The Production of Green Hydrogen

FRIDAY, 12 MARCH 2021 9:00 – 10:30 (CET)

The Energy of the Future

Analyzing the challenges of producing green hydrogen and discussing industry outlooks.

GERMANY WORKS.

HY-5

Agenda

Opening Speech:

Thorsten Herdan (Federal Ministry of Economic Affairs and Energy)

Inspirational Speaker:

Heinrich Klingenberg (Hamburg Invest | Hydrogen Expert)

Power Briefs:

André Steinau (GP Joule | Head of Business Unit)

Dr. Oliver Weinmann (Vattenfall Innovation | Managing Director)

Dr. Saskia Greiner (Invest in Bremerhaven | Innovation Manager)

Dr. Geert Tjarks (EWE | Innovation Manager)

Dr. Mischa Paterna (APEX Technology | Managing Partner)

Q+A w/GTAI & HY-5 Investment experts

GERMANY WORKS. HY-5

HY-5

NORTHERN GERMANY

GREEN HYDROGEN INITIATIVE OF NORTHERN GERMANY


NORTHERN
GERMANY
Northern Germany: 5 strong federal states
Bremen
Hamburg
Mecklenburg-Vorpommern
Niedersachsen
Schleswig-Holstein

Most up and coming hydrogen region in Europe

Source: OECD 2019

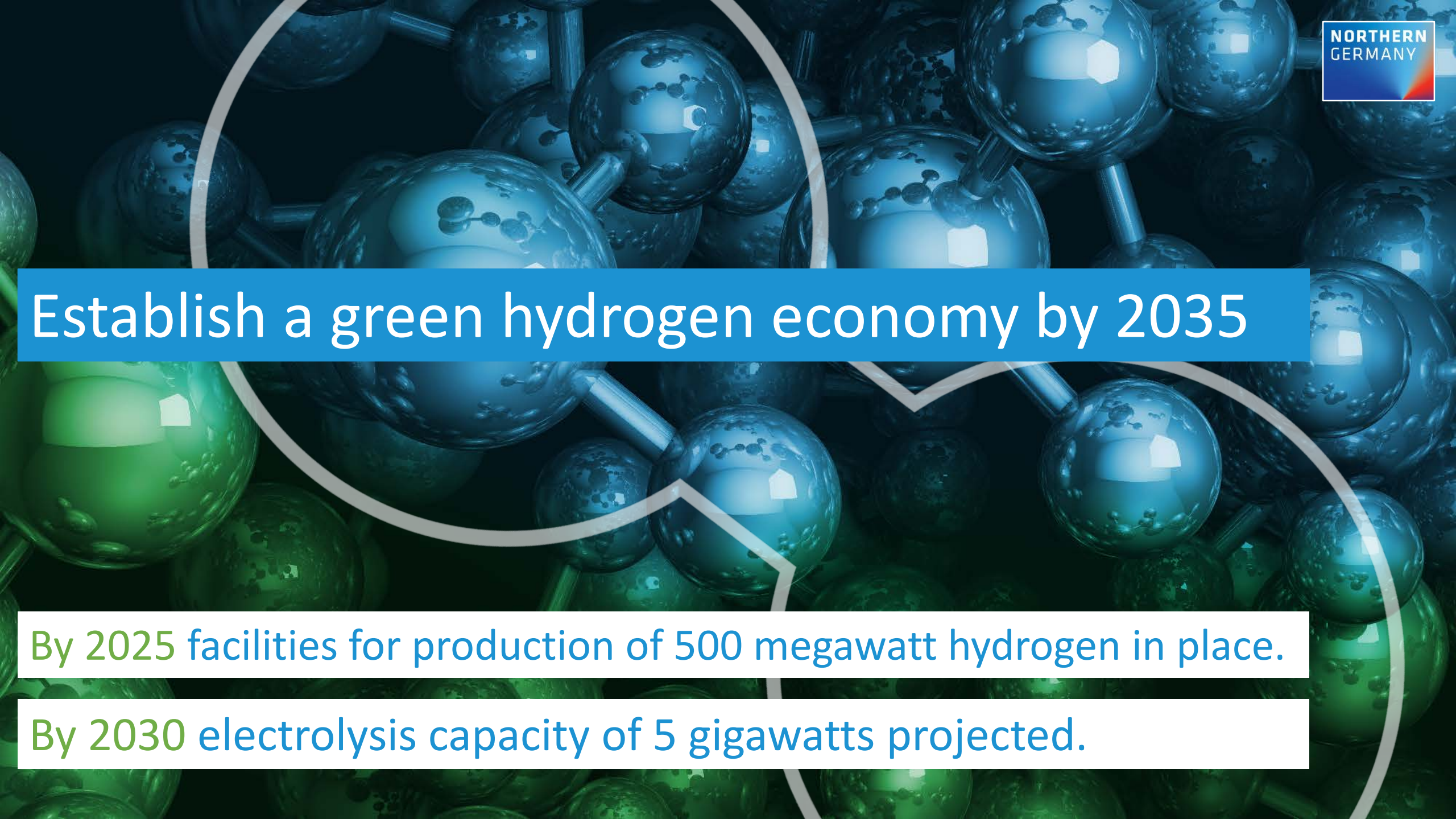
15 mio inhabitants

> 600 billion euro GDP.

Cradle of wind power 40 years of pioneering.

As large as the Netherlands and Denmark.

Close to the Netherlands, Scandinavia and UK.



Establish a green hydrogen economy by 2035

By 2025 facilities for production of 500 megawatt hydrogen in place.

By 2030 electrolysis capacity of 5 gigawatts projected.

Political and economic tail wind

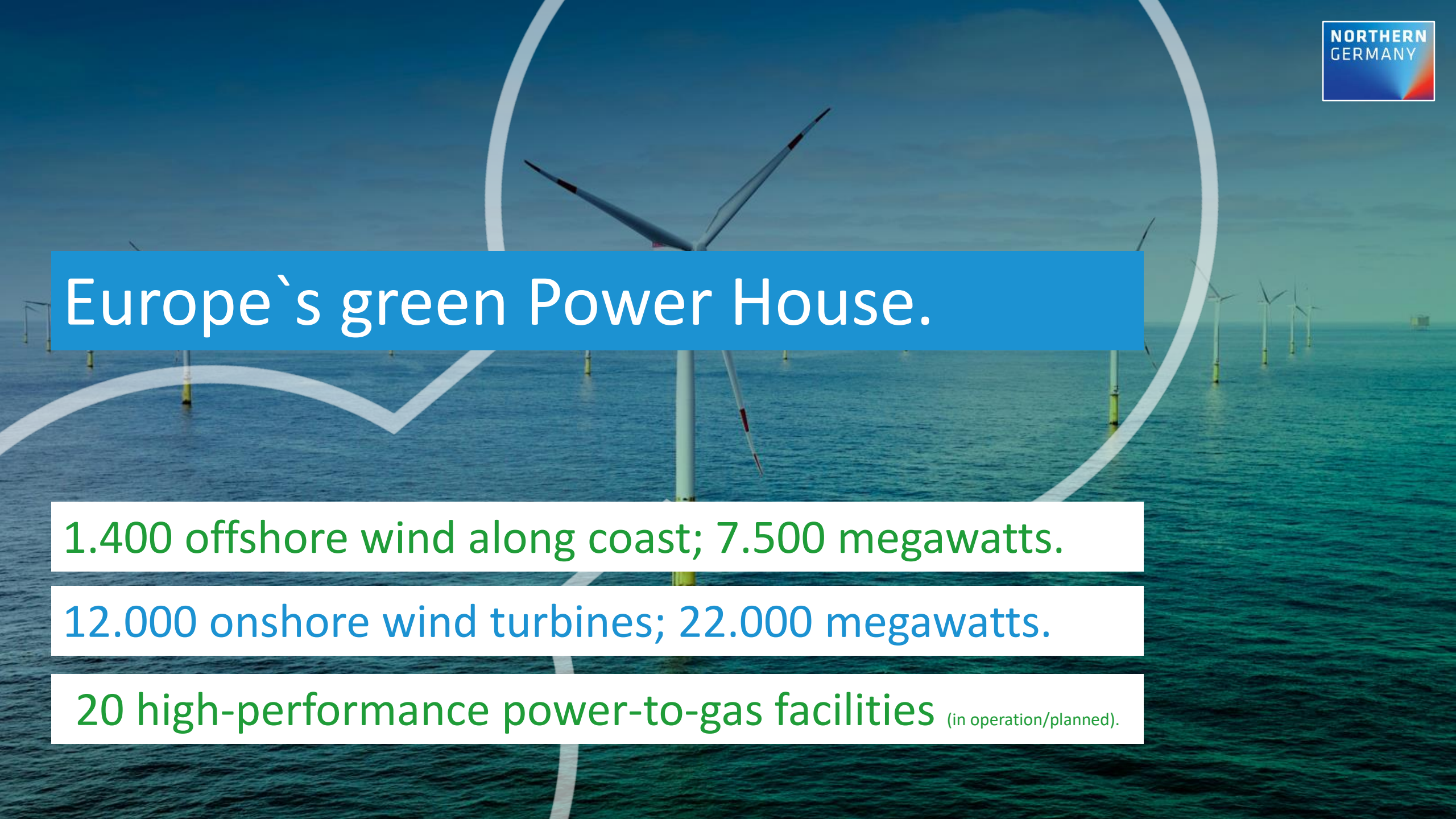
Economies of Scale through immediate industry demand.

German National Hydrogen Strategy: 9 billion Euro funding.

Northern German Hydrogen strategy of 5 Federal States.

Important Projects of Common European Interest (IPCEI).

