



# Hydrogen Infrastructure

Accelerating Electric Drive: The Next Generation of Hydrogen Fuel Cells

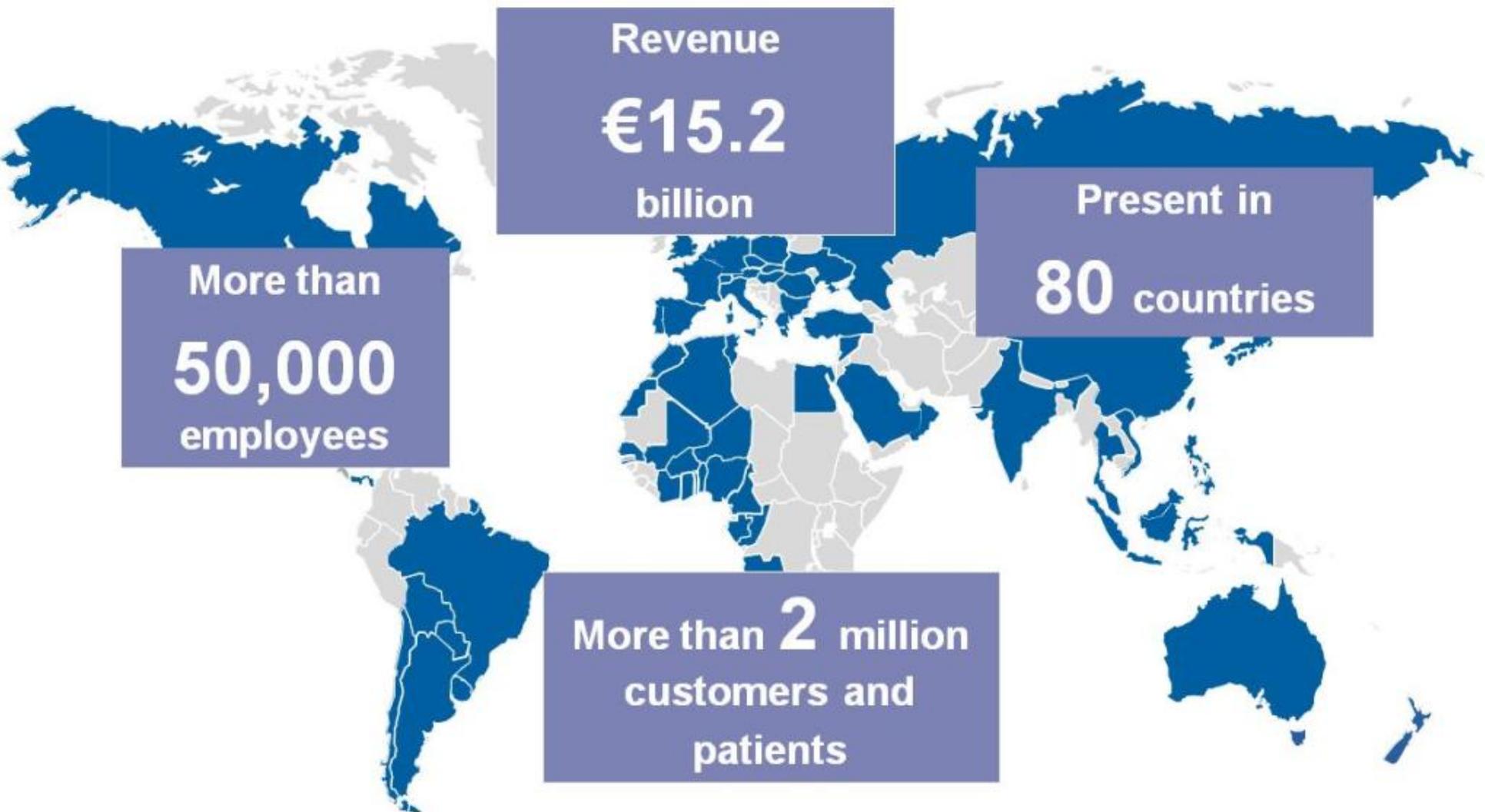
Dave Edwards, Air Liquide

DOE HTAC Meeting, October 27, 2015





# Who is Air Liquide?



# Megatrends driving our current and future business



**AIR LIQUIDE'S GROUP MEGATRENDS**

- Industry globalization and resource constraints** (Icon: World map with location pins)
- Evolving consumption and demographics** (Icon: Pyramid of people)
- Appetite for innovation** (Icon: Person with gear and lightbulb)

