

Driving Tomorrow's fuel today

What role does H2 play in mobility

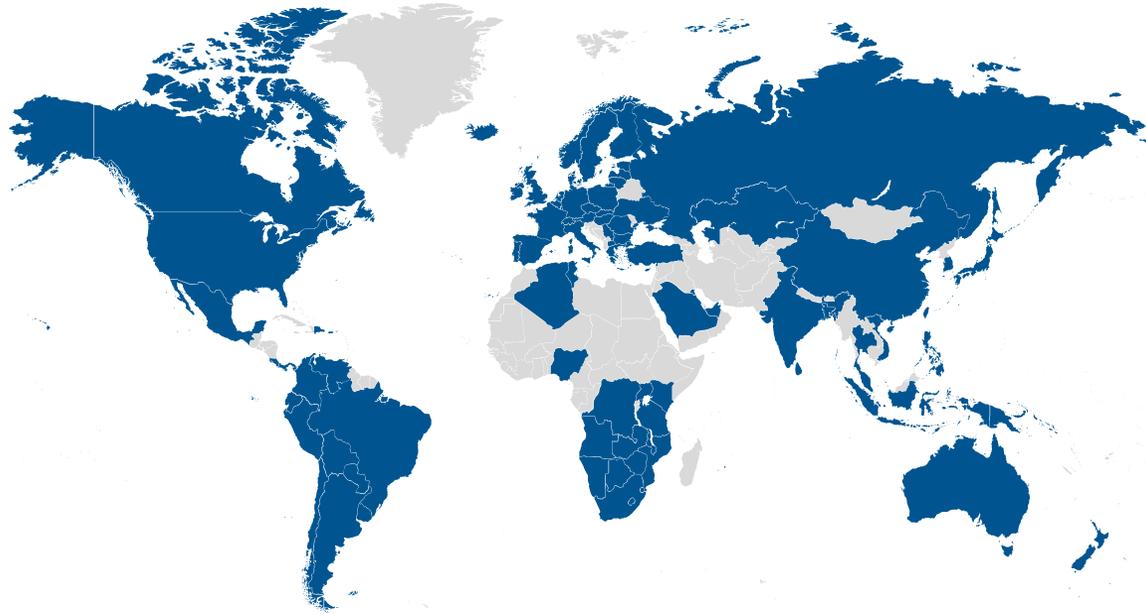
Energy4Mobility ExpertTalk
15.06.2023
Thomas Schaefer

