Hydrogen, Its Transportation and Markets

Presentation by

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60+ Years of Hydrogen Experience

- One of world’s largest producers of merchant hydrogen
  - >5.0 million kg per day H₂ production
- Bulk, liquid, and pipeline distribution
- Onsite generation (SMR, electrolysis)
  - Waste gas clean-up technologies
- 40 worldwide central plants, 50 small on-site generators
- H₂ energy projects since 1993
  - > 250 hydrogen station projects globally
    - 1,000,000 fuelings/yr
- Built >29 fueling stations in California
- Design, build, own, operate hydrogen fueling stations and hydrogen supply
Redefining Fuel

Moving from fueling vehicles... to powering vehicles!

- Fuel Cell Electric Vehicles
- Battery Electric Vehicles
Redefining Hydrogen

- Hydrogen all around us
- From reactant/process chemical... to fuel... to renewable fuel
Making Hydrogen

- Steam methane reforming
  - CH4 + 2 H2O + Heat → 4 H2 + CO2
  - Natural gas and/or biogas as feedstock

- Waste gas purification
Smaller On-Site Hydrogen

**PHG100**
- 1 container w/equipment inside
- Up to 216kg/day

**PHG250**
- 1 container w/equipment inside
- Up to 539kg/day

**PHG830**
- 2 skids w/utilities on one skid
- Up to 1790kg/day

**Features:**
- Industry’s BEST efficiency
- Automatic, unmanned operation
- Remotely operated & remote monitoring
- Modular, simple installation
- 99.999% H2 Purity Standard
Other Ways to Make Hydrogen

- Electrolysis
  \[ 2 \text{H}_2\text{O} + \text{Electric} \rightarrow 2 \text{H}_2 + \text{O}_2 \]
Hydrogen Energy Markets

• Transportation

• Power Generation

Air Products has fueled vehicles on these markets in Europe, Asia and US
Hydrogen Energy Storage

- Check overall efficiencies
- Need to have a hydrogen end use in mind

http://energystorage.org/energy-storage/technologies/hydrogen-energy-storage
Getting Started – Hydrogen Supply

Temporary Fueling
- Days, weeks, or months
- Minimal site preparation
- Outdoor fueling
- Ideal for early days, start-up
  • ie. – 1-3 buses, 3-5 cars, 1-10 forklifts, 1 ship?
Scaling Hydrogen Supply

• Various Options
  - Liquid hydrogen
  - Making gaseous hydrogen
    • Reforming – natural gas, biogas
    • Electrolyzer
    • Tri-generation
  - Pipeline hydrogen
Orange County Transportation Authority Station (2019)

- Delivered liquid hydrogen (AP LHY)
- Air Products design & key equipment
  - Air Products proprietary dual-phase compressors
  - 6-10 min. fills
- 10 buses initially
  - Can scale to 30 or more buses
  - Multiplicative scaling
- Two dispensers
- Planned on-stream Spring 2019
Hydrogen Supply Options and Scaling

- Trigen
- Electrolyzer
- On-Site Reformer
- Delivered gas
- Delivered LHY

Footprint vs. Scalability
Traditional Hydrogen Supply Integration/Distribution

1. **SMR** (CH₄, Biogas Offgas Fuel)
2. **Reforming**
3. **Purification**
4. **Cryogenic Liquefaction**
5. **Liquid Storage**

- **Cryogenic Tanker**
- **Cylinders**
- **Tube Trailer**

- **Steam / Power**
- **Waste Gas / Feedstock**
- **Gaseous Pipeline**

- **Customer(s)**

- **Merchant Market**
Conventional Hydrogen Delivery Methods

- Gas Pipeline
- Liquid Tank Trailer
- Gas Cylinders
- Gas Tube Trailer
Newer Hydrogen Delivery Methods

CT-250 (7500 psi)

CT-1000 (7500 psi)

HF-150 (6600 psi)

Microbulk H2 Truck (7500 psi)
Hydrogen Supply Options vs. Challenges

- Trigen
- Electrolyzer
- On-Site Reformer

Delivered gas
Delivered LHY

Footprint
Scalability
Thank you...
Tell me more

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