Hydrogen's role in industrial decarbonization

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Also, in this presentation we may refer to Shell's "Net Carbon Footprint", which includes Shell's carbon emissions from the production of our energy products, our suppliers' carbon emissions in supplying energy for that production and our customers' carbon emissions associated with their use of the energy products we sell. Shell only controls its own emissions. The use of the term Shell's "Net Carbon Footprint" is for convenience only and not intended to suggest these emissions are those of Shell or its subsidiaries.

Hydrogen in the future energy system

Enable deep renewables penetration, distribution and system resilience

Enabling **large-scale renewables penetration** and **power generation**

Distribute energy across sectors and regions

Act as a **buffer or storage** to increase **system resilience**

Electrolysers as real-time sinks for an oversupplied renewable system

Decarbonise hard-to-abate end-uses

Decarbonising transportation leveraging higher energy density uses

Decarbonising industry energy use replacing coal and other fossil fuels

Decarbonising building heat and power leveraging existing gas infrastructure

Decarbonising grey H_2 use in fertiliser, refineries and chemical industries

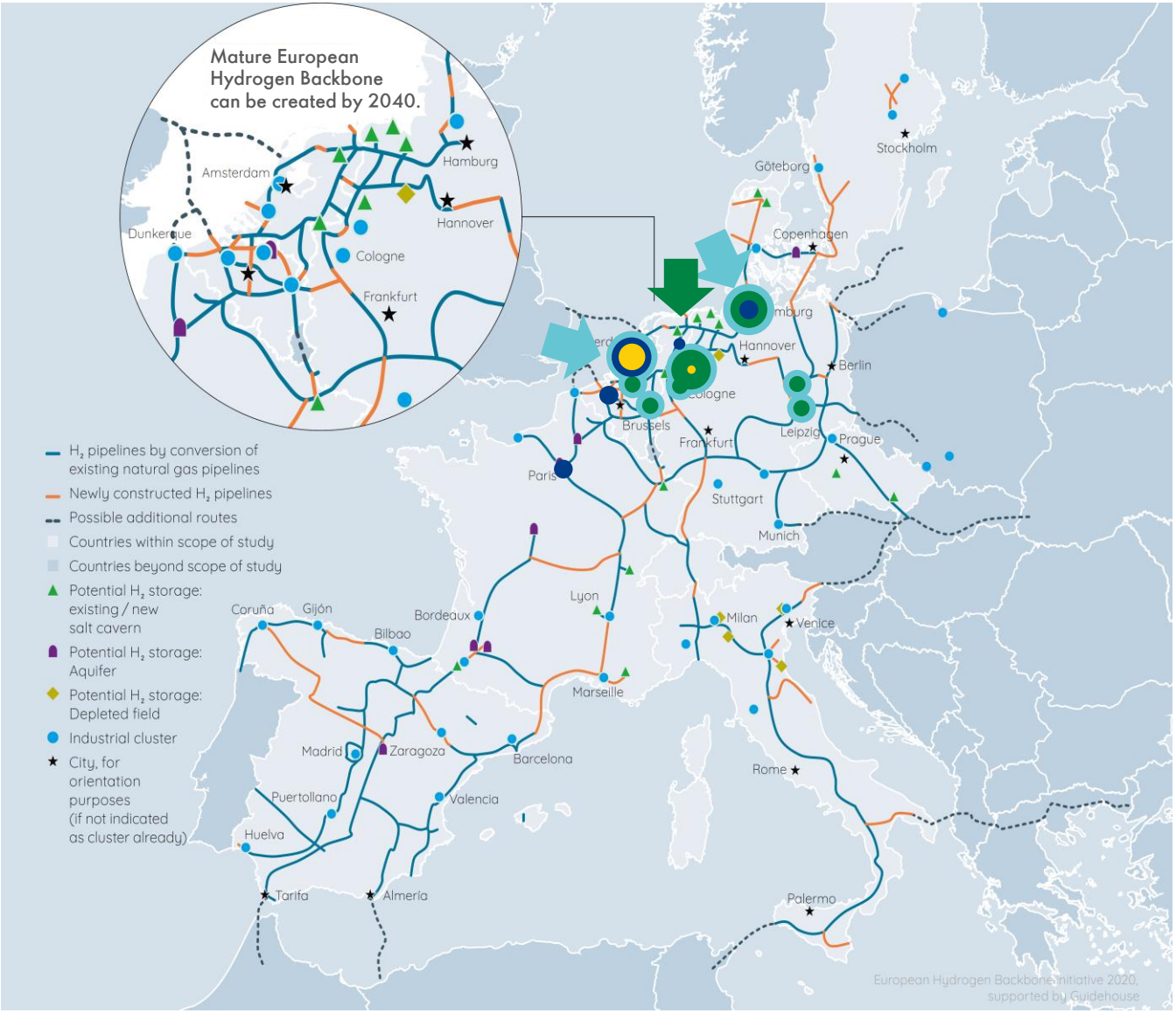
How Shell is advancing hydrogen for industry

