Hydrogen Fuel Cell Electric Vehicle Station Development

- March 10th, 2019 -
Introduction to Fuel Cells

Fuel Cell
- Produces electric power through electrochemical reaction of hydrogen and oxygen

Fuel Cell Stack + Hydrogen Supply
- Replaces the battery in electric drive systems
How Fuel Cell Electric Vehicles Work

1. Air (oxygen) taken in
2. Oxygen and hydrogen supplied to fuel cell stack
3. Electricity and water generated through chemical reaction
4. Electricity supplied to motor
5. Motor is activated and vehicle moves
6. Water emitted outside vehicle
Hydrogen Fueling Station – Behind the Wall

1. H2 Supply
2. Compression
3. H2 Storage
4. Temp Control
5. Dispensing
Fuel Cells – Used in Many Applications Today
Introduction to Hydrogen

Hydrogen from Water
Electrolysis
Uses electricity to split the molecule

Hydrogen from Natural Gas
Reforming
Uses heat + catalytic reaction to split the molecule

Hydrogen is:
• Odorless, colorless, and tasteless
• Non-toxic and non-poisonous
• Lighter than other fuels
• Flames have low radiant heat
• Wide flammability range
• Low risk of asphyxiation
Hydrogen – the Pathway to Renewable

The Hydrogen Production Transition

- Natural Gas Pipeline
- Renewable Power Sources
- Electric Grid
- Water Electrolysis
- Reformation

- Transportation Fuel
- On & Off Grid Power + Storage
- Traditional Markets
- Fertilizers
- Pipelines & New Storage Technologies

- Fossil Fuel Sources
- Bio-Methane Sources
State of California Goal
(Executive Order B-48-18)

200 hydrogen stations by 2025
CaFCP Goal

Enable market conditions to support:

1,000 hydrogen stations

and

1,000,000 fuel cell vehicles

by 2030
A Path to California’s Hydrogen Goals

Currently Funded Stations

Growth of H2 Infrastructure Statewide
Released in October 2015

Developed to aid with timely completion of hydrogen fueling stations.

The primary question at the time was, “Can this market work?”
Can we make the market work?

“Yes!”
H2 Station Development Time

- Local permitting = 333 days, on average (purple bar)
- #1 Lesson?
  - Communication is key
Today, scale is the key to market acceleration
Part 3. Station Development Process
We’re Here to Help

- Education
- Connecting with other jurisdictions
- Safety
Contact us with your questions!

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Subscribe to our Newsletter: The Plug and the Nozzle
Hydrogen Infrastructure

Funding for hydrogen fueling infrastructure in California

KEITH MALONE | PUBLIC AFFAIRS

March 10, 2020
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NREL

PDC
Sandia National Laboratories
Sempra Energy
SunLine Transit Agency
TATSUNO
United Hydrogen

Illegible logos

— 20 years of collaboration —
February 2020

Northern CA Hydrogen Stations

- **Retail: Open**
  - Campbell - Winchester Blvd
  - Citrus Heights
  - Emeryville
  - Fremont
  - Hayward
  - Mill Valley
  - Mountain View
  - Oakland - Grand Ave
  - Palo Alto
  - Sacramento
  - San Francisco - Harrison St
  - San Francisco - Mission St
  - San Francisco - Third St
  - San Jose
  - San Ramon
  - Saratoga
  - South San Francisco
  - Lake Tahoe-Truckee
  - West Sacramento

- **Heavy Duty: Bus**
  - Oakland - AC Transit
  - Emeryville - AC Transit

- **Retail: In Development**
  - Berkeley
  - Campbell - East Hamilton Ave
  - Concord
  - Redwood City
  - San Jose - Bernal Road
  - Santa Nella
  - Sunnyvale
  - Woodside
## By the Numbers

in California

<table>
<thead>
<tr>
<th>Numbers as of March 1, 2020</th>
<th>Total</th>
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<tbody>
<tr>
<td>*FCEVs—Fuel cell cars sold and leased in US</td>
<td>8,225</td>
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<tr>
<td>FCEBs—Fuel cell buses in operation in California</td>
<td>42</td>
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<tr>
<td>Retail hydrogen stations open in California</td>
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<tr>
<td>Fuel cell buses in development in California</td>
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<tr>
<td>Fuel cell shuttles in development in California</td>
<td>4</td>
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<tr>
<td><strong>Retail hydrogen stations in development in California</strong></td>
<td>18</td>
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</tbody>
</table>
Fuel cell passenger cars on the road

