



GREEN HYDROGEN

SEPTEMBER 2023



Today's speaker



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**Burckhardt Compression
Hydrogen Mobility & Energy Leader**



**Ausbildung:
BSc Maschinenbau, MSc Verfahrenstechnik ETH**



**13+ Jahre Erfahrung in der Polymer / Öl & Gas / Wasserstoff-Industrie in
den Bereichen:
Prozesse, Anlagenbau für internationale Projekte, Technischer Verkauf,
Business Development, Strategie**

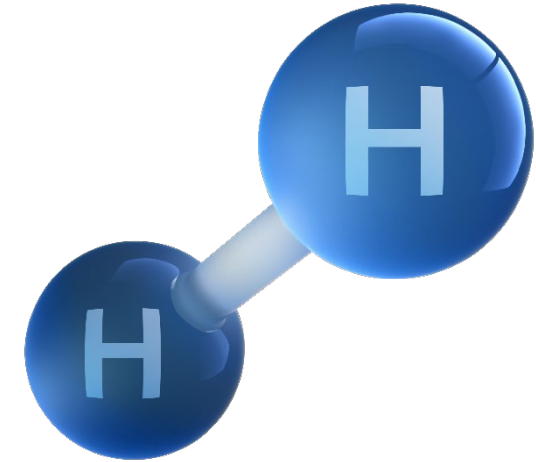


Wohne mit meiner Familie in Winterthur, Schweiz

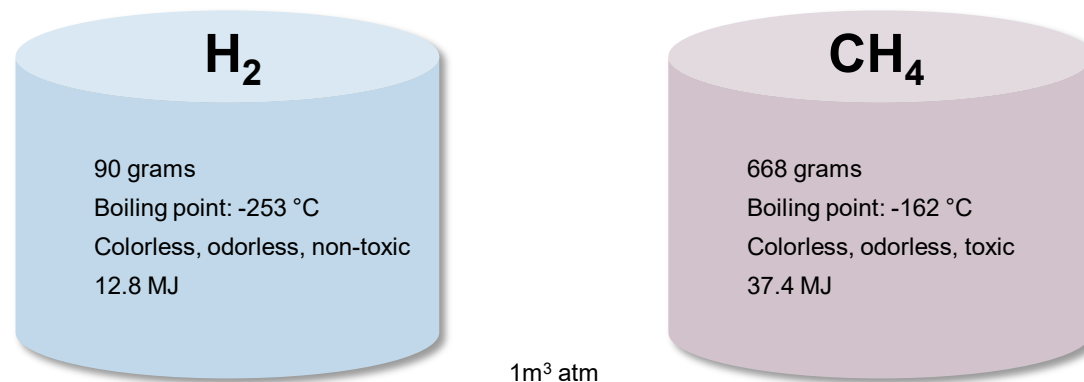
Hydrogen

Hydrogen is the most abundant chemical substance in the universe, constituting roughly 75% of all normal matter.

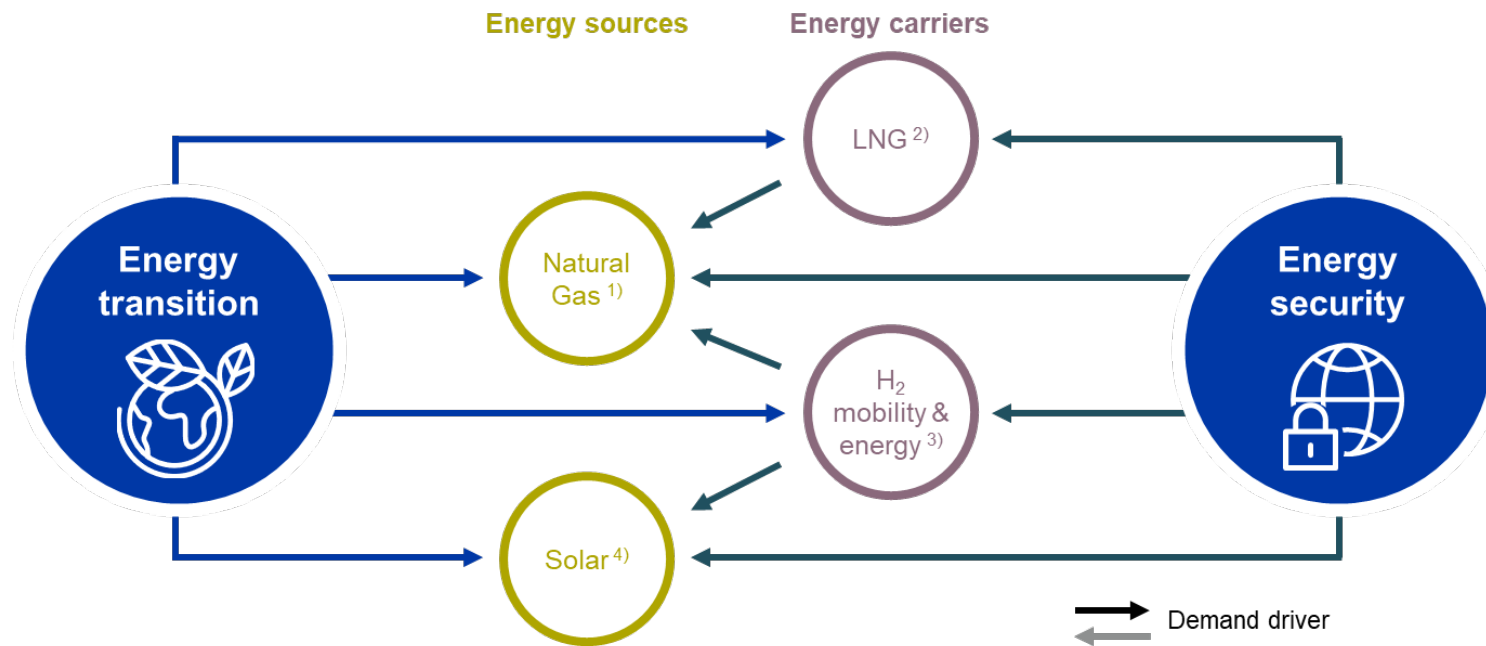
Here on earth, vast numbers of hydrogen atoms are contained in water, plants, animals and, of course, humans. But while it's present in nearly all molecules in living things, it's very scarce as a gas – less than one part per million by volume.