Northern Germany has numerous advantages as a business location

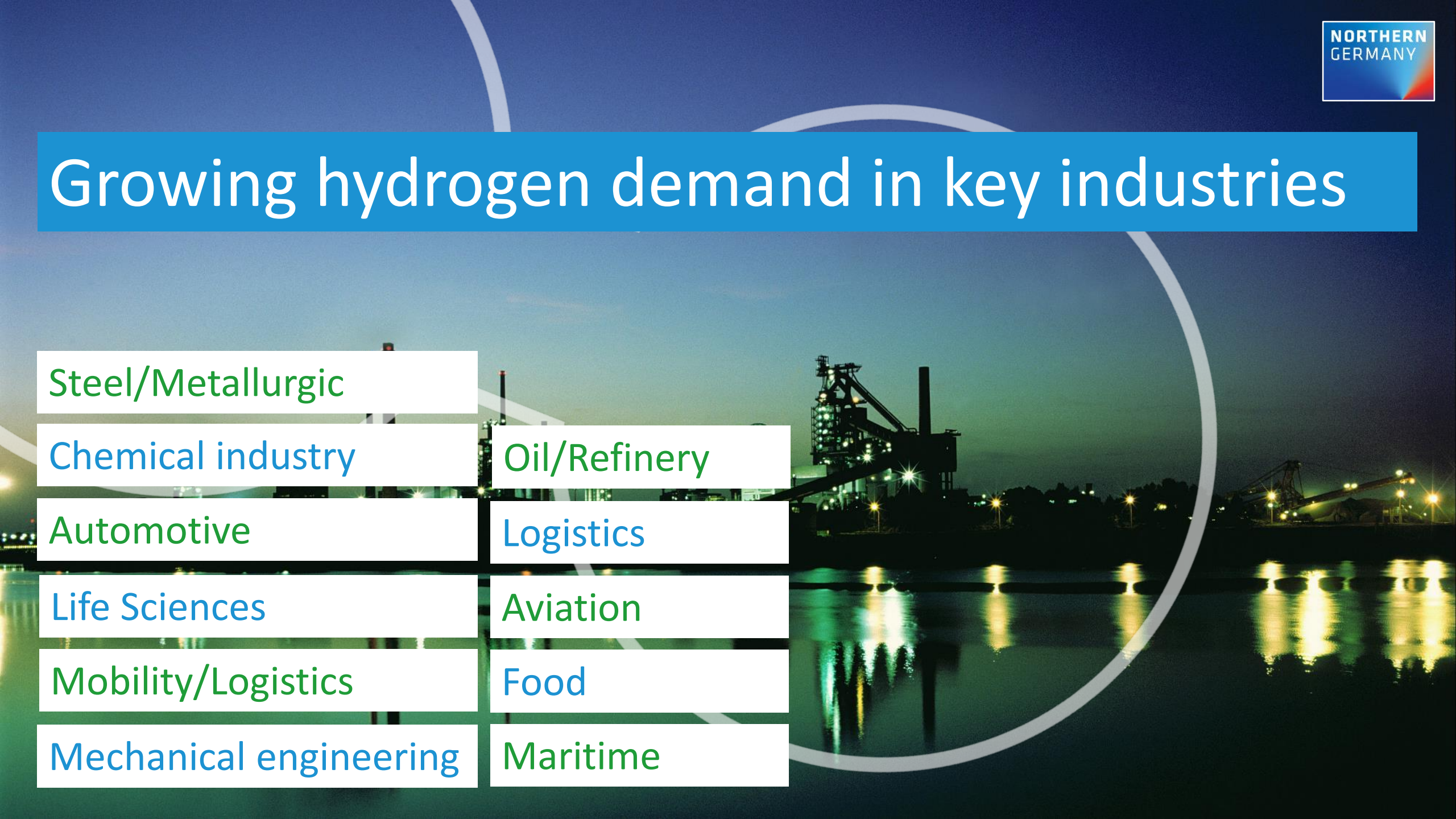


Europe`s green Power House.

1.400 offshore wind along coast; 7.500 megawatts.

12.000 onshore wind turbines; 22.000 megawatts.

20 high-performance power-to-gas facilities (in operation/planned).



Growing hydrogen demand in key industries

- Steel/Metallurgic
- Chemical industry
- Automotive
- Life Sciences
- Mobility/Logistics
- Mechanical engineering
- Oil/Refinery
- Logistics
- Aviation
- Food
- Maritime

Northern Germany is Europe`s logistic hub

More than a dozen seaports with logistics and import terminals.

Excellent port, rail and logistics infrastructure.

Kiel Canal is most frequented artificial seaway in the world.

Hamburg and Bremen as large universal ports.


Northern Germany is already on it`s way
to a self sustaining hydrogen economy.

Hamburg Energy Hub in Port

- 100 megawatts ++ Electrolyser – Green Energy Hub.
- 380 KV connection to high performance energy grid.
- Conversion of existing gas pipeline in port.
- Connection to pan-European gas/hydrogen network.
- Short distance to industrial demand in the area.

NORTHERN GERMANY

Westküste 100 project

Hydrogen economy on industrial scale.

Electrolysis, sector coupling, decarbonisation.

Sustainable heating, building, kerosene.

Electrolyser Bremerhaven

Most important applications for green gas.

Alternative fuels, mobility and logistics.

Sustainable food industry.

Hydrogen Center Rostock

Power-to-gas-facilities of the future.

Production, distribution and storage on industrial level

Worlds first hydrogen train

A visionary idea becomes reality

Operated and manufactured in Lower Saxony

More than 100.000 tons of green metals on hydrogen basis by 2025

H2H Hamburg, HyBit Bremen, SALCOS

Conversion to gas in steel already under way (next step: hydrogen)

Hydrogen in reduction of copper ore

Europe‘s think tank for the future of hydrogen

Fraunhofer, Helmholtz, DLR, universities within 200 km.

Hydrogen accelerator/incubator with industry support.

Norddeutsches Reallabor (+ 100 partners from industry, science, politics to demonstrate CO2 free energy supply).

And there is plenty of room for your project!

- Hydrogen Production
- Demand-Side
- Components
- Energy Sector
- Systems/Integration
- & ……..

In Northern Germany. For the world.

- Center of highest expertise
- Fully functioning network
- Strong political commitment
- Economies of scale
- Support with Funding, Akquisition
- Constant demand, different sectors

HY-5

GP JOULE
TRUST YOUR ENERGY.

The GP JOULE Group

Germany's largest green hydrogen mobility project - eFarm

GP JOULE in numbers

GP JOULE
TRUST YOUR ENERGY.

>750
MW Power plant capacity - installed since 2003
-

290
employees at 11 sites

>121
PV projects - implemented since 2009

54000
charging points in the CONNECT network

1 GW (p)
Operational management commercial/technical wind/solar

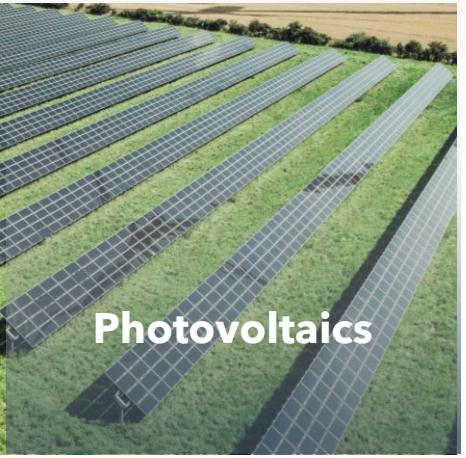
2009
founded

>14
wind farm projects - implemented since 2009

GP JOULE at a Glance

GP JOULE
TRUST YOUR ENERGY.

Services of the GP JOULE Group.



Green hydrogen for clean energy and mobility

Our solutions

The GP JOULE Group's THINK H2 business unit develops hydrogen ecosystems along the entire value chain:

- **Integration of** regeneratively generated electricity
- **Production of** green hydrogen by means of electrolysis at your site
- **Compression, storage and transport of** the hydrogen to the respective hydrogen filling station
- **Marketing** at hydrogen filling stations for vehicles such as buses, trucks, cars
- **Consulting on** hydrogen mobility solutions

Our reference project - eFarm

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Specificity of our project: Germany's largest green hydrogen mobility project in operation

eFarm maps the entire value chain from the production to the use of green hydrogen in mobility.

- Joint company with 20 shareholders
- 16 million euros of project volume

GP JOULE's services in this project:

- Concept development (from 2017)
- Project development (technical, commercial, legal)
- Realisation and construction
- Organisation of the operating company
- Financing and funding management
- Operations management (operational, technical and commercial)
- Commercialisation of the hydrogen

2
H2 filling stations

5
Production locations

1.125 MW
total output

100 %
Green hydrogen

2
Fuel cell buses

35
CAR

Building of the value chain

Hydrogen produce: Elektrolysis/compression at the wind park

Hydrogen transport: System of the transport

Hydrogen process: Building of a hydrogen filling station in Niebüll, efarm

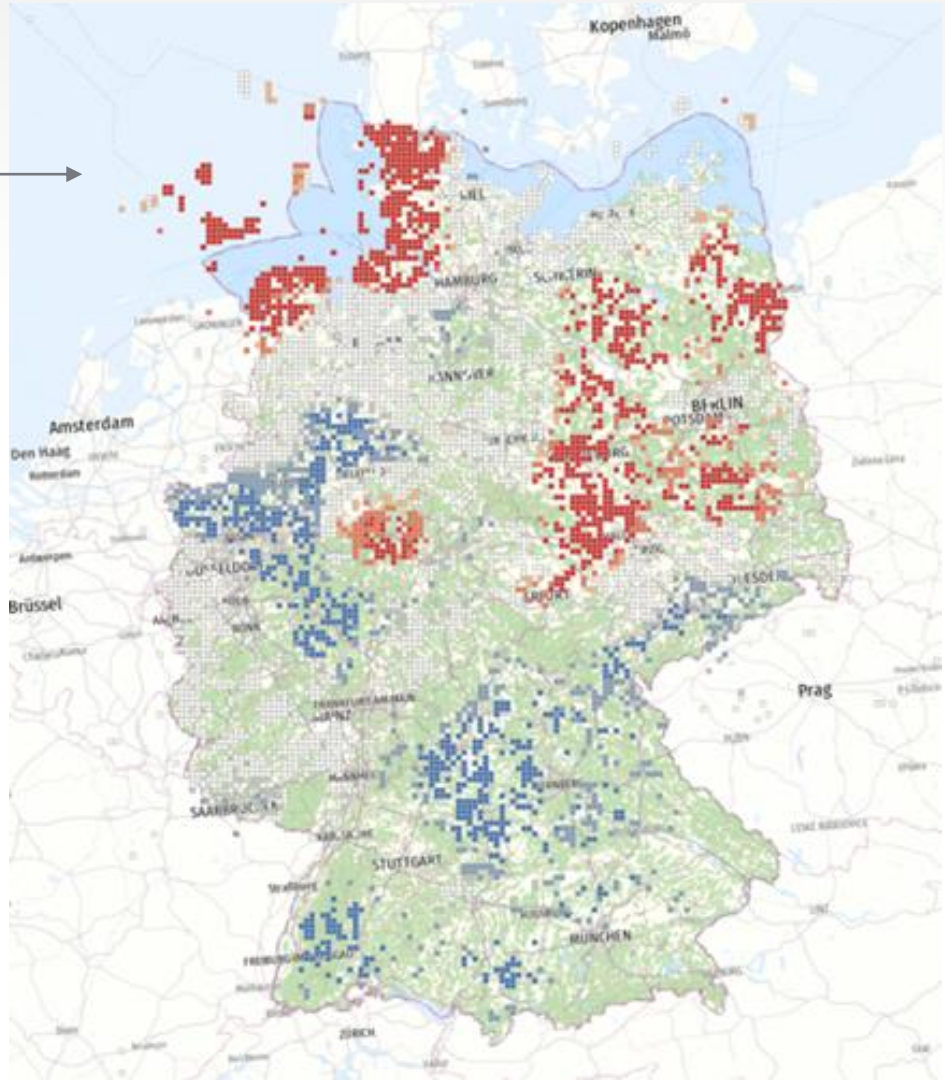
Hydrogen selling: 2 busses for public transport

Northern Germany as an investment location

HY-5 as a less expensive hydrogen production location

- Northern Germany offers ideal climatic conditions for a less expensive energy production
- More favourable to transport the refindes product (hydrogen) compared to the raw material
- Large and cheap storage options → caverns
- Perspectively transportation through pipelines possible

The HY-5 region has unique advantages for the production of renewable energies and a large demand potential for green hydrogen



Cluster of wind turbins in Germany, January 2021

Conclusion

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Northern Germany as a strong emerging region for green hydrogen

- Schleswig-Holstein introduces itself as a strong emerging region for green hydrogen and already presents solutions along the entire value chain for green hydron → eFarm
- Due to the ideal conditions Northern Germany has the properties to be a hotspot for green hydrogen in the centre of Central Europe

What does GP JOULE want to achieve?

