Green Hydrogen State of the Nation Report

Germany

A report highlighting the Status and Development of the Green Hydrogen Sector in the clusters of Belgium, the UK, Germany and the Netherlands.

Contents

1. Introduction

Green hydrogen and offshore wind are already a promising combination today. The offshore wind industry, combined with the maritime industry, the onshore wind industry and the upcoming hydrogen economy, creates important employment and export potential. After the economic damage caused by Corona the necessary economic stimulus by triggering the necessary investments in the climate-protecting and powerful energy source of offshore wind power and by pushing ahead with an accelerated expansion of offshore wind turbines for electricity production and the production of "green" hydrogen has a huge employment potential next to the important potential for decarbonization. Innovative and experience Offshore and Onshore Wind SMEs and the bigger wind industry players can meet the current sector coupling requirements.
A successful energy transition means combining security of supply, affordability and environmental compatibility with innovative and intelligent climate protection. To achieve this, we need alternative options to the fossil fuels currently still in use. This applies in particular to gaseous and liquid energy sources, which will remain an integral part of the energy system in the long term in an industrialized country like Germany. Hydrogen will play a central role in the further development and completion of the energy turnaround.

About Inn2POWER

This report has been produced by the international partnership Inn2POWER and provides a snapshot of the current green hydrogen landscape in the UK, Belgium, Netherlands, and Germany.

The Inn2Power project has been delivered from 2016 and since 2021 has moved into an extension phase which incorporates the Green Hydrogen supply chain with a focus on SMEs. The aim of the project is to expand the capacity for innovation and improve access to the Offshore Wind industry and Green Hydrogen for SME's by connecting the relevant businesses that are situated in the North Sea Region.

About the Authors

Bremerhaven-based WAB is the nationwide contact partner for the offshore wind industry in Germany and the leading business network for onshore wind energy in the north-west region. The association fosters the production of "green" hydrogen from wind energy. It comprises some 250 smaller and larger businesses as well as institutes from all sectors of the wind industry, the maritime industry as well as research.WAB e.V. supports the realization of growing, complete and cost-efficient value chains in the offshore wind industry, the onshore wind industry. WAB is committed to supporting the emerging market of **"green" hydrogen in Germany** and other regions. The **wind industry and hydrogen association WAB e.V.**, as the voice of the supply chain, supports expansion targets that will enable us to achieve climate neutrality quickly with green energy as

electrons and molecules. WAB published the first own Wind-to-Gas-Strategy for Bremen in September 2016.

2. Defining Green Hydrogen

In Germany, green hydrogen is defined by the fact that the energy to produce green hydrogen comes from renewable energy sources. Hydrogen is not an independent energy vector; it is always paired with or dependant on another technology to produce the power for hydrogen production. For this report, and the Inn2POWER project, we will focus on the developing 'Green Hydrogen' Sector across the North Sea Region (NSR). This chapter defines what is meant by this definition.

The Rainbow of Hydrogen Production

The source of power used to drive the process of hydrogen production is commonly referred to as colours. The term 'Green Hydrogen' has become commonly used to describe hydrogen production powered by low-carbon and renewable sources of power. The following table summarises the general definitions of green hydrogen as compared to other types of hydrogen production.

Colour	Process	Impact
Green Hydrogen	Electrolysis, using renewable energy (wind, solar etc.) to split water into its component parts (H2 + O2).	No carbon emissions, ability to "store" surplus electricity from renewable sources.
Yellow Hydrogen	As above, using nuclear power instead of renewable energy.	Low carbon emissions, ability to "store" surplus electricity.
Brown Hydrogen	Gasification, using coal/biomass/waste to heat water and break it down. Also known as "town gas".	Along with the component parts of water, other harmful elements are produced: carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), and ethylene (C2H4).
Grey Hydrogen	Steam Methane Reforming (SMR), using methane to heat water and break it down.	As above, produces other harmful elements: CH4 and CO2.
Blue Hydrogen	SMR and carbon capture, use and storage (CCUS).	Grey hydrogen but with carbon capture so it is seen as a lower carbon option.
Turquoise Hydrogen	Using Molten Metal Pyrolysis, natural gas is passed through a molten metal that releases hydrogen and solid carbon.	Solid carbon can be used for industrial applications, so it is seen as a lower carbon option.

