



Hydrogen Strategy

Metropolitan Region Northwest



METROPOLREGION
NORTHWEST



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Dear readers, dear hydrogen enthusiasts and interested parties,

the Metropolitan Region Northwest is not only an extraordinarily suitable location for developing a self-sustaining hydrogen economy, it also self-identifies as the driving force behind this process in Germany. With our hydrogen strategy, we reinforce this clear statement and shape the continued regional process together with all relevant stakeholders.

This present strategy results from a strong alliance and a close exchange between public administration, public enterprises, the private sector, and the scientific community. The hydrogen networks and cooperations that have been developed during this process show how fundamental interlocking and continuous coordination is for regional success. Together, we developed and defined overlaps and thus developed concrete action guidelines for the imminent challenges. This means that we can get active today already, independent of obstacles that will surely arise and will have to be overcome.

Under the umbrella of the Metropolitan Region Northwest, there will be additional approaches specific to subregions that will benefit the metropolitan region as a whole: be it the specification of subregional hydrogen strategies, the realisation of concrete construction projects, or the acquisition of additional funding programmes for hydrogen projects. This is because the connecting element, in the full sense of the word, is the regional hydrogen strategy and the networking between the relevant players.

On behalf of all members and supporters of the Metropolitan Region Northwest

Yours,

Peter Hoffmeyer

First chairman Metropolregion Nordwest



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Preamble and mission statement

Climate change is the greatest challenge of our time. In the Metropolitan Region Northwest, we stand determined against climate change. The comprehensive use of green hydrogen along a clear CO₂ reduction path is one of our non-negotiable goals for 2045.

Emissions in Germany have been reduced continuously during recent years, but not even close to the degree that would be required to reach the climate goals for 2030 and 2045 respectively. In 2021, they even increased considerably again.¹ According to calculations of the Federal Environment Agency (UBA), the emission reduction has to be tripled in order to reach the goal.² The longer the necessary measures are put off, the more expensive it will be for Germany to reach the climate goals on time.

It is not only for this reason that it is our responsibility to fight climate change with determination and to take a sustainable and future-oriented approach here in the Metropolitan Region Northwest. Therefore, the overarching objective of the Metropolitan Region Northwest's new Plan of Action 2022-2025³ is to ensure "climate neutrality and biodiversity". Consequently, the other innovation paths to "ensure livelihoods" and to push "sustainable, intelligent mobility" are bound to this goal as well. We want to make our region climate-neutral by pushing the implementation of a sustainable hydrogen circulation economy hand in hand with politics, economy, science, public administration, and the general public.

1 <https://www.agora-energiewende.de/veroeffentlichungen/abschaetzung-der-klimabilanz-deutschlands-fuer-das-jahr-2021/>; accessed on 20.8.2021.

2 Umweltbundesamt, 2019. Europäische Energie- und Klimaziele, see <https://www.umweltbundesamt.de/daten/klima/europaeische-energie-klimaziele>; accessed on 13.8.2021.

3 <https://www.metropolregion-nordwest.de/ueber-uns/entstehung-handlungsrahmen-2022-2025/>; accessed on 7.6.2021.

Green hydrogen

Hydrogen generated via electrolysis on the basis of renewable energies (wind, sun etc.).

Grey hydrogen

Usually generated on the basis of natural gas (fossil fuel) by supplying heat via steam reforming. Carbon dioxide is released into the atmosphere.

Blue hydrogen

Hydrogen is called “blue” if it is, like the grey variant, generated traditionally via steam reforming with natural gas as the raw material. However, 90% of the carbon dioxide are collected and bound or used otherwise and not released into the atmosphere.

Orange hydrogen

Hydrogen generated on the basis of bioenergy (e. g. biogas or biomass).

Red hydrogen

Hydrogen generated on the basis of nuclear energy.

Brown hydrogen

Hydrogen generated on the basis of lignite.

Black hydrogen

Hydrogen generated on the basis of coal.

Turquoise hydrogen

Hydrogen generated by thermally splitting methane gas. This generates solid carbon instead of carbon dioxide. In order to be climate-neutral, turquoise hydrogen has to be generated on the basis of renewable energies (wind, sun etc.) and the carbon has to be bound permanently.

along a clear CO₂ reduction path based on the national climate protection law is our non-negotiable goal for 2045. Together with electrification, green hydrogen will be established as one of the most important options for decarbonisation. Supply reliability and environmental protection will go hand in hand and the economic opportunities related to the technological change will be used.

For hydrogen technology to prevail, we need pioneers and visionaries who pave the way for production, for transport, and for ordering large quantities of climate-friendly and affordable hydrogen and thus build a functioning hydrogen economy. The Verein Metropolregion Bremen-Oldenburg im Nordwesten demonstrates the potential of the united and cross-linked approach by the players from economy, science, politics, and public administration. It pools these potentials and thus initiates projects and activities. The Metropolitan Region Northwest demonstrates the region's strengths and, together with the pioneers, develops perspectives for establishing itself as the leading hydrogen region in Europe.

1. Integration of the strategy into already existing strategies

Different strategic approaches to building a hydrogen economy have been and are still being developed on a European as well as a national level. Examples are, among others, the Hydrogen Strategy for a Climate-Neutral Europe, the National Hydrogen Strategy including the

“Our future is green, the way there is colourful.”⁴ True to this motto, blue and turquoise hydrogen are recognised as interim technologies to support a successful market launch. **However, the comprehensive use of green hydrogen**

4 The meaning of the colours and further basic knowledge regarding the subject of hydrogen can also be found at www.wasserstoff-region.de.

Hydrogen Action Plan Germany 2021-2025 by the National Hydrogen Council, the Northern German Hydrogen Strategy, or the Strategic Concept for the Realignment of the Future Green Energy Industry of Wesermarsch County as well as the Integrated Hydrogen Plan for the Northern Netherlands. The state of Bremen is currently developing its own hydrogen strategy. The regionally focussed strategy of the Metropolitan Region Northwest is, among others, based on these initiatives and plans to especially strengthen the specific regional level, utilise the distinctive spatial, economic, and infrastructural conditions, and strengthen the well-proven cross-border cooperation.

The common points and goals of the listed strategies relevant to the Metropolitan Region Northwest were picked up and, through dialogue with the stakeholders, matched, expanded, and processed with the ideas of the regional players.

All strategies that were taken into consideration are focussing on implementing a green hydrogen industry and on the economic opportunities of the domestic market. Moreover, all strategies recognise the predicted deficit in producing renewable energies, which will have to be addressed by expanding the production of renewable energies as well as a continued increase in energy efficiency. However, in the end, importing hydrogen will be unavoidable. After an intensive analysis of the regional energy consumption structure, the entry into a hydrogen economy will initially take place through those sectors whose decarbonisation is essential to reach the climate goals, but which have a high


energy usage and cannot be electrified: the steel and chemical industries as well as heavy traffic and parts of railway transport, shipping, and public transport.

At the same time, the Metropolitan Region Northwest wants to emphasise the resulting opportunities for regional economic growth. It sees the development of a domestic market as a chance for the players to work on the region's leadership concerning hydrogen technology.

The Metropolitan Region Northwest will do its part in confronting the challenges that result from the necessary expansion of renewable energies and of production capacities for hydrogen.

However, the cross-sector supply of green hydrogen does not only depend on national production capacities, but also significantly on developing the relevant import and distribution infrastructures. The Metropolitan Region Northwest has excellent prerequisites for these infrastructures, which will have to be expanded in the coming years.

The Metropolitan Region Northwest's strategy is based on the central goals of the aforementioned strategies. However, a specifically developed process and a regional strategy are necessary to closer connect the regional players as well as better pool the various individual strategies and approaches of the region along the value chain. By showcasing regional potentials in detail, the Metropolitan Region Northwest is sending a strong signal inward and outward and



urges everyone to go on working together on these ambitious goals with commitment and courage.

1.1. Development process

To develop the hydrogen strategy, the Metropolitan Region Northwest used a comprehensive regional bottom-up participation process. To achieve this, a work group with six **subgroups** was set up, which began their work in November 2020:

- Comparison of existing and relevant strategies/editorial team
- Production
- Storage and reconversion
- Import and distribution
- Applications in mobility/logistics (fields of application and relevant infrastructure)
- Applications in companies and industry along the value chain

The subgroups were staffed by the members and advisors of the Verein Metropolregion Nordwest e. V. as well as representatives from businesses, institutions, networks, and associations. An overview of all participants can be found on our website www.wasserstoff-region.de.

At the meetings of the subgroups and through accompanying queries the strategy's structure as well as the content-related objectives and design were developed in a joint process with all relevant stakeholders.

Parallel to the strategy process, the website www.wasserstoff-region.de was developed, including an interactive map. This website allows its users to get a quick and easy overview of the respective infrastructural prerequisites for the developing hydrogen economy in the Metropolitan Region Northwest. The tool includes the depiction of wind parks, gas pipelines, power lines, caverns, ports, relevant transport operations and networks as well as educational and research facilities, which are essential for the further expansion of the hydrogen economy.

2. The energy industry in the Metropolitan Region Northwest: current status

Entering the hydrogen economy means special opportunities for the Metropolitan Region Northwest with regard to its future economic development as well as to the goal of becoming a climate-neutral region. Even if there is already a long list of regions that count on this new energy technology, the Metropolitan Region Northwest has special framework conditions and relevant unique selling points.

The Metropolitan Region Northwest has an energy system with excellent perspectives for a transformation. Although the region has some fossil fuel power plant capacities (coal, natural gas) and plays a major part in the German production of oil and natural gas, its exposed location enabled it to be a pioneer in the energy revolution early on. Initially, the development of

renewable energies was primarily carried by onshore wind energy and bioenergy and later expanded to offshore facilities; photovoltaic plants were added during recent years. Currently, the percentage of renewable energies in the energy market of the Metropolitan Region Northwest has reached a magnitude that Germany as a whole has as its goal only for 2050. For example, 95% of the electricity requirements in the supply area of the biggest energy supplier, EWE, are covered by renewable energies. There are over 2000 wind turbines and ca. 52,000 solar systems in the counties and cities of the Metropolitan Region Northwest, which feed energy into the regional power grids.⁵ Added to that are the offshore wind parks in the adjacent North Sea, which land their electricity at the coast of Lower Saxony and will take over a large part of the power supply. Like for many other regions, this transformation process poses various challenges for the Metropolitan Region Northwest, which result from the modification of a complex, capital-intensive system based on fossil fuels. However, the region is efficiently dealing with these challenges through the swift expansion of renewable energies.


This consistent expansion of renewable energies contributed to the region's positive economic development. The energy sector has become an important regional economic factor as well as a motor for employment. The transition to a renewable energy system was accompanied and supported through developing research and science capacities in the region which consistently deal with different technical, economical, and institutional aspects of the transformation process.

In the past, the expansion of renewable energies was facilitated by the Renewable Energy Sources Act (EEG) support scheme. However, this dependence on laws and regulations carried risks as well, and many plant construction businesses in the bioenergy and wind energy sectors found themselves in financial difficulties, since production capacities had to be partly shut down and employees dismissed.

The Metropolitan Region Northwest has recognised these challenges, confronted them, and repositioned itself. The use of flexibility options and new concepts of linking sectors (electromobility, power-to-X etc.) is an important approach that contributes to improving the integration of renewable energies into the energy system. Above all, this necessity results from the duration of the expansion of the transmission grids, since the power lines could not be finished in the allotted time, which resulted in transmission bottlenecks. Still, in certain phases renewable energy plants have to be throttled to a considerable degree. Considering the sluggish expansion of the transmission grids also in the Metropolitan Region Northwest, an increase of necessary regulatory interventions to the energy grid can be anticipated.

Therefore, the expansion of the regional hydrogen production is a promising opportunity to contribute to climate neutrality and open new economic perspectives for the region. The conditions are favourable: the Metropolitan Region Northwest has the necessary energy infrastructures (gas networks, grid nodes, and connection capacities, cavern storage facilities, ports as energy hubs etc.), diverse experience with

⁵ <https://www.marktstammdatenregister.de/MaStR/Einheit/Einheiten/OeffentlicheEinheitenuebersicht>; accessed on 7.6.2021.



handling natural gas as energy source, committed businesses, potential hydrogen users, research and transfer institutions, and above all networks and clusters of cooperating businesses and organisations from the energy sector. Politics and public administration on the municipal as well as the regional level have recognised the energy sector's importance as well as the necessity of transforming this economic sector that is essential for the development of the region. They support the relevant activities, initiatives, and research projects. Moreover, there is a focus on creating the appropriate planning and institutional frameworks for this transformation process.

