



Transportation Committee Workshop
Transportation Fuel Infrastructure Issues

California Energy Commission
May 11, 2011

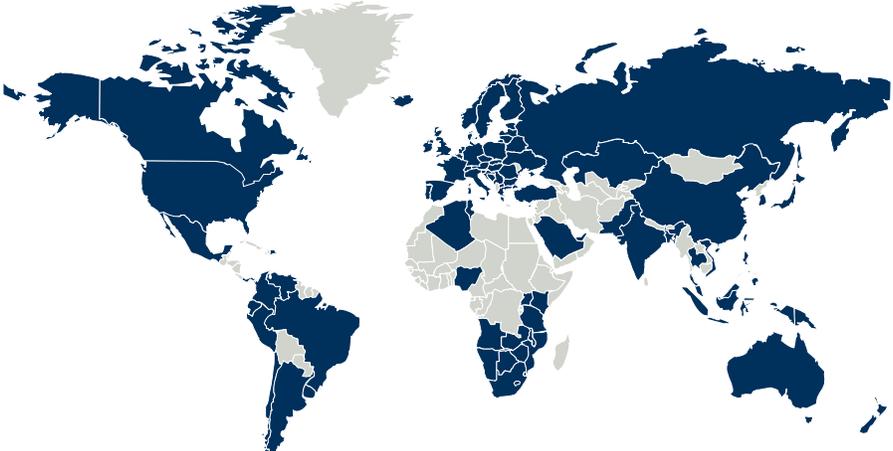
LeadIng.  **THE LINDE GROUP**

Steve Eckhardt, Head of Business Development,
Alternative Energy, Linde North America

The Linde Group
Global industrial gases presence in more than 100 countries



THE LINDE GROUP



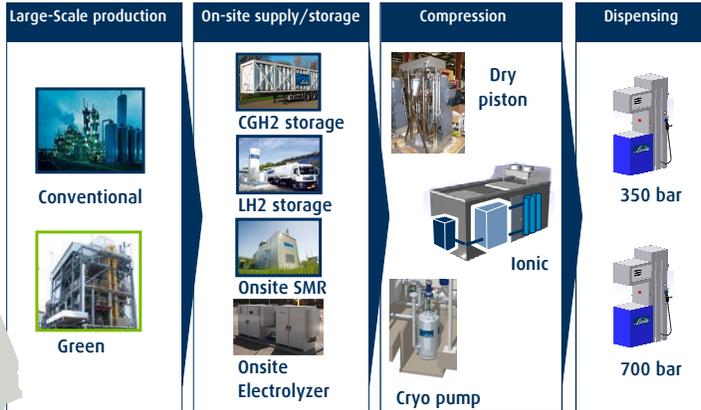
Industrial gases and related applications for oxygen, nitrogen, hydrogen, helium and other gases
Engineering, design and build of air separation, hydrogen syngas, and natural gas processing plants.
A world leader in hydrogen production and applications technology

2

Linde hydrogen fueling installations in California
Operational by 2012



The Linde value chain for hydrogen fueling



3

What do Fuel Cell Vehicles uniquely offer?



A no compromise zero emission vehicle!

Range of 250 – 450 miles

Fast fueling -- in three minutes

Comparable (or better) performance

The OEM's have met and exceeded DOE targets and now plan to introduce commercial vehicles by 2015



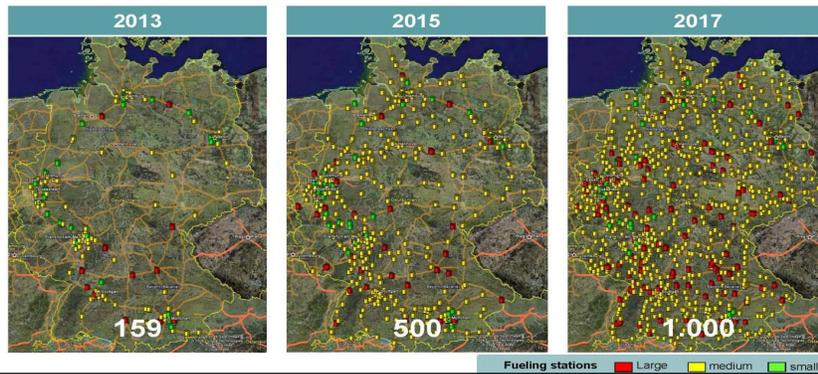
4

International competition for fuel cell and hydrogen leadership



- ▶ Germany: 2007-2016, \$1B (500 stations by 2015)
- ▶ Japan: 2008-2012, \$1B (100 stations by 2015)
- ▶ Korea: 2008-2013, \$600M

