The California Experience: Commercializing Hydrogen Fuel Cell Vehicles

Hydrogen and Fuel Cell Technical Advisory Committee

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California Fuel Cell Partnership
Overview

✓ Market status
✓ What comes next
✓ Opportunities and needs
How to launch the market?

2012 California Roadmap

- Establish initial network coverage to enable launch
  - Stations must come first!
- Early market clusters in big cities
- “Connector” & “destination” stations across California
- Common vision for starting commercial rollout

www.cafcp.org/roadmap
Market launch – leadership and commitments

• Governor’s leadership
  o Executive Order – 1.5M ZEV target
  o ZEV program manager
  o ZEV Action Plan & Permitting Guidebook

• AB8 legislation
  o $20M annually for HRS, to reach 100 stations
  o ARFVTP program confirms programmatic foundation

• Provided industry confidence
  o Automakers expanded FCEV deployment
  o Fleets of “100’s” by several automakers
Progress in California’s Market Launch
<table>
<thead>
<tr>
<th>Number</th>
<th>Total</th>
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<tbody>
<tr>
<td>Fuel cell cars sold and leased</td>
<td>7,570</td>
</tr>
<tr>
<td>Fuel cell buses in operation in California</td>
<td>31</td>
</tr>
<tr>
<td>Retail hydrogen stations open in California</td>
<td>41</td>
</tr>
<tr>
<td>Fuel cell buses &amp; shuttles in development in California</td>
<td>25</td>
</tr>
<tr>
<td>Fuel cell trucks in development in California</td>
<td>35+</td>
</tr>
<tr>
<td>Retail hydrogen stations in development in California</td>
<td>22</td>
</tr>
</tbody>
</table>

https://cafcp.org/by_the_numbers
California’s Experience – Customer Focus!

- The technology works – *customers are coming!*
- Need to know where, when and if hydrogen is available
- Tools for customers & stakeholders; quarterly webinars, Station Status (SOSS), reports

http://m.cafcp.org
California’s Experience – Stakeholder Progress

Average Station Development Time (days)

Expected Annual Benefits from ARFVTP Investments to Date

<table>
<thead>
<tr>
<th>Project Type</th>
<th>NOx Reductions (Tonnes/Year)</th>
<th>PM2.5 Reductions (Tonnes/Year)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
<td>2025</td>
</tr>
<tr>
<td>Electric Chargers</td>
<td>1.89</td>
<td>1.57</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>9.31</td>
<td>8.51</td>
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<table>
<thead>
<tr>
<th>Project Type</th>
<th>Petroleum Displacement (Million Gallons)</th>
<th>Greenhouse Gas Emission Reductions (Thousand Tonnes CO2e)</th>
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<tr>
<td></td>
<td>2020</td>
<td>2025</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>BEV Charging</td>
<td>2.8</td>
<td>2.6</td>
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<tr>
<td>Hydrogen</td>
<td>13.6</td>
<td>14.3</td>
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<tr>
<td>Natural Gas</td>
<td>35.3</td>
<td>35.3</td>
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</table>

Source CEC
Positive Momentum

• Energy Commission’s *Draft Solicitation Concepts* adopts market building strategies to achieve scale

• Low Carbon Fuel Standard Amendments enable credits for installed capacity of HRS and fast charging, increases renewable hydrogen content to 40%

• Air Liquide announces 30ton/day H2 production facility

• Air Products announces liquid H2 production facility

• Hyundai announces 17 ZEV models over next decade, 10 of those will be FCEVs

• Toyota announces FCEV production of 30,000 units/year

• Trajectory of customer FCEV rollout is positive
California Heavy-Duty ZEV Regulations

Heavy-Duty On-Road and Off-Road Regulations that Impact ZEVs

- ZE Airport Shuttle
- ZE HD Certification
- Advanced Clean Trucks
- ZE Airport Ground Support Equipment
- ZE Truck/Trailer Refrigeration Units
- ZE Forklifts
- ZE Truck Fleets, including drayage
- ZE Cargo Handling Equipment

2018
2019
2020
2021
2022

 Already considered by the Board

CARB
California’s ZEV Strategy

- Success requires ZEVs on the market that meet all possible use cases
- Different drivers have different vehicle needs, usage patterns, and ZEV fueling ability
- FCEV and BEV compliment each other, where one faces challenges other typically excels
- Multiple technology options provides greater chance of success and potentially faster ramp up
- Both ZEV fuel pathways offer unique and exciting opportunities to enable greater renewable penetration on the electric grid
MISSION

accelerate
commercialization of hydrogen
and fuel cell vehicles
California Fuel Cell Revolution

Enable market conditions to support:

1,000 hydrogen stations

and

1,000,000 fuel cell vehicles

by 2030
Image of a Successful Self-Sustaining Market

8,000 retail gas stations

1,000 retail H2 stations

≈ HD Truck Infrastructure

Potential Corridor Co-Location
- Funded Stations
- Signage Ready
- Signage Pending
- Additional Routes

Truck Activity
- High
- Low
Strategies for reaching market success

MISSION
Accelerate commercialization of hydrogen and fuel cell vehicles

OUTCOMES
Economic, Social, and Environmental Benefits

FOSTER H₂ INFRASTRUCTURE
- Market Policies
- Economies of Scale

BUILD CONSUMER DEMAND
- Customer Incentives
- Hydrogen Network
- Dedicated Supply

AMPLIFY INNOVATION
- Trucks
- Diversify
- Grid Integration

SELF-SUSTAINING MARKET
- Private investment
- Growing market
- Costs parity
- Renewable H₂
Next for California

- **Policies** that encourage **investment**
- Addressing **cost challenges**
- **Renewable** production pathways
- **Expanding Stations** across and beyond CA
- **Sustainable freight and transit**
Lessons from California’s Market Launch

• Three key lessons
  – State leadership was crucial
  – Shared vision or plan is fundamental
  – Policy and investment commitments move the market

• Partnership between industry and government

• Education and awareness is ongoing

• Safety and emergency response training – builds confidence, support and speed

• Models for guidance and consensus – then let industry drive the market

• Build a house you can grow into

• Scale is the keystone to market sustainability – what drives us there faster?
Opportunities & Needs

- H2@Scale
- H2 & Grid interaction and analysis
- FCEV to grid analysis
- Scale scenarios and analysis
- Cost reductions and analysis
- LD and HD synergies
- Codes and standards
- HD analysis and development
- Underground
- Safety and ER training
- Environmental analysis
- SOSS expansion