# Air Liquide - Hydrogen



## Hydrogen: 40 years in industry

- \$2.5B Revenue (refinery and chemicals)
- 1,800 km of pipelines
- 1,000 trucks
- 13 Billion Nm<sup>3</sup>/year  
(enough for 10M vehicle refills)
- 60 filling stations
- 300 fuel cell installations



Large H<sub>2</sub> Plants and Pipelines



## Air Liquide Hydrogen Mobility:

### Light vehicle refueling

- GM/Shell demo stations- NY and CA
- Germany - H<sub>2</sub> mobility
- California - 3 stations in development
- NE Fueling network

### Mass transit stations

- BC Transit - Whistler Station
- Oslo, Norway
- Birmingham, AL -Demo

### Materials handling applications

- Walmart
- Coca Cola
- Procter & Gamble

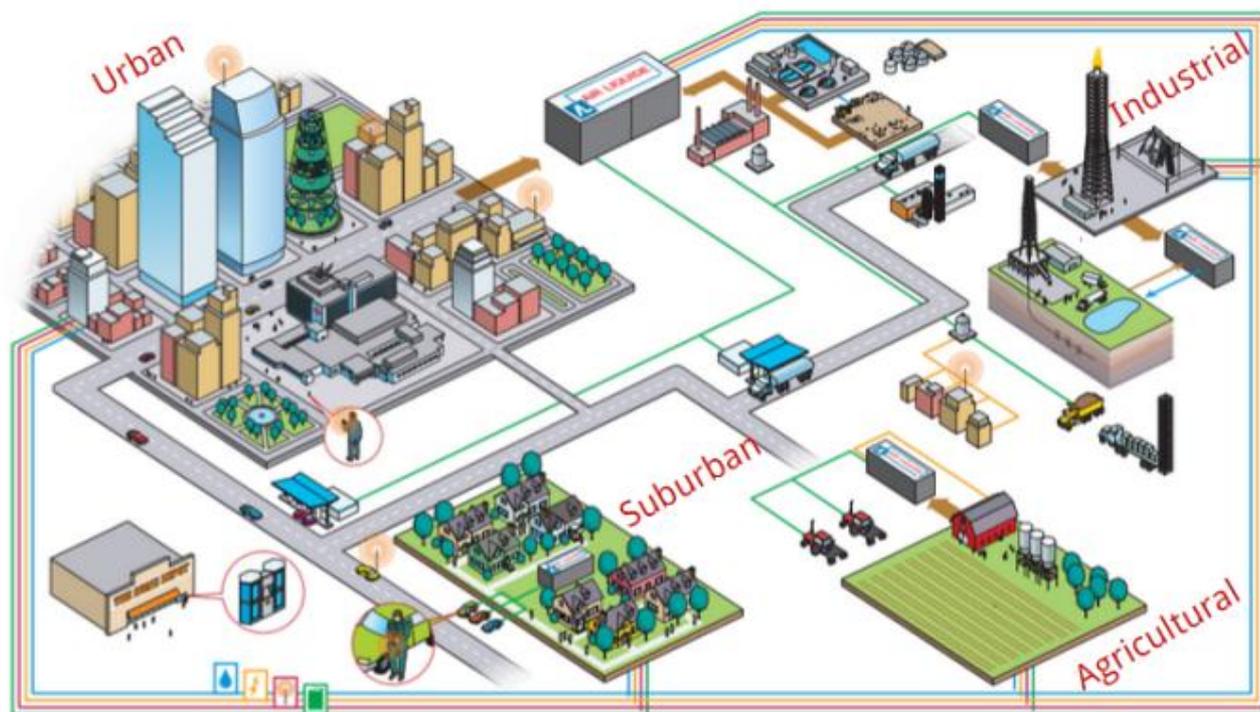




# What are the Future Possibilities?



# Sustainable Communities and Interconnectivity



In the future, we must be **sustainable** to be **profitable**.

