SCC Hazmat Subcommittee
Linde H2 Fueling

Sunnyvale, CA
July 10, 2012

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Nitin Natesan
Linde North America, Hydrogen Fueling

Linde Covers The Entire Hydrogen Value Chain

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Large-Scale Production

Conventional
(e.g. SMR)

Green
(e.g. BTH)

On-site Supply & Storage

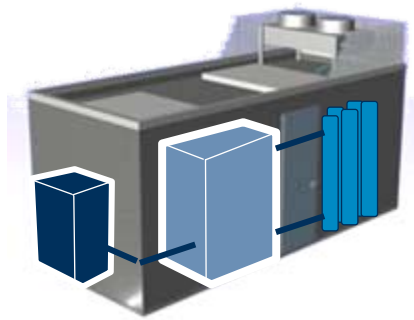
CGH2 storage

LH2 storage

Onsite SMR

Onsite Electrolyzer

Compression/Transfer



Ionic compressor

Cryo pump

Dispenser

350 bar

700 bar

AC Transit Project Profile

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Customer:
AC Transit, Emeryville, CA

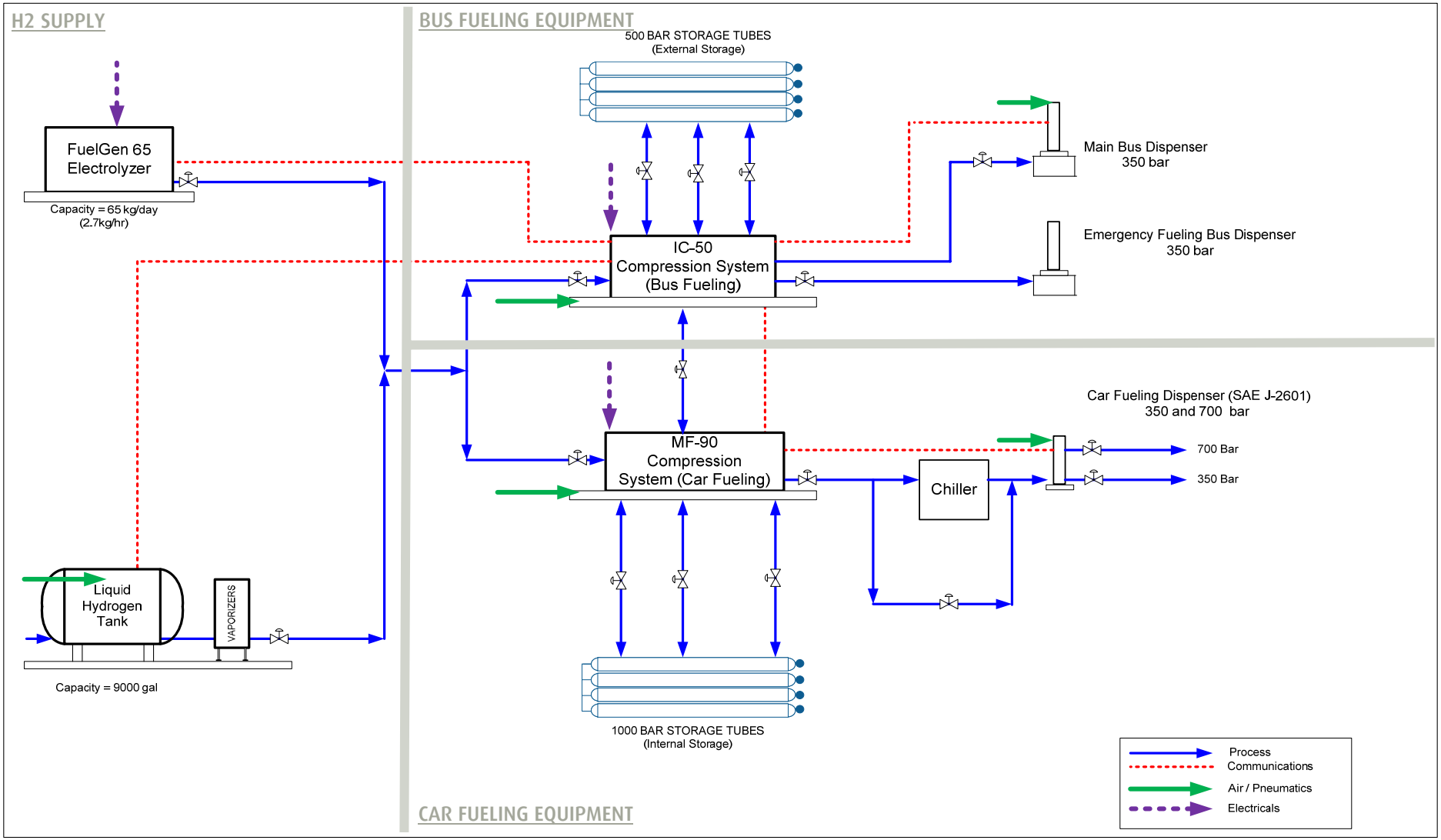
Project Features:
-12 fuel cell buses (350 bar) – in fueling times similar to diesel
-Public fueling (350/700 bar) per J2601 Category A
-Dual Hydrogen Supply – Liquid and On-Site Electrolysis
-Integrated Solar Cells to Supplement Power Consumption
-Linde Compression Technologies - 350 bar Ionic Compression and 700 bar Piston Compression
-Combined Car and Bus Fueling Station & Integration

