

**Ministries of Economy and Transport
of the North German Coastal
States**

Bremen, Hamburg, Mecklenburg-Western Pomerania, Lower Saxony and Schleswig-Holstein



HYDROGEN STRATEGY FOR NORTH GERMANY

7 November 2019

Summary

The Hydrogen Strategy for North Germany is the result of close cooperation of a number of Federal States and of comprehensive and constructive involvement of active players from the areas of business, research and administration.

Unique characteristics of North Germany

Compared to other regions, North Germany features unparalleled locational advantages for establishing a 'green' hydrogen economy:

- great generating capacity for **onshore and offshore wind-generated electricity** with further expansion potential,
- **underground formations** for storing hydrogen,
- **seaports** whose import terminals are going to play a decisive role as logistics and business hubs, when it comes to importing and distributing green hydrogen and synthetic energy carriers, as well as for using hydrogen and exporting hydrogen-related technology and components,
- **maritime enterprises** and **scientific expertise**, as well as
- industry sectors with significant **experience in handling hydrogen**. Additional know-how is being generated in the six North German "Regulatory Sandboxes for the Energy Transition".

Based on their economic policy, the North German States are able to offer attractive location perspectives for local companies and companies willing to settle in the area, to ensure that value is created, and that high-quality jobs are preserved in the region and new ones are created. They are going to encourage innovation and economic growth and therefore strengthen North Germany as a business location. By establishing a green hydrogen economy, the States are thus also going to continue their existing ambitious economic policies.

North Germany strives for hydrogen economy by 2035

Planning provides for a green hydrogen economy to be established in North Germany by 2035, aiming to realise practically full supply coverage for all interested purchasers of green hydrogen.

The five North German States are going to launch a transformation process and to actively support Germany as a whole, when it comes to creating a level playing field for climate-neutral energy sources. Sustainable business models require competitive pricing for green hydrogen. For example through internalisation of external costs for fossil energy sources, a reform of state-induced electricity price mark-ups (SIP) and start-up funding in the form of subsidy programmes. Such measures will also allow for cost reductions due to scale effects for facilities that generate, distribute and use hydrogen.

At least 500 megawatts of electrolysis capacity for green hydrogen shall be installed in North Germany by 2025, and at least five gigawatts by 2030.

Planning provides for hydrogen hubs to serve as starting points for establishing a hydrogen economy in North Germany. These provide for the generation, distribution and use of hydrogen to be pooled (geographically), e.g. for the areas of mobility and industry. Regional basic supply of green hydrogen is therefore realised gradually, and this can be extended across the entire region in the medium-term.

North Germany's potential for renewable energy is not going to suffice for ensuring adequate supply of green hydrogen for mobility and industry in the future. It will therefore be necessary to import green hydrogen and other synthetic energy carriers. The North German seaports provide for ideal infrastructure for this purpose and are going to prepare accordingly.

A network of hydrogen refuelling stations shall be established in order to support hydrogen-powered mobility. These should ideally be multi-modal service stations that are readily accessible for various different modes of transport. Around 250 hydrogen refuelling stations could be necessary in the five North German States alone, to allow for adequate supply coverage.

North German States are taking on a pioneering role

The five North German States are going to draw up technology-neutral tendering proceedings for the area of procurement that allow for realistic opportunities for undertakings and projects based on green hydrogen.

For their state-owned vehicle fleets, the five North German States strive to cooperate to exceed the minimum quotas for sourcing clean road transport vehicles, stipulated in the Clean Vehicles Directive. Furthermore, the five North German States are going to review initiatives for using hydrogen-powered vehicles in municipalities and in public transport.

The North German States would like to support the establishment of a green hydrogen economy, by designing funding programmes in a manner that allows for know-how in the field of hydrogen technology and innovations to be developed; including, for example, operational programmes of the European Regional Development Fund (OP ERDF) 2021-2027. This is why the five North German States are going to strengthen networking and cooperation, in particular between the areas of business and research.

Exchange among the regulatory bodies of the different States and optimised approval processes are intended to contribute to speeding up the realisation of investments in facilities for the generation, distribution and use of hydrogen.

The five North German States are going to maintain close and constructive cooperation with their national and international neighbouring regions and the Association for the Establishment of a Hydrogen Economy.

Suitable structures for handling the outlined fields of action, are going to be built up in cooperation with stakeholders of the North German hydrogen industry. This process will be coordinated and promoted by a ministerial working group.

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1. Introduction

North Germany is not merely a particularly suitable location for establishing a self-sufficient hydrogen economy. The region also considers itself a driving force¹ of this process. Over the first few months after the publication of the “Key points for a North German hydrogen strategy” (May 2019), a number of Federal States and the national government have announced their own hydrogen strategies. The North German States would now like to shape the further process in cooperation with the relevant stakeholders, in particular from the areas of business, research and the municipalities.

The Hydrogen Strategy for North Germany is a clear statement that the establishment of a hydrogen economy is politically wanted in North Germany, and that planning provides for this to happen based on certain guidelines. The essential players involved in establishing a hydrogen economy are thus provided with orientation that is vital to upcoming investment decisions. A close exchange between the administration, public enterprises, the private sector and the area of research is vital to ensure that any important political decisions are made in line with the market and the latest state of technology. North Germany’s hydrogen networks are examples of first approaches to such cooperations. Planning provides for collaboration to be expanded and interlinked more effectively.

The Hydrogen Strategy for North Germany shall be considered a guideline for action for the North German States, both on the international and the national level with regard to the intended National Hydrogen Strategy (NSW, Nationale Strategie Wasserstoff). The strategy presented here, provides for a definition of the North German States’ common ground, highlighting the areas in which they can and want to become active together now, regardless of any obstacles that need to be overcome. Planning provides for cooperation and coordinated action in and for North Germany, where appropriate.

Under the umbrella of the Hydrogen Strategy for North Germany, there are still going to be state-specific and regional approaches. These include, for example, the specification of hydrogen strategies for the individual states, realisation of specific construction projects, or the initiation of additional funding programmes for hydrogen projects. This can and should give rise to constructive competition for the best ideas among the North German States. However, it is vital in this context that any competitive situations promote the vision of establishing a hydrogen economy in North Germany, and that North Germany as a whole will benefit. The Hydrogen Strategy for North Germany and the cooperation of relevant stakeholders that is based on it, shall remain the connecting element.

2. North German hydrogen strategy process

Please find below an outline of the development process for the Hydrogen Strategy for North Germany and the related stakeholder involvement to date.

2.1 History

On 26 November 2018, the Ministers and Senators of Economics and Transport of the five North German States decided to draw up a joint hydrogen strategy. In January 2019, a ministerial working group of representatives of the departments involved, took up work on a Hydrogen Strategy for North Germany and drew up a key issues paper as a first step.

During their “North German Conference” (KND) held on 2 May 2019, the government leaders of the five North German States expressed appreciation for the key issues paper for the Hydrogen Strategy for North Germany and asked for the strategy to be completed in time for the Conference of Ministers and Senators of Economics and Transport for the Coastal States held in Lübeck on 7 November 2019, and to report again at the next KND.

2.2 Involvement of stakeholders to date

Stakeholders involved in establishing a hydrogen economy come from a diverse range of backgrounds: companies (e.g. industrial, services, crafts businesses, transport), associations, networks, initiatives, science, other specialised departments (e.g. environment, energy, science, finance, education), further (partially) public bodies (e.g. procurement bodies, business developers, marketing companies, port management), as well as the interested general public.

The cross-state working group drew up a questionnaire, aiming to get as many North German players involved in the development process for the hydrogen strategy as possible. The questionnaire was sent to all known stakeholders in early July 2019. The recipients were also asked to pass on the questionnaire to any other stakeholders. Around 230 completed questionnaires arrived within the 4-week deadline. An initial excerpt of the analysis was provided to all participants.

Around 25 selected experts from the five States were invited to take part in in-depth discussions on the strategic issues of “Hydrogen in the industrial sector”, “Hydrogen provision”, and “Hydrogen in the area of mobility”, held in August 2019. Parts of the analysis of the questionnaires were presented in the workshops, and they were discussed, amended and developed further.

This strategy paper is a document by the Conference of Ministers and Senators of Economics and Transport for the Coastal States. It is based on the discussions with and input from stakeholders, in particular from the areas of business, research and other specialist departments. The comprehensive and qualified results of the questionnaire campaign and the in-depth workshops² have been used for devising and preparing the Hydrogen Strategy for North Germany, and they are reflected in the explanatory texts, the targets and the fields of action.

2.3 Joint future efforts

The North German States hope that the hydrogen stakeholders from North Germany will continue their contributions and commitment also for the further process of implementing the strategic targets. At the same time, the North German States are going to support the stakeholders, especially in the area of business, by clearly promoting the establishment of a hydrogen economy via the strategy presented in this document, by defining political goals, and by promoting favourable general conditions. A hydrogen economy cannot be established successfully without coordinated involvement of all players affected.

This strategy outlines the first implementation steps in four fields of action, as well as rough timelines (see Appendix 1):

- Field of action “Hydrogen infrastructure”,
- Field of action “Creating value with hydrogen”,
- Field of action “Hydrogen in guidelines, licensing practice and programmes”,
- Field of action “Hydrogen acceptance and education”.

² scheduled for online publication soon after 7 Nov. 2019.

The North German States and interested stakeholders from the areas of business and research shall cooperate to identify suitable structures for addressing these fields of action. These future structures should have manageable dimensions and be staffed in a manner that is well-balanced and a good match for the tasks that arise due to the fields of action on the one hand, and the competences of the North German hydrogen players on the other hand. Particular emphasis should be placed on using any existing work structures (e.g. in networks, specialist working groups, metropolitan regions) and building upon them if possible. Duplicate structures should be avoided as far as possible, and synergies should be exploited instead.

The cross-state ministerial working group (“North German Hydrogen Coordination Group” in the future) is going to organise and moderate the process of creating suitable working structures. Please refer to the chapter “Networking and cooperation within North Germany” and Appendix 2 for further details.

3. Hydrogen – now and in the future

The North German States are committed to global and national climate goals. The internationally recognised climate goals require that global warming is limited to significantly less than two degrees. To achieve this, greenhouse gas emissions must be sustainably reduced and the energy transition must be realised across all sectors (electricity, mobility, industry, households). Further challenges for our current business practice and lifestyle, in particular in urban areas, include air and noise pollution, as well as demands regarding a sustainable use of resources.

3.1 Green hydrogen is vital for reaching climate goals

Outside the electricity sector, the share of renewable energies has been stagnating for a few years now. A substitution of fossil energy sources with hydrogen that is generated from renewable energy sources (subsequently referred to as ‘green hydrogen’³) or synthetic energy carriers based on green hydrogen, provides for the option to realise the energy transition in sectors in which an approach based on direct electrification is difficult for technical or financial reasons. It has been found in various current studies⁴ that a significant part of overall greenhouse gas emissions cannot be avoided by using electricity, but that green hydrogen or energy carriers based thereon are needed. Furthermore, electrolytic hydrogen production is also a flexibility option that can be used to stabilise electricity networks and to reduce temporary grid bottlenecks.

3.2 Hydrogen technology is mature

Using hydrogen does not mean that entirely new territory is entered. Hydrogen has long played an important role as a raw material and process gas used in industrial applications, such as in fertiliser production, refinery processes or in the chemical industry. Hydrogen generated from fossil natural gas (e.g. by means of steam reforming) or that arises as a by-product in other

³ To allow for easier readability, hydrogen generated using renewable energies is referred to as ‘green hydrogen’ in this document.

⁴ e.g. *dena (Deutsche Energie-Agentur, German Energy Agency)*, integrated energy transition pilot study. Impulses for designing the energy system until 2050, 2018, *EFI (Expertenkommission Forschung und Innovation, Expert Commission Research and Innovation)*, expert report 2019. Expert report about Germany’s research, innovation and technological capacity, 2019, *BCG / prognos (on behalf of BDI The Voice of German Industry)*, Climate paths for Germany, 2018.

industrial processes (e.g. chlorine-alkali electrolysis) is currently used in most industrial applications. In addition to this, the production of hydrogen by means of electrolytic splitting of water is a technologically mature process, also when based on renewable energies.

3.3 Possible future applications

What is new, on the other hand, are the currently discussed further possible uses for green hydrogen in the context of the energy transition, and the use of electricity for hydrogen electrolysis, performed in a way that is as compatible with the grids as possible (as switchable/interruptible loads). Green hydrogen is very versatile, also from a purely technical point of view:

- for example as a substitute for the fossil-based hydrogen that has been used to date, and
- for direct use (power-to-hydrogen) in applications in which hydrogen is not used at the moment, such as in mobility, in industrial processes (such as steel production), fuel cell heating systems, for system integration of electricity and heat in the area of building technology, for long-term electricity storage and reconversion.
- Green hydrogen can also be used for the synthesis of further energy carriers, fuels or other chemical compounds (power-to-gas, power-to-liquid, power-to-chemicals) that are each associated with a wide range of possible uses.

