



6/23/2022

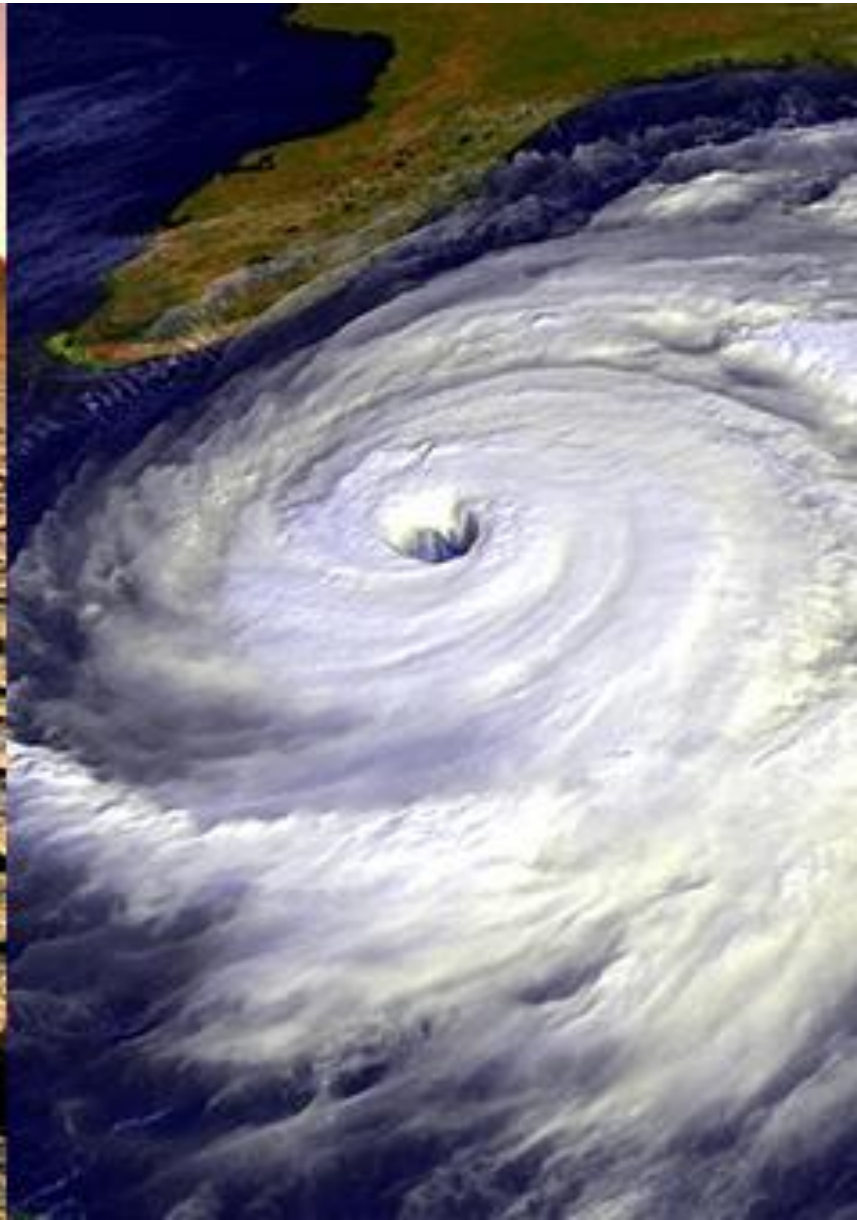
# Hydrogen Mobility in California: Driving the Market Forward

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Washington Legislator Visit  
Clean & Prosperous Institute

Bill Elrick, Executive Director  
California Fuel Cell Partnership

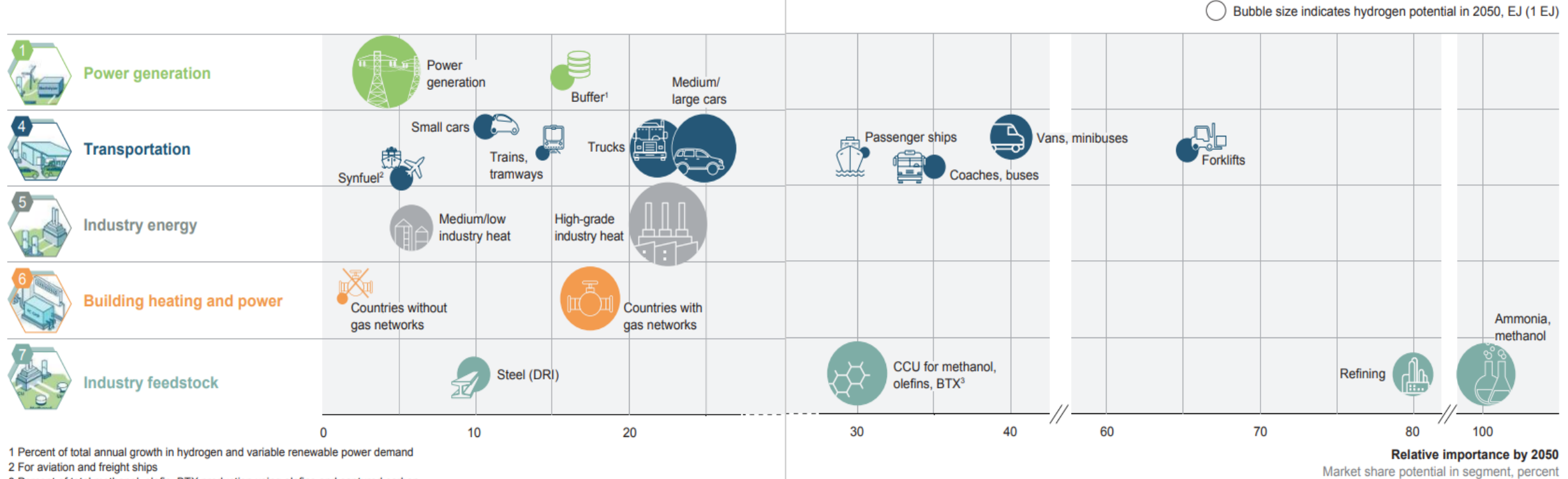
# Energy & Transportation Systems are Transitioning Globally...



# Hydrogen has a Significant Role in Global Decarbonization



Exhibit 4: Hydrogen can play a critical role in the low-carbon technology portfolio



1 Percent of total annual growth in hydrogen and variable renewable power demand  
 2 For aviation and freight ships  
 3 Percent of total methanol, olefin, BTX production using olefins and captured carbon

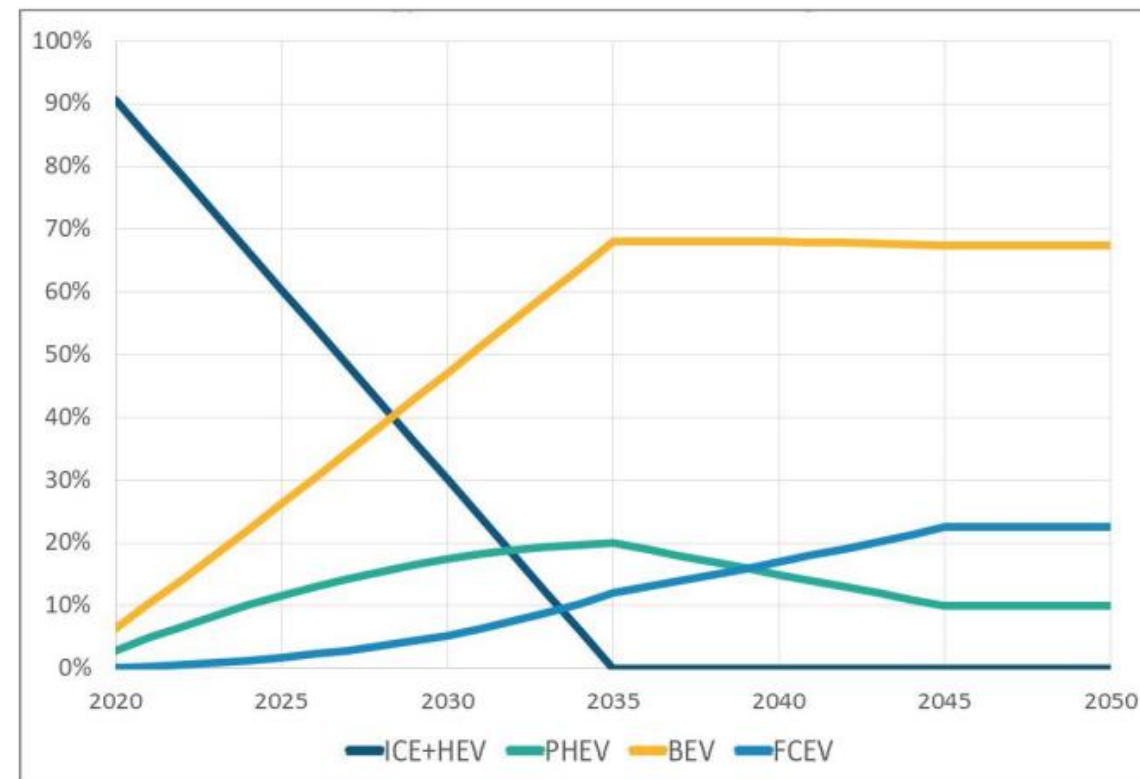
SOURCE: Hydrogen Council



# California's environmental challenge – and ZEV actions

- 1990 zero emission vehicle regulation (ZEV) to curb tailpipe emission
- Requires automakers sell ZEVs in California and other states
- Complimentary nature of BEVs & FCEVs
  - Hydrogen and electricity system enables larger decarbonized energy transition in all sectors
- Provides consumer choice