Timing:
Fueling buses - Aug 2011, Fueling cars - January 2012

Linde Scope of Supply & Service:
Major Equipment Design and Installation - limited site infrastructure

Service:
Majority of equipment owned by AC Transit. Operations and Maintenance agreement with Linde

Overall Process Block Diagram



Linde Plot Overview
AC Transit, Emeryville

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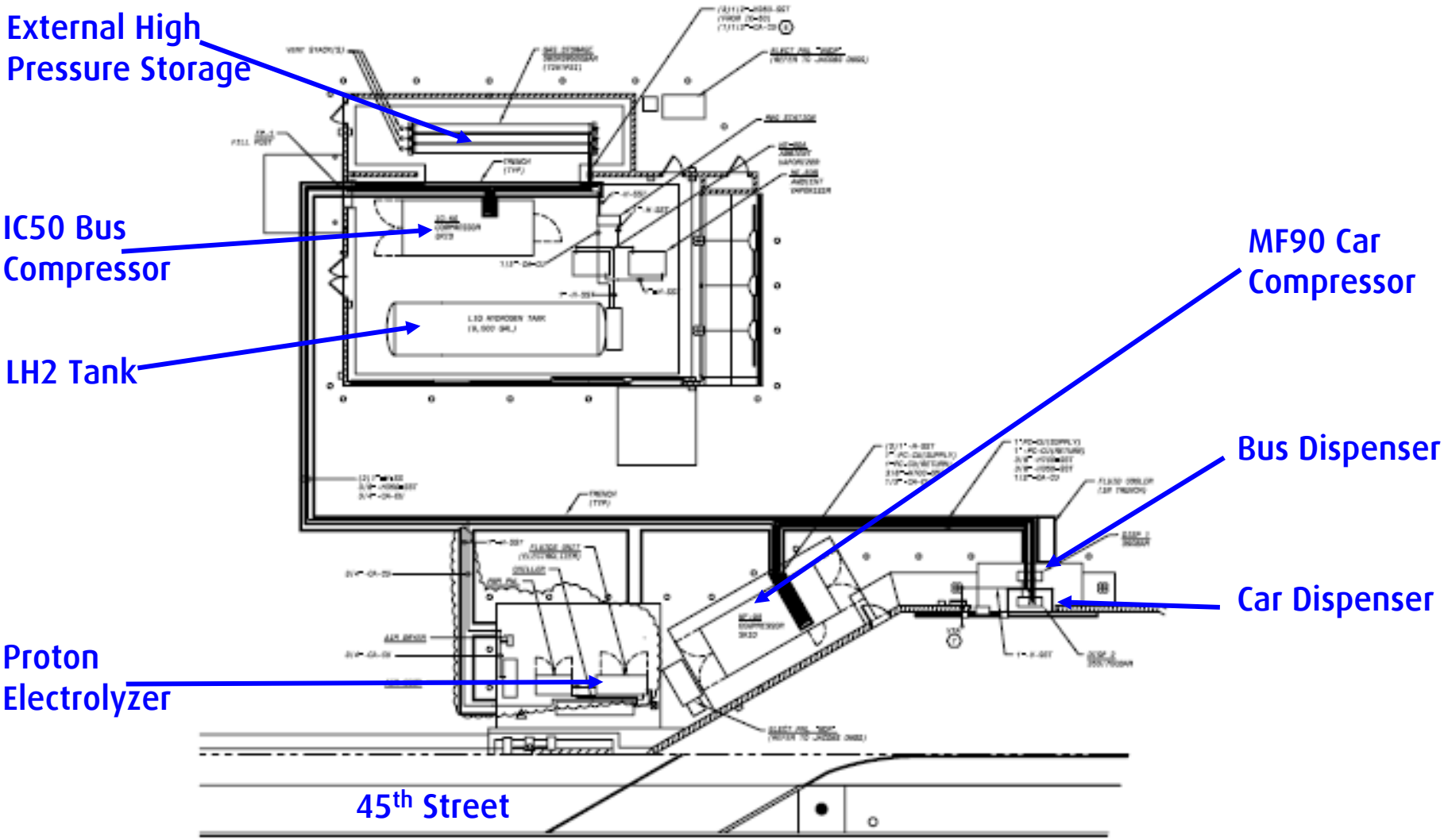

