Agenda

• H2 Value Chain
• H2 Forklift Fueling
• H2 Bus Fueling
• H2 Car (FCEV) Fueling
  — US (California)
  — Global
• Hurdles
# Linde covers the entire hydrogen value chain

## Production
- Conventional H₂ (e.g. SMR)
- Green H₂ (e.g. BTH)

## Supply/ Storage
- CGH₂ storage
- LH₂ storage
- Onsite SMR
- Onsite electrolysis

## Compression/ Transfer
- Ionic compressor
- Cryo-pump

## Dispenser
- 350 bar
- 700 bar
Linde Magog, Quebec Liquid Hydrogen Facility
-- Supplying the NE with Renewable Hydrogen

- Byproduct of Sodium Chlorate production
- Brine as feedstock
- 97% hydro-electric power
H2 Fuel Cell Forklift Fueling:
BMW - Hydrogen Forklift Fueling...largest H2 fueling site in the world! >600kg/ dy H2 use...and growing

Equipment:
- 3 x IC45 ionic compressors
- High pressure H2 storage
- 18 indoor 350bar dispensers
Hydrogen Bus Fueling
AC Transit - Linde Hydrogen Fueling Stations

The Largest Hydrogen Bus Station in the World

12 Fuel Cell Buses
350 Bar FC Bus Fueling
350/ 700 Bar FCEV (car) fueling
Hydrogen FCEV (Car) Fueling
-- California Infrastructure Update

• Assembly Bill 8 passed - $20 MM per year in funding for next 10 years
• Governor Brown’s Zero Emission Vehicle (ZEV) Mandate - 1.5 MM ZEV vehicles in CA by 2025,
  25% of State’s new vehicle purchases to be ZEV by 2020
• Governor’s Office has created a position in GoBiz department to facilitate permitting hurdles of
  hydrogen fueling stations
• H2 USA and H2FIRST private / public partnerships established to reduce barriers for
  infrastructure deployment
• CEC awarded $46.6 MM in funding in the most recent round in 2014
  — $18.6 MM higher than planned based on applications
  — Over 50 applications received
  — 28 successful station awards (7 different companies)
  — Offered up to 85% project funding (up from 60% before AB8 was passed)
  — Up to $100k per year for three years of O&M funding
  — Total number of stations funded by CEC thus far = 49 + 1 mobile refueler
— Past Industry Projections have projected 50,000 vehicles and 100 Stations by 2020
— Latest Projections taking into account station progress and OEM schedules show moderate increase in stations by 2020 ~ 87
— Low Vehicle Estimate by 2020 = 18,465, High Vehicle Estimate by 2020 = 31,244
— Volume assumption in financial case used Low estimates
### H2 Retail Fueling: Active Linde California Hydrogen Fueling Project Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Customer</th>
<th>Station Type</th>
<th>Operations Date</th>
<th>Linde Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emeryville, CA</td>
<td>AC Transit</td>
<td>Bus / Car</td>
<td>2011</td>
<td>IC50, MF90</td>
</tr>
<tr>
<td>Livermore, CA</td>
<td>Lawrence Livermore Labs</td>
<td>Research / Testing</td>
<td>Jul-13</td>
<td>Liquid Pump</td>
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<tr>
<td>Oakland, CA</td>
<td>AC Transit</td>
<td>Bus</td>
<td>Nov-14</td>
<td>IC50</td>
</tr>
<tr>
<td>West Sacramento, CA</td>
<td>Public</td>
<td>Car</td>
<td>Oct-14</td>
<td>IC50</td>
</tr>
<tr>
<td>San Juan Capistrano, CA</td>
<td>Public</td>
<td>Car</td>
<td>Feb-14</td>
<td>IC50</td>
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<tr>
<td>Cupertino, CA</td>
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<td>Car</td>
<td>4Q 2015</td>
<td>IC50</td>
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<tr>
<td>Foster City, CA</td>
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<td>Car</td>
<td>4Q 2015</td>
<td>IC50</td>
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<tr>
<td>Mountain View, CA</td>
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<td>Car</td>
<td>4Q 2015</td>
<td>IC50</td>
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<tr>
<td>San Ramon, CA</td>
<td>Public</td>
<td>Car / FLT / Shuttle Bus</td>
<td>Nov-15</td>
<td>IC50</td>
</tr>
<tr>
<td>Oakland, CA</td>
<td>Public</td>
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<td>IC50</td>
</tr>
</tbody>
</table>

