



# H2 Infrastructure Development Update

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# Overview

- Who is Air Products?
- Approach to Developing Infrastructure
- Lessons Learned
- Progress – What does it look like?
- Summary

# About Air Products

- Manufacturer of industrial gases
- \$9 billion in sales
- Largest supplier of hydrogen in the world
- Our products are used to do a lot of things, including:
  - Freeze food, make semi-conductors, produce clean burning fuels and manufacture steel
- Facilities in over 40 countries
- ~18,000 employees worldwide



# 50+ Years of Hydrogen Experience

- >5.0 million kg per day H<sub>2</sub> production
  - >600,000 kg/day in Canada
  - 38 miles of H<sub>2</sub> pipelines
- Bulk, liquid, and pipeline distribution
- Onsite generation
- Unique product offerings for H<sub>2</sub> fueling
- H<sub>2</sub> energy projects since 1993
  - > 120 hydrogen station projects
  - > 350,000 fuelings/yr



# Air Products Approach to H2 Fueling Infrastructure Development

- Leverage existing infrastructure whenever possible
- Develop solutions that support a variety of supply options suited to the customers' requirements and location:
  - Liquid
  - Pipeline
  - Gaseous
  - Onsite generation
  - Renewables
- Build, Learn, Improve



# Lessons Learned

- Actual demand often doesn't match forecasted demand.
- Various hydrogen distribution technologies provide different cost/benefits
  - Liquid, gaseous, mobile fuelers, onsite generators
- Expectations for reliability increasing. Trade-offs between capital and operating costs must be considered.
- Compression - highest maintenance item and critical to reliability
- Need to deliver lower hydrogen prices at lower station capacities
- Need to deliver to places not accessible by traditional delivery vehicles