Defining Green Hydrogen Across the NSR

More specifically, Green Hydrogen has been defined at the European level in the EU's Hydrogen Strategy; A case for urgent action towards implementation published in July 2020. This defines green hydrogen as follows:

"*hydrogen produced through the electrolysis of water (in an electrolyser, powered by electricity), and with the electricity stemming from renewable sources. The full life-cycle greenhouse gas emissions of the production of renewable hydrogen are close to zero. Renewable hydrogen may also be produced through the reforming of biogas (instead of natural gas) or biochemical conversion of biomass, if in compliance with sustainability requirements".*

Across the other countries in Europe, definitions are outlined across strategy and policy documents published by each nation.

UK - UK Hydrogen Strategy (publishing.service.gov.uk)
DEFINITION: Hydrogen which is produced through electrolysis, where electricity is used to split water into hydrogen and oxygen – gas from this process is often referred to as 'green hydrogen' or zero carbon hydrogen when the electricity comes from renewable sources.

For the purposes of the UK definition, hydrogen production via nuclear powered electrolysis is considered within the scope of Green Hydrogen.

Germany – National Hydrogen Strategy 2020 (bmwk.de)
DEFINITION: The Federal Government considers only hydrogen that has been produced using renewable energy (green hydrogen) to be sustainable in the long term. The Federal Government therefore seeks to use green hydrogen, promote its rapid market rollout and establish the necessary value chains. The National Hydrogen Strategy is about to receive an update, which is expected by the end of 2022.

The Netherlands & Belgium seemingly use the EU definitions with hydrogen papers published by Netherlands government (Government Strategy on Hydrogen | Publication | Government.nl) about the existing state of the nation and market for hydrogen (transport, electricity, agriculture, buildings).

3. The Green Hydrogen Policy Landscape

On 10 June 2020, the German government adopted the National Hydrogen Strategy (NWS) with the aim of establishing green hydrogen and its derived products as a key technology for the energy transition through a rapid market ramp-up and thus making a significant contribution to achieving the climate targets.

The Federal Government has vigorously pursued the implementation of the NWS, thereby laying important foundations for investments from industry and for research initiatives. These contribute to positioning Germany as a pioneer and technology leader. One important measure was the launch of the so-called "Important Projects of Common European Interest" (IPCEI) in the field of hydrogen. Here, 62 large-scale hydrogen projects were selected, for which the Federal Government and the Länder will provide a total of eight billion euros in funding. A special focus is on the industrial and transport sectors. The decarbonisation of the steel sector is important for Germany as a business location. An overall framework for this was also proposed with the "Steel Action Plan". The start of funding for transformation projects in the industry planned for 2022 through industry through climate protection contracts ("Carbon Contracts for Difference") is also intended to make an important contribution to this.

The German government foresees a hydrogen demand of approx. 90 to 110 TWh by 2030. In order to cover part of this demand, generation plants with a total capacity of up to 5 GW are to be built in Germany by 2030, including the necessary offshore and onshore energy production. This corresponds to a green hydrogen production of up to 14 TWh and a required renewable electricity quantity of up to 20 TWh. It must be ensured that the demand for electricity induced by the electrolysis plants does not lead to an increase in CO_2 emissions as a result. As part of the monitoring of the national hydrogen strategy, the German government will also record the development of demand for green hydrogen in detail. For the period up to 2035, a further 5 GW will be added if possible, by 2040 at the latest.

The amendment of Germany's Wind Energy at Sea Act (July 7, 2022) includes the plan to tender 500 MW of offshore wind annually over six years from 2023 for the production of "green" hydrogen at sea is also an important step for the ramp-up of the "green" hydrogen economy. Here it remains important that production must be economically feasible in order to quickly achieve the necessary scaling. Another area (SEN-1) in the North Sea has been explicitly identified for the production of so-called “other energy generation” ("green hydrogen") and has been included in the current area development planning by the Federal Maritime and Hydrographic Agency. This area has its own tender criteria published by the Federal Ministry of Economics and Climate Protection 2021.

In the international arena, the German government has launched several funding measures and initiatives to promote the import of green hydrogen from outside Europe

(e.g. projects in Saudi Arabia and Chile) and to strengthen the export opportunities of German technology leaders abroad. The first deliveries of sustainable hydrogen-based energy carriers to Germany and Europe are planned for 2024 (H2Global).
Another aim was and is to improve the framework conditions to produce green hydrogen, especially about an appropriate design of the state-induced price components of energy carriers. Reforms of the state-induced price components are to be examined; at the same time, CO_2 pricing is to be established as a central guiding instrument. It should also be examined whether the production of green hydrogen can be largely exempted from taxes, levies and surcharges. In particular, the aim is to exempt the production of green hydrogen from the EEG levy.