The use of hydrogen fuel cells, for example in buses, passenger cars, trucks or trains, does not only allow for a reduction of emissions of air pollutants and noise compared to conventional combustion engines. Based on the current state of technology, these drive systems also feature advantages compared to purely battery-powered electric vehicles, when it comes to their reach and the duration of the refuelling process. This makes hydrogen drive systems particularly suitable also for passenger transport, for example in taxis, rental cars or for the new car pooling schemes.

3.4 Hydrogen infrastructure required

To cater for the new hydrogen-powered applications, significantly greater quantities of hydrogen will need to be produced in the future, using renewable electricity. Furthermore, hydrogen needs to be stored, transported and distributed, and corresponding processing options and related services (e.g. project planning, funding, maintenance) are also needed. Technical solutions for each of these issues exist. Hydrogen is currently the subject of intensive research, which means that further innovations are to be expected. To exploit the full potential of green hydrogen, it is necessary to establish an entire value creation chain: a green hydrogen economy, i.e. from producing renewable electricity, via the transformation into green hydrogen and further synthetic fuels derived thereof, including the creation of facilities and components, through to marketing and regional use of hydrogen and its derivatives. In the dena pilot study⁵, an electrolysis capacity of 15 gigawatts is assumed for Germany in 2030, and it is stated that the “corresponding development must start in a timely manner.”

3.5 Hydrogen as an economic policy opportunity

If the existing obstacles can be overcome, this will give rise to new attractive economic opportunities for the region, along with qualified employment opportunities. The creation of a value creation chain is an important incentive with regard to growth and structural policy, especially for regions in North Germany whose industrial structure is not particularly pronounced to date, and that are thus encouraged to promote the establishment of a green hydrogen economy. The move into a hydrogen economy would furthermore enable German manufacturers to gain a technological advantage in the area of

⁵ dena (Deutsche Energie-Agentur, German Energy Agency), integrated energy transition pilot study. Impulses for designing the energy system until 2050, 2018.

hydrogen / electrolysis, and to roll out industrial production in Germany, for example of facility technology.

Establishing a green hydrogen economy has not only an important ecological dimension (energy transition, climate protection, keeping the air clean, reducing noise), but there is also an economic side (value creation, safeguarding the location, company profits, tax income) and a social dimension (workplaces). The endeavour can thus be considered an example of a 'green economy' and of holistic realisation of the energy transition, and it therefore contributes to achieving the UN sustainability objectives.

4. North Germany as a predestined region

The five North German States are united by their political willingness to establish a hydrogen economy, as they feature extremely favourable local conditions that cannot be found anywhere else in Germany.

4.1 The five North German States – about us

Each of the North German States – Bremen, Hamburg, Mecklenburg-Western Pomerania, Lower Saxony and Schleswig-Holstein – features very specific local advantages that ideally complement each other when considered as a whole.

4.1.1 Free Hanseatic City of Bremen

“The State of Bremen is going to cooperate with the other coastal states to look intensively into the technology for using excess wind-generated electricity for generating hydrogen, and to therefore advance an important competence area of the energy transition [...].”

“The use of hydrogen as a medium for energy storage is an important pillar of sector coupling, and it opens up promising future markets for Bremen and Bremerhaven.”



Excerpt from the coalition agreement for the 20th legislative period of Bremen's State Parliament 2019 – 2023

While Bremen is the smallest of the federal states, with a size of 419 square kilometres and 683,000 inhabitants, it is the state with the highest export rate and it features a high industrial share. The biggest industry sector is vehicle construction with cars, ships, planes and spacecrafts, including rocket stages. Further broad international know-how can be found in the maritime industries and the logistics sector, as well as the wind energy industry, and the food and beverage sector. The ports of Bremerhaven and Bremen are hubs of Bremen's economy and they characterise the identity of the twin-city state. Issues surrounding renewable energies, and increasingly also the hydrogen economy and sector coupling, have long been addressed in research conducted at the State's universities and research institutes.

Potential for producing and using hydrogen is going to develop in new commercial estates that are to be developed and established in Bremen and Bremerhaven, in particular in the planned sustainable commercial estate Lune Delta. Further promising connecting points are provided by the industrial sector, including the steel plant as the largest energy consumer and the wide range of vehicle construction facilities. In addition to this, the locations of the coal-fired power plants that – according to the coalition agreement – are to be taken out of service by 2023, might offer good conditions for

producing and storing hydrogen, thanks to their existing electricity and heat networks. All of these aspects suggest that the State of Bremen can take on a key role in the context of the upcoming energy transition, in particular with regard to the production and use of green hydrogen and the establishment of a hydrogen economy.

4.1.2 Free and Hanseatic City of Hamburg

“Hydrogen offers great opportunities for Hamburg as a major hub of industry and transport in the North, when it comes to a further strengthening of our city’s economic capacity and quality of life. Thanks to growing demand for green hydrogen in Hamburg, we can contribute to scale effects from which the entire energy region of North Germany can benefit.”



Michael Westhagemann
Senator for Economy, Transport and Innovation

As the biggest metropolis in North Germany, Hamburg is facing particular challenges with regard to climate protection and a sustainable safeguarding of the city’s economic capacity. This includes a reduction of traffic-related emissions, e.g. by using emission-free drive systems, and the orientation of the industrial sector towards products that will continue to be competitive and in demand, even after fossil energy and raw materials have been given up as is politically wanted and ecologically necessary. To ensure that Hamburg will continue to be a sustainable business location and urban living environment in the future, the issue to secure sufficient supply of emission-free energy from renewable sources that is required for mobility and the industrial sector, must be addressed systematically and in a timely manner.

Owing to the fact that the options to produce and store green energy in Hamburg are limited, due to its structure as a city state and its urban density, Hamburg must source its green energy largely in the surrounding region, both now and in the future. North Germany is a major producer of green energy, and this gives rise to a market that is ideal for cooperation between the metropolis and its surrounding region. This is true not only for purchasing renewable energy. The conversion of excess wind-generated electricity into hydrogen and its use in the industry, contributes to a stabilisation of grids and an increase of value creation, especially in Hamburg. However, it is necessary in this context that hydrogen is provided at an appropriate price. Increasing demand in Hamburg on the other hand, provides for the required economic scale effects.

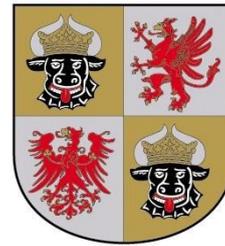
Hamburg already has several years of experience in using hydrogen-based technology, for example for producing green hydrogen, using fuel cell-powered buses, and in the use of hydrogen in industrial processes. Based on this learning curve and taking the increasing climate protection requirements into account, there is now a growing willingness among commercial enterprises as well as public service providers to introduce green hydrogen when developing their processes and offerings further. Various energy research projects about hydrogen technologies and related issues are currently being conducted in Hamburg. The findings of these projects are going to provide important contributions to the establishment and further development of a hydrogen economy. For a number of decades now, Hamburg has been able to build upon a diverse and highly committed array of stakeholders in the area of hydrogen. Activities have been pooled and structured

by the Senate, in the form of a cross-cluster initiative. When preparing the Hydrogen Strategy for North Germany, Hamburg has therefore been able to draw upon comprehensive expertise that will also be used for the further implementation process and the operationalisation for Hamburg and North Germany as a whole.

Furthermore, this transformation process is supported by Hamburg's Senate that is dedicated to drawing up, implementing and developing the Hydrogen Strategy for North Germany, and provides further assistance through political guidelines, such as the obligation to procure emission-free public service buses from 2020.

4.1.3 Mecklenburg-Western Pomerania

“Comprehensive sector coupling is necessary for a successful energy transition. Green hydrogen is a key element for long-term storage of the renewable electricity produced in our state, and for making it usable for other sectors. The establishment of a green hydrogen economy is an economic and structural opportunity for the coastal states and especially for Mecklenburg-Western Pomerania. We want to grasp this opportunity and to quickly advance and implement the hydrogen strategy.”



Christian Pegel
Minister of Energy, Infrastructure and Digitalization

Mecklenburg-Western Pomerania offers ideal natural conditions for generating electricity from renewable energy. In 2013, Mecklenburg-Western Pomerania was the first Federal State that reached full calculative coverage of its electricity needs with renewable energies. However, simply producing electricity is not enough. Storage options are necessary to compensate for its volatility.

In addition to this, we also want to use the opportunity of the energy transition for realising a mobility and heat revolution, and to promote an interconnection of the traffic, heat and electricity sectors. Sector coupling paves the way for an integration of economic growth and climate protection, and for realising the energy transition in a holistic manner.

Hydrogen can help to make both of these endeavours a success: storing renewable electricity and to thus compensate for natural fluctuation, as well as using renewable electricity also for transport and heat applications. Another central goal of the energy transition in Mecklenburg-Western Pomerania is to intensify the use of locally produced electricity.

Mecklenburg-Western Pomerania features a diverse spectrum of players in the hydrogen economy, even now. In addition to technology manufacturers (electrolysis/fuel cells) and potential users (such as public transport, maritime mobility), there is also significant research competence.

Mecklenburg-Western Pomerania is in particular committed to ensuring that the currently difficult economic conditions for hydrogen projects are improved. Measures to date include the presentation of specific proposals for amendments to legislation. These are intended to facilitate sector coupling projects based on experimentation clauses.

With the Hydrogen Strategy for North Germany, the State of Mecklenburg-Western Pomerania cooperates with the other North German States to commit to hydrogen as a technology of the future. A joint hydrogen strategy is intended to pool the powers available in North Germany and to promote extensive use of hydrogen-based technologies.

4.1.4 Lower Saxony

“Together with the other North German States, Lower Saxony has the potential to become the leading region of a green hydrogen economy. We have the very potential that is needed for taking on a leading role: we have a high electricity production output based on renewable energies, the necessary infrastructure for hydrogen storage, transport and distribution, and a wide range of possible uses in the areas of energy, mobility and industry. These are the strengths that we are going to contribute for establishing a North German hydrogen region.”



Dr. Bernd Althusmann
Minister of Economic Affairs, Employment, Transport and Digitalisation

Covering just under 48,000 square kilometres, Lower Saxony is home to around 7.9 million people. This makes Lower Saxony the second biggest Federal State by surface size and the fourth biggest one by number of inhabitants. The five biggest industrial sectors are vehicle construction, the foodstuffs industry, mechanical engineering, the chemical industry, as well as the rubber and plastic industry.

More than 60 % of electricity consumption are on average covered with renewable energy. In some regions, such as north-western Lower Saxony, this share is even far above 100 %.

With its high production output of electricity generated using renewable energies (for producing green hydrogen), its ports (for future hydrogen import), the existing transport and storage infrastructure (for liquid and gaseous substances), its research landscape and wide range of companies, networks and active regions, Lower Saxony is already in an excellent position for taking on a national and European leadership role in developing a hydrogen economy, along with the other North German States.

Some industrial sectors (e.g. refineries, chemical industry, steel industry) already possess comprehensive knowledge and experience in handling hydrogen. The world's first passenger train powered by a hydrogen fuel cell was developed in Lower Saxony, where it is used for regular scheduled services. A high-temperature electrolysis facility has been set up, in which hydrogen is produced using the waste heat of a steel mill. Planning provides for a facility for direct reduction of iron ore using hydrogen to be constructed in the next step. Furthermore, a drive system for waste collection and road sweeping vehicles has been developed, in which battery and fuel cell technologies are combined, and the specific requirements of waste collection are taken into account.

There continues to be great interest in advancing the issue of a hydrogen economy. A total of 22 projects from Lower Saxony have been submitted for the federal “Regulatory Sandboxes for the Energy Transition” programme alone, 16 of which are related to hydrogen/sector coupling. 25 regions have expressed their interest in the HyStarter programme.

The issue of hydrogen is also promoted in the political sphere. The current coalition agreement of the state government includes statements regarding hydrogen with regard to rail vehicles, electric mobility, fuel station infrastructure and general regulatory conditions. Advancement of the energy transition is intended to be used to make Lower Saxony more competitive, especially in the European Union, and to generate new growth opportunities.

4.1.5 Schleswig-Holstein

“Despite the fact that there is now a widespread consensus that the energy system cannot be converted without hydrogen, there are currently no decisive impulses from the federal government, for truly advancing the issue. This is why we have now decided to stop waiting for the federal government, and for the coastal states to move ahead.”



