

Hydrogen Fueling Infrastructure for ZEB Fleets

2019 CalTrans Bus Conference



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60+ Years 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)
 - Renewable or traditional
- 40 worldwide central plants, 50 small on-site generators
- H₂ energy projects since 1993
 - 250 hydrogen station projects globally
 - 1,000,000 fuelings/yr
 - Major CA H₂ mobility supplier
- Built >29 fueling stations in California
- Complete H₂ solutions provider

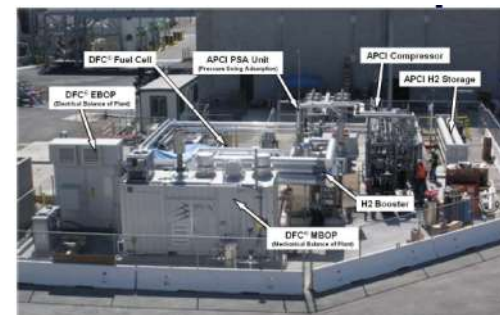


Hydrogen Mobility & Energy Markets

- Transportation



- Power Generation



Air Products fueling vehicles on these markets in Europe, Asia and US



Air Products and Hydrogen Bus Fueling

- Fueling buses with hydrogen for 20 years
 - SARTA
 - Transport for London
 - Koln Germany
 - Penn State
 - Flint MTA
 - Allentown
 - BP Beijing
- Offer delivered gas, delivered liquid, on-site generation (SMR & electrolyzer), and pipeline hydrogen H₂ supply



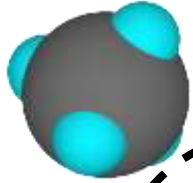
Orange County Transportation Authority Station (2019)

- Delivered liquid hydrogen (AP LHY)
- Air Products design & key equipment
 - Air Products proprietary dual-phase liquid pumps
 - 6-10 min. fills
 - Two dispensers
- 10 buses initially
 - Can scale to 30 or more buses
 - Multiplicative scaling
- Planned on-stream Nov./Dec. 2019



Redefining Fuel

Moving from fueling vehicles...



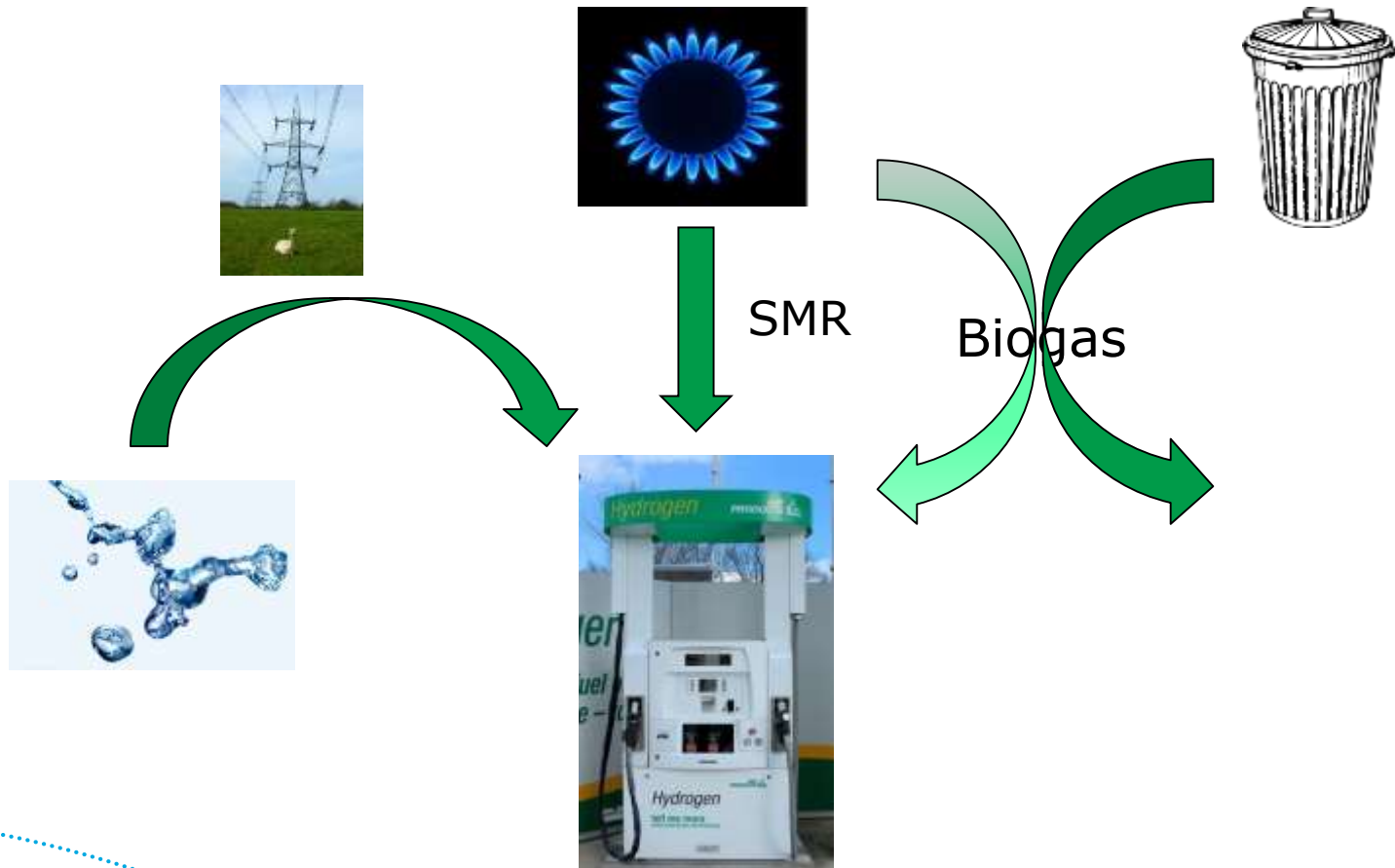
... to powering vehicles!