3. Strengths and unique selling points of the Metropolitan Region Northwest

The production, storage, distribution, and use of green hydrogen are elementary components of reaching climate neutrality across sectors. Briefly summarised, what is needed to achieve this are renewable energies, electrolysis and storage capacities as well as distribution and import structures. Due to its geographic location and its economic structure, the Metropolitan Region Northwest has excellent prerequisites for producing, storing, and transporting hydrogen. The political and institutional structure of the Verein Metropolregion Bremen-Oldenburg im Nordwesten, competent networks, and an internationally renowned research landscape predetermine the northwest for accompanying the trans-

formation process in a goal-oriented manner. Thus, it will contribute considerably to reaching the Northern German and the national climate goals. Germany's northwest and the northern provinces of the Netherlands also play a decisive role in all European plans concerning hydrogen. Moreover, with more 100-MW electrolyser projects than any other place in Germany, Lower Saxony is currently a leader when it comes to thinking on a big scale.⁶

The following section focusses on the unique selling points along the hydrogen value chain in the Metropolitan Region Northwest. You can find the entire range of regional expertise and competencies on our website

www.wasserstoff-region.de.

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3.1. Infrastructures along the value chain

3.1.1. Production including renewable energies

The unique selling points described below regarding the production of green hydrogen were identified in the participation process described in chapter 1.1.

Due to its governance structures and infrastructures, the Metropolitan Region Northwest covers the entire value chain of a green hydrogen economy and thus offers the best prerequisites for a large-scale market launch. These prerequisites will have to be used for success.

6 Minister Birgit Honé and Thosten Herdan, department head at the Federal Ministry of Economics, at the Hydrogen Cross Border Conference on 5.2.2021.

The focus is on green hydrogen, since only green hydrogen is produced exclusively using renewable energies and thus CO₂-neutral. All other ways of producing hydrogen cause greenhouse gas emissions.⁷

Therefore, the availability of renewable energies is the basic prerequisite for the production of green hydrogen. According to the market master data register⁸, the Metropolitan Region Northwest has at its disposal **wind parks** with an output of 4,400 MW and an extensive potential for expansion capacities.⁹ At the same time, wind turbines with a rated output of more than 500 MW will be dropped from Renewable Energy Source Act (EEG) funding in 2021, and more turbines with an output of up to 700 MW will follow until the end of 2025.

From an economic standpoint, operating these post-EEG turbines is currently unprofitable. The direct delivery of electric energy through so-called power purchase agreements (PPA) might be a new perspective for old facilities. PPA are long-term electricity supply contracts between the operator of a facility and an elec-

tricity user. Within the framework of such a contract, the delivery of a certain amount of electricity for a fixed price or an equal financial compensation is determined.¹⁰ The calculation for one wind energy turbine is ca. 1,920 full load hours¹¹ per year and a remaining term of about five years. Based on these numbers, this means that in the year 2021 there would be 1920h x 500 MW = 960 GW from wind power available for electrolysis.

With an output of almost 580 MW¹², **biogas plants** have a large potential for the production of hydrogen as well.¹³ As with wind turbines, the operation of post-EEG facilities is currently unprofitable. Since the remaining term of biogas plants is at least ten years, they offer great potential for the production of hydrogen.

The energy suppliers of the Metropolitan Region Northwest have more than enough experience and expertise in the area of so-called feed-in management¹⁴ or rather the storage of renewable energies in the case of an impending network overload. One example is the hybrid large-scale battery storage (lithium-ion and sodium-sulphur

7 The meaning of the colours and further basic knowledge regarding the subject of hydrogen can also be found at www.wasserstoff-region.de.

8 <https://www.marktstammdatenregister.de/MaStR>; accessed on 1.3.2021.

9 <https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/windenergie-an-land#strom;%20abgerufen%20am%2027.04.2021>; accessed on 27.4.2021.

10 <https://www.contextcrew.de/geschaeftsmodell-power-purchase-agreement-ppa-potenzial-zum-megatrend/>; accessed on 26.4.2021.

11 <https://www.bdew.de/service/daten-und-grafiken/jahresvolllaststunden/>; accessed on 26.4.2021.

12 <https://www.marktstammdatenregister.de/MaStR>; accessed on 1.4.2021.

13 If biogas is used to produce bio-methane instead of converting it into electricity, hydrogen can be produced via methane pyrolysis, methane plasmalysis, or steam reforming (see chapter 5.1.).

14 Feed-in-management: Curtailment of renewable energy facilities, for example in the case of an impending network overload due to too high feeding volumes and too low consumption.

batteries) in Varel¹⁵, which is part of the research project enera that concerns itself with the storage of energy produced by wind turbines. Another example is the hybrid backup plant (short HyReK)¹⁶ that combines a 15 MW battery storage unit with a power-to-heat facility in the swb power plant in Bremen. It enables the linking of the electricity and heat sectors and makes the overproduction of electricity available for the district heating supply in the form of heat. This combination allows for regular power plants with CO₂ emissions to be replaced in the long term by using renewable energies. This way, the region has solutions for the future of power plants that have yet to be shut down and emphasises its fundamentally innovative focus.

The supply of renewable power for supplying electrolyzers and thus producing green hydrogen is ensured in the Metropolitan Region Northwest (see chapter 2). The existing extra-high voltage grid is currently being expanded so that an efficient grid infrastructure will soon be available in the entire region. To build electrolyzers, locations where several power lines come together suggest themselves, like Conneforde in Ammerland County, Unterweser in Wesermarsch County, and the town of Wilhelmshaven.

The following currently planned projects will increase these locational advantages:

- The need for an offshore grid connection system to Wilhelmshaven (NOR-12-1) and two systems to Unterweser (NOR-9-1 and NOR10-1) with a transmission capacity of 2 GE respectively was confirmed by the Federal Network Agency in 2019.¹⁷
- A direct current interconnector between Germany and Great Britain (project NeuConnect) has also been confirmed as necessary by the Federal Network Agency and is now listed in the Federal Requirement Plan Law and undergoing the plan approval process. It will be connected to the substation Fedderwarden in Wilhelmshaven.
- The expansion and the new construction of 380 kV lines on the following routes are currently being planned under the specifications of the Grid Development Plan and the Federal Requirement Plan Law:
 - Wilhelmshaven/Friesland County – Fedderwarden – Conneforde
 - Elsfleth West – Ganderkesee with a junction to Niedervieland
 - Conneforde – Unterweser
 - Conneforde – Elsfleth West – junction to Blockland – joint municipality of Sottrum
 - Dollern – Elsfleth West
- The current 2nd draft of the Grid Development Plan 2035, version 2021 (2) plans for up to three further offshore grid connection systems to Rastede (Ammerland County).

15 <https://projekt-enera.de/blog/der-hybrid-grossspeicher-in-varel-einfach-erklaert/>; accessed on 27.4.2021.

16 <https://www.swb.de/ueber-swb/unternehmen/nachhaltigkeit/hyrek/>; accessed on 27.4.2021.

17 https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2019/20191220_NEP.html; accessed on 8.7.2021.

In conclusion, the Metropolitan Region Northwest has excellent prerequisites for producing green hydrogen on the basis of renewable energies.

An analysis of the local conditions is necessary to effectively use these infrastructures for the development of a hydrogen economy. This analysis is planned within the framework of the **Energiewendedrehkreuz Wesermarsch**¹⁸ project of Wesermarsch County, which is supposed to conduct a study to answer the question how green hydrogen can be put to concrete use for decarbonisation within a value chain. The county's local conditions necessary for this use will be analysed: production, storage, transport, and distribution as well as application sectors and users. The study includes a legal assessment and also takes the problem of societal acceptance into consideration. Its goal is to provide comprehensive location criteria for the practical development of hydrogen hubs.

In project-based **pilot or demonstration projects**, the players of the Metropolitan Region Northwest are working on the construction and expansion of electrolyzers for hydrogen production. The goal is to make them profitable in the foreseeable future within the framework of the expected market launch. You can find an overview of projects as well as pilot or demonstration projects in the Metropolitan Region Northwest at

www.wasserstoff-region.de.

The central projects for the Metropolitan Region Northwest are:

The ERFE-funded project **Wasserstoff – grünes Gas für Bremerhaven**¹⁹ is dedicated to setting up a value chain from the production to the storage of green hydrogen and its use in pilot applications. To this end, the Fraunhofer-Institut für Windenergiesysteme built the Hydrogen Lab Bremerhaven, where the interaction between electrolyzers and wind turbines is tested and validated. Moreover, grid compatibility and different network states are being tested with the network simulator belonging to the Fraunhofer-Institut.²⁰ This is necessary because electrolyzers rely on a steady power supply while the production of renewable energies is inconsistent and can lead to considerable frequency changes in the transmission grid. Studying the electric properties of electrolyzers in connection with wind energy thus contributes to creating a resilient and flexible power grid for the future. A wind turbine is used to produce green hydrogen. The plan is to produce ca. one ton of hydrogen per day – with the development stage of the electrolyser unit at ca. 2 MW. The hydrogen that is produced is available to users who strive for a power supply from renewable sources – e. g. at the adjacent industrial park Lune Delta. More space for additional electrolyzers is kept ready so that manufacturers can have their products tested there.

18 The project is based on the suggestion of the Energiewendedrehkreuze Wesermarsch in the Strategic Concept for the Realignment of the Future Green Energy Industry of Wesermarsch County by EnergieSynergie: <https://bit.ly/3qfKqky>; accessed on 15.12.2021.

19 <https://wind-wasserstoff-bremerhaven.de/wordpress/wp-content/uploads/2020/06/Studie-Integriertes-Gesamtkonzept-Fischereihafen.pdf>; accessed on 7.6.2021.

20 <https://www.iwes.fraunhofer.de/de/testzentren-und-messungen/gondelpruefung.html>; accessed on 7.6.2021.

An electrolyser with an output of 2 MW can produce about 160 tons of green hydrogen (hypothesis: 4,000 full load hours per year and 70% efficiency).

1 kg of gaseous hydrogen yields 33.3 kWh of energy and 1 t green hydrogen yields 33,300 kWh.

For orientation: 1 household uses on average ca. 3,500 kWh of power per year.

Another part of the project is the testing of fields of application for green hydrogen. To this end, the project partners Hochschule Bremerhaven and the ttz Bremerhaven are researching and testing the production of synthetic natural gas, a hydrogen oven, hydrogen in mobility and logistics, and a hydrogen microgrid.

The **ArcelorMittal Bremen steelworks** is planning to build a pilot facility for producing hydrogen.²¹ The electrolysis output is supposed to be increased step by step from 12 MW per year in 2023 to up to 300 MW in the following years. This way, the steelworks can reduce Bremen's greenhouse gas emissions by a considerable degree. Future hydrogen requirements going above these production capacities will be covered by connecting the steelworks to the cavern storage facility in Huntorf, where the electrolysis capacities will be expanded, the construction of a future supra-regional hydrogen network through coastal production, or the import of hydrogen via the north German harbours.

The project **Energiewende zum Anfassen** deals with storing green hydrogen, on-site hydrogen production, and H₂ mobility at the EWE cavern storage facility in Huntorf. Currently, their scalable electrolyser has an output of 25 KW and draws power from a 100-kW photovoltaic system located in the immediate vicinity. The green hydrogen produced on-site is being stored in overground storage facilities for now. A hydrogen fuelling station on the premises in Huntorf allows the refuelling of a small EWE-owned fleet of fuel cell vehicles. In the framework of a cooperation contract, the energy companies EWE and Uniper substantiated the plan to increase the electrolysis output, connecting the site to a power grid, and storing the hydrogen in underground storage caverns.²² From 2023 onwards, the capacity will already be increased to up to 30 MW, with an expected increase to 300 MW²³ – in theory, an increase up to 500 MW is possible.

Overall, an electrolysis capacity of approximately 2 GW can be reached in the Metropolitan Region Northwest until 2030. This calculation considers the planned facilities at the steelworks in Bremen and at the cavern storage facility site in Huntorf with up to 300 MW each as well as the facilities from the projects “Wasserstoff – grünes Gas für Bremerhaven” with an output of 2 MW, “Green Wilhelmshaven” with an output of up to 400 MW (see chapter 3.1.3.) and “green Hydrogen Coastline” with an output of up to 400 MW (see chapter 3.1.4.). Additionally, it considers the potential at the grid hub at the former nuclear power plant Unterweser,

21 <https://www.swb.de/ueber-swb/unternehmen/nachhaltigkeit/wasserstoff/elektrolyseur>; accessed on 7.6.2021.

22 <https://www.ewe.com/de/media-center/pressemitteilungen/2021/04/ewe-und-uniper-planen-wasserstoffhub-am-stan-dort-huntorf-ewe-ag>.

23 <https://www.swb.de/ueber-swb/unternehmen/nachhaltigkeit/wasserstoff/elektrolyseur>; accessed on 7.6.2021.

where the operation of an electrolyser with a capacity of up to 500 MW will be possible. For comparison: overall, Germany currently has an electrolysis capacity of 67 MW, the worldwide capacity is ca. 8 GW.²⁴ The largest electrolysis plant on the planet, which is in Fukushima (Japan), currently produces 10 MW of output (linked to a 20 MW photovoltaic system), which should emphasise the scale of the transformation process.