Making our world more productive



Introduction Linde plc

Linde is global gas and engineering company and a leader in technology



100+

countries

Enabling strong, complementary positions in all key geographies and end markets

~75,000

employees

Achieving our full potential, individually and collectively

\$31 billion

2021 sales

Established presence where customers are and where their operations are growing

6,500+

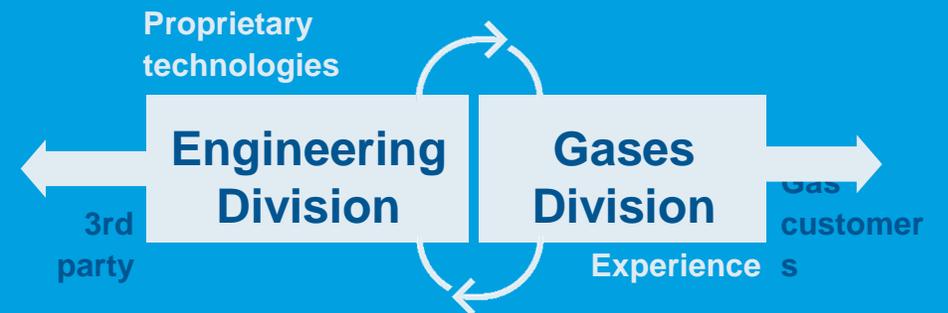
active patent assets worldwide

Leading with innovative products, solutions and technologies

Our Mission

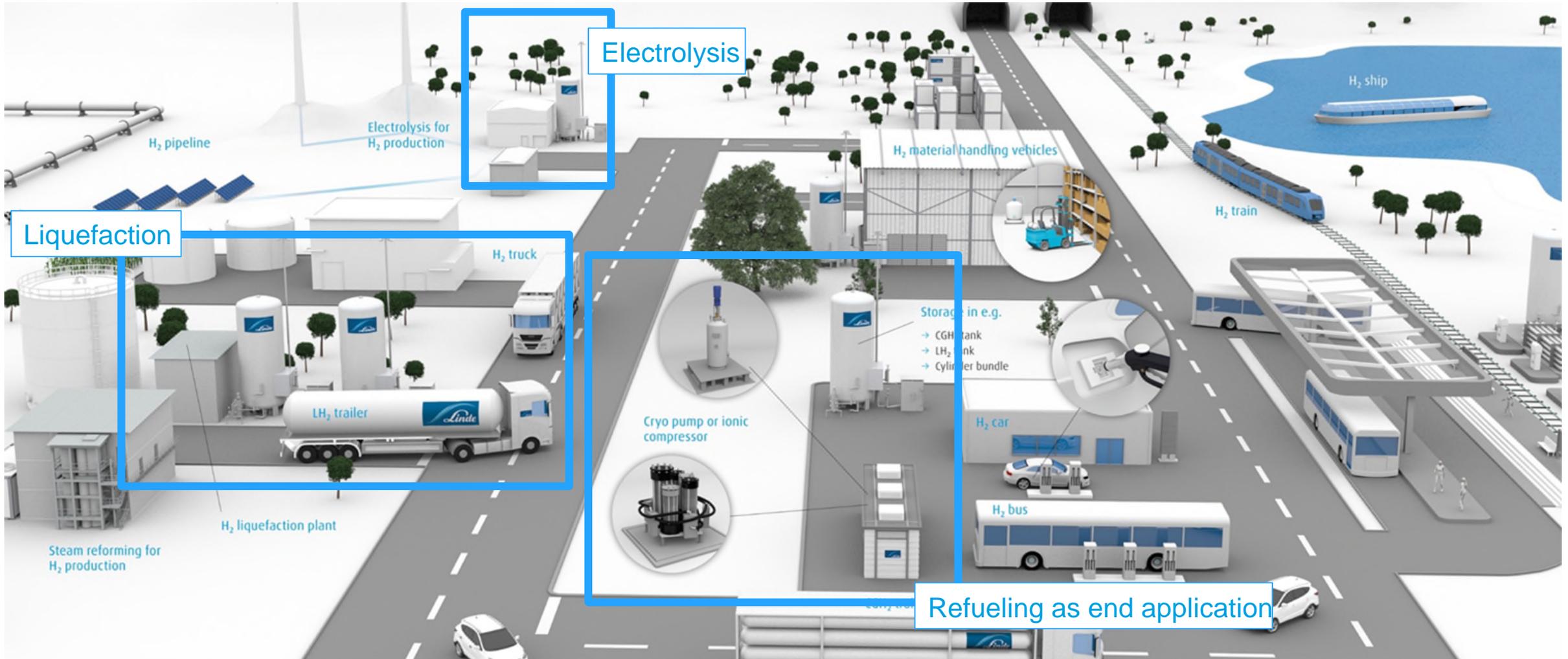
We live our mission of **making our world more productive every day**. Through our high-quality solutions, technologies and services we are making our customers more successful and helping to sustain and protect our planet.

