemented by a reduction of the [Renewable Energy Act] EEG surcharge." The EEG surcharge is used to finance the expansion of renewable energy in Germany. Operators of renewable energy systems that provide electricity into the public grid receive a fixed remuneration. The resulting additional costs are passed on to all electricity consumers.

Incentives for Green Hydrogen

- "Our analysis will also include the question as to whether it might be possible to largely **exempt electricity used for the production of green hydrogen from taxes, levies, and surcharges.** In particular, we are working towards exempting the production of green hydrogen from the EEG surcharge. As we do so, we will ensure that the EEG surcharge does not rise."
- "As part of our Climate Action Innovation Pact, we are also supporting the switchover to hydrogen in the industrial sector by providing **funding for investments in electrolysers.**"
- "We are also exploring potential tendering schemes for the production of green hydrogen, e.g. to help decarbonise the steel and chemical industries."
- "Potential adjustments that will be discussed include the **designation of additional areas that can be used for offshore production of hydrogen/PtX, the infrastructure necessary for this, and the potential for additional auction rounds for the production of renewables** (implementation starts in 2020)."

Transport

"An **ambitious GHG (greenhouse gas) reduction ratio** will increase the share of renewables in transport. If combined with specific other measures, it can provide incentives for the use of hydrogen or hydrogen products as an alternative fuel for transport."

Incentives for Green Hydrogen

- "The Federal Government has decided to make its objective to **increase the minimum share of renewables in Germany's final energy consumption in transport significantly** beyond what is required under EU rules by 2030."
- "**Market activation to boost investments in hydrogen-powered vehicles** (light and heavy-duty vehicles, buses, trains, inland and coastal navigation, car fleets)".
- "Development of and **funding for installations for the production of electricity-based fuels,** in particular electricity-based kerosene, and advanced biofuels."

[1] *National Hydrogen Strategy*, FED. MIN. FOR ECONOMIC AFFAIRS AND ENERGY (June 2020), https://www.bmbf.de/files/bmwi_Nationale%20Wasserstoffstrategie_Eng_s01.pdf.

- "**Funding for the construction of a needs-based refueling infrastructure for vehicles,** including heavy-duty road haulage vehicles, vehicles public transport and in local passenger rail services."
- "Advocacy for an ambitious development of the European infrastructure facilitating cross-border transport powered by fuel-cells."
- "**Support for** the establishment of a competitive **supply industry for fuel-cell systems.**"
- "Target-driven transposition of the Clean Vehicles Directive (CVD) to support zero-emissions vehicles in local transport."
- "Advocacy for a **carbon-based differentiation of the truck toll** with reduced rates for climate-friendly drivelines under the Eurovignette Directive."

Industrial Sector

Many industrial processes already depend on the use of hydrogen today. In the chemical industry, for example, hydrogen is used as a starting material for the production of ammonia. In the production of primary steel, hydrogen is currently regarded as the most promising solution for replacing hard coal coke.

Incentives for Green Hydrogen

- "The tools available for this are the fund for 'Decarbonising the industrial sector' and the programs for 'hydrogen use in industrial production' (2020-2024) and *'***avoiding and using CO2 in industries relying on base substances'**."
- "A **demand quota for climate-friendly base substances**, e.g. green steel, is being considered."
- **"Develop hydrogen-based long-term decarbonisation strategies** together with stakeholders—particularly from the energy-intensive industries—within sector-specific dialogue formats (beginning in 2020 for the chemical, steel, logistics, and aviation sectors, with others to follow step-by-step)."