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West Sacramento, CA – First US Linde Retail H2 Station
-- First US IC90

- Up to 30 kg/hr production
- Back-to-back fueling
- DMS approved dispenser
Overview IC90: layout / performance

- Small footprint: 2.7m x 3m
- Height: 3m (without roof coolers and vents)
- Noise emission: <65dB(A)
- Supply: gaseous or liquid
- Connected load: 90kW
- 5 Stage compression w/ flexibility
- 30 kg/hr
- Possible option to double capacity
- Low power consumption vs. traditional GH2 compression
- Serial production capability
Overview IC90: functionality

- **Input**: 5-10 bara
- **Output**: 900 bara (1,000 bara max.)
- **Stages**: 1 to 5
- **Hydrogen**: 5 to 900 bara
- **Ionic liquid**
- **Hydraulic oil**
- **Coalescer for ionic liquid**
- **Hydraulic/radial piston engine**
Lawrence Livermore National Laboratory - Cryogenic Liquid Pump Project (> 100 kg/hr capacity at > 350/900 bar)

Technology to supply Bus stations or high throughput (> 1,000kg/dy) FCEV stations
Headline:
H2 Mobility initiative agrees on $474M plan for hydrogen refueling network in Germany; 400 stations by 2023
Realities of locating at a gasoline station: Liquid storage

Typical 150’ x 150’ gas station (22,500 ft²)

Setback distances are significantly greater for liquid

Risk assessments and worst case scenarios much more challenging for increasing storage quantities

Impacts on neighbors - reduction in property value, could veto project

Sandia National Labs analytical work on liquid/vapor dispersions to support changing code
Challenges the industry faces

Proving infrastructure commercialization can happen...safely

Finding good retail sites for deploying stations
  Space is tight in general
  **Setback distances** in the US for liquid storage is a huge obstacle
    Both gas and liquid storage volumes are limited on sites due to codes and limited space

Green hydrogen production

Equipment component costs are high...need economies of scale

Lack of qualified/ experienced contractors for installation - limited vendors = higher cost

Uncertainty over funding levels and year to year consistent support

Overcoming the early lack of cars...and uncertainty on financial case

Ramping up production (large scale plant) to meet demand
Hurdles with H2 Station deployment

- Local AHJ interpretation of code and overly conservative (CYA) requests (i.e. berm around LH2 tank, fire-eyes - pressure drop analysis controls this exposure)
- Franchisor agreement on retail station sites - need approval to sell and market H2
  - Energy independence & security act of 2007 (section 241, sub 107) covers ethanol, but not H2... yet?
- Power required (480V) typically requires new transformer... requires add’l cost AND property owner agreement
- Local planning department “aesthetic” requests which add cost/ complexity (i.e. artistic walls, landscaping)
- Negotiating lease agreements with small business/ land owners
- ADA compliance costs of entire site that may be triggered by H2 station installation
- Property tax potential reassessment due to H2 station installation
- Environmental liability concerns of leasing property on existing gas station sites
- Existing stations should be grand-fathered into any changes to code (i.e. NFPA2 2016 version)
- NFPA 2016 version will add significant cost to HEE (H2 Equip Enclosures) stations
  - Separation (firewall) btwn storage and compressor (gas tight, flame-proof)
  - 6’ 8” of egress the length of the egress (must have headroom to the exit)
- Accuracy classes will become increasingly more difficult to meet, in part due to issues such as GH2 trapped in dispenser hose and purged
Provocative Ideas...

• A paradigm shift is needed...
  — Recognized there is a societal cost to gasoline/diesel → Increase the cost of conventional fuel instead of trying to reduce the early cost of H2

• Recognize that H2 is a better fuel...today! There is a clear pathway to get to green H2, and this will become economically viable with higher volumes

• Set up a publically funded “Hydrogen Fueling Company” to overcome early investment hurdles
THANK YOU