Linde Profile



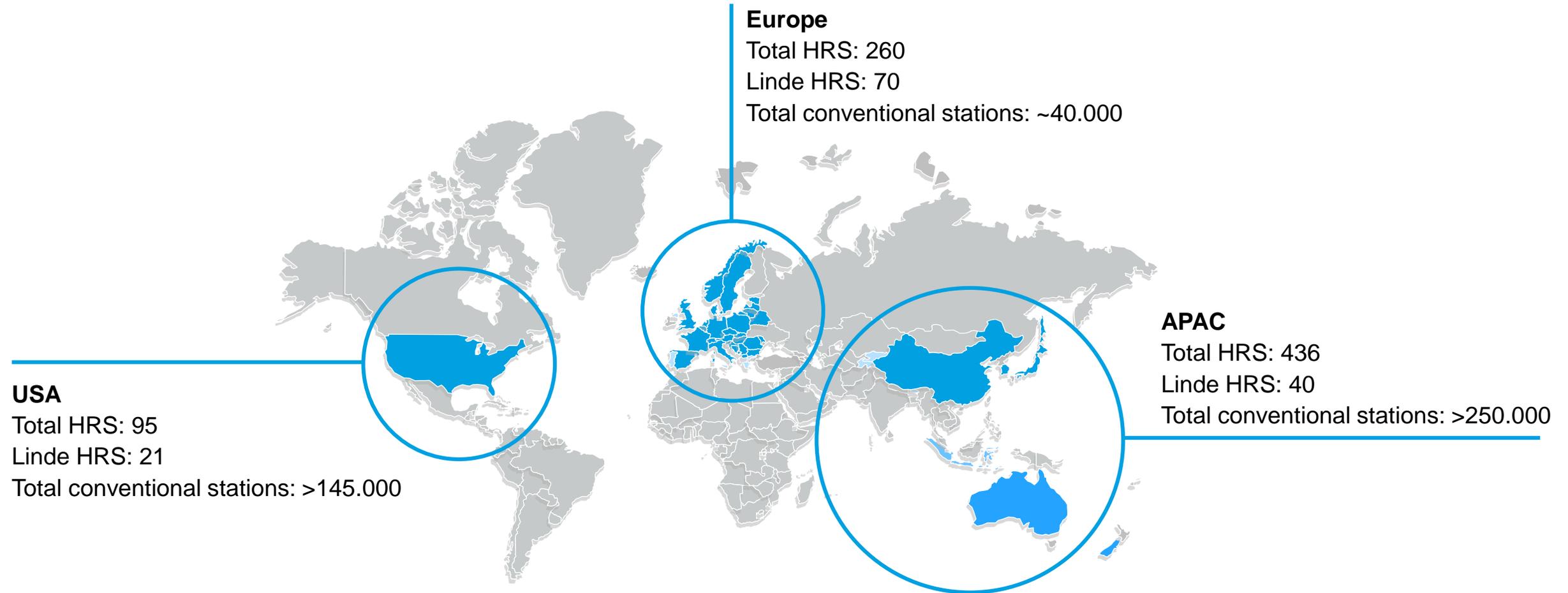
Linde's Hydrogen Value Chain

With leading technology, Linde optimizes the efficiency of hydrogen as energy vector



Hydrogen Refueling Stations globally in operation

Hydrogen mobility is an established and proven technology



HRS infrastructure by Linde

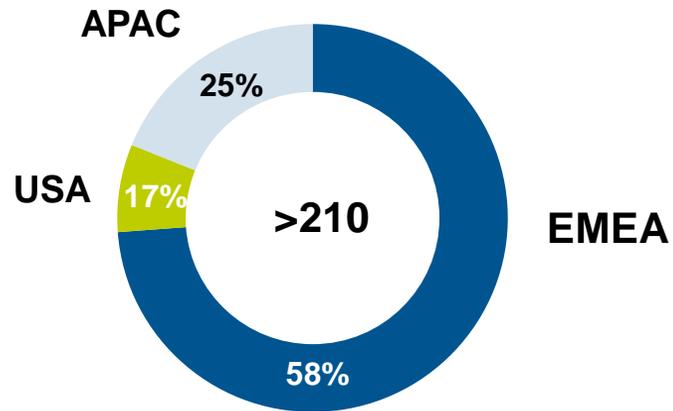
With more than 210 HRS built, Linde has a big impact on decarbonizing mobility



