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# Terminal Operations for Tube Trailer and Liquid Tanker Filling: **Status, Challenges and R&D Needs**

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# Linde covers the entire hydrogen value chain

## Production



Conventional H<sub>2</sub>  
(e.g. SMR)



Green H<sub>2</sub>  
(e.g. BTH)

## Supply/Storage



CGH<sub>2</sub> storage



LH<sub>2</sub> storage

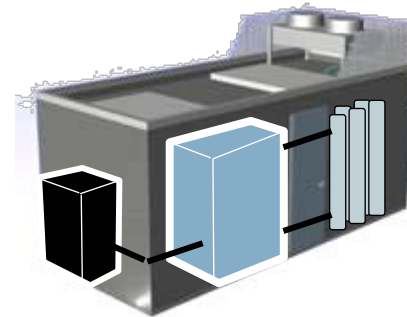


Onsite SMR



Onsite electrolysis

## Compression/Transfer



Ionic compressor



Cryo-pump

## Dispenser



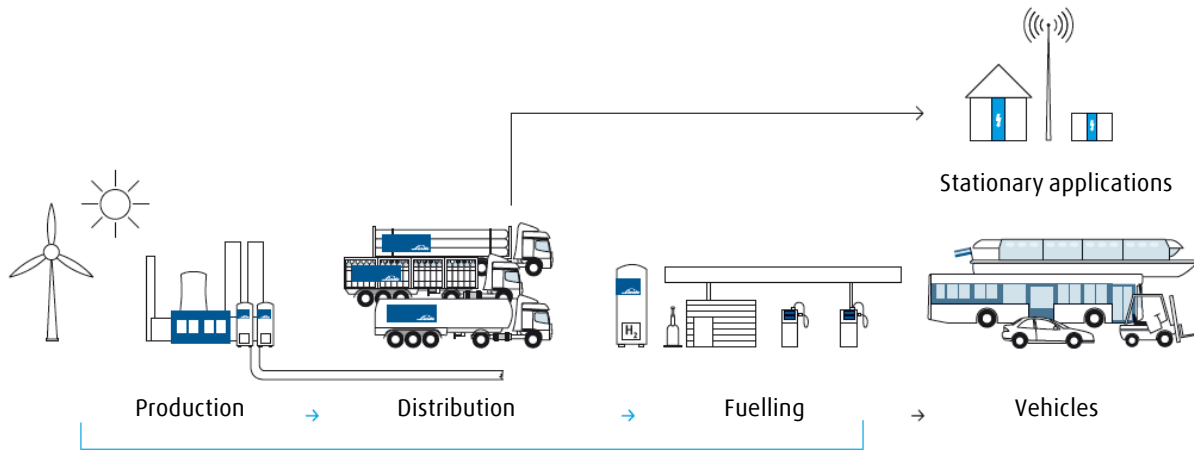
350 bar



700 bar

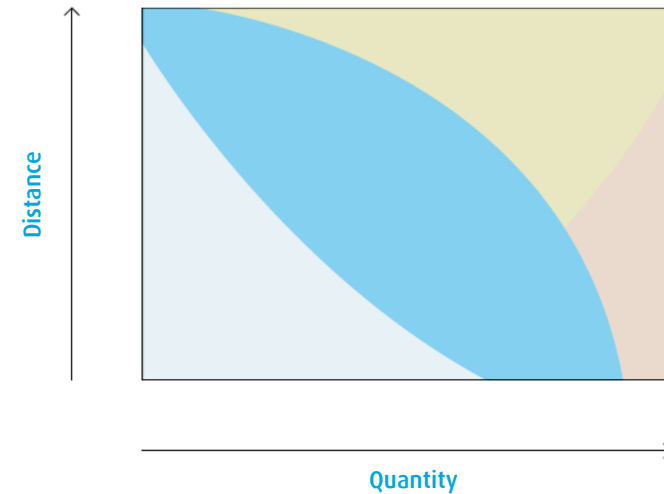
# Hydrogen fueling value chain

## Distribution options



Preferred methods of supplying fuelling stations with hydrogen

CGH<sub>2</sub> trailer   LH<sub>2</sub> trailer   On-site   Pipeline



### Distribution method

### Facts

### Advantages

### Disadvantages



CGH<sub>2</sub> trailers

- Transport at 20MPa and higher
- Capacity:  $\leq 10,000 \text{ Nm}^3$  (~900 kg)

- Economical transport for short to medium distances

- Comparatively low capacity (high delivery frequency)
- Comparatively large on-site footprint (required space)



LH<sub>2</sub> trailers

- Transport at -253°C
- Capacity:  $\leq 40,000 \text{ Nm}^3$  (~3600 kg)

- Economical transport for medium to long distances
- Comparatively small footprints

- Comparatively high energy requirement (for hydrogen liquefaction)

# Key operating parameters (current typical)

Mode of supply	LH <sub>2</sub>	CGH <sub>2</sub>	Comments
Time to fill	4 – 6 hours	~4 hours	Size dependent
Typical capacity	>3000 kg	~300 kg	Size dependent
Typical pressure	110 – 140psi	2,400psi	Current
Time to off-load	~1 – 2 hours*	30-45 minutes**	Size dependent

