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OVERVIEW OF THE **HYDROGEN STRATEGY** OF THE FEDERAL STATE OF BREMEN

Ministry of Economic Affairs,
Ports and Transformation



**Free
Hanseatic City
of Bremen**

ENERGY CONSUMPTION AND EMISSIONS 2019

Structure of energy consumption	in TJ	in TWh
Primary energy consumption	143,153	39.8
Losses, differences etc.	36,930	10.3
Final energy consumption	106,223	29.5

Energy consumption by fuel	in TJ	in TWh	as a %
Coal	28,303	7.9	26.6
Lignite	2,287	0.6	2.2
Oil/oil-based products	24,350	6.8	22.9
Natural gas	23,491	6.5	22.1
Other gases	6,002	1.7	5.7
Electricity	16,225	4.5	15.3
District heating	3,892	1.1	3.7
Renewable energies	1,672	0.5	1.6
Total	106,222	29.5	100

Energy consumption by sector	in TJ	in TWh	as a %
Manufacturing	56,822	15.8	53.5
Households, commerce, trade, services	29,734	8.3	28.0
Transport	19,666	5.4	18.5
Total	106,223	29.5	100

CO ₂ emissions from final energy consumption (originator balance)*	in million tonnes	as a %
Manufacturing	5.1	58.6
Households, commerce, trade, services	2.2	25.5
Transport	1.4	15.9
Total	8.8	100
Electricity share	1.8	20.2

TRANSPORT AND TRAFFIC 2019

- approx. 38 million tonnes of cargo handled by maritime transport
- approx. 32 million tonnes of cargo handled for hinterland transport
- approx. 3 million trucks for hinterland transport
- approx. 36,000 trains for hinterland transport
- approx. 7,200 barges
- approx. 7,000 seagoing vessels
- approx. 14,700 take-offs at Bremen airport

* CO₂ emissions based on the originator balance. Includes emissions of final energy consumption in the state.
The source balance includes all CO₂ emissions generated in the state, including exported electricity, for example.

Statistical Office of the State of Bremen, Statistical Yearbook 2021, pages 354-358; https://www.statistik.bremen.de/sixcms/media.php/13/Jb2021_pdfa.pdf

OVERVIEW OF THE HYDROGEN STRATEGY OF THE FEDERAL STATE OF BREMEN

Bremen’s road map for the transformation of its key industries and the contribution for CO₂ emission reduction through hydrogen technologies

INITIAL SITUATION

Bremen is one of the top 10 industrial locations in Germany. For this reason, the state of Bremen has above-average CO₂ emissions in relation to its economic output and population size. Per capita, this is about twice the national average. Special efforts are therefore needed to reduce CO₂ emissions. For this purpose, the state of Bremen has set the necessary framework for the transformation to a climate-silent state of Bremen with net zero CO₂ emissions with the establishment of an Enquete Commission „Climate Protection Strategy for the State of Bremen“ in 2020 and the adoption of the resulting Climate Protection Strategy 2038 in 2023. At the same time, the transformation process is to be used to build sustainable and competitive economic, industrial and transport structures in Bremen.

One route through which CO₂ reduction is to be achieved is the development of a green hydrogen economy. There are many industries in Bremen in which the so-called „green gas“ can find application. For this to happen, the corresponding infrastructures have to be built and the concrete technologies still have to be developed or scaled for the corresponding end application.

FRAMEWORK AND MILESTONES

- 2019 North-German Hydrogen Strategy
- 2020 Establishment of the Committee for the Climate Protection Strategy in the State of Bremen
- 2020 Hydrogen Strategy for a Climate-Neutral Europe
- 2021 Innovation Strategy State of Bremen 2030
- 2021 Hydrogen Strategy State of Bremen
- 2021 Hydrogen Strategy for the Northwest Metropolitan Region
- 2023 Climate Protection Strategy 2038 of the State of Bremen

In recent years, strategies have been adopted at EU, national, regional and local level to provide a robust roadmap to realise the potential of hydrogen as a climate-neutral energy carrier: The German government and the EU both published their strategies in 2020. In association with the northern German coastal states, Bremen has already (co-)formulated a strategy in 2019, the North German Hydrogen Strategy. Due to the special importance of the hydrogen economy for the state of Bremen and in order to formulate and delineate its needs and strategic orientation in detail, it has drawn up its own, the hydrogen strategy of the state of Bremen. It complements the state’s innovation strategy and is set in the context of strategies at the northern German, national and European levels.

