Clean hydrogen for the steel industry

Blue hydrogen in a European context

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H2morrow
steel


equinor

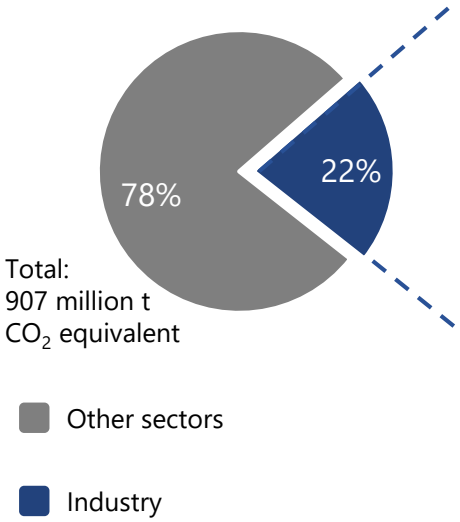

OGE


thyssenkrupp

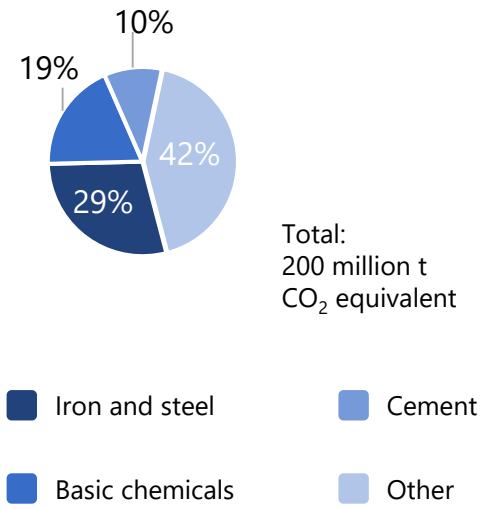
The backgdrop is German industrial CO2 emissions

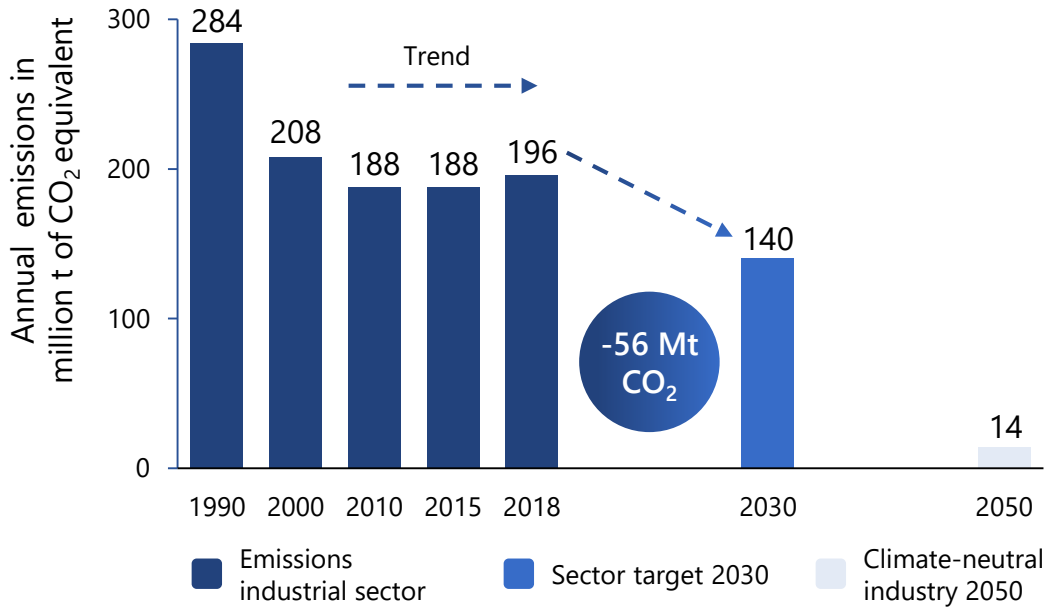
A large share of total CO2 emissions, sticky and hard to abate in sectors facing global competiton

Total German emissions



Breakdown by industrial sectors





For 2017, Source: Agora Energiewende: UBA, 2019a; WV Stahl, 2018; Wuppertal Institut, 2019

Source: Agora Energiewende: UBA, 2019a; BMU, 2016; Sector target 2030 according to government draft Bundes-Klimaschutzgesetz; Sector target 2050 according to climate protection plan 2050

Steel a strategic industry, but a large emitter

Must decarbonize - enormous efforts required

Changes take time:
Appropriate framework conditions needed now!