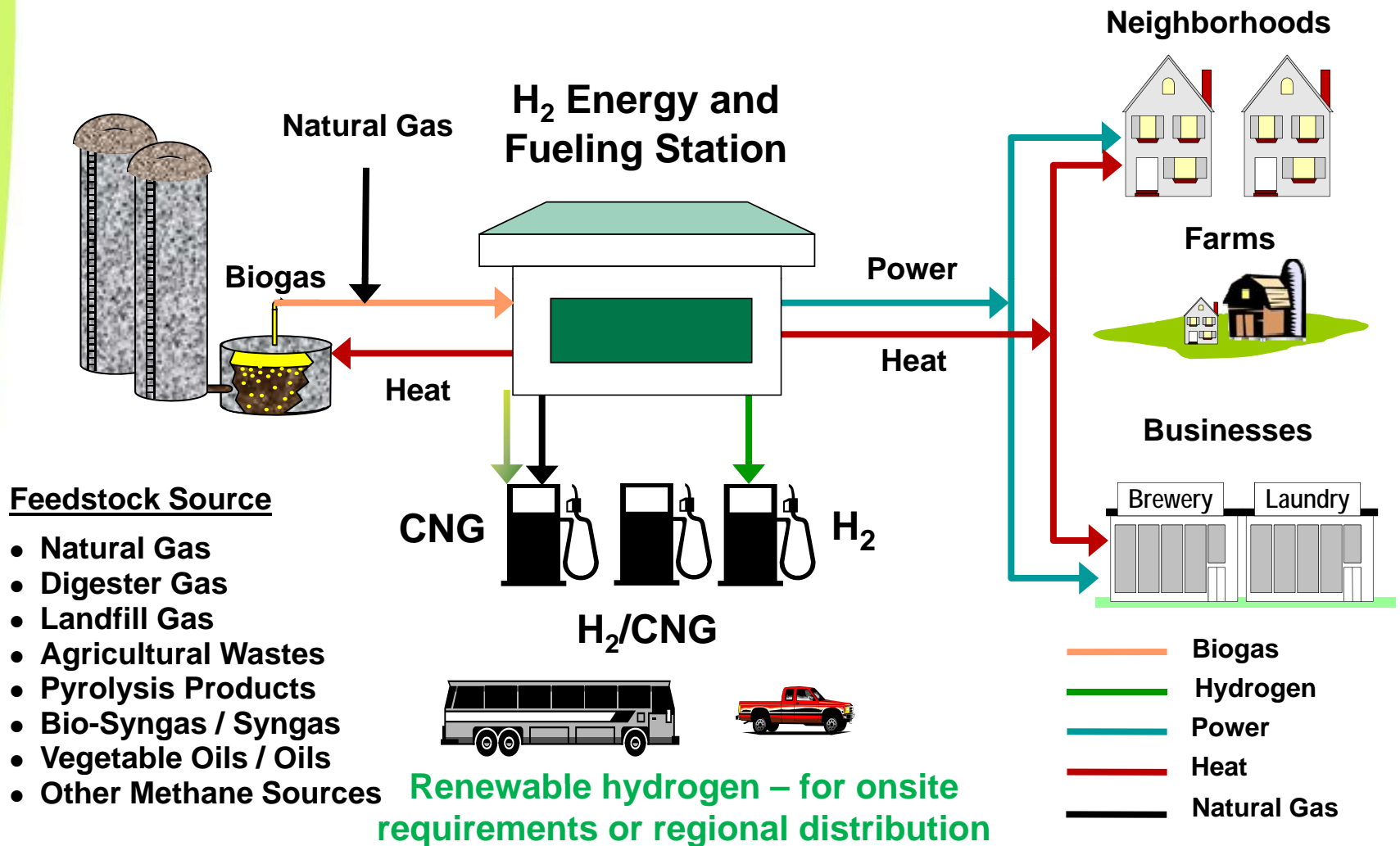


# Air Products Infrastructure Priorities

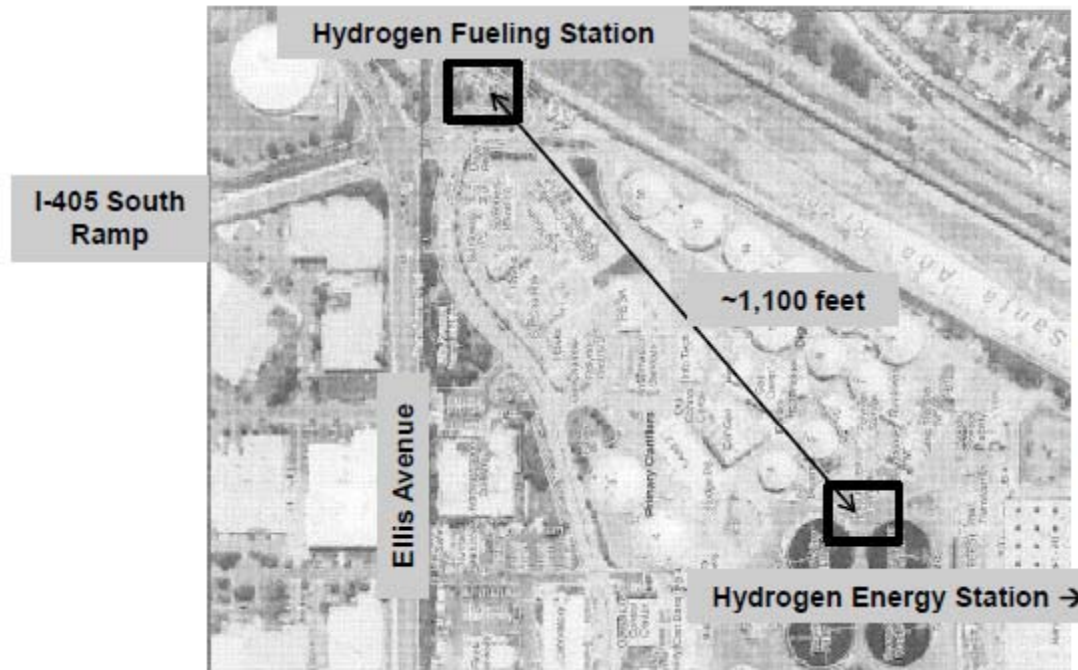
- H2 Production
  - Renewables
- Distribution
  - Lower Cost
  - New methods
  - Access to difficult sites- expand the delivery window
- Fueling Stations
  - Lower cost
  - Smaller footprint
  - Reliability
  - No/less compression
  - High volume fueling
  - Scalable
  - Retail capabilities