To date, this has hindered the emergence of a domestic hydrogen economy and thus sustainably reduced export potential. The long-term goal of the NWS is to establish an efficient market for green hydrogen in Germany and to embed it in a global context to enable and secure imports and trade. Germany will intensify cooperation with partner countries within the framework of a hydrogen alliance in coordination with EU initiatives. One focus will be on cooperation along the entire value chain. A platform will be created for German companies to position themselves in foreign markets. The amendment to the law for offshore and onshore wind energy takes the production of green hydrogen into account.

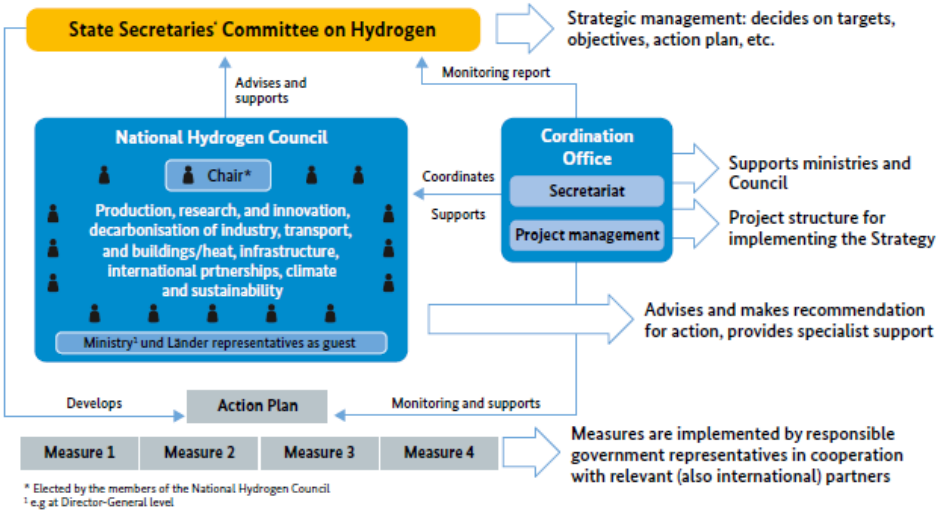
For the long-term success of the energy transition and for climate protection, we need alternatives to fossil fuels. Hydrogen will play a key role as a versatile energy carrier and for the maritime energy transition as well as for the decarbonization of energy-intensive industries (e.g. steel and chemical industries). Hydrogen produced in a climate-friendly way makes it possible to significantly reduce CO_2 emissions, especially in industry and transport.

In addition to the climate policy aspects, hydrogen technologies are also about many sustainable jobs, new value creation potentials and a global export market. German companies are already very well positioned in this field, for example in fuel cells and electrolysis for green hydrogen production. The goal is for Germany to maintain its global pioneering role in hydrogen technologies. The Federal Government has therefore announced to update its 2020 National Hydrogen Strategy and the corresponding action plan. In parallel, a flexible and results-oriented governance structure is being created for the consistent implementation and further development of the strategy.

National Policy Landscape

National energy policy in Germany is the responsibility of the Federal Ministry of Economics and Climate Action (BMWK). The National Hydrogen Strategy has been addressed by the Federal Government. On 30 September 2020, the Hydrogen Research Network began its work with over 1,000 members. As an element of the National Hydrogen Strategy, the research network is an important driver of research and

innovation policy in the hydrogen sector with a focus on application proximity and practical transfer. The Hydrogen Research Network is funded by BMWK as part of the 7th Energy Research Programme. Due to the interdepartmental importance of the topic of hydrogen, the Federal Ministries of Transport and Digital Infrastructure (BMVI) and Education and Research (BMBF) are involved.



A State Secretaries' Committee on Hydrogen, composed of the relevant ministries, will provide continuous support for the activities under the National Hydrogen Strategy. In the event of delays in implementation or a failure to meet the targets of the Strategy, the State Secretaries' Committee will immediately take corrective action in coordination with the Federal Cabinet, adapting the action plan to the new requirements. The aim is to ensure that the National Hydrogen Strategy remains in line with market developments and delivers on its overall targets.