Figure 13 – Light-Duty Vehicle Sales Fractions by Technology Type



Source: CARB's Mobile Source Strategy

*Both ZEV technologies needed to reach environmental goals*



# California Environmental Goals

Legislation and Executive Orders are driving the state towards 100% zero-emission transition

<b>Climate</b>	<ul style="list-style-type: none"><li>• 2045 – 100% zero carbon electricity (SB 100)</li><li>• 2045 – Carbon neutral economy (EO B-55-18)</li></ul>
<b>Air Quality</b>	<ul style="list-style-type: none"><li>• 2031 – 80% reduction in smog-forming Nox</li></ul>
<b>Zero Emission Vehicles (ZEVs)</b>	<ul style="list-style-type: none"><li>• <i>ZEV regulation</i> – increasing ZEV sales requirement for LD automakers</li><li>• <i>Innovative Clean Transit</i> – 100% new bus purchases ZEV by 2029, and 100% of all operating buses ZEV by 2040</li><li>• <i>Advanced Clean Trucks</i> – increasing sales requirement for MHD manufacturers starting 2024, and 100% ZEV sales by 2045</li><li>• 2025 – 1.5 million ZEVs (EO B-16-12)</li><li>• 2030 – 5 million ZEVs (EO B-48-18)</li><li>• 2035 – 100% in-state passenger vehicle sales are ZEV (EO-N-79-20)</li><li>• 2045 – 100% in-state M-HD vehicle sales are ZEV (EO-N-79-20)</li></ul>
<b>ZEV infrastructure and fuels</b>	<ul style="list-style-type: none"><li>• 2025 – 200 hydrogen stations and 250,000 chargers (EO B-48-18)</li><li>• Low Carbon Fuel Standard – sets carbon intensity standard for fuels, with fuel producers producing and selling credits around the standards</li></ul>



# CaFCP Members



Alameda-Contra Costa Transit District (*AC Transit*)  
 BAE Systems  
 Ballard Power Systems  
 Bay Area Air Quality Management District  
 California Department of Food and Agriculture  
 California State University - Los Angeles  
 The Center for Energy Efficiency and Renewable Technologies (*CEERT*)  
 Center for Transportation and the Environment (*CTE*)  
 Chart Industries, Inc.  
 Choshu Industry Corporation  
 City of Lancaster  
 City of San Francisco  
 Comdata  
 Compressed Gas Association  
 CSA Group

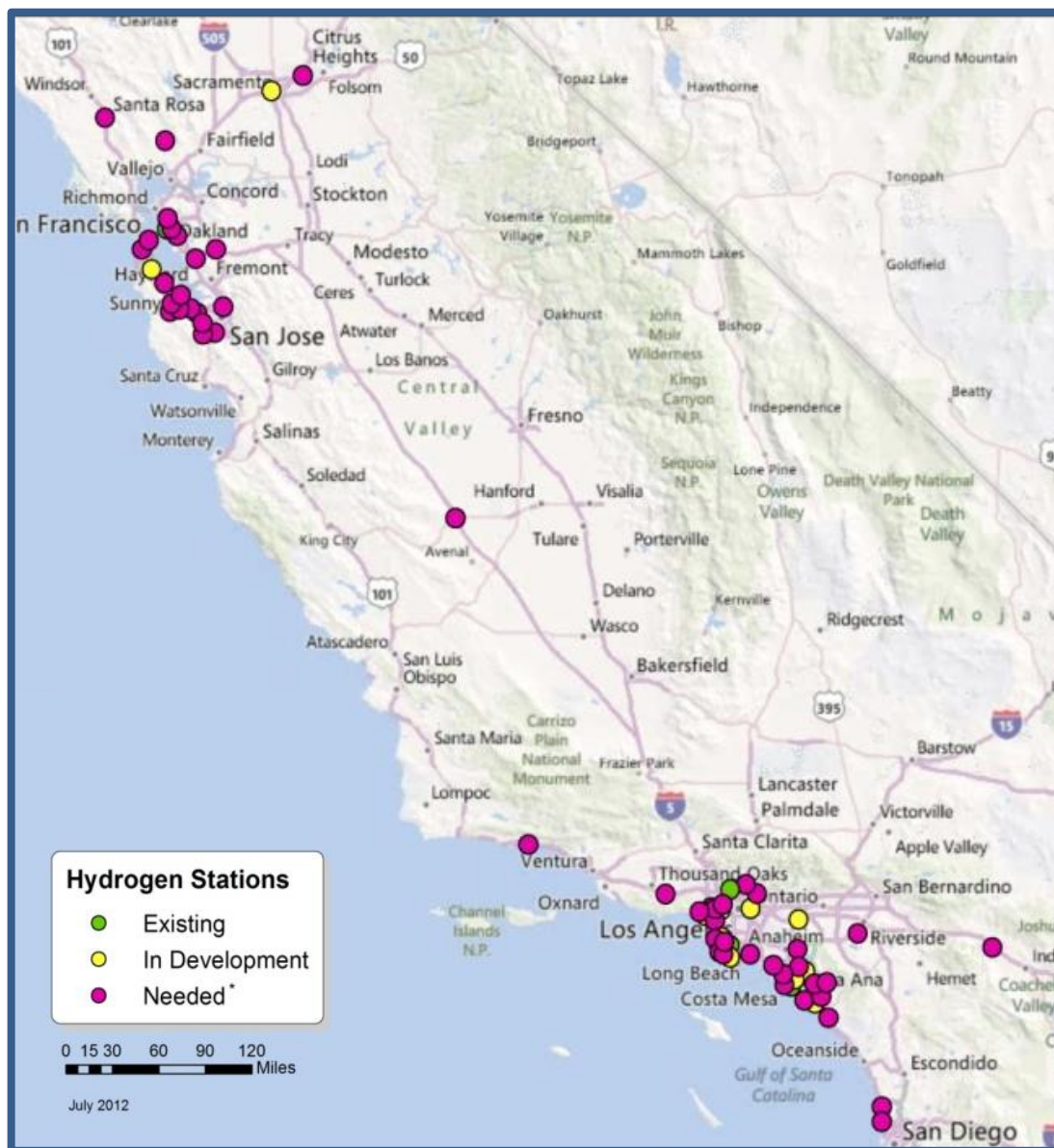
Element Markets  
 FASTECH  
 FirstElement Fuel, Inc.  
 Hexagon  
 Institute of Transportation Studies, UC Davis  
 Ivys Energy Solutions  
 Kobelco  
 Liberty Utilities  
 Linde North America, Inc.  
 Look, Inc.  
 National Fuel Cell Research Center, UC Irvine  
 National Renewable Energy Laboratory (*NREL*)  
 Nel Hydrogen  
 New Flyer of America

NICE America Research, Inc.  
 Nikkiso Clean Energy  
 PDC Machines  
 Plug Power  
 Sandia National Laboratories  
 Shasta Regional Transportation Agency  
 Sirius XM  
 SPI, ESI, and North America Smart Energy Week  
 SunLine Transit Agency  
 Tatsuno North America, Inc.  
 TLM Petro Labor Force, Inc.  
 University of California, Berkeley  
 WEH Technologies  
 Woodside Energy