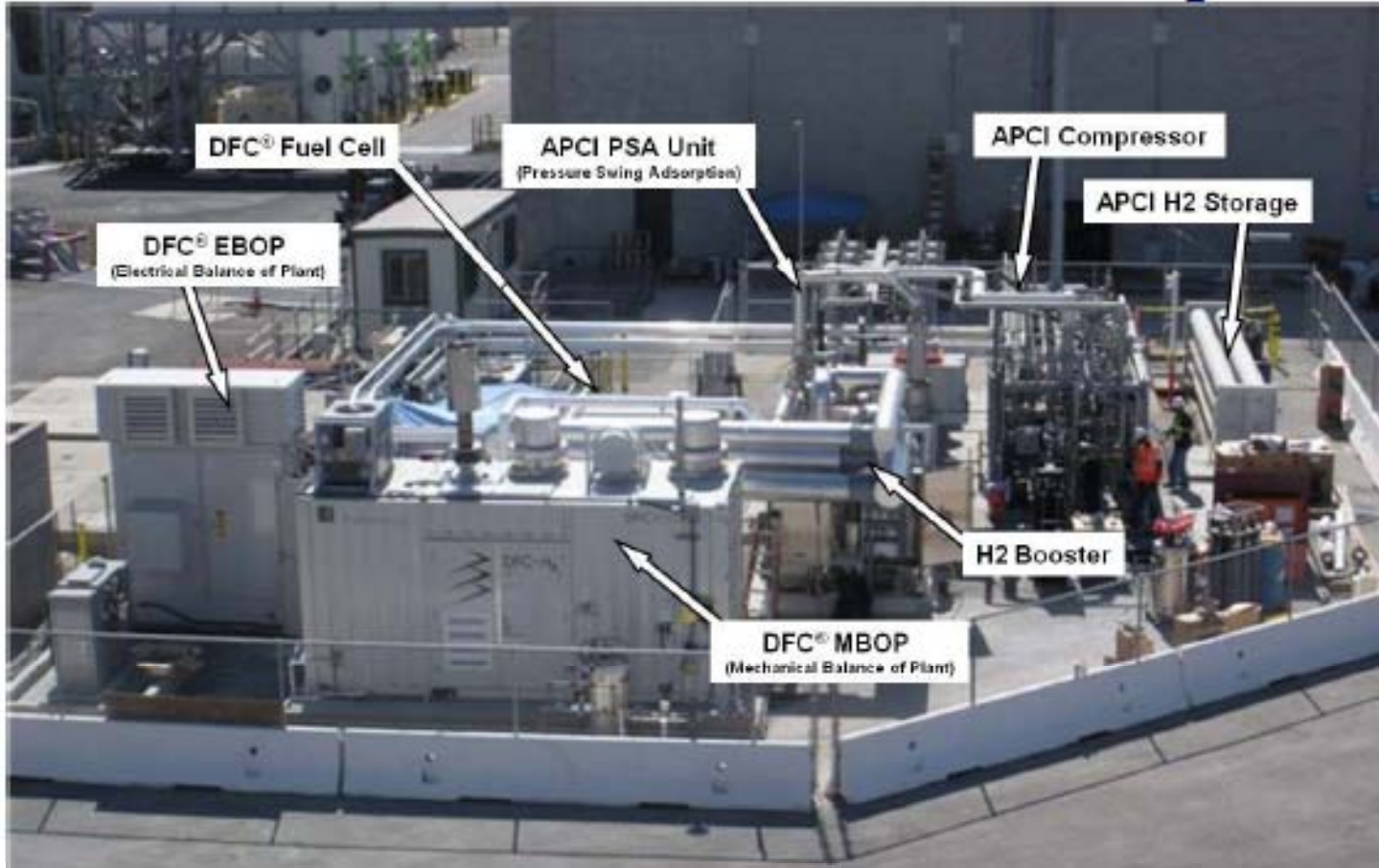
# H2 Production – Renewables Hydrogen Energy Station Vision