Dr. Bernd Buchholz
Minister of Economic Affairs, Transport, Employment, Technology and Tourism for
Schleswig-Holstein

Schleswig-Holstein shares borders with Denmark, Mecklenburg-Western Pomerania, Hamburg and Lower Saxony and is located between the Baltic Sea and the North Sea. Schleswig-Holstein has around 2.9 million inhabitants and a surface size of around 15,800 square kilometres.

Wind energy plays an important role, owing to the State’s geographic location. Wind energy facilities with a capacity of around 6.7 gigawatts onshore and around 1.8 gigawatts offshore are currently connected to Schleswig-Holstein’s electricity network. A total capacity of more than ten gigawatts is installed, along with photovoltaic and biomass systems. Planning provides for the onshore wind energy plants to be expanded to ten gigawatts by 2025. In 2017, renewable energy accounted for a share of 156.6 percent of Schleswig-Holstein’s gross electricity consumption.

Various medium-sized companies and facility producers have settled in Schleswig-Holstein, in order to offer products and services to facilitate a successful energy transition. Current focus areas include sector coupling, the integration of new technologies into the energy system, e.g. green hydrogen and synthetic fuels, electro mobility, digitisation of the energy industry, energy efficiency and energy storage.

A range of federally-funded projects regarding sector coupling and the use of hydrogen are proof of the innovative capacity of enterprises in Schleswig-Holstein. Most recently this could be seen from the successful submission of projects from Schleswig-Holstein in the ideas competition “Regulatory Sandboxes for the Energy Transition”. With their scientific expertise, the state’s universities and scientific research facilities contribute to a successful energy transition.

The Ministry of Education, Science and Cultural Affairs (MBWK), the Ministry of Energy, Agriculture, the Environment, Nature and Digitalization (MELUND), and the Ministry of Economic Affairs, Transport

Employment, Technology and Tourism (MWWATT) strive for a better interconnection of the various research activities, aiming to sharpen Schleswig-Holstein's scientific profile in the area of energy transition research. Their common goal is high-performance energy transition research for Schleswig-Holstein that is perceptible nationwide, and that substantially contributes to the issues of climate protection, advancement of the energy transition, and to strengthening the area as a business and research location.

Energy transition research in Schleswig-Holstein is intended to produce solutions that address specific macrosocial challenges in the context of a networked European energy transition. In addition to this, application options for renewable energies with potential for creating value and jobs for Schleswig-Holstein are to be highlighted. Stand-alone solutions are not desirable, but the individual endeavours are to be integrated systematically into a cross-sector energy transition.

4.2 Unique characteristics of North Germany – what makes us special

For the sake of a sustainable development, established structures and existing locational advantages should be used for establishing a green hydrogen economy and for an efficient realisation of the energy transition. North Germany is prepared to take on a pioneering role in establishing a green hydrogen economy.

With its large share of electricity from renewable sources, North Germany already contributes to achieving the objectives of the energy transition, more than any other German region. This also provides for the requirements for the next transformation step of sector coupling. The aim of this step is to largely abolish fossil fuels in sectors such as mobility and the industry, by using hydrogen as a storage medium, raw material, energy carrier and for drive energy. The required location conditions are pooled in North Germany to an unparalleled degree.

4.2.1 Reliable offshore wind power

There is already a large number of offshore wind farms in the constantly windy coastal waters. Great potential for further expansion has been identified in this area. The North German coasts are home to the landfall points for offshore wind energy as a source for green hydrogen. Thanks to the large number of annual operating hours of offshore wind turbines that may be combined with photovoltaics field facilities on the coast, conditions are particularly favourable here in the North for achieving a high level of utilisation for electrolysis units, and as a result for lower production costs for green hydrogen.

4.2.2 Underground storage formations

The geological conditions on the North German Plain are unique in Europe, when it comes to temporary large-volume storage of hydrogen in caverns. In theory, all caverns in Germany (when converted for hydrogen) have a total storage capacity of around 28 terawatt hours⁶. This corresponds to the amount of energy used in Germany in around three days⁷. This means that North Germany features ideal conditions for becoming Europe's climate-neutral energy reservoir. The North German caverns can be gradually converted in line with demand or be newly developed.

4.2.3 Seaports as logistics and business hubs

The German seaports are available in the near term for use as logistics centres for the provision and import or export of hydrogen,

⁶ Energy research centre for Lower Saxony (Energie-Forschungszentrum Niedersachsen), study "Suitability of storage technologies for maintaining system reliability". FA 43/12 final report, 8 March 2013.

⁷ Own calculations based on *Arbeitsgemeinschaft Energiebilanzen e. V.* (working group for energy balances), Energy consumption in Germany in 2018, as of: February 2019.

as well as for fuels made from it. As intersections between maritime and inland shipping on the one hand, and rail and road transport on the other hand, ports play an important role in the transport sector. They are places where different modes of transport converge and benefit from each other (combined transport). Ports and their surrounding areas are also home to a concentration of industrial and commercial businesses. Ports are the structural key element that links the North German States.

4.2.4 Many years of industry experience and commitment

North Germany is an important industry location, for example of the chemical industry, refineries and metallurgy. The use of hydrogen in industrial processes is part of the day-to-day business here. The corresponding infrastructure (e.g. for producing, storing and distributing hydrogen) and comprehensive knowledge and experience regarding the safe handling of hydrogen technology already exist, as a result. Local industrial companies have been committed to the issue of hydrogen for many years, both on the supply and the demand side of the market. These companies form a solid foundation for a working and expandable market in a large-scale hydrogen economy.

4.2.5 Six “Regulatory Sandboxes for the Energy Transition”

Projects aiming to practically test and evaluate suitable technical, legal and economic conditions are an important entry point into a comprehensive hydrogen economy. Based on this notion, the Federal Ministry for Economic Affairs and Energy has selected a number of projects from North Germany for funding⁸, as part of the “Regulatory Sandboxes for the Energy Transition” competition:

- *North German Regulatory Sandbox*, Hamburg, Mecklenburg-Western Pomerania, Schleswig-Holstein – sector coupling and hydrogen
- *Regulatory Sandbox West Coast 100*, Heide (SH) – production of hydrogen and synthetic fuels
- *DOW Stade Green MeOH*, Stade (NI) – generation of green methanol
- *CCU P2C Salzbergen* (NI) – systematic sector coupling in the area of chemistry
- *Element Eins*, north-western Lower Saxony – production of synthetic gas
- *IW3*, Hamburg – energy-optimised districts

The fact that six out of ten chosen endeavours located outside the regions that are subject to structural change, are planned in North Germany, highlights the region’s significance with regard to the energy transition and sector coupling, also from a national perspective.

4.3 Further favourable location factors – other things we have to offer In addition to the unique characteristics outlined above, North Germany features many other favourable location conditions. These include:

- a growing number of **operators** of wind turbines that do not qualify for EEG support, who come here for new market opportunities for their renewable electricity (development of business models based on Power Purchase Agreements, PPA),
- various operators of virtual power plants and direct sellers who come here looking for alternatives to the electricity stock market at low electricity costs,
- a hydrogen pipeline and well-developed natural gas grid infrastructure, allowing for hydrogen transport,

⁸ see map of Germany <https://www.bmwi.de/Redaktion/DE/Downloads/P-R/reallabore-der-energiegewende-karte.pdf?blob=publicationFile&v=8> and project summaries <https://www.bmwi.de/Redaktion/DE/Downloads/P-R/reallabore-der-energiegewende-gewinner-ideenwettbewerb-steckbriefe.pdf?blob=publication-File&v=7>, [27 Sept. 2019].

- logistics facilities, as well as vehicle, plane and ship construction facilities that can become relevant as users of hydrogen and / or electricity-based fuels directly or through their products,
- a certain level of experience in using green hydrogen in the area of mobility,
- a growing number of potential buyers who are interested in green hydrogen, and many other stakeholders, e.g. from the areas of electricity generation, hydrogen production, transport, temporary storage, project planning, funding,
- numerous research facilities that conduct intensive work, addressing hydrogen from various different angles,
- established and successful business clusters and networks that deal with issues related to hydrogen and whose structures and existing results can be built upon,
- an innovation-friendly climate with many innovative companies,
- initial funding options for hydrogen production and hydrogen-based applications,
- many individual endeavours at different levels of a hydrogen value creation chain, such as the world's first hydrogen fuel cell-powered train and flexible PEM electrolysis systems,
- established multi-state cooperation, especially regarding the subject of hydrogen,
- political willingness to support these technologies across different states and departments.

The Hydrogen Strategy for North Germany is designed to further intensify the cooperation among the North German states.

5. Obstacles on the path towards a green hydrogen economy

While a green hydrogen economy is a key element of an inter-sectoral energy transition, the related technology is not used on a large industrial scale at this point. Research and development of hydrogen technology have been advanced extensively. A significant increase of efficiency has, for example, been achieved for the individual steps of energy transformation. It has been shown in many demonstration projects that generation of hydrogen and methane (power-to-hydrogen / power-to-gas) using renewable electricity is technically feasible. However, for the time being, no large-scale production is taking place and there is no wide market penetration of hydrogen and the related power-to-x technologies.

There is a number of reasons for this. The list below is not intended to be exhaustive. It was drawn up based, among other information, on feedback provided by private stakeholders in the context of the questionnaire campaign and the expert workshops. There are various other challenges that must be met on the path towards a large-scale hydrogen economy.

5.1 Lack of a level playing field

The fundamental reason for the lack of a development towards wide market penetration is the fact that there are currently no economically viable business models for generating and using green hydrogen. In the mobility, heat and industrial sectors, hydrogen from renewable electricity must compete with conventionally produced hydrogen and other energy carriers. Green hydrogen produced under the current conditions, is not competitive compared to these alternatives, and it has therefore not been possible to generate relevant demand to date.

A particularly disadvantageous aspect is the fact that power-to-gas facilities currently have to bear almost the full amount of any incidental expenses, such as taxes, levies and charges. The resulting high operating and therefore production costs for electricity-based hydrogen give rise to systematic market disadvantages when competing with conventionally produced hydrogen and fossil heating and motor fuels. This situation is far from a level playing field.

Investments into hydrogen production are not attractive as a result. Demand for facilities and components is accordingly low, and the still very high unit prices do not decrease. Both investment costs and operating costs for producing green hydrogen have a prohibitive effect on the development of viable business models.

5.2 Incomplete internalisation of external costs

Another systemic problem that exists on the EU level, is the currently still incomplete internalisation of external costs. This gives rise to distortions and to the fact that environmentally disadvantageous products and processes are often more affordable than environment-friendly alternatives such as green hydrogen.

5.3 Lack of incentives

Furthermore, the rewards for using environmentally beneficial products and processes are not sufficient. Such incentives could include: consideration of CO₂ reductions in the upstream chain and corresponding creditability towards climate and environmental targets that are in place, or (financial) privileges for low-emission vehicles within existing systems (taxes, charges, user fees/road charges, driving restrictions). Higher prices combined with a lack of incentives lead to a lower demand for environment-friendly alternatives, they fail to penetrate the market, technology innovations are not granted the opportunity to mature in the market, and are thus unable to unfold their full potential with regard to climate and environmental protection.

5.4 Insufficient funding options

Potential project sponsors criticise the existing funding landscape for being not flexible enough, or not compatible with hydrogen projects. Measures that are considered desirable and necessary include start-up funding, adequate compensation for operational expenses (OPEX), or a market incentive programme for generating green hydrogen and for using hydrogen in general. Funding programmes should cover the use of green hydrogen both in the transport sector and the industrial sector, also and in particular in large enterprises, where the leverage effect of using green hydrogen is especially high. Projects on an industrial scale (generation and use) should receive particular support, as there is still a lack of facilities and related experience and scale effects. The supported projects will later have to continue their operations, fitting in and competing in the market, and better economic conditions are required for this purpose.

5.5 Expansion of renewable energy capacities capped

On a national level it could be observed so far that the approach of the energy transition has been based largely on the electricity sector and direct electricity-based applications. However, at this point power transmission capacities do not suffice for transporting renewable electricity from the generation centres in the North to the major consumption centres in the West and South of Germany. The expansion of renewable electricity generation capacities has therefore been capped by law. This applies in particular for the network expansion area in North Germany, despite the fact that potential for using wind energy is especially high here. Industrial electrolytic production of green hydrogen provides for the opportunity to put renewable energy to good use, even while the required electricity network

capacities are being developed, for example in mobility and the industrial sector. The development limit for renewable energies⁹ that is currently still in place, therefore inhibits that climate goals are reached, not only in the electricity sector but especially in other sectors. This is detrimental to a holistic energy transition.