— 20+ years of collaboration —



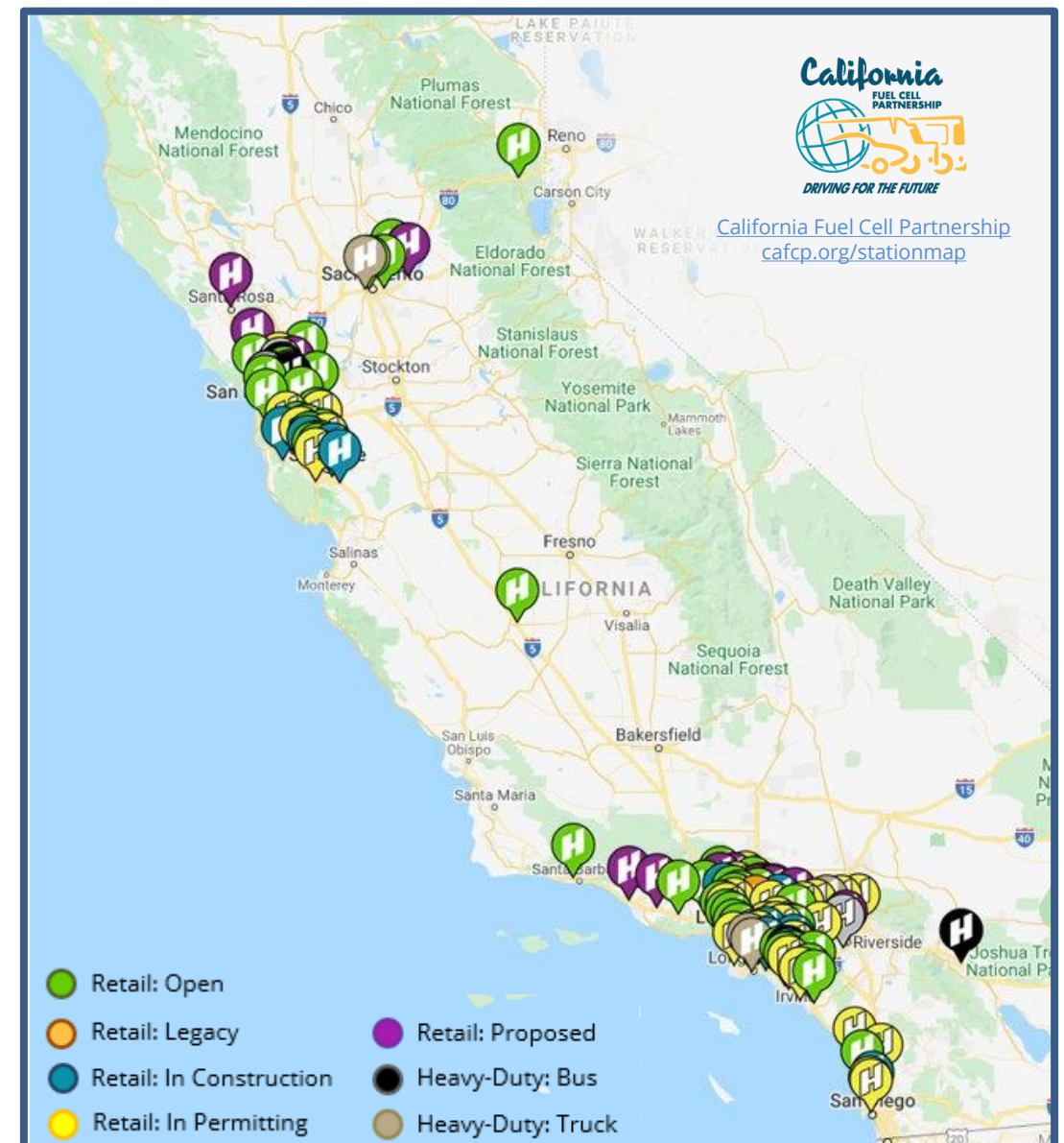
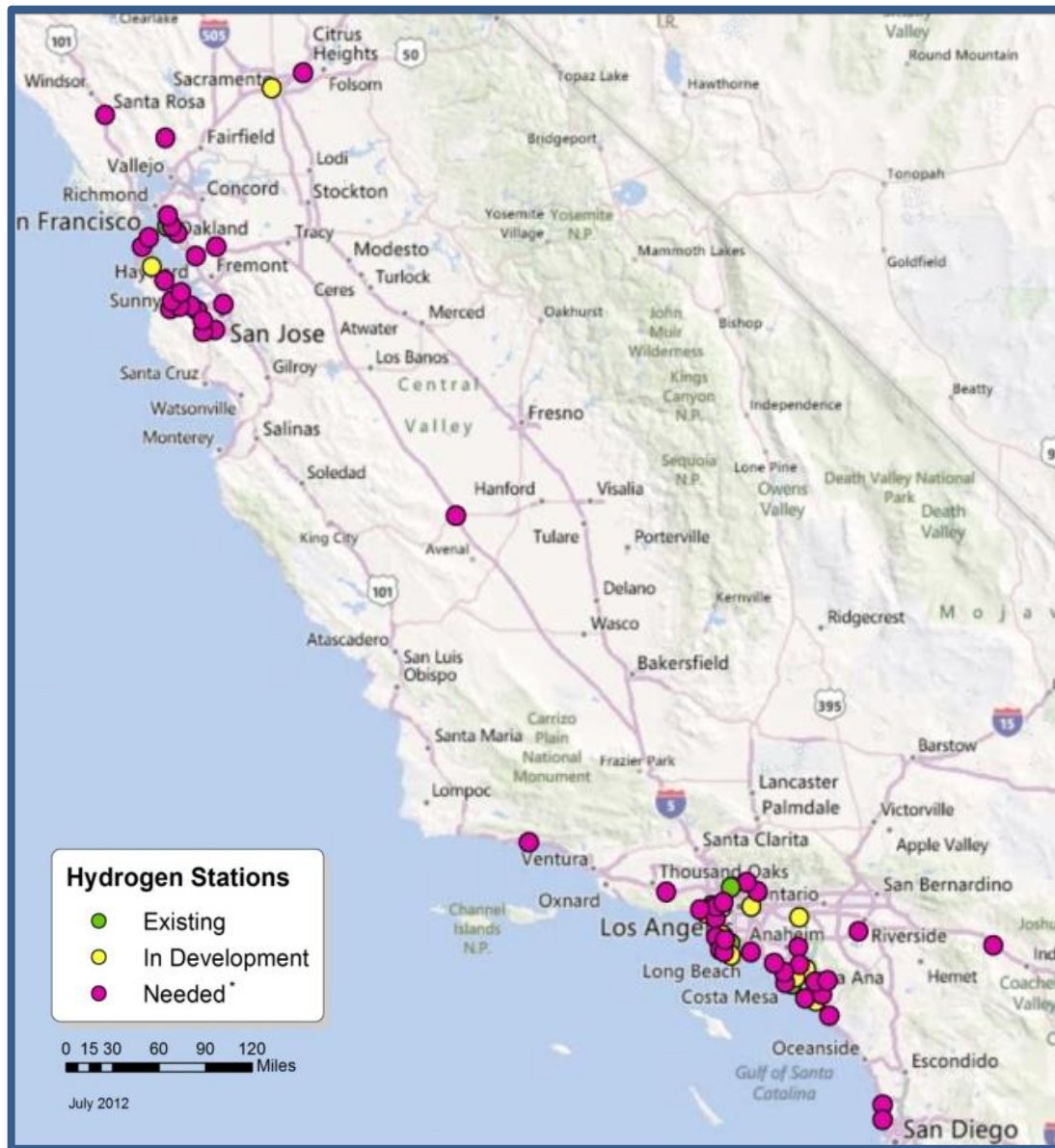
# 2012 Market Launch Image – *California Roadmap*



- 68-100 stations to enable market launch
  - Supports convenient fueling in early markets
  - Enables travel throughout early market regions & state
- Accelerate station implementation
- Promote hydrogen readiness
- Focus on public consumer fueling
- Potential model for other regions



# 2012 Market Launch Image – 2022 Market Progress







# Retail Vehicles & Stations – 2022 Market Progress

Numbers as of May 31, 2022	Total
<b>FCEVs—fuel cell cars sold and leased in US</b>	<b>13,806</b>
<b>Hydrogen stations available in California**</b>	<b>56</b>
Retail hydrogen stations in <i>construction</i> in California	9
Retail hydrogen stations in <i>permitting</i> in California	28
Retail hydrogen stations in <i>proposed</i> in California	11
Retail hydrogen stations <i>funded</i> , but not in development in CA	70
<b>Total retail hydrogen stations in development in California</b>	<b>118</b>
<b>FCEBs—fuel cell buses in operation in California</b>	<b>66</b>
Fuel cell buses in development in California	76
<b>FCETs—fuel cell trucks in development in California</b>	<b>45+</b>
Retail truck hydrogen stations in development/open in CA	3/9

[https://cafcp.org/by\\_the\\_numbers](https://cafcp.org/by_the_numbers)





# Envisioning the Transition: *CA Fuel Cell Revolution*

**100**  **BY 2020**

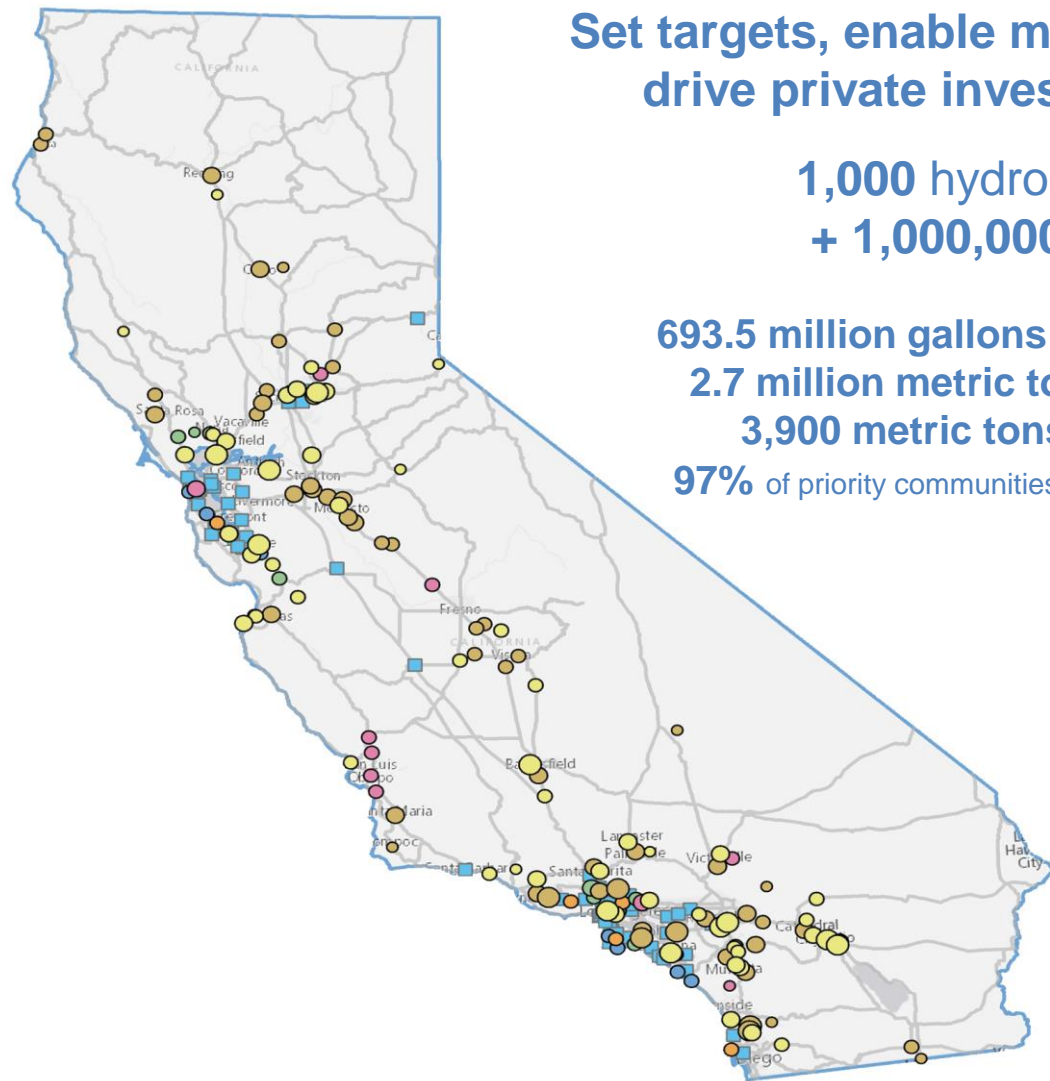
hydrogen stations by **2020**.  
Funded by Assembly Bill 8 (2013).