Steel industry is energy- and resource-intensive and has **long investment cycles!**

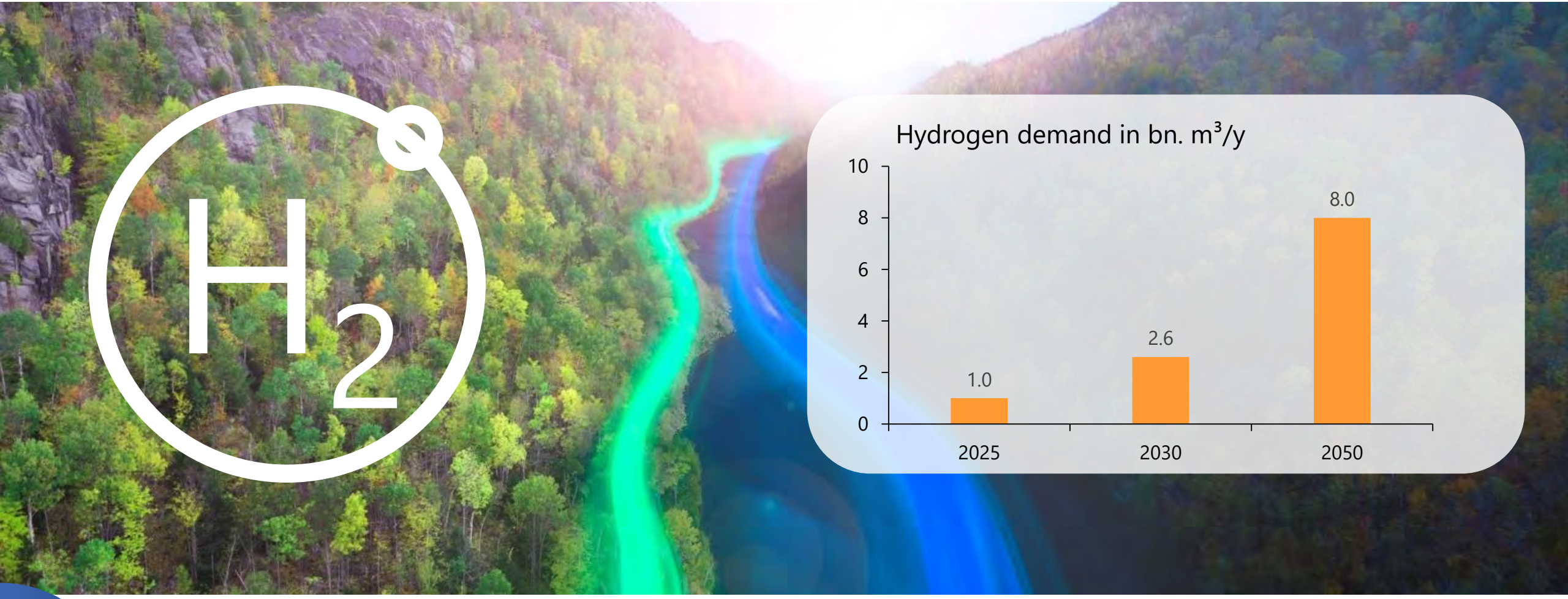
CO_2 emissions of the European steel industry:
>200 million t p.a.*

*Eurofer, November 2019:
http://www.eurofer.org/Issues%26Positions/Climate%20%26%20Energy/20191106%20EUROFER%20Low%20Carbon%20Roadmap%20FINAL.pdf