We believe that as a **company** and as a **society**, sustainability is not optional, but **imperative**.



# The market potential



Global Industrial Gases Business X 2

10% → \$120B

“If 10 percent of cars around the world were powered by fuel cells, it would amount to €100bn (\$120B) in sales, which is “twice the size of the entire global industry today”\*

Benoit Potier – Air Liquide CEO

\*M. Stothard, “Air Liquide looks to fuel cells to drive results” [Financial Times](#), 5Jan2014





# What will it take to get there?

## Infrastructure - Autos

**Air Liquide has built more than 60 hydrogen stations worldwide;  
15 additional stations planned to open in the U.S**

Flexible infrastructure products  
to supply various markets and offer competitive costs



More deployments, helping the societal acceptance



Forklifts  
35 MPa  
100–300 kg/day

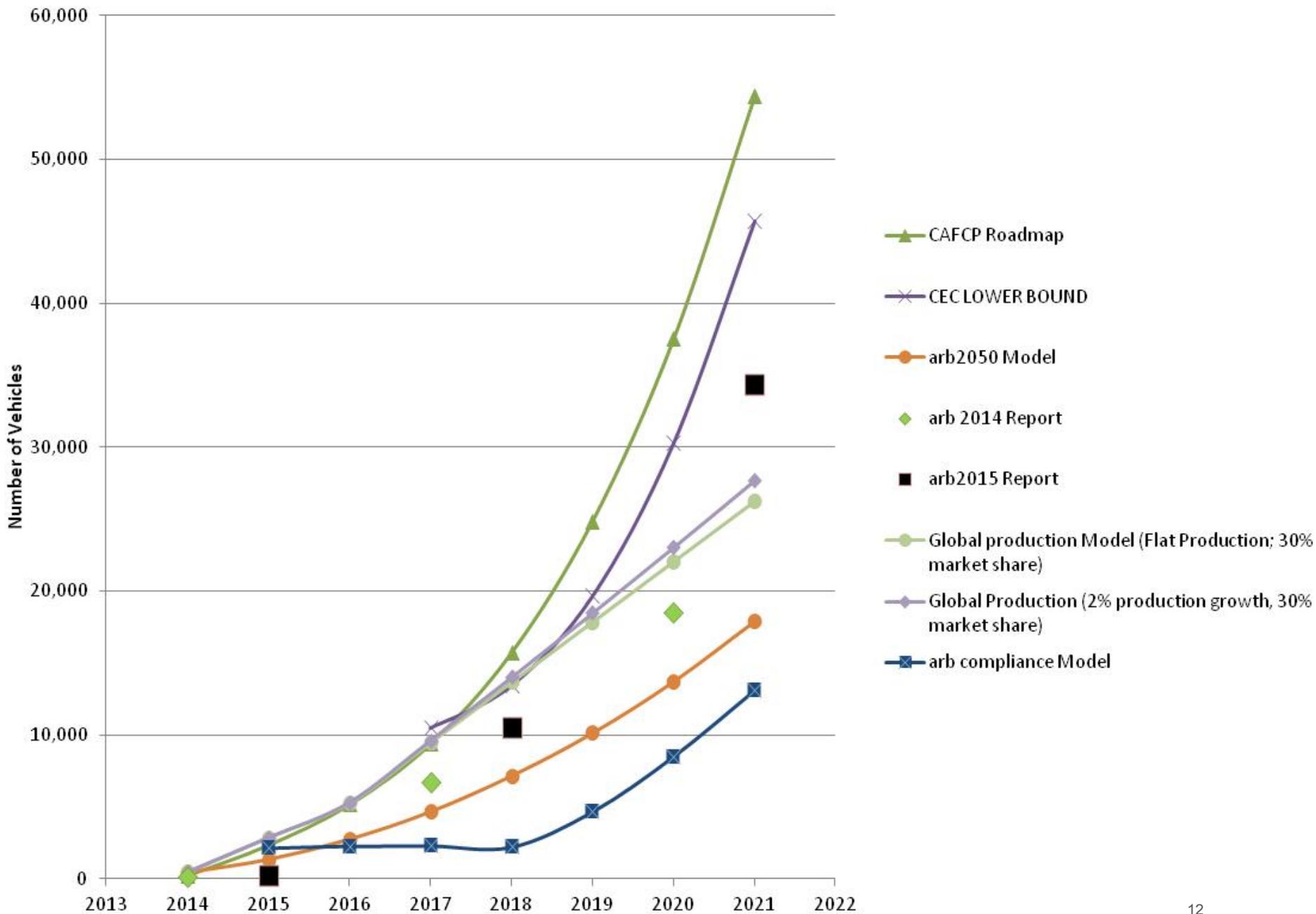


Buses  
35 MPa  
100–300 kg/day



Cars  
70 MPa  
50–200 kg/day

# California Car Population Predictions

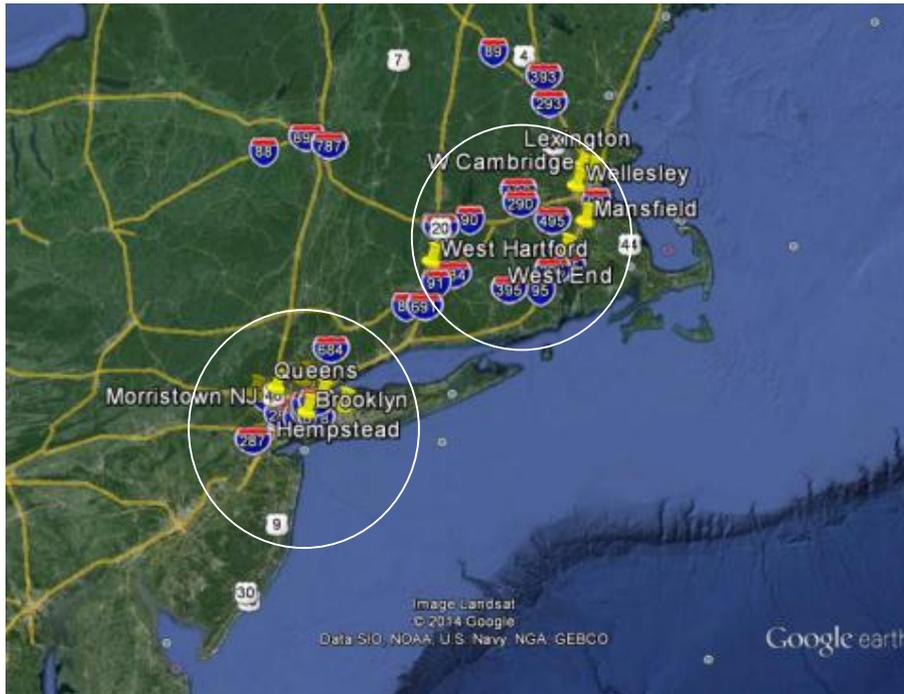




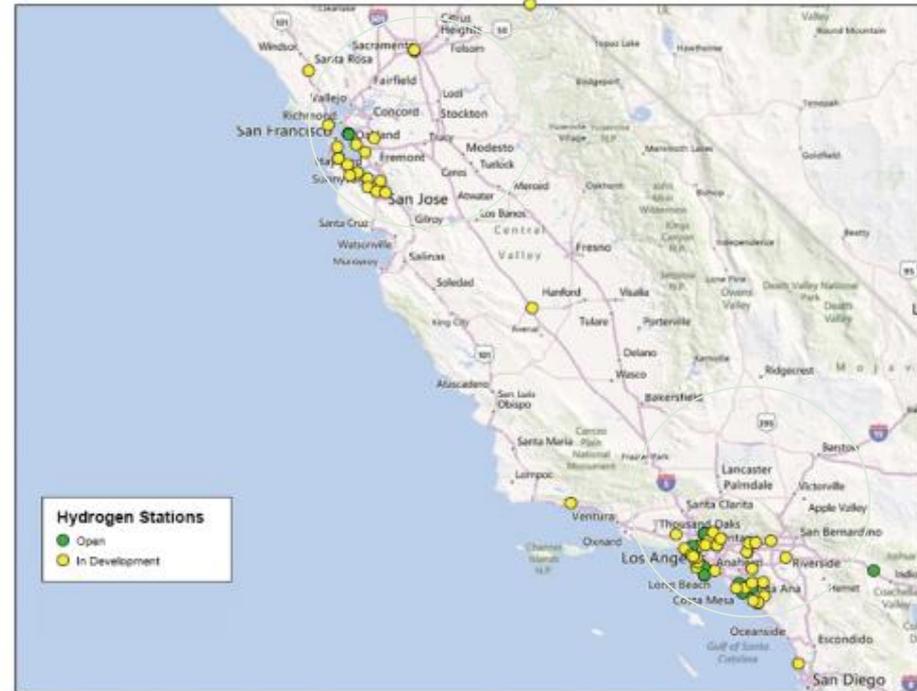
# How are we moving forward?

## Sites – Equipment - Supply

# East and West Coast Planned Fueling networks



12 Stations for the Northeast  
Air Liquide and Toyota partnering



48 Total Stations Planned in California  
(9 operational today)

- Specific locations/schedule are contingent upon ongoing site negotiations
- Connector stations located on major travel routes between clusters

## Retrofit of an existing station



## Design standards

- NFPA, CGA and local fire codes
- Use permits typically not necessary at existing stations
- SAE standards compliance