Highlight

Bremens Industrial Transformation
The core – green steel made in Bremen

- A step by step decarbonization of steel production through coal substitution, direct reduced iron and electric arc furnaces

Cross-sectoral approach

- Hydrogen use in heavy industry, logistics and mobility
- Joint transformation process of industrial, scientific and public partners

Infrastructure for transformation

- Large scale electrolyzers (up to 300 MW)
- Hydrogen backbone and cavern storage
- High Voltage grid for connecting renewable energies

It defines five concrete fields of action, highlights the accompanying major projects and derives from them concrete strategic activities, goals and milestones for the periods up to 2025/26 and 2035.

STEP TOWARDS A BREMEN HYDROGEN ECONOMY

Specific goals until 2025/26

- > Steelworks: increase in electrolysis capacity beyond 10 MW aiming for 100 MW. Steelwork and mobility applications are supplied with hydrogen
- > Steelworks uses hydrogen for a direct reduction blast furnace and an electric arc furnace
- > IPCEI projects implemented or close to completion
- > electrolyser test field in Bremerhaven has started full-scale operation (10 MW) and is a nationally recognised provider
- > Necessary port infrastructures in the hydrogen sector have been identified
- > Hydrogen-powered vehicles municipal and port transport reach fleet share 10%
- > Capacity building: Networking with the region takes place in established structures and training / further education offers exist

Specific goals until 2030

- > Steelworks: Electrolyser capacity expanded to 300 MW and pipeline connection to Huntorf storage facility in place
- > Bremerhaven test field operates 1 MW seawater electrolysis plant and a pilot plant for bio-methanol
- > Maritime: Construction of Zero Emission Ship
- > Aviation: Zero Emission Aircraft Competence
- > Fire Safety Certification Centre (FSCC) for aviation in operation for cross-sector use
- > Establishments in the hydrogen sector

The fields of action

1. steel industry
2. research and research infrastructure
3. aerospace field of action
4. ports field of action
5. logistics and transport field of action

Major projects as initial impulse generators

- > IPCEI projects DRIBE2, Clean Hydrogen Coastline, Hyperlink, WopLin
- > hyBit / HyBit
- > Innovation and Technology Centre Aviation/Maritime (ITZ Nord)
- > Hydrogen – Green Gas for Bremerhaven

Using the strengths and opportunities of the location

Political framework regional / Northern Germany, national, international / EU

THE OVERARCHING GOALS OF THE HYDROGEN STRATEGY FOR THE STATE OF BREMEN

To contribute to CO2 reduction and the transformation of the economy.

To contribute to the success of measures at the North German, national and European level, to use it strategically, and to contribute to the development of national and European funding opportunities.

To contribute to a common understanding of the initial situation and to define goals, to further develop measures that have already been started and to prepare additional ones.