- Fuel Cell Electric Vehicles
- Battery Electric Vehicles

Redefining Hydrogen

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

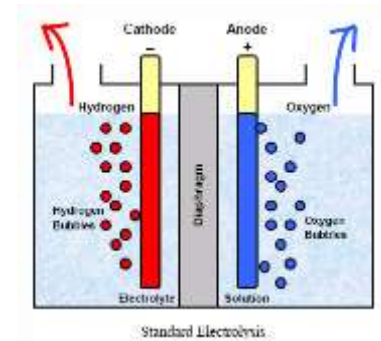


Making Hydrogen

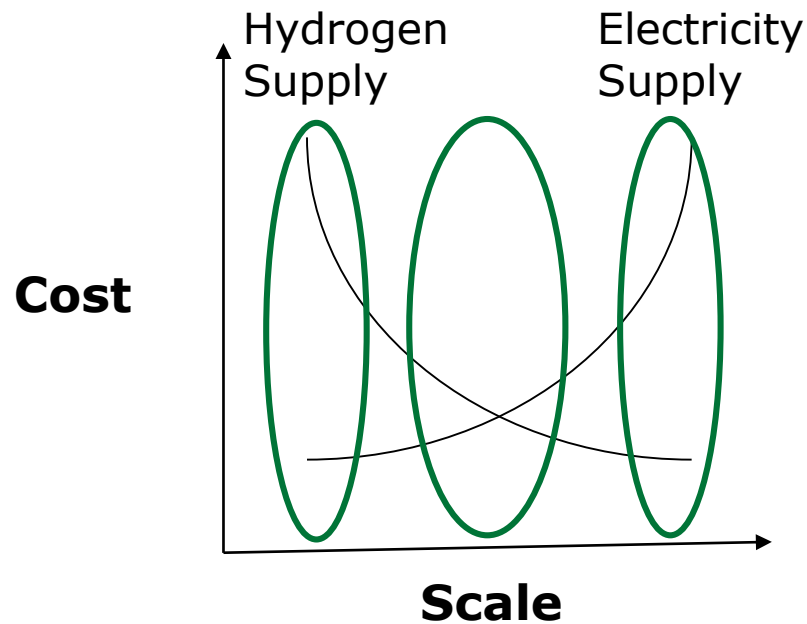
Traditional & Renewable H2 via ...

