Storage - Challenges and Opportunities.
Workshop on forecourt compression, storage and dispensing RD&D to enable cost reduction.

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Linde Covers The Entire Hydrogen Value Chain

**Large-Scale Production**
- Conventional (e.g. SMR)
- Green (e.g. BTH)

**On-site Supply & Storage**
- CGH2 storage
- LH2 storage
- Onsite SMR
- Onsite Electrolyzer

**Compression/Transfer**
- Ionic compressor
- Cryo pump
- 350 bar
- 700 bar

**Dispenser**
- Fast Fueling (3 min)
- Back to Back Peak fueling
- High Throughput (>400 kg/day)
Current Status of Technology

• Linde has operating fuelling stations with liquid, gaseous and on-site supply options around the world

• Each option presents its advantages and has its drawbacks

• Current technology and established standards exist for each of the different supply technologies

• Industry has met the challenges to fuel fast, peak fuel, and increasing throughput
  — Investing only in technologies cannot capture full benefit without improving the hard limit placed on station forecourts by existing codes and standards on storage
  — Increased throughput (>200 cars per day) will soon be needed demanding more storage or more deliveries
  — Liquid Site = deliveries per week ; Gaseous site = Multiple deliveries per day

• To make a step change in station forecourt competitiveness and viability will require:
  — Further RD&D in storage technology
  — Further RD&D in site related aspects
  — Advancement and industry-wide acceptance of Codes and Standards (will become the limiting factor)
## Current Challenges

### Liquid Storage
- Setback distances (75 feet to operable windows / doors / air compressors and 50 ft to flammable objects) = difficulty in finding sites
- Area utilization
- Ventilation
- Other code requirements

### Gaseous Storage
- Area utilization
- Limited Usable Capacity (need a lot of it or frequent deliveries)
- Readily available ASME certified high pressure safety relief devices (>14000 psi) for Hydrogen use
- Limited Cycle Life for > 700 bar
- Setback distances
### Key RD&D Activities Necessary for Cost Reduction

**Liquid Storage**
- Code Case review to Reduce 75ft, 50 ft and Other key restrictive NFPA setback distances to exposures (reduces cost of slow deployment)
- In many areas this a low cost / high density delivery option
- Demonstration low cost underground or partially below ground options
- Vent stack designs that improve dispersion

**Gaseous Storage**
- Demonstration project which improves “usable quantity” in gas cascade storage (> 80% usable)
- More ASME certified equipment for 700 bar filling (i.e. Safety valves matching vessel MAWP)
- Underground options (Cost / Code)
- Improved cycle life for > 700 bar
- Code Harmonization with Europe
Thank you for your attention.

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