3.1.2. Storage and reconversion

1 kg of gaseous hydrogen yields 33.3 kWh and has a volume of 11.12 Nm³.

1 Nm³ of gaseous hydrogen at 1 bar (1 Nm³ = Normal cubic meter) produces 3 kWh of energy and weighs 0.08988 kg.

If 1 Nm³ is compressed at 100 bar, the same volume yields 100 times more energy, namely 300 kWh. However, the energy per mass stays the same.

Hence, when storing hydrogen, the amount of energy it yields depends significantly on the pressure at which the hydrogen can be stored.

In its **gaseous state**, hydrogen can be stored in storage caverns (salt domes or pore storages) as well as in pressure vessels at over 500 bar.²⁵ After North Rhine-Westphalia, the Metropolitan Region Northwest has the **highest density of caverns by working gas volume**. One of the **largest pore storages** in Western Europe with a surface of approximately 8 km² and a working gas capacity of ca. 4 billion m³ is in Rehden in Diepholz County.²⁶ There are four storage caverns for natural gas in Bremen-Lesum²⁷ with a working gas volume of 215 million m³ after their final completion, and in Nordenham-Blexen, there is the possibility of leaching new gas caverns in the immediate vicinity of the storage caverns for crude oil, petrol, and heating oil. Huntorf has seven cavern storage facilities for natural gas²⁸ with a working gas volume of 308 million m³ after their final completion and access to the long-distance gas network of the Gastransport Nord GmbH (market area Gaspool). In Etzel in Wittmund County, there are 51 storage caverns for natural gas with a cavity volume of ca. 46 million m³. Although these caverns are not located in the Metropolitan Region Northwest, they are to be considered as pipeline connections between the deep-sea port Wilhelmshaven and the region, since their potential for storage options and storage volume has a direct connection to the port. There are storage caverns in Wilhelmshaven as well, but they are currently used exclusively for storing crude oil.

24 DIHK-factsheet Wasserstoff

25 https://www.ewe-gasspeicher.de/home/produkte/speicher/speicherzone_l_gas; accessed on 7.6.2021.

26 <https://www.astora.de/speicher/erdgasspeicher-rehden/>; accessed on 7.6.2021.

27 https://www.lbeg.niedersachsen.de/energie_rohstoffe/erdoel_und_erdgas/untertagegasspeicher/publikation_untertageerdgaspeicherung/publikation-zur-untertage-gasspeicherung-in-der-zeitschrift-erdoel-erdgas-kohle-898.html; accessed on 23.3.2021.

28 https://www.lbeg.niedersachsen.de/energie_rohstoffe/erdoel_und_erdgas/untertagegasspeicher/publikation_untertageerdgaspeicherung/publikation-zur-untertage-gasspeicherung-in-der-zeitschrift-erdoel-erdgas-kohle-898.html; accessed on 23.3.2021.

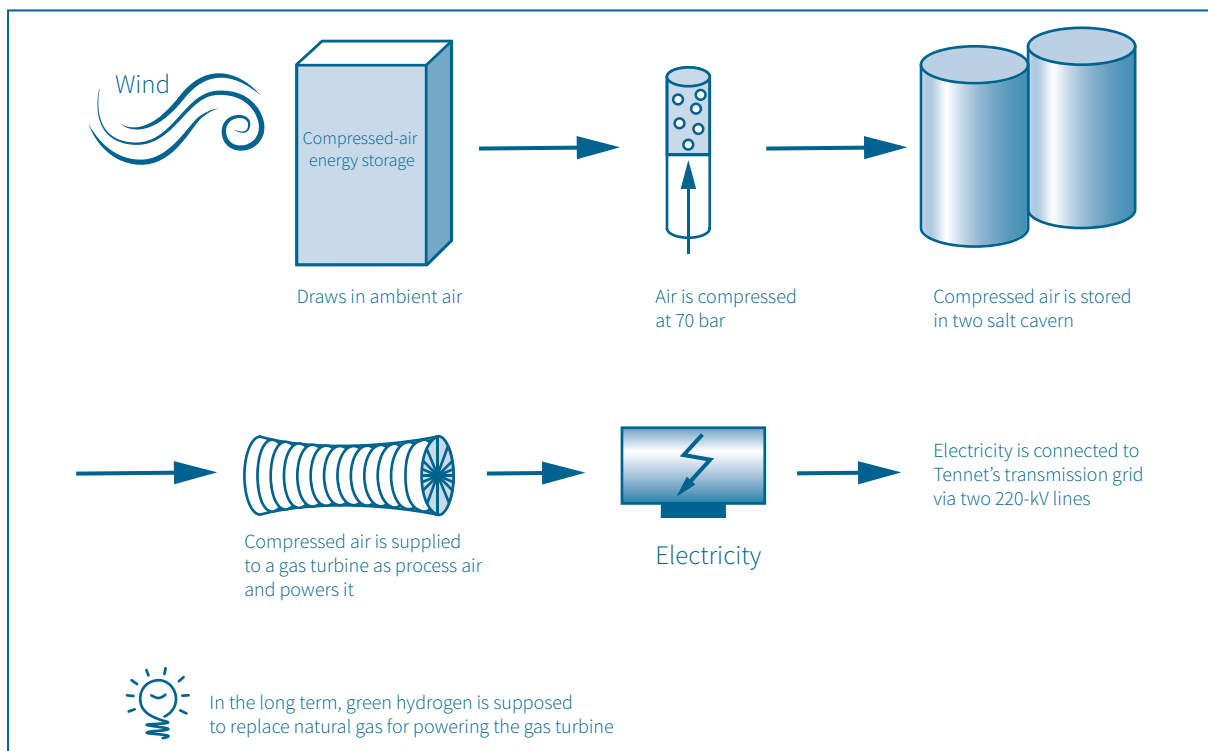
If, in the future, the demand for hydrogen increases, there would be the additional possibility of leaching two new gas caverns in Blexen, with a hollow of 300,000 m³ each. Leaching one new cavern has already been authorised; moreover, in Blexen the water supply for dissolving the existing salt deposits during the building process is guaranteed. The necessary distribution infrastructures are present as well.

Stored hydrogen can be reconverted. However, due to high energy losses in the form of waste heat, this is not a realistic option from both an ecological and an economic perspective. If the technology is refined accordingly and thus the energy loss reduced, reconversion could, in the long term, be an option for storing volatile wind energy. Considering the rising demand for elec-

tricity, reconverting imported hydrogen could make sense in the long term as well. Initial experience with reversion is already being gathered in the Metropolitan Region Northwest through pilot projects:

Together with partners from industry and science, Uniper is researching the future of storage power stations and power plants that can bridge gaps in production of solar as well as wind energy when both sources fail due to weather conditions as well as the reversion of hydrogen from regenerative production at the **compressed air storage gas turbine power plant in Huntorf, the only plant of its kind worldwide**. The facility has a storage capacity of 1,680 MWh.²⁹

3



Content source: <https://energieregion-wesermarsch.de/fuehrung/druckluftspeicherkraftwerk-uniper/>

29 Storage power station pushes compressed air into a salt cavern and powers a gas turbine when the air escapes again.

In the scope of the project **Wasserstoff – grünes Gas für Bremerhaven**, the University of Bremerhaven is testing a 10-kW electrolyser as a self-sufficient microgrid for storing and reconverting wind energy.

3.1.3. Import and distribution

The National Hydrogen Strategy assumes a hydrogen demand of 90 to 110 TWh for 2030.³⁰ These estimates and the necessary amounts of hydrogen were recently adjusted considerably upwards by the Federal Ministry of Economics.³¹ A supply gap of at least 76 TWh has to be covered by imported green hydrogen.³² Like natural gas, hydrogen can be imported via pipeline or tanker in the long term. Therefore, the supply of green hydrogen across sectors strongly depends on developing the relevant import and distribution infrastructures

The **ports** play a key role in the large-scale import of hydrogen and especially its derivatives like ammonia and methanol. The Metropolitan Region Northwest borders the North Sea and thus one of the most intensely sailed sea areas

worldwide. It is part of the so-called North-range with the seaport Bremerhaven and the deep sea port Wilhelmshaven. Moreover, the ports of Bremen-Stadt, Brake, Nordenham, and Cuxhaven as well as the inland ports of Oldenburg, Bramsche, and Bohmte (in planning) also belong to the Metropolitan Region Northwest. The Hydrogen Action Plan Germany 2021-2025 attributes a substantial role to the inland ports along the European rivers for establishing Germany as the leading market.

Due to its bunker complexes, Wilhelmshaven has a locational advantage for the large-scale import of hydrogen, which means that implementing a **CO₂ cycle economy** is possible there. Bremerhaven, too, shows the beginnings of implementing CO₂ deposition technologies, the creation of international CO₂ transport chains, and allocated storage tanks. In a preliminary investigation and in their plans for CO₂ cycles, Wilhelmshaven as well as Bremen and Bremerhaven are counting on the CCU method³³ instead of CO₂ storage (CCS method³⁴).

In the framework of a project in Wilhelmshaven called “Green Wilhelmshaven”³⁵, the energy supplier Uniper is planning a terminal for green

30 https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Energieeffizienz/nationale_wasserstoffstrategie_bf.pdf; accessed on 7.9.2021.

31 <https://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2021/07/20210713-erste-abschaetzungen-stromverbrauch-2030.html?view=renderNewsletterHtml>; accessed on 13.7.2021.

32 ISL-position paper 2020: Wasserstoff – Logistik ist Schlüssel zum Erfolg der Nationalen Wasserstoffstrategie.

33 Carbon Capture and Utilisation: CO₂ is captured (for example at combustion engines) and used again as starting material in chemical processes.

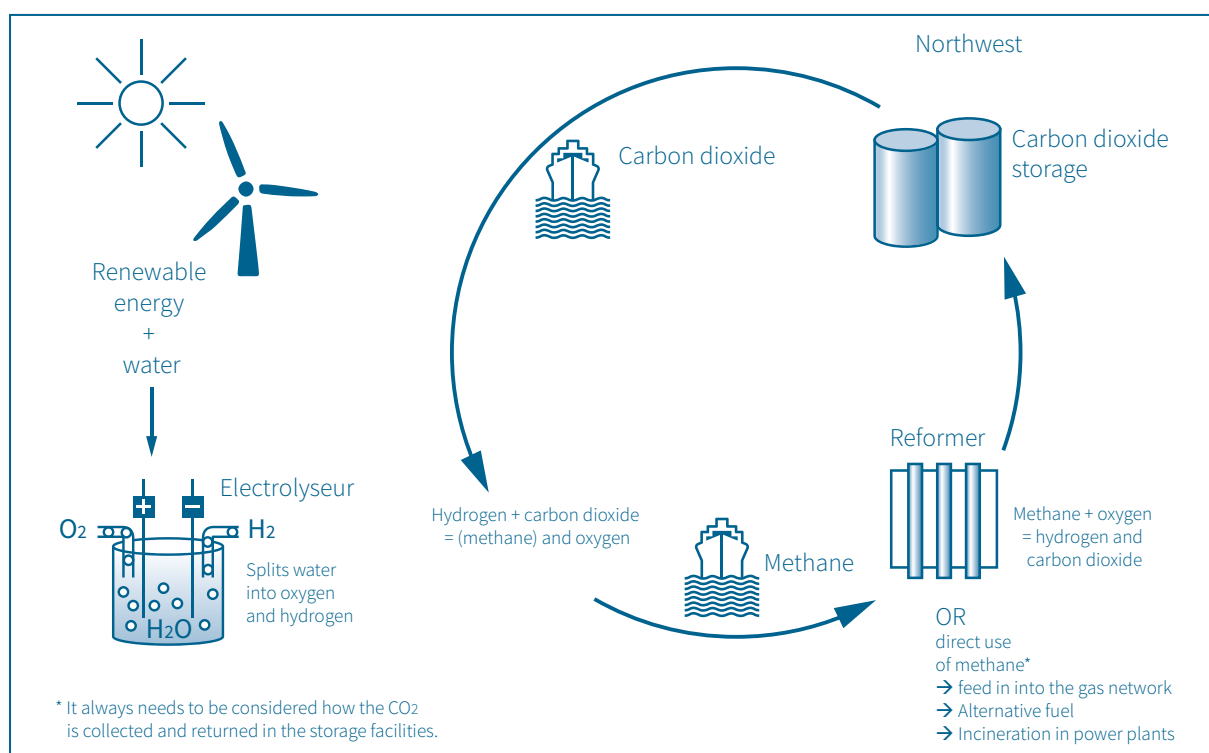
34 Carbon Capture and Storage: Method for decarbonisation of blue hydrogen. CO₂ is separated and stored in depth ranges of 1,000 and 4,000 m.