- Establishment of further regional ecosystems to strengthen regional value creation from renewable energies in northern Germany
- Building a green hydrogen supply for the mobility sector, in particular for the application of commercial vehicles
- Our goal is to be able to offer 100% green hydrogen at competitive prices on the market. Through our projects, we want to provide the important impulses

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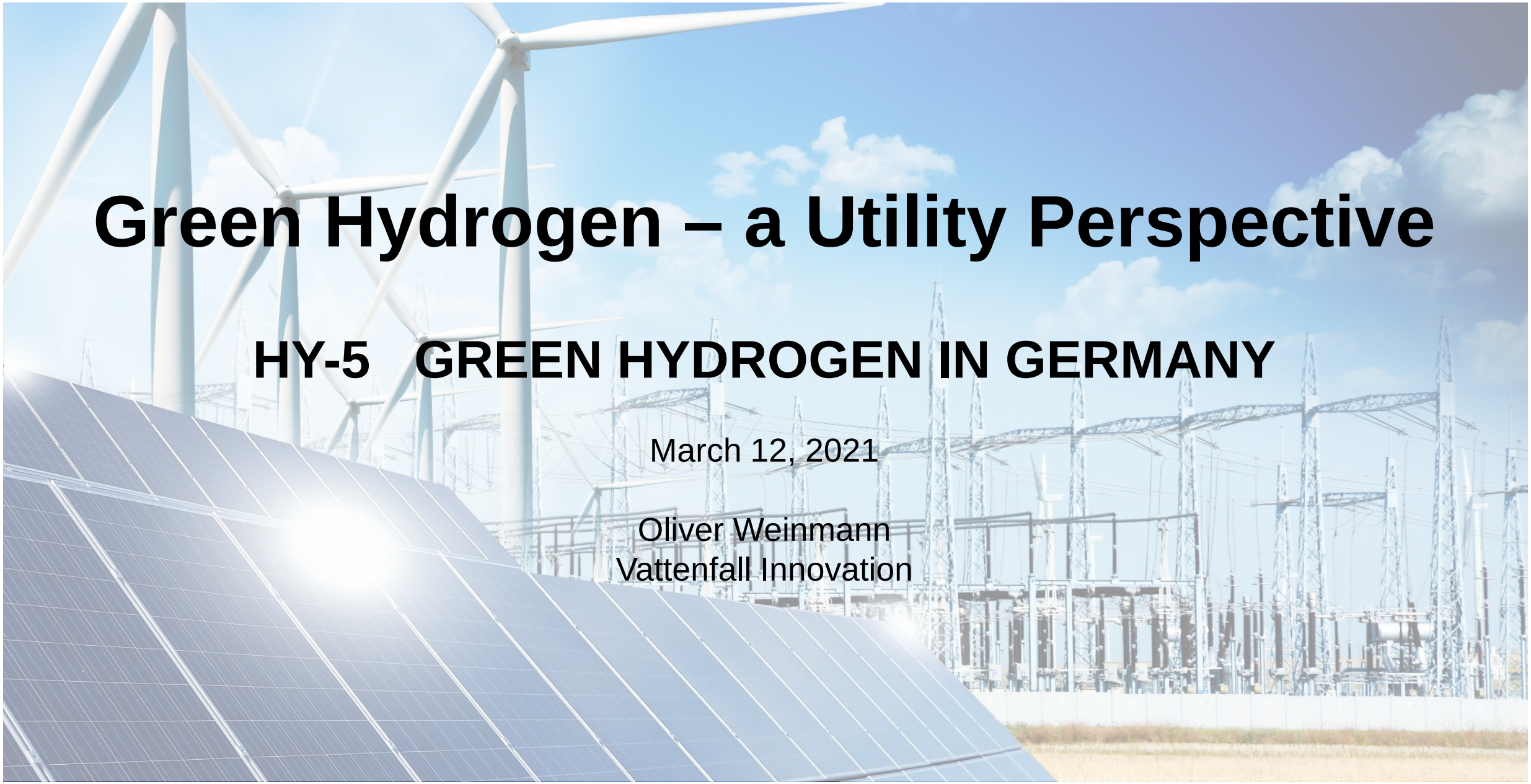
Thank you very much for your attention

Your contact

André Steinau
Head of Business Unit
THINK Hydrogen



Green Hydrogen – a Utility Perspective

HY-5 GREEN HYDROGEN IN GERMANY

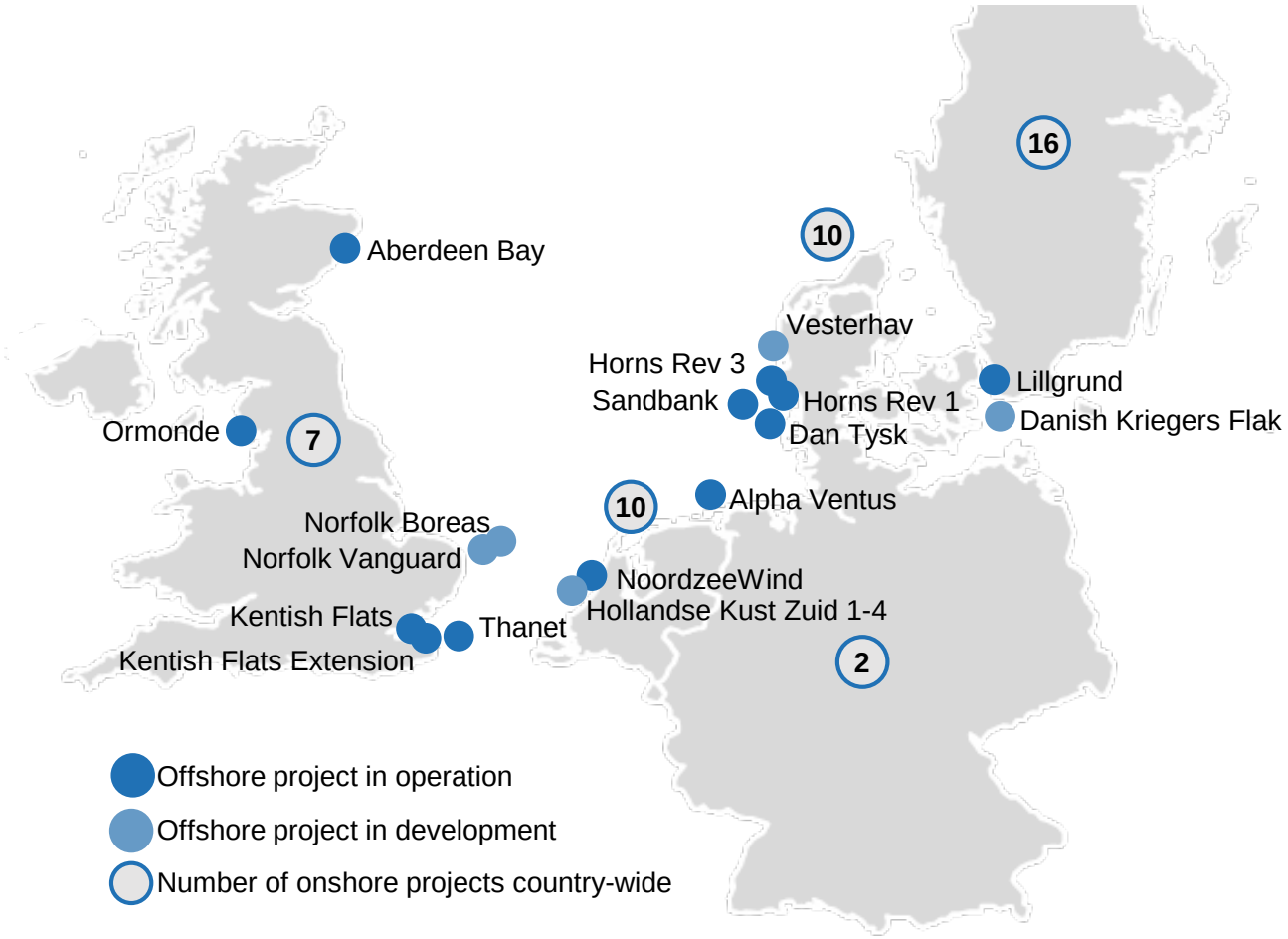
March 12, 2021

Oliver Weinmann
Vattenfall Innovation

VATTENFALL

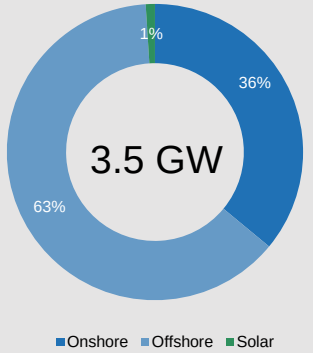
Vattenfall - significant growth in renewable power generation

Geographical overview

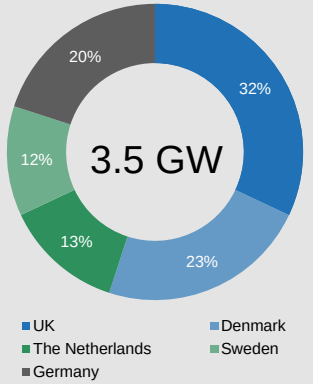


Operating assets

Split by type of generation



Split by geography



Under construction and pipeline

> 3 GW	Wind projects under construction
> 6 GW	Wind projects in development
> 1 GW	Solar projects in development
60 MW	Batteries pipeline

