

## Linde – a global player dedicated to hydrogen.

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The 2nd Hydrogen Energy Ministerial Meeting, Tokyo, September 25<sup>th</sup>, 2019

Making our world more productive



# Ground breaking projects.

Linde is an industrial gas and engineering player with strong focus on hydrogen.



## About Linde

Key products: Plants, components, services & molecules

- Separation
- Thermal Cracking
- Liquefaction

Hydrogen  
 Rare gases  
 Carbon dioxide  
 Nitrogen  
 Carbon monoxide  
 Synthesis gas  
 Oxygen  
 Olefins

## Key financials

Key metrics (2018)

- Sales ~\$28B
- Op. Profit ~\$5B
- Market Cap ~\$90B
- Employees ~80K
- Customers ~+2M

Industrial Gas Companies  
 (2018 sales in \$B)

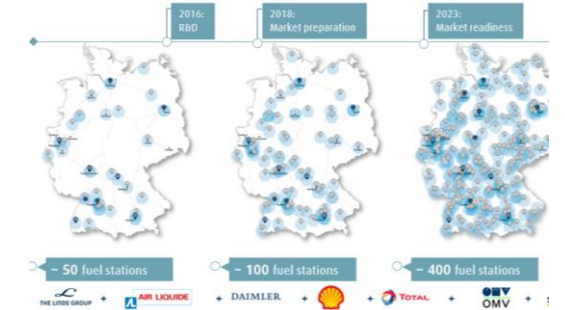


## Hydrogen Examples

### Cooperation with Iwatani Corporation (Japan)



### Hydrogen Mobility JV (Germany)



### Power-to-gas (Germany)

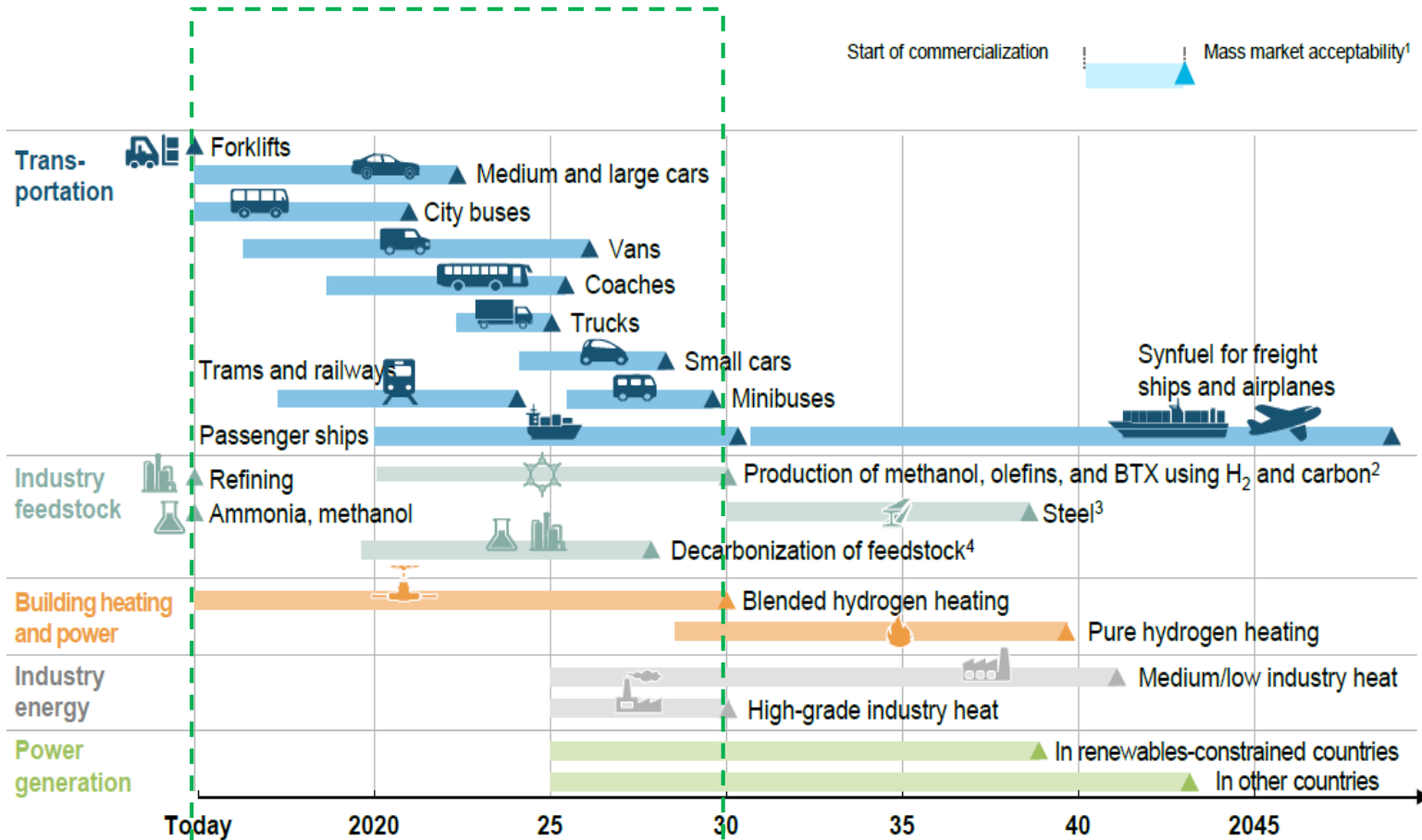