35 <https://www.uniper.energy/news/de/uniper-will-wilhelmshaven-zum-knotenpunkt-fuer-klimafreundlichen-wasserstoff-machen>; accessed on 28.4.2021.

ammonia with an ammonia cracker and a connection to the future hydrogen network. Moreover, an electrolysis output of 410 MW is planned to be established, which could – together with imports – cover about 10% of Germany's hydrogen demand. According to Uniper, this ammonia splitting plant for producing green hydrogen would be the first of its kind worldwide. The hydrogen will then be stored in the storage caverns in Etzel (see chapter 3.1.2), which the storage operator STORAG ETZEL wants to convert into one of Europe's leading hydrogen storages in the framework of the development project HYDRA and the research project H2CAST Etzel. Wilhelmshaven's connec-

tion to the hydrogen starter network operated by the gas transmission system operators Norwega and OGE, and thus the distribution of green hydrogen, will be ensured by the project WH2Connect.³⁶

Hydrogen can be distributed via roads or via grid, but also via rail or inland waterways. Which **transport technology** is most **cost-effective** depends on factors like the end use (i. e. which state of aggregation is needed at the destination), the distance between production facility and destination, the size of the market, and the technological development.³⁷ Due to the well-developed federal motorway network with



Content source: Wilhelmshavener Hafenwirtschafts-Vereinigung e. V. (WHV e. V.)

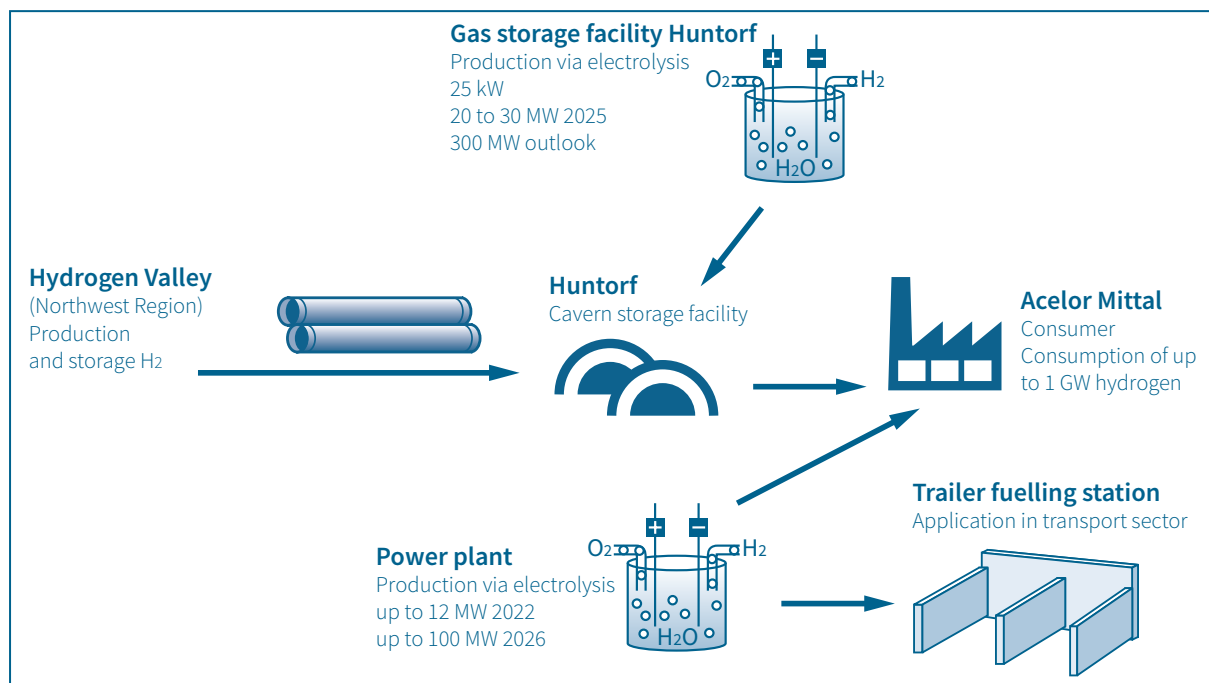
36 <https://oge.net/de/pressemitteilungen/2021/wilhelmshaven-kann-drehkreuz-fur-deutsche-und-europaische-wasserstoff-wirtschaft-werden>; accessed on 8.7.2021.

37 DLR study Wasserstoff als ein Fundament der Energiewende.

the A 1 and A 27 as access roads to the A 7, the Metropolitan Region Northwest has vital north-south routes and therefore **significant infrastructures for road-bound transport**. In the long term, the A 20 will add to this network. Moreover, already existing **pipelines for natural gas** can be converted **to distribute hydrogen**; these pipelines already provide comprehensive coverage for the entire Metropolitan Region Northwest. Already, the EWE Netz GmbH has developed a concept to convert existing infrastructures. You can find the gas pipeline network and the most important road-bound transport routes visualised on our interactive map at www.wasserstoff-region.de.


Currently, the total length of pure hydrogen pipelines being operated worldwide is only 1000

km.³⁸ Since the costs for transport via trailer (ca. 2 € per kg) are significantly higher than the costs for transport via pipeline (ca. 0.30 € per kg), building an extensive distribution grid suggests itself as the better option. The first expansion stage of the **HyPerLink** project, which plans to build a continuous hydrogen pipeline system with a total length of 610 km is being implemented in the Metropolitan Region Northwest. Until 2030, the transmission system operator Gasunie Deutschland Transport Services wants to create a connection between important production and storage sites on the one side and relevant markets on the other side via long distance gas pipelines. The establishing and commissioning of the first section from Leer to beyond Bremen – directly across the Metropolitan Region Northwest – is planned to be finished by



Content source: EWE Gasspeicher GmbH

³⁸ <https://www.tuvsud.com/de-de/indust-re/wasserstoff-brennstoffzellen-info/wasserstoff/transport-von-wasserstoff>; accessed on 27.4.2021.



2025. The project HyPerLink is closely connected to the project Clean Hydrogen Coastline (see chapter 3.1.4). Both projects were handed in as IPCEI³⁹ outlines, have now qualified for the second stage of the IPCEI proceedings, and will be merged with other European project plans.

Considering these excellent infrastructures, the Metropolitan Region Northwest offers optimal site conditions for **hydrogen hubs**⁴⁰. All connections (power grid connections, natural gas connections) to large consumption centres, federal roads, future motorways, and the federal waterways Hunte and Weser are available at key locations like the nuclear power plant Unterweser or Huntorf.

The state of Bremen also has two locations for potential hydrogen hubs: the ArcelorMittal steelworks in Bremen as well as the seaport location Bremerhaven. **The steelworks in Bremen with the adjacent industry ports** has an anticipated hydrogen consumption of several hundred MW, which will be covered by successively building up electrolysis capacities at the power plant Mittelsbüren and, in the long term, a connection to the cavern storage facility in Huntorf.

Several electrolysis sites are planned at and around the port of Bremerhaven: at the fishing port, in the international port area, and at the incineration plant. Moreover, the construction of a large-scale electrolysis plant and/or a facility for PtX⁴¹ production, and the turnaround of hydrogen and CO₂ are being considered.

The **coal plant Wilhelmshaven (Uniper)** will live on as an energy hub after the end of coal-fired power generation as well. Currently, an extensive hydrogen infrastructure is being built there. The companies Uniper, Rhenus, and Salzgitter are cooperating in planning to build a facility for direct reduction in the production of iron ore with the help of hydrogen. The deep sea port Wilhelmshaven allows for the import of hydrogen. Other options are the combination with the neighbouring air reservoir Huntorf and the connection to gas storage facilities.⁴²

3.1.4. Fields of application (mobility/logistics and industry)

The transport sector is the third largest CO₂ emitter after the chemical and steel industry and the energy industry. Therefore, the objective is to gradually replace fossil fuels with renewable energies in these sectors. In many areas, the transition can be achieved by electrification; however, from today's point of view there are only limited possibilities for electrification especially in the iron/steel and chemical industry as well as in the areas of heavy traffic, rail transport, shipping, and aviation. This is why the strategy mainly focusses on the industry and transport sectors.

³⁹ Important Project of Common European Interest.

⁴⁰ Locations of production, storage, direct usage and/or the turnover of hydrogen.

⁴¹ The use of energy through power-to-x (PtX) involves the conversion of electricity into the energy sources gas, heat, and fuel.

⁴² <https://www.uniper.energy/news/de/uniper-standort-wilhelmshaven-beendet-noch-in-diesem-jahr-die-verstromung-von-kohle-und-richtet-den-blick-auf-wasserstoff>; accessed on 7.6.2021.

Mobility/logistics

In the **transport sector**, the areas heavy traffic, non-federally owned railway transport, and aviation as well as public transport and maritime applications are most affected, since in these areas electrification does not make sense due to the low energy density of batteries. Hydrogen and its derivatives can be used as CO₂ free power supply for these areas.

The National Hydrogen Council calculates a hydrogen demand of approximately 25 TWh or 750,000 tons⁴³ in the mobility sector for the year 2030. However, since the reduction goals are rising significantly from 2035 onward, a demand of three or four times this number will arise within a short time.⁴⁴

Accordingly, this strategy undertakes the following prioritisations for the Metropolitan Region Northwest:

Priority 1 (high H₂ readiness and quick need for implementation/high likelihood of implementation):

- Rail transport
- Public transport
- Heavy traffic

Priority 2 (lower H₂ readiness, but high likelihood of implementation due to regional strengths):

- Aviation (Airbus is planning the development of an LH₂ fuelled plane until 2035)
- Maritime applications

Summary of demands for the transport sector

	Total demand transport		e-fuels land-bound transport		e-fuels air transport	
	million t H ₂	TWh	million t H ₂	TWh	million t H ₂	TWh
2030	0,8	25	0,17	5,7	0,1	2,7
2035	2,0	67	0,24	8	0,2	6,3
2035*	2,8	92	0,9	30	0,2	6,3
2040	3,8	128	0,3	11	0,4	12,1
2050*	6,1	203	2,2	72	0,4	12,1

* Scenario with a high production of e-fuels (data: own)

Source: Hydrogen Action Plan Germany 2021-2025 of the National Hydrogen Council

⁴³ 1 ton of hydrogen yields about 33,330 kWh of energy.

⁴⁴ Hydrogen Action Plan Germany 2021-2025 by the National Hydrogen Council.

Individual transport was not prioritised, since the battery-powered electric drive is considered to play a deciding role in this area due to ecological and economic factors.

On **public transport lines without overhead contact lines**, trains with hydrogen or battery technology can be employed. You can find the ratio of electrified versus non-electrified transport lines in the Metropolitan Region Northwest visualised on an interactive map at www.wasserstoff-region.de.

From summer 2021 onward, the Coradia iLint, a train owned by Alstom and the first train powered by fuel cells, will go into regular operation. It can be operated emission-free on non-electrified lines in the entire Weser-Elbe network operated by Eisenbahnen und Verkehrsbetriebe Elbe-Weser (evb). Another 14 Coradia iLint trains will be added from 2022 onward. Currently, it is being considered whether the non-electrified lines between Wilhelmshaven, Oldenburg, and Osnabrück as well as between Bremen and Osnabrück, whose operator will be newly awarded probably in 2026, can be operated with trains powered by fuel cells.⁴⁵

According to current knowledge, shunting locomotives, for example in ports, cannot be electrified. Hence, it makes sense to convert those used in shunting yards, freight centres, and ports. The project **H2Bx.HyShunter** in Bremerhaven is already working on developing a hydrogen fuelled shunting locomotive. Moreover, the DB vehicle maintenance plant in Bremen will build up know-how regarding the use of hydrogen as well as repair capacities for hydrogen drives.

The Zweckverband Verkehrsbund Bremen/Niedersachsen (ZVBN) is planning to substantiate its strategy for the change to alternative propulsion. There will be concrete numbers regarding the demand of hydrogen for **road-bound public transport** in the area covered by the ZVBN in 2022 as well as information on where the necessary locations for hydrogen fuelling stations will be. Already, the ZVBN is planning the conversion of the most important bus lines for the two states into lines operated with fuel cell vehicles – this goes for Ammerland County, Oldenburg County, and Wesermarsch County, with the last stop at Oldenburg ZOB. The vehicles' supply will be ensured via a **multimodal hydrogen fuelling station at Oldenburg ZOB** (Wehdestraße/Stau/Hafenbereich), which could, in the long term, receive the green hydrogen via a pipeline from Huntorf. The constructional realisation is planned for 2022/2023. Moreover, this multimodal fuelling station will ensure the supply for initially four hydrogen buses of the Verkehr und Wasser GmbH (VWG) in the ZVBN area and two refuse collection vehicles of the waste management service of the town of Oldenburg. Bremerhaven and Cuxhaven, too, are planning to acquire hydrogen vehicles and further invest in a hydrogen fuelled chassis-mounted road sweeper.