Decarbonising industry starts at hubs, expanding to industry clusters as the infrastructure develops

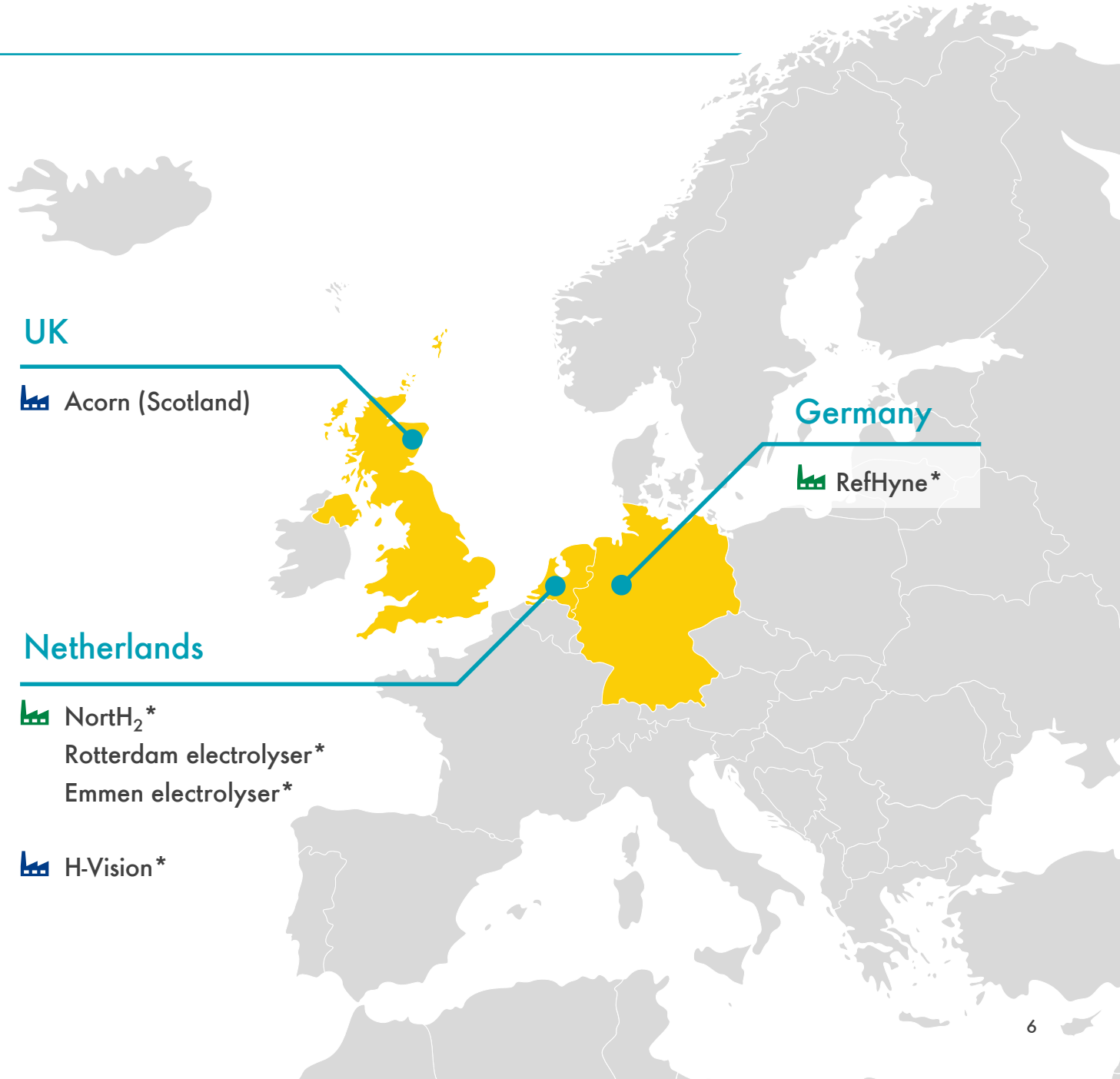
Shell aims to serve big industrial clusters to help decarbonise their businesses. We get started by serving our own anchor demand in e.g. refineries, expanding to local hub demand close to the supply and finally connecting to large industry hubs when the infrastructure becomes available.