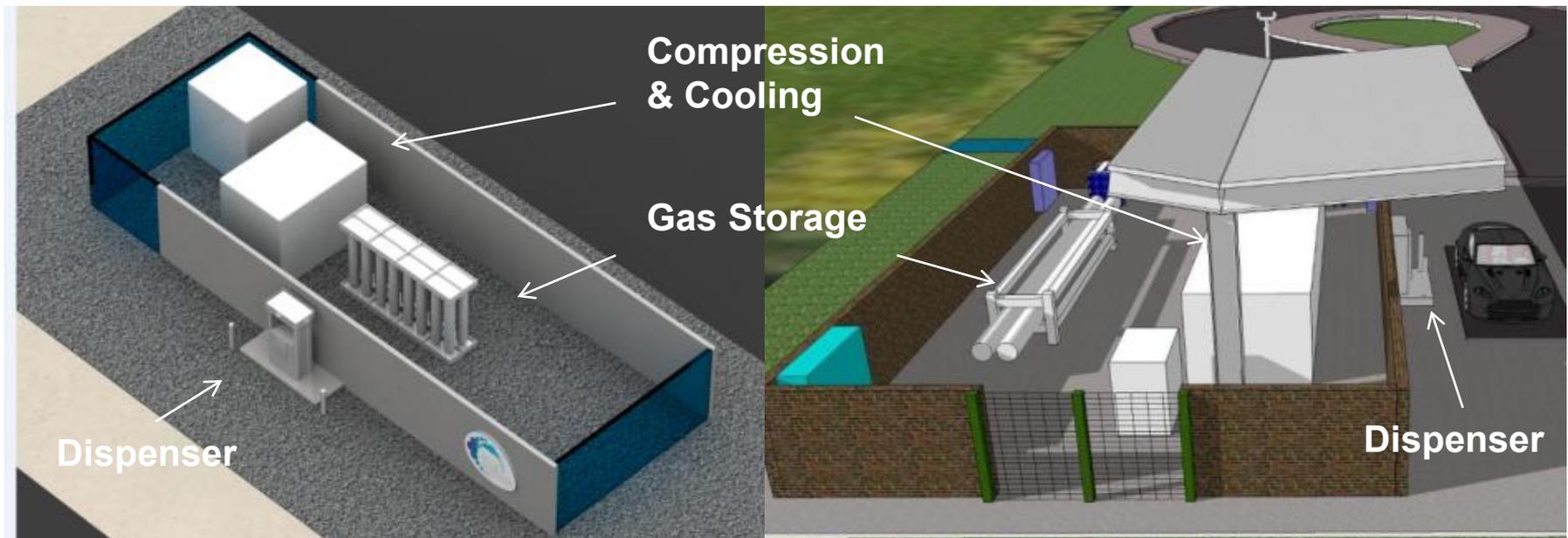




# Station Design



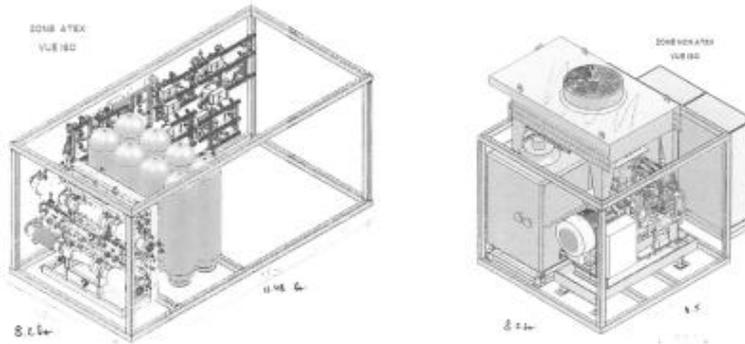
- Small foot print 1,500-2,000 ft<sup>2</sup>
- All equipment modular, above ground and expandable
- Fueling time 3–5 minutes
- NFPA 2 and CGA compliant



# Station Components



## Compression and cooling



Conditions H2 for achieving high density and SAE compliant fills



## Dispensers



- Standard retail point of sale system or customized fleet systems
- SAE fueling nozzle and protocol
- Metering systems advancing to weights & measures approvals
- Station status broadcast to the cloud or internet

Business Model	Fleet Advantage/Synergies
<p><u>Retail Gas Stations</u></p> <ul style="list-style-type: none"><li>• Station provider rents space required for equipment from owner</li><li>• Station provider owns and operates station</li><li>• Station provider sells fuel to vehicle owners</li></ul>	<ul style="list-style-type: none"><li>• Adds stable demand to public station</li><li>• Improves asset utilization</li><li>• Point of sale can be customized</li></ul>
<p><u>Behind the Fence Fleet Stations</u></p> <ul style="list-style-type: none"><li>• Station provider installs station at central fleet location</li><li>• Station provider owns and operates stations</li><li>• Fleet operators lease equipment and pay for fuel with monthly invoicing</li></ul>	<ul style="list-style-type: none"><li>• Large fleets (50 cars) can have a dedicated station</li><li>• No point of sale transaction necessary</li><li>• Permitting is usually easier</li><li>• Equipment operation can be customized to fleet characteristics</li></ul>

# Hydrogen Supply and Distribution



## Large Scale Production

### H<sub>2</sub> Source:

- Steam Methane Reforming
- Waste gas purification
- Electrolysis

Gaseous (200–450 bar)