Oktober 2019 | Transformation der Stahlproduktion

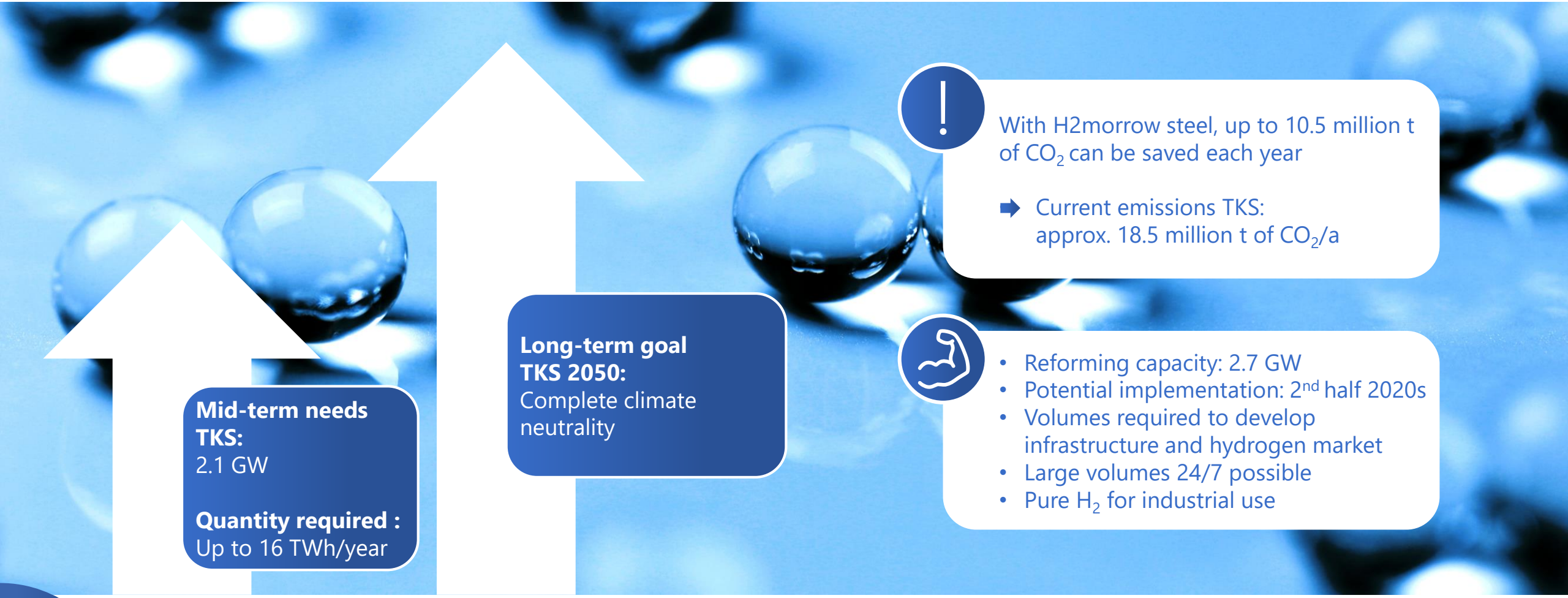
The transformation pathway for thyssenkrupp Steel

Large volumes of hydrogen are required



Significant quantities of hydrogen required

H2morrow can supply on short notice



Mid-term needs TKS:
2.1 GW

Quantity required :
Up to 16 TWh/year

Long-term goal TKS 2050:
Complete climate neutrality

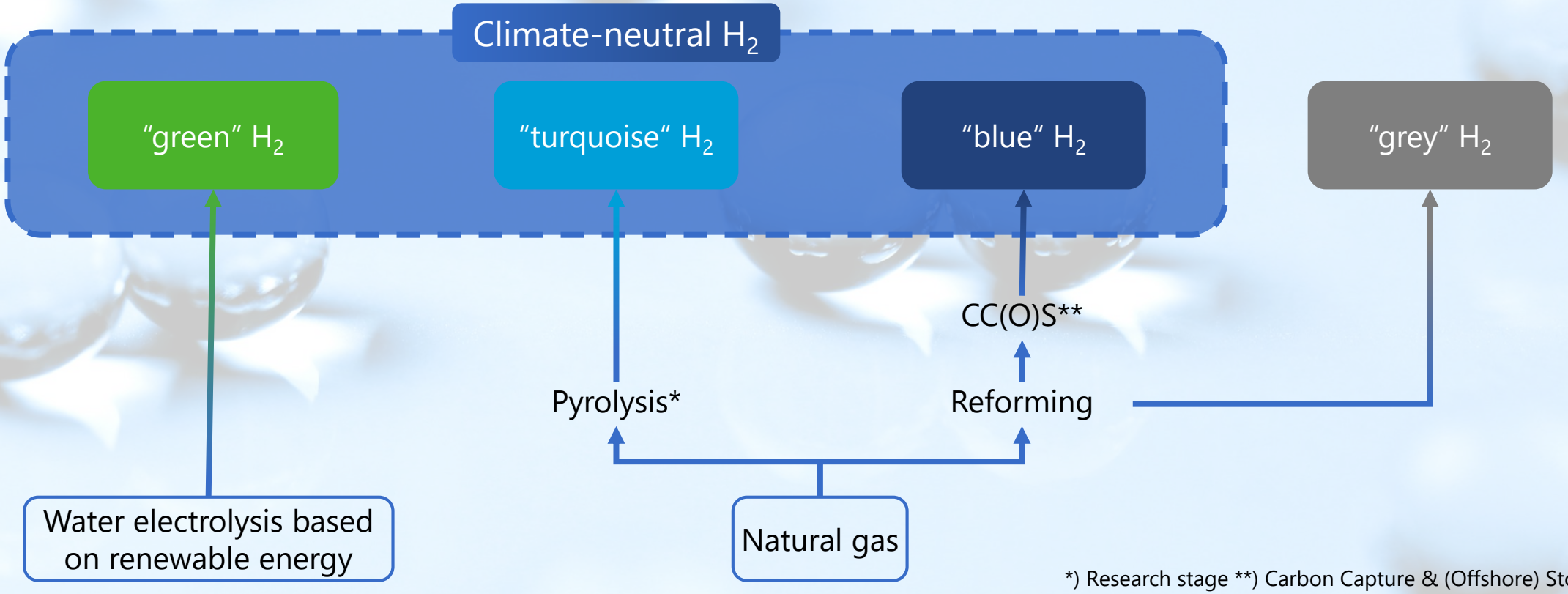
With H2morrow steel, up to 10.5 million t of CO_2 can be saved each year