Increasing uncertainty & risk

	Proof points
Step 1 – Own Use Serve own-use as anchor demand in hubs – enables to build supply positions and gain experience and credibility	RefHyne - Rhineland Rotterdam Electrolyser
Step 2 – Serving the hubs Serve local third party customers in hubs - create market and solutions, expand supply position	GZI - Emmen Rotterdam Electrolyser Hamburg
Step 3 – Starting the clusters Serve inter-regional and international industrial demand through an expanding hydrogen backbone network	NorthH$_2$ Ingoland
Step 4 – Fully developed Traded hydrogen commodity market – facilitated by a wide-spread hydrogen pipeline network, including import	Rotterdam import Hamburg Import



Where we are working on hydrogen industry projects



Key

- Industry projects, green hydrogen
- Industry projects, blue hydrogen

*In progress

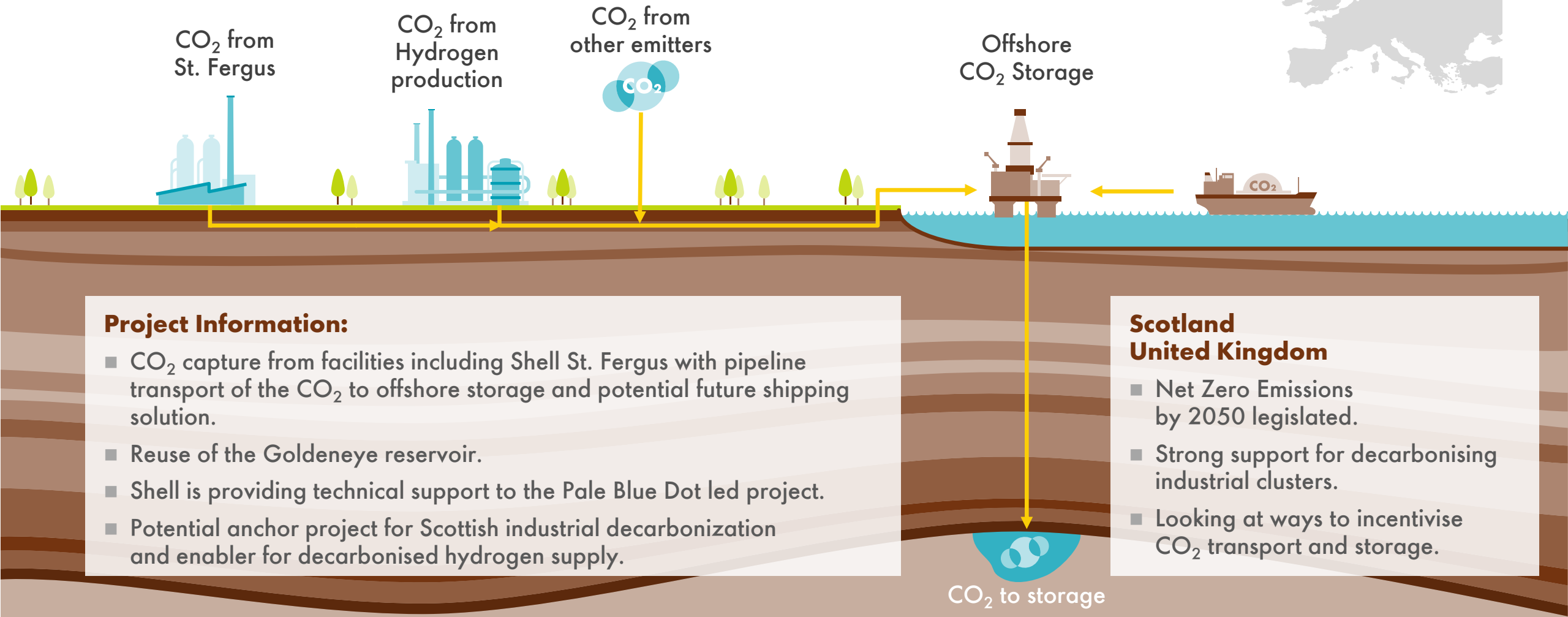
H-vision

- In the Port of Rotterdam, Shell is partner in H-vision, a consortium of 5 project partners and 7 support partners studying the technical and economic feasibility to decarbonise industry via large-scale production and use of decarbonised hydrogen (H2 production paired with CCS) well before 2030.