# H2 Production – Renewables Orange County Sanitation District



# H2 Production – Renewables Hydrogen Energy Station



# H2 Production – Renewables Hydrogen Energy Station



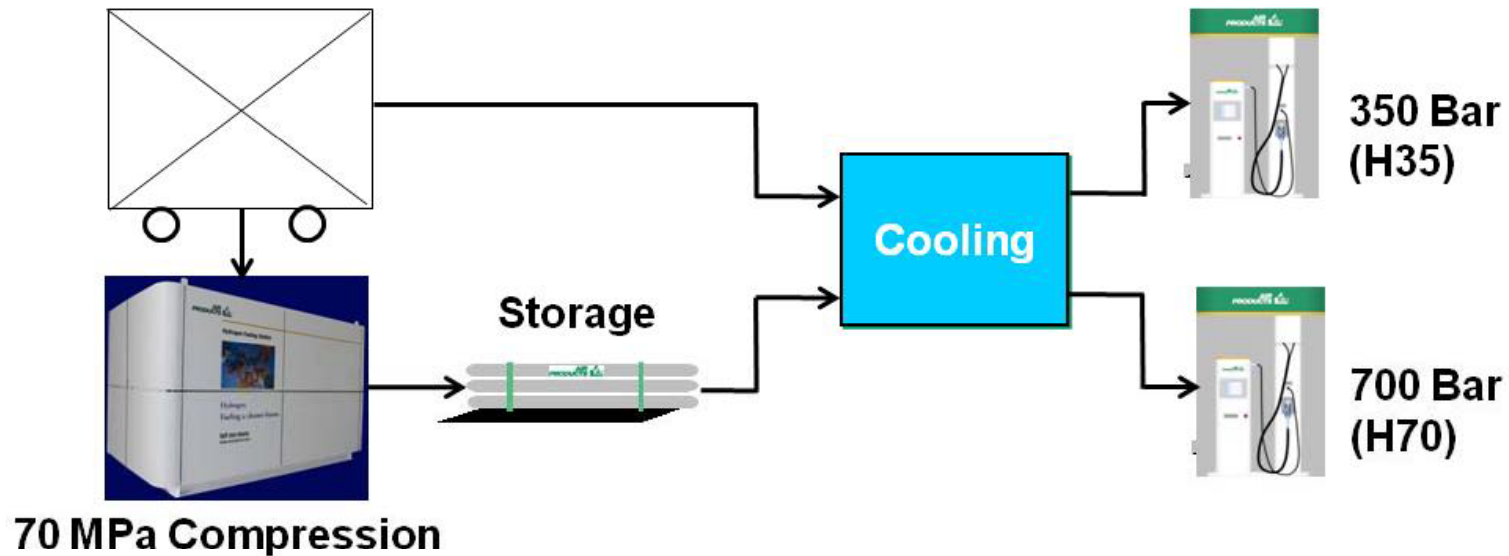
**Fountain Valley Station**

# Torrance Pipeline Station



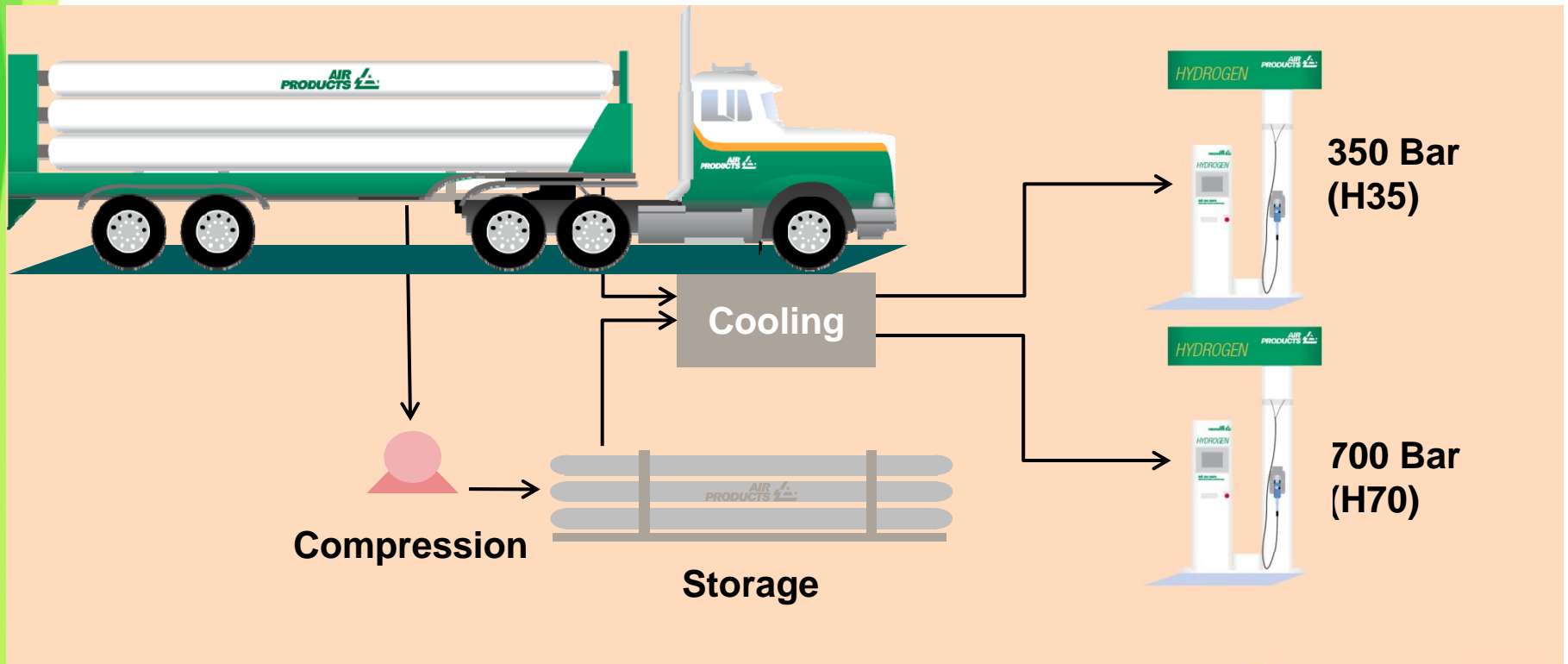
- Station supplied from active industrial pipeline
- H35 and H70 fueling capability
- Use of 15,000 psig ground storage, enabling 70 MPa cascade fueling
- Capable of 4 simultaneous vehicle fuelings (2 @ 35 MPa, 2 @ 70 MPa)
- Vehicle identification system for OEM-specific fueling protocols (HVAS)
- Meets SAE TIR-J2601