### Hydrospider JV (Switzerland)



# Hydrogen is a game changing molecule.

The mobility sector will benefit from the emergence of hydrogen first.



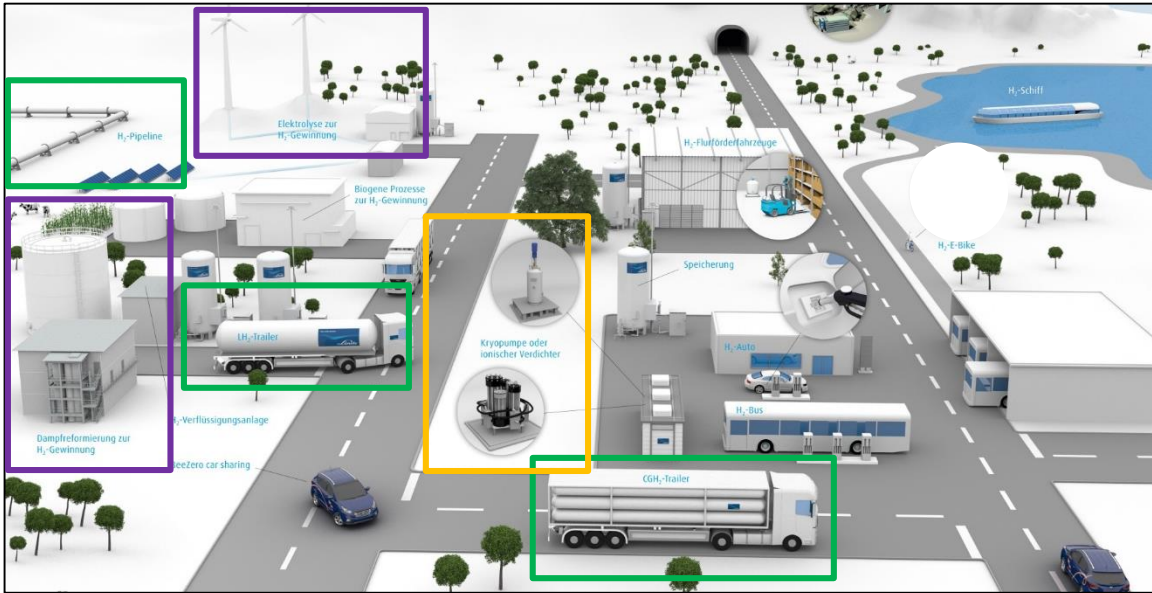
## Drivers for hydrogen mobility

- ✓ Increasingly strict legislation of emissions
- ✓ Quick impact due to vehicle park turnover cycles
- ✓ High economic value of hydrogen in mobility vs. hydrogen in other sectors
- ✓ Few zero emission alternatives to hydrogen in mobility
- ✓ Advantages of hydrogen over batteries in mobility: long ranges, quick refuelling, lower vehicle weight

<sup>1</sup> Source of graph: H2 Council, units: Exa Joule, 1 EJ = 7m tons H<sub>2</sub> = 80Bn Nm<sup>3</sup> H<sub>2</sub> <sup>2</sup> Source of graph: H2 Council

# The world of hydrogen for mobility.

Linde ensures highest efficiency and safety along the entire hydrogen value chain.