Infrastructure/Supply

Incentives for Green Hydrogen

- "The possibilities for **using existing structures** (dedicated hydrogen infrastructure as well as parts of the natural gas infrastructure than can be adjusted and backfitted to make it H2-ready) […] The necessary regulatory basis for the construction and expansion of a hydrogen infrastructure will be prepared swiftly. For this purpose, **a market exploration procedure** is to take place shortly."
- "As a new infrastructure is being created, special attention must be given to a **needs based expansion of the network of hydrogen refueling stations** in road transport, at suitable locations within the **railway** network (e.g. Municipal Transport Financing Act), and for the **waterways (cf. fields of application). Target groups here include individual users and operators of a large fleet of hydrogen-powered or fuel-cell-powered vehicles."**

Research, Education, and Innovation

Incentives for Green Hydrogen

- "A joint hydrogen roadmap that is to serve as guidance: Germany wants to position itself as a lead provider of green hydrogen technology on the global market. For this purpose, **a roadmap for the German hydrogen industry** will be developed together with the science and business communities and civil society."
- "A new cross-ministry **research campaign entitled 'hydrogen technologies 2030'** will see a strategic bundling together of research activities into hydrogen- related key-enabling technology."

Need for Action at European Level

As noted above, the German National Hydrogen Strategy mentions in several instances that European, or even global, cooperation will be key for further developing commercial-scale hydrogen end-use. This is particularly clear from the two highlights below. For further information on the EU hydrogen plans, please refer to the European Union chapter of *The Hydrogen Handbook.*

Incentives for Green Hydrogen

- "The German EU Council Presidency offers a good opportunity in the second half of 2020 to proactively progress key hydrogen-related dossiers, e.g., in the context of the preparations for the **legislative package on sector coupling and gas market design.** These particularly include the Hydrogen Action Plan envisaged by the European Commission and the strategy on **Smart Energy System Integration."**
- "International cooperation in the field of hydrogen offers opportunities in the fields of economic policy, climate change mitigation, foreign policy and development policy. We aim to make use of this, and the coalition committee's 'package for the future' of 3 June 2020 offers an additional €2 billion for this. We are therefore stepping up our efforts to build up and intensify international cooperation on hydrogen at all levels."

PART V - WHERE ARE THE BUSINESS OPPORTUNITIES IN THE HYDROGEN INDUSTRY IN GERMANY?

Based on the German hydrogen strategy, interesting business opportunities in the hydrogen sector are opening up in Germany—for German and also for international companies.

At the same time, many international projects will also be initiated from Germany, for which stakeholders and partners are needed. The German hydrogen initiative could thus create national, as well as international, business opportunities.

Hydrogen Business Opportunities *in* Germany or *with* Germany?

International cooperation is key for the German hydrogen policy. While there is a clear focus on the production of green hydrogen in Germany, the National Hydrogen Strategy acknowledges that (at least for a potentially long interim period) the volumes that can be produced this way will not be sufficient to reach Germany's ambitious climate and carbon neutrality goals. Imports of hydrogen will be a substantial component of the mix for the foreseeable future, as production of the target volumes of green hydrogen likely is not achievable today with domestic resources alone. The production of green hydrogen by electrolysis still requires a significant quantity of renewable energy. And, even though wind and solar energy have grown significantly in Germany in recent decades, Germany alone cannot provide the renewable energy volumes required for the target amount of hydrogen.

The German government has considered potential partner regions from which hydrogen could be imported. For example, the Baltic Sea countries have sizable offshore wind energy areas, southern Europe has sunny and windy areas, as do many parts of Africa. The German Development Minister Gerd Müller (CDU) specifically mentioned that countries in North Africa would be suitable production sites for green hydrogen due to their climate

conditions. Against this background, the joint development of the first industrial hydrogen plant in Africa already has kicked off in Morocco, supported by German funding from the COVID-19 package. The aim is to create jobs for many young people, strengthen Germany's technological leadership, and achieve compliance with international climate targets. The project in Morocco alone is expected to save 100,000 tons of carbon emissions annually. The German Development Minister also considers other partner countries in North Africa, as well as in South America, to be potential locations for production plants.