Hydrogen is a clean alternative to methane, also known as natural gas:

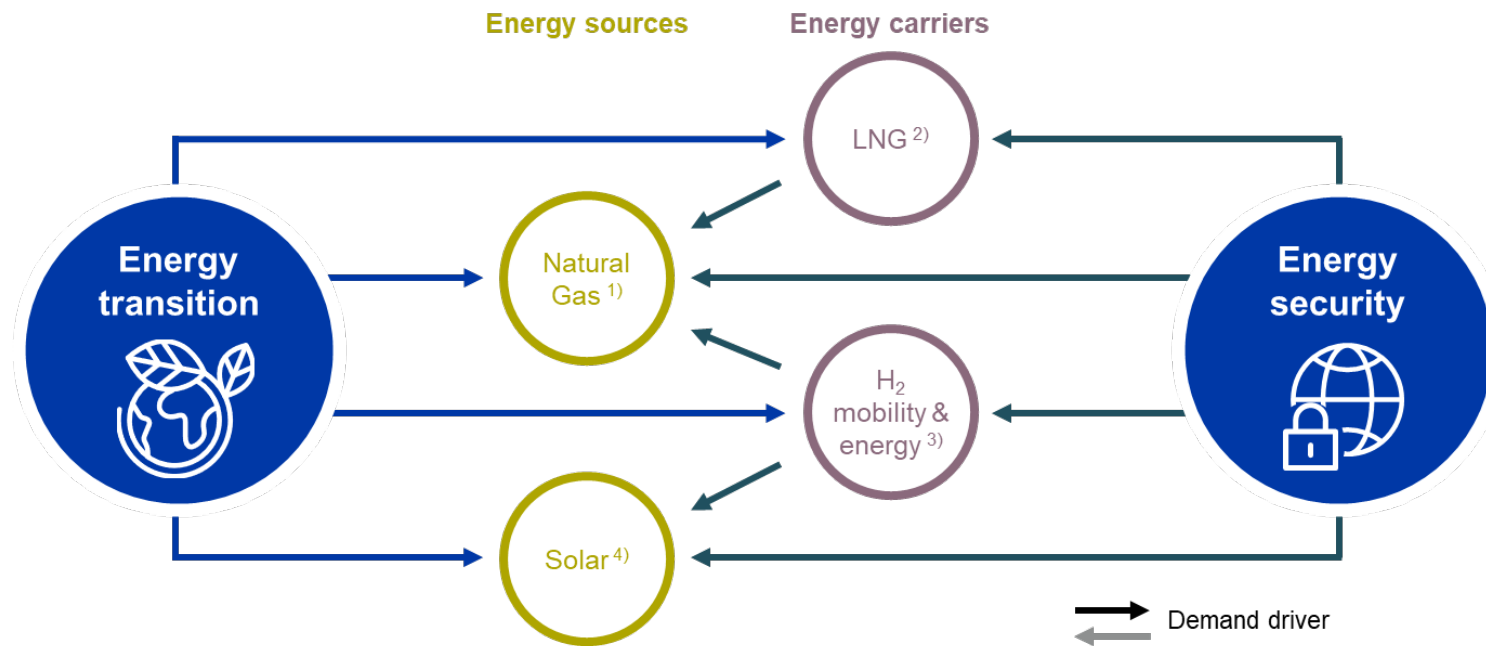


Hydrogen is needed for the energy transition & energy security



- 1) Gas gathering, processing, transport and storage
- 2) LNG terminals, dual-fuel ship engines, bunkering
- 3) Liquid H₂ production, transport, storage, trailer-filling, fuel stations, ammonia, steel
- 4) LDPE/EVA and polysilicon production

Hydrogen is needed for the energy transition & energy security



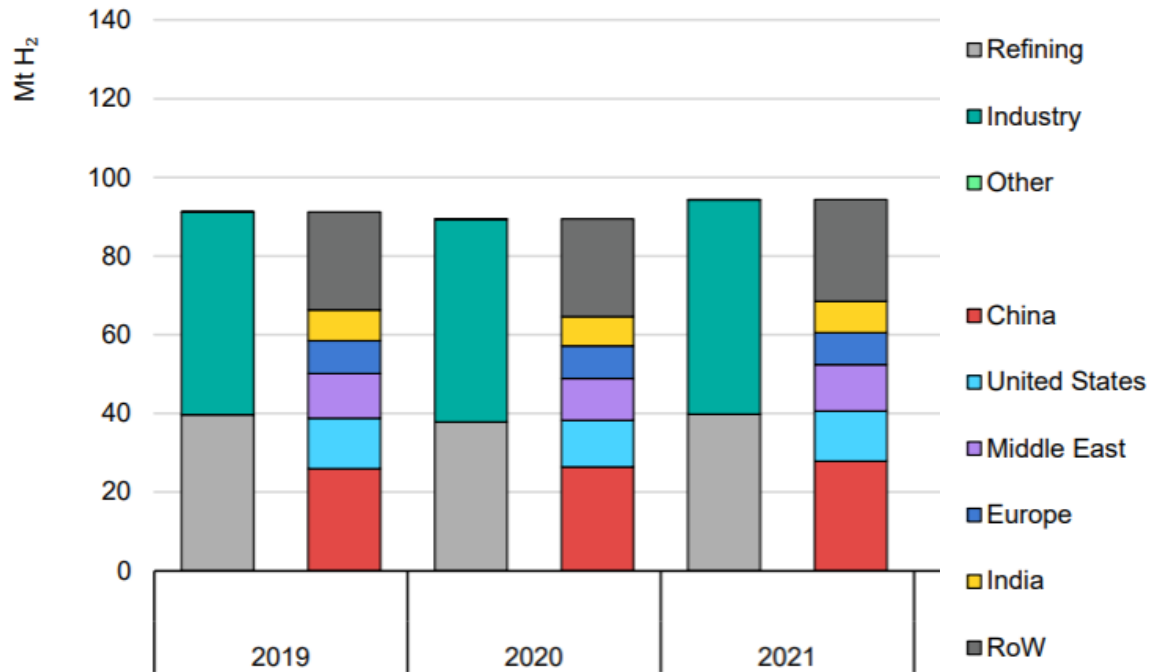
Transport and storage of renewable energy