- H-vision could offer an annual CO_2 reduction of 1.6 million tons with the first production facility, increasing potentially to 3.2 million tons per annum if the second unit is operational in 2032.

Acorn

Low-carbon power generation



Project Information:

- CO_2 capture from facilities including Shell St. Fergus with pipeline transport of the CO_2 to offshore storage and potential future shipping solution.
- Reuse of the Goldeneye reservoir.
- Shell is providing technical support to the Pale Blue Dot led project.
- Potential anchor project for Scottish industrial decarbonization and enabler for decarbonised hydrogen supply.

Scotland
United Kingdom

- Net Zero Emissions by 2050 legislated.
- Strong support for decarbonising industrial clusters.
- Looking at ways to incentivise CO_2 transport and storage.

Rotterdam electrolyser

~200 MW electrolyser in the Port of Rotterdam

Renewable-based hydrogen hub in the Port of Rotterdam:

- CrossWind joint venture (Shell and Eneco) winner of tender for Hollandse Kust (Noord) wind farm with an estimated installed capacity of 759 MW.
- A potential renewable-based hydrogen plant in the Port of Rotterdam with capacity to produce 50,000 – 60,000 kg of hydrogen per day.
- Hydrogen to be initially used at the Pernis refinery, with possible future application in the trucking sector.

1

759 MW; On stream: 2023

Rotterdam Electrolyser

2

Maasvlakte 200 MW on stream 2023

3

Decarbonising the Refinery's hydrogen supply

4

Pan European Hydrogen Retail network

RefHyne
Building a 10mw PEM electrolyser

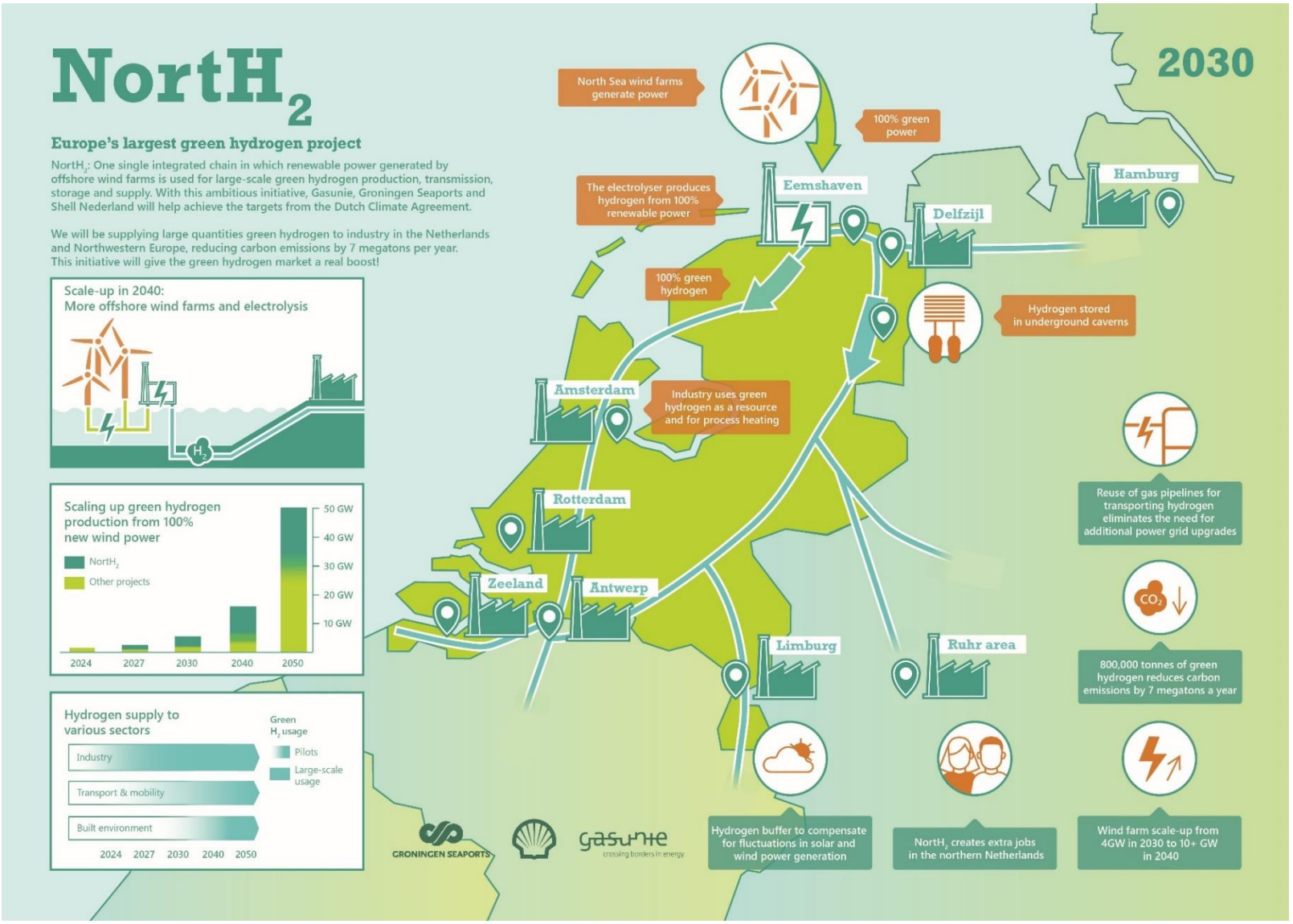
- Shell has opened a 10-megawatt PEM (polymer electrolyte membrane) electrolyser, the largest of its kind, to produce hydrogen at the Rhineland refinery in Germany.
- Considering possibility to scale up to 100 megawatt in time with ITM Power.
- This project is supported by the European Union.