The Federal Government further appointed a National Hydrogen Council, made up of 26 high-level experts from business, science, and civil society who are not part of the public sector. The members of the Council are chosen for their expertise in the fields of production, research and innovation, decarbonisation of industry, transport and buildings/heat, infrastructure, international partnerships, as well as climate and sustainability. In its first meeting, the Council elects one of its members as Chair. The task of the National Hydrogen Council is to advise and support the State Secretaries' Committee through proposals and recommendations for action in implementing and enhancing the Hydrogen Strategy. The Council and the State Secretaries' Committee hold regular joint meetings to facilitate coordination between the Federal Government and the Council and to ensure the Council's work ties in closely with the activities of the various ministries during the implementation of the National Hydrogen Strategy. Also, designated representatives of the ministries concerned (e.g. from the competent Directorates-General) attend the Council's meetings as guests. At the request of the Länder, two Länder representatives may attend the meetings as guests. The National Hydrogen Council meets at least twice a year. Aside from the measures taken at federal

level, the Länder have also been planning and implementing their own hydrogen-related measures that are just as important in terms of the creation of a hydrogen economy and the leadership of German companies. So far, there is no prioritisation of the different sectors about the supply of green hydrogen.

Regional / Cluster Policy Landscape

One example of the regional development of green hydrogen is the North German Hydrogen Strategy under the responsibility of the Ministers of Economics of five northern German states in Germany. Their target: A green hydrogen economy will be established in northern Germany by 2035 to enable an almost complete supply to all customers interested in green hydrogen. In addition, there are many other regional initiatives nationwide.

The five northern German states will initiate a transformation process and actively support the federal government in creating a level playing field for climate-neutral energy carriers. Sustainable business models require a competitive price for green hydrogen, e.g. through the internalisation of external costs for fossil fuels, a reform of the state-induced electricity price components (SIP) and start-up financing in the form of support programmes. This can also lead to cost degression in plants for the production, distribution and use of hydrogen due to economies of scale.

By 2025, at least 500 megawatts of electrolysis capacity for the production of green hydrogen should be installed in northern Germany, and by 2030 at least five gigawatts. Hydrogen hubs are to serve as starting points for the development of a hydrogen economy in northern Germany. They bundle (spatially) production, distribution and use, e.g. in mobility and industry.
In this way, a regional basic supply of green hydrogen will gradually be made possible, which can be expanded over the entire region in the medium term. In northern Germany, a green hydrogen economy will be established by 2035 to enable an almost complete supply to all customers interested in green hydrogen.

High generation capacities for onshore and offshore wind power with further expansion potential, underground formations for storing hydrogen, Seaports, which as logistics and economic centres with their import terminals will play an essential role in the future in the import and distribution of green hydrogen and synthetic energy carriers, in the use of hydrogen as well as in the export of hydrogen technologies and components, maritime companies and scientific expertise as well as industries with considerable experience in dealing with hydrogen; further know-how is being built up in the six northern German "real laboratories of the energy transition".

The Northern strategy outlines initial implementation steps in four fields of action:

- Field of action "Hydrogen infrastructure",
- Field of action "Value creation through hydrogen",
- Field of action "Hydrogen in guidelines, regulations and programmes",
- Field of action "Hydrogen acceptance and education".

WAB e.V. leads field of action four and is involved in all three other fields of action. There are many local hydrogen networks in all federal states, most of which target the local public and promote acceptance of and information about green hydrogen.
This North German Hydrogen strategy is also currently in the process of being updated.

4. The Green Hydrogen Development Pipeline

Infrastructures such as pipelines are necessary prerequisites for transporting the hydrogen from the producer to the user. Due to high investment requirements for such infrastructures, it is important to create adequate framework conditions for investment security in good time. For this reason, transitional amendment to the German Energy Act (EnWG) for the conversion of existing natural gas pipelines to pure hydrogen pipelines and introductory regulations for the regulatory treatment of pure hydrogen networks that create planning and investment security for hydrogen networks, as well as how other transport solutions besides the route of transport via a pipeline need to be implemented. These framework conditions are also to be amended in the light of developments at the European level.

Central to this are the "Important Projects of Common European Interest" (IPCEI) in the field of hydrogen. They include electrolysis projects with more than two gigawatt and enable the development of a hydrogen start-up network with 1,700 km of pipelines. On the applications side, the decarbonisation of the steel and chemical industry. In the mobility sector, the focus is on the industrial ramp-up of fuel cell systems, e-fuels, hydrogen vehicles and ships and the development of a hydrogen refuelling infrastructure.