\*Depending on tank size at delivery site (3,000 – 15,000gal)

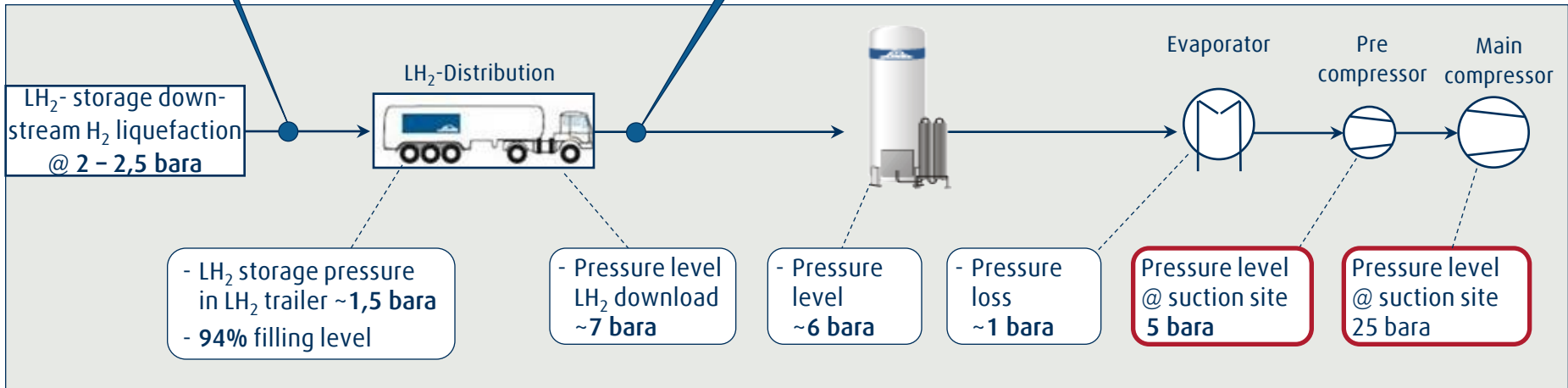
\*\*Tube Trailer swap

# LH<sub>2</sub> chain – from H<sub>2</sub> liquefier to H<sub>2</sub> compressor unit

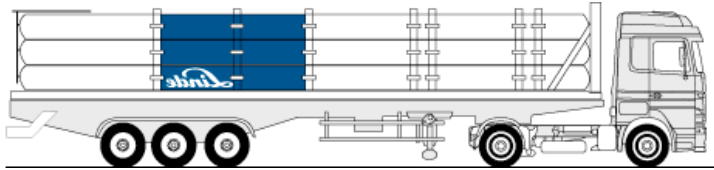


- Trailer filling requires  $\Delta p$  of about 1,0 bar
- Purging & cooling of filling hose necessary

- Purging (He & H<sub>2</sub> consumption) & cooling of filling hose
- $\Delta p$  for H<sub>2</sub> LH<sub>2</sub> download 1 – 2 bar
- Mass flow ~0,5 t/h



180 – 500 Bar tube trailer



- Trailer drop-off or filling ground tubes from delivery trailer needs more space
  - Also time consuming (need at least 2 hr)
  - Need to develop cascade filling logistics for max utilization
  - **Major issue: Residual gas in trailer (waste)**

Trailer with ISO container; 250 – 500 Bar



- Drop and swap trailers
  - Truck mounted ISO containers with hydraulic mechanism for loading & unloading
    - E.g. Lincoln Composites (Hexagon) CNG truck
  - Suitable from space perspective
- ISO container serves as ground storage
  - With drop & swap, minimum driver time at site

*Linde recently rolled out a 500 Bar trailer in Germany (1100 kg capacity)*

- Trailers with pressures >500 Bar (900 Bar??)
  - Can eliminate compressor at site
  - Can serve as ground storage for direct dispensing into vehicles
  - May be most suitable from space perspective
  - **Weight/volume & Cost/benefit issues**
  - **Challenging DOT approval**



## **GH<sub>2</sub> supply**

- Off-load speed or difficulty (i.e. maneuvering TTs on site)
- Space required for deliveries (i.e. cramped access issues)
- Ramping up at new facilities (how to cover early investments)
- Storage of hydrogen produced by SMR or large-scale Electrolysis for intermittent use
  - demand profile issue...how to store 24/7 production when use is sporadic

## **LH<sub>2</sub> supply**

- Off-load speed or difficulty
- Space required for deliveries (i.e. cramped access issues). Also, set-back distances at fueling station
- How to justify incremental large investment (\$70 - \$100mm) in large LH<sub>2</sub> plant
  - Who takes this risk on a developing market

## **Green H<sub>2</sub> production**

## **Meeting regulations for new delivery and storage equipment**

- Help streamline DOT approval process for new equipment
- Investment support for large-scale green H<sub>2</sub> production
- R&D investment in New delivery methods
  - Light weight, high pressure tubes for transport
  - Cryogenic, medium to high pressure gas transport
- Funding required to
  - Optimize solutions & conduct economic analysis
  - Final selection based on location specific factors
  - Obtain DOT/ASME approvals
  - Pilot of selected option(s)
  - Commercialize