INITIAL SITUATION AND FRAMEWORK CONDITIONS



Research and Technology Centre ECOMAT

Using the

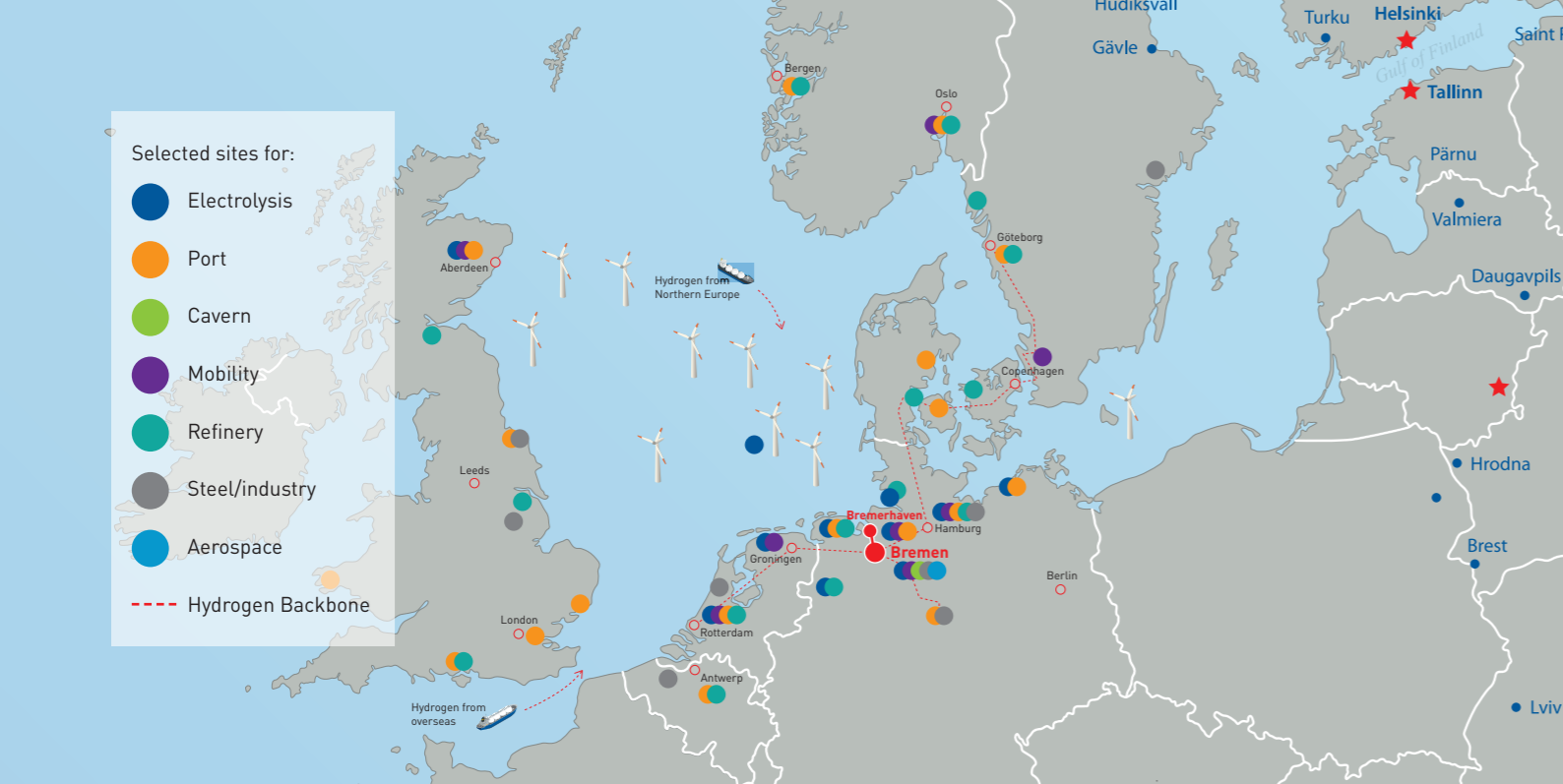
STRENGTHS AND OPPORTUNITIES of the location

The location of Bremen and Bremerhaven in the region of north-west Germany and the industrial and scientific competences in the two cities offer unique opportunities for the regional production as well as distribution and use of green hydrogen:

- Industries and maritime companies already have experience as well as considerable potential in the field of hydrogen.
- Ports serve as transport hubs as well as logistics and economic centres, in the future also for the import of hydrogen.
- Underground formations for hydrogen storage, connected to a pipeline system that is being converted from natural gas to hydrogen.
- Extensive competencies at universities and scientific research institutions specifically on hydrogen and in areas necessary for the hydrogen economy such as materials, simulations or logistics.
- Regional and supra-regional networking in business clusters, at the political level and in science.

As a logistics hub and industrial location, Bremen is embedded in economic sectors that can benefit greatly from a hydrogen transformation in the long term. The geographical conditions, i.e. the proximity to the coast, the proximity to the generation of renewable electricity and the ground structures for cavern storage, as well as the logistics infrastructure for national as well as international truck, rail and water transport, shape the current profile of the economy and, if used correctly, can drive transformation processes. The steel production at the location helps Bremen to have a good starting position, a reliable large-scale consumer of hydrogen on site and thus to be able to scale up the ramp-up of a hydrogen ecosystem more reliably.