# Air Products' Low-Cost Fueling Station



- Station cost: ~ \$1 million
- No/reduced compression depending on fueling pressure
- Easily expandable
- Smaller footprint than liquid H<sub>2</sub> or onsite generator designs
- Leverages low cost H<sub>2</sub> production

# Low Cost Fueling Station



# South Torrance, CA



- H35 and H70 fueling capability
- Use of 15,000 psig ground storage, enabling 70 MPa cascade fueling
- Utilizes new, low cost fueling station design
- Meets SAE TIR-J2601
- Technology will be further deployed as part of CA Energy Commission infrastructure award

# Material Handling Infrastructure



Greater than two dozen dispensers fueling more than 700 trucks in eleven different facilities. And more under construction!



- Reliability Requirements – 24/7
- High Volume Fueling Experience



# Fueling Infrastructure with Horizontal 15,000 Gallon Tank and Liquid Compression



- Two CHC's installed on far side of tank
- System capacity limited by tank size and # of dispensers
- In commercial operation TODAY supporting 24/7 fueling

# Aiken County



- Shared infrastructure for multiple customers
- Material handling and vehicle fueling
- Spreads cost of infrastructure over larger hydrogen volume

# Traditional Hydrogen Delivery Methods



**Gas Pipeline**

**Liquid Tank Trailer**



**Gas Cylinders**



**Gas Tube Trailer**



# Dual Phase Hydrogen Tanker

Liquid H<sub>2</sub> trailer modified to deliver both liquid and gaseous product up to 7200 psi.



LH<sub>2</sub> Tank



Bulk H<sub>2</sub>



Mobile Fueller



Tube Trailers

- Optimize logistics model
- Opportunity for improved economics
- Deployed in US and Europe

# TfL, London



# Mobile Fueling Stations

- HF 150 Mobile Fueler
- Compression-less fueling station
- No utilities required
- Contains 150 kg hydrogen at 6,600 psig.
- Modular. Can be combined with other units and high pressure tube trailers to support larger fleets



# Microbulk H2 Delivery Vehicle



- Enables deliveries of small quantities of H2
- Provides access to challenging sites
- Eliminates need for cylinder swapping – storage is refilled when needed



# Summary

- Infrastructure costs have continued to decrease as a result of innovations in delivery methods and station equipment
- Reliability of fueling infrastructure has been demonstrated
- Station technology is changing rapidly in response to changing requirements
- Infrastructure is ready for larger deployments of fuel cells!



**AIR  
PRODUCTS** 



# Thank You!

[www.airproducts.com/h2energy](http://www.airproducts.com/h2energy)

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