- 312-380 miles
- 3-5 minute fill
- Extreme temp performance
- Sedans and SUVs
- Audi, BMW
- Most automakers have fuel cell tech
2020 Toyota Mirai

- 400 miles
- 5 passengers
Hydrogen stations

La Canada Flintridge hydrogen station
Hydrogen Fueling Station

The Customer Experience
General description

Passenger, bus and truck H2 stations

- Passenger/Light duty
  - Small numbers of delivery vans
- Based at a gas station
  - Urban/neighborhood, connector and destination
  - Familiar location to drivers
  - Matches the business case of station owners
  - Hydrogen offers a just transition and business opportunity

- Transit stations
  - Exclusively bus
  - One exception in Emeryville

- Truck/heavy duty stations
  - Likely exclusively heavy duty
  - Possible exceptions – Nikola Motor stations

- CaFCP station map (Google based)
  - Light, bus and truck stations
Funding for hydrogen fueling infrastructure

**Passenger stations**
- Assembly Bill 8
  - 100 stations+
  - Current GFO 19-602
    - $115 million
    - Likely 40-50 stations
- Low Carbon Fuel Standard ZEV infrastructure credit

**Local jurisdiction efforts**
- BAAQMD - $5 million
- SLO APCD - $0.25 million

**Heavy/medium duty and transit**
- CARB
- CEC
- Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)
- Carl Moyer Program
- Advanced Technology Freight Demonstration Projects
- Stakeholders are currently advocating for more infrastructure funding for medium and heavy-duty vehicles
CARB annual survey: Automaker projections for fuel cell vehicles

Station costs decreasing

- **Shell paper**
  - “…over 50% of the current [infrastructure cost can be reduced in the next 2 years with small actions taken.”

- **NREL study**
  - Up to 35% reduction in costs of hydrogen refueling station systems with 100 units per year

Manufacturing competitiveness analysis for hydrogen refueling stations
Where are the future stations?

Several sources that can give you an idea as to where the first 100-200 hydrogen stations will likely go

- Automaker letter to stakeholders
  - Recommend future locations

- CHIT – California Hydrogen Infrastructure Tool
  - Used to help site stations for state grant funding opportunities
  - Utilized for selecting grant awardees

Automaker letter to stakeholders

California Hydrogen Infrastructure Tool
http://californiaarb.maps.arcgis.com/apps/webappviewer/index.html?id=f2bc784715984f3cb2905dbc4a0391b6
Good news

- High hours on fuel cell stack lifetime
- Availability numbers are looking good
- Transit agency comfort levels increasing
- Learning curves are not as steep anymore
- Bus OEMs taking on leadership role

- 42 buses in revenue service
- Another 7 funded
- 4 agencies

- New Flyer bus gets 350 miles
- 19+ years of experience
- 14 years of federally collected performance data

- >4.6M miles in service
- >Millions of passengers carried
“Our testing shows that this truck performs equally as well, if not better than, current diesel trucks on the market.” -Kenworth
Online resources

CaFCP staff

Codes and standards  
Emergency responder training  
Safety and hydrogen information  
Buses and trucks  
Passenger vehicles  
Test drives  
Briefings and presentations  
Community event displays  

CaFCP online resources

Hydrogen station map - https://cafcp.org/stationmap  
Documents and reports database - https://cafcp.org/resources  
News clips - https://cafcp.org/news
H2 fuel in California is on a renewable pathway

✓ 33% renewable content (2006)
✓ Low Carbon Fuel Standard
✓ ZEV infrastructure credit
✓ Renewable content increases to 40% (2019)
✓ Legislation proposed this year for 100% renewable and decarbonized H2 fuel
✓ Hydrogen Council goal for 2030
Hydrogen Council: 100% Decarbonized by 2030

Established January 18, 2017

11 Countries   53 Companies

Global Climate Action Summit, San Francisco, U.S.

We call on governments to build a global alliance that will help us deliver on an ambitious goal of decarbonizing 100% of hydrogen fuel used in transport by 2030.

Transport may be our first target—but with the right level of support, we will see positive effects across many sectors.
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