**200**  **BY 2025**

hydrogen stations by **2025**,  
pursuant to the Governor's 2018  
ZEV infrastructure Proposal.

**1000**  **BY 2030**

hydrogen stations by **2030** with favorable  
market conditions and state policies pursuant  
to the CAFCP 2030 vision. Will support  
1,000,000 fuel cell electric vehicles.



Set targets, enable market conditions, and  
drive private investment to support:

**1,000** hydrogen stations  
**+ 1,000,000** vehicles =

- 693.5 million gallons** per year of gasoline displaced
- 2.7 million metric tons** per year GHG avoided
- 3,900 metric tons** per year NOx avoided
- 97%** of priority communities within the network coverage



# Market Transformation Focus

- **3-8x Increase in Station Capacity**
  - 2016: ~180-400 kg/day
  - 2020: ~1,200-1,600 kg/day
  - Largest stations fill 4 cars simultaneously
- **Station Cost**
  - 40% decrease in station costs
  - 80% decrease in \$/kg/day
- **60% Reduction in Cost per Vehicle Enabled**
  - 2016: \$6K per vehicle
  - 2020: \$2.4K per vehicle
- **Cost Share**
  - 2016: state put up 70% of the capital cost
  - 2020: industry is bringing ~70% capital cost
- **20%-300% Increase in Renewable Content**
  - Overall network dispensing over 90% renewable hydrogen
- **Low Carbon Fuel Standard**
  - Hydrogen Refueling Infrastructure credits (HRI)





# Achieving the Transition: *CA Self-sufficiency Study*

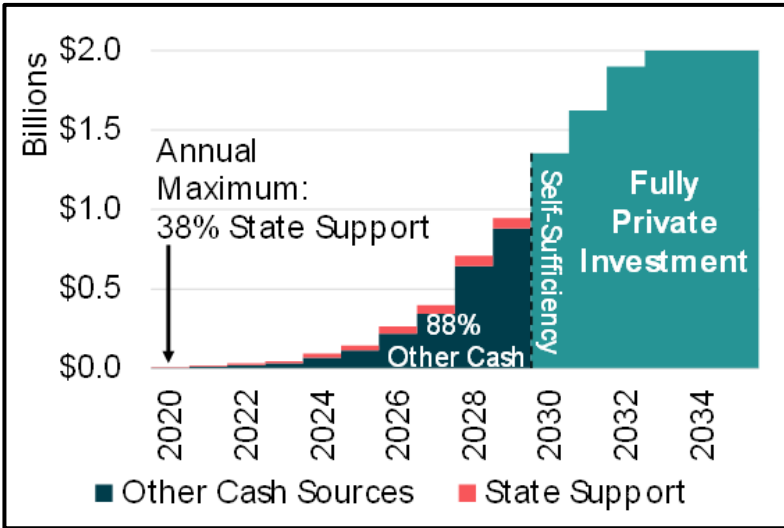
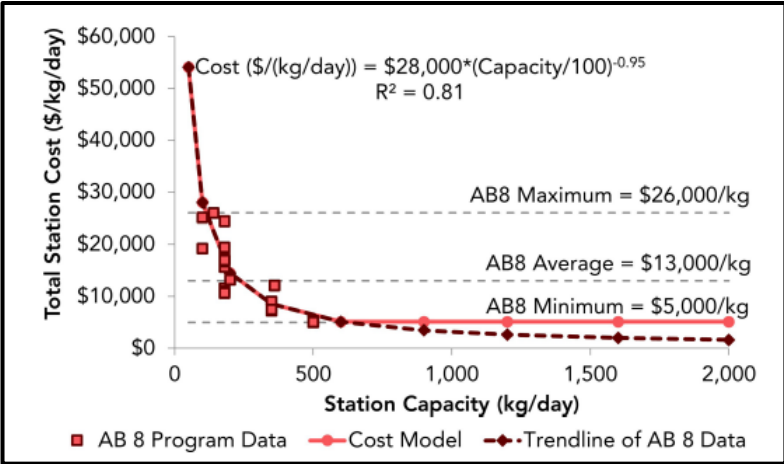
Self-Sufficiency Achieved by:

2030

With State Support up to:

300M

- Self-sufficiency is possible with State support
- Industry supports the majority of network growth
- California’s network growth rate drives its own economies of scale
- Stations and FCEV deployments need to grow together to gain full benefit
- State support offers benefits to the consumer and may be sufficient to accelerate reductions in price at the pump





# Envisioning the Transition: *Fuel Cell Truck Vision*

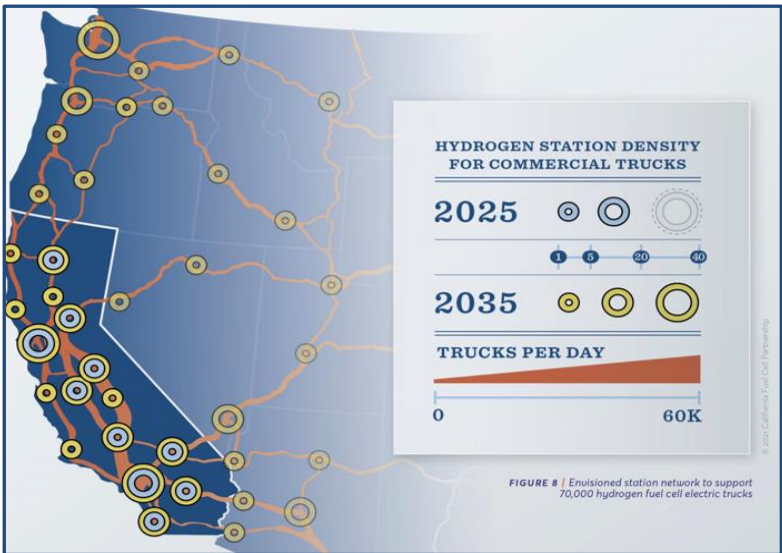
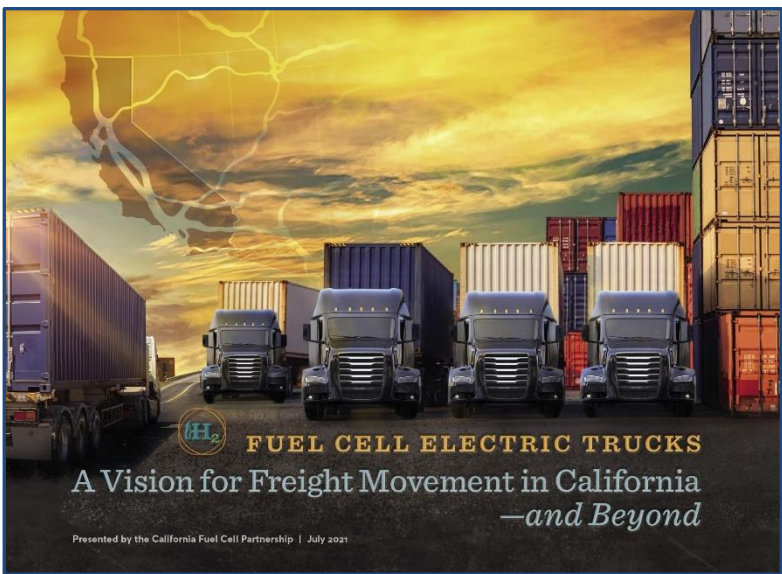


FIGURE 8 | Envisioned station network to support 70,000 hydrogen fuel cell electric trucks