5.6 Insufficient system integration

The future role of hydrogen as a key element for realising the energy transition and for achieving the climate protection goals, has so far not been sufficiently taken into account in a cross-system approach. This is detrimental to the necessary sector coupling. A planning scenario for the electricity network development plan has been drawn up, based on a joint approach to electricity and gas infrastructure planning. The existing technical rules regarding blending rates for hydrogen in the gas infrastructure need to be adjusted accordingly.

5.7 Insufficient commitment of public authorities

Private stakeholders demand that politicians and public administration should show greater dedication and visible commitment to hydrogen-based technology. Binding political guidelines and targets need to be specified, e.g. in the form of a hydrogen strategy. This is considered an important signal to allow for long-term planning security for investments. The public sector should also lead by example, for example by sourcing hydrogen-powered vehicles for public fleets or public transport.

6. Hydrogen mission statement for North Germany

The North German States believe that establishing a hydrogen economy provides for considerable opportunities, but the obstacles outlined above are considered to be serious. At the same time, North Germany is currently characterised by an optimistic mood that feels encouraging and suggests that now is the time to embark on this journey.

The Hydrogen Strategy for North Germany is based on the following **mission statement**.

6.1 Our motivation – why we are looking into hydrogen

1. In line with the decisions taken in Paris, the North German States strive for greenhouse gas emissions to be reduced as far as possible in all sectors. – Green hydrogen can help to achieve the climate goals, especially in the industrial and mobility sector.
2. The North German States aim to enable that the entire amount of renewable electricity generated in North Germany (including the part that is currently limited) can be used in an economically useful way. – The production of green hydrogen can make energy quantities that cannot be fed into the electricity network usable, or suitable for long-term storage.
3. The North German States strive for a use of renewable heat and electricity that is as direct as possible, in order to reduce greenhouse gas emissions, as the share of usable energy is reduced with every transformation step. However, there are many areas of application, in which direct substitution with renewable electricity or heat is not expedient. – Green hydrogen made using renewable electricity, or synthetic energy carriers made using green hydrogen, can be suitable alternatives in such cases.
4. With their economic policy, the North German States would like to offer attractive perspectives for local companies and those wishing to relocate, to maintain and create value and high-quality jobs in the region, to provide incentives for innovation and economic growth, and to thus strengthen North Germany as a business location. – The establishment of a green hydrogen economy fulfils all criteria of this type of economic policy.

⁹Raising the offshore cap and removing the PV cap in the context of the federal government's climate protection package are good first steps.

5. The North German States consider the establishment of a green hydrogen economy an expedient endeavour, especially where locational conditions are particularly favourable. – North Germany possesses all necessary economic-geographic requirements for establishing a full value creation chain for a green hydrogen economy in a particularly efficient manner.

6.2 Our vision – what we want to achieve

6. The North German States think of green hydrogen as a vital element to a comprehensive energy transition, for stabilising the overall energy system that is based on fluctuating, renewable sources, as well as for a climate-friendly transformation of mobility and a number of industrial processes.
7. The North German States further understand the entry into a green hydrogen economy as an economic and structural opportunity that should be swiftly grasped, and resolutely turned into sustainable economic growth in line with a 'green economy'. This also involves that the competitiveness of North Germany as an industrial location must be reinforced both within Germany and on an international level.
8. The North German States want to make use of their favourable locational conditions to generate a comparative locational advantage for North Germany, by initiating the establishment of a green hydrogen economy now.
9. Planning provides for North Germany to be established and stabilised as the leading German region of a green hydrogen economy, featuring a full value creation chain. Cooperation with neighbouring regions in Germany and Europe is desired in this context.
10. The North German States want to initiate and shape a transformation process, the result of which should ideally allow for current and future demand for hydrogen in North Germany to be fully catered for with green hydrogen.

6.3 Our tasks – how we would like to approach our vision

11. In order to start this transformation process, the North German States want to actively support the federal government in creating a level playing field for all energy sources, allowing for sustainable business models to be developed also for green hydrogen right from the start, and counteracting any uncertainties with regard to the provision of the required quantities of green hydrogen early on. This is the only way to create a demand pull that allows for cost reductions, which may give rise to competitive prices for green hydrogen.
12. The North German States consider the further expansion of capacities for generating renewable electricity a top priority, to ensure that sufficient amounts of hydrogen can be produced, also for future applications. It is feasible in this context, that additional capacity could be created that is not fed solely into the network, but is intended for the production of green hydrogen.
13. The North German States strive to realise the first visible steps towards a green hydrogen economy by 2025, especially in the areas of stakeholder networking, the construction of technical facilities, as well as progress regarding competitive business models.
14. The North German States want to promote the establishment of a competitive green hydrogen economy, based around the hydrogen hubs in which the generation, temporary storage, distribution and use are geographically concentrated.
15. The North German States think of themselves as drivers of the transformation process towards a green hydrogen economy. Using the available control elements, the relevant public players from North Germany want to take on a leading role, when it comes to establishing hydrogen applications, especially in the field of mobility.

This mission statement reflects the current status of discussions, and will be open to any necessary future adjustments.

7. Establishing a North German hydrogen economy – first steps

Target

A green hydrogen economy shall be established in North Germany by 2035, providing for virtually full supply for all interested buyers of green hydrogen.

The overall objective of this strategy is to have established a green hydrogen economy in North Germany by 2035 – provided that the obstacles described above are removed by the federal government in a timely manner. For this purpose, the share of green hydrogen of the total amount of hydrogen, used should gradually be increased, ideally up to a hundred percent. The identified targets are intentionally very ambitious, in order to send a strong political signal for North

Germany, and to underline the aspiration to take on a pioneering role. They are also intended to provide investors with the indication of direction they need, and therefore with planning security.

The first few steps towards these goals are outlined below. No measures are described. On the one hand, these will be drawn up in close coordination with all stakeholders in the context of the fields of action. On the other hand, the progress of establishing a hydrogen economy depends strongly on the course set on the national level, as explained above in the section about obstacles. This strategy with its targets and first steps reflects the current situation. It is subject to ongoing reviews and further development, aiming to adjust it to the circumstances at the time. This is a work in progress.

As a basis for further actions, the current status for North Germany shall be identified in a number of key areas, and be compiled to illustrate the status quo. These areas include the current demand quantities of hydrogen used for industrial uses and mobility, local producers in the area of hydrogen technologies, North German hydrogen funding programmes, curriculum content on the subject of hydrogen, as well as active local networks and other groups in the area of hydrogen (see Appendix 2).

Planning provides for so-called hydrogen hubs to serve as starting points for establishing a hydrogen economy in North Germany. These are the places where the identified strategic high-priority axes are geographically pooled: the supply side of hydrogen provision including generation and distribution infrastructure, and the demand sides of mobility and the industry. The hydrogen hubs are expected to expand over time and to become interconnected, ultimately providing for supply for North Germany that is as comprehensive as possible, and allows for all interested buyers to be supplied with hydrogen. This should result in the establishment of an ideally complete hydrogen value creation chain for North Germany.

7.1 Starting point: hydrogen hubs

From the point of view of the North German States, it would be an advantage especially in the early stages of establishing a hydrogen economy, if a number of segments of the hydrogen value creation chain could be pooled at concentrated locations.

This is why in the joint process of preparing the Hydrogen Strategy for North Germany in coordination between the States and representatives from the area of business, the concept of so-called hubs¹⁰ has been suggested for establishing a hydrogen economy in North Germany. Hydrogen hubs in this contexts are locations that feature a critical mass of demand for hydrogen in geographic proximity to hydrogen production facilities and hydrogen infrastructure (storage, transport). The generation and distribution (provision), as well as use (e.g. in mobility or industry) are pooled by the hydrogen hub.

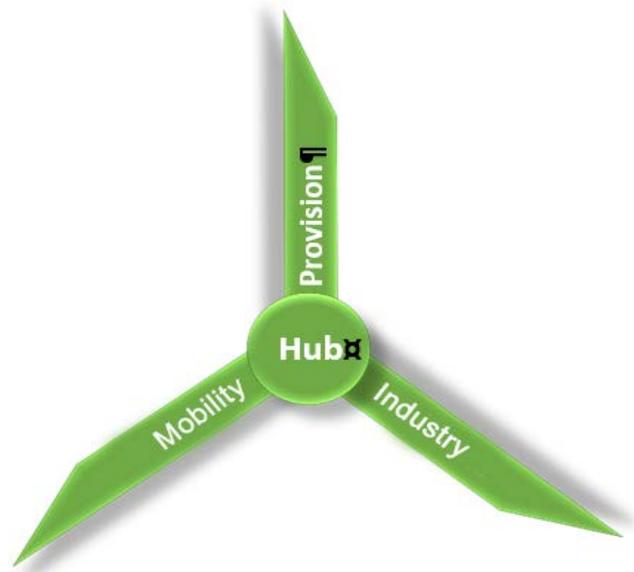


Figure 1: Hydrogen hub (original illustration)

By concentrating the production, distribution infrastructure and use in hubs, and pooling demanders from different sectors (e.g. mobility, industry) and applications (e.g. trains, trucks, ships, passenger cars) to increase the required quantities, the cost per unit is reduced and profitability is increased.

The option to use waste heat of hydrogen electrolysis is an aspect that should not be neglected, in order to improve the profitability and the effect on climate protection of the overall endeavour. Another useful element of hydrogen hubs could also be demanders for oxygen, which is a by-product of hydrogen electrolysis.

Target

The first hydrogen hubs should be set up and taken into service at suitable locations in North Germany by 2025.

The goal is to set up the first centres shortly, that provide for value creation that is as comprehensive as possible (hydrogen generation, temporary storage, distribution, use).

Planning provides that the first hydrogen hubs should already cater for production and use on an industrial scale. This is important to be able to learn in practice with a significantly larger facility size and capacity,

and to trigger the much needed scale effects. Appropriate accompanying research will be conducted to support the achievement of series readiness.

The first hydrogen hubs should be clearly perceptible. This can be promoted through choice of location, as well as additional public relations work. Hydrogen technology and applications can thus become visible and perceivable, which is vital for gaining public acceptance.

Suitable locations for creating hydrogen hubs are places that already feature favourable conditions, such as:

- a geographic concentration of potential users, giving rise to a critical mass of demand,
- geographic proximity to existing hydrogen providers,

¹⁰ Hub = the central or main part of something where there is most activity.

- a geographic concentration of facilities for renewable electricity generation, ensuring that sufficient renewable electricity for hydrogen electrolysis is available,
- geographic proximity to seaports, to be able to use existing infrastructure, also for possible imports,
- geographic proximity to existing underground storage facilities,
- geographic proximity to electricity and gas transmission networks, allowing for synergies based on infrastructure interfaces to be tapped, and for future use to be prepared, in particular with regard to the gas grid for storage and pipeline infrastructure,
- geographic proximity to large heat sinks and / or oxygen consumers, to be able to improve overall profitability by using waste heat or oxygen, or
- usability of electrolysers in a manner that is beneficial to the system, e.g. as switchable/interruptible loads.

Locations on the premises of companies that already benefit from favourable electricity prices, due to legal privileges such as the compensation scheme of the Renewable Energies Act (EEG), or that already possess the relevant licences, can also be good starting points for hydrogen hubs.

The list above is intended to be exemplary, and not all criteria must necessarily be met. The further process provides for coordination with interested commercial companies regarding suitable location criteria for hydrogen hubs, and ultimately the identification of suitable locations for hubs (see Appendix 1 field of action “Hydrogen infrastructure”). Potential partners on the provider and demand side and investors could be individually addressed in the next step. Options such as cooperative models or crowd funding should also be considered in this context.

7.2 Simultaneous development of value creation

The North German Ministers and Senators of Economics think of the establishment of a

hydrogen economy mostly as an industrial policy opportunity for strengthening existing locations and for generating more value in the North. In the first step, planning provides for a focus on companies from the areas of facility, component and vehicle production. This includes, for example, the production of:

- facility technology and components for
 - fuel cells,
 - electrolysers,
 - hydrogen compressors / pressure systems,
 - storage caverns and containers for hydrogen storage and transport,
 - hydrogen pipelines,
 - conversion of natural gas pipelines (hydrogen readiness),
 - methanisation plants,
- vehicles (road, rail, water) for hydrogen transport,
- hydrogen-powered vehicles (road, rail, water, air)

Target

The North German States are going to advocate for favourable general conditions, in order to provide that companies from the hydrogen value creation chain (in particular from the areas of facility, components and vehicle production), who are new to North Germany, will have settled at suitable locations by 2025, allowing for the North German value creation chain to be completed and reinforced.

as well as the related supply industries. Settlement of new companies along the

hydrogen value creation chain or changes to product ranges offered by companies that are already based in North Germany, can contribute to strengthening North Germany's economic structure and to a redirection towards greater sustainability.