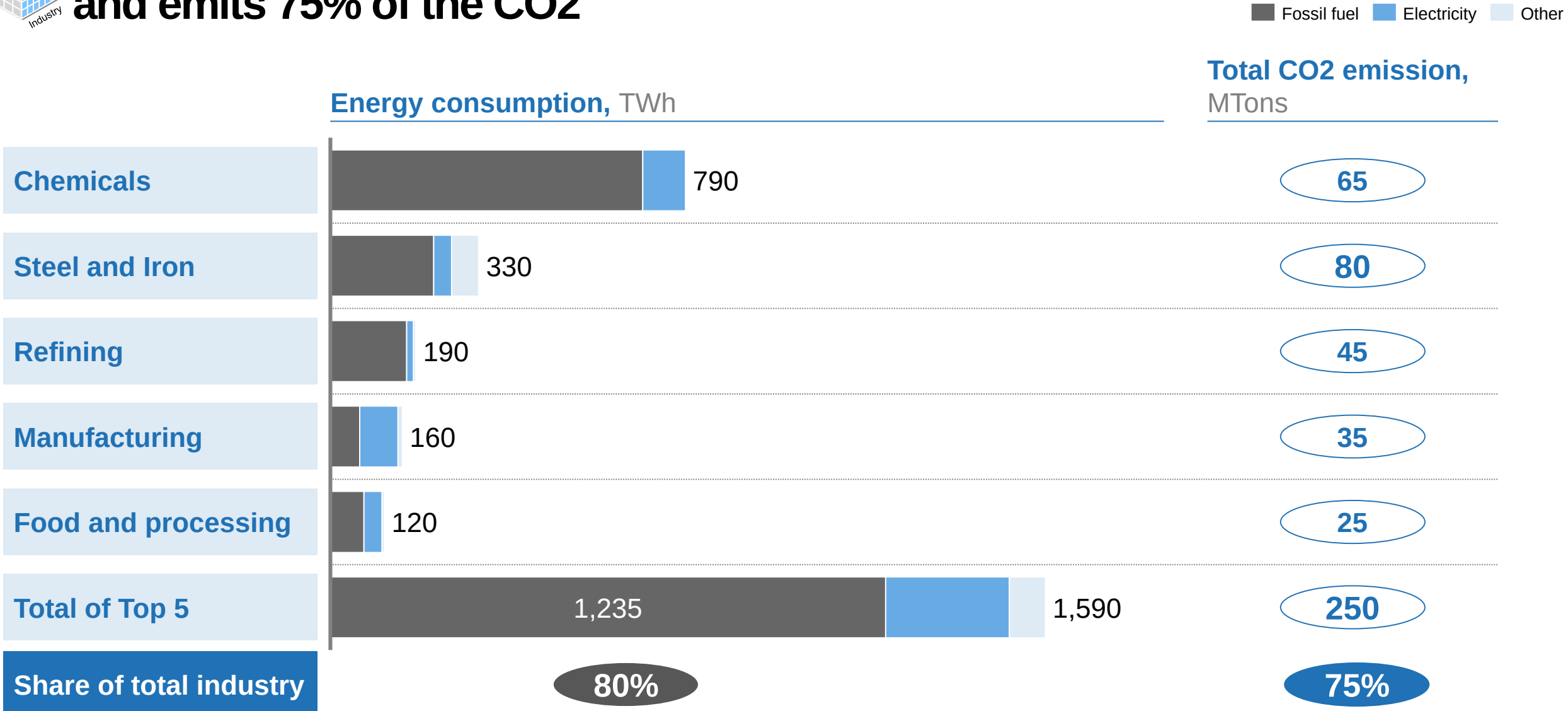
as of June 2020

Industrial Decarbonization

Sector coupling as key to decarbonize industry

Assessment on Vattenfall‘s core markets

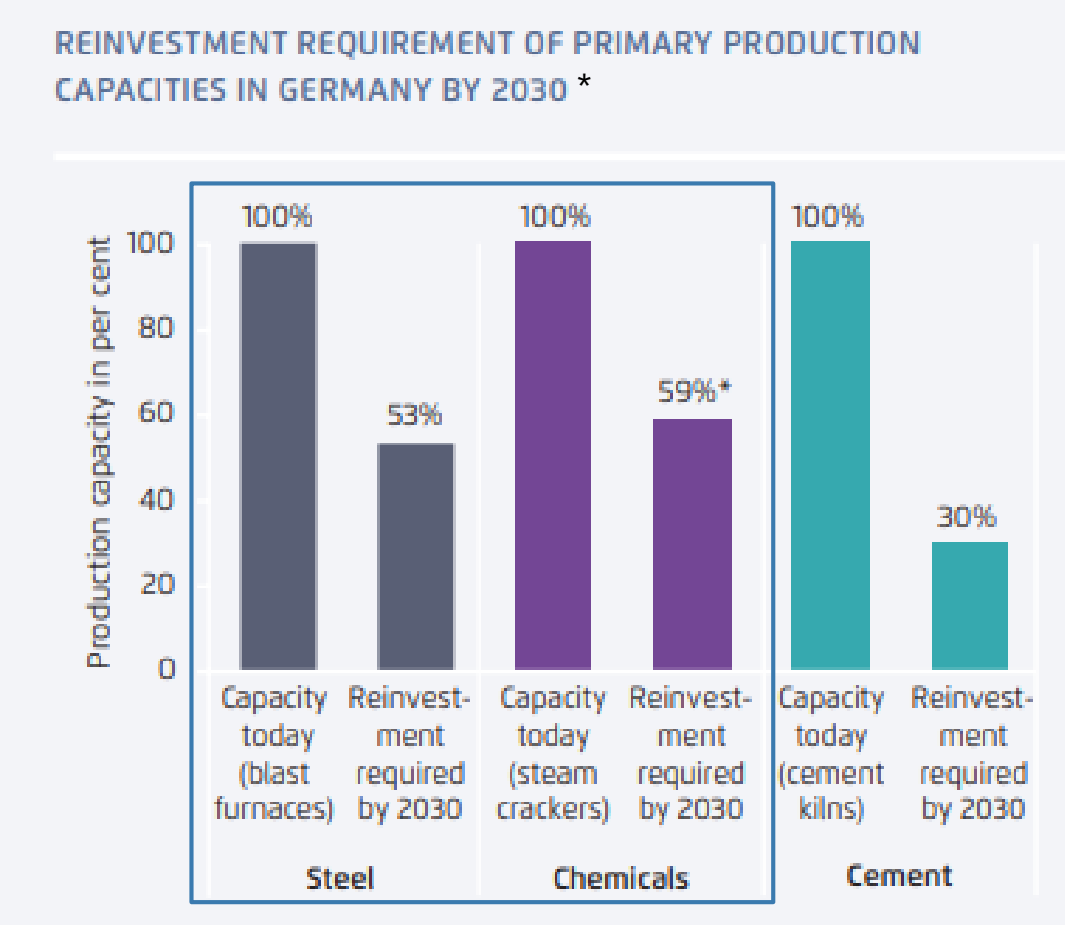
Top 5 industries consume 80% of the fossil fuel (1,235 TWh) and emits 75% of the CO2



SOURCE: Voorstel voor hoofdlijnen voor het Klimaatakkoord

Industrial investment needs

Push for decarbonisation efforts across German industries needed



- Chemical and Steel Industry and Steel with high investment needs short- to mid-term.
- Investment cycles for furnaces 30-40 years – new assets will reach far into a potentially carbon-neutral future. Likely to trigger a strong push for high sustainability requirements
- Investment cycles for chemical assets approx. 15 years – less danger of "stranded assets" due to increasing sustainability requirements

* Agora Energiewende, Climate Neutral Industry, 12.2019 (link)

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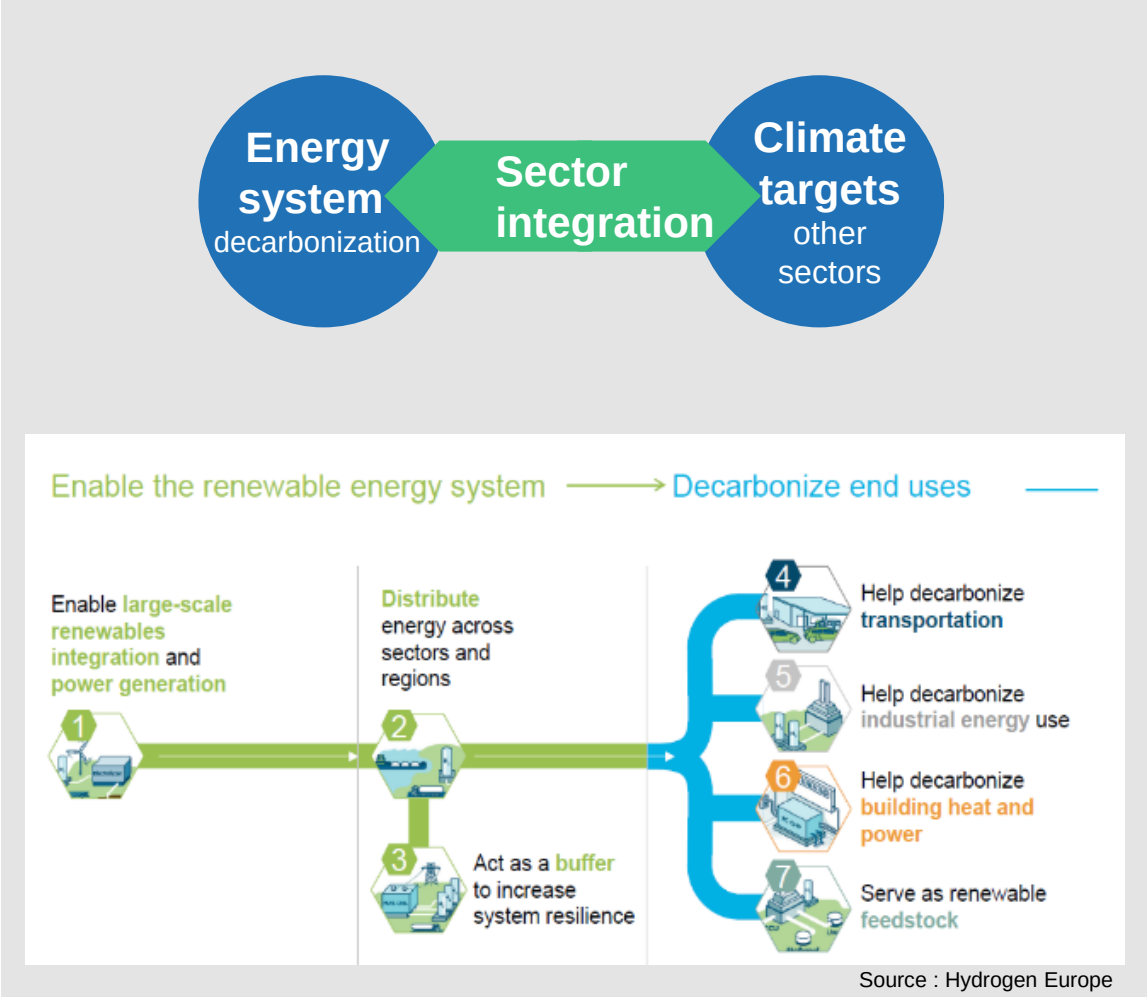
Focus area: Green Hydrogen

Green Hydrogen as carbon free energy / feedstock

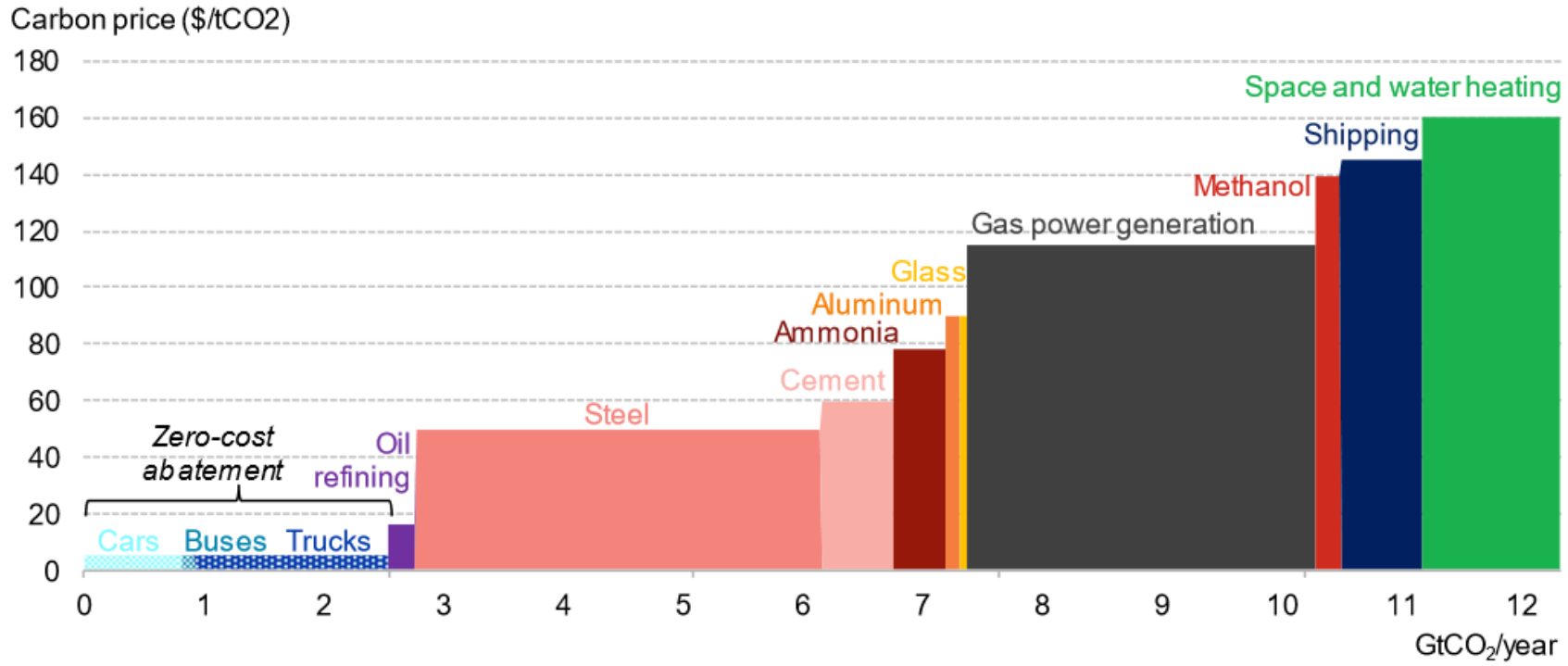
Why is sector integration with green hydrogen important?