While green hydrogen is the primary goal of the German Strategy, blue hydrogen (produced from natural gas, with CCS) and even grey hydrogen (produced using fossil fuels and without CCS) could also be funded under the strategy. At the moment, it is not yet clear the extent to which Germany will support the import of each type of hydrogen. To date, the only identified project is the Morocco one discussed above, where green hydrogen will be produced and delivered to Germany with the help of German technology and knowledge. In addition, while the strategy mainly focuses on climate-neutral green hydrogen, it would also allow support for the import of blue and grey hydrogen, possibly even by using German subsidies. The direction in which the promotion of hydrogen imports in Germany will develop will be revealed in the coming months and years through the federal ministries' concrete projects.

In Which Industries Will Hydrogen Initially be Relevant in Germany?

The strength of the German government's promotion of hydrogen demonstrates its belief that hydrogen has the potential to revolutionize the energy, business, and industrial worlds in the long term. At the moment, however, hydrogen use is not yet economically viable in many areas. In the new National Hydrogen Strategy, some applications have, however, been singled out as being very close to economic viability. These relate to areas for which there are no alternative decarbonization options, in particular the chemical and steel industries, as well as the transportation sector and, in the long term, heat recovery in residential and nonresidential buildings. However, even these sectors can logically work successfully with hydrogen only if sufficient hydrogen supply is available and its reliable distribution is ensured.

Development of Domestic Hydrogen Production

The National Hydrogen Strategy is initially aimed primarily at establishing domestic green hydrogen production.

To this end, the German government has set up the Hydrogen Power Storage & Solutions East Germany (HYPOS), a project consortium dedicated to hydrogen, in the "Zwanzig20" innovation partnership program—"Twenty20" is a federal government project that promotes partnerships between economy and science in the eastern German federal states. The aim of the project is to advance the economic production of

hydrogen via water electrolysis on a large scale. The comprehensive use of electricity from renewable energy sources is addressed, particularly the ability to use temporary power surpluses generated from renewable energy in a meaningful way in the future. HYPOS is researching various areas along the entire hydrogen value chain and is thus working on various joint projects, including the chemical conversion of electricity, transport, and storage, as well as the utilization and sale of hydrogen. Approximately 100 members have already come together under this framework to pursue the goal of an economically viable and socially accepted hydrogen infrastructure. Interested companies, universities, research institutes, associations, clubs, similar institutions, and private individuals are invited to contact HYPOS for a partnership.

The next important step will be to secure the availability of hydrogen throughout the country. This requires certain infrastructure, including pipeline and filling station systems. The National Hydrogen Strategy mentions some positive aspects in this respect:

- Hydrogen has favorable storage and transport characteristics. Renewable energy generated by wind turbines and solar plants can be stored in hydrogen and transported easily via pipelines. Green hydrogen can be produced in regions with significant wind, sun, and water and exported from there to meet the energy needs of the rest of the world.
- Germany already has a comprehensive system of gas service pipelines. It is possible that these could be used for hydrogen transport by rededication after adjustment and refitting. In addition, more new pipelines will certainly have to be built and the public hydrogen filling station system expanded in order to secure a solid supply network overall. The respective construction contracts will be tendered in the years to come and will be open to national, as well as international, companies.

Steel and Chemical Industry

The commercial use of hydrogen must be further developed in research projects. Companies likely will be motivated to produce more climate-neutral products in the future due to the European emissions trading system and the German obligation to purchase carbon certificates that will apply from 2021.

In the particularly energy-intensive chemical and steel industries, meaningful industrial processes using hydrogen are already conceivable as they are closer to being profitable relative to other industries. The hydrogen strategy therefore assumes that the following areas must be addressed in a sensible manner.

In the steel industry, alternative processes, such as the injection of hydrogen into blast furnaces to avoid greenhouse gas emissions or direct carbon reduction in special plants, can contribute significantly to reducing carbon emissions.

It is therefore not surprising that successful research projects already exist in this area. For example, the "Carbon2Chem" project is dedicated to a climate-friendly steel industry. It aims to use the waste gases produced in ThyssenKrupp's steel mill (so-called metallurgical gases) as raw materials—instead of allowing these emissions to escape into the atmosphere in a way that is harmful to the climate. To achieve this, it uses hydrogen from the steel mill gases, adds self-produced hydrogen, and finally produces fertilizers, plastics, and synthetic fuels from the resulting gas mixture.