**H2 fueling**

- liquid hydrogen
- gaseous hydrogen

**H2 production**

- renewable production
- conventional production
- Central or on-site

**H2 distribution**

- pipeline
- trailer transport

**H2 liquefaction/storage**

- liquefaction plants
- storage tanks

Cryopump (LH2)

Ionic Compressor (GH2)





# The hydrogen fuelling station: enabler of hydrogen mobility. Linde is the most experienced provider of hydrogen infrastructure.



## Global H2 fueling projects



## Leading expertise and know-how

- ✓ Leading fueling technologies
- ✓ More than 160 fueling stations installed worldwide
- ✓ More than 1.5 million successful fuelings of cars, buses and forklifts
- ✓ Only provider of LH2-based 90 MPa fueling technology: small footprint, low energy consumption
- ✓ Supplier of the world's biggest hydrogen bus depot in California
- ✓ Supplier of the world's first hydrogen station for a passenger train



Tokyo



Emeryville (Cal.)



Berlin

# Key challenges of hydrogen mobility

There is some way to go in order to be successful



## Key challenges

Overall: hydrogen mobility attractiveness for end customers

HRS: network build-up

HRS: total cost (CAPEX, OPEX)

HRS: land use

HRS: regulations, codes, and standards (RCS)

HRS: availability

## Measures

- Attractive and cost competitive vehicles
- Convenient, cost competitive, and safe refueling infrastructure

- Partnering / JV: e.g., Japan Hydrogen Mobility, H2 Mobility Deutschland
- Public funding

- Scaling up volumes
- Modularization and standardization
- Larger stations incl. increased share of LH2 technology

- Compact design
- Medium / long term: underground storage

- Global alignment (e.g., material and safety standards)
- Certified bodies

- Modularization, standardization, supplier qualification
- Online monitoring and fast feedback to R&D
- Fast response service teams

# Linde Hydrogen FuelTech's HRS addresses these challenges.

## Efficient and large scale H2 fuelling stations: Cryopump station.



### Key challenges and measures

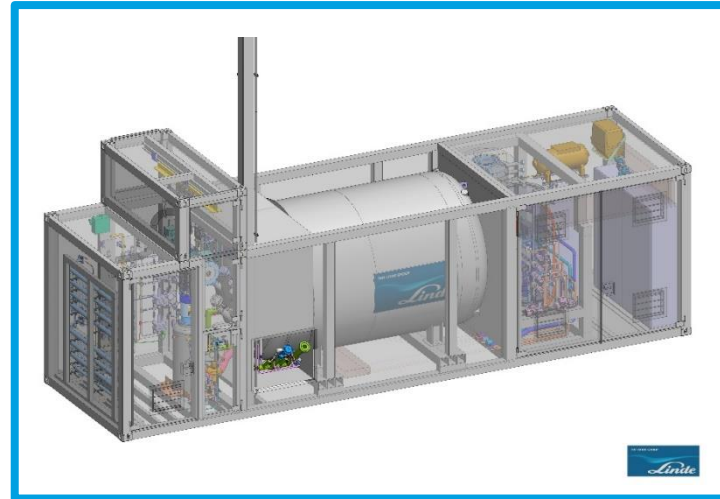
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HRS:  
land use

- Compact design

### Linde Cryopump design



- Very small footprint (10.0 m length x 2.8 m width x 3.1 m height)

- Fully integrated in existing conventional fuelling station

- Lot size: 12

- Standardized station

- Fuelling capacity: 480 kg in 12 hrs / 900 kgpd

- Integrated storage capacity: 800 kg LH2

- Simultaneous car and bus refuelling

- Energy consumption reduced by 70% due to liquid compression <sup>(1)</sup>

<sup>1</sup> compared to conventional piston compressor

Summary: huge potentials and very promising developments.  
Linde fully supports the “Ten, Ten, Ten” goals.



Hydrogen mobility and energy have gained a lot of momentum since 2018.