➡ Current emissions TKS:
approx. 18.5 million t of CO_2/a

- Reforming capacity: 2.7 GW
- Potential implementation: 2nd half 2020s
- Volumes required to develop infrastructure and hydrogen market
- Large volumes 24/7 possible
- Pure H_2 for industrial use

Different production technologies

Production of H_2

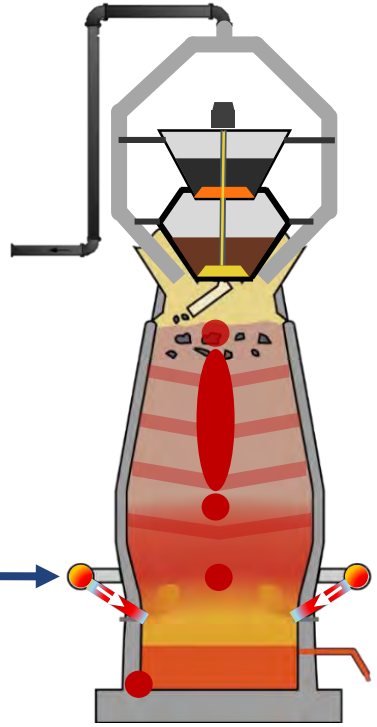


Gas will replace coal as reduction agent

Coal-based blast furnace route reached technical optimum

Raw iron production in blast furnace:
reduction agent coke takes up structural role

Additional reduction agent (pulverized coal, natural gas, coke oven gas, H2)

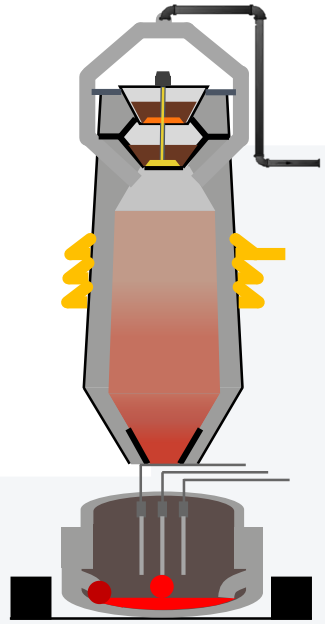


1800 kilo CO2/t steel

kg CO_2 emission per t crude steel

c. -95%

Iron sponge production in direct reduction plant:
Gas (natural gas, coke oven gas or hydrogen) as reduction agent

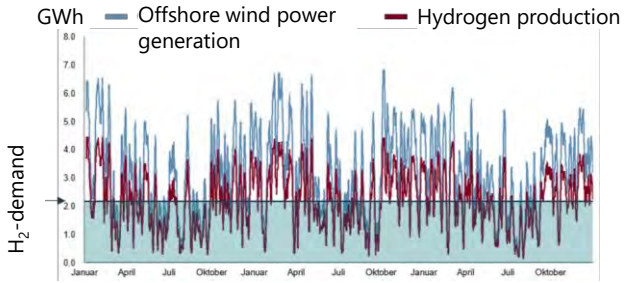


100 kilo CO2/t steel
(electric melting with renewable energy)

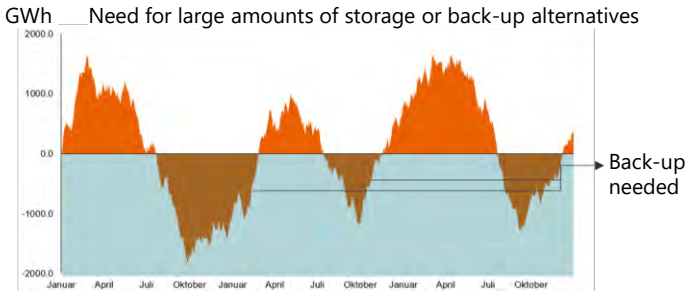
Sources:
https://www.tec-science.com/material-science/steel-making/blast-furnace-process/
https://www.tec-science.com/material-science/steel-making/direct-reduced-iron-dri-process/

Multiple routes, but different challenges

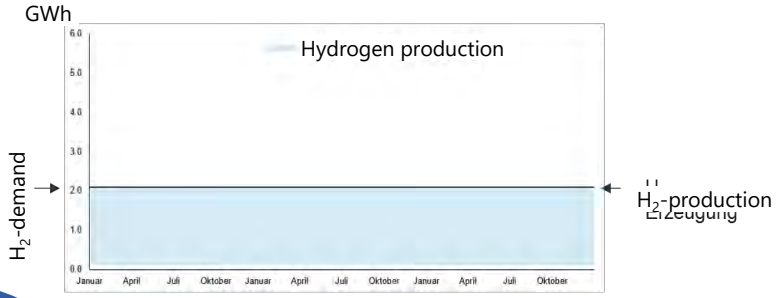
Covering the demand by green H_2 is challenging in the short to medium term