Decarbonization of Industry and Mobility

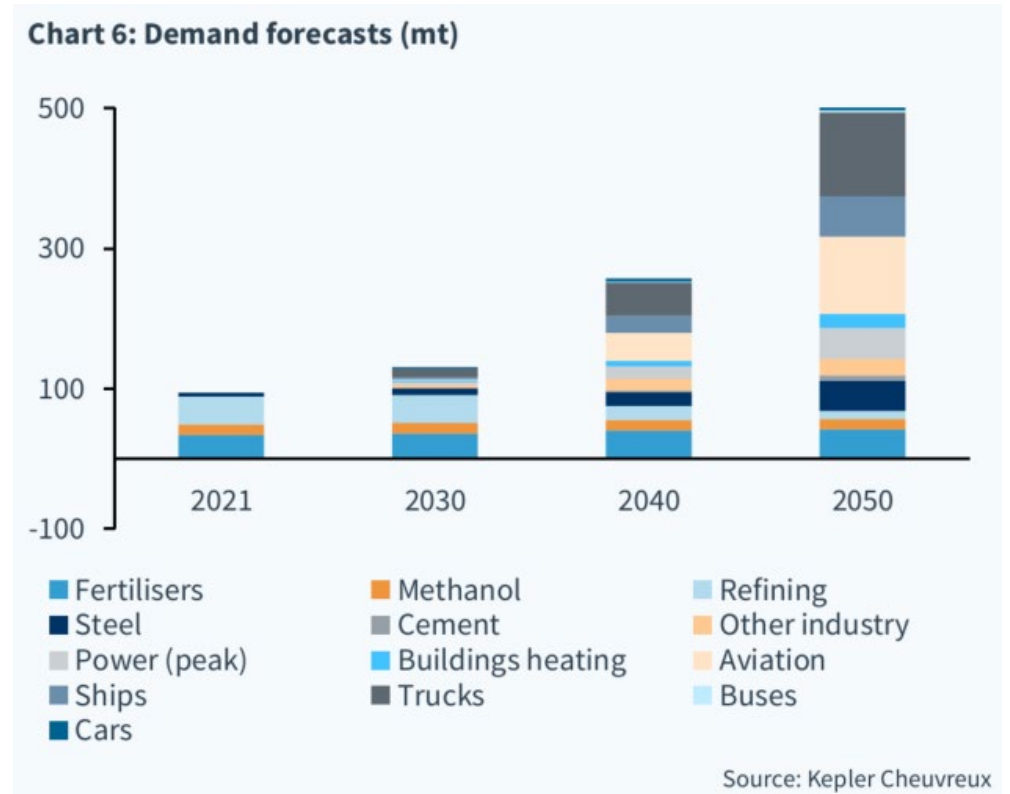
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- 4) LDPE/EVA and polysilicon production

The Hydrogen demand today and in future

Today's main consumer of Hydrogen is the industry (refineries, fertilizer, methanol).
 Future Hydrogen demand will extend to other end-use such as mobility and power generation.

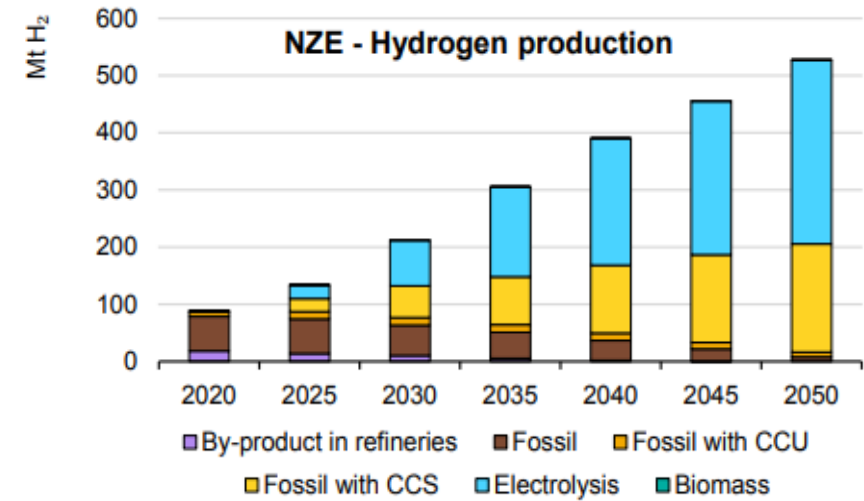
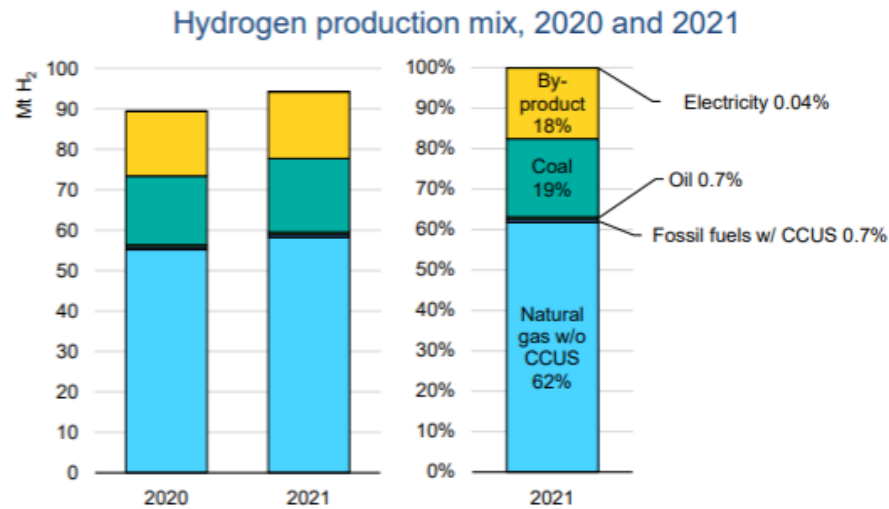


IEA. All rights reserved.