The creation of the first hydrogen hubs and the perspective provided by this strategy for establishing a complete hydrogen economy, will encourage companies along the entire hydrogen value creation chain to settle in North Germany, or to increase existing activities. The expertise and support of regional business development agencies and regional marketing companies should be used early on.

Based on a status analysis (that is to be drawn up) of local companies that are part of the hydrogen value creation chain, planning provides for a joint location, settlement and marketing concept to be drawn up under the working title "Strengthening the hydrogen location of North Germany" (see Appendix 1 field of action "Creating value with hydrogen"). Joint marketing could help to promote visibility of our region as a hydrogen region among its own population, as well as beyond North Germany's borders.

One prerequisite for establishing a self-sufficient hydrogen economy is that supply and demand capacities are built up largely simultaneously. This must take place in a modular fashion, along promising strategic axes, to allow for activities that are commercially adequate as far as possible, even in the early stages of the market. It must be ensured in this context, that in addition to a pure increase of demand, synergies of the provision and distribution infrastructure must be utilised to allow for further cost reductions.

7.3 Hydrogen provision

Provision in the context of this strategy is understood as the generation, temporary storage and distribution of hydrogen to the consumer.

7.3.1 Generating green hydrogen

Target

At least 500 megawatts of electrolysis capacity for green hydrogen shall be installed in North Germany by 2025, and at least five gigawatts by 2030.

There are particularly favourable location conditions for a local production of green hydrogen in North Germany. It is possible to establish a full value creation chain here. A key element in this context is the production of green hydrogen and of fuels, chemicals and energy carriers based upon it. North Germany wants to think big. There are currently ideas for creating production capacities for a total of at least 300 megawatts of

electrolysis output. Building upon this and provided that the federal government provides for a suitable legal framework for green hydrogen in a timely manner (including the removal of the legally prescribed cap regarding the expansion targets for onshore and offshore wind power), the goal should be to have at least 500 megawatts of electrolysis capacity installed by 2025, and at least five gigawatts by 2030 – one third of the electrolysis capacity that is assumed for Germany in 2030 in the dena pilot study¹¹. This is the basis for taking the first hydrogen hubs into operation by 2025, and for establishing a green hydrogen economy that is as comprehensive as possible by 2035.

¹¹ dena (Deutsche Energie-Agentur, German Energy Agency), integrated energy transition pilot study. Impulses for designing the energy system until 2050, 2018.

Large-scale local generation also plays an important role for the technology to mature. This would allow us to gather know-how locally, to gain technological leadership, and to establish hydrogen technology as an export product.

In order to reduce the costs for transport infrastructure, green hydrogen can either be produced in close proximity to future hydrogen consumers, or close to renewable energy production facilities. In North Germany we have the geographic advantage that potential hydrogen customers generally tend to locate their premises close to renewable energy generation facilities, and that most of these sites also feature potential for using waste heat. Offshore production could also be cost-effective in the long term. Electrolysis facilities would need to be built offshore, either in direct proximity to wind farms or on artificial islands, and the hydrogen would then be transported to the shore.

7.3.2 Import

To meet the demand, in particular from the industrial sector, significant quantities of green hydrogen will be required for realising the target scenario of a large-scale hydrogen economy. Owing to the fact that expansion potential for renewable energy is very high in Germany, but still limited, energy imports will be inevitable for ensuring working sector coupling, once the local potential has been fully exploited. It must be reviewed in this context, which option is viable in economic terms: importing renewable electricity, in order to produce green hydrogen here in North Germany, or importing green hydrogen or synthetic fuels.

In addition to promoting a rapid expansion of renewable energies in North Germany and of international electricity transmission capacities, corresponding import structures for green hydrogen and synthetic fuels must also be created in a timely manner. The German seaports with their existing import terminals (logistics) will take on a key role in this context, and they should be adequately prepared. They could also be used for exporting hydrogen facilities and components in the future.

In particular with regard to a future import of green hydrogen, questions are going to arise concerning a uniform definition of 'green' hydrogen and a traceability to verify that the product in question is actually 'green' hydrogen from renewable energy production. Blockchain applications may allow for solutions in this context. These questions should be addressed by the federal government on an international level to find common answers.

7.3.3 Temporary hydrogen storage

The demand for temporary storage is going to increase in line with increasing production volumes. As quantities increase, supply and demand are not going to develop in a time-synchronised manner on the long run. The big advantage of hydrogen – unlike electricity – is that it can be 'stored', even for longer periods of time. Underground formations (caverns) that are abundantly available in North Germany are a good option for this.

Activities concerning the maintenance and conversion of the cavern infrastructure and technical adjustments to existing gas grid structures carried out by the energy industry for the purpose of storing and transporting hydrogen, should take place with appropriate guidance from the federal states, for example within the framework of gas network development planning and state development planning and / or strategies.

7.3.4 Hydrogen distribution

For reasons related to scarcity, costs and efficiency, hydrogen may be used directly and without any transformation losses (e.g. for industrial processes or in fuel cell vehicles), especially in the earlier stages, in which only limited amounts of green hydrogen will be available.

However, the natural gas grid as an important future transport and storage option must be taken into account even now. The existing natural gas grid can absorb ('blending') and transport a certain percentage of hydrogen, in addition to the natural gas that passes through the grid. However, at this point it is not possible to extract the pure hydrogen at the destination, as it is blended with the natural gas. Technical solutions are still under development. The mixture of natural gas and hydrogen (blended gas) can already be used for many end-use applications, analogous to natural gas.

The option to create a separate transport infrastructure would need to be reviewed for applications requiring pure hydrogen. A well-developed natural gas grid for the distribution of different gas qualities (known as L-gas and H-gas) is already in place in North Germany. The L-gas and H-gas infrastructures are physically separated and they often run parallel to each other. Owing to the development of demand, there are often also multiple parallel pipelines for a single gas quality. There is a strong decrease of L-gas production in Germany and the Netherlands are planning to withdraw from L-gas production. In the future, only H-gas will be transported and used in Germany as a result. Existing L-gas lines are gradually being converted into H-gas lines. As gas flows are being relocated, parts of the current L-gas infrastructure can be released for other transport tasks in the medium term. If natural gas consumption decreases on the long run, as is to be expected, existing gas pipelines for both gas qualities could be technically converted with reasonable effort, and be used for transporting pure hydrogen in the future. In replacement investments, grid operators strive to make the natural gas grid H₂-ready even now.

Another aspect is that a network of refuelling stations must be established. Based on a rough estimate, around 250 hydrogen refuelling stations will be needed to provide full supply coverage for North Germany¹². Wherever possible, refuelling stations should not be limited to individual modes of transport (e.g. only road vehicles), but be freely accessible for various transport modes including, for example, trains or ships. The term multi-modal service stations is used to describe refuelling stations at which vehicles of at least two different transport modes can be filled up (e.g. road and rail vehicles).

7.4 Hydrogen in the area of mobility

The North German States consider the use of hydrogen in the area of mobility a strategic axis of high priority, owing to the key role of the mobility sector with regard to establishing a hydrogen economy. The use of hydrogen-powered vehicles is currently still limited, due to a low availability. Experts expect that by the middle of the next decade, supply and demand will have increased significantly in various traffic sectors.

7.4.1 Mobility industry as a trigger for the hydrogen economy

Green hydrogen is considerably more expensive than competing energy carriers, such as fossil natural gas or fossil-based fuels, and this will continue to be true in the near future. However, in the area of mobility, it is often not possible to relocate to places with more favourable conditions (lower fuel prices in particular). Refuelling must usually take place where the mobility services are to be performed.

A side-effect of using hydrogen in the area of mobility is the high degree of public attention. Hydrogen-powered buses, for example, are very visible in road traffic and they can be

¹² The consultancy firm *Ernst & Young* estimates that around 1,000 hydrogen refuelling stations are required to realise full supply coverage for Germany. North Germany accounts for around 25 percent of the area. The estimate of 250 hydrogen refuelling stations was derived based on these figures.

used and therefore experienced by everyone. This can give rise to a positive effect concerning public acceptance of hydrogen.

Pressure to act with regard to achieving climate goals is particularly high in the transport sector, after all. Rather than decreasing, greenhouse gas emissions due to traffic have increased in recent years and in 2016 they were even slightly above the level of the base year of 1990, with a further increasing trend for the years ahead¹³.

The area of mobility can serve as a trigger for making green hydrogen marketable and improving its acceptance. Planning therefore provides for a promotion of green hydrogen applications in the mobility sector. For this purpose, the number of hydrogen-powered vehicles that are in use and the resulting volume of demand for hydrogen, must be increased significantly. This challenge must be met by mobility customers as well as vehicle manufacturers. Corresponding service station infrastructure must be established at the same time.

Target

The North German States are going to advocate for favourable general conditions to provide that the demand for green hydrogen for mobility applications will increase significantly by 2025.

Based on the current demand volume for hydrogen for mobility applications in North Germany that is yet to be determined, and an estimate for 2025, vehicle manufacturers shall be addressed in a targeted manner to promote the provision of sufficient numbers of vehicles as well as suitable vehicle types (see Appendix 1, field of action “Hydrogen infrastructure”).

7.4.2 Growing number of applications

Hydrogen-powered vehicles are already in regular use – both globally and in North Germany – as public buses, in rail transport, as passenger cars and in the intralogistics sector (industrial trucks). Hydrogen-powered trucks will be taken into service soon. However, availability of vehicles, especially in the German market, and high acquisition costs are currently limiting factors for regular procurement. Research is currently being conducted concerning application options for hydrogen and other electricity-based fuels, such as green methanol, green ammonia or synthetic kerosene, in ship and air traffic.

An interesting possibility for boosting the availability of suitable hydrogen-powered vehicles is the use of existing and establishment of further development partnerships with vehicle manufacturers for the traffic sectors that we consider to be most important (e.g. public transport or logistics). This would not only signal to manufacturers that there is a strong interest in suitable vehicles, but they would actually be asked to provide such vehicles. This type of partnerships also contributes to ensuring series maturity and therefore suitability for everyday use in line with existing requirements. Last but not least, an early provision of vehicles to the region can secure availability in the initial phase, in which the number of available vehicles is usually limited.

7.5 Hydrogen in the industrial sector

In the context of ambitious climate protection targets, the industrial sector is itself interested in developing alternative low-emission processes to stay internationally competitive, as environmental regulations are becoming stricter and energy costs are rising.

¹³ Federal Environmental Agency, projection report 2019 for Germany, August 2019, https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-09-06_climate-change_33-2019_pb19-ksp2050_teilbericht-psz-ix.pdf [12 Sept.2019].

7.5.1 Challenges in the industrial sector

The industrial sector is second only to the energy industry in the ranking of industries with the highest greenhouse gas emissions in Germany¹⁴. The industry accounting for the greatest share of industrial emissions is the iron and steel industry with around 30 percent, followed by refineries (19 percent), the cement clinker production (16 percent) and the chemical industry (14 percent). The remaining industrial emissions (about 21 percent) are accounted for by four other industries and sub-industries¹⁵.

With six plants and a total of 7,380 kilotons of CO₂ equivalents (more than 4,000 kilotons of which are accounted for by a single plant), the iron and steel industry accounts for the greatest share of industrial emissions also in North Germany. Next up are refineries with a total of 4,400 kilotons of CO₂ equivalents, and three cement production facilities with a total of 2,293 kilotons of CO₂ equivalents. The other industries are represented with 99 facilities and a total of 5,372 kilotons of CO₂ equivalents¹⁶.

In energy-intensive industries (e.g. steel industry, chemical industry), energy prices are a decisive factor for international competitiveness, far more so than in other industries. Additional costs for low-emission and emission-free energy sources compared to fossil energy sources (natural gas, mineral oil, coal), due to the currently existing legal conditions, can therefore quickly lead to a loss of competitiveness in the industrial sector, or to a relocation of facilities to regions with lower energy prices. This cannot be in the interest of North Germany's industrial policy. International competitiveness of companies based in North Germany must be safeguarded. This applies for competition between different companies, as well as between different sites operated by one company, with regard to investments in new methods.

7.5.2 Industrial sector as a trigger for the hydrogen economy

The industrial sector is the producer as well as the biggest consumer of hydrogen. Hydrogen, which is currently almost exclusively fossil-based, is used for example as a basic chemical product for producing, processing and finishing intermediate and final products. Around 55 percent of the hydrogen produced worldwide is used for ammonia synthesis, while 25 percent are used in refineries and about ten percent are used in methanol production. The remaining ten percent are used for further material or industrial uses (metal processing and sheet glass production in particular)¹⁷.

Target

The North German States are going to advocate for favourable general conditions to provide that the demand for green hydrogen for use in the industrial sector will increase significantly by 2025.

