

# Hydrogen Energy Systems Experience - Supply Chain Challenges

**2016 Ohio Fuel Cell Symposium  
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# 60+ Years of Hydrogen Experience

- One of largest hydrogen producers in the world
  - Produce 5 million kgs/day
- Bulk, liquid, and pipeline distribution
- Unique product offerings for H<sub>2</sub> fueling
- H<sub>2</sub> energy projects since 1993
  - > 200 hydrogen station projects
  - > 1,500,000 fuelings/yr
  - Twenty countries

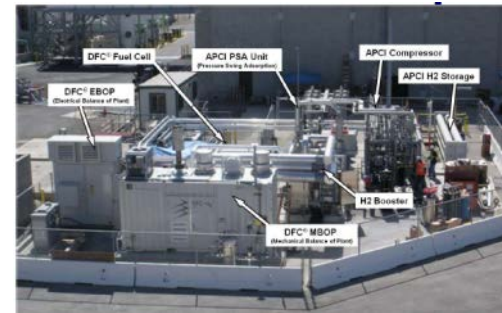


# Hydrogen Energy Markets

- Transportation



- Power Generation





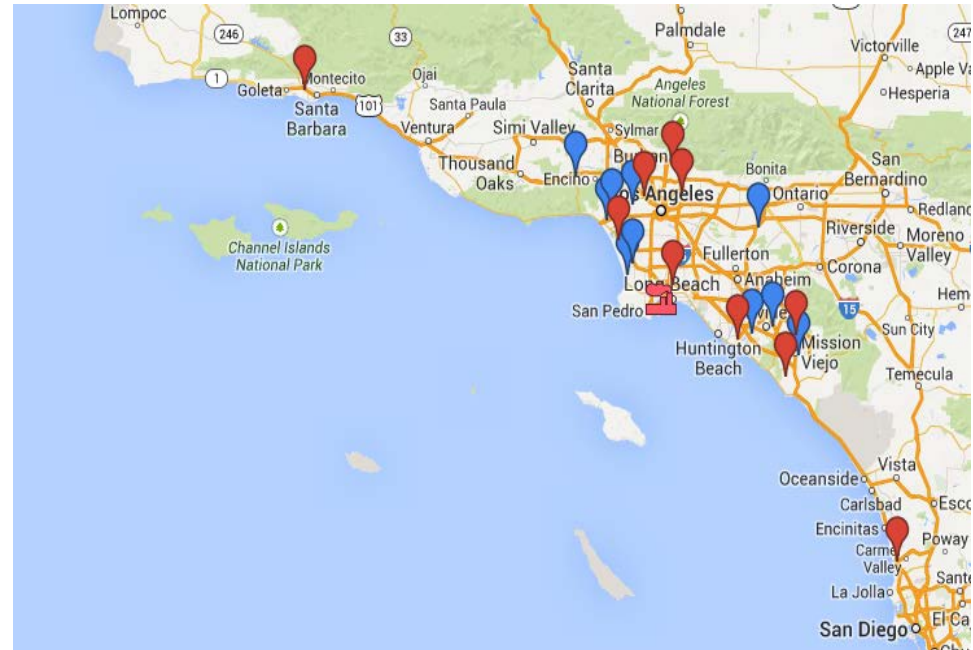
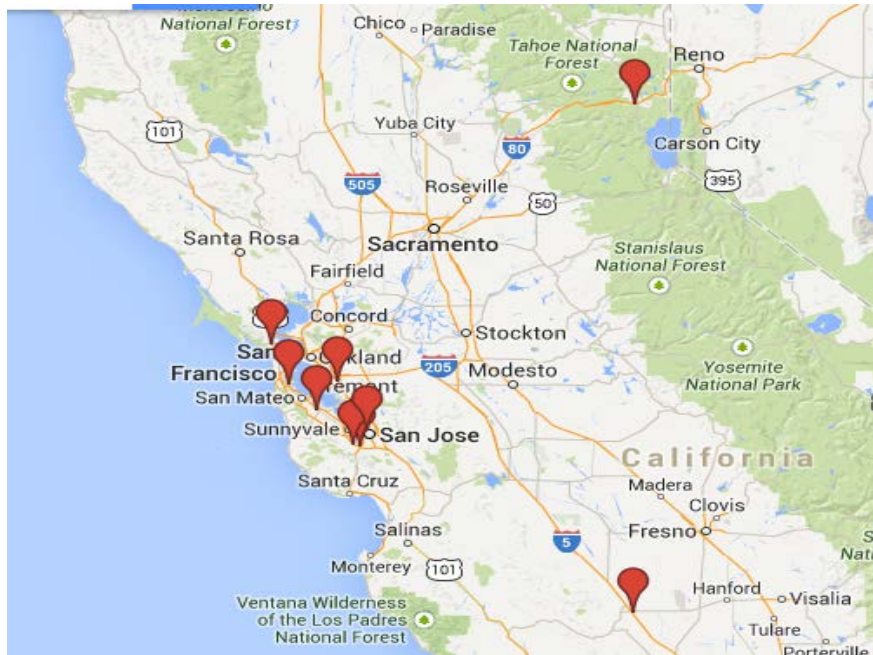
# Automotive Experience