National Development Pipeline

The planned hydrogen backbone in Europe, with a focus on the Netherlands to northern Germany, will be commissioned in sections (2025/2030/2035) and will lead to potential regions.

Imports and the development of sales markets for hydrogen and its downstream products require the availability of a corresponding transport and distribution infrastructure, especially in the area of transmission networks. With its extensive natural gas network and connected gas storage facilities, Germany has a well-developed infrastructure for natural gas. In the future, it should also be possible to use part of the gas infrastructure for hydrogen. In addition, networks for the exclusive transport of hydrogen should be created. Against the background of Germany's geographical

location and its role as an important transit country in Europe, these processes of change can only be shaped in cooperation with European neighbours as well as connected third countries. In addition to production, uniform quality and sustainability standards must also be developed for the transport of hydrogen and the associated emissions, and corresponding verification procedures must be established. A hydrogen market also entails technical challenges in Germany for some components of the infrastructure as well as for certain devices and equipment at the end user. Therefore, necessary transformation processes (H2 readiness, etc.) must be enabled and initiated in good time. However, in order to avoid stranded investments, this transformation process should be oriented towards the anticipated demand considering the goal of greenhouse gas neutrality in 2050.

Liquid hydrogen, e-fuels, PtL/PtG downstream products can be transported easily and safely over long distances. Here, too, the use of existing transport capacities and dedicated infrastructure (e.g. pipelines, methanol and ammonia tankers) is an option, in addition to the development of new ones. Under the motto "Shipping the sunshine", new potentials in the production and transport of green hydrogen on a large scale could thus be developed for the first time with the help of research. The trade in PtX products over long distances and the transport of hydrogen via pipeline networks can complement each other. GHG emissions from the transport of hydrogen must be avoided.

A hydrogen pipeline offers considerable advantages over sea and land cable laying or even ship transport, especially for longer distances. The advantages come into play above all when production is scaled up to an industrial scale of 10 gigawatts, whereas 5 cable systems would be required for a comparable electrical output, even with rapid further development of cable technology. A recent study clearly proves this and shows considerable potential benefits in terms of time savings and environmental compatibility.

The adaptation of regional planning for an efficient routing is therefore imperative. In this respect, we welcome the initiative in the WindSeeG amendment, according to which collection pipelines from other energy generation areas are to be treated in the same way as previously planned direct current routes and their approval is henceforth to be determined within the framework of the planning approval procedure according to §§ 45 ff. WindSeeG. In the onshore grid planning, a landfall in Brunsbüttel and/or Wilhelmshaven is outlined. A specification of this transport route in the hydrogen strategy of the Federal Government would already offer planning security and expansion potential with the European Hydrogen Backbone.

We must prepare and sustainably design the future supply of hydrogen and its derived products. Germany will also import hydrogen to a considerable extent. Together with other future importers, we share the interest in establishing a global hydrogen market as soon as possible. In view of their potential for renewable energies, there are also

attractive opportunities for the current fossil fuel producing and exporting nations to convert their supply chains to the use of renewable energies and hydrogen and thus become potential supplier countries for hydrogen. In this way, these countries can also benefit from existing trade relations in the long term. In this context, it is important to ensure that local markets and a local energy transition in the partner countries are not hindered but supported by the production of hydrogen.

International trade in hydrogen and synthetic downstream products will not only create new trade relations for Germany and the EU but will also enable further diversification of energy carriers and sources as well as transport routes, thereby strengthening security of supply. International trade in hydrogen and its derivatives will thus become a significant industrial and geopolitical factor that requires strategic objectives and decisions, but also offers new opportunities for all sides.

5. Developing a Hydrogen Network

The wind industry and hydrogen association WAB e.V., as the voice of the supply chain, supports expansion targets that will enable us to achieve climate neutrality quickly with green energy as electrons and molecules. WAB was founded in 2002 and comprises some 250 smaller and larger businesses as well as institutes from all sectors of the wind industry, the maritime- and hydrogen industry as well as research.

More than 80% of WAB member companies are SMEs and a large proportion are very interested in the emerging hydrogen market. Whether the offshore wind farm produces electricity or hydrogen or even the onshore wind turbines makes little difference to energy production. The commitment to downstream electricity generation or the production of "green" hydrogen depends on the remuneration of the respective energy carrier.