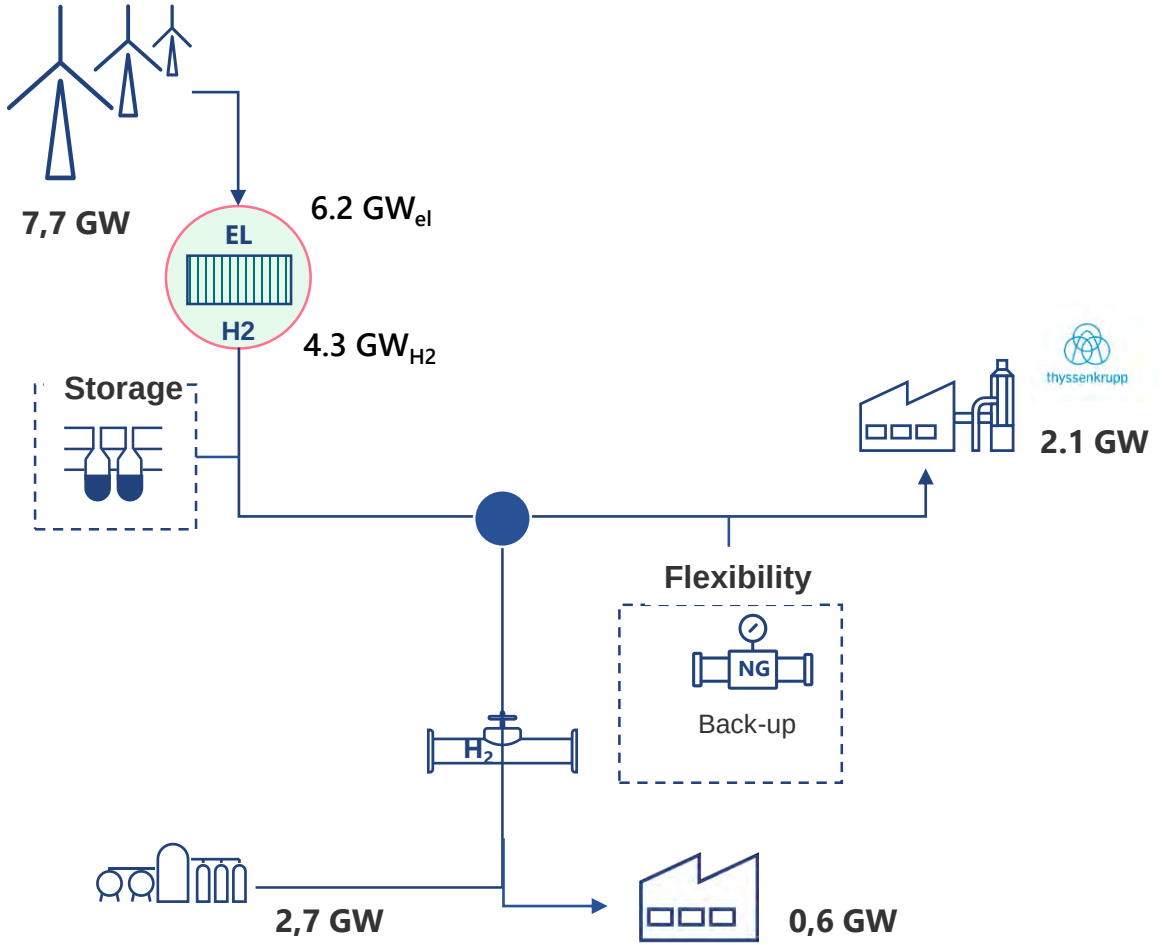
green H2 route



green H2 route



blue H2 route

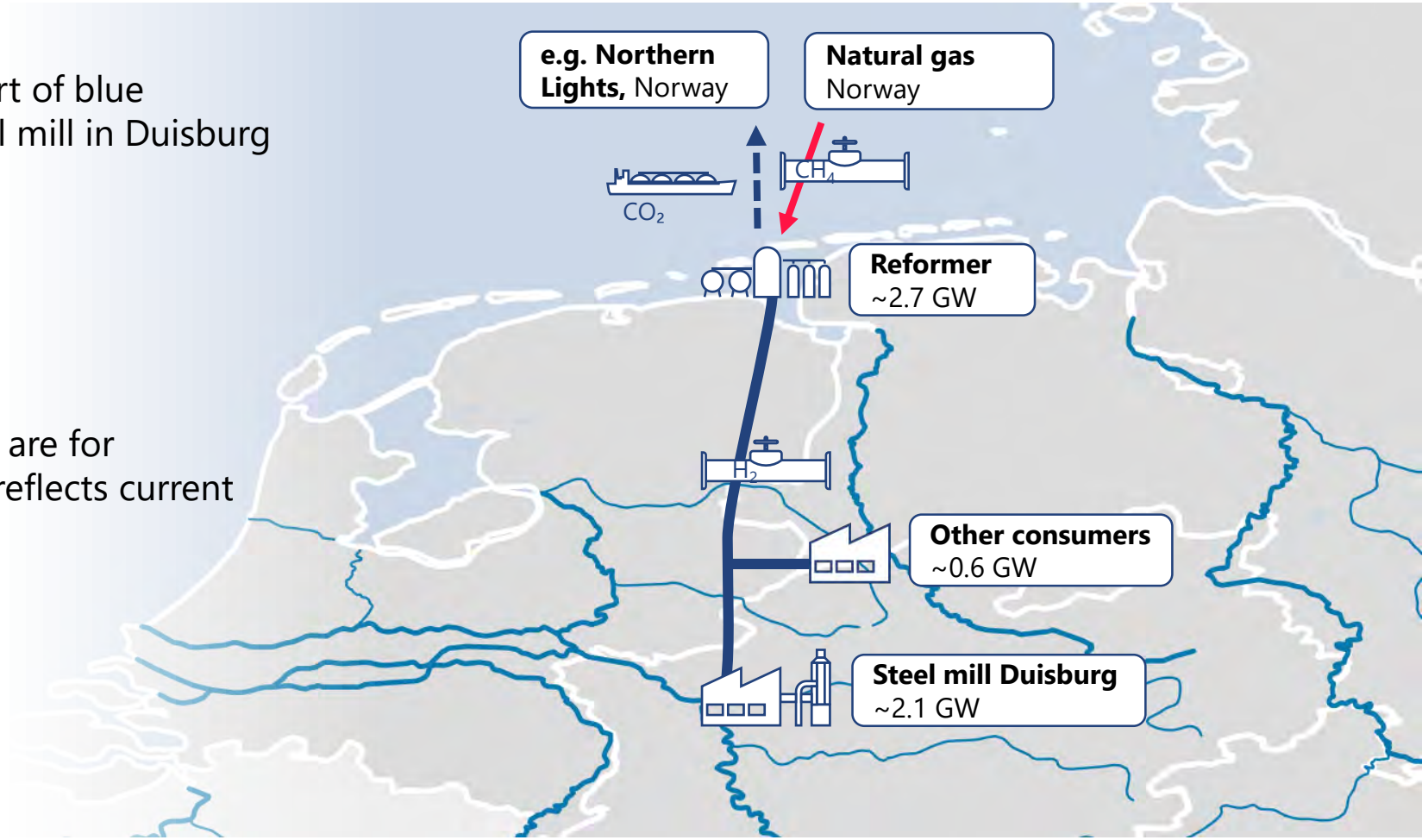


Joint feasibility study “H2morrow steel“

Climate-neutral hydrogen for a decarbonized steel industry

Concept of production and transport of blue hydrogen to Germany’s largest steel mill in Duisburg