In some branches of industry, using green hydrogen, whether it be directly as an energy source or raw material, or indirectly for synthesising electricity-based energy carriers, is currently the only conceivable option for reducing CO₂ emissions significantly. A use of green hydrogen in the industrial sector has very strong leverage,

¹⁴ Federal Environmental Agency, Projection report 2019 for Germany, August 2019,

https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-09-06_climate-change_33-2019_pb19-ksp2050_teilbericht-psz-ix.pdf [25 Sept. 2019].

¹⁵ German Emissions Trading Authority (DEHSt), greenhouse gas emissions 2018. Fixed installations subject to compulsory emissions trading and air traffic in Germany (VET report 2018),

https://www.dehst.de/SharedDocs/download_loads/DE/publikationen/VET-Bericht-2018_Summary.pdf?blob=publicationFile&v=2 [1 Oct. 2019]

¹⁶ Original calculations, installations subject to compulsory emissions trading in Germany 2018, as of 2 May 2019.

¹⁷ Paul Zakkour and Greg Cook, CCS Roadmap for Industry. High-purity CO₂ sources, 2 Sept. 2010, Carbon Counts Company (UK) Ltd.

due to the sector's high CO₂ emissions. Due to climate protection considerations as well as in order to quickly achieve a significant increase of demand volumes for green hydrogen, priority should be given to a restructuring of the sector for using CO₂-free energy sources.

It would therefore be expedient to gradually replace the fossil-based hydrogen that is currently being used in the industry with green hydrogen. As prices for fossil energy sources are currently low worldwide, hydrogen substitution will take place gradually with the share of green hydrogen increasing steadily, to ensure that German companies remain globally competitive. Very high demand for green hydrogen is generated as a result, and this will contribute to a reduction of the unit price and of the price gap between green hydrogen and fossil-based alternatives.

In a second step, processes that have been based directly on fossil energy sources to date, could be adjusted for using hydrogen. The area of steel production is particularly suitable for such measures. The blast furnace route (usually using coking coal to date) can be replaced with a hydrogen route. This requires huge investments that must be taken into account early on, when it comes to plans for regular replacements of facility components at steel companies' production sites. While green hydrogen is not a cost-efficient alternative to using fossil process materials and fuels, it is important that an appropriate perspective is offered even now, to allow for the necessary planning processes to be launched, and for required process changes to be tested.

7.5.3 Indirect applications

A gradually increasing addition of green hydrogen could be an alternative for any industrial processes that are currently based on natural gas. This would allow for a reduction of the companies' own CO₂ emissions. Issues with turbines that currently still occur when using natural gas containing a higher percentage of hydrogen, will be counteracted with an adjustment to turbine technology (H₂-readiness) that has been announced by a number of turbine manufacturers. Also in this context it must be pointed out, however, that there are important reasons why green hydrogen should be used directly as hydrogen in industrial processes for now, to replace fossil-based hydrogen.

CCU processes (carbon capture and utilisation) are another interesting option for improving the greenhouse gas balance that is also based on green hydrogen. In these processes, CO₂ is captured at point sources (combustion systems in particular) for further use as a raw material for chemical processes. Together with green hydrogen, it can be synthesised to produce electricity-based fuels and other hydrocarbon compounds. Emission into the atmosphere would either occur later on (e.g. combustion of electricity-based fuels in the engine of a vehicle / aircraft) or, provided that the CO₂ is captured once again and kept in constant circulation, not at all. The issue of the origin of the CO₂ is vital in this context. CCU processes should ideally not be used as an excuse for further power generation using fossil materials, but rather be used for preventing that CO₂ emissions that are inevitable in the medium term (e.g. from cement production) are released into the atmosphere. CCU is considered a possible basic technology for producing electricity-based fuels in fully regenerative energy systems. A number of projects is currently underway for testing the industrial usability of CCU processes.

The possible industrial uses of green hydrogen mentioned above require that much larger volumes of hydrogen are produced than before, and that this hydrogen must originate entirely from renewable sources in the long term. The demand volumes for green hydrogen for industrial applications will be estimated in coordination with the industry.

Based on this, a tiered quantity structure will be drawn up to determine the required renewable electricity capacities over time. Initial conclusions regarding the dimensions and geographic distribution of possible import and pipeline structures will be drawn in the next step (see Appendix 1, field of action “Hydrogen infrastructure”).

8. North German States as driving forces

To be able to lead by example, the North German States are planning activities in particular in their original areas of competence. Another aim is to establish cooperations with regional and international partners. Collaboration with the federal government is the final significant area of activity for the North German States, especially in the context of the National Hydrogen Strategy (NSW) that has been announced for the end of 2019.

8.1 Leading by example

The North German States and municipalities have a wide scope for action, also in their own areas of responsibility. These opportunities can be taken even now, despite the fact that the outlined obstacles for establishing a hydrogen economy have not been overcome yet. Please find below a description of initial steps in the form of targets and fields of action.

The next steps will be derived gradually, with particular emphasis placed on the creation of a suitable legal framework by the federal government, to provide a level playing field for green hydrogen. The federal government can support and accelerate the establishment of a hydrogen economy in North Germany, by taking suitable measures in the context of its National Hydrogen Strategy (NSW).

Such measures include the creation of a regulatory framework, market incentive programmes, etc.

The North German States can highlight their role as drivers of the establishment of a hydrogen economy, especially in the areas of generating local demand for hydrogen, as well as networking and cooperations among business and science. Furthermore, they want to increase their activities in the areas of licensing, project funding, and the promotion of acceptance and education.

Target

The North German States are going to present themselves as hydrogen consumers and drivers of the establishment of a hydrogen economy.

8.1.1 Strengthening demand for hydrogen from the public sector

The Clean Vehicles Directive¹⁸ that was amended in 2019 and must be translated into national legislation, contains specific targets for each member state, with regard to public procurement of clean commercial vehicles (light and heavy duty). These targets are expressed as a minimum share of clean vehicles of the total number of road vehicles that are acquired by the public sector from mid-2021 (first acquisition period) or 2026 (second acquisition period). This applies in particular for public transport buses and public vehicle fleets (e.g. road cleaning and waste collection vehicles). The following minimum quotas have been specified for Germany: 38.5 percent clean light commercial vehicles (LNF), ten or from 2026 15 percent clean trucks, 45 or from 2026 65 percent clean buses (see figure 2).

¹⁸ DIRECTIVE (EU) 2019/1161 OF THE EUROPEAN PARLIAMENT AND THE COUNCIL of 20 June 2019 amending Directive 2009/33/EG on the promotion of clean and energy efficient road transport vehicles, EU Official *Figure 2: Minimum quotas for Germany for procuring clean road vehicles (green), based on the Clean Vehicles Directive (original illustration).*

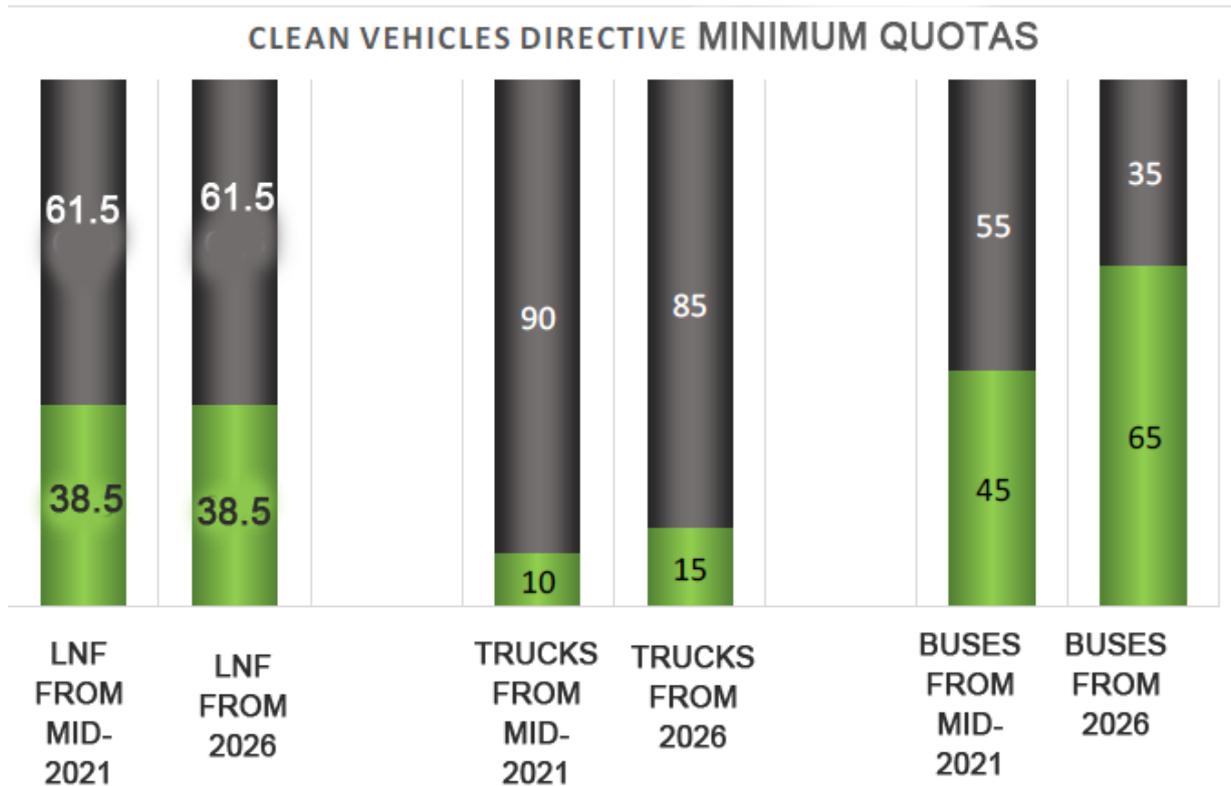


Figure 2: Minimum quotas for Germany for procuring clean road vehicles (green), based on the Clean Vehicles Directive (original illustration).

The cleanness criterion covers air pollutants as well as CO₂ emissions. An emissions cap of 50 grammes of CO₂ per kilometre applies for LNF, and zero grammes per kilometre from 2026. To be considered clean in the sense of the Directive, buses and trucks must be powered with alternative fuels¹⁹. Hydrogen fuel cell drives are an option for clean LNF, buses and trucks in this context.

Target

For their state-owned fleets, the North German States intend to jointly surpass the minimum ratio for acquiring clean road vehicles that is prescribed for Germany in the Clean Vehicles Directive.

In the future, the public authorities therefore must make sure that a sufficient number of clean road vehicles is acquired, when designing calls for tenders and awarding contracts. North Germany strives to lead by example and to jointly surpass the mandatory minimum quotas prescribed for Germany. Hydrogen-based technology should be granted a fair chance in this context. Furthermore, the five North German States are going to review initiatives for using hydrogen-powered vehicles in municipalities and in public transport.

The public authorities have options for promoting the use of clean vehicles, also beyond the guidelines provided by the Clean Vehicles Directive, for example through calls for tenders in the areas of rail (e.g. regional trains) and ship traffic (e.g. harbour ferries, survey boats, water police).

As far as hydrogen-based technologies are (also) used here, the segment of publicly procured vehicles could generate initial demand for hydrogen that would be very important to

¹⁹ 'Alternative fuels' pursuant to Directive 2014/94/EU of the European Parliament and the Council of 22 Oct. 2014 regarding the establishment of alternative fuels infrastructure (OJ L 307 of 28 Oct 2014, p. 1) include: electricity, hydrogen, biofuel, synthetic fuels, natural gas (CNG, LNG), liquid gas (LPG).

the market. This combined demand volume of the five coastal states will provide the public authorities with a certain level of market power that allows for scale effects with manufacturers and therefore for better purchasing conditions for the public authorities.

The North German guidelines for procurement and contracting shall be reviewed with regard to H₂-readiness, and applicable suggestions shall be made as to how the design of guidelines can be used to promote that hydrogen technology is considered in procurement and contracting decisions. It shall further be checked, whether hydrogen vehicles could be acquired in bulk (see Appendix 1, field of action “Hydrogen in guidelines, licensing practice and programmes”).

8.1.2 Networking and cooperation within North Germany

A large number of networks, initiatives and working groups concerning hydrogen already exists in North Germany. The structure and number of members, regional responsibility, functional self-image, task design and working methods are very diverse. This allows for the option to address a very wide range of issues based on the respectively required intensity. Regional, functional and content-related supplementation gives rise to Synergies and allows for duplicate efforts to be avoided. The existing North German networks, initiatives and working groups concerning hydrogen should intensify their long-term cooperation.

The first step is to prepare an overview of the active networks, initiatives and working groups in North Germany, and to invite the network managers and spokespersons to a meeting. Cooperation will be encouraged, and suitable structures for addressing the fields of action will be identified (see Appendix 2). Existing working structures shall be used and built upon, where this appears suitable. In addition to this, it will be necessary to consider the involvement of further suitable stakeholders that may not be organised in networks or similar structures. This enables us to systematically draw upon expertise, for example from individual companies or research institutions.