The MACOR project is also part of the climate-friendly steel industry program. It is a feasibility study that uses the example of the steelworks in Salzgitter to investigate whether and how more environmentally friendly steel production is possible by using green hydrogen instead of coal for heating.

The chemical industry already has a high demand for hydrogen as a feed material. Currently, mostly grey hydrogen is used for this purpose. The goal of the National Hydrogen Strategy's focus on green hydrogen is to replace grey hydrogen with green hydrogen in future projects.

Furthermore, there are areas where hydrogen is produced as a byproduct, like chlorine-alkali-electrolysis. In light of the described difficulties producing sufficient hydrogen to reach the ambitious sustainability goals of both the German government and the EU Commission, the National Hydrogen Strategy puts emphasis on the development and implementation of new methods to transfer this unused potential into usability.

Transport Sector

In the transport sector, the National Hydrogen Strategy centers on public transportation with trains and buses and goods transportation with trucks. With regard to individual transportation by car, German car manufacturers and politicians seem to agree that, at present, too much energy has to be generated to produce hydrogen to make its use in cars economically viable. Therefore, it is mainly still assumed that battery-powered electric vehicles make more sense for private transport.

However, in local public transport with buses and trains and heavy goods traffic on the road with trucks, as well as commercial vehicles (e.g., for use in the construction industry, in agriculture and forestry, or in logistics with forklifts), the introduction of hydrogen fuel cell vehicles is being considered as a viable option to complement battery-powered electromobility in the future and to help significantly reduce air pollution and carbon emissions.

Here, too, many research projects have been initiated and continue to be promoted through public funds to drive forward the market launch of hydrogen in the transport sector. For example, the NAMOSYN project for climate-friendly fuel is dedicated to the analysis and evaluation of synthetic fuels produced using green hydrogen.

Many see the transport sector as the first industry sector where hydrogen is leaving the laboratory and results are being implemented. More and more public tender opportunities have been published in Germany for trains or buses for public transportation (and the respective fueling infrastructure) in which either it has been left open whether those are diesel, battery, or fuel-cell powered (technology-neutral tenders) or where hydrogen has even been explicitly requested. Several public transportation authorities have procured hydrogen buses, and tenders also have been issued for the respective infrastructure (hydrogen filling stations). Many more such tenders can be expected to follow in the coming months. While demand is high and continuing to grow, vehicle manufacturers, construction companies with a focus on hydrogen infrastructure, and hydrogen suppliers do not seem to have entered the German market in big numbers yet; consequently, there is still high potential.

Longer-Term Goal: Heat for Residential and Nonresidential Buildings

In the long term, the National Hydrogen Strategy in Germany also pursues the goal of using fuel cells in the basements of residential and nonresidential buildings to generate electricity and heat. Even though this is still a long-term goal, there are already projects and test programs to get closer to this goal.

Under the HYPOS project at the Bitterfeld-Wolfen Chemical Park, the infrastructure for using hydrogen as an energy carrier for buildings is being tested and further developed. On a 12,000 square meter test field, called "H2-Netz," the distribution of hydrogen is simulated up to the connection to private households. More than 100 scientific institutes, research facilities, and companies from all over Germany are part of the HYPOS alliance. As noted above, the Federal Ministry of Education and Research has been supporting this initiative for over five years as part of the "Zwangzig20" (Twenty20) program.

On a European level, the German-French projects BRIDGE and LivingH2 are also noteworthy. These projects are investigating how hydrogen fuel cells could be improved and what a complete home energy supply with hydrogen could look like.

PART VI – WHICH PUBLIC FUNDS ARE AVAILABLE?

There are currently many support programs for the purpose of market ramp-up in the hydrogen sector. Not only the federal government but also the governments of the German states have been aware of the potential of hydrogen technology for many years. As noted above, within the framework of the National Innovation Program for Hydrogen and Fuel Cell Technology, around €700 million in funding has been approved between 2006 and 2016, and a total of €1.4 billion will be made available by the federal government between 2016 and 2026.