SMR-
Steam
Methane
Reforming

Electrolysis

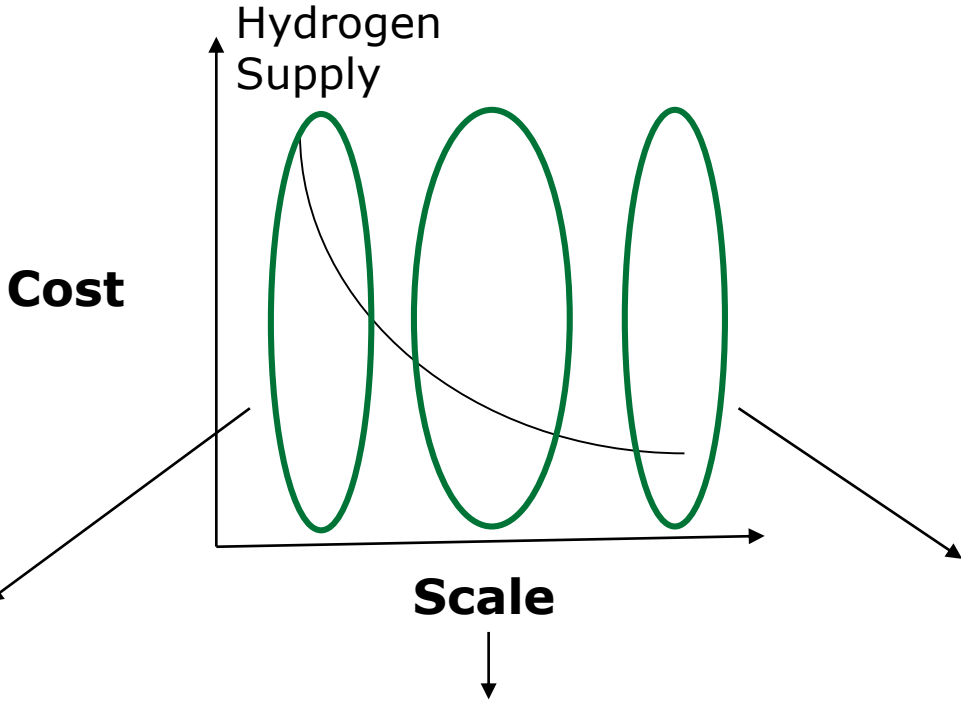


Why Hydrogen and Fuel Cells for Your ZEB Fleet?



- Bus Range
- Infrastructure Scalability
- Partner and Supply Options

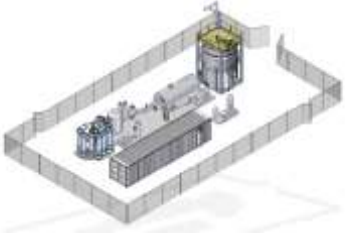
Scaling ZEB Fleets with Hydrogen



1-2 buses

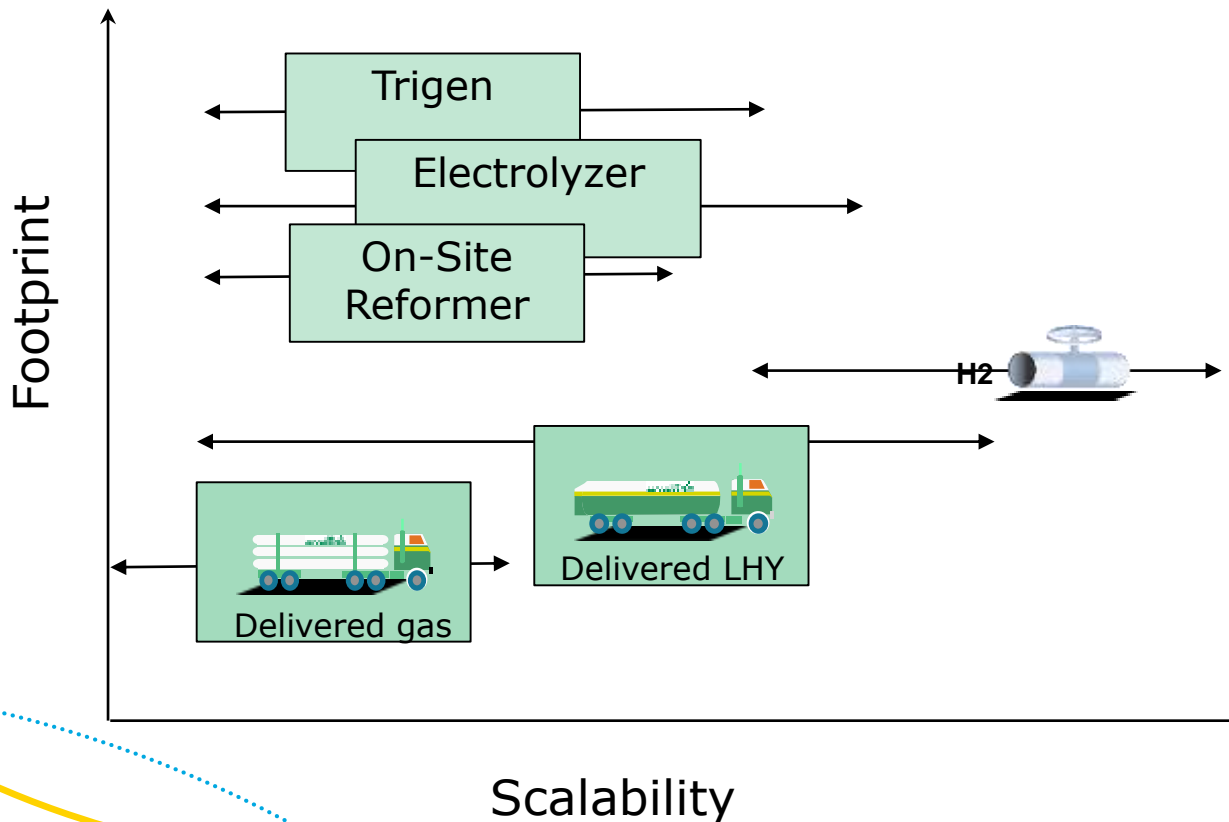


100-300 buses



Hydrogen Provides Energy Diversity

- Less dependent upon a single energy source (power)
- Multiple back-up options for large fleets
 - NG, power, H2 as energy input options