Source: Kepler Cheuvreux

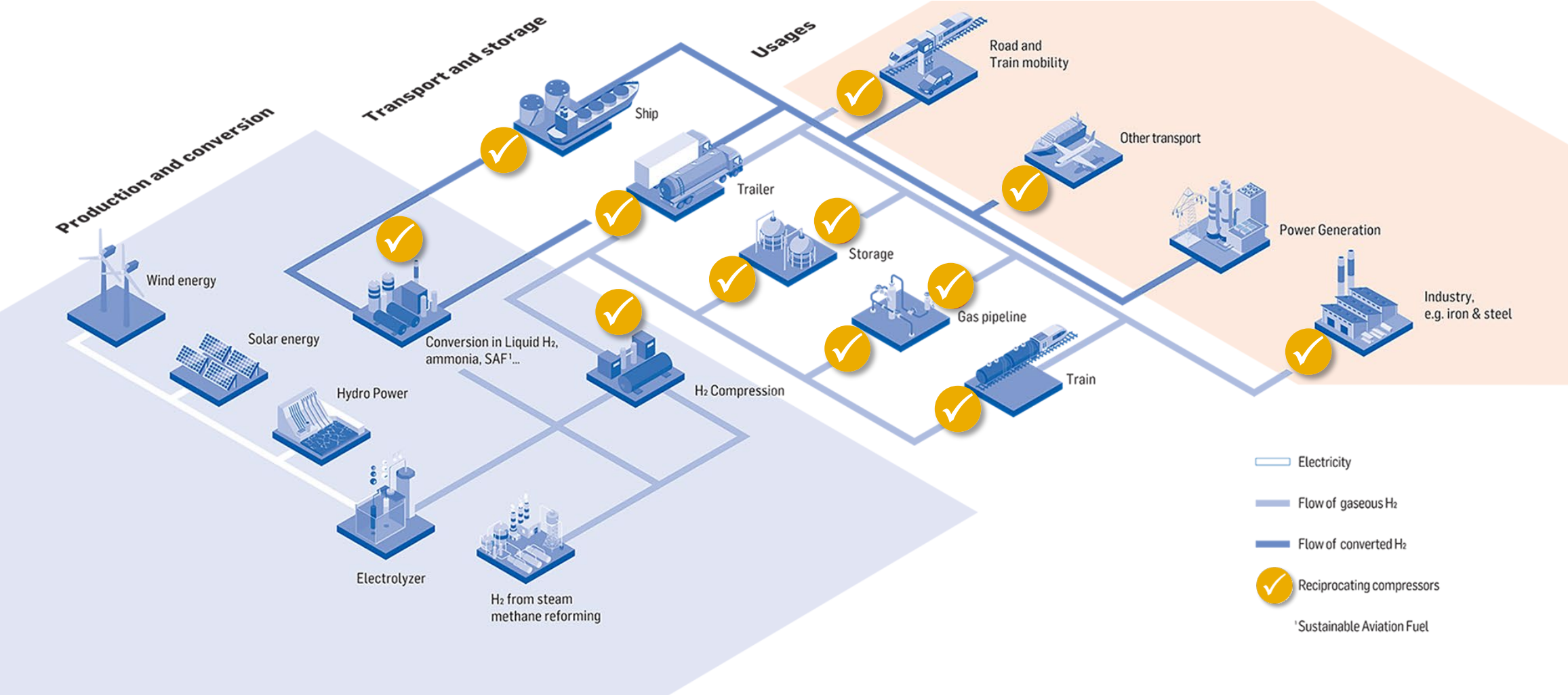
Hydrogen production – from grey to renewable



IEA. NZE: Net Zero Emission

	Process	H molecule source	Power source	Carbon intensity
Green	Electrolysis	Water	Renewable: wind, solar, hydro	Very low
Grey	Steam Methane Reformer (SMR)	Natural gas	Non-renewable	Very high
Blue	SMR + Carbon Capture	Natural gas	Non-renewable	Low
Turquoise	Pyrolysis	Natural gas	Various	Very low
Purple	Electrolysis	Water	Nuclear	Very low

We offer Compression Solutions for the entire Hydrogen value chain



We are wherever gases are compressed



Petrochemical and chemical industry



Gas transport and storage



Hydrogen mobility and energy



Industrial gas



Refinery



Gas gathering and processing

Our purpose is our DNA

Our Purpose

**We create leading compression solutions
for a sustainable energy future**

We believe in long-term commitment

> 50%

of compressors with Burckhardt Compression serial number have been in service for more than

20 years

Our oldest known compressor still in service is in Canada and has an age of

93 years



Our 2027 sustainability targets



Climate

-50%

Greenhouse gas emission intensity*
2021: 2.1 kg CO₂e/h



Energy

>75%

Share of renewable electricity*
2021: 23%



Longevity / cyclability

+100%

Revamp + upgrades activities in Services
2021: 100 (Index)