In addition, the federal government has used the funds provided under the Energy Research Program to establish an excellent research landscape in the last couple of years.

Between 2020 and 2023, the Energy and Climate Fund will provide €310 million for practice-oriented basic research on green hydrogen, and a further €200 million is planned during this period to strengthen practice-oriented energy research on hydrogen technology. The fund is administered by the Federal Ministry of Finance, which then releases the funds for the respective ministries, which, in turn, invest the amounts in concrete projects.

In addition, between 2020 and 2023, a total of €600 million will be made available to promote "Regulatory Sandboxes for Energy Change," which will help to accelerate the transfer of technology and innovation from the laboratory to the market. These real-life laboratories (Reallabore der Energiewende) function as test rooms for innovation and regulation and should serve as a source of inspiration. In this way, companies, research institutions, and administrations will be able to test innovations that would not yet be permitted under the current legal framework. For example, the federal government is supporting a real laboratory that will focus on the establishment of a regional hydrogen economy on the west coast of Schleswig-Holstein with €30 million. According to the responsible consortium, the "West Coast 100," the notice of approval of the Federal Ministry for Economic Affairs and Energy was issued in summer 2020.

The 10 partners in the consortium are looking to produce green hydrogen from wind power, transport it in the gas grid, use it in industrial processes, and interlink different material cycles within an existing infrastructure. The project is expected to cost a total of €89 million.

The German Decarbonisation Program supports investment in technologies and large-scale industrial plants that use hydrogen to decarbonize their production processes. More than €1 billion will be made available for this purpose between 2020 and 2023. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety has lead responsibility, with the participation of the Federal Ministry for Economic Affairs and Energy and the Federal Ministry of Education and Research.

As already mentioned, the most important federal funding program is certainly the "package for the future" adopted by the coalition committee on 3 June 2020, which provides €7 billion to accelerate the market introduction of hydrogen technology in Germany and another €2 billion to promote international partnerships. The exact amounts available for each of these programs depend on the budget estimates of the responsible ministries.

Opportunities for engagement by and benefits to the private sector will be case-specific. There are, for example, opportunities to obtain government contracts, subsidies, and support with regard to hydrogen R&D, production, manufacture of vehicles or vessels, or delivery of hydrogen. The funding varies from project to project.

In some cases, such as in the transport sector, subsidies are paid out to the state authorities and then passed on to a company as remuneration for products and services delivered after winning a respective tender procedure. German tenders are generally open to any company interested in and able to provide the tendered services—foreign bidders may not be discriminated against. One of the challenges in early hydrogen-related tenders has been helping public contracting authorities determine how best to tender new solutions with regard to hydrogen projects in a way that allows for a meaningful competition. Market players can and should voice their ideas about how hydrogen-related tenders could be structured. The public procurement rules allow for such interaction if done the right way.

In other sectors, such as the steel and chemical industries, usually the public funds flow directly to companies. These funds may be used for things like amending companies' current production processes by using hydrogen or developing new innovative technologies that can then be used in such industries. Again, national, as well as international, initiatives can apply for such hydrogen-related federal or state grants. There is, unfortunately, no complete overview of all funds available for hydrogen projects; however, overviews of at least some of the programs can found at **www.now.gmbh.de** and **www.ptj.de**.

If you have further questions about business opportunities in the German hydrogen industry, please do not hesitate to contact us.

GLOSSARY GERMANY

CCS	carbon capture and sequestration
CDU	Christian Democratic Union of Germany
CVD	Clean Vehicles Directive
EU Council	Council of the European Union
GHG	greenhouse gas
HYPOS	Hydrogen Power Storage & Solutions East Germany
NIP I	National Hydrogen and Fuel Cell Technology Innovation Programme
NOW GmbH	National Organisation for Hydrogen and Fuel Cell Technology
PtG	Power-to-Gas
PtX	Power-to-X
R&D	research and development
SPD	Social Democratic Party of Germany
TWh	terawatt hour

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