## —Fuel Cell Electric Truck Vision—

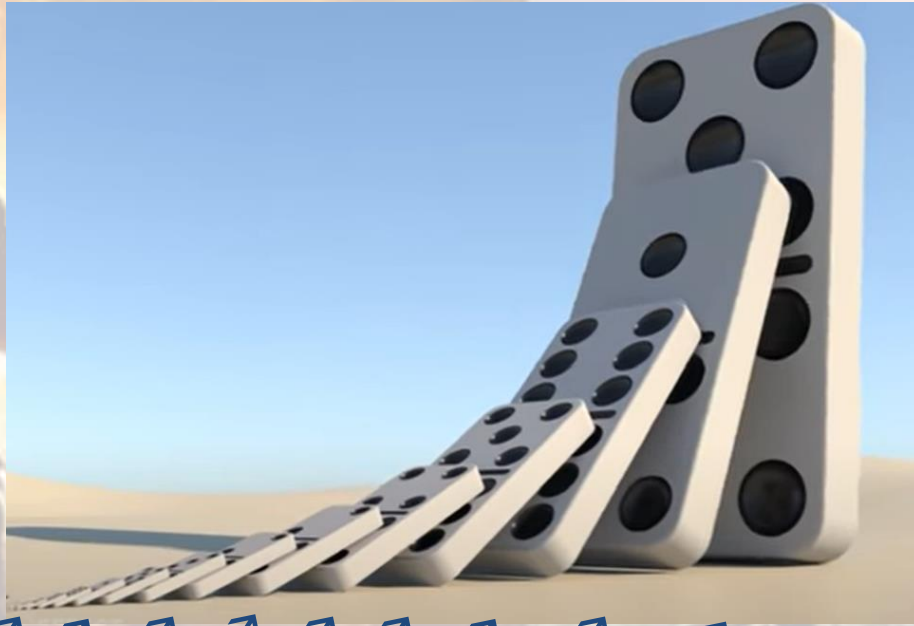
*Enable market conditions to support:*

**200** hydrogen stations  
**+ 70,000** trucks =

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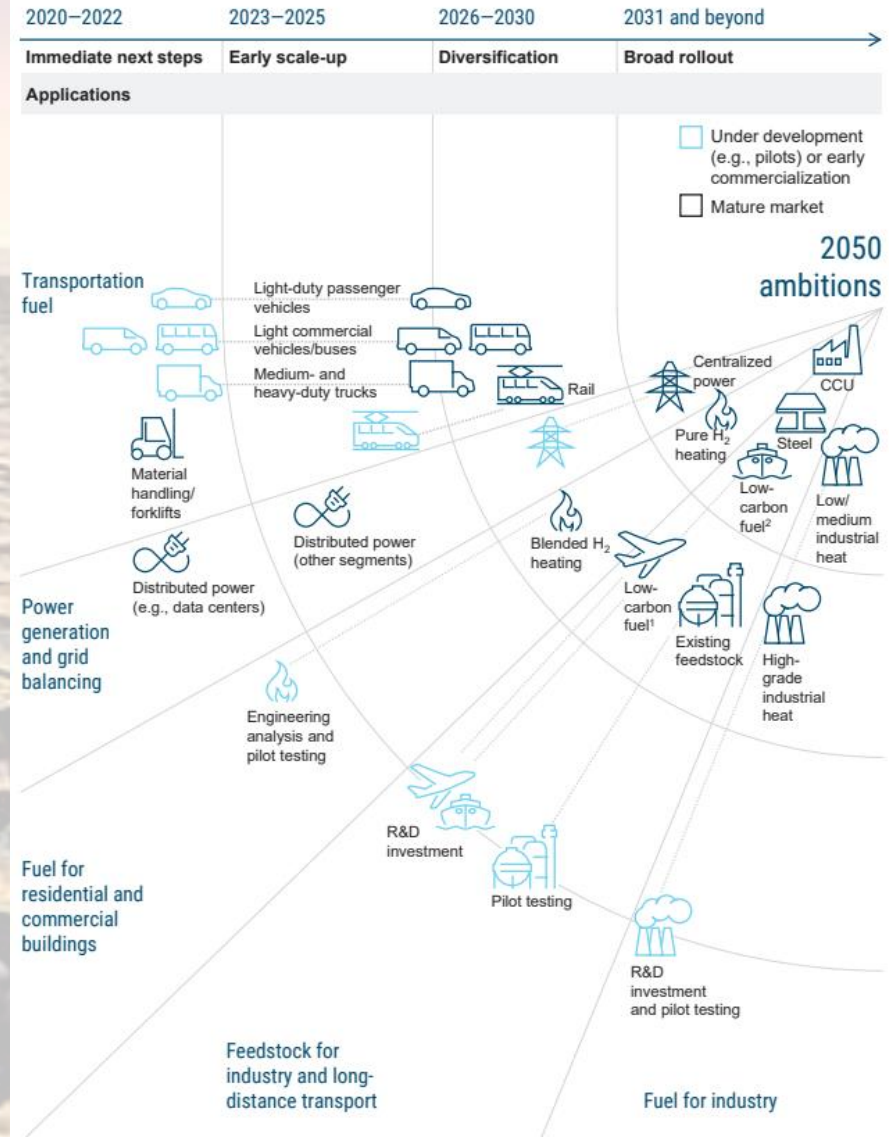
**541.8 million gallons** per year of diesel displaced  
**6.7 million metric tons** per year GHG avoided  
**18,100 metric tons** per year NOx avoided

# Hydrogen has a Significant Role in Global Decarbonization... and California's FCEV Market Can Accelerate the H2 Economy



Forklifts →  
 Light Duty Cars →  
 Transit Buses →  
 M-HD Trucks →  
 Rail →  
 Aviation →  
 Maritime →  
 Industrial Heat →  
 Steel & Manuf →

Hydrogen applications road map





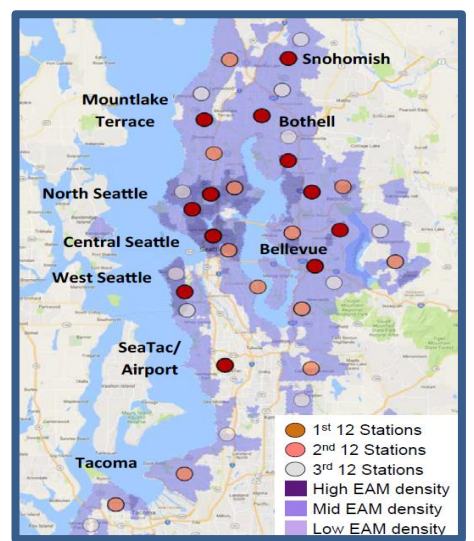
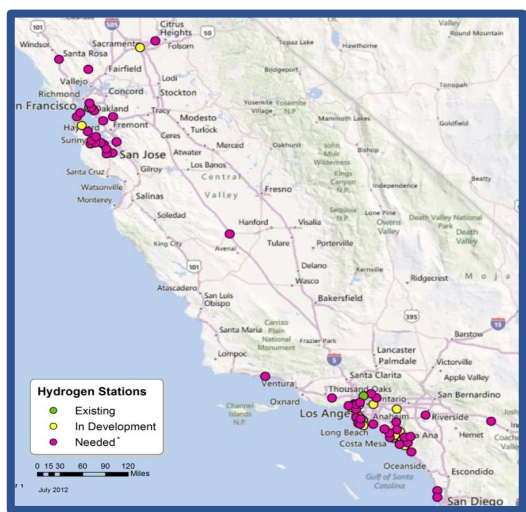
# Lessons Learned

- Global hydrogen and fuel cell markets have launched
- Three key California lessons;
  - Leadership is crucial
  - Shared vision and plans are fundamental
  - Policy & investment commitments move markets
- Partnership between government and industry
- Hydrogen enables greater renewable penetration, energy resiliency & transition
- Build a house you can grow into
- Scale and private market opportunities are the key to a sustainable market
- All ZEVs will be needed!

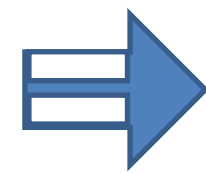
It is not a question of “**IF**”, rather “**WHERE FIRST**” and “**HOW FAST**”



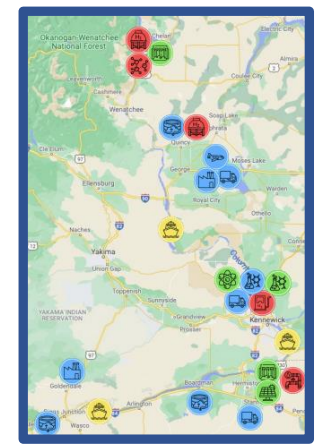
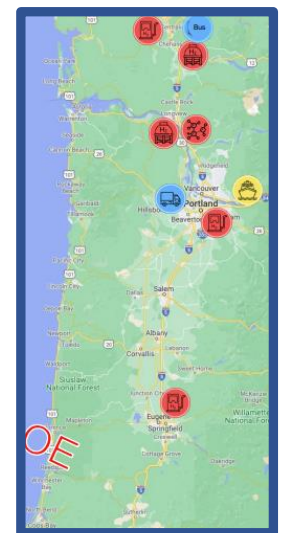
# Turning Visions & Leadership into ZEV Realities



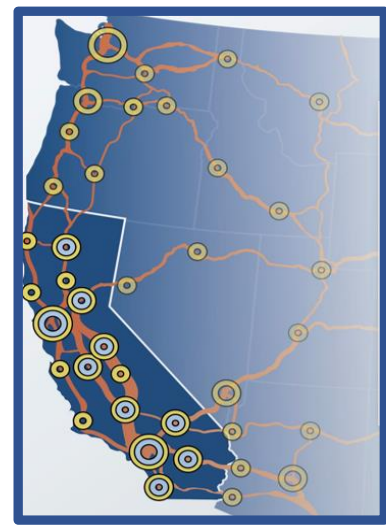
HTEC



National Renewable Energy Laboratory



NW Hydrogen Hub-CH<sub>2</sub>ARGE



Hydrogen-  
West Coast Electric Highway



Bill Elrick  
linkedin.com/in/bill-Elrick  
[info@cafcp.org](mailto:info@cafcp.org)  
[cafcp.org](http://cafcp.org)