WAB members decided to include green hydrogen in the association's 2020 statutes. Since 2019, the association's members have been participating very actively in the Wind Power Hydrogen Working Group with between 40 and 60 company and institute representatives and representatives of the maritime industry and business development agencies from Germany and abroad. WAB e.V. has already organized cross-cluster workshops with France and Scotland and is part of the hydrogen working group of the Business Network for Offshore Wind in the USA. In cooperation with seven other regional hydrogen initiatives, a first joint political advocacy for green hydrogen has already been formulated. In addition, WAB e.V. has signed a declaration of cooperation with four other networks from a total of five northern German states.

Our ongoing study results are expected for end of Q4 2022. We commissioned the experienced market research company wind:research, a brand of trend:research GmbH, Institute for Trend and Market Research, with the following study: “Value creation potential - Hydrogen in Northern Germany Employment, market participants and sales - status quo and forecast”. In the study area: Bremen, Hamburg, Lower Saxony, Mecklenburg-Western Pomerania and Schleswig-Holstein, almost 100 market participants have been evaluated so far. Market participants are still being added as the evaluation is currently ongoing. We will endeavor to extend this study to the whole of Germany.

Value creation area	Part of the value chain
Distribution	EVU etc.
Consumption/Application	DSO, TSO
Processing	Plant operators, constructors, ...
Storage	Consumers (Industry, Maritime Industry, Heat and transport sector)
Transport	Gas grid operators
Generation (electricity)	Trade
Generation/electrolysis (H2)	Removal
Research and development	Project development
Education	Financing/insurance

Engineering	Service and consulting
Plant construction	Wind energy on land and at Sea
Service and maintenance technician	Infrastructure building companies
Operation	Logistic companies (on land /at Sea)
Production workers	Cable and pipeline producers
Management	Platform construction
Training	Vehicle construction incl. shipbuilding

Consulting with the Industry

WAB e.V. has been able to start the work of a working group already in 2019 with initial support from the local hydrogen network H2BX and supported by WAB members. Together in the context of association partnerships as part of the Northern Alliance or in support of the NorthmeetsNorth exchange with the UK or together with other partners such as the German Hydrogen and Fuel Cell Association in the context of the Offshore Wind H2 Eight as well as in exchange with the Inn2Power project partners and with Cross Cluster workshops, we try to advance the topic of hydrogen production from onshore as well as offshore wind energy for and with our members.

WAB e.V. has been offering its own beginners' seminar with green hydrogen experts since 2021. How to assess, initiate and manage hydrogen projects will be taught in a new, in-service training course offered for the first time by the C3L - Center for Lifelong Learning at the University of Oldenburg together with the University of Hannover and the Fraunhofer Institute for Wind Energy Systems IWES as scientific partner from September 2022. Here, WAB supports the activities at the Bremerhaven location.

6. Challenges and Opportunities of the Green Hydrogen Sector

Currently, there are still challenges in different areas: General conditions, Political and legal framework conditions, Social framework conditions and Economic framework conditions. Against the background of the requirements of the energy transition and a

dramatically changing global political situation, the German government must now create the conditions for the ramp-up of a German hydrogen economy and industry - embedded in European cooperation.

The development of a hydrogen economy is associated with enormous growth potential for the German mechanical engineering sector and other branches of industry. At the same time, green hydrogen is better able than any other renewable energy carrier to transport and store large amounts of energy over long distances at low cost. Both are prerequisites for a secure, economical and sustainable energy supply.

The programme to support the market ramp-up of a German hydrogen industry and green hydrogen production should comprise a funding volume of at least 10 billion euros in order to achieve the set climate targets on the one hand and to secure the security of energy supply on the other.

The funding concept should be based on the tested EU-compliant market-oriented system of H2Global and initially fund at least 2 gigawatts of electrolysis capacity. The focus must remain on the system concept, i.e. the interlocking of all components of production, transport, storage and consumption. Hydrogen production integrated into offshore wind turbines offers considerable potential for reducing hydrogen production costs.