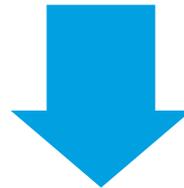
HRS infrastructure installed by Linde

Total H₂ refueling capacity

“Save-the-planet” potential



15 million kg
of hydrogen
per year



1,5 billion km zero
emission
per year

**180.000 tons
of CO₂ per
year
avoided**



Linde's 200th HRS installed in Alesio Viejo (CA, USA) in 2021

The power of hydrogen and fuel cell technology

Due to the technical facts, hydrogen is inevitable for decarbonizing truck mobility



Truck refueling station by Linde at MPreis, Austria

FCEV

- **Range**
500 km (also in winter times) @ 350 bar; for 700 bar: >1.000 km
- **Refueling time**
10 minutes
- **Weight**
Significantly less than BEV



plus

HRS

- **Connecting power**
<250 kW for 30 Trucks per day and 12 Trucks back-to-back
- **Footprint**
<200 m²
- **Flexibility**

= super efficient zero emission solution

Unique in experience

Linde has already built many different HRS meeting all kind of fueling needs!



Bus / Public Transport



350 bar buses,
green GH2
supply

ESWE; Wiesbaden, Germany

Twin IC 50/60 for eight busses (350 bar) in eight hours



350 bar buses,
largest FC

RVK; Cologne, Germany

2x Twin IC 90/60 for 20 busses (350 bar) per day; 10 busses back-to-back



700 bar buses,
LH2
supply

Iwatani; Tokio, Japan

CP 90/100 for >30 busses (700 bar) per day

Heavy duty / Logistics



350 & 700 bar commercial vehicles

EMS; Jeonju, Korea

Twin IC 90/60 first HRS for trucks (350 bar) and commercial vehicles such as garbage trucks



350 bar trucks, 10 minutes

MPREIS; Völs, Austria

Twin IC 90/60 for > 10 trucks (350 bar) back-to-back in three hours; Europe's most powerful HRS and the first with new CEP fueling protocol (A-Map with B-Map as fallback)

Public network



Parallel refueling of 4x 700 bar

FirstElement Fuel; Fountain Valley, USA

CP 90/100-L for passenger vehicle refueling; four fueling points for parallel fueling



700 bar trucks, buses and cars

SK Group & LG Korea; Daejeon, Korea

IC 90/30-S for 700 bar passenger cars and 700 bar bus refueling



350 bar trucks & buses and cars

Customer: Eni; Venice, Italy

IC 90/30-S for 700 bar passenger cars and 350 bar bus refueling

Train & Forklifts / Special



350 bar trains, 180 kg per min

Alstom; Bremervörde, Germany

3x Twin IC 50/60-L for 14 passenger trains (1.800 kg/day)



350 bar forklifts and 700 bar cars

Daimler; Düsseldorf, Germany

IC 90/30-S for 30 forklifts (350 bar); refueling of passenger cars also possible; highly flexible as dispensers can be installed at two different locations

Reliability & safety are key

Linde is leading in reliability based on long-lasting experience



Industry benchmark for reliability

- 99,5% availability with 150.000 kg of H₂ dispensed
- Equipped with **Twin IC90/60-L**
- High redundancy
- Refueling of 350 bar and 700 bar vehicles: buses, cars, council vehicles and other types
- Location & customer: Aberdeen, UK; BOC



99,5% Availability*



* HyTransit Report 2019: [HyTransit Period 1 Technical Report \(europa.eu\)](https://www.europa.eu)

High efficient HRS technology

Leading HRS technology to maximize end customer acceptance and satisfaction



Industry benchmark for reliability

Availability of >98%



Minimized Total Costs of Ownership

- Unique service concept
- Low energy consumption (<230 kW)



Leading by performance

- 1,7 kWh / kg*
- High flow rate also at low inlet pressures of > 5 bar



Highest Safety Standards

- Zero incidents!