Application purpose

40%

Order intake supporting the energy transition
2021: 16%



Working conditions

≥80%

Engagement Score in employee survey**
2020: 79%



Health & safety

<0.7

Lost Time Injury Rate below 0.7 each year
2021: 1.1



Product safety

0

Incidents related to product safety
2021: 0



Business conduct

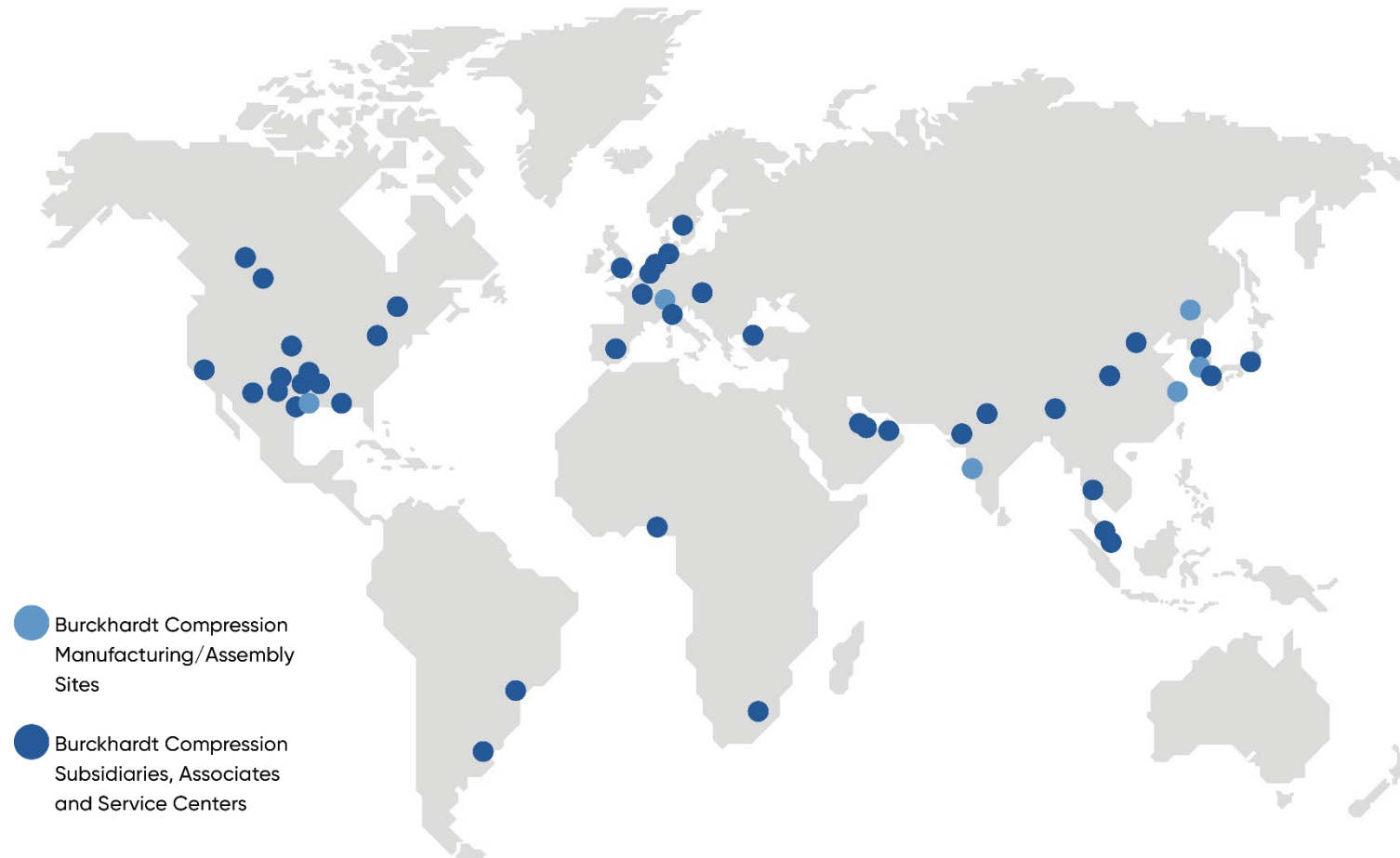
0

Incidents on corruption or anti-competitive behavior
2021: 0

* Excluding the Shenyang foundry, where we rely on renewable grid electricity or technological developments for our ambitions.

**Based on current survey methodology

2'973 qualified employees around the world for new compressor systems and services



Compression systems



Highly reliable compressors
Full compression solutions

Services solutions



Optimizing your compressor system
Turning partnership into success

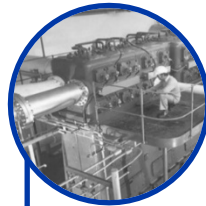
From Engineering Workshop to Global Market Leader