Furthermore, there is great potential for innovation in the state of Bremen. Many relevant companies and research infrastructure with hydrogen applications as well as R&D are already located locally. With the continuation of coordination within the region and steering on the part of the state, Bremen will anchor its pioneering role in the long term (see Innovation Strategy of the State of Bremen). If technological innovations from the research sector are developed and established locally, this will be a trend-setting building block for securing the location.



Future scenario "Hydrogen Hanse"

MAJOR PROJECTS

as initial impulse generators

To support the ramp-up of the hydrogen economy, major projects in key sectors have been driven forward in the state of Bremen since 2020, with an investment volume of well over one billion EUR. The funding comes from the EU, the federal government and the state of Bremen itself. The so-called IPCEI projects (Important Projects of Common European Interest) deserve special attention here. They are a European instrument for promoting strategically important developments in industry and the economy in a way that complies with state aid. An IPCEI must contribute to the strategic goals of the European Union, be carried out by several Member States, provide for its own co-financing by the participating companies/institutions, have positive spill-over effects throughout the EU and pursue very ambitious goals in terms of research and innovation, i.e. go significantly beyond the international state of the art in the sector concerned.

For the hydrogen sector, over 60 such large projects have been selected in Germany. Four are also being implemented in the state of Bremen (see box). Funding is provided by the member states; in the case of Germany, 70% is provided by the federal government and 30% by the federal states. In addition to the IPCEIs, other large-scale projects are flanking the ramp-up of the hydrogen economy in the state of Bremen: the large-scale research project hyBit for scientific support of the transformation - managed by the University of Bremen and funded by the BMBF -, the first large-scale electrolyser HyBit with 10 MW at the steelworks - funded by the state of Bremen, the ITZ Nord in the field of aviation

and maritime economy - funded by the BMDV - and Hydrogen - Green Gases for Bremerhaven with the Hydrogen Lab - funded by the state of Bremen and the European Union. An up-to-date list of hydrogen projects in the state of Bremen can be found in a separate document and on the website of the Hydrogen Economy Office (<https://www.bremen-innovativ.de/green-economy/wasserstoff/>).

Major projects as initial impulse generators

- IPCEI-Project DRIBE – Direct Reduced Iron Bremen und Eisenhüttenstadt
- Former IPCEI-Project Clean Hydrogen Coastline
- IPCEI-Project WopLin – Hydrogen for Aviation Infrastructure and Production in North Germany
- IPCEI-Project Hyperlink
- hyBit – initial stimulus for developing a North German hydrogen economy
- Innovations- und Technology Centre Aviation/Maritime (ITZ Nord)
- Hydrogen – Green Gas for Bremerhaven

FIELDS OF ACTION

of the strategy

Steel industry

The concentration of CO₂-intensive heavy industry at the site results in great potential for savings in Bremen's industry. The ArcelorMittal steelworks in particular stands out here; this alone is responsible for about 50% of the emissions in the federal state. The efforts to reduce emissions, which are already underway, are correspondingly great. Two major projects, which are, however, causally connected, are being realised here at the same time. On the one hand, one of the two blast furnace roads is being rebuilt. This can then reduce the iron ore with gas instead of coal coke. Initially, this will be done with natural gas or a natural gas-hydrogen gas mixture, and if available, only with hydrogen. This conversion is being carried out in the project DRIBE2.

Analogously, in order to realise the availability of hydrogen at the site, the HyBit project, a large-scale electrolyser, which is 50% funded by the state of Bremen, is being built. This plant can cover part of the demand in the smelter and thus at the same time has a calculable large-scale consumer in the immediate vicinity. This holistic approach is what distinguishes the projects in the Bremen steel industry.