- Enable decarbonization in hard to abate sectors like industry, transport, (heat)
- Increase volatile renewable production implies grid congestion and increasing demands for flexibility -> hydrogen production with electrolysis
- Green hydrogen production offers additional value stream for green electricity



Source : Hydrogen Europe

Marginal abatement cost curve from using $1/kg hydrogen for emission reductions, by sector in 2050



Source: BloombergNEF. Note: sectoral emissions based on 2018 figures, abatement costs for renewable hydrogen delivered at $1/kg to large users, $4/kg to road vehicles. *Aluminum emissions for alumina production and aluminum recycling only. Cement emissions for process heat only. Refinery emissions from hydrogen production only. Road transport and heating demand emissions are for the segment that is unlikely to be met by electrification only, assumed to be 50% of space and water heating, 25% of light-duty vehicles, 50% of medium-duty trucks, 30% of buses and 75% of heavy-duty trucks.*

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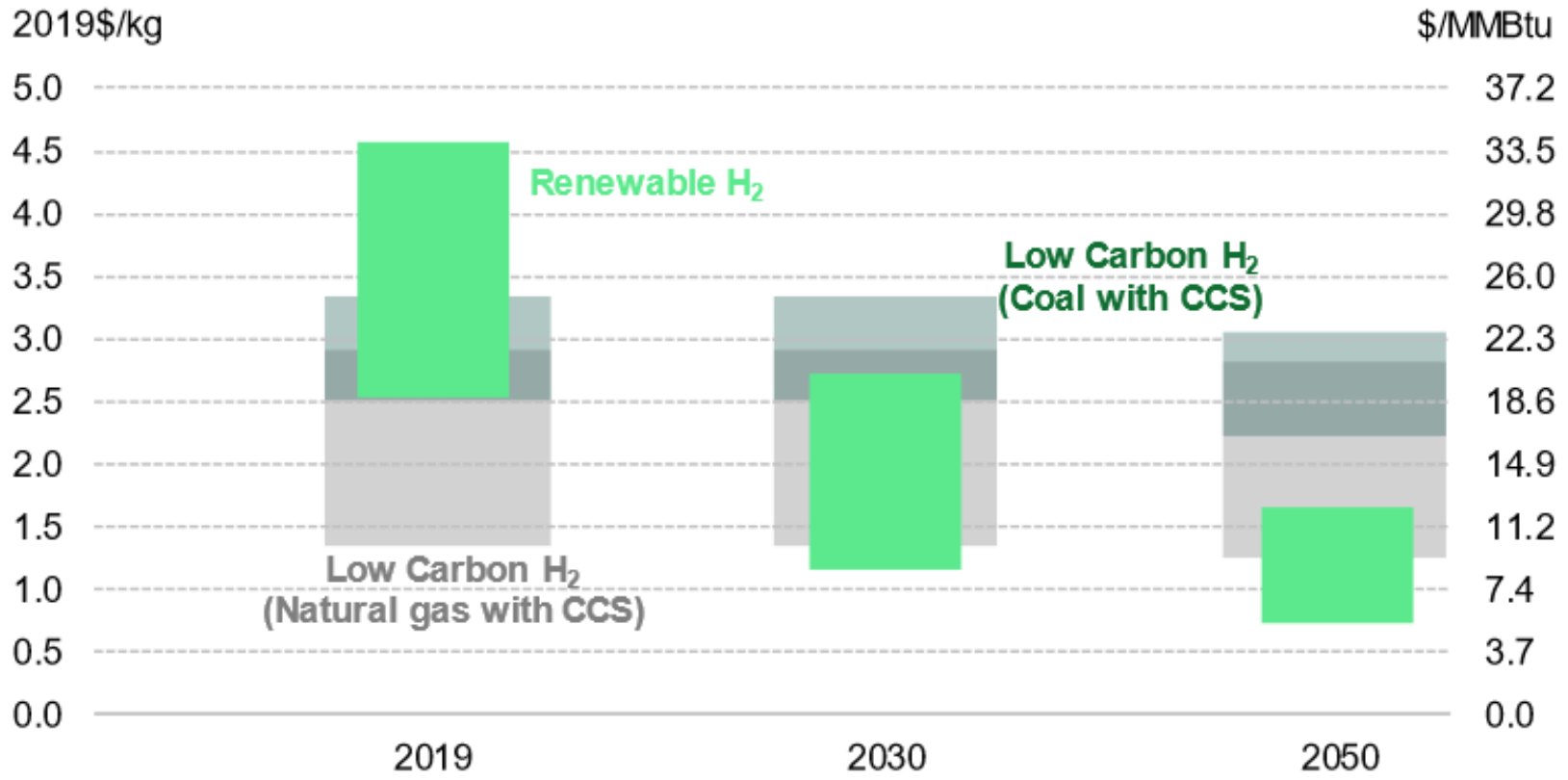
Forecast global range of levelized cost of hydrogen production from large projects (BloombergNEF)



Source: BloombergNEF. Note renewable hydrogen costs based on large projects with optimistic projections for capex. Natural gas prices range from $1.1-10.3/MMBtu, coal from $30-116/t.

Applications for clean hydrogen

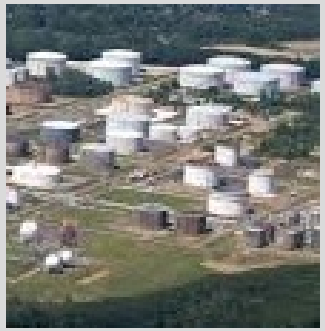
„Electric where possible, hydrogen where needed“

TRANSPORTATION

Green hydrogen as fuel for

- ✓ **Public Fuel cell busses**
- ✓ **Fuel cell trains**
- ✓ **Heavy duty trucks**
- ✓ FCEV Passenger vehicles

REFINERIES



- ✓ **Substitution of biofuel additives (e.g. RME) in conventional fuel production by green hydrogen (REDII)**
- ✓ Synthetic fuels

INDUSTRIES

Substitution of industrial process gases by green hydrogen

- ✓ **Steel production**
- ✓ **Ammonia production**

Vattenfall Initiatives and Projects

Vattenfall’s engagement in hydrogen projects

Partnership between Vattenfall and the industry

Research project for a carbon dioxide free steel industry

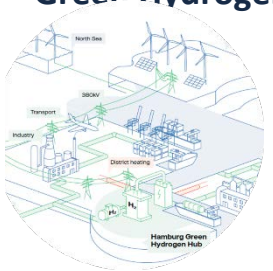
HYBRIT FOSSIL-FREE STEEL

LKAB

SSAB

VATTENFALL

Green Hydrogen Hub Hamburg



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Wärme Hamburg

Use of CO_2 neutral hydrogen in flexible gas plants

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Large-scale electrolysis as feedstock for industries

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Cooperation in large scale bio-diesel production

preem

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Various green hydrogen applications for transportation sector

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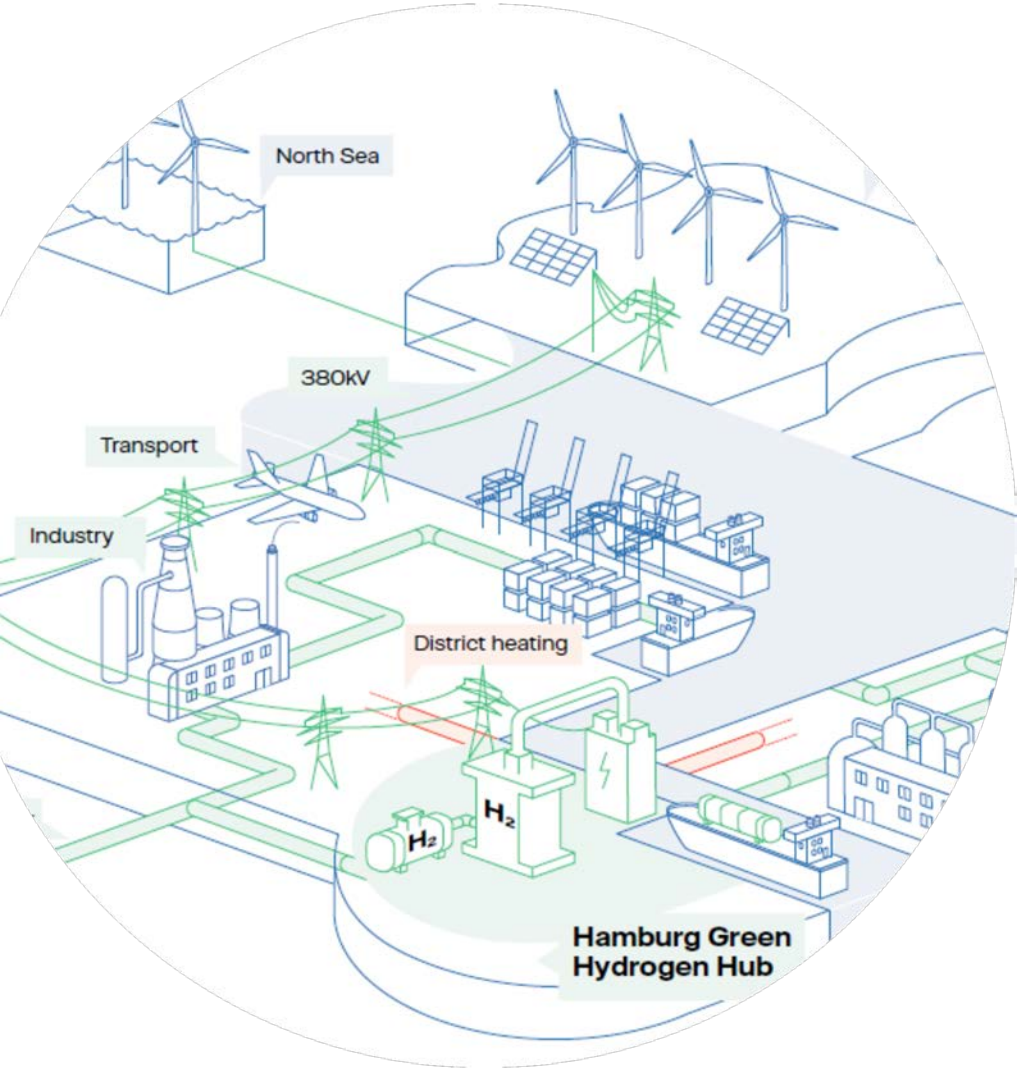

Hamburg Green Hydrogen Hub

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Project pitch: Hamburg Green Hydrogen Hub

Large-scale industrial and transport decarbonisation through the production and utilization of green H_2

ACHIEVEMENT:

Pro-active re-dedication of 1,600 MW hard coal plant for industrial decarbonisation

OUR WINNING FORMULA:

