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

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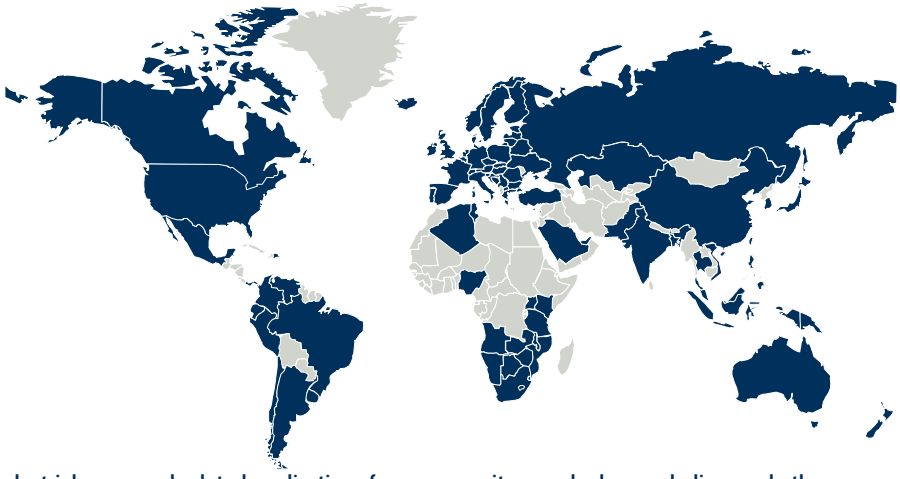

Industrial gases and related applications for oxygen, nitrogen, hydrogen, helium and other gases

Engineering, design and build of air separation, hydrogen syngas, and natural gas processing plants.

A world leader in hydrogen production and applications technology

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Linde hydrogen fueling installations in California
Operational by 2012

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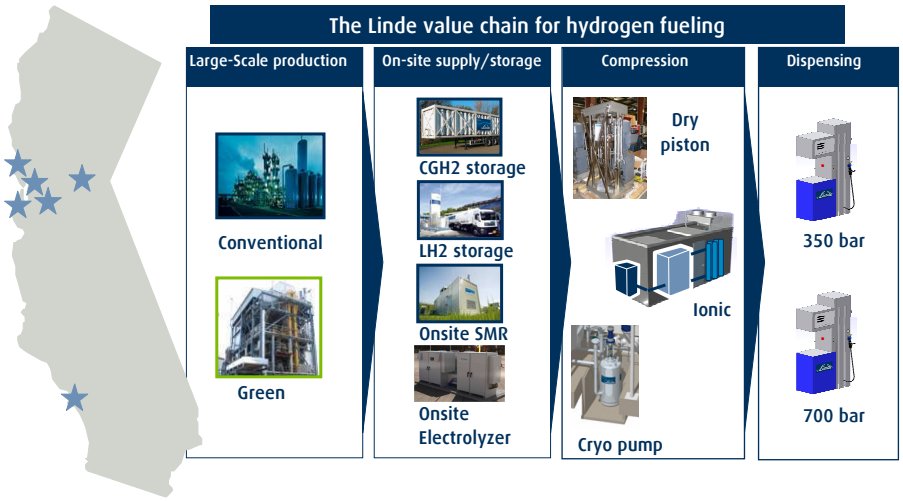

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What do Fuel Cell Vehicles uniquely offer?

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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

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International competition for fuel cell and hydrogen leadership

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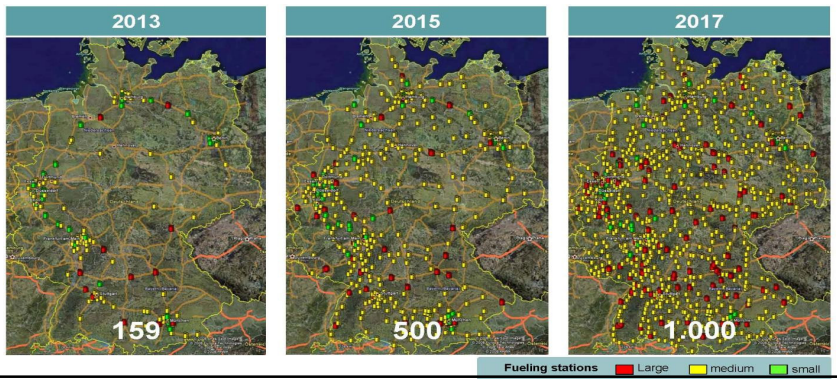
- Germany: 2007-2016, $1B (500 stations by 2015)
- Japan: 2008-2012, $1B (100 stations by 2015)
- Korea: 2008-2013, $600M