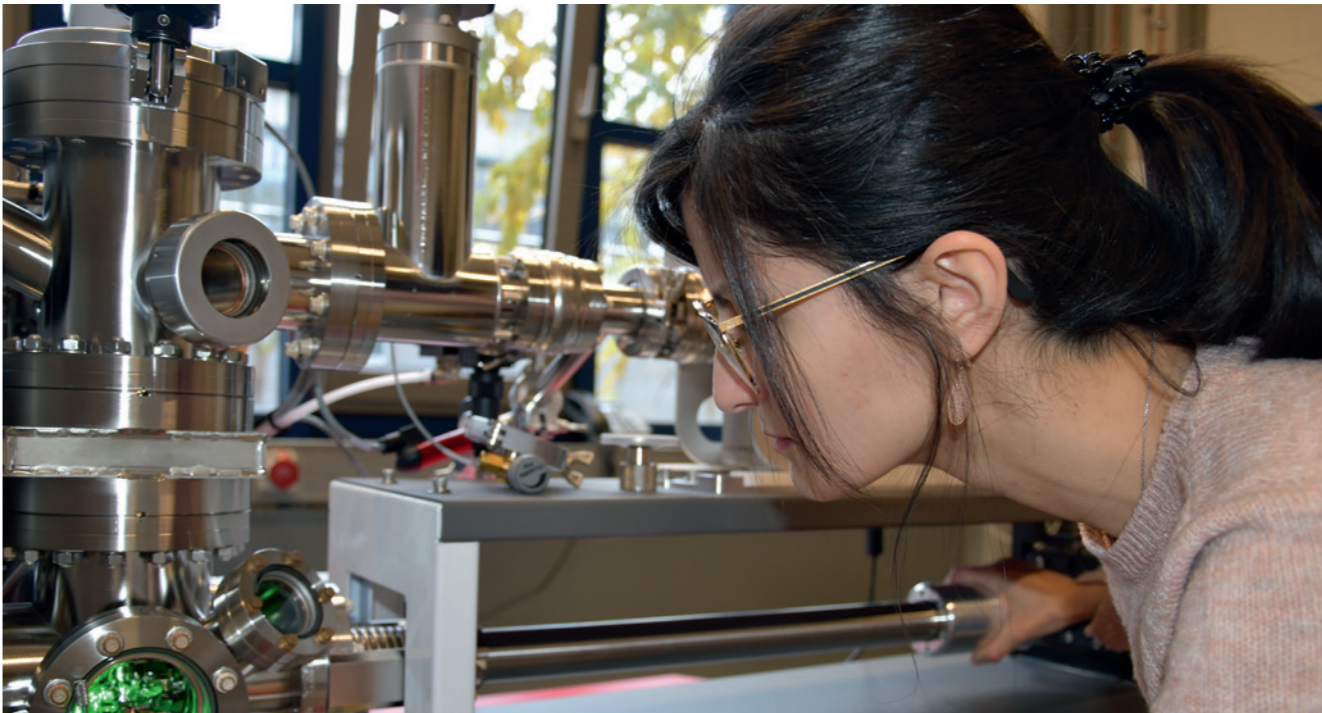
Steel production in Bremen

Research and Research Infrastructure

In the state of Bremen there is an enormous accumulation of competence in all research areas that are industrially important for hydrogen. At the university and the colleges, there are various institutes that deal with many important issues related to hydrogen and its integration into the economy. These include: BIAS, BIBA, BEST, ECOMAT, Faserinstitut, HS Bremen, HS Bremerhaven IFAM, ISL, ITZ Nord (H2AM), IWES, Leibnitz-IWT & ttz Bremerhaven.

This multitude of facilities unites unique innovation potential in Bremen and Bremerhaven and enables partners from industry to test and further develop their applications there.

Atom probe tomography at Leibniz Institute for Materials Engineering – IWT





Container terminal Bremerhaven



Production of hydrogen fuel cell HGV in Bremen



Vehicle of the Enginius Bluepower series by the Faun Group

FIELDS OF ACTION

of the strategy

Aerospace

This link between science and business is particularly evident in the aerospace sector. With Airbus, ArianeGroup and OHB, Bremen unites production facilities of heavyweights in this industry and, with ECOMAT, has created a research centre that is mainly oriented towards development projects in this industry. Airbus is developing a cryogenic H₂ propulsion system for flight applications as part of the IPCEI project WopLin. Airbus focuses on infrastructural issues of an H₂ air transport economy, part of which will be the Fire Safety Certification Centre (FSCC).



Hydrogen tanks in the future A380 ZEROe flight test demonstrator

Ports

Ports will be a central hub in the hydrogen economy. They are closely linked to the field of action logistics and transport, where the transfer of goods to the downstream modes of transport takes place. Due to the transport hub function and the economic activity of the resident companies, there is a wealth of possible applications for hydrogen and its derivatives, as well as further synergy effects. Hydrogen also has the potential to achieve climate-neutral port operation itself. In the long term, Bremen's and above all the supraregional demand for hydrogen can only be met from international sources. The opportunities and possibilities arising from this, as well as from the possible applications of hydrogen, for Bremen's ports are currently being examined in various contexts.