In parallel, the process of creating the technical licensing requirements and standards needs to be supported, as well as a solution for guarantees of origin for green hydrogen. So far, green hydrogen is not yet competitive with hydrogen produced from fossil fuels. This is primarily due to the significantly higher production costs of electrolysis-based production. The development of a competitive market design for offshore wind hydrogen is therefore a necessary step to balance cost differences. The coalition agreement announced the examination of the introduction of hydrogen difference contracts (Carbon Contracts for Difference, CCfD or Contracts for Difference CfD). Basically, the H2Global concept is a CfD model, but for the import of hydrogen and hydrogen derivatives from other countries, outside the EU. The advantage of this model is that it has already been examined by the EU and its compatibility with European law confirmed. CCfD should therefore, analogous to the H2Global programme, offer the possibility of significantly bringing forward the market introduction of green hydrogen from domestic green electricity production, especially in the primary industries, by cushioning the aforementioned cost differences and thus stimulating the willingness to purchase green hydrogen. We therefore call for the rapid introduction of an instrument based on CCfD, whereby the emissions avoided by the subsidised project and the additional costs related to CO2 reduction resulting from production with the climate protection technology compared to a reference technology should be taken into account.

Hydrogen production at sea in the German Exclusive Economic Zone (EEZ) can contribute significantly to the expansion of electrolysis capacity within the framework of the national and European hydrogen strategy and accelerate offshore wind energy development in Germany as a whole. It is synergistically suited to effective defossilisation of the industry. Marine areas far from the coast could be developed more quickly and cheaply for energy production. At the same time, it makes a substantial contribution to the diversification of supply sources for the procurement of domestically produced green hydrogen.

In addition, cross-border cooperation with neighbouring European countries will be fundamentally strengthened through the establishment of a Green Hydrogen Union. This will create opportunities for domestic production and the establishment of green hydrogen production plants with northern European partner states.
With a view to the necessary continuation of the national hydrogen strategy and all related legal and regulatory framework conditions, the importance of green hydrogen from offshore wind energy must be given even greater consideration.

WAB e.V. proposed a sprinter programme for "green hydrogen production" in Germany for 3 gigawatts (2 gigawatts offshore plus 1 gigawatt onshore). The first tenders would be targeted for the 1st quarter of 2023. This way, investors, developers and the supply industry would have the certainty that the costs are covered. In this way, the market ramp-up could be supported.

In addition to the provision of sufficient areas for offshore electrolysis, it must also be ensured that hydrogen is available on the market in sufficient quantities and at competitive prices. To this end, it is important, especially in the initial phase, to define the requirements for the purchase of electricity for electrolysis as broadly as possible. The requirements of the Renewable Energy Directive (RED II) do not do justice to this. According to Frontier Economics, the restriction to new plants alone, which excludes the use of electricity from subsidised existing plants, leads to a considerable increase in costs for electrolysis. In addition, significantly less green hydrogen could be produced with the same electrolyser capacity.

Here follows a list of studies and relevant position papers on the development of a green hydrogen economy in Germany:

1. *Potenzialstudie Wasserstoffwirtschaft; Auftraggeber EE:SH; Auftragnehmer: IPP ESN Power Engineering GmbH/SKL Engineering & Contracting GmbH*
2. *Wasserstofferzeugung in Kombination mit Offshore-Windausbau; Auftraggeber Deutsche Shell Holding GmbH, Siemens AG, TenneT TSO, Auftragnehmer E-Bridge*
3. *Wind-to-Gas-Strategie Bremen, WAB e.V., September 2016*
4. *Defossilisierung des Transportsektors, Ford Werke GmbH, ..., FVV, 2018*
5. *Norddeutsche Wasserstoff Strategie. Wirtschafts- und Verkehrsministerien der nordd. Küstenländer, November 2019*