In addition, hydrogen for use in public transport will be produced in Bremerhaven from 2022 onward. The electrolysis facility intended for this purpose, which has an output of 2 MW, and the hydrogen fuelling station on the site of the Bremerhaven Versorgungs- und Verkehrsgesellschaft GmbH (Bremerhaven Bus) will be operated by **HY.City.Bremerhaven GmbH & Co. KG**, which was founded for this specific purpose. The

⁴⁵ LNVG press release on 29.12.2020.

main shareholders are the North-Frisian energy revolution company GP JOULE and the Bremerhaven start-up company Green Fuels. As a first step, Bremerhaven Bus wants to fuel seven fuel cell buses with this locally produced hydrogen.

FAUN Umwelttechnik GmbH & Co. KG is located in the Northwest Metropolitan Area, an innovative company that was sponsored by the Federal Ministry of Transport and Digital Infrastructure for the development of refuse collection vehicles and sweepers with fuel cell propulsion based on hydrogen. It was able to open its first production line for the serial production of the so-called **BLUEPOWER** vehicles in August 2020. The relevant practical tests were conducted in Bremen in the autumn of 2020.⁴⁶ Since every incineration plant has the potential for building an electrolyser, these refuse vehicles are basically collecting the foundation for their operation. On the site of the Abfall-Service Osterholz GmbH, green hydrogen will be won via a fermentation plant for organic waste within the framework of the **Reallabor WaMoBa**. The facility for the production of bio-methane will be ready for use in 2023 and will yield an output of one million m³ per year. This bio-methane will then initially be fed into the gas network, one or two years later the production of green hydrogen will begin. According to conservative calculations, 180 tons of green hydrogen per year could be won from this methane via plasmalysis. The bio-hydrogen created this way will supply a fuelling station at the adjacent business park A 27, and the company FAUN Umwelttechnik GmbH, which resides there, can fuel its company-owned hydrogen vehicles on-site. The production and

use as well as the supply of hydrogen will be going hand in hand in a small area.

The project **Wasserstofftechnologie Business Process Management Modeling** (H2BPMM), which is being conducted by the Hochschule Bremerhaven, is trying to tackle the problem of insufficient hydrogen fuelling station infrastructure. In the scope of this project, a tool for standardising the licencing of hydrogen fuelling stations is being developed in order to shorten the currently lengthy approval procedures.

The implementation project **Hyways for Future**, which is being funded by the Federal Ministry of Transport and Digital Infrastructure in the framework of HyLand, is focussing on supplying the transport sector with green hydrogen across sectors. Thus, EWE GASSPEICHER GmbH, in consortium with around 90 partners from the industries and politics, is pushing the market launch of regeneratively produced hydrogen in the northwest. In 2021 it could already put in grant applications for fuelling stations, production facilities, buses, refuse collection vehicles, and sweepers from within the project. A consortium of businesses along the entire hydrogen economy value chain applied for high-volume subsidies within the framework of an IPCEI⁴⁷ outline in order to consistently pursue the market boosting approach by Hyways for Future in the transport sector. This North German project idea has already qualified for the second stage of the IPCEI proceedings and will now be merged with other European project plans. Together with the project **Clean Hydrogen Coastline**, the partners are planning the goal-oriented integration of an electrolysis

⁴⁶ <https://www.bremen-innovativ.de/2020/08/wasserstoffantrieb-im-muellwagen-bremen-startet-testbetrieb/>; accessed on 7.6.2021.

⁴⁷ Important Project of Common European Interest.

capacity of up to 400 MW into the energy system until the year 2026, with according hydrogen storage. To achieve a sustainable coverage of an according demand, the project is addressing the steel location in Bremen as well as the heavy traffic sector. To this end, the consortium wants to take 12,000 fuel cell vehicles into operation and build a decentralised fuelling station network.

The project **Future Mobility**, which is being funded within the framework of the HyLand tender as well, aims at the sustainable design of heavy traffic in the northeast of Lower Saxony by linking the production of renewable energies with freight traffic. Concrete business plans will be developed and implemented with this approach. From within this project the **Wasserstoffnetzwerk-Nordostniedersachsen (H2.N.O.N)** was founded, which currently comprises 50 businesses that cover the entire value chain of a hydrogen economy.

With the port of Brake serving as an example, a concept for the creation of infrastructures for the use of hydrogen in the port and logistics sectors is being developed in the scope of the project **H2BrakeCO2**. The inclusion of “smart logistics” across the entire value chain makes an additional contribution on the path to sustainable port and logistics processes. Moreover, in September 2021 the construction of the **Truck Point Station Braker Hafen** will begin near the port in Brake. Approximately 500 lorries a day pass through the port’s central entrance and exit. Based on the consortium’s aim of decarbonisation, a hydrogen fuelling station will be built there as well – an application for subsidies

for this project was handed in via Hyways in June 2021. EWE Gasspeicher GmbH and Faun Umwelttechnik GmbH are participating as project partners. The fuelling station could be supplied with green hydrogen for example by the gas storage tank Huntorf.

Fuel cell or combustion engine? The Jade Hochschule is dealing with this question. Together with a regional engine converter, it is working on **investigating the material compatibility and controllability of supercharged combustion engines operating in lean burn mode for the supply of secondary balancing energy during internal carburetion** and thus on an increase of efficiency and durability of lorry engines for the direct combustion of liquid hydrogen. Combustion engines are considered reliable and well-studied, moreover, they are currently more durable and lighter than fuel cells. Since May 2021, Lower Saxony’s Ministry of Science and Culture has been funding a research association in which, among others, the Jade Hochschule Wilhelmshaven is participating. This association is tasked with developing sustainable hydrogen combustion concepts. In the framework of so-called innovation laboratories the different competencies in the area of hydrogen technologies will be purposefully pooled and the hydrogen research in Lower Saxony will be strengthened and developed further.⁴⁸

In the project **H2Cool Prelude** conducted by the Institut für Seeverkehrswirtschaft und Logistik (ISL), the Hochschule Bremerhaven, and other partners, the research into hydrogen and fuel cell technology is being expanded to include frozen cargo transports.

48 <https://www.mwk.niedersachsen.de/startseite/aktuelles/presseinformationen/sechs-millionen-euro-fur-grunen-wasserstoff-199721.html>; accessed on 29.4.2021.



Bremen is one of the largest aerospace locations in Germany. Cryogenic hydrogen (LH₂) has long been standard in space travel, and therefore the OHB-Gruppe, the DLR-Institut für Raumfahrt, Airbus, and the ArianeGroup, have longstanding experience with hydrogen technology as well as experience in the areas of material development and system integration. In the long term, the plan is for LH₂ to be used as fuel in aviation as well to ensure climate-friendly global mobility. However, this necessitates a tank volume four times as high as the current one, increasing the size and weight of aeroplanes. Therefore, lightweight construction plays a key role especially in tank construction.

3


For this reason, Airbus has started two Zero-Emission Development Centres (ZEDC) in Europe in order to develop and test LH₂ tank systems for aviation until 2025. The goal is to fly with LH₂ by 2035. These ZEDC are located in Nantes (France) and Bremen. Bremen was chosen due to the space travel competencies and the good research infrastructure of ECOMAT (Bremen Center for Eco-efficient Materials and Technologies). Therefore, the Faserinstitut Bremen (FIBRE) and the DLR-Institut für Raumfahrtssysteme are building a material testing infrastructure for LH₂, with a particular focus on LH₂ application of carbon-reinforced plastics. Besides the material characterisation, the focus at ECOMAT is on the inspection and approval of materials, construction methods, and components in the context of the future requirements placed on them. The medium-term goal within

the framework of the ZEDC is for this work to lead to the creation of a cross-sector licencing centre for fire safety (Fire Safety Certification Centre).

Moreover, Bremen and Bremerhaven, together with the locations Hamburg and Stade, are building the hydrogen technology-focussed Innovations- und Technologiezentrum (ITZ Nord) for aviation and shipping. The Technologiezentrum Nordenham (ITZN) in Wesermarsch is involved as the “IZT Nord’s” cooperation partner. The ITZ Nord will be built as a new kind of service centre in the future network of the German Centre for Future Mobility. The concept with a focus on aviation and shipping addresses a service centre geared towards small and medium-sized enterprises (KMU) as well as start-up companies, segment specific testing and innovation centres, and laboratory capacities. The focus is on the development and integration of fuel cell systems and corresponding components, on the hybridisation of drives, refuelling concepts, the logistics, storage, and processing of green hydrogen and hydrogen-based fuels as well as the testing of components and systems. Moreover, competencies regarding the question of standardisation and certification will be pooled, in close cooperation with classification societies.⁴⁹

Logistics hubs like the Bremen ports are confronting the upcoming transformation process as well. Together with the partners Siemens, Eurogate GmbH & Co. KGaA, and BLG Logistics Group, bremenports GmbH & Co. KG as

⁴⁹ <https://www.bmvi.de/SharedDocs/DE/Pressemitteilungen/2021/102c-scheuer-standortentscheidung-innovations-technologiezentrum-norden.html:%20abgerufen%20am%2010.09.2021>; accessed on 10.09.2021.



the leading manager is developing a model for creating a CO₂ neutral port infrastructure in Bremen within the framework of the project **Smart Harbor Application Renewable Integration Concept (SHARC)**. SHARC analyses the current and future energy demands at the international port and – under fixed premises – develops appropriate area-wide solutions for the transition of the entire energy supply to renewable energies. The goal is a CO₂ free port. In this context, the use of hydrogen technologies for linking the gas, heating, propulsion, and electricity sectors is addressed as well and will be implemented in follow-up projects (among others SHARC II). In the context of this project, however, the priority is the supply of local needs in the port area.

In the joint project **H2Bx.Mari-TransGate** the seaport Bremen will be established as a testing field for hydrogen technologies in maritime economy and its development towards a CO₂ neutral port will be supported. To this end, additional renewable energies will be produced and a port electrolyser, combined with a smart microgrid, will be installed. These infrastructures will supply mobile power packs, ship engines, shunting locomotives, lorries, and finally also handling equipment with hydrogen and its derivatives. This will provide a blueprint for the transformation of mobility and logistics in ports. Further subprojects aim at building import and distribution structures for hydrogen and its derivatives as well as the production of derivatives of green hydrogen.

Moreover, the Metropolitan Region Northwest distinguishes itself through **innovative applications and prototypes in specific niche areas**, which can be expanded to become relevant technology carriers with the help of regional partners. The Alfred-Wegener-Institut (AWI) deals with the potential applications of hydrogen fuel cells for supplying energy to self-sufficient measuring platforms in polar regions and to underwater robots. The new findings discovered there can be used as the basis for the further development of self-sufficient pump stations for draining agricultural areas based on renewable energies and hydrogen. Moreover, innovative contributions concerning high performance structures for hydrogen storage facilities and lighter hydrogen tanks can be expected from the Arbeitsgruppe Bionik at the Alfred-Wegener-Institut, which, among other things, deals with the subject of structure lightweight design in connection with wall permeability and wall strength. The production of this kind of structure (“generative engineering”) can be supported by Elise GmbH (Bremen), a spin-off company of the Alfred-Wegener-Institut. The research ship “**FK Uthörn II**” is another prototype by the Alfred-Wegener-Institut and the first ship in the public sector fuelled by methanol. This project will contribute to increasing the use of methanol as a derivative of green hydrogen.

You can find an overview over the projects as well as pilot and demonstration projects in the Metropolitan Region Northwest under www.wasserstoff-region.de.

Industry

The industry is using hydrogen as an energy source, as raw material, and as process gas in its pure form. However, it is currently primarily produced on the basis of fossil fuels (so-called grey hydrogen).

In 2018, approximately 6% of the entire final **electricity consumption** in Germany could be allocated to the industry and mobility/logistics sectors.⁵⁰ About 36% of electricity consumption in the industry sector (the equivalent of 262 TWh) is based on gas. Those 36% comprise electricity production and high-temperature heating processes. In 2015 for example, about 65% of industrial energy was used as process heat. The primary fuel used was natural gas, which could be replaced by hydrogen in the long term. However, especially the supply of high-temperature process heat – which pertains particularly to the energy-intensive medium-sized companies – has been only insufficiently included into the strategic considerations of the industry and its future hydrogen needs.⁵¹

The chemical industry currently needs more than a million tons of hydrogen as **raw material**. This consumption will significantly rise in the near future, since hydrogen can substitute other climate-damaging raw materials in this industry sector.⁵² And the Hydrogen Action Plan Germany 2021-2025 by the National Hydrogen Council foresees a demand of ca. 2 million tons of hydrogen as **process gas** for the steel industry alone.