REFHYNE
CLEAN REFINERY HYDROGEN FOR EUROPE

NortH$_2$

Europe's largest renewable-based hydrogen project in Groningen

- A consortium of Gasunie, Groningen Seaports, RWE, Equinor and Shell Nederland announced the launch of this project in 2020.
- Ambition is to produce hydrogen using renewable electricity generated by a mega offshore wind farm (3-4 GW in 2030; 10+ GW by 2040). ~1M tonne H2 production by 2040.
- Could avoid 8-10M tonnes of CO2/year.
- Supported by Province of Groningen



Zhangjiakou JV

Integrated value chain hub for northern China

- Joint venture with government and industry experts established in September 2020
- Develop a 20MW renewable power-to-hydrogen electrolyser plant and build a network of high-throughput HRS serving city buses
- With route to scale for near-term expansion (50-100MW) to serve the fast-growing Beijing-Tianjin-Hebei (JJJ) regional market.

Jing-Jin-Ji = Beijing-Tianjin-Hebei

H2 electrolyser 1

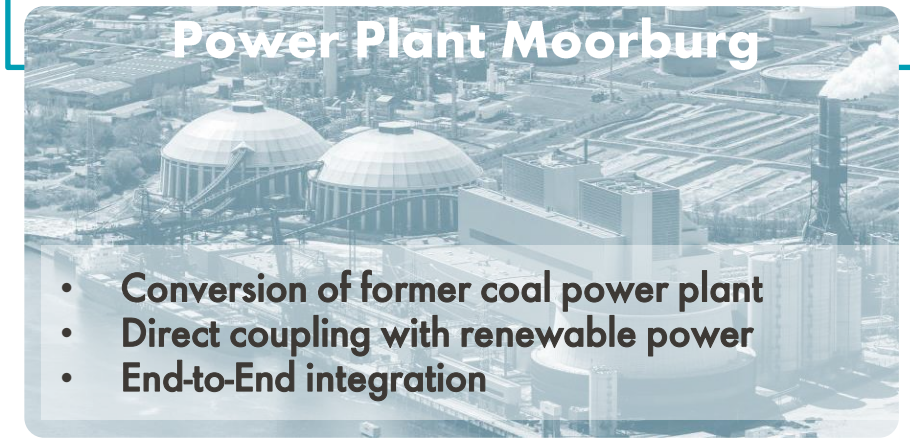
H2 refilling station 2

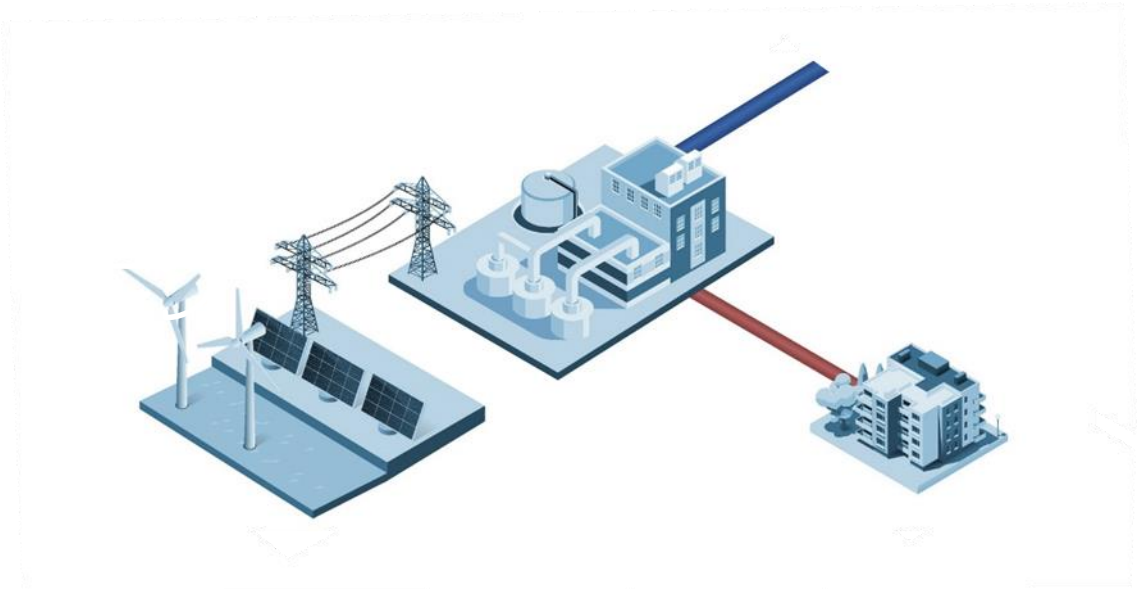
H2 fuel cell bus 3

Hamburg Renewable-based Hydrogen Hub

- ***In January 2021 Shell along with Mitsubishi Heavy industries, Vattenfall and Wärme Hamburg announced the signing of a letter of intent to build a 100 megawatt electrolyser at the Hamburg-Moorburg power plant site.***
- ***Subject to final investment decisions and approvals the site is expected to produce its first***

- 100 MW Electrolyser
- 11.500 t H2 per year
- 92.000 t CO2 per year GHG reduction