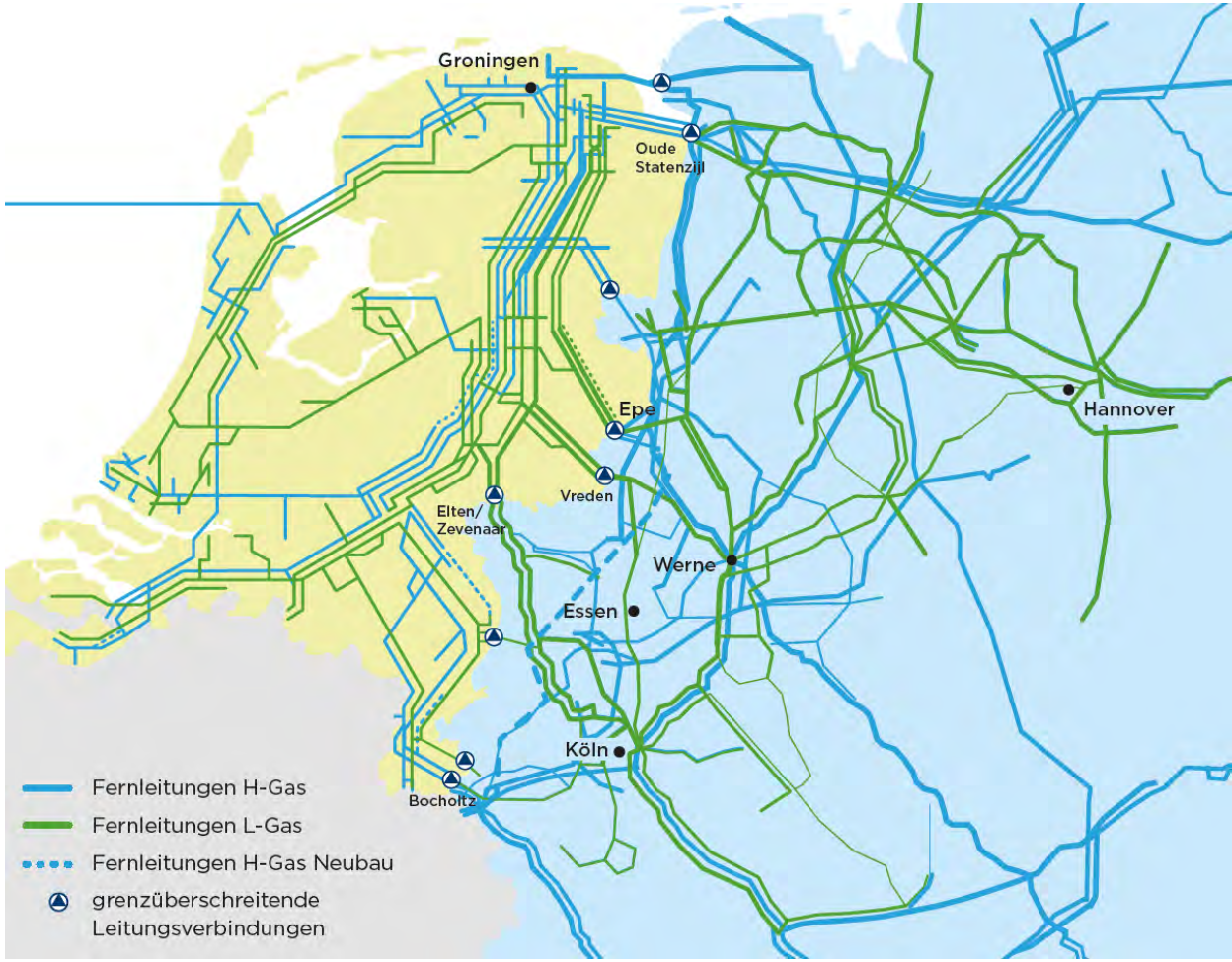
Locations of reformer and pipelines are for illustration purpose only. Numbers reflects current planning assumptions



Development of an (EU-wide) H_2 infrastructure

The Netherlands and Germany offer ideal starting conditions

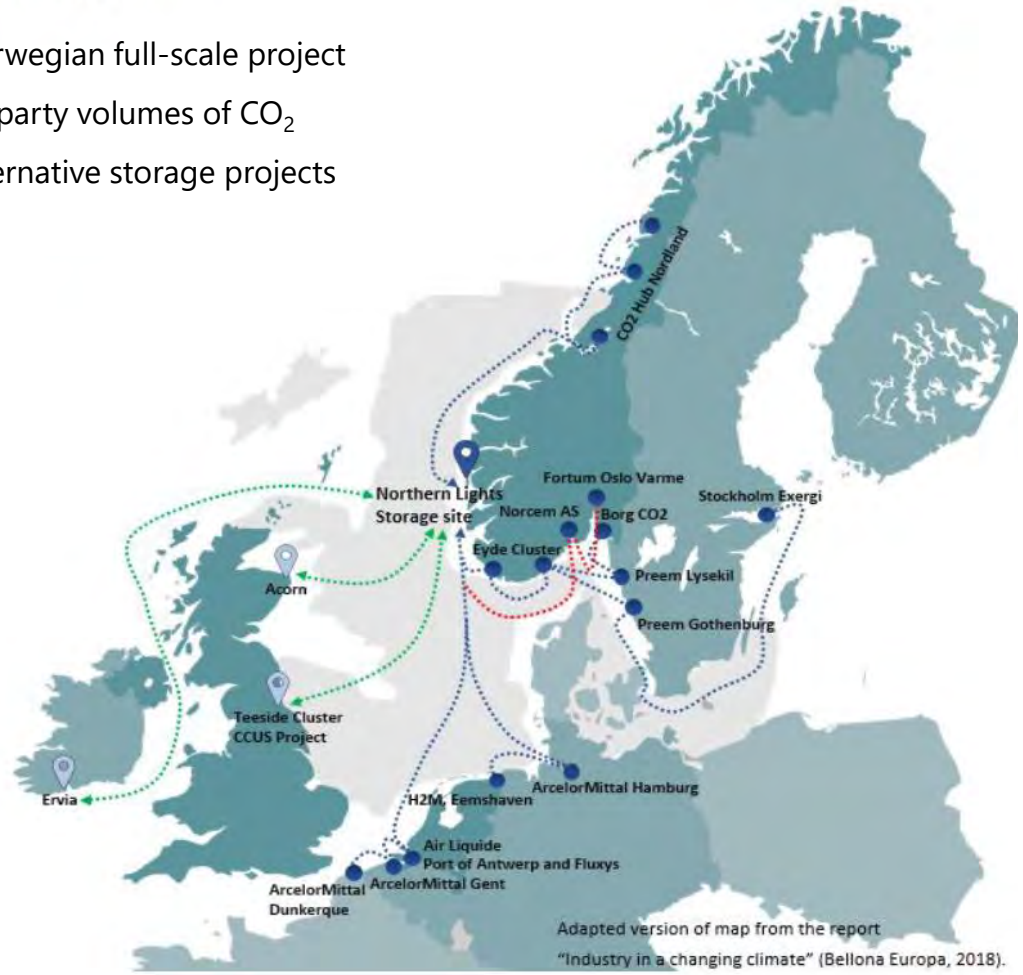
- **L-gas pipelines** for H_2 transport **available** in principle
- **Large storage potential** of H_2 in caverns
- **Practical experience** in the separate **transportation** of two types of gas
- Large **potential** for transportation of climate-friendly H_2