Engineering workshop founded in Basel



1844 | 1883

Safe compression of oxygen in the steel industry



1935

Liquefaction and transport of natural gas



1971 | 1999 | 2002

H₂ Pipeline Injection



2008

Use of LNG as fuel for maritime carriers



2013

Bulk LH₂ Compressor



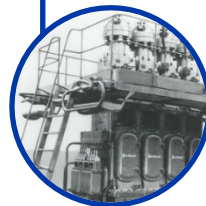
2019

1878



Production of fertilizers

1920



Production of plastics

1951

1969



H₂ compressors for refineries

1972

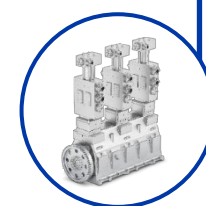
1982



Oil-free hydrogen compression for trailer filling

2001

2020



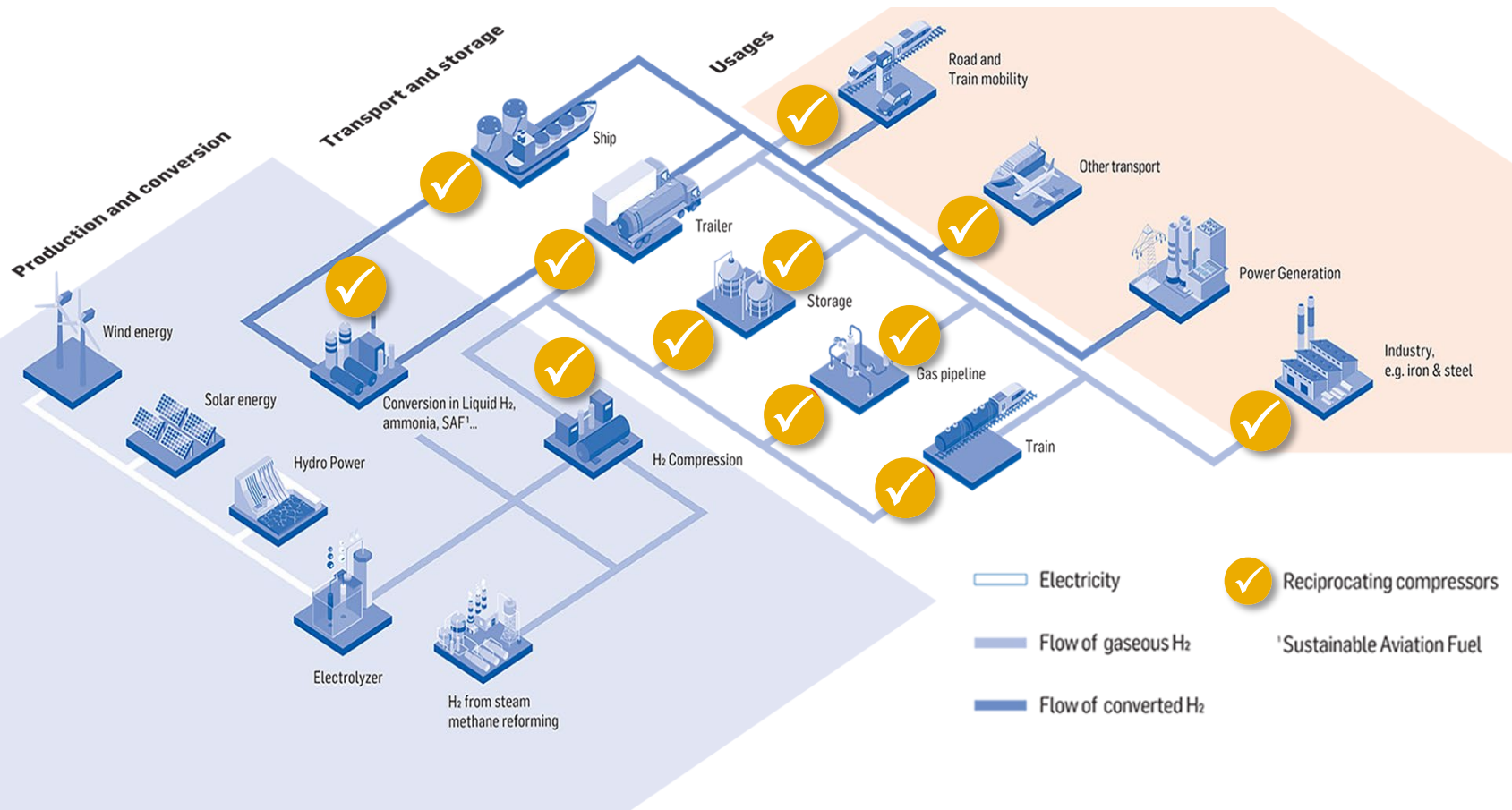
H₂ Trailer filling & fuel stations

2021



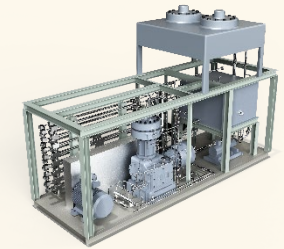
550 bar oil-free for H₂

Hydrogen for Mobility & Energy – Our Compressors are Required Across the Entire Hydrogen Value Chain



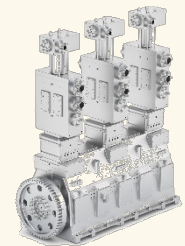
Diaphragm Compressor

- Containerized
- Small Flows
- High Pressure
- › Trailer filling
- › Fuel stations



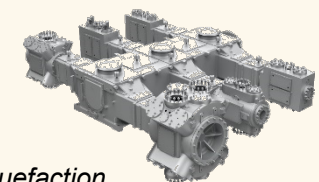
Vertical Piston Compressor

- Oil-free
- Large Flows
- High Pressure
- › Trailer filling
- › Fuel stations



Horizontal Piston Compressor

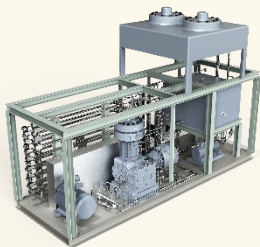
- Oil-free
- Large Flows
- Medium Pressure
- › Pipeline injection, Liquefaction
- › Syngas & Ammonia



Key Products for Hydrogen Mobility & Energy Applications: Today's products, references and further developments

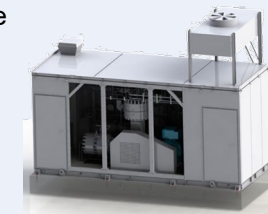
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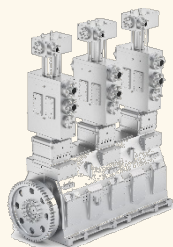
MD10-L EU Package

- Standardized package
- Optimized container
- Safe zone integrated
- › Trailer filling
- › Fuel stations



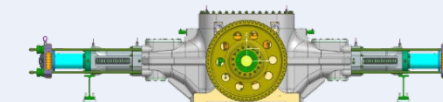
Vertical Piston Compressor

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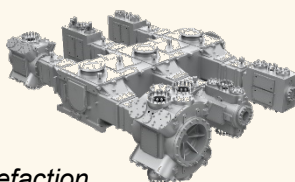
H₂ booster to 900bar

- Oil-free piston compressor
- › Ultra-heavy refueling



Horizontal Piston Compressor

- Oil-free
- Large Flows
- Medium Pressure
- › Pipeline injection, Liquefaction
- › Syngas & Ammonia



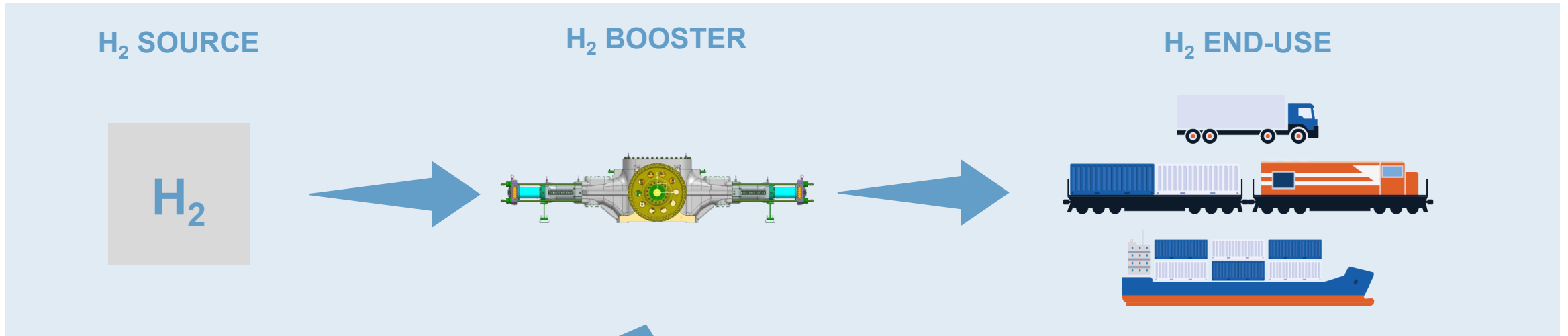
Large piston

- Light-weight piston design
- Optimized cylinder design
- › Pipeline injection
- › Liquefaction



Innovation – Pushing the Limits of Oil-Free High-Pressure Hydrogen Compression

Partnership with Shell New Energies for development of Heavy-duty Hydrogen Refueling Station Compressor Systems



Compressor development with new test facility in Winterthur, Switzerland, for 900bar compression:

- Advancement of sealing technologies and solutions for HRS serving heavy-duty vehicles
- First results will be available beginning of 2024



New solution can be scaled-up and applied for entire hydrogen energy and mobility industry

Hydrogen Compressor References in Operation

Hydrogen Pipeline Injection, NL

Hydrogen pipeline from production site in Botlek, Rotterdam to Antwerp (B) distribution center to industrial end-users in North of France. Start-up 2009.

H₂ compression 22-100 barg, 6'052 kg/h, 3 units in parallel
6BA Compressor Unit with 4.8 MW motor power



Hydrogen Liquefaction, USA

Hydrogen liquefaction plant in Las Vegas, US. Distribution of LH2 to various end-users in California. Start-up 2019.