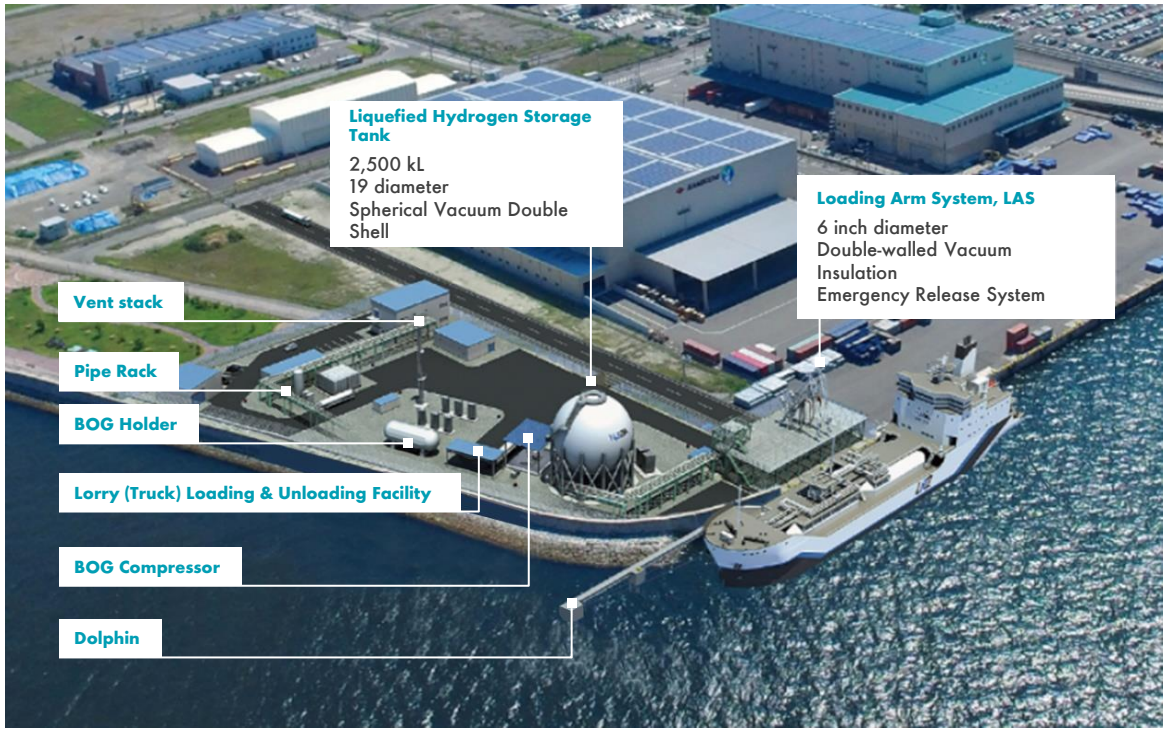


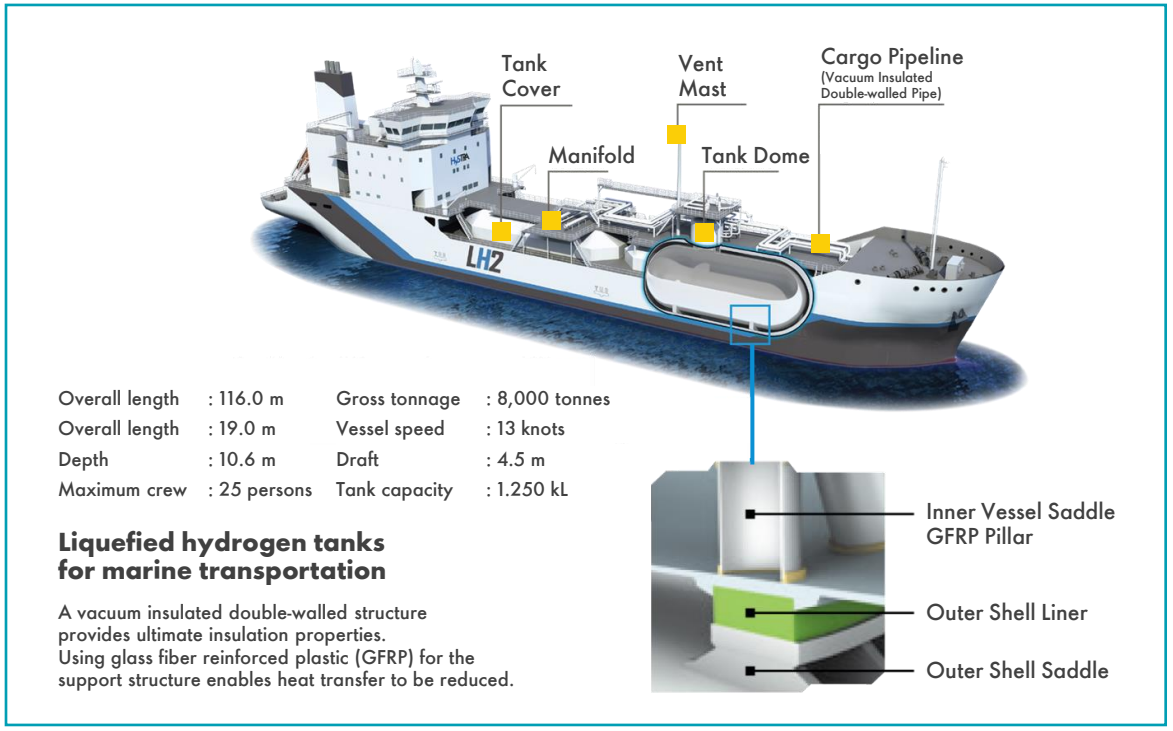
INDICATIVE TIMELINE

2019	2020	2021	2022-2024	2025
First talks with potential renewable-based 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 H2 supply

VATTENFALL MITSUBISHI HEAVY INDUSTRIES Wärme Hamburg

Developing methods of transport





- Shell's experience and expertise in transporting liquefied natural gas across the world is key to developing a hydrogen supply chain including for liquefied hydrogen.

- Liquid H_2 long range research
- HySTRA project
- Partnership with Kawasaki Heavy Industries + Iwatani
- End 2019, launch of ship Suiso Frontier (Hydrogen Frontier)