Site Photographs – H2 Equipment Yard Aerial

AC Transit, Emeryville

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Site Photographs – Bus Station Driveway (Inside)
AC Transit, Emeryville

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Site Photographs
Proton Electrolyzer - 65kg/day, PEM, Solar Power

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Site Photographs

Over 1500 Fuel Cell Bus Fueling Events To Date (25,000 kg)

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Site Photographs

Car fueling – Mercedes, Toyota, Nissan and GM Cars Fueled

3 Back to Back Fueling Events of Mercedes

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May 4, 2012 – Incident Overview

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- **What Happened?**
  - Pressure Relief Valve mechanical failure resulted in extended venting and igniting of pressurized hydrogen gas through vent stacks
  - No injuries
  - No property damage {Charring of Canopy}
  - Local area was safely evacuated by local authorities as a precaution for several hours
- **Current**
  - Root cause analysis in process
  - Customer following specific protocols for review before re-start

Linde Experience

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- Experience
  - Over 10,000 fuel cell bus fuelings globally
  - Over 80 hydrogen fueling stations to date globally
  - Leverage Linde operations personnel and technicians worldwide
  - Over 241,000 fueling events in US
  - Actively participate in CaFCP, FCHEA, SAE, CSA, NFPA

Thank You For Your Attention

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Backup Slides

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Hydrogen Fueling
Core Technologies & Product Lines

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Fueling Technology

	Description	Capacity[1]	Pressure	Linde US Installations
Dry Runner 	Lubricant free piston compression Flexible Design / Transportable	5 – 11 kg/hr	350 - 700 bar	AC Transit Emeryville
Ionic 	Ionic liquid as piston for compression. Near Isothermal Design	8 – 30 kg /hr	450 - 900 bar	BMW, Whole Foods, AC Transit, Coca Cola
Cryo Pump 	Processes liquid hydrogen feed High Throughput	100 kg /hr	350 - 900 bar	Lawrence Livermore National Laboratory (in execution)

1 Single train, compressor system ISO-containers can accommodate two trains

Linde's Ionic Compression Technology

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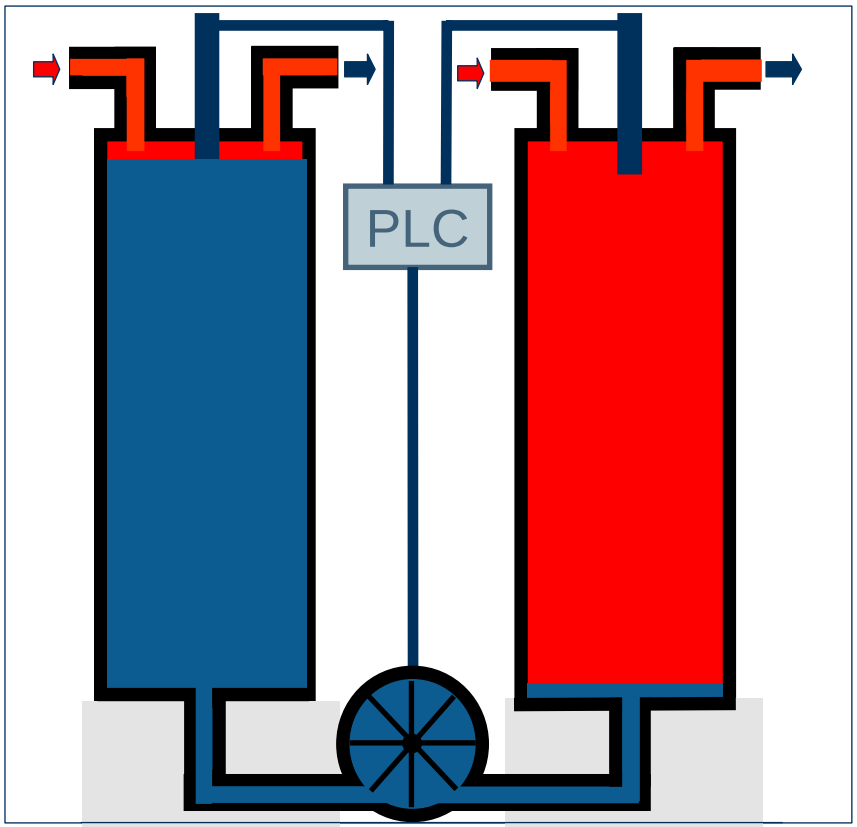
Principle functionality & basic facts

Gas - to be compressed

Ionic Liquid



- **Works like** conventional piston compressor
- Solid piston is **replaced** by ionic liquid
- **Advantages** of the concept:
  - Nearly 100% **volumetric efficiency**
  - Nearly **isothermal** compression[1]
  - Abrasion **free**
  - **Best conversion** of electrical energy into compression work
  - Gas **tight** system
- **Benefits**
  - low **energy** consumption
  - high **durability**
  - high **output**

1 Due to the very good conduction of compression heat via the ionic liquids