In the scope of developing the hydrogen strategy for the Metropolitan Region Northwest, the fields of application of hydrogen in the industry sector were examined closely, matched with the primary CO₂ emitters in the region⁵³, and categorised as follows:

- **Users who already use hydrogen** and consequently possess the technical prerequisites and who have an urgent need for implementation, like refineries and the chemical industry. Here, the focus is on a quick transition from grey to green hydrogen.
- **Users with a short-term high hydrogen demand who are not yet using hydrogen on a large scale** and therefore do not possess the technical prerequisites (yet), like energy producers and gas network operators, the steel industry, power plants as well as the mobility, logistics, and shipping sector. Here, the focus is on reliable financial and regulatory support for the transformation process in these businesses. Especially in the steel industry, the key technologies needed are already available in principle.⁵⁴
- **Users with a long-term high to medium hydrogen demand who so far primarily use natural gas to supply high-temperature process heat**, like for example the brick, cement, glass, chemical, and steel industries. Here, the focus is on the transition from grey to green hydrogen and the development and the demonstration of climate-friendly alternatives for these businesses.

⁵⁰ Energy Balance of the Federal Republic of Germany (as of October 2019).

⁵¹ <https://www.bundestag.de/resource/blob/800132/6ddf5daf7fc253845a1e7113e0a35977/sv-baumguertel-data.pdf>; accessed on 7.5.2021.

⁵² Hydrogen Action Plan Germany 2021-2025 by the National Hydrogen Council.

⁵³ Facilities that are subject to emissions trading in Germany 2019 (as of 4.12.2020).

⁵⁴ Hydrogen Action Plan Germany 2021-2025 by the National Hydrogen Council.

- **Users with a low hydrogen demand who are already using hydrogen as process gas**, like the food, metalwork, electronics, and car industries. Here, the focus is on the transition to green hydrogen.
- **Users who can utilise the by-products** like waste heat and oxygen, for example aquacultures and sewage treatment plants. Here, the focus is on ensuring the businesses are supplied with these “waste products”, of which there will be an increased amount in the future.

In a first step, these industrial projects in the Metropolitan Region Northwest are focussing on users with a short-term high hydrogen demand who are not yet using hydrogen on a large scale and therefore do not (yet) possess the technical prerequisites but have an urgent need for implementation. These are especially the steel production industry, but also the ports as industrial end users and greenhouse gas emitters. But many projects also consider users who can utilise the by-products like waste heat and oxygen.

The projects **H2B** and **HyBIT** focus on the steel industry in Bremen, which alone causes about half of the Hanseatic city's greenhouse gas emissions and needs to be defossilised. Within the framework of the project **H2B – Roadmap für eine graduelle Defossilisierung der Stahlindustrie und urbaner Infrastrukturen mittels Elektrolyse-Wasserstoff**, an electrolyser that is being built on the ArcelorMittal Bremen premises will serve as an “energy hub” and, in the spirit of linking sectors, supply the industry and transport sectors with green hydrogen. The necessary renewable energy can

be supplied by nearby wind turbines. To this end, an electrolysis facility will be built at the power plant site Mittelsbüren. This facility will, as a first step, generate an output of 12 MW and supply the ArcelorMittal steelworks with green hydrogen. EWE, together with its daughter swb and ArcelorMittal, is developing a strategy under the project name HyBit (Hydrogen for Bremen's industrial transformation), which will showcase the prospects of building a complete hydrogen value chain during the following years.

You can find further projects as well as pilot or demonstration projects in the Metropolitan Region Northwest under

www.wasserstoff-region.de.

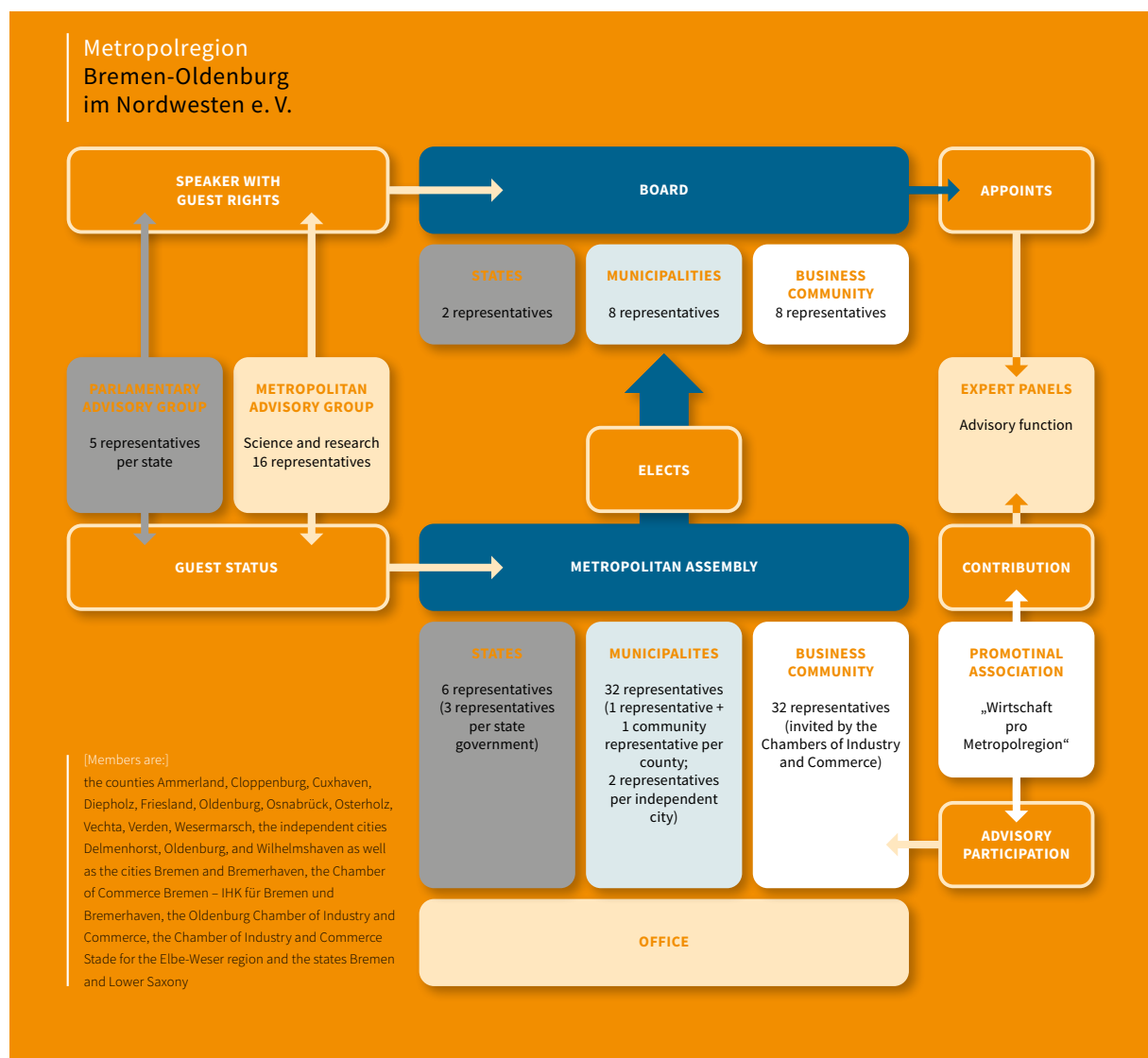
3.2. Governance structures

European metropolitan regions in Germany are based on the concept of regional governance. A central aspect is the creation of independent regulatory structures for the involved individual players to effectively manage coordination and cooperation. Aside from the state-run institutions, interest groups, associations, economy, and science play an important role in the choice and implementation of topics. This usually comes with a complex managing structure that is put in place to safeguard the common regional interests, which usually exist beyond fixed administration and state borders. Voluntariness is a key principle of regional self-regulation in order to use shared opportunities – so-called win-win situations. Building a regional hydrogen economy is such an opportunity that has been seized by the Metropolitan Region Northwest.

3.2.1. Political and institutional structures

The Metropolitan Region Northwest is one of eleven German European metropolitan regions. Economy, administration, politics, and science have been closely working together since 2006 to develop the region and its future fields and set it up as a strong player in international competition. Eleven counties, five independent towns, three Chambers of Industry and

Commerce, and the states of Bremen and Lower Saxony have joint together in the Verein Metropolregion Nordwest to prepare the region for the future. This cooperation structure has since frequently proven itself and, through targeted funding of innovative regional cooperation projects, has been able to repeatedly develop solutions to the big societal questions and challenges and test them in the Metropolitan Region Northwest. Especially regarding the devel-



Source (October 2022): www.metropolregion-nordwest.de

opment of the hydrogen strategy and the creation of specialist and cooperative structures, these already existing trust-based structures and networks are vital for the joint effort of establishing the German northwest as a Europe- and worldwide flourishing hydrogen region.

3.2.2. Academic institutions

The close connection between economy and science is not only important for the implementation of pilot and demonstration projects, but also necessary for expanding the hydrogen economy. The Metropolitan Region Northwest has the necessary range of academic institutions and research institutes. Each of the following institutes contributes its expertise to getting considerably closer to the ambitious goal of building a hydrogen economy. The entirety of the research institutes and facilities in the Metropolitan Region Northwest, with their respective focus areas and expert knowledge, is one of its unique selling points. You can find comprehensive information about the respective academic institutions on our website

www.wasserstoff-region.de.

- Alfred-Wegener-Institut (AWI), Fachbereich Logistik/Stabsstelle Technologietransfer
- BIAS – Bremer Institut für angewandte Strahltechnik GmbH, Abteilung Füge- und Pulverbettverfahren (Forschungsschwerpunkt HyLaP)
- DLR-Institut für Vernetzte Energiesysteme
- Faserinstitut Bremen e. V.
- Fraunhofer Institut für Angewandte Materialforschung in Bremen (IFAM)
- Fraunhofer-Institut für Windenergiesysteme IWES, Hydrogen Lab Bremerhaven (HLB)
- Hochschule Bremen, IEKrW – Institut für Energie und Kreislaufwirtschaft

- Hochschule Bremerhaven, Fachbereich 01 – Technologie
- Hochschule Osnabrück, Fakultät Ingenieurwissenschaften und Informatik
- Hochschule Vechta, Referat Forschungsentwicklung und Wissenstransfer
- Institut für Seeverkehrswirtschaft und Logistik (ISL)
- Jade Hochschule Wilhelmshaven, Oldenburg und Elsfleth, Institut für nachhaltige Energieversorgung (INEV)
- Leibniz-Institut für Werkstofforientierte Technologien – IWT
- OFFIS Institut für Informatik Anwendungsbereich Energie
- Technologie Transfer-Zentrum an der Hochschule Bremerhaven (ttz)
- Technologiezentrum Nordenham (TZN), Forschungs- und Entwicklungsbereich Wasserstoff
- Universität Bremen, Bremer Forschungszentrum für Energiesysteme „Energie für Wirtschaft und Gesellschaft“, Fachbereich 4/ Fachgebiet Resiliente Energiesysteme
- Universität Oldenburg, Institut für Chemie/ Technische Chemie

3.2.3. Networks and associations

Networks create a platform for exchange between players. They enable finding partners for projects and plans as well as developing solutions and marketable innovations and implementing them together. Additionally, networks increase the visibility of joint activities to the public and enable joint lobbying on the national and the European level. The Metropolitan Region Northwest has complex networks which cover all parts of the value chain, work together, and are pursuing the joint target of building a hydrogen technology through their respective

specialised direction expertise. You can find comprehensive information about the respective networks on our website

www.wasserstoff-region.de.

- Agrotech Valley Forum e. V. (complete hydrogen value chain)
- Automotive Northwest e. V. (mobility)
- Aviaspace Bremen (mobility)
- Deutsche Wasserstoffliga (complete hydrogen value chain)
- Energieregion Wesermarsch (complete hydrogen value chain)
- Hafennetzwerk e4-ports (mobility/logistics)
- Maritimes Cluster Norddeutschland (mobility/logistics)
- Netzwerk Nordwesthäfen (mobility/logistics)
- OLEC e. V. (complete hydrogen value chain)
- Stiftung OFFSHORE-WINDENERGIE (production)
- WAB e. V. Industrieverband und Innovationscluster für Windenergie (production)
- Wadden Sea Forum e. V. (complete hydrogen value chain)
- Wasserstoffnetzwerk H2BX – Wasserstoff für die Region Bremerhaven e. V. (complete hydrogen value chain)
- Wasserstoffnetzwerk Nordostniedersachsen (H2.N.O.N.) (mobility)
- Wilhelmshavener Hafenwirtschafts-Vereinigung e. V. (WGV e. V.) (import/distribution/industry)
- ZIM-Netzwerk Green Meth (mobility/logistics)

4. The Metropolitan Region Northwest and hydrogen

4.1. Which role will hydrogen play in the region?

The regionally focussed strategy of the Metropolitan Region Northwest is embedded in the political and local structures and takes up the significant joint issues and goals of the Hydrogen Strategy for a Climate-Neutral Europe, the National Hydrogen Strategy, the North German Hydrogen Strategy as well as for example the Strategic Concept for the Realignment of the Future Green Energy Economy in Wesermarsch County, and the Integrated Hydrogen Plan for the Northern Netherlands. These create the foundation for the goals of the Metropolitan Region Northwest, which were deduced in an extensive dialogue with the stakeholders.