H₂ compression from 6-60 barg
30 tons per day of liquid hydrogen production
4BE Compressor Unit with 7.4 MW motor power



Test field for Electrolyzers and hybrid power plants in Bremerhaven, Germany

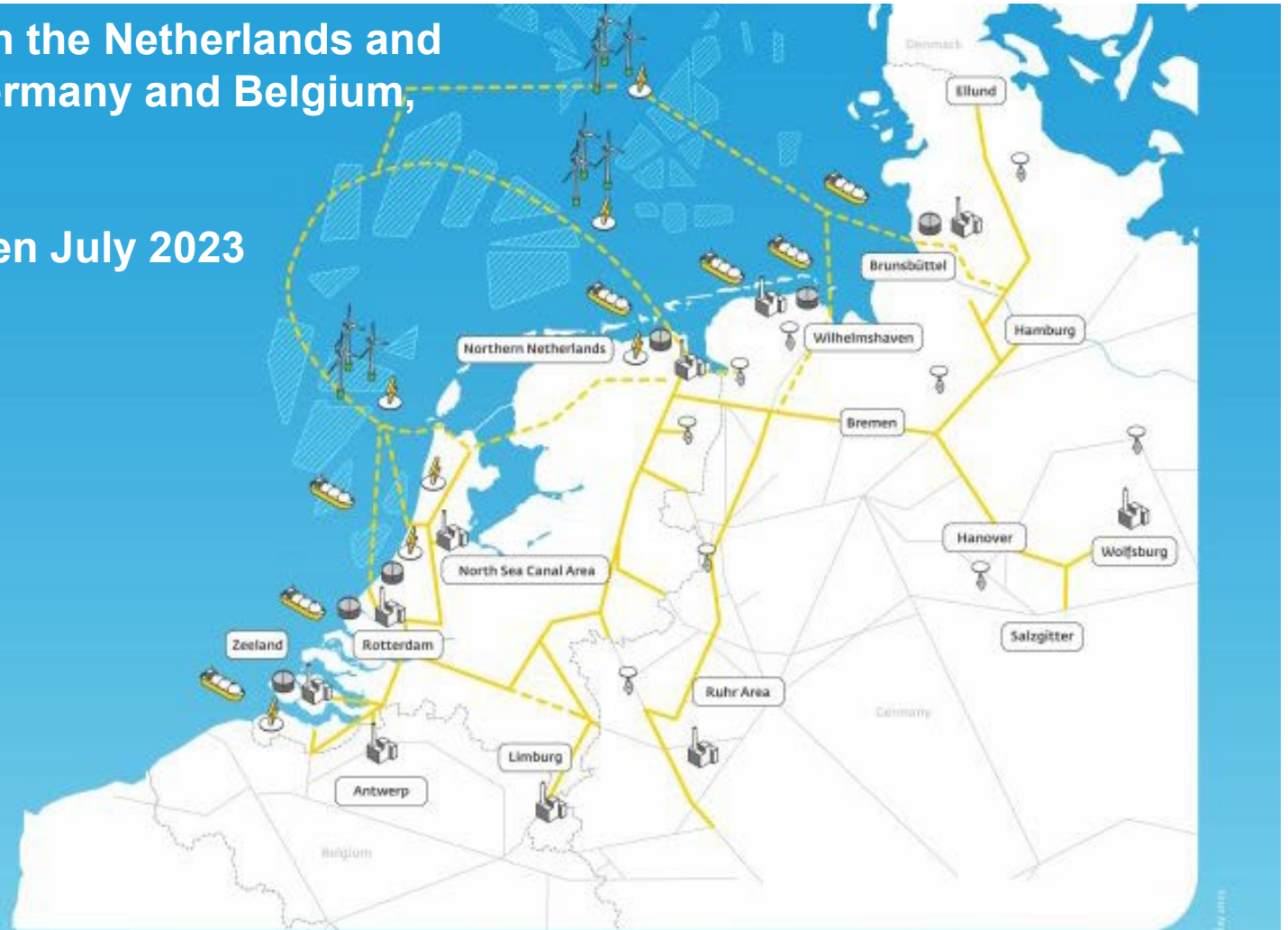
- Fraunhofer IWES (Institute for Wind Energy Systems)
- Experimental testing and modeling up to 10MW
- Core competency grid integration tests
- Simulation of entire hydrogen value chain from production through to usage
- BC to supply 3 diaphragm compressor units for trailer filling
- Prof. Dr.-Ing. Jan Wenske, Deputy Director Fraunhofer IWES:
“We will test and optimize the procedure for direct electrolysis with wind energy in the megawatt range independent of the manufacturer.”

[Test Field for Electrolyzers and Hybrid Power Plants \(fraunhofer.de\)](https://www.fraunhofer.de)