Highlight

Aerospace in Bremen

City of Aerospace Bremen: Here, 40 years of hydrogen expertise from the space industry meets aeronautics.

Our hydrogen expertise:

- ZEROe LH2 Development Centre by Airbus Bremen and Nantes with ECOMAT
- Reduction of air traffic impact on climate
- ArianeGroup's experience in space and cryo-hydrogen applications
- Comprehensive R&D infrastructure for hydrogen
- Design and construction of entire tank systems
- Engineering, testing and certification resources, such as fire test facility and a cryogenic laboratory
- Aviaspace Bremen connects

Highlight

Bremen Ports

PtX-production and Hydrogen import gateway

- Import-hub for hydrogen and derivatives
- Local production of green e-fuels
- Enabler for bunkering of hydrogen-based fuels

Specialist maritime technology

- Leading shipbuilding industry
- Dual-fuel propulsion with hydrogen and e-fuels
- Use of hydrogen and e-fuels

Furthermore, in a research and pilot project funded by the Federal Ministry for Digital and Transport (BMDV), the trial operation of an AWI ship running on H₂ derivatives has already begun; in addition to the functionality of the drive itself, investigations into the economic efficiency and scalability of the storage and transshipment possibilities of the derivative are also being tested. Furthermore, the ITZ Nord, a research centre for testing hydrogen technologies in maritime applications and for flight applications, is being built in Bremen and Bremerhaven (together with IWES and with funding from the BMDV).

Logistics and transport

In addition to its extensive port infrastructure, Bremen has the largest freight transport centre (GVZ) in Europe. In the course of this logistics consolidation, unique development potentials are opening up in this area. On the one hand, in the handling of goods in connection with the port industry, and on the other hand, in the operation of logistics in the

GVZ itself. Here, development potentials and application scenarios are being analyzed in a large-scale study that aims to break down the hydrogen economy as a complex network.

In the field of logistics, new ground is already being broken elsewhere; the truck retrofitter FAUN is already building H₂-powered medium-duty trucks in Bremen in small series. The automotive refueling infrastructure is also part of this field of action; in addition to the two stations currently in operation in Bremen City, another one is planned to be built in Bremerhaven in the course of 2023, and further refueling stations for Bremen City are in the planning stage. (IPCEI: Clean Hydrogen Coastline)

Training and skilled workers

Bremen developed a skilled Labour strategy with hydrogen related labour aspects as a main pillar. Furthermore Bremen is engaged in a joint strategic undertaking of the northern five german states the „north german hydrogen strategy“ and closely accompanies and supports the development process in the field of training and skilled labour. To strengthen Bremens ability to recruit and train skilled workers Bremen furthermore just hosted a dialogue forum where companies and state officials got together to deliberate and publicly highlight the importance of the adoption of new training schedules for the next generation of skilled work in the field of hydrogen. Bremen funds a training campus for exactly this purpose with its credit funded climate strategy fond. The training campus will be opening soon. The State of Bremen is activating additional resources to scientifically analyze the needs and requirements for future labourforce skill demands.

STRATEGIC ACTIVITIES

- Make the best possible use of funding opportunities and supplement with federal and EU state programmes, ensuring a solid regional hydrogen industrial base
- Establish clusters in the metropolitan region and networking in the North Sea-Baltic region
- Governance and monitoring for best implementation and information transfer
- Current planning for the Energy infrastructure of tomorrow is closely and actively monitored by the State of Bremen in order to give Bremens economy the best possible connection to the power highways of the future
- The need for skilled workers must be identified and vocational and academic education and training opportunities must be adapted and expanded accordingly
- Northern Germany and the state of Bremen have unique locational advantages for the development of a hydrogen economy. These are actively communicated within the framework of the initiative „HY-5 – Green Hydrogen Initiative of Northern Germany“, of the five northern German federal states
- Public relations and acceptance are needed if hydrogen is a broadly used commodity in the future, therefore Bremen hosts events to provide information and local participation
- The state of Bremen is working intensively on the necessary framework conditions to create stable conditions for the development of the hydrogen economy and, together with the other northern German states, is advocating the need for such framework conditions at federal and EU level



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