- exchanging grey- with green hydrogen, mainly in industrial applications (steel and refining; backed by long-term Carbon CfD and REDII), but also heavy transport;
- direct matching of renewables assets and electrolyser via 380 kV TSO grid
- optimal utilization of electrolyser ‚waste' streams: oxygen for industry and waste heat for the Hamburg district heating grid (80˚C, with HP increased to 180˚C)

KEY DATA

Electrolyser capacity	100 MW (+ hundreds of MW scale-up potential)
Grid connection	380 kV (TSO 50Hertz)
Average Production	Ca. 30 tons H2 per day

Four strong parties for success:

INDICATIVE TIMELINE

2019	2020	2021	2023-2024	2025
First talks with potential green hydrogen users in the Hamburg harbour	Partnering companies find together	Various Letters of Intent signed; Joint IPCEI application (Q1); Closure of Moorburg	FID, investment and construction	Commissioning and H_2 supply

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Hamburg Green Hydrogen Hub

Vattenfall H2-Station

Shell Lubricants

New Vattenfall Office

Public hydrogen pipeline grid by Gasnetz Hamburg

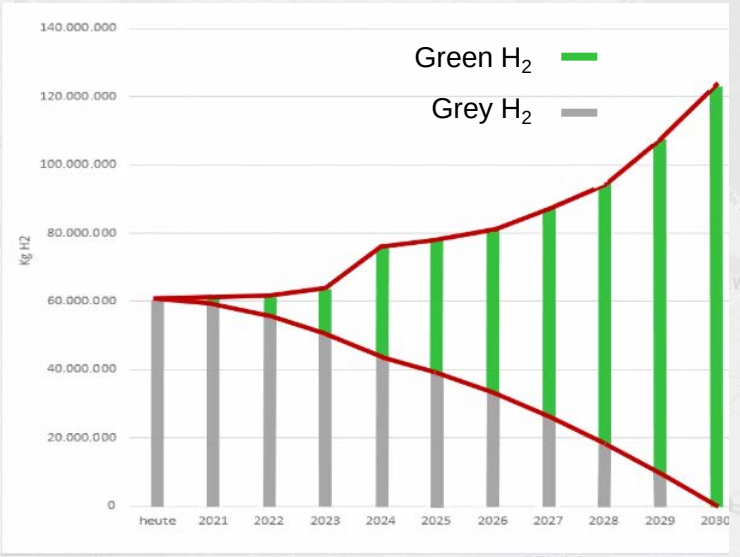
Moorburg Power Plant

Shell Technology Centre

Vattenfall Moorburg location:

- Only TSO connected site in the harbor (380 kV); capacity >1000 MW
- Proximity to many potential hydrogen customers; access by road, rail and water
- Distribution of H_2 and waste heat by city-operated grids (Gasnetz and Wärme)

Existing and projected H2 demand in Hamburg
Source: city of HH (Abnehmerkonferenz Jan 2020)



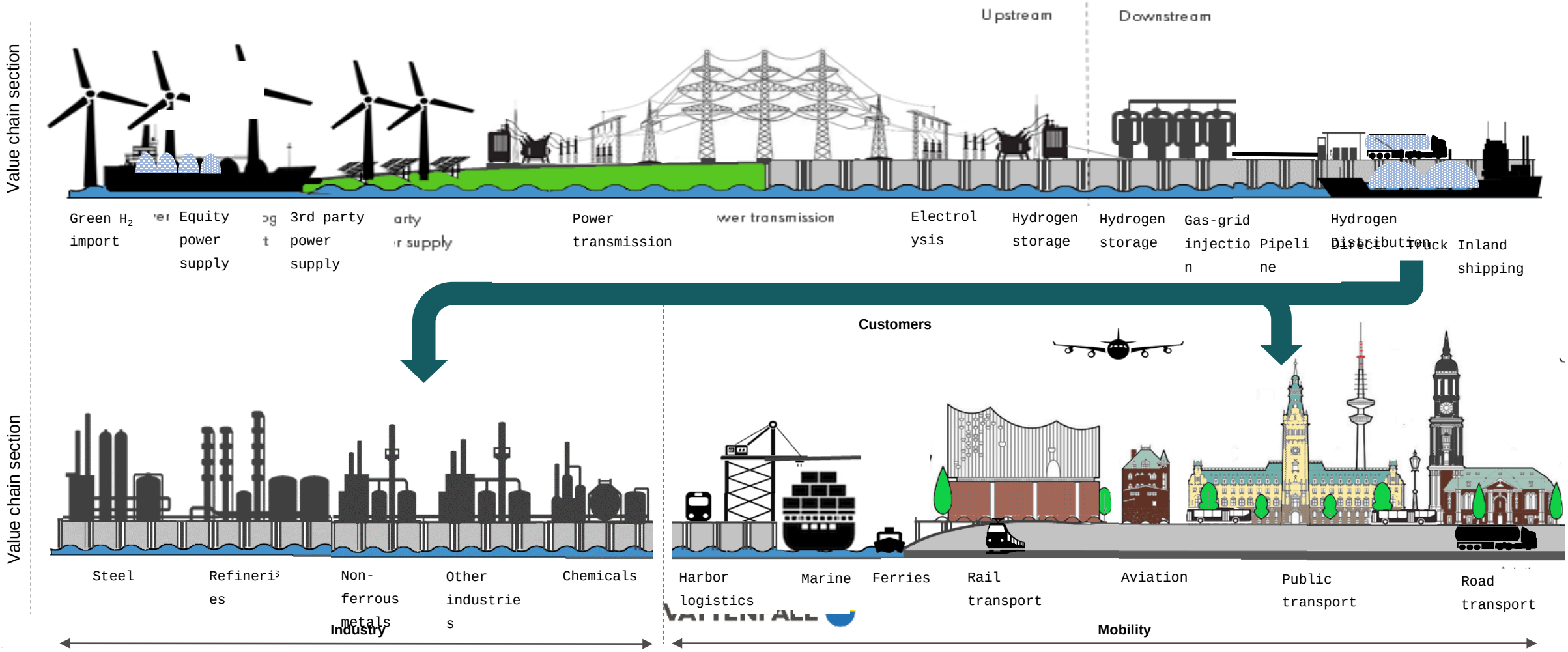
Existing and potential H_2 demand in Hamburg

Shell & Vattenfall sites

1 km

Develop an integrated green hydrogen value chain in the Hamburg Harbor Area to satisfy customer demand, by commissioning 100MW of electrolyser capacity by ideally 2025, with the goal to decarbonize mobility and industry with green hydrogen, produced from renewable power. Shorter term, regulatory support is needed to close the price gap between green hydrogen and existing fossil-fuel based solutions.

Mid- to longer term, the green hydrogen capacity should grow to at least 500MW and possibilities for import, with the resulting economies of scale leading to carbon-free solutions that outperform fossil-fuels.



BREMERHAVEN
KURS INNOVATION

Innovative site for hydrogen

Bremerhaven

A unique „Test Area“ and investment opportunities.

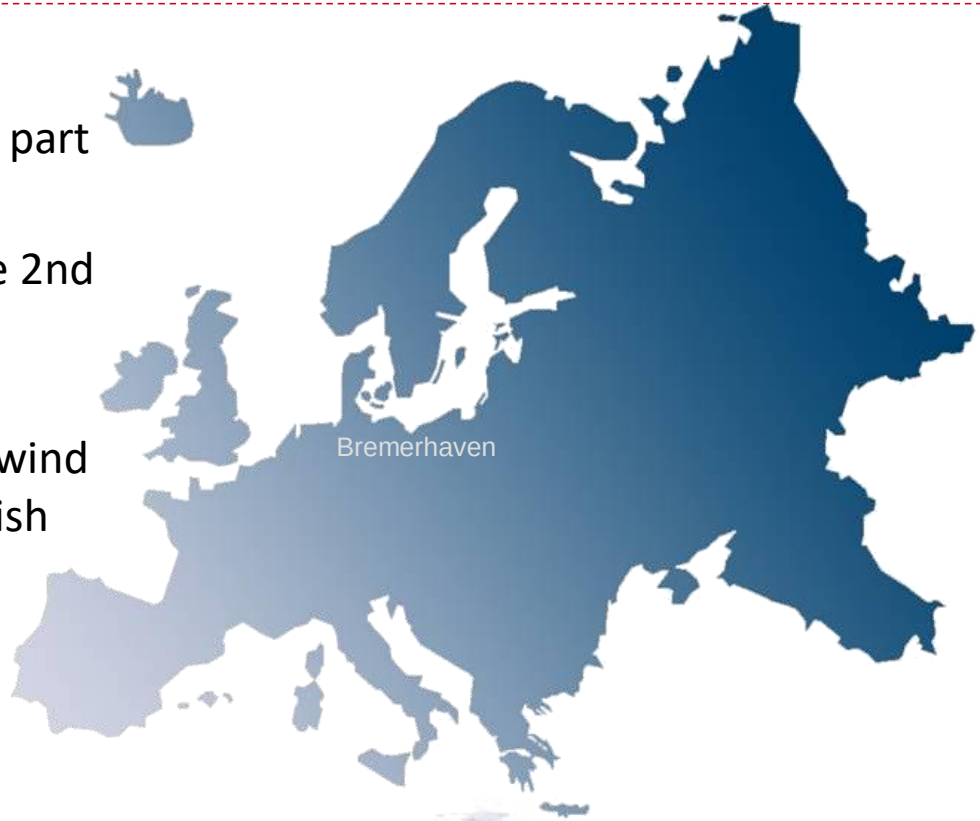
Presented by BIS Economic Development Company Ltd.

March 2021

Economic Development Company Ltd. bis

Maritime City Bremerhaven.

- Largest city on the German North Sea coast and part of the state of Bremen
- Seaport is the 4th largest port in Europe and the 2nd largest port in Germany.
- Business location is characterized by its ports, shipbuilding and maritime economy, (offshore) wind energy industry, marine research, tourism and fish and food processing.
- Attractive place to work and live.



Test region for hydrogen applications.

BREMERHAVEN
KURS INNOVATION


[Bremerhavenbus]


[Pragma Industries]

[Brüssel&Maass]

[BIS Bremerhaven]


[BIS Bremerhaven]

[Ortspolizeibehörde Bremerhaven]

[FAUN Umwelttechnik]


[BIS Bremerhaven]

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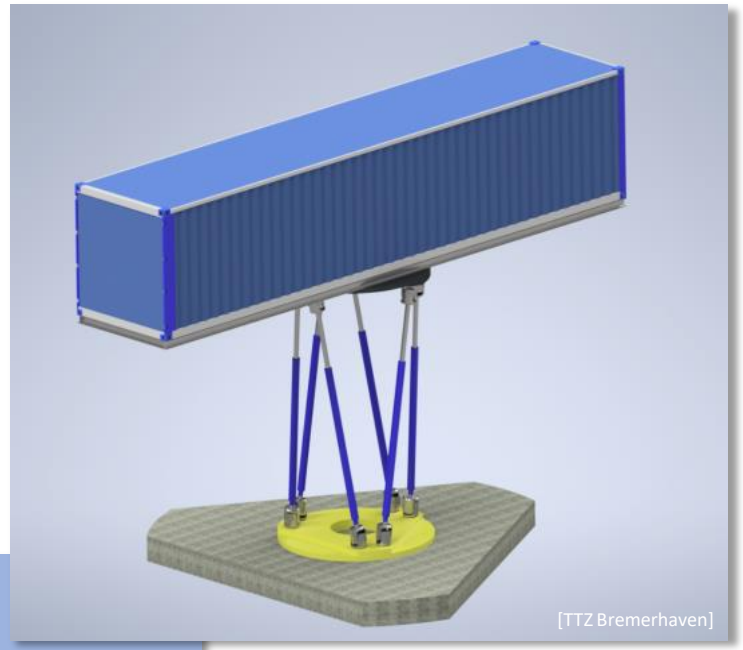
Electrolysers test field.