Proposed rollout for Germany



5

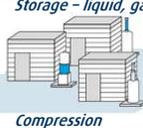
Key Elements of a stationary hydrogen fuelling station



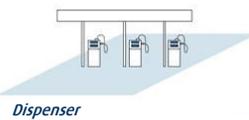
Supply / On-site Production



Storage and Compression



Dispensing and Application



Linde renewable hydrogen production in Quebec



Elements On site

6

Hydrogen fuel is cost competitive with gasoline



Hydrogen fuel is cost competitive with gasoline today



Future larger hydrogen plants can bring economies of scale



On-site production can provide cost savings compared to delivered hydrogen



7

Hydrogen value proposition



Cost competitive

Eliminate tailpipe emissions

Significantly reduce well-to-wheels carbon emissions

Use a domestically produced fuel

Can be produced from renewable sources

8

Linde's industry-leading hydrogen fueling product line

THE LINDE GROUP

Linde

AC Transit ionic compression



Shell Berlin Cryogenic liquid pump



Hydrogen Compression High performance, compact, relocatable



Hydrogen Dispensing Reliability, convenience, speed



Mobile Fueling Options 700 bar, 350 bar



Factors to consider when defining the number of hydrogen fueling stations required

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- **Number of fueling points by geographic area**
 - To ensure sufficient local coverage
- **Peak three hour fueling capacity**
 - To ensure continuous back-to-back fueling capability during rush hours
- **Daily fueling capacity**
 - To understand total long term capability of the stations

Fuel cell vehicles in California



2010 CaFCP survey of automaker passenger fuel cell vehicles

	Hundreds	Thousands	Tens of thousands
	Through 2013	2014	2015-2017
Total Passenger Vehicles	430	1,400	53,000



How can we
cost effectively
fuel these vehicles?
Lowest cost per kilogram

11

A mix of smaller and larger stations can meet the demand.....



	2014	2015	2016	2017
# of FCV's	1400	10,000	20,000	53,000
Kilograms per day consumption (1 kg per car per day)	1400	10,000	20,000	53,000
<u># of stations required</u>				
150 kg per day		30	58	
750 kg per day		10	15	
TOTAL		40	73	

....and industry must prove the technology and business model for large stations to attract future investment

Assumptions:

1. CaFCP Feb 2011 Progress Report
2. Potential/estimated ramping assumptions in 2015-2016 (not part of CaFCP Progress Report)
3. FCV H2 consumption of 1.0 kg per day
4. Stations operate at 83% capacity utilization

12

Practicality

Can hydrogen fueling be successfully integrated into gasoline station forecourts?



Show stakeholders we can leverage scale economies at a single site, meet driver expectations and drive down costs



Performance

Cost

13

Technology

Can hydrogen fueling be successfully integrated into gasoline station forecourts?



High throughput liquid H₂ compression



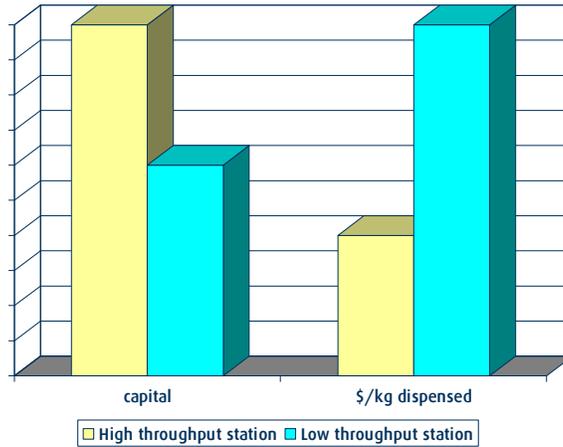
High throughput gaseous H₂ compression



14

Economics

Can hydrogen fueling be successfully integrated into gasoline station forecourts?



15

The many benefits of high throughput stations



- Long life with no major upgrades needed
- Prove the technology
- Show the industry that commercial-scale technology works
- CEC investment yields more H2 dispensing capacity
- Infrastructure is ready when cars arrive!

Investors, station owners,
government, OEM's

16



European Fact-based Analysis: The Role of Battery Electric Vehicles, Plug-in Hybrids and Fuel Cell Electric Vehicles



<http://www.zeroemissionvehicles.eu/>

Thank-you



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