6. *Integriertes Gesamtkonzept Fischereihafen Bremerhaven (und angrenzende Gebiete) zur Senkung der CO2 Emissionen Ergänzungsstudie Wasserstoff, fk-wind, H2BX, Hochschule Bremerhaven, März 2019*
7. *Wirtschaftl. Bewertung der HYPOSWertschöpfungsketten zur Wasserstofferzeugung im Kontext der versch. Nutzungspfade; Potenzialanalyse zum Absatz von Wasserstoff in der Modellregion HYPOS HYDROGEN POWER STORAGE & SOLUTIONS EAST GERMANY (HYPOS); DBI – Gastechnologisches Institut gGmbH; 2016*
8. *H2-Industrie Potenzialstudie Brandenburg; Deutscher Wasserstoff- und Brennstoffzellen-Verband e.V.; Juli 2019*
9. *Integration von Power to Gas/Power to Liquid in den laufenden Transformationsprozess, Herausgeber UmweltBundesamt, März 2016*
10. *Markteinführungsprogramm für Power to X-Technologien, Allianz, April 2019*
11. *Regionalökonomische Effekte des Vorhabens von Greenpeace Energy – Eine Einordnung auf der Basis aktueller Studien – IÖW + btu, November 2018*
12. *7-Punkte-Plan der Arbeitsgruppe Verkehr und digitale Infrastruktur der CDU/CSU Bundestagsfraktion zur Nationalen Wasserstoffstrategie der Bundesregierung, Dezember 19*
13. *www.westkueste100.de*
14. *Fachworkshop „Sonstige Energiegewinnungsbereiche"; Bundesamt für Seeschiffahrt und Hydrographie (BSH) Berlin, 25.09.2019*
15. *Kurzzusammenfassung der Ergebnisse der Potenzialstudie zur Nutzung von Wasserstoff in der Metropolregion Rhein-Neckar; Prognos/thinkstep AG, 2019*
16. *Weiterentwicklung der Wasserstoffstrategie für die Stadt Cuxhaven - (CuxH2aven Maritime Hydrogen); KONGSTEIN GmbH 2020*

7. Barriers and Opportunities for Innovation

Opportunities

The ongoing IPCEI projects offer many opportunities to rapidly advance the development of green hydrogen production.
Northern Germany has unique locational advantages for building a green hydrogen economy:
High generation capacities for onshore and offshore wind power with further potential for expansion,
underground formations for hydrogen storage,
Seaports, which as logistics and economic centers with their import terminals will play an essential role in the future in the import and distribution of green hydrogen and synthetic energy sources, in the use of hydrogen, and in the export of hydrogen technologies and components,
maritime companies and scientific expertise as well as
industries with considerable experience in dealing with hydrogen; further know-how is being built up in the northern German "real laboratories of the energy transition".
The development of seawater electrolysis technology is an extremely important topic and we expressly welcome this project by Fraunhofer IWES in collaboration with Fraunhofer IFAM. The desalination of seawater has so far been a basic prerequisite for producing green hydrogen at sea.
The first key points for the amendment of the National Hydrogen Strategy contain important steps on the way to a national hydrogen economy.

Challenges

Due to the high demand for green hydrogen to decarbonize the energy-intensive industry in Germany, there is a high dependence on imports. At the same time, it is imperative to establish a domestic hydrogen economy in order to be able to use the hydrogen produced in Germany. To date, there is no regulatory framework that allows business models that go beyond research projects. Here, the H2Global concept can be used in an adapted form for domestically produced Hydrogen.
Sufficient quantities of water suitable for electrolyzer use are in short supply if the required quantities of green hydrogen must be produced.
As is the case for all growth industries, the shortage of skilled workers is also becoming more acute in offshore wind energy and all other areas of the energy transition. The foreseeable employment effects are fundamentally pleasing, but also entail a corresponding need for additional skilled workers in Germany.
It will hardly be possible to cover the demand with domestic skilled workers alone, but it must always be kept in mind that there is also an increasing demand for skilled workers in other markets. There is great competition here for the best talents.
We are not yet aware of the regulatory framework via RED III at the European level, and this will play a role in determining the regulatory framework in Germany. Therefore, it is necessary to act quickly here so that the European regulatory development does not further slowdown the national regulatory developments.

8. Conclusion

First, we need a basis for the economic production of green hydrogen at sea. This can only be solved through the appropriate regulatory framework in Germany and for the EU. We will assemble and present the advisory group from industry. Through our wind power-hydrogen working group, we can work on the needs of large and small companies, and within the framework of our Legal Offshore Day and the Legal Working Group, we work out the current developments for our member companies in order to create an optimal information basis for market entry.

Between 40 and 50 WAB member companies are planning to enter the hydrogen economy. The development of the offshore wind industry and that of the hydrogen economy show strong parallels. Here, too, we assume that the market ramp-up will require close interaction between players from industry, innovative small and medium-sized enterprises, financiers and insurers, political players at national and regional level, and research. We will equip our advisory board accordingly. The next international wind fair offers space for international exchange in the context of our Inn2Power project. We already see a clear added value of the project and the necessity of the participation of small and medium-sized enterprises in the market ramp-up.

We look forward to continuing to support the respective market entry with our Inn2Power project partners and thus to promote the emergence of a green hydrogen economy.