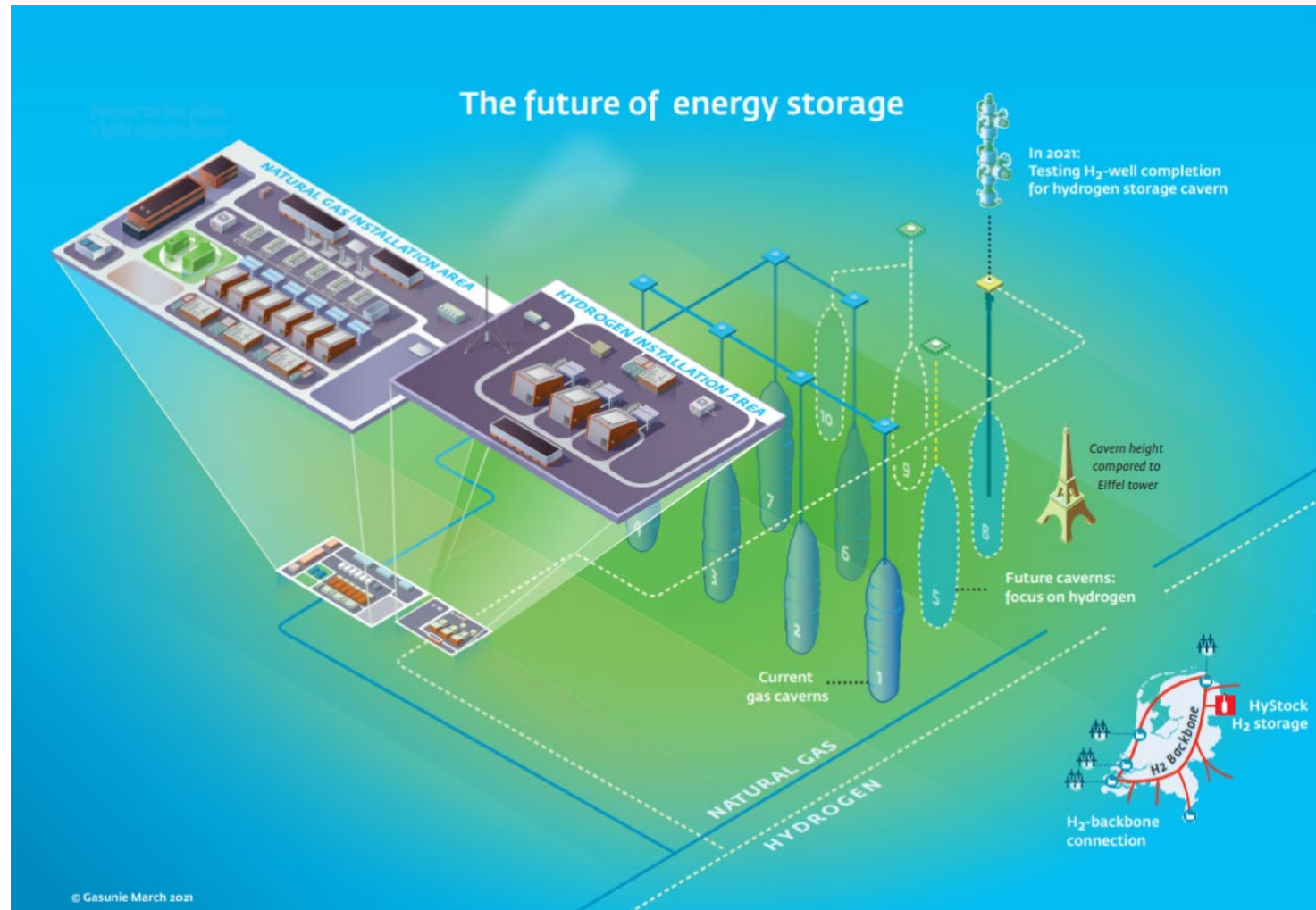


Hydrogen Network HyNetwork in The Netherlands

- Connect major industrial regions in the Netherlands and surrounding countries, such as Germany and Belgium, from 2030 onwards
- Total cost around €1.5 billion
- FID (final investment decision) taken July 2023



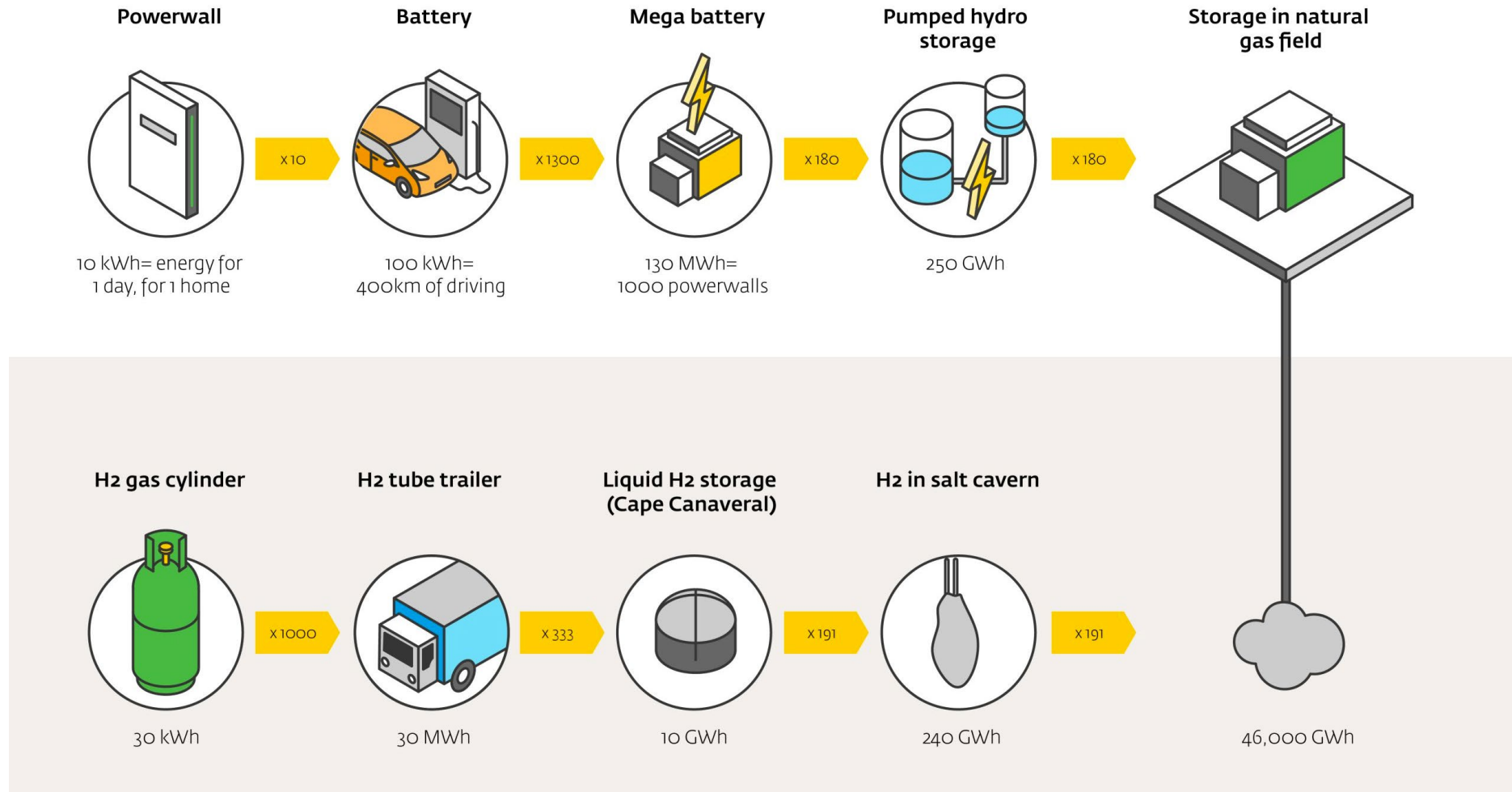
Hydrogen Storage Project HyStock, The Netherlands



**Capacity of one salt cavern:
22-25 kton; 80 t/h send-in & send-out**

- 2020: Feasibility study
- 2021: Basic design and start permitting
- 2022: Small scale tests
- 2022: Start with detail design and RFQ
- 2027: First storage facility ready

Electrical and hydrogen storage capacity comparison



Questions?



VIELEN DANK!

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