***Thank you!***





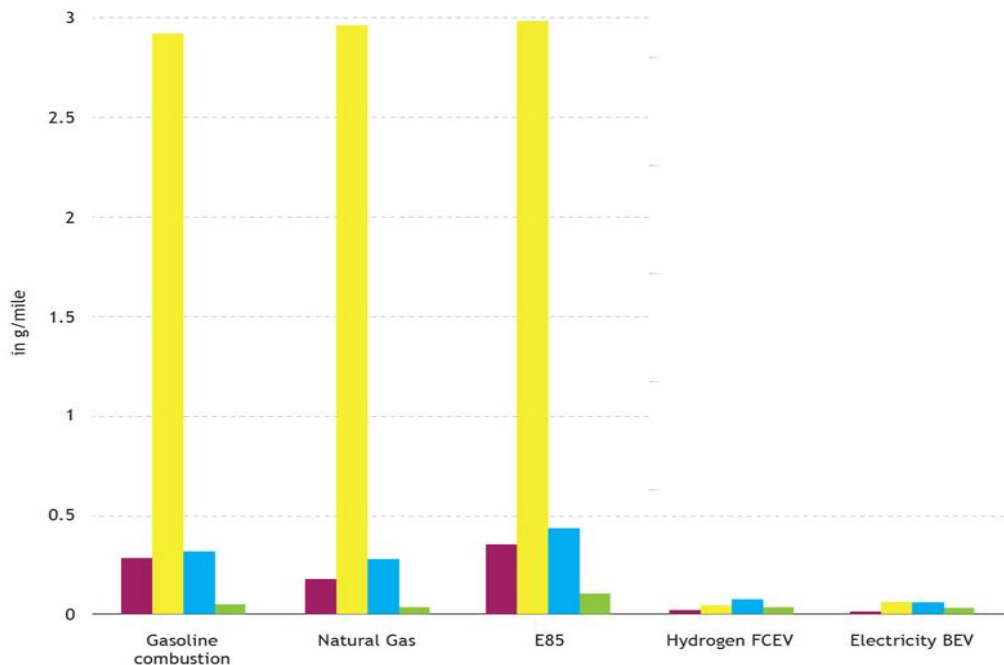
# Backup Slides



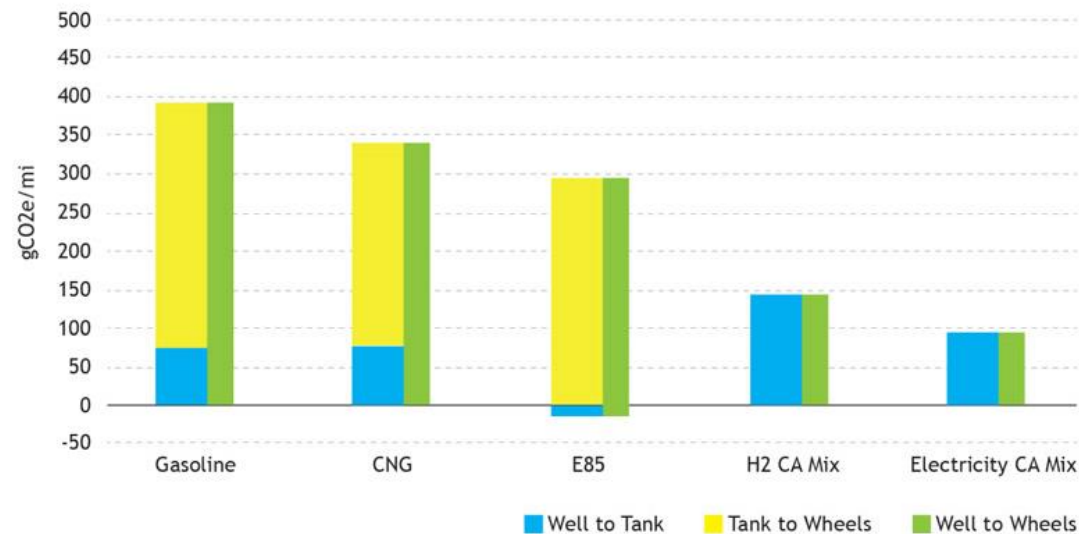
# Hydrogen - the Swiss Army Knife of Energy

- Highest renewable requirement of any motor fuel in California – 33% to 40%
- Use in transportation, stationary power, mobile applications and more
- Enables greater renewable penetration

## Air Pollution



## Greenhouse Gases



- Excellent energy carrier
- Nonpolluting and non-toxic
- Multiple feedstock options
- Reduces GHGs & Pollutants by 50-100%
- Economically competitive
- As safe as gasoline



# Hydrogen fuel cell electric cars – the “other EV”



312-400 miles



3-to-5 minute fill



Makes electricity on board vehicle



Extreme temperature performance



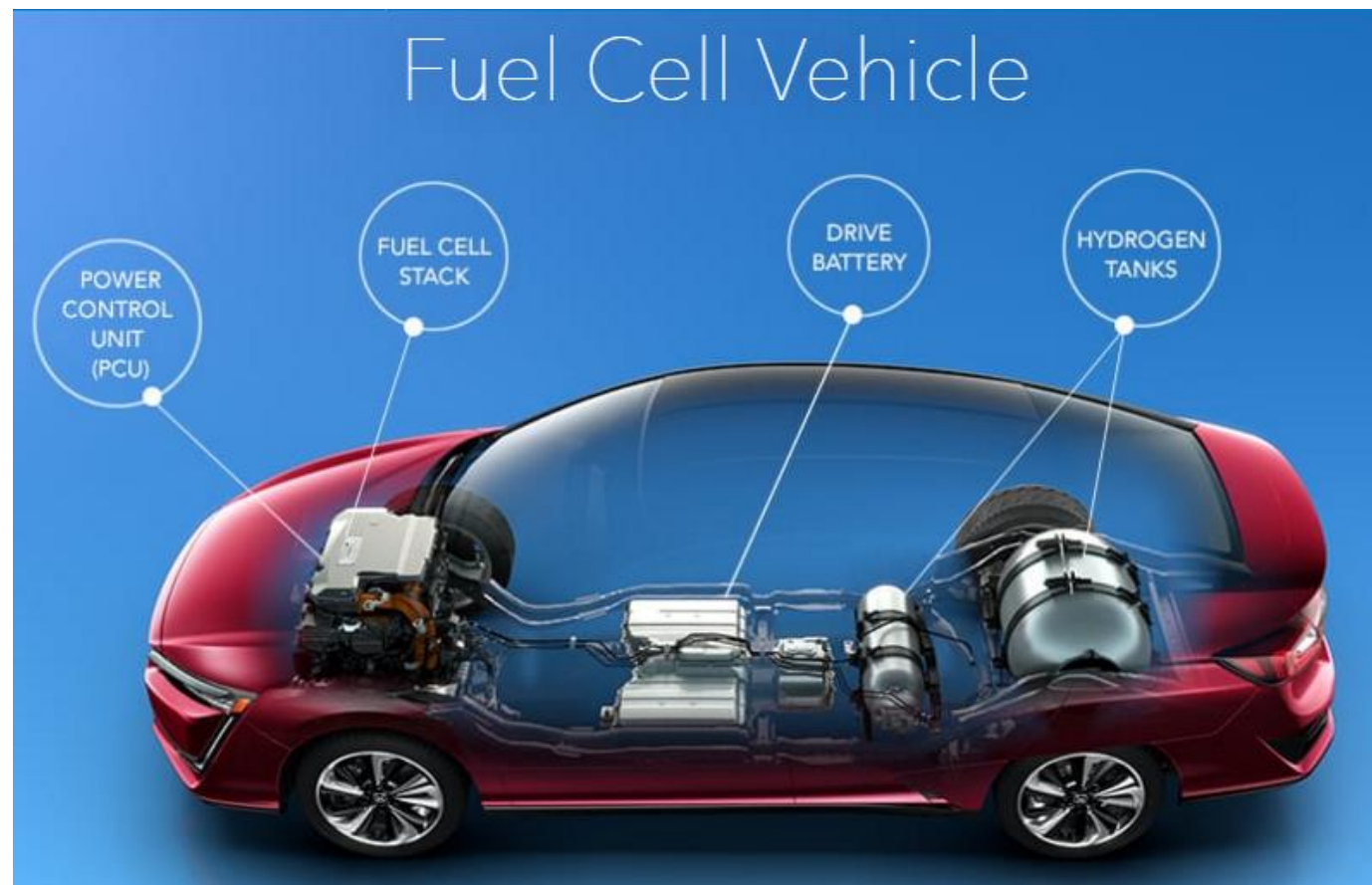
Multi-unit dwellers and on-street parkers



Meet all global safety specifications



Most automakers have fuel cell tech





# Hydrogen Fuel Cell Vehicles – Light-Duty



Honda Clarity



Hyundai NEXO



Toyota Mirai



Toyota Mirai



BMW

Hopium



Hyperion

Hyundai



Riversimple

Stellantis





# Hydrogen Fuel Cell Vehicles – Transit Buses

## California Transit Agencies with fuel cell electric buses on the road and in the pipeline

1. AC Transit (East Bay)
2. Eastern Contra Costa Transit Authority (East Bay)
3. Fresno Area Express
4. Golden Empire Transit (Bakersfield)
5. Montebello Transit\*
6. North County Transit (San Diego)
7. OCTA (Orange County)
8. Riverside Transit Agency
9. SunLine Transit (Coachella Valley)
10. UC Irvine

\*recently noted in a legislative hearing that they are pursuing fuel buses



## Zero Emission Transit Bus Technology Analysis



REPORT PERIOD : JULY 2020 – DECEMBER 2020

## AC Transit 5x5 Study

Five technologies evaluated

1. Fuel cell (legacy)
2. Fuel cell (new buses)
3. Battery electric
4. Hybrid diesel
5. Conventional diesel



# Hydrogen Fuel Cell Vehicles – Trucks & more



- Cellcentric
- Cummins
- Daimler Truck North America
- Hino
- Hyundai
- Hyzon
- Kenworth
- Nikola

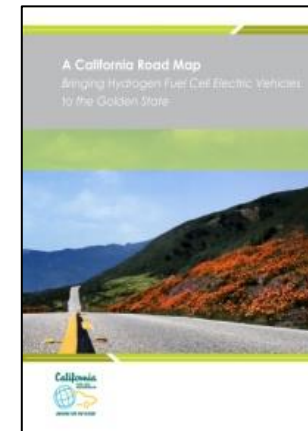
Many more HD FCVs...