The process for drawing up the Hydrogen Strategy for North Germany has so far been managed by a ministerial cross-state working group. The future duties of this “North German Hydrogen Coordination Group” include the organisation and moderation of the implementation process, and the coordination of the political reconciliation of the North German States. Further tasks are listed in Appendix 2. Appendix 1 includes initial suggestions for fields of action, tasks and timelines. The “North German Hydrogen Coordination Group” can arrange for any necessary adjustments to the fields of action, tasks and timelines, or present any significant changes to the Conference of Ministers of Economics and Transport for the North German Coastal States (KüWiVerMinKo) for decision making.

The North German States often share very similar interests and assessments regarding the issue of hydrogen. A joint presentation, e.g. before the federal government or the EU, as well as North German hydrogen stakeholders, can help to improve the visibility of North German interests and provide the region with a stronger voice. Each of the five North German States will benefit from this effect. This is why the North German States would like to cooperate in the area of hydrogen and to appear as a unit when dealing with third parties.

Target

The North German States are going to cooperate in the area of hydrogen and to appear as a unit when dealing with third parties, aiming to provide the North German States with a stronger voice.

Especially in the areas of research and development, a network of stakeholders can give rise to comprehensive information exchange and to synergies due to cooperations. The North German States therefore expressly welcome joint research projects of institutes and universities,

as well as demonstration projects. In addition to projects with a practical orientation, such as regulatory sandboxes, basic research also constitutes an important component for a successful future hydrogen economy. Existing technologies must be developed further and optimised, but we must also be open for new findings in the areas of generation, storage / transport and use.

This also includes a joint North German presentation of hydrogen research at national and international events, aiming to promote and strengthen North Germany as a place of research and innovation.

8.1.3 Optimising approval processes and technical standards

As the number of projects increases, for example in the fields of electrolysers and hydrogen refuelling stations, so does the pool of experience that applicants and regulatory authorities can draw upon, and therefore also the likelihood of an optimised process. To make this experience available to all regulatory authorities in North

Target

<i>The regulatory process for hydrogen facilities in the North German States shall be optimised by 2022.</i>
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Germany, the relevant regulatory authorities shall enter into cross-state exchange with each other and with project sponsors (see Appendix 1, field of action “Hydrogen in guidelines, licensing practice and programmes”).

Uniform technical standards (e.g. for transfer processes, calibrations, measuring) are beneficial to a swift establishment of a hydrogen economy. Suggestions shall be drawn up by the relevant associations (e.g. DVGW), regarding any differences that still exist and that are not technically necessary. In subsequent discussions held between the states and the federal government, the North German States are going to advocate for a swift harmonisation of technical standards (see Appendix 1, field of action “Hydrogen in guidelines, licensing practice and programmes”).

The objective to establish nationally uniform approval and testing procedures under calibration law, is currently also being pursued with regard to the approval of hydrogen refuelling pumps in the form of a conformity assessment procedure under measuring and calibration law. Regarding this issue, the “Working committee for volume measuring equipment” of the German calibration authorities led by the Calibration Authority North, is currently in consultation with the involved representatives of the manufacturers, operators, federal ministry and the Physical-Technical Federal Institute.

8.1.4 H₂-ready funding programmes

There are already numerous funding programmes in the North German States that qualify for projects in the fields of environmental and climate protection. Others are being planned. It is not always clear for project sponsors, which funding programmes are worth considering for their project. This is also true for hydrogen projects along the entire value creation chain, such as

- the production of facilities / components for hydrogen generation,
- optimisation of electrolysers with regard to fluctuating feed-in of electricity from renewable energy sources,
- conversion of caverns for hydrogen storage, development of further storage facilities,
- conversion of the natural gas grid for hydrogen transport,
- construction of multi-modal hydrogen refuelling stations,
- acquisition of hydrogen-powered vehicles,
- substitution of fossil fuels with hydrogen in industrial processes,
- further processing of hydrogen to produce synthetic methane (power-to-gas) and other synthetic fuels and base chemicals.

The goal is to provide that established funding programmes should always allow for the funding of investments in hydrogen projects, provided that such technological openness appears expedient. Potential project sponsors have also requested that funding programmes, especially those intended as market incentives, should have a sufficiently long running time (at least three to five years).

Target

Technology and infrastructure funding programmes by the North German States should always allow for funding of hydrogen projects.

The existing funding programmes must be reviewed. For any new funding programmes, this aspect shall be considered from the start. An overview of existing funding options would allow for easier access to funds for hydrogen projects. Affected stakeholders have further requested that provisions in funding guidelines are adjusted to the requirements of sector coupling. For example in the area of hydrogen refuelling stations where funding guidelines currently provide in certain cases that these must not cater for multiple transport modes (e.g. trains and road vehicles). The responsible bodies should address these tasks, taking the experiences of project sponsors into account. Proposals shall be drawn up as needed, regarding ideas for making North German funding programmes H₂-ready and for preparing them for sector coupling. This requires clear coordination with federal subsidies and regarding the accumulation of funds. The North German States would like to support the establishment of a green hydrogen economy, by designing funding programmes in a manner that allows for know-how in the field of hydrogen technology and innovations to be developed; including, for example, in the context of operational programmes of the European Regional Development Fund (OP ERDF) 2021-2027 (see Appendix 1, field of action “Hydrogen in guidelines, licensing practice and programmes”).

8.1.5 Information and acceptance

Knowledge about hydrogen is distributed unevenly in the population. Knowledge is a prerequisite for acceptance, and public acceptance is in turn a prerequisite for the successful establishment of a hydrogen economy.

Target

Distribution of information about the perspectives, potential and application options for green hydrogen shall be significantly intensified in North Germany by 2022.

Concerns regarding hydrogen technology (e.g. due to different requirements for handling hydrogen compared to natural gas, petrol or diesel) should be actively counteracted through education. Suitable ways for providing adequate information about the issue of hydrogen in North Germany shall be examined (see Appendix 1, field of action “Hydrogen acceptance and education”).

Planning provides for joint public relations work for the Hydrogen Strategy for North Germany and hydrogen technology in general. Suggestions should be drawn up for this (see Appendix 1, field of action “Hydrogen acceptance and education”).

At the same time, it should be arranged that broad sections of the population are provided with access to positive experiences in connection with hydrogen, such as virtually noise and odour-less rides on hydrogen-powered buses and trains or tours of technical facilities (see Appendix 1, field of action “Hydrogen acceptance and education”).

Confidence-building measures also include trust in measuring systems, in particular at refuelling pumps, regarding the indicated volume and pricing. In commercial practice, such confidence-building is achieved successfully through calibration inspections and approval procedures under calibration law.

Further aspects for promoting acceptance include regional points of reference and participation options. Green hydrogen produced with North German wind power creates high-quality jobs here in the region. Anyone who works in this field or even participates financially in an electrolyser (e.g. analogous to community wind farms) is unlikely to reject hydrogen technology. Comprehensive process involvement and participation schemes (as included in this strategy), in particular for regional business and research stakeholders, are vital for promoting acceptance of the upcoming transformation process.

With regard to acceptance of the energy transition as a whole, it is also important to ensure as soon as possible that renewable electricity produced in North Germany is used directly here in the region. The expansion of the electricity transmission network must still be pressed ahead, to enable that in the future also regions that are far from the coast can be fully supplied with renewable electricity to cover their own demand. In this context it is urgently necessary that generation capacities are increased, especially in the windy north.

8.1.6 Education

A vital component for generating knowledge about hydrogen technology and its significance in the context of the energy transition and for reaching climate goals, is to integrate suitable learning content in the curricula of universities, schools, vocational schools and professional training courses. This allows for broad parts of the population to be reached, beyond expert circles and interested non-professionals. This is very important for achieving acceptance, and

it also counteracts the scarcity of qualified staff. Specialised professionals with knowledge in the field of hydrogen will be required across all educational backgrounds, to cater for an established comprehensive hydrogen economy.

Target

Expertise in the area of hydrogen shall be increased in North Germany by 2025.

An overview of the contents on the subject of hydrogen that are already taught in relevant education programmes in North Germany will be prepared, and based on this, suggestions will be drawn up, as to how the issue of hydrogen can be firmly integrated into suitable courses of education (see Appendix 1, field of action “Hydrogen acceptance and education”).

8.2 Cooperation with other regions and international partners

In Germany and other European countries there are by now a number of regions that are interested in establishing a hydrogen economy. The North German States are going to get involved in cooperations with other regions, in particular their immediate neighbours, such as the northern Netherlands (Groningen region), Brandenburg, North Rhine-Westphalia or Scandinavia. Mutual intentions to cooperate have already been expressed between North Germany and the northern Netherlands. Discussions are scheduled to take place shortly, regarding possible specific designs for a cooperation between the two regions in the area of hydrogen. There has also been communication regarding a possible international cooperation with Japan. Further possible cooperations will be reviewed, as will be the option to open up delegation trips by North German ministers for (business) representatives from the other North German States or partner regions (see Appendix 2).

Target

The North German States strive to develop synergies with neighbouring regions by 20205.

Cooperation with neighbouring regions allows for a development of synergies. These can arise, for example, if demand for hydrogen is pooled, infrastructure is created and used jointly, market segments are consolidated to form an uninterrupted value creation chain, through joint representation of interests before the federal government or the EU, or through a regular exchange of information and experience.

International cooperation is of vital importance to a North German hydrogen economy with regard to technology transfer as well as access to new markets. More and more countries identify hydrogen as a strategic energy carrier for the future. In addition to European countries that are committed to active climate protection, countries that should be mentioned in this context include the USA and Canada, as well as Japan, China and South Korea for the Asiatic region. A replacement of fossil fuels with hydrogen in energy-consuming sectors, will require such large volumes of green hydrogen in the medium to long-term that the option to import green hydrogen is becoming increasingly important with regard to international cooperation. Further regions of the world that have certain advantages for generating renewable energy move into focus here, such as North Africa, the Middle East and Australia.

8.3 Cooperation on a national level

With regard to green hydrogen there is a circle of self-inhibiting effects including high investment and operating costs for production on the one hand, and low demand on the other hand. This circles must be broken. Suitable legal conditions are required to achieve this. The North German States consider the federal government in its role as legislative body to be responsible for this, also with regard to its possibilities for using existing leeway when it comes to translating EU law into national law, and in its involvement in EU lawmaking.

This is why the North German States are going to continue to urge the federal government to create a favourable framework for sector coupling and green hydrogen. Two of the endeavours that the federal government is currently working on, allow for good starting points in this context: the Climate Protection Act and the National Hydrogen Strategy (NSW).

Target

In coordination with the federal government, the North German States want to achieve by 2025 that the federal government provides for suitable conditions for establishing a green hydrogen economy, in particular via its energy and climate policies.

In October 2019, the federal government presented the Climate Protection Programme 2030 and a draft for a Federal Climate Protection Act. The North German

States take note of these and are going to provide constructive support for the further process. The National Hydrogen Strategy (NSW) will be presented to the federal cabinet for approval in December 2019²⁰. The North German States are going to provide comprehensive guidance for both processes, to offer support to the federal government, and they will be available for a constructive exchange.

In the area of regulations, the North German States are going to focus on the following high-priority topics to begin with:

- They are going to urge the federal government to quickly reform the state-induced electricity price mark-ups (SIP) for hydrogen and power-to-x applications. This should lead to a reduction of operating costs (OPEX).

²⁰ As of: 25 Oct. 2019 (editorial deadline for the Hydrogen Strategy for North Germany).

- They are going to advocate for an effective CO₂ price while maintaining the international competitiveness of German companies, and for creditability towards sectoral CO₂ targets in the context of the national implementation of the Renewable Energies Directive (RED II). This should boost the demand for CO₂-free energy carriers and for green hydrogen in particular. It is assumed that an SIP reform and an effective CO₂ price will provide for a level playing field for green hydrogen.
- They believe that a market incentive programme is necessary until an effective CO₂ price has been implemented. Such programme should decrease investment costs (CAPEX) through subsidies, and reduce operation costs (OPEX) via further instruments (e.g. government tenders, minimum blending ratios, guaranteed feed-in remuneration, etc.).
- Experimentation clauses are required in the short term, if the implementation of the SIP reform is delayed.
- They are going to push for a faster expansion of renewable electricity generation capacities (offshore and onshore wind power and photovoltaics) to provide for the necessary conditions for producing green hydrogen.