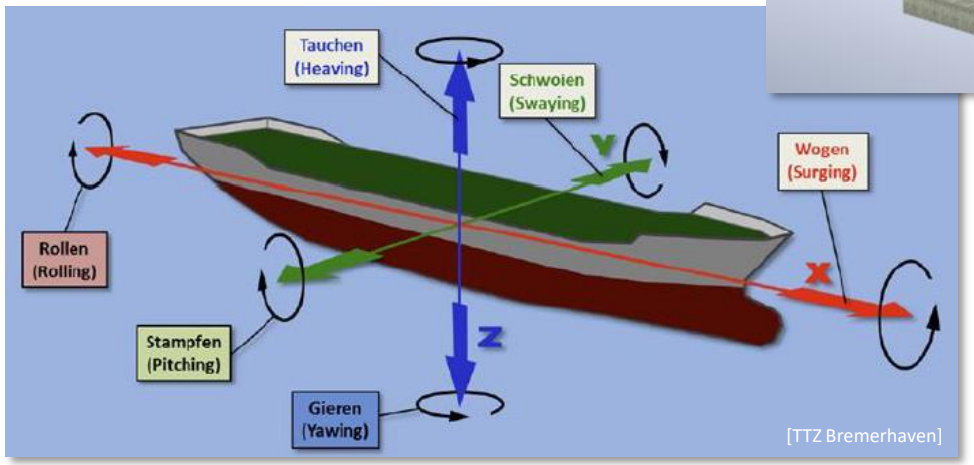
- Infrastructure for testing up to 10 electrolysers with a total capacity of over 10 MW.
- Two electrolysers for research purposes (PEM and alkaline - rated power 1 MW each).
- From 2023, approximately 1t of hydrogen/day, oxygen and exhaust heat will be produced.
- More information: https://wind-wasserstoff-bremerhaven.de/
- Funded by

Europäische Union
Investition in Bremens Zukunft
Europäischer Fonds für regionale Entwicklung

3D-test utility for mobility applications.

- **Testing of H2-based systems** for fast and efficient market entry (approx. from 2023).
- Test **new technologies** for their **seaworthiness** under realistic conditions before installing them on a ship or deploying them at sea, avoiding expensive and time-consuming sea trials.
- **Transferable to various industries**, e.g. R&D, aerospace, automotive, civil engineering and earthquake research.





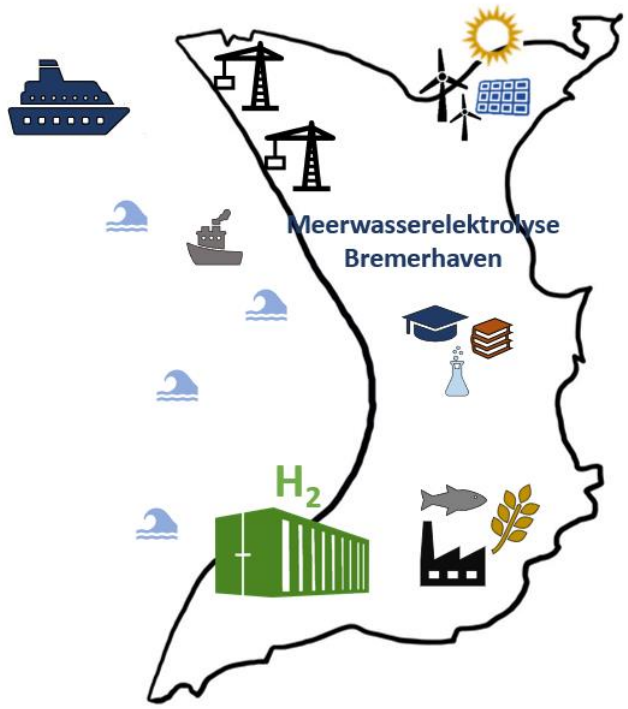
ttz Bremerhaven

Economic Development Company Ltd.

Sea water electrolysis.

- A technology for maritime cities.
- Our focus: water treatment, material flow management, life cycle analysis, plant engineering, regulatory conditions.
- Use in the shipping, port and food industries.

bremenports
greenports
EnPro
H2BX
Wasserstoff. bewegt. uns.
Hochschule Bremerhaven



ISL
Fraunhofer IWES
Fraunhofer IFAM
ttz Bremerhaven
berlin

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Bremerhaven - Innovative city for hydrogen.

- Maritime industry.
- Green Economy.
- Available areas for industry and commerce.
- Infrastructure of wind energy industry.
- Offshore wind energy competences.
- Wind and hydrogen associations.
- Scientific institutions with hydrogen knowhow and experiences.
- Various training and further education institutions.
- Klimahaus Bremerhaven 8° Ost – Platform for communication of energy turnaround.

We look forward to talking to you.

Dipl.-Ing. Nils Schnorrenberger
Managing Director

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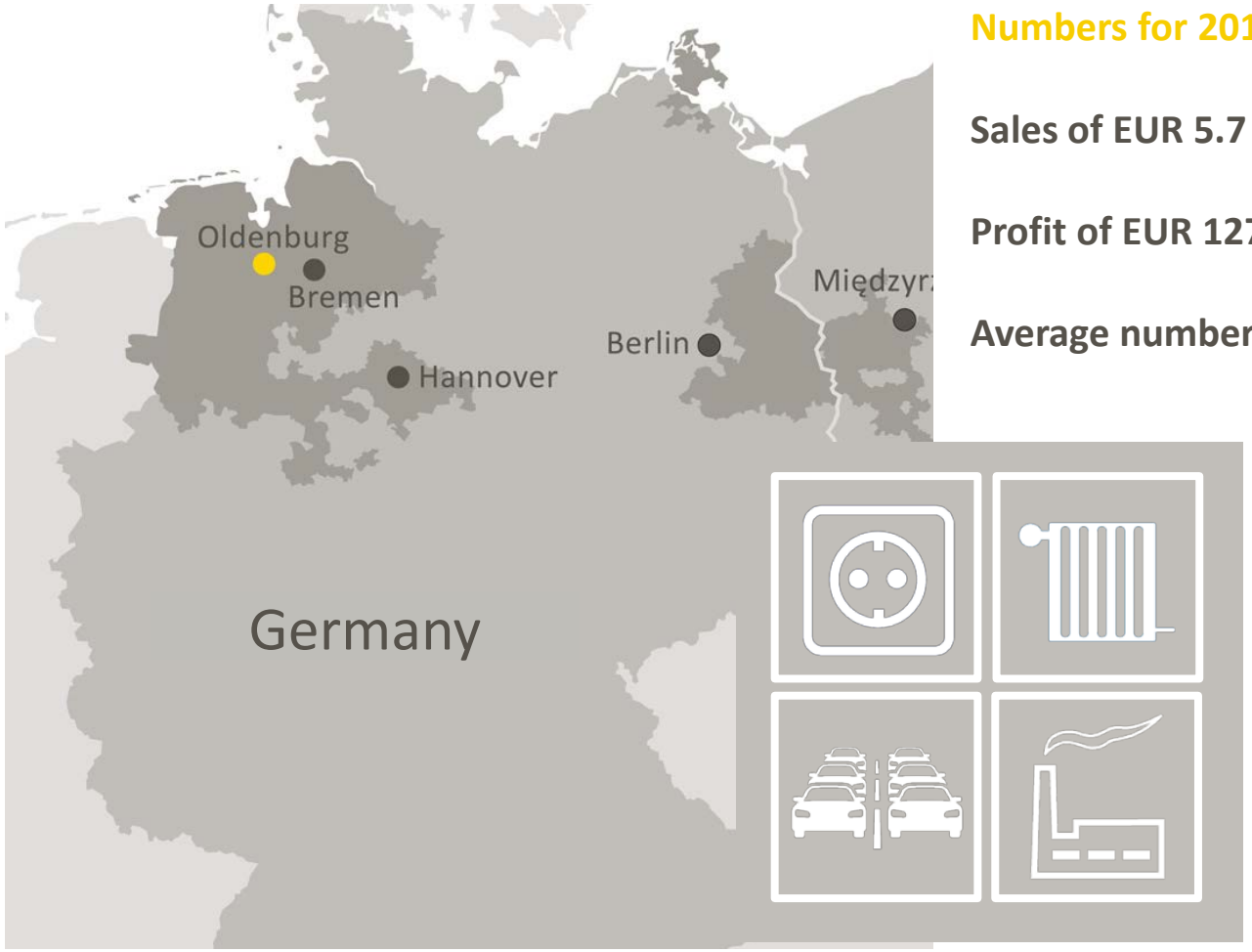
Developing a Hydrogen Economy in the North West of Germany

HY-5 Webinar – The Production of Green Hydrogen

Dr. Geert Tjarks, EWE AG

EWE Group – Energy supply for North West Germany



Numbers for 2019

Sales of EUR 5.7 billion

Profit of EUR 127.5 million

Average number of employees 8,831

EWE aims to take a leading role in shaping the energy revolution and ensuring its implementation.

EWE is capable of seeing the energy revolution in a global context.

The areas of electricity, heat and mobility are reflected within the Group.