# 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](http://www.cafcp.org/roadmap)

**A CALIFORNIA ROAD MAP**  
Bringing Hydrogen Fuel Cell Electric Vehicles to the Golden State

**COMMERCIAL LAUNCH OF FCEVS**  
EXPECTED AROUND 2015

Zero-emissions → 250-400 mile range  
Minutes to refuel  
Domestically produced hydrogen

**THE NETWORK:**  
CLUSTERS  
CONNECTORS  
DESTINATIONS

*“Consumers need CONFIDENCE in a hydrogen fueling network”*  
Initial station deployments will focus on geographic clusters in key markets with additional stations connecting these clusters into a regional network.

**68 STATIONS**  
NEEDED TO LAUNCH THE EARLY FCEV MARKET

**\$65 MILLION**  
IN ADDITIONAL FUNDING NEEDED!

Download A California Road Map at [www.cafcp.org/roadmap](http://www.cafcp.org/roadmap)

The California Fuel Cell Partnership is a collaboration of organizations that work together to promote the commercialization of hydrogen fuel cell electric vehicles.

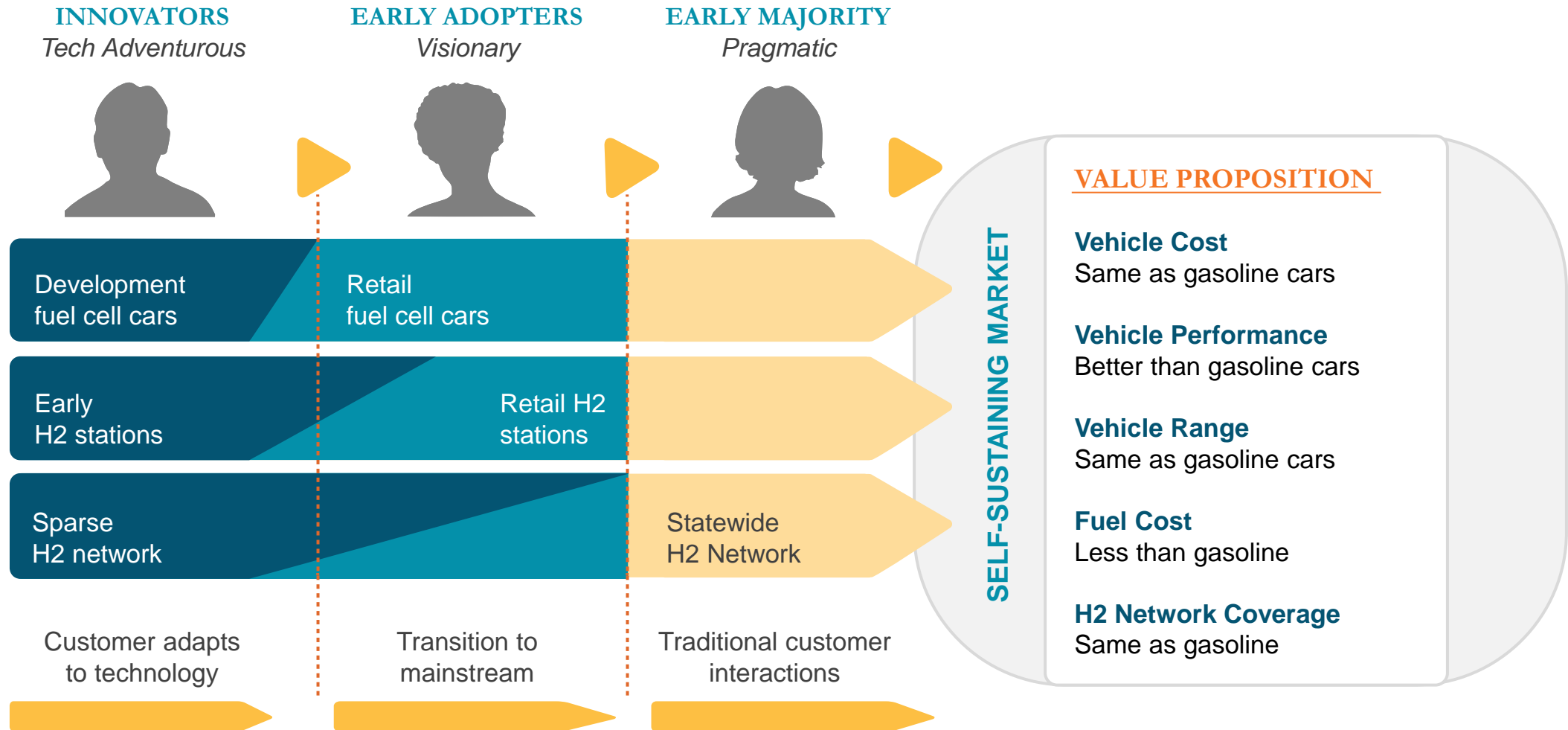
By working together, we help ensure that vehicles, stations, regulations and people are in step with each other as the technology comes to market.

[www.cafcp.org](http://www.cafcp.org)





# Envisioning the Transition: *Customer Adoption is Key*





# Strategies for reaching market success





## CaFCP 2030 Vision Target

**Consumer Demand Exceeds 1,000 H2 Stations and 1,000,000 Fuel Cell Vehicles by 2030**

### Strategic Pathways

#### Enable the Market

Foster large-scale infrastructure development

#### Objectives

- Leverage market-based policy to attract private capital
- Activate economies of scale for large-scale infrastructure development

➤ **Enable H<sub>2</sub> & FCV Sales**

#### Establish the Market

Improve customer value proposition for H2 and FCV

#### Objectives

- Motivate consumers to buy fuel cell vehicles
- Establish a statewide hydrogen fueling network
- Develop a dedicated hydrogen supply

➤ **Better Than Gasoline**

#### Expand the Market

Amplify innovations in fuel cell technologies

#### Objectives

- Diversify the portfolio of fuel cell products
- Deploy heavy-duty hydrogen infrastructure in California's freight corridors
- Connect hydrogen and electricity as energy carriers

➤ **Ubiquity**

**Build Self-Sustaining Market**



## —California Fuel Cell Revolution—

*Enable market conditions to support:*

**1,000** hydrogen stations  
**+ 1,000,000** vehicles =

---

**693.5 million gallons** per year of gasoline displaced

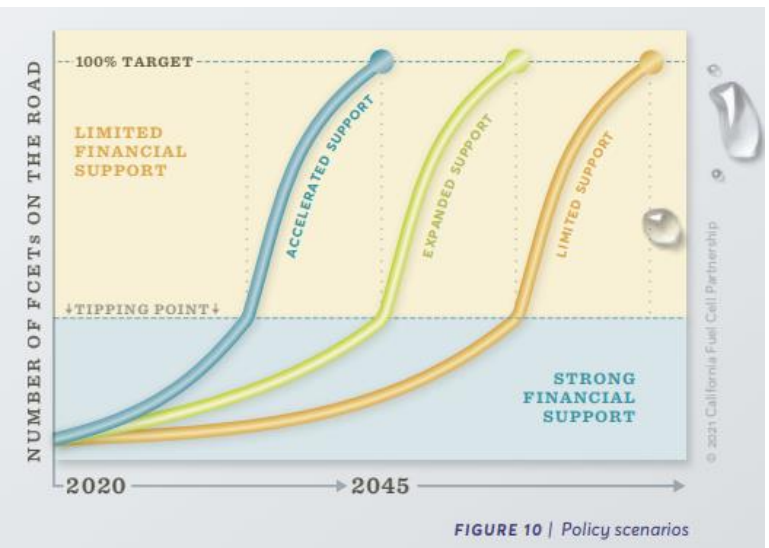
**2.7 million metric tons** per year GHG avoided