Liquid



## Onsite Production

Reforming NG

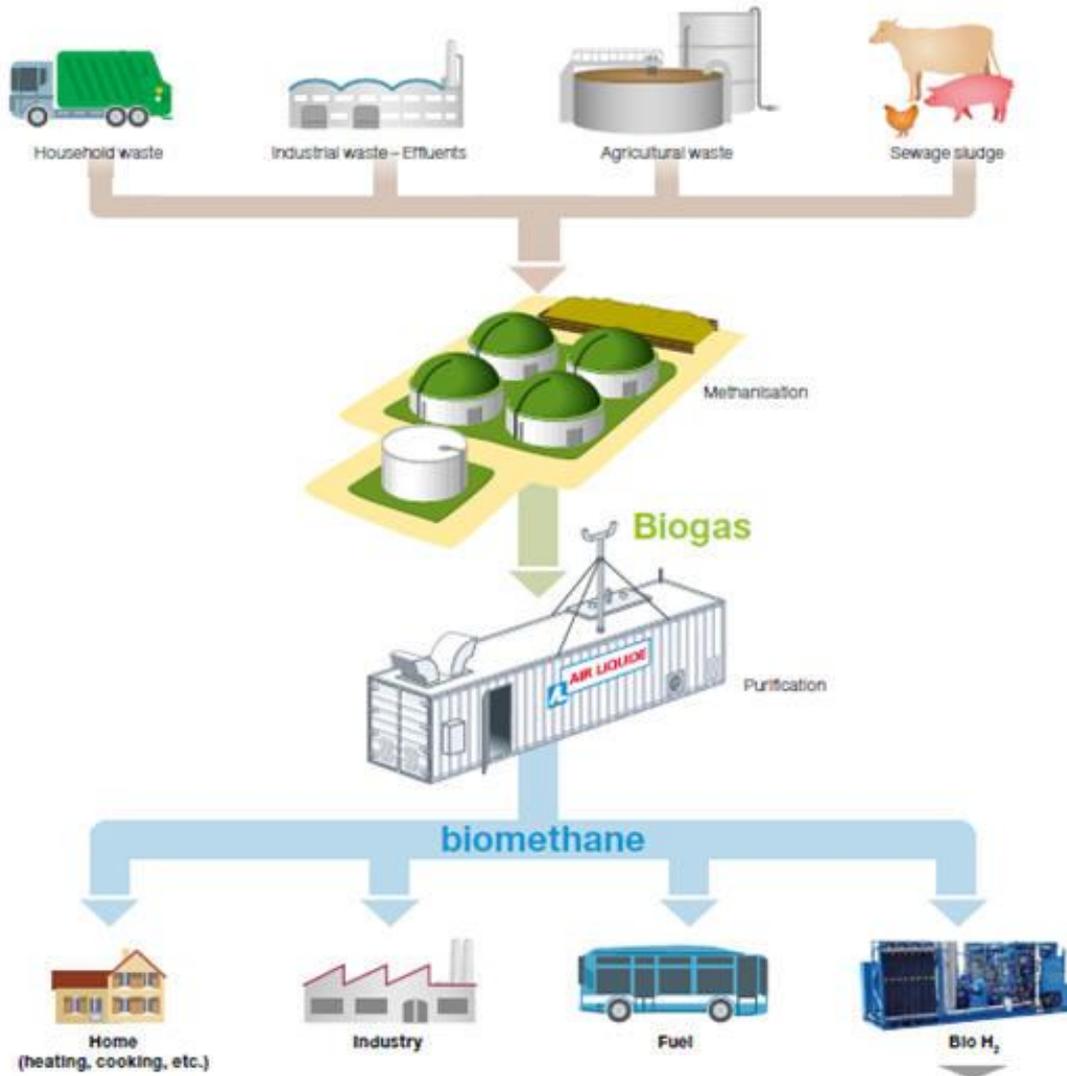


Electrolysis



NG – natural gas

# Hydrogen Supply and Distribution



# Summary and Key Points



- The cars are coming
- The infrastructure will be ready
- California and Northeast states lead the way
- Targeting existing retail sites with enough space
- Hydrogen stations and fueling equipment are commercially available
- Blue hydrogen enables sustainable supply







Thank You