The Hydrogen Strategy for a Climate-Neutral Europe was published by the EU in the summer of 2020 and is part of the European Green Deal. The European strategy formulates as its central goals a **CO₂ neutral European economy until 2050** and the gradual expansion of the production of green hydrogen to an extent of at least **40 GW of electrolysis output until the year 2030**.⁵⁵

The National Hydrogen Strategy has as its goal to implement the **installation of an electrolysis output** of at least 5 GW for producing green hydrogen to cover an energy demand of 90 to 100 TWh. The amended climate protection law

⁵⁵ https://germany.representation.ec.europa.eu/index_de; accessed on 29.3.2021.

declares climate neutrality by 2045 as its binding national goal. Moreover, an **orientation framework for politics, public administration**, and the economy as the basis for the creation of a **hydrogen home market** will be developed.⁵⁶ In addition, the federal government decided in the beginning of February 2021 to raise the **share of renewable energies in the transport sector** to 28% by 2030 and thus to exceed the EU target of 14%.⁵⁷ Germany is setting ambitious goals for itself, and as proven by the numerous different activities at research facilities, businesses, and public institutions, the Metropolitan Region Northwest gladly joins the country in striving for them (see chapter 3.1.4).

The North German Hydrogen Strategy aims at being able to supply nearly all interested buyers with hydrogen by 2035. To this end, the first **hydrogen hubs** will go into operation until 2025. Moreover, an **electrolysis output** of at least 500 MW until 2025 and at least 5 GW until 2030 will be established in Northern Germany for the production of green hydrogen. The licencing practice for the necessary facilities will be optimised until 2022. Another point in the Northern German agenda is the strengthening of specialist skills at the relevant public authorities. To ensure the purchase of the produced hydrogen, the Northern German states will be strengthened in their demand role and relevant support programmes for municipalities and businesses will be created.

The energy region Wesermarsch has already redefined these supra-regional goals for the

local level and listed them in its Strategic Concept for the Realignment of the Future Green Energy Economy in Wesermarsch County.⁵⁸ The goals defined in this strategy are the linking of relevant players on the county level, creating new impulses in the area of energy economy, structured working on projects in the energy sector, the advancement of sector linking via hydrogen and green gasses, creating jobs in the energy sector, and positioning Wesermarsch as an energy or rather hydrogen region.

The Metropolitan Region Northwest takes up the international as well as the national and local strategies. Thus, green hydrogen – next to electrification – is defined as the most important decarbonisation option. **The aim is the comprehensive use of green hydrogen along a clear CO₂ reduction path on the basis of the national climate protection law as non-negotiable goal until 2045.** Blue and turquoise hydrogen are recognised as interim technologies for launching the market.

Functioning and widely available relevant infrastructures are essential for building an efficient regional hydrogen economy. To this end, these infrastructures like grids, caverns etc. are to be examined regarding their possible uses and put into operation as quickly as possible. The economic players in the Metropolitan Region Northwest can contribute significantly to the realisation of Germany's and Europe's climate goals through reasonable (subsequent) use of completely functional already existing infrastructures (see chapter 3.1). Realising the second

⁵⁶ BKW BD. 72 (2020) No. 12.

⁵⁷ <https://www.bmu.de/pressemitteilung/schulze-wir-foerdern-kraftstoffe-die-das-klima-schuetzen-ohne-die-natur-zu-zerstoeren/>; accessed on 7.6.2021.

⁵⁸ <https://bit.ly/3qfKqky>; accessed on 15.12.2021.



stage of the planned electrolyser at the steel plant in Bremen alone could cover a large part of the electrolysis output aimed at in the North German Hydrogen Strategy. This output can even be exceeded by far by connecting the grid nodes in Wesermarsch to the offshore wind parks while at the same time installing an electrolyser at the former power plant. Through the electrolysis capacities of ca. 2 GW that can be realised until 2030, the players in the Metropolitan Region Northwest are making a decisive contribution to reaching the defined goals regarding the production of green hydrogen (see chapter 3.1.1).

However, in 2019 240 TWh of electricity were created from renewable energy sources in Germany, which is about 46% of the net electricity production.⁵⁹ With the efficiency of an electrolyser at about 70%, this means that the demand for green hydrogen calculated in the national hydrogen strategy of 700 TWh in the year 2050 would need 1,000 TWh of electricity for electrolysis alone. That is about four times the amount in comparison to today.⁶⁰ The Metropolitan Region Northwest does have the relevant capacities to expand the wind energy sector, although conflicts about land use are to be expected. Due to the national and the Northern German goals, the players in the Metropolitan Region Northwest see the support for expanding the wind energy sector – as well as the regulation of the distribution networks of regenerative electricity and the hydrogen produced with it – as guaranteed and are

working at high pressure on the relevant construction and expansion projects.

At the same time, it can be foreseen that the bulk of the renewable energy produced will, on the balance sheet, be used as direct energy and that the capacities of renewable energies for the production of hydrogen and its derivatives will not be sufficient in Germany in the long term. Hence, creating import capacities is inevitable. The port operators in the Metropolitan Region Northwest have recently joint with each other and with subject-relevant networks, businesses, and scientific institutions to make the ports H₂ ready. Presuming the existence of adequate financial support, it can be assumed that the ports are prepared for the landing of the first hydrogen ships.

The future hydrogen economy, for whose construction the players in the Metropolitan Region Northwest play a key role, is considered to be extremely important for the entire region: hydrogen is the opportunity to create economic growth that is sustainable in every way, to stimulate the economy, and to thus create a significant number of new jobs. As shown in chapter 3, the players in the Metropolitan Region Northwest have already proven their expertise in projects and joint projects. Federal grants for creating a home market can contribute to transitioning these promising approaches into profitable ventures and thus push a quick market launch.

59 ISL-position paper 2020: Wasserstoff – Logistik ist Schlüssel zum Erfolg der nationalen Wasserstoffstrategie.

60 ISL-position paper 2020: Wasserstoff – Logistik ist Schlüssel zum Erfolg der nationalen Wasserstoffstrategie.



4.2. Which role does a hydrogen strategy play in this context?

Through its strategy paper, the accompanying website with the project database, and the interactive hydrogen map, the Metropolitan Region Northwest demonstrates the favourable local characteristics and regional strengths along the hydrogen value chain. Thus, it creates a basis for the regional players to create a public image, to acquire funding, and to increase acceptance – also in the general public – as well as to develop own strategies. Through the extensive regional participation process (see chapter 1.1), the foundation for a comprehensive linkage of regional players across structures has been laid, which can, in the future, also lead to the creation of know-how, the transfer of knowledge, and the initialisation of joint projects.

This strategy shows the Metropolitan Region Northwest's strengths and unique selling points, which potentials can be tapped into, which concrete goals are being pursued, and which perspectives there are for the entire region. This way, the regional players have the opportunity of prioritising and planning investments and projects. But above all, the plan is to address and motivate businesses to implement business models for building a hydrogen economy in our Metropolitan Region Northwest. Together, we are sending the strong message that the Metropolitan Region Northwest is ready for the creation and expansion of a regional hydrogen economy and thus contributes significantly to reaching the goal of a climate-neutral Metropolitan Region Northwest and the implementation of the European and national climate goals.

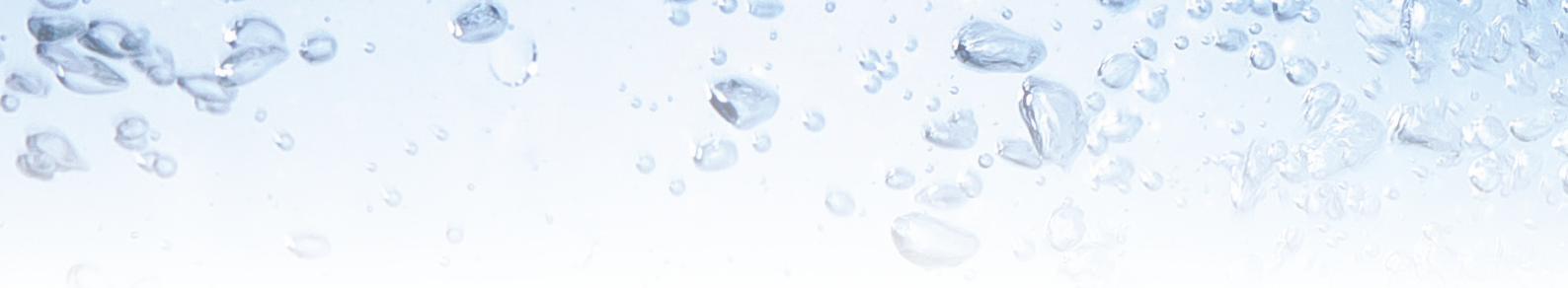
5. Regional demands for the market launch of hydrogen

The Metropolitan Region Northwest is predestined to become Germany's leading hydrogen region. It has all relevant prerequisites: from the infrastructural conditions over the research institutions, networks, and innovative businesses to promising trial projects. However, there are various challenges to the market launch of green hydrogen which will need to be overcome. These challenges are pertaining to the entire value chain, meaning the production as well as the storage and conversion and the import and distribution of hydrogen. During the development of this strategy, the demands for the market launch of hydrogen that are immediately connected to the framework in the Metropolitan Region Northwest have been established:

Building a hydrogen economy in the Metropolitan Region Northwest will be successful if...

- ... political stakeholders will manage within a short time to set **clear, binding, and quantitative goals** and supply **funding instruments** geared towards continuity in order to create planning and investment security for the businesses.

Since hydrogen applications are currently not competitive due to high prices, the industries and businesses in the northwest need financial support for investing in these technologies (CAPEX) as well as for the running costs (OPEX). The funding should primarily go to those industries that can utilise hydrogen most effectively to reduce emissions: the steel and chemical industry, the energy economy, and businesses in the mobility/logistics sector. So-called Carbon



Contracts for Difference (CCfD)⁶¹ offer an opportunity to do this. In this context, subsidies for fossil fuels should be gradually reduced.

Accordingly, the industrial projects in the Metropolitan Region Northwest are focussing on users with a short-term high hydrogen demand who are not yet using hydrogen on a large scale and therefore do not (yet) possess the technical prerequisites but have an urgent need for implementation. Moreover, users who can utilise by-products like waste heat and oxygen are already being considered in many projects. But the players in the Metropolitan Region Northwest also include industries in which hydrogen can replace natural gas for the supply of high-temperature process heat. To support these as of now mostly overlooked industries in the energy transformation process in a financial manner, our industrial players need support programmes aligned with these requirements.⁶² Moreover, industry consumers with a future high hydrogen demand will have to be connected to developing infrastructures as quickly as possible while ensuring the transport charges for hydrogen in the long term in order to facilitate their decision for such high investments.

➤ ... a **regulatory framework for pure hydrogen networks** is created.

All projects regarding the construction of or the conversion to hydrogen infrastructures touch upon the subjects of emission protection, environmental protection, and construction law in the planning and licencing processes. Creating a regulatory framework for pure hydrogen networks can accelerate the construction and conversion and will be supported for this reason.

Project developers as well as the licencing and planning authorities in the Metropolitan Region Northwest are used to working together closely from the beginning when projects are being developed. However, due to the novelty of their nature, there is often a lack of experience when it comes to the licencing process of hydrogen projects. The Metropolitan Region Northwest's Arbeitskreis Raumstruktur can function as networking platform and support the exchange between the different licencing authorities. Established networking structures, like the Metropolitan Region Northwest's Arbeitskreis Raumstruktur are used in a goal-oriented manner to receive and exchange information in

61 CCfD are a financial product for hedging an uncertain price for the sellers as well as the buyers. Both sides agree on a guaranteed price for a climate-friendly product. The differential cost between conventional and climate-friendly production is compensated until competitive distortion can be ruled out or a market for climate-friendly products has emerged.

62 <https://www.bundestag.de/resource/blob/800132/6ddf5daf7fc253845a1e7113e0a35977/sv-baumguertel-data.pdf>; accessed on 7.5.2022.



order to gain as much security as possible and quickly implement the projects.

- ... **internationally compatible frameworks, rules, and standards** for hydrogen, hydrogen components, and hydrogen-based products are established.

To ensure a qualitative supply of climate-neutral hydrogen, internationally compatible frameworks, rules, and standards need to be developed within a short timeframe. To this end, test organisations will have to be appointed and authorised. Additionally, labels to mark products (e. g. cars or steel) and system components that are produced with green hydrogen (proof of origin) can increase transparency for potential buyers and thus increase the market for businesses willing to invest. Aside from a CO₂ footprint, the proof of origin needs to contain information regarding the production method, the amount of energy contained, and other sustainability criteria. A certification system coordinated on a European level seems mandatory in order to ensure a general comparability of hydrogen quality and to demonstrate the potential for the reduction of greenhouse gas emissions to consumers.