**3,900 metric tons** per year NOx avoided

**97%** of disadvantaged communities within the station network coverage



# Envisioning the Transition: *Fuel Cell Truck Vision*



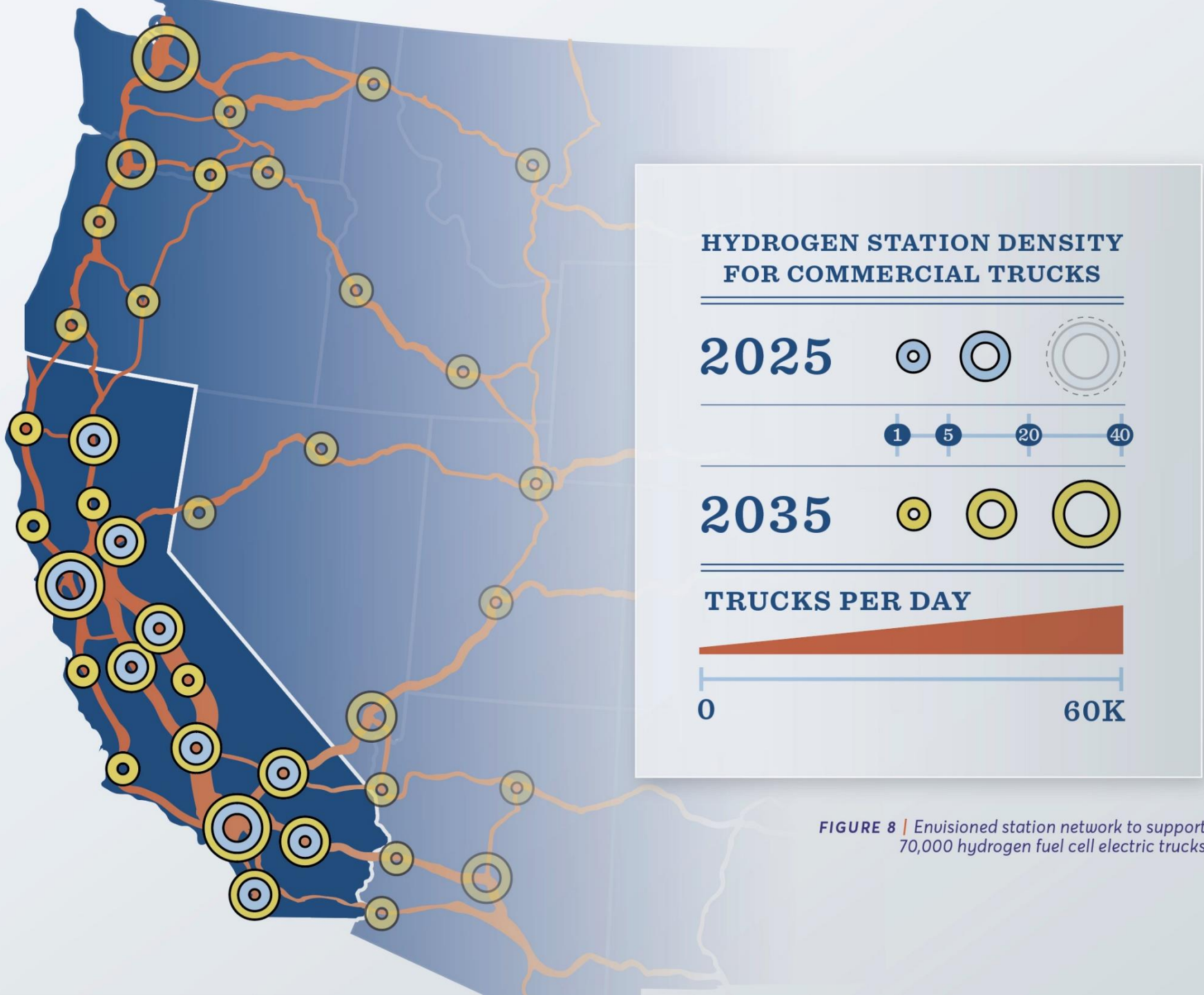


FIGURE 8 | Envisioned station network to support 70,000 hydrogen fuel cell electric trucks

© 2021 California Fuel Cell Partnership

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Present



## —Fuel Cell Electric Truck Vision—

*Enable market conditions to support:*

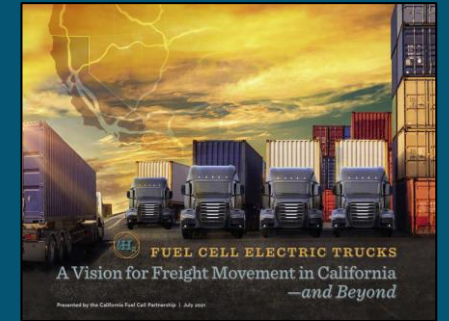
**200** hydrogen stations  
**+ 70,000** trucks =

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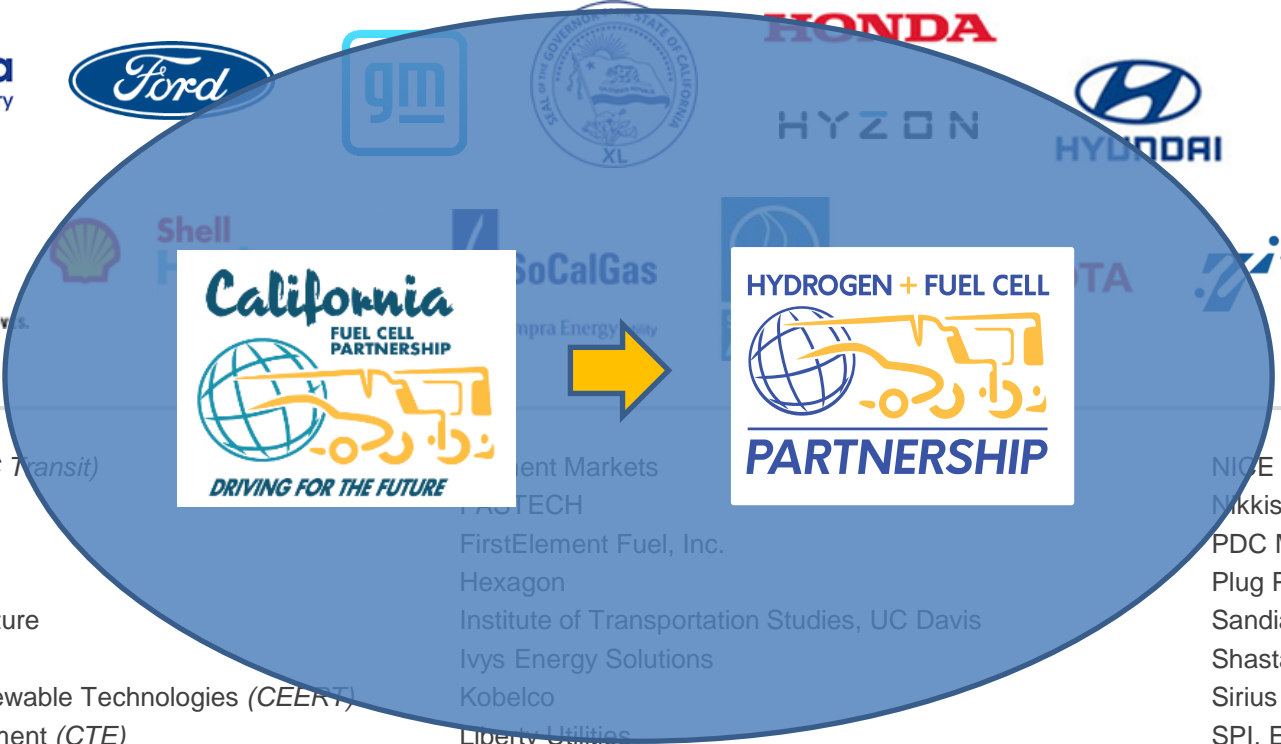
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FirstElement Fuel, Inc.  
 Hexagon  
 Institute of Transportation Studies, UC Davis  
 Ivys Energy Solutions  
 Kobelco  
 Liberty Utilities  
 Linde North America, Inc.  
 Look, Inc.  
 National Fuel Cell Research Center, UC Irvine  
 National Renewable Energy Laboratory (NREL)  
 Nel Hydrogen  
 New Flyer of America

NICE America Research, Inc.  
 Nikkiso Clean Energy  
 PDC Machines  
 Plug Power  
 Sandia National Laboratories  
 Shasta Regional Transportation Agency  
 Sirius XM  
 SPI, ESI, and North America Smart Energy Week  
 SunLine Transit Agency  
 Tatsuno North America, Inc.  
 TLM Petro Labor Force, Inc.  
 University of California, Berkeley  
 WEH Technologies  
 Woodside Energy

— 20+ years of collaboration —





# CaFCP – Advancing the Market in Multiple Ways

## Planning & Roadmaps

- Assess progress
- Identify market challenges
- Consensus outputs



## Targeted Outreach

- Engage in events & meetings
- ER/permitting training
- Legislative, NGO, local leaders
- Stakeholder group support



## Data and information needs

- SOSS and station map
- Lead stakeholder workgroups
- Information clearinghouse for public and private stakeholders



## M/HD and FCEB

- Build participation & consensus
- Participate in and lead meetings
- Develop Action Plans & Roadmaps

## Station implementation

- Participate in code & standards meetings
- Objective inputs



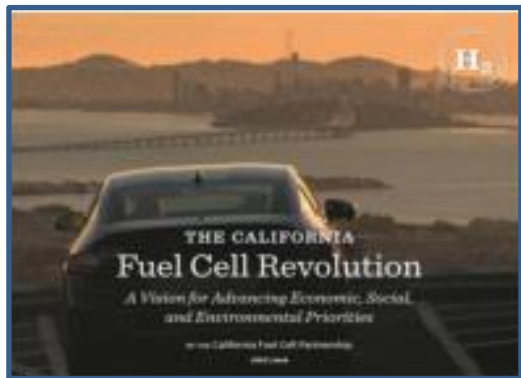
## Public Awareness

- Website and social media
- Outreach materials
- Host major events





# Success via Vision, Leadership and Engagement



100

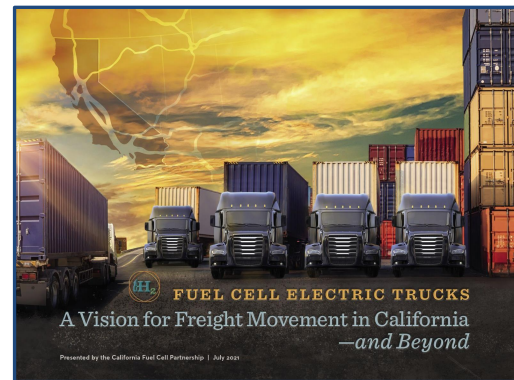
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## —Fuel Cell Electric Truck Vision—

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