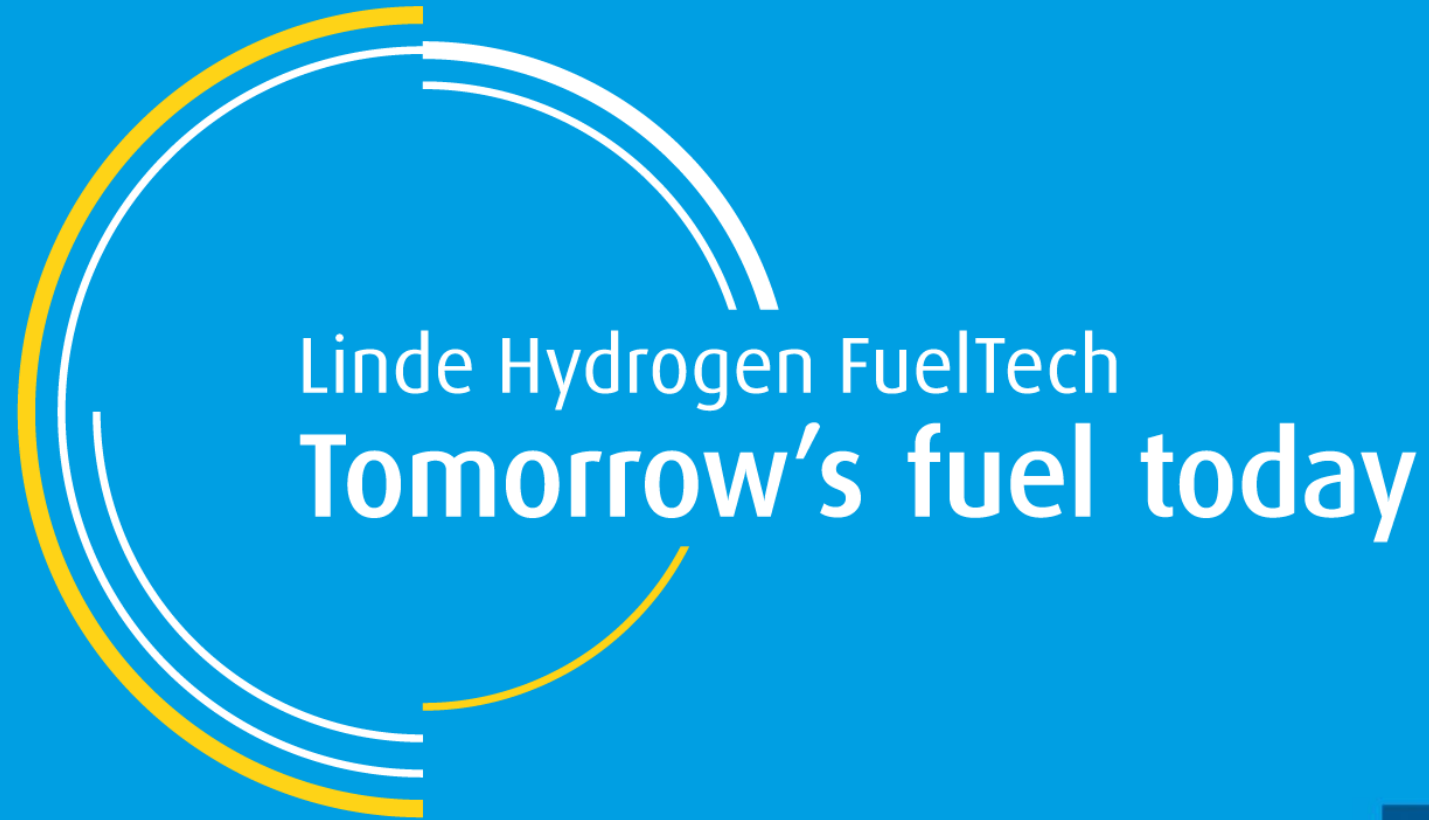
But there is still a long way to go.

So let's cooperate to reach the „Ten, Ten, Ten“ goal:

- 10 million hydrogen powered systems
- 10 thousand Hydrogen Refueling Stations (HRS)
- in 10 years



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Linde Hydrogen FuelTech  
**Tomorrow's fuel today**

Making our world more productive