- ... a **market framework for climate-friendly energy sources in the transport sector** is established.

Especially in the areas of commercial vehicles and public transport, climate-friendly vehicles are not yet competitive. Therefore, the first priority is to lower production costs by upscaling hydrogen-fuelled and battery-powered drives. For applications that can neither be directly electrified nor utilise hydrogen (see chapter 3.1.4), electricity-based fuels (so-called eFuels⁶³) have to be considered. The reduction of greenhouse gases achieved in this manner will be considered in the CO₂ fleet target for lorries and buses and acknowledged in the scope of the Renewable Energy Directive (RED II)⁶⁴. Moreover, the energy tax for eFuels should be decreased by linking this tax to a vehicle's greenhouse gas emissions instead of its energy consumption. In this way, the different climate-friendly energy sources in the transport sector can become more attractive for fleet operators as quickly as possible. To create further incentives for the reduction of greenhouse gas emissions, hydrogen-fuelled lorries can be exempted from tolls. Due to higher efficiency, direct electrification is still to be favoured for passenger cars.

63 eFuels are synthetic fuels. To produce them, water is split into hydrogen and oxygen via the use of regenerative power and then converted into synthetic petrol or diesel.

64 The goal of the new Renewable Energy Directive (RED II, 2018/2001) is the increase of the share of renewable energies in the electricity, heat, and transport sectors until the year 2030.

- ... an **immediate action programme for funding hydrogen fuelling stations** is created.

In addition, an immediate action programme for funding hydrogen fuelling stations is needed that goes beyond the current federal funding for a refuelling infrastructure for passenger cars and instead specifically focusses on lorries and buses. Due to the enormous hydrogen demand that will arise from 2035 onward as a result of the reduction goals, the construction and expansion of the relevant infrastructure should be started immediately.

- ... green electricity is completely exempted from the **Renewable Energy Sources Act (EEG) levy and other government-induced price components**.

In connection with the expansion of renewable energies, green electricity, which is used for electrolysis, should be completely exempted from the EEG levy and other government-induced price components (taxes and levies), since the market launch of hydrogen cannot be guaranteed without competitive electricity prices. The passing of the draft law for the implementation of the Renewable Energy Sources Act (EEG) has been welcomed as an interim solution in this context.

- ... **wind energy is expanded**, the **expansion goals** are increased, and the **expansion corridors** are broadened.

As shown in chapter 3, an electrolysis capacity of altogether 2 MW can be reached until 2030 in the Metropolitan Region Northwest. Aside from the existing production capacities of renewable energies, the already existing grid nodes and the expanded transmission grids are contributing to this goal and thus to the energy transformation. However, to reach the aforementioned production capacity, a massive expansion of renewable energies is mandatory. The regional players are aware of their responsibility regarding the further expansion of these capacities and are driving them forward. Still, a significant increase of the expansion goals for wind power and the broadening of the expansion corridors are necessary. A study conducted by the Landesverband Erneuerbare Energien Niedersachsen/Bremen shows significant areal potential for wind energy facilities in Lower Saxony's counties and thus for large parts of the Metropolitan Region Northwest.⁶⁵ Especially for this reason, the capping by the Federal Network Agency through determining maximum tender limits for wind power projects needs to be suspended. The existing areal potential has to be utilised so that the output of regenerative energy that is produced can make a significant contribution to satisfying the calculated demand for green hydrogen. Moreover, the full expansion of the

⁶⁵ <https://www.lee-nds-hb.de/windenergiepotenzial-in-vielen-landkreisen-nicht-ausgeschoepft/>; accessed on 9.6.2021.



offshore wind turbines to 50 GW needs to be driven forwards, if possible with a yearly growth of ca. 2 GW. Thanks to the offshore grid connection in Wilhelmshaven and Unterweser (see chapter 3.1.1), the well-developed grid nodes and the existing and planned transmission grids for transporting green electricity to the production facilities can be used to full capacity.

- ... the on-site **port infrastructure** is expanded in preparation of high-volume imports.

According to the National Hydrogen Strategy, 14 TWh of green hydrogen will be produced by 2030. But the actual demand, according to the strategy, will be at least 90 TWh. Moreover, the estimates and the necessary amounts of green hydrogen were recently adjusted significantly upward by the Federal Ministry of Economics.⁶⁶ Accordingly, there will be a deficiency of at least 76 TWh of green hydrogen by 2030, which will have to be covered by imports.⁶⁷ Like natural gas, hydrogen can be imported via offshore pipeline or tanker in the long term. Especially for high-volume imports, ports in the Metropolitan Region Northwest come to mind. As discussed in chapter 3, these ports are already confronting this task within the framework of projects, studies, and pilot projects. However, the cross-sector supply of green hydrogen depends significantly on the creation of relevant infrastructures, for which fitting support measures are absolutely necessary.

- ... the **technologies for importing hydrogen** and the relevant derivatives are successfully scaled up.

In principle, the technology for importing and distributing hydrogen and its relevant derivatives is operational and already being used in different projects. However, it has not yet been scaled up. Currently, only one tanker for the large-scale transport of liquid hydrogen is operating worldwide, with a load capacity of 1250 m³ of strongly compressed hydrogen.⁶⁸ To master these diverse challenges, closer coordination between the technological demands and the research activities or offers as well as ongoing research funding are needed.

The hydrogen economy in the Metropolitan Region Northwest will gather momentum if...

- ... the region positions itself **internationally**.

It is necessary to think beyond national borders when creating import structures in order to make the energy transformation compatible for all involved parties worldwide – especially concerning the safeguarding of national resources in the export nations.

⁶⁶ <https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2021/07/20210713-erste-abschaetzungen-stromverbrauch-2030.html?view=renderNewsletterHtml>; accessed on 13.7.2021.

⁶⁷ ISL-position paper 2020: Wasserstoff – Logistik ist Schlüssel zum Erfolg der nationalen Wasserstoffstrategie.

⁶⁸ <https://de.wikipedia.org/wiki/Wasserstofftanker>; accessed on 8.9.2021

- ... players are **connected in a target-oriented manner**.

The Metropolitan Region Northwest is already supporting the outlined approaches through the target-oriented exchange of representatives from business and science. This exchange – especially between parties interested in projects and parties involved in projects – needs intensifying in order to ensure the coordination between the diverse projects. The Metropolitan Region Northwest's hydrogen work groups can, among other things, contribute to this goal.

- ... the **regional networks** manage to ensure the knowledge exchange between the players.

Businesses and industries that are willing to invest in the future technology hydrogen can currently hardly estimate their needs, ranging from financial support to the necessary specialists. Therefore, the regional players are working with high pressure in their networks to ensure the necessary flow of information and the mutual exchange of information in order to facilitate a basic orientation for these businesses. Already, the first fleet operators have been supported in calculating their hydrogen demands (amount, consumption, range) to facilitate a qualified calculation of costs and structured procedural planning.

- ... new and customised **concepts for apprenticeship and training offers can be successfully developed and implemented**.

The changed requirements for employee qualifications accompanying the energy transformation process are already being analysed by the

regional networks, business development programmes, or academic institutions in the Metropolitan Region Northwest. Regional players from the apprenticeship and training sector can prepare for this by developing new offers which will be optimised and custom-fit through qualified feedback from the economy.

- ... **regional demand in the mobility sector** is successfully quantified.

To transform the mobility/logistics sector, alternatives and additions to battery-powered electric mobility are needed. The players in the Metropolitan Region Northwest are working on quantifying the relevant demands in order to further push the market launch of hydrogen-based fuels. Aside from qualified cost estimates and well-structured procedural planning, this also creates the basis for identifying potential fuelling station sites. This knowledge regarding the regional demand facilitates the creation of a national hydrogen demand registry and thus a supra-regional or rather nationally coordinated approach to reach the climate goals that have been set.

- ... **land-use conflicts** can be communicated transparently and solved through dialogue.

Players who are planning and implementing the creation and operation of facilities along the hydrogen value chain are confronted with increasing land-use conflicts. The Metropolitan Region Northwest is aware of this challenge. It has been offering a communication and networking platform to the players for many years in the form of its different work groups and can support the coordination processes in this way.

- ... **acceptance in the general public** can be increased.

In the end, the energy transformation can only be successful if the regional players manage to include the people and increase the acceptance of hydrogen in the general public. To this end, transparent communication is needed that also considers – aside from the enormous chances a hydrogen economy offers – the resulting land-use conflicts, the changes in scenery, and the price increase of hydrogen-based products. The office of the Metropolitan Region Northwest can weigh in here with its experiences and expertise in the conception of transfer formats, marketing and PR instruments, and platforms for positioning and creating a good public image of the region.

6. What we have and what we want

In conclusion, we have...

- ... wind parks with an output of over 4,400 MW and an extensive potential of expansion capacities.
- ... all prerequisites to significantly contribute to the needed electrolysis output and to gradually expand it.
- ... condensed transmission grids to transport the regenerative electricity and to install the relevant electrolysis facilities.
- ... a well-established gas network as basis for the conversion and the addition of further hydrogen pipelines.
- ... the necessary caverns to store hydrogen and committed operators.
- ... seaports that are already preparing for the energy transformation through various projects and that are extraordinarily suitable for the upgrade necessary to import hydrogen and its derivatives.

- ... all necessary prerequisites to quickly solve the “hen and egg” problem in the transport sector and to expand the fuelling station infrastructure, thanks to the inland ports, the density of logistics specialists, the first running hydrogen trains, and the transport infrastructure.
- ... the networks, the clusters, the scientific expertise, and the industrial application that are necessary to accompany a market launch in a competent manner.
- ... the relevant governance structures to link all involved players, to create transparency, and thus to create the basis for a cooperation based on trust.
- ... highly motivated players who are working at high pressure to solve the challenges which arise along the value chain (see www.wasserstoff-region.de).

- ... four planned transnational important projects of joint European interest (IPCEI) with regional involvement: the project DRIBE2 at the Bremen steelworks, the project “Clean Hydrogen Coastline” for the realisation of hydrogen projects along the entire value chain, the research project WIPLiN for the use of liquid hydrogen in aviation, and the project HyPerLink for linking of import sources, production sites, large industrial consumption centres, and underground hydrogen storage facilities.

The regional players in the Metropolitan Region Northwest are aware of their responsibility to further expand these capacities and are driving these projects forward accordingly. The Metropolitan Region Northwest wants to constructively accompany and support these projects to the best of its abilities.

Our goals are...

- ... to become climate-neutral by 2045.
- ... to exclusively use green hydrogen from 2045 on.
- ... to use renewable energy as directly as possible to reach climate-neutrality in the transport sector.
- ... to reach the increase of renewable energies to 28%⁶⁹ that was decided upon by the federal government for the transport sector until 2030 and, if possible, to exceed it.
- ... to effectively utilise the existing regional capacities for expanding wind energy.
- ... to examine if generally functional existing infrastructures are up to (subsequent) use and to take up operation as quickly as possible.
- ... to expand the medium-term electrolysis output to 2 GW and thus significantly contribute to the national and Northern German expansion goals.
- ... to prepare the seaports for a high-volume import of hydrogen and its derivatives and thus contribute to closing the supply gap that results from the hydrogen demand and the planned production capacity of green hydrogen in the National Hydrogen Strategy until 2030.
- ... above all to think beyond national borders when creating import structures in order to make the energy transformation compatible for all involved parties worldwide.

Our approach is...

- ... to utilise established association structures, like for example the work groups of the

Metropolitan Region Northwest, to advance the linkage between project development and the relevant players on the county level on the one side and licencing and planning authorities on the other side and thus to support optimising the licencing practice.

- ... to increase societal acceptance through transfer formats, marketing and PR instruments, and platforms for positioning and creating a public image of the Metropolitan Region Northwest.
- ... to be available to interested players as their first contact point regarding the subject and to pass on their queries to the appropriate contacts.
- ... to link regional stakeholders for transfer events and projects and accompany them on this path.
- ... to focus on users with a short-term high hydrogen demand who are not yet using hydrogen on a large scale and therefore do not (yet) possess the technical prerequisites where industrial projects in the Metropolitan Region Northwest are concerned.
- ... to consider the users who can utilise by-products like waste heat and oxygen for industrial projects.
- ... to also include those industries in projects in which hydrogen can replace natural gas for the supply of high-temperature process heat.
- ... to constructively link and accompany projects and work groups that analyse the changed requirements for the qualification of employees, develop new apprenticeship and training programmes based on these results, and optimise these programmes based on qualified feedback from the economy.

⁶⁹ <https://www.bmu.de/pressemitteilung/schulze-wir-foerdern-kraftstoffe-die-das-klima-schuetzen-ohne-die-natur-zu-zerstoeren/>; accessed on 13.7.2021.



Notes

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Notes



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