Detailed requests have been addressed in various ways in recent years, for example in resolutions by the Federal Council, the Conference of Ministers of Economics, the Conference of Environmental Ministers, the Conference of Ministers of Economics and Transport for the North German Coastal States (KüWiVerMinKo) or in the “Wind energy appeal”. The North German States are going to submit further specific change requests to the federal government and the EU in due course (see Appendix 2).

9. Monitoring, reporting, controlling

Planning provides for an annual brief report of the latest progress in establishing a hydrogen economy in North Germany and the implementation of the targets described in this strategy to be presented to the Ministers and Senators of Economics and Transport for the Coastal States. The standing agenda item ‘Hydrogen’ is therefore going to be adopted for the KüWiVerMinKo for the time being. The standard implementation report should cover three focus areas:

- What substantial progress can be reported for the reporting period in establishing a hydrogen economy?
- In which areas are there challenges that must be met and are not foreseeable at this point?
- Which further steps are planned? Who will implement them and by when? (updating and amendment of appendices)

The Hydrogen Strategy for North Germany shall be fully revised by 2025. Such update shall cover the contents of the annual reports, as well as full stock-taking of the targets reached to date, a critical review of the mission statement and targets, and the definition of new interim targets (see Appendix 2).

10. The next steps

Essential milestones within the next six months include:

1. The Hydrogen Strategy for North Germany shall be presented to the KüWiVerMinKo for approval. It will then be published in a suitable format.
2. Along with the decision that is to be made by the KüWiVerMinKo, the strategy shall be submitted to the federal government.
3. The Hydrogen Strategy for North Germany will be provided to the KND for acknowledgement in spring 2020.
4. The spokespersons of existing networks, initiatives, etc. shall be invited for a first meeting by the end of the first quarter of 2020, for discussing the future structure for handling the fields of action.

Appendix 1: Fields of action – the first tasks, rough timeline

This strategy outlines the first implementation steps in four fields of action, as well as rough timelines:

- Field of action “Hydrogen infrastructure”,
- Field of action “Creating value with hydrogen”,
- Field of action “Hydrogen in guidelines, licensing practice and programmes”,
- Field of action “Hydrogen acceptance and education”.

The interested stakeholders from the areas of business, science and public administration shall identify suitable structures for handling these fields of action together. The “North German Hydrogen Coordination Group” is going to organise and moderate this process.

Hydrogen Strategy for North Germany

Field of action “Hydrogen infrastructure”	Realisation by
Hydrogen hubs	
Developing a catalogue of selection criteria for suitable locations for hydrogen hubs, based on the requirements of the Hydrogen Strategy for North Germany.	End of 3rd quarter 2020
Identifying suitable locations for North Germany’s first hydrogen hubs, by means of the defined criteria.	End of 1st quarter 2021
Contacting potential partners on the supply and demand side, investors and licensing authorities, encouraging investors with regard to the creation of hydrogen hubs.	End of 2nd quarter 2021
Multi-modal service stations	
Recording current demand volumes of hydrogen used in the area of mobility (part of stock-taking); this could be based, for example, on the volumes delivered by the hydrogen refuelling stations in North Germany in 2019.	End of 3rd quarter 2020
Estimating the demand volume that is to be expected for hydrogen used in the area of mobility in 2025.	End of 1st quarter 2021
Drawing conclusions for future dimensions and the distribution of refuelling infrastructure based on expected demand volumes. Developing proposals for suitable locations for multi-modal hydrogen service stations in North Germany in coordination with H2 MOBILITY.	End of 2nd quarter 2021
Contacting vehicle manufacturers, outlining the expected demand volumes of hydrogen used in the area of mobility in North Germany in 2025, and advocating for the provision of sufficient numbers of vehicles and suitable vehicle types.	End of 3rd quarter 2021
Import and pipeline infrastructure	
Consulting with the industry regarding <ul style="list-style-type: none"> - Current demand volumes for green and other hydrogen used in the industry (part of stock-taking) - Future demand for hydrogen (volume and time) The ChemCoast study (2013) might be used as a basis.	End of 3rd quarter 2020
Drawing up a proposal for funding, if external support is to be sought for upcoming tasks.	End of 3rd quarter 2020
Determining a tiered quantity structure based on demand estimates for hydrogen over time, and deriving the demand of renewable energy generation capacity based on this (with external support if needed).	End of 1st quarter 2021
Estimating (with external support if needed) the share of the renewable electricity generation capacities required for hydrogen production that can be created in Germany, and the volumes that will need to be covered through imports including the expected timeline.	End of 2021
Drawing conclusions (with external support if needed) regarding the required dimensions of import structures.	End of 2022
Drawing conclusions (with external support if needed) regarding the necessity and possible suitable routes of hydrogen pipelines.	End of 2022

Hydrogen Strategy for North Germany

Field of action “Creating value with hydrogen”	Realisation by
Location, settlement and marketing concept	
Preparing an overview of companies based in North Germany that are active in the value creation areas of facility, component and vehicle production (part of stock-taking).	End of 3rd quarter 2020
Identifying high-priority industries based on this overview, which should be particularly addressed in the context of a settlement concept.	End of 4th quarter 2020
Drawing up a proposal for funding for the preparation of a concept.	End of 4th quarter 2020
<p>Drawing up a location, settlement and marketing concept under the working title “Strengthening the hydrogen location of North Germany” (with external support if needed), addressing the issues</p> <ul style="list-style-type: none"> - How existing local industries and sites can be supported and further strengthened - How further companies from the value creation areas of facility, component and vehicle production can settle successfully - How North Germany’s commitment and location advantages with regard to establishing a hydrogen economy (these should be developed further based on the facts outlined in this strategy) can be communicated and marketed nationally and internationally. <p>The concept shall be presented to the KüWiVerMinKo 2021 for approval.</p>	End of 2nd quarter 2021
Cooperation	
Establishing a suitable form of cooperation with interested partners from the neighbouring region of the northern Netherlands, with involvement of business development organisations and network agencies.	End of 4th quarter 2020
Reviewing whether and with whom further cooperations and activities (e.g. jointly organised events, application for joint research projects) may be expedient. Possible partners from today’s view are in particular Brandenburg, North Rhine-Westphalia and France.	End of 2021
Reviewing, whether (business) representatives from the other northern states or from cooperating regions can take part in delegation trips by North German politicians concerning the issue of hydrogen, or if a joint delegation trip might be an option.	Ongoing

Field of action “Hydrogen in guidelines, licensing practice and programmes”	Realisation by
Guidelines	
Reviewing, whether the North German States’ procurement guidelines for vehicles of the state-owned fleets are designed to <ul style="list-style-type: none"> - Ensure that the minimum quotas provided in the Clean Vehicles Directive are met - Enable the acquisition of hydrogen-powered vehicles as an equitable alternative. 	End of 3rd quarter 2020
Compiling best practice examples as sample guidelines and providing these to the North German procurement offices as orientation.	Ongoing
Reviewing, whether other award guidelines in the North German States already facilitate a use of hydrogen-based technologies (e.g. for electricity and heat provision for events, use of hydrogen fuel cells for uninterrupted electricity supply, linking the awarding of concessions to emission criteria).	End of 3rd quarter 2020
Drawing up proposals, if needed, for ensuring (e.g. via the design of tendering procedures and contracting) that <ul style="list-style-type: none"> - The minimum quotas according to the Clean Vehicles Directive are surpassed - Hydrogen technology qualifies for receiving a contract as an equitable alternative, and presenting these to the relevant committees for approval.	End of 4th quarter 2020
Checking, whether hydrogen-powered vehicles can be sourced jointly in the North German States.	End of 3rd quarter 2020
Licensing practice	
Exchange of experiences between the responsible licensing authorities in North Germany, regarding current approval processes for hydrogen facilities (e.g. refuelling stations, electrolysers), checking whether licensing practice can be optimised. The experiences of project sponsors should be taken into account in a suitable manner.	End of 3rd quarter 2020, and regularly thereafter
Compiling best practice examples and providing these to the North German licensing authorities as orientation, if applicable.	Ongoing
Technical standardisation	
In the relevant committees, the North German States advocate for a quick harmonisation of technical standards.	Ongoing
Funding programmes	
Preparing an overview of all relevant funding programmes that are currently applicable for hydrogen projects along the entire value creation chain (part of stock-taking). This overview shall be updated on a regular basis in the future.	End of 3rd quarter 2020
Exchange regarding the demand for such funding options and practical usability of funding programmes. The experiences of project sponsors should be taken into account in a suitable manner.	End of 3rd quarter 2020
Reviewing, whether and in which form the issue of hydrogen / hydrogen-based technology is already considered in North German funding programmes along the entire value creation chain, and, if applicable, how this could be reinforced.	End of 3rd quarter 2020
Preparing suggestions, if necessary, for suitable adjustments to existing funding programmes, which are then presented to the responsible committees for approval.	End of 4th quarter 2020
Preparing suggestions for adopting corresponding options in favour of hydrogen projects in future programmes, for example in the context of the OP ERDF 2021-2027.	End of 4th quarter 2020

Field of action “Hydrogen acceptance and education”	Realisation by
Website	
<p>Determining, whether a joint website on the subject of hydrogen in North Germany should be set up. Suitable information to be published on such a page could include (exemplary list):</p> <ul style="list-style-type: none"> - Information about hydrogen technology (e.g. various application options for hydrogen, and its potential for contributing to the energy transition and to climate protection) - Political resolutions etc. relating to hydrogen on the state, national and EU level (e.g. Hydrogen Strategy for North Germany, National Hydrogen Strategy and those of individual states) - Working results from the fields of action and other networks, initiatives, etc. that are suitable for publication, e.g. stock-taking regarding hydrogen in North Germany - Information about events - Information about safe handling of hydrogen - Information about current studies, reports, research results 	End of 3rd quarter 2020
Drawing up a proposal regarding the ongoing updating and funding of the website.	End of 3rd quarter 2020
Public relations work and promotions	
<ul style="list-style-type: none"> - Collecting ideas for further suitable forms of joint public relations work for the Hydrogen Strategy for North Germany and hydrogen technology in general. - Determining, which of the collected ideas should be jointly realised by the five North German States. - If applicable, drawing up a proposal for funding. - Presenting corresponding proposals to the “North German Hydrogen Coordination Group”. 	End of 3rd quarter 2020
<ul style="list-style-type: none"> - Collecting ideas for possible forms of participation to promote acceptance, e.g. North German hydrogen day with hands-on activities (‘touchable’ hydrogen), community electrolysers as cooperative or crowd funding models. - Determining, which of the collected ideas should be jointly realised or supported by the five North German States. - If applicable, drawing up a proposal for funding. - Presenting corresponding proposals to the “North German Hydrogen Coordination Group”. 	End of 3rd quarter 2020
Curricula	
Drawing up an overview of the extent and depth at which the subject of hydrogen is already part of curricula for school and university teaching, vocational training and professional training in the North German States (part of stock-taking).	End of 4th quarter 2020
If applicable, developing proposals for making the subject of hydrogen a fixed part of school education and suitable vocational and professional training courses. Particular emphasis shall be placed on suggestions for training programmes for licensing authorities and other institutions (e.g. funding banks), in the first step.	End of 2nd quarter 2021

Appendix 2: Coordination Group – the first tasks, rough timeline

“North German Hydrogen Coordination Group”	Realisation by
Monitoring, reporting, controlling of the strategy	
Monitoring of the achievement of goals and work in the fields of action, updating the appendices, related reporting and the provision of any draft resolutions to the KüWiVerMinKo.	Annually for the KüWiVerMinKo
Submitting the Hydrogen Strategy for North Germany to KND, possibly annual presentation of the implementation report that is prepared for the KüWiVerMinKo.	May 2020 + annually if applicable
Revising and updating the Hydrogen Strategy for North Germany.	2025
Coordination	
Coordinating political reconciliation of the North German States.	Ongoing
<ul style="list-style-type: none"> - Inviting spokespersons of existing networks, initiatives, working groups etc. to a first meeting. - Identifying suitable structures for addressing the fields of action at the meeting, possibly delegating the first tasks to stakeholders. - A cooperation between the networks managed by the participants themselves shall be encouraged in dialogue with the partners. University and research networks in particular should be motivated to conduct joint research regarding hydrogen-related subjects, and to reinforce research and teaching competence in this field. 	End of 1st quarter 2020
Stock-taking	
Preparing an overview of the active networks, initiatives, research and working groups that exist in North Germany (part of stock-taking).	End of January 2020
Compiling suitable work results from the fields of action to illustrate the status quo.	End of 1st quarter 2021
Dialogue with the federal government	
Starting joint initiatives and presenting proposals in consultation with experts and associations, regarding improvement options for the regulatory framework for sector coupling, and therefore for the establishment of the hydrogen economy.	Ongoing
Establishing a dialogue with the federal government regarding the future National Hydrogen Strategy (NSW)	After the NSW has been presented