Over 25 years Hydrogen Fueling Station Experience  
Built wide variety of stations for customers



# Air Products Fueling Stations for 2015 Vehicle Rollout



- Twenty nine new fueling stations are being built in CA with Air Products SmartFuel® technology in 2015-2016
- Owned and Operated by Air Products or our Customers
  - Fueling Station Equipment and hydrogen supply

# Supply Chain Challenges

- Equipment needed for highly specialized market
- Technology pushing past industrial limits
  - High Pressure hydrogen
  - Features required for H2 fueling market
    - Cooling, metering, etc
- Has been relatively small market thus far
  - Limited volume
- However, market is growing fast
  - Finally now is the time to start seeing volumes
  - C&S are starting to develop
  - Can list and provide competitive advantage
- Limited domestic supplier base for critical components

# Hydrogen Nozzles and Breakaways

- Key technology item for all Fueling Stations
  - Must meet J2600, J2799 for IR
  - Third party certification/listing required
- 350 bar for material handling, buses
- 700 bar for light duty automotive
- Current nozzles
  - Expensive
  - Have been unreliable
  - Very limited supply base
- Significant design challenges
  - High pressure
  - Wide range of temperature
  - Built in communications for light duty automotive



# Hoses

- Difficult service
  - Up to 15000 psig
  - Transients down to -40 C
  - Subjected to torque
- Current hoses are unreliable
  - Short life
  - Leaks/failures
- Effectively one supplier
- Some alternates available, but also have shortcomings
- Need certification to standards....and meet actual performance





# Meters and Instrumentation

- Retail dispensers require meters for fuel measurement
- Meters need to be very accurate despite difficult conditions
- Meter challenges:
  - Accuracy and reliability
  - Very expensive
  - Few suppliers
- Instrumentation
  - Similar challenges
  - Limited availability of pressure transmitters, low cost sensors, etc
  - High costs

# Compressors

- Stations require up to 15000 psig
  - Multiple suction pressures: 100 -6000 psig
- Exceed typical pressures in industry
- Most compressors are light duty
  - Require frequent rebuild/maintenance
- High cost
  - Not mass produced
  - Most not purpose built
- Particular need for low suction, high discharge pressure machines

# Storage Vessels

- Vessels needed for up to 15000 psig
- Traditional metal Type 1 vessels have not been economic
  - Heavy wall, small volume
  - Material compatibility
- Recently added ASME Code language
  - Composite Type 2, 3, 4 vessels
  - Material, design, and cycle life requirements
- Limited suppliers
  - New supplier investment
  - Especially up to 8000 psig
- Custom designs not mass produced yet
- Some success stories
  - 15000 psig, Type 2 vessel developed for market

# Supply Chain Summary

- Numerous components with single supplier
- Reliability issues with many of those components
- High cost of components drive up station cost
- Market need for additional suppliers
- Numerous “choke” points in supply chain have no domestic supplier



Thank you...  
tell me more