* > 100 bar inlet pressure

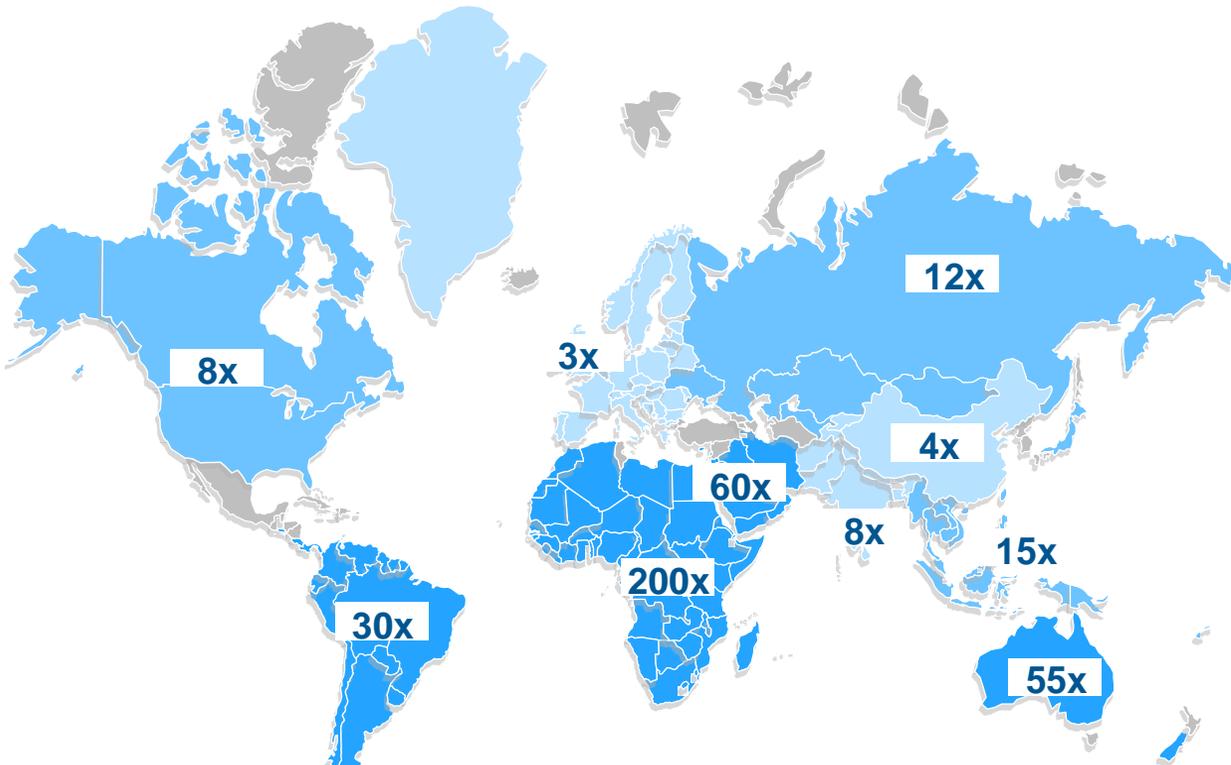
Hydrogen will enable the energy transition

It is not about availability, it is about cost-efficient distribution



Potential of renewable energies bigger than energy demand

Solving the distribution challenge!



Source: IPCC-SRREN



The power of hydrogen

And with improving technologies, the decarbonizing potential gets enormous



New benchmark for a
Off-shore wind turbine

Nominal Power
14 MW

Daily capacity
7.000 kg H₂

Fuel cell truck



Zero Emission
84.000 km



- Hydrogen refueling has been happening for many years, and the technology is state-of-the-art!
- Hydrogen resp. fuel cell technology is most effective for decarbonizing mobility, especially truck mobility
- Linde has the best technology portfolio – and experience – to fulfill customer needs today despite of some uncertainties still existing
- With the proceeding energy transition towards renewables, green hydrogen will be available
- Let's together make it happen: Tomorrow's Fuel Today!



Linde Hydrogen FuelTech
Tomorrow's fuel today

Making our world more productive