Image: EWE AG

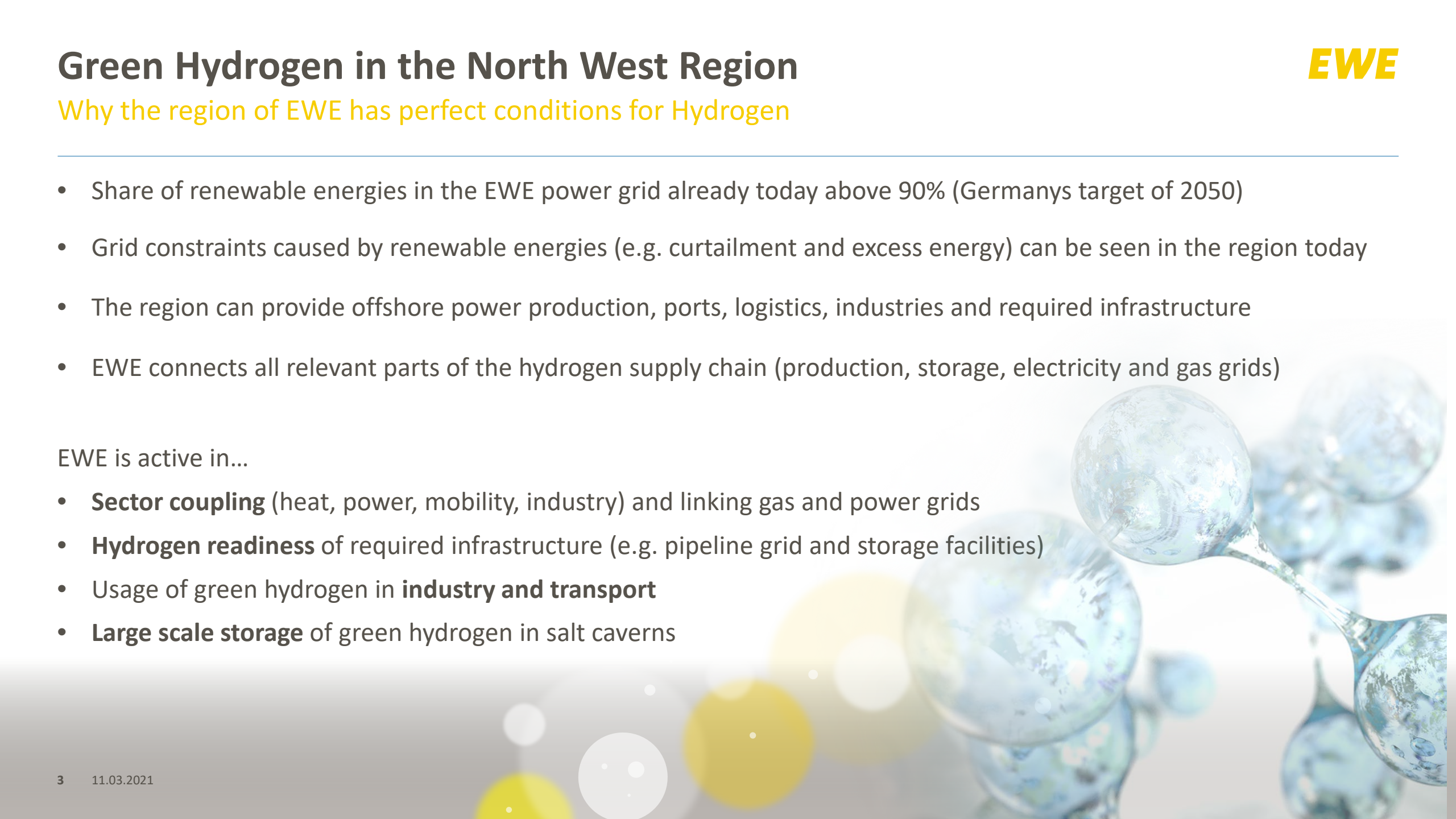
Green Hydrogen in the North West Region

Why the region of EWE has perfect conditions for Hydrogen

- Share of renewable energies in the EWE power grid already today above 90% (Germanys target of 2050)
- Grid constraints caused by renewable energies (e.g. curtailment and excess energy) can be seen in the region today
- The region can provide offshore power production, ports, logistics, industries and required infrastructure
- EWE connects all relevant parts of the hydrogen supply chain (production, storage, electricity and gas grids)

EWE is active in…

- **Sector coupling** (heat, power, mobility, industry) and linking gas and power grids
- **Hydrogen readiness** of required infrastructure (e.g. pipeline grid and storage facilities)
- Usage of green hydrogen in **industry and transport**
- **Large scale storage** of green hydrogen in salt caverns



Hydrogen Valley North West Germany

Project HyWaysForFuture for hydrogen usage in the transport sector

Ca. 90 partners | ca. 90 Mio.€ Budget | 2020-2023

Green H2-Hub
e.g. located near steel plant

H2 trailer
(potential for H2 pipeline)

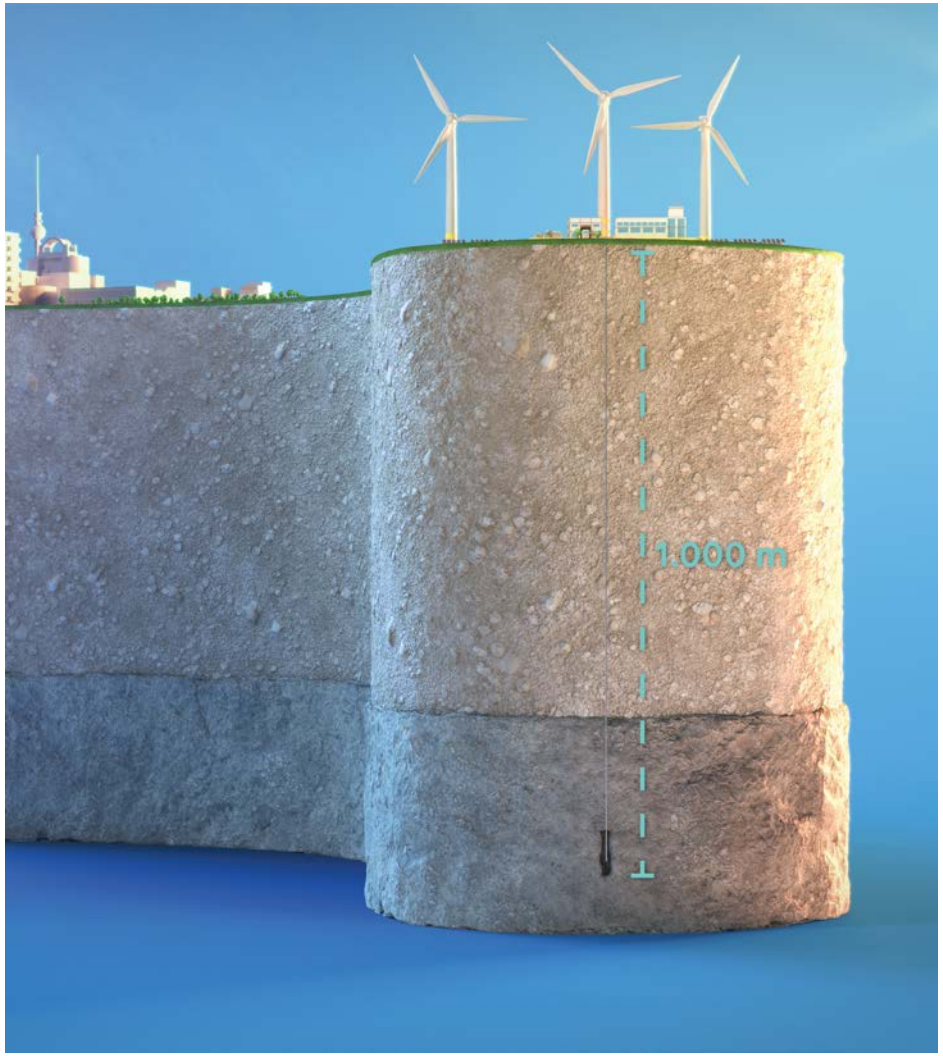
Deployment of more than 200 **FCEVs**
(Busses, Garbage Trucks, Heavy Duty, Passenger vehicles)

Pressure Storage
inkl. H2 trailer
(potential for Salt caverns)

Deployment of **Hydrogen Refueling Stations**

Hydrogen storage in salt caverns

Flexibility for an integrated and renewable energy system



EWE GASSPEICHER GmbH

- **2 billion cubic metres of working gas**
- **38 salt caverns for natural gas**
- **over 40 years of experience**

EWE GASSPEICHER is one of the largest storage facility operators in the European natural gas market.

Research Project HyCavMobil

- **Enabling hydrogen storage in salt caverns**
- **Funded by the Federal Ministry of Transport**
- **June 2019 to May 2022**

Salt caverns for seasonal storage of hydrogen can play a major role for the combination of gas and electricity grids

A holistic approach for a European hydrogen economy

Perspective until 2030

- Create a hub, that will secure **hydrogen production capacities** for an Intra-European energy market
- Development of an **trans-european hydrogen infrastructure** for transport and storage in the region and beyond
- Enable **first markets for green hydrogen** in industry and transport
- Connecting **HyWaysForFuture** and **HEAVENN**
- Sharing lessons learned with the political level
- Suitable **funding scheme and regulatory framework** is required

Thank you for your attention.

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If you are interested in co-operating with German hydrogen companies or if you plan to expand your hydrogen business in Germany, the following organisations will support you!

- Germany Trade & Invest
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Smart Grids & Energy Storage
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- Bremen Invest
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- Niedersachsen Ministry of Economic Affairs, Labour, Transport and Digitalisation
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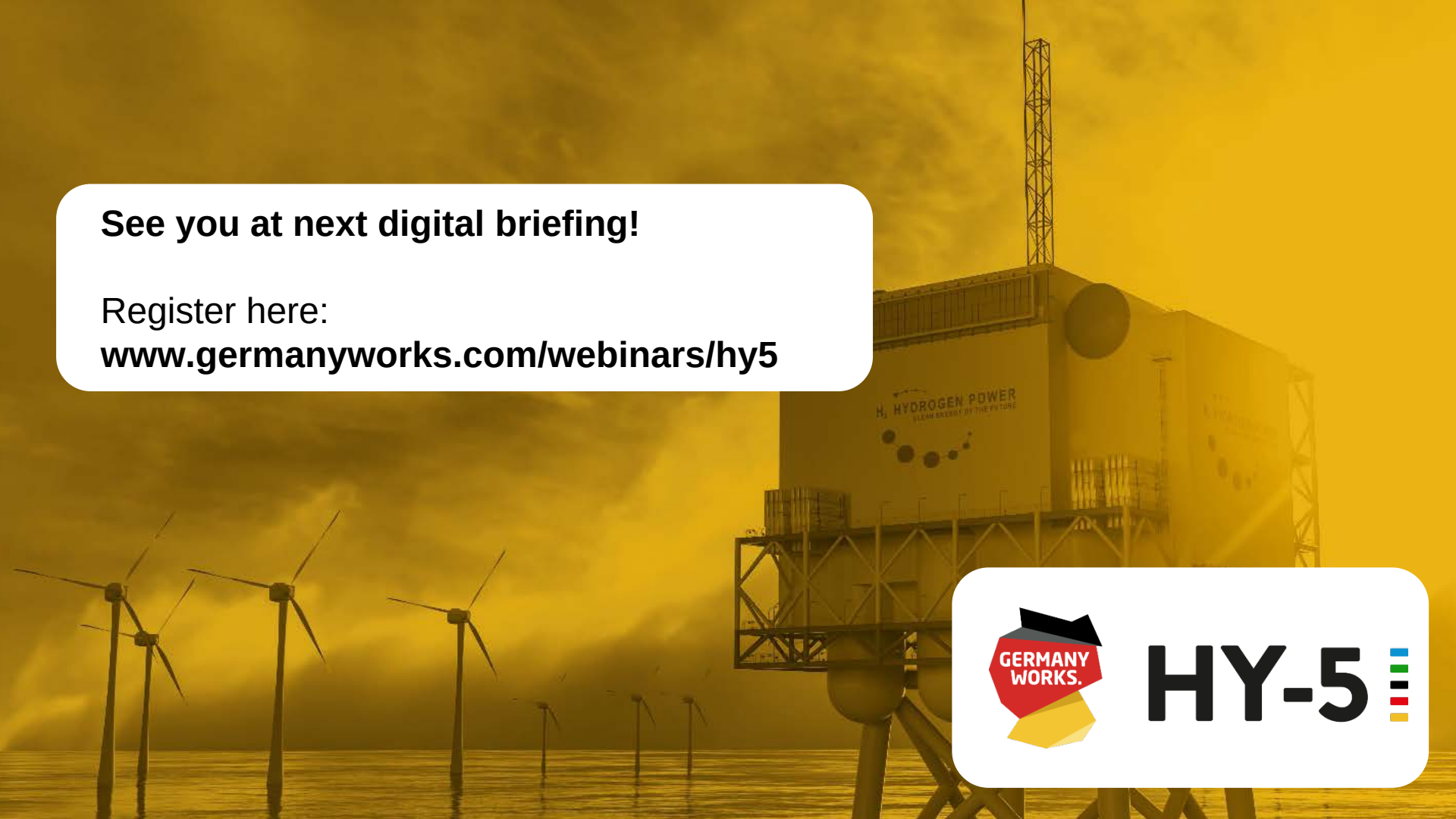

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