Northern Lights

Safe and permanent CO_2-storage under the Norwegian seabed

- Norwegian full-scale project
- 3rd party volumes of CO_2
- Alternative storage projects



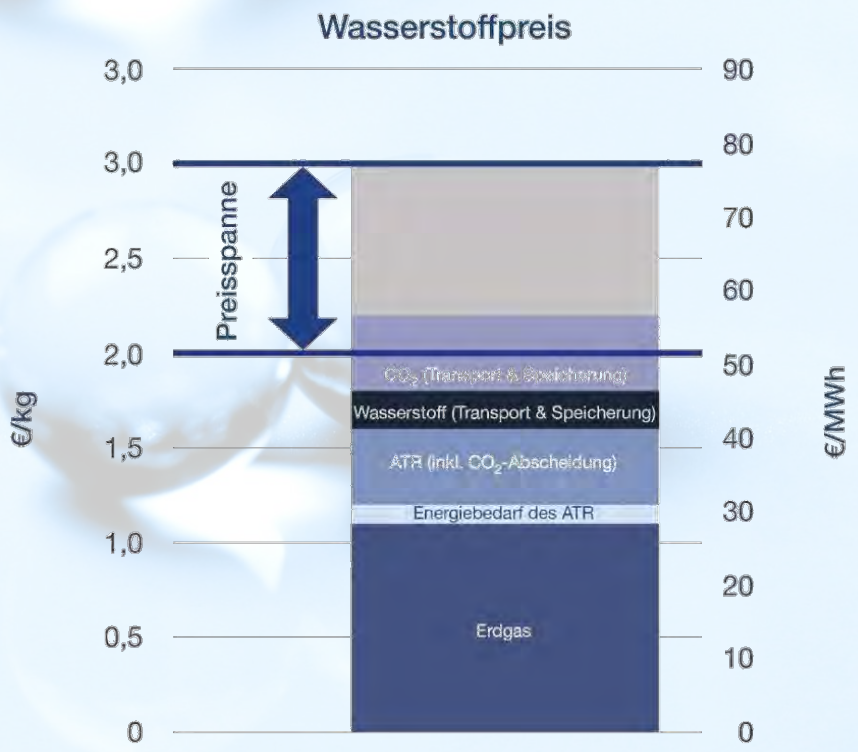
Carbon Capture & Offshore Storage (CCOS) in Norway:

- More **than 20 years of experience**
- **Safe storage**, 2 600 – 3 000 m below seabed
- **CO_2 mineralisation** in the long-term
- **Large Capacities underneath** the North Sea

Affordability of blue hydrogen

Cost breakdown – assuming 23 EUR/MWh long term natural gas price

Pre-study estimate



Estimate of the current feasibility study

58 EUR/MWh Hydrogen

2,1 EUR/kg Hydrogen

Summary (2/2)

- Blue hydrogen allows for the **transformation** to a hydrogen based economy and justifies the construction of a pure hydrogen infrastructure, for example by conversion of existing natural gas pipelines
- The **H2morrow steel** project: Blue hydrogen from natural gas reforming combined with the Norwegian CCOS-project Northern Lights
- **CCOS-technology**: Applied and monitored in Norway for more than **20 years**
  Safe and permanent storage at depths between 2 600 and 3 000 m below seabed
- For the realisation of the project certain existing legislative and regulatory **hurdles** must **be removed** and appropriate **compensation mechanisms** for industry in international competition are required

Vielen Dank
für Ihre Aufmerksamkeit!

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