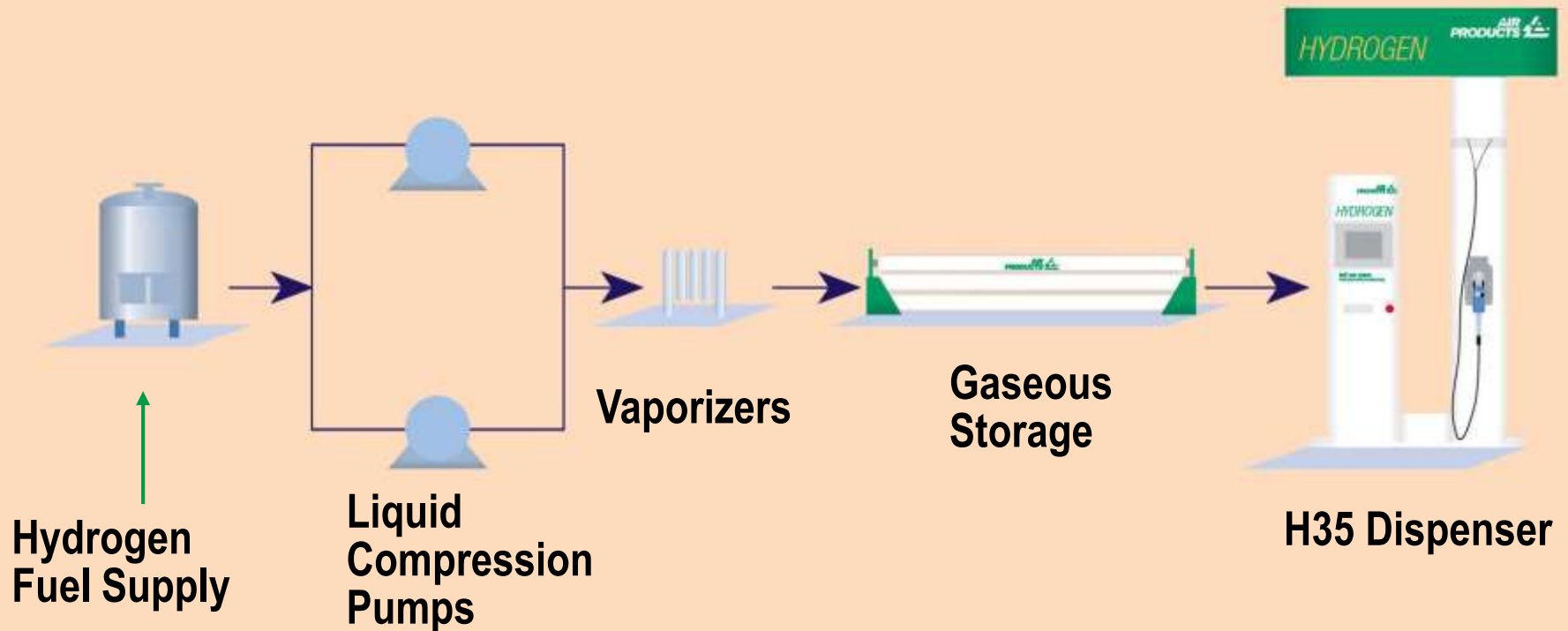
Getting Started – Hydrogen Supply

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-Up SmartFuel® H2 Bus Fueling Infrastructure



- Readily expandable to 30, 50 or 200 buses
- Ability to introduce renewables by changing supply

H2 Fueling Station Considerations

- Footprint & Scalability

- Understand the fueling options at your site for...

- 5-10 buses
- 25-50 buses (or max.)
- 100-200 buses (or max.)

- Consider best/worst case scenarios

- Vocalize operational limitations early



- Renewable Content

- Must have vs. nice to have

- No one right answer

- Use your local assets



- Price- consider TCO, demo vs. full adoption

- Pathways to lower price & larger scale exist

Path Forward to Zero Emissions with H2

- Consider the Possibilities
 - Starting technology for low/zero emissions doesn't have to be final one
- Ask the experts
- Know Thyself, Dialogue, & Decide
 - Articulate what you want, how you operate, site
 - Communication is a two-way street
 - Scope changes & creep are a normal part of the process
- Each powering technology has it's own development cycle
- Pick the right partners

Thank you...
tell me more

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