Proposed rollout for Germany



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Key Elements of a stationary hydrogen fuelling station

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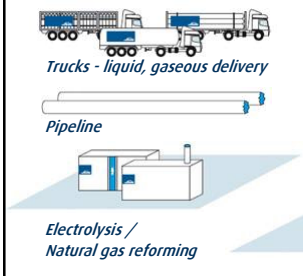
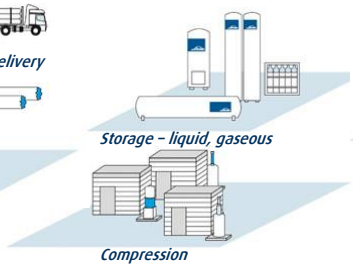
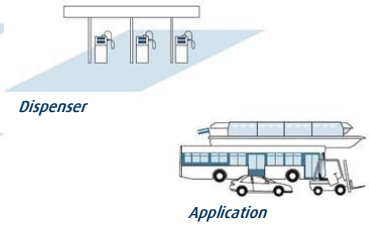
Supply / On-site Production

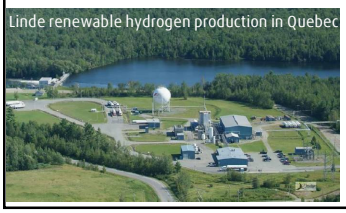


Storage and Compression



Dispensing and Application





Elements On site

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Hydrogen fuel is cost competitive with gasoline

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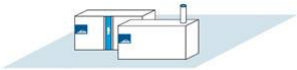
Hydrogen fuel is cost competitive with gasoline today

Future larger hydrogen plants can bring economies of scale

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



On-site natural gas reforming

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Hydrogen value proposition

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Cost competitive

Eliminate tailpipe emissions

Significantly reduce well-to-wheels carbon emissions

Use a domestically produced fuel

Can be produced from renewable sources

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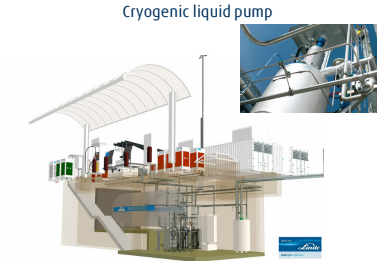
Linde's industry-leading hydrogen fueling product line

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

- **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

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Fuel cell vehicles in California

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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

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

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	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
# of stations required				
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

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Practicality

Can hydrogen fueling be successfully integrated into gasoline station forecourts?

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

Performance

Cost

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Technology

Can hydrogen fueling be successfully integrated into gasoline station forecourts?

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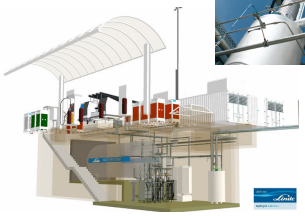
High throughput liquid H2 compression



High throughput gaseous H2 compression

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Economics

Can hydrogen fueling be successfully integrated into gasoline station forecourts?

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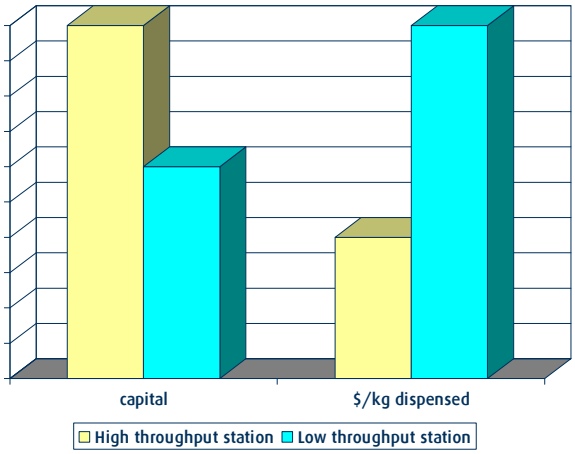

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The many benefits of high throughput stations

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- 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

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

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http://www.zeroemissionvehicles.eu/

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Thank-you
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