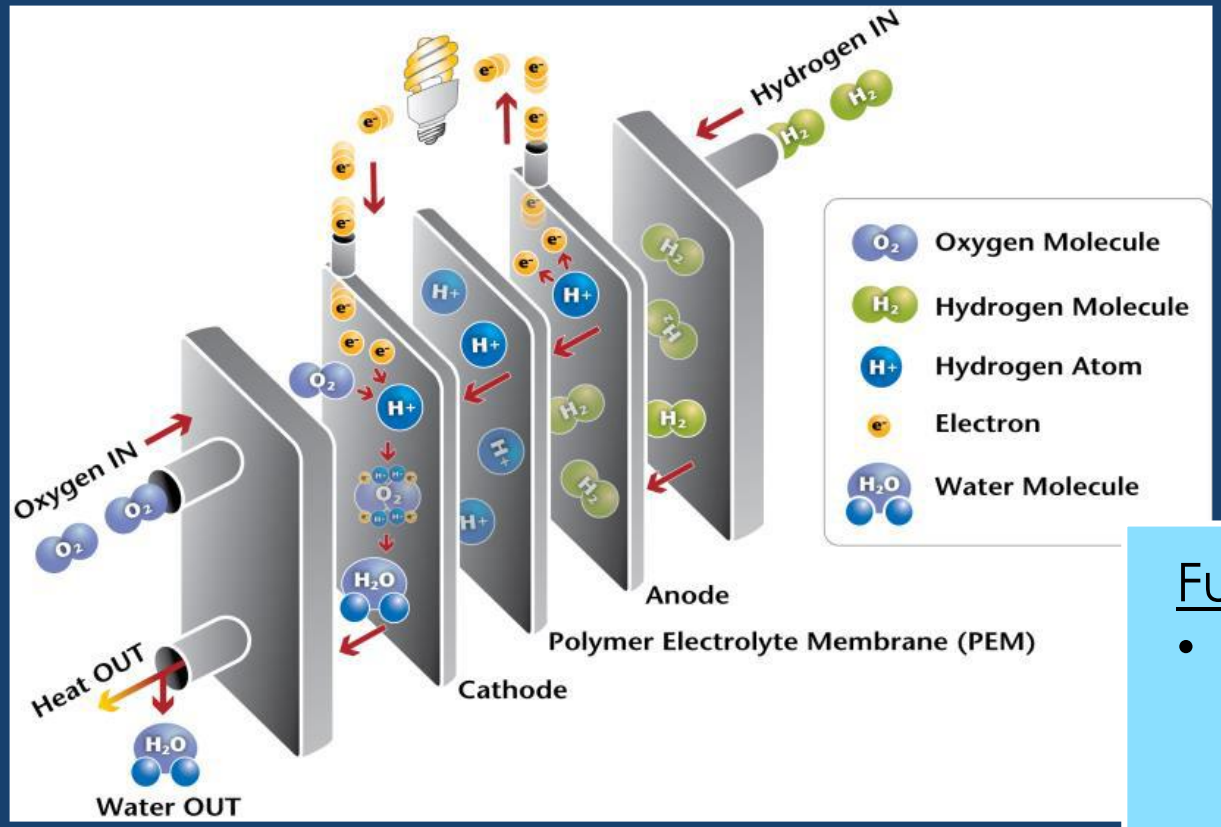
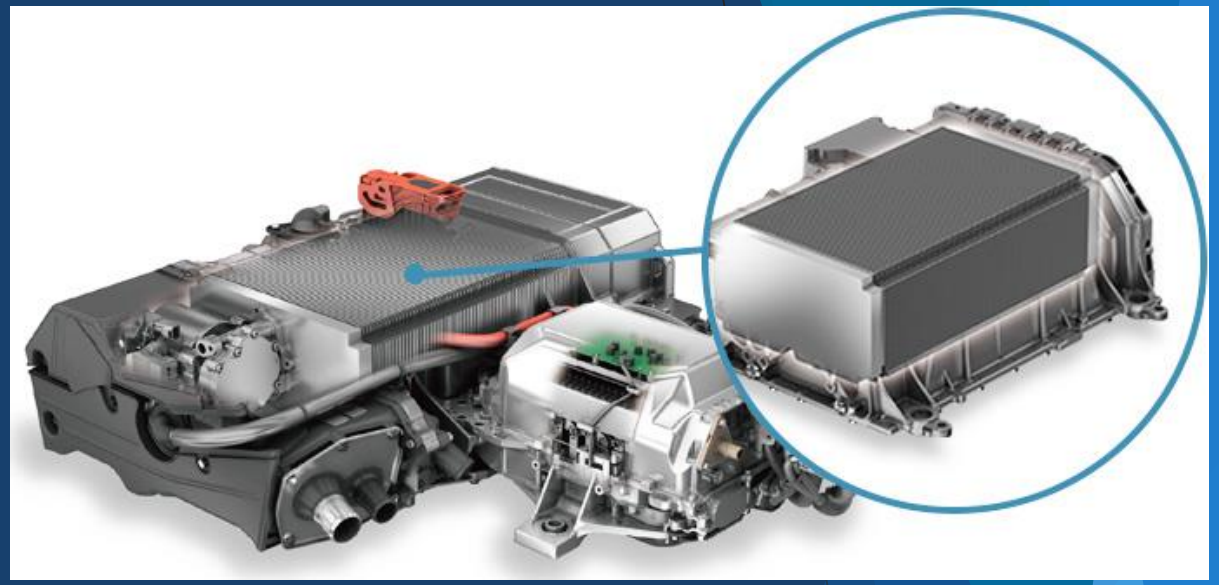
Hydrogen Fuel Cell Electric Vehicle Station Development

CALIFORNIA GOVERNOR'S OFFICE OF BUSINESS AND ECONOMIC DEVELOPMENT

- March 10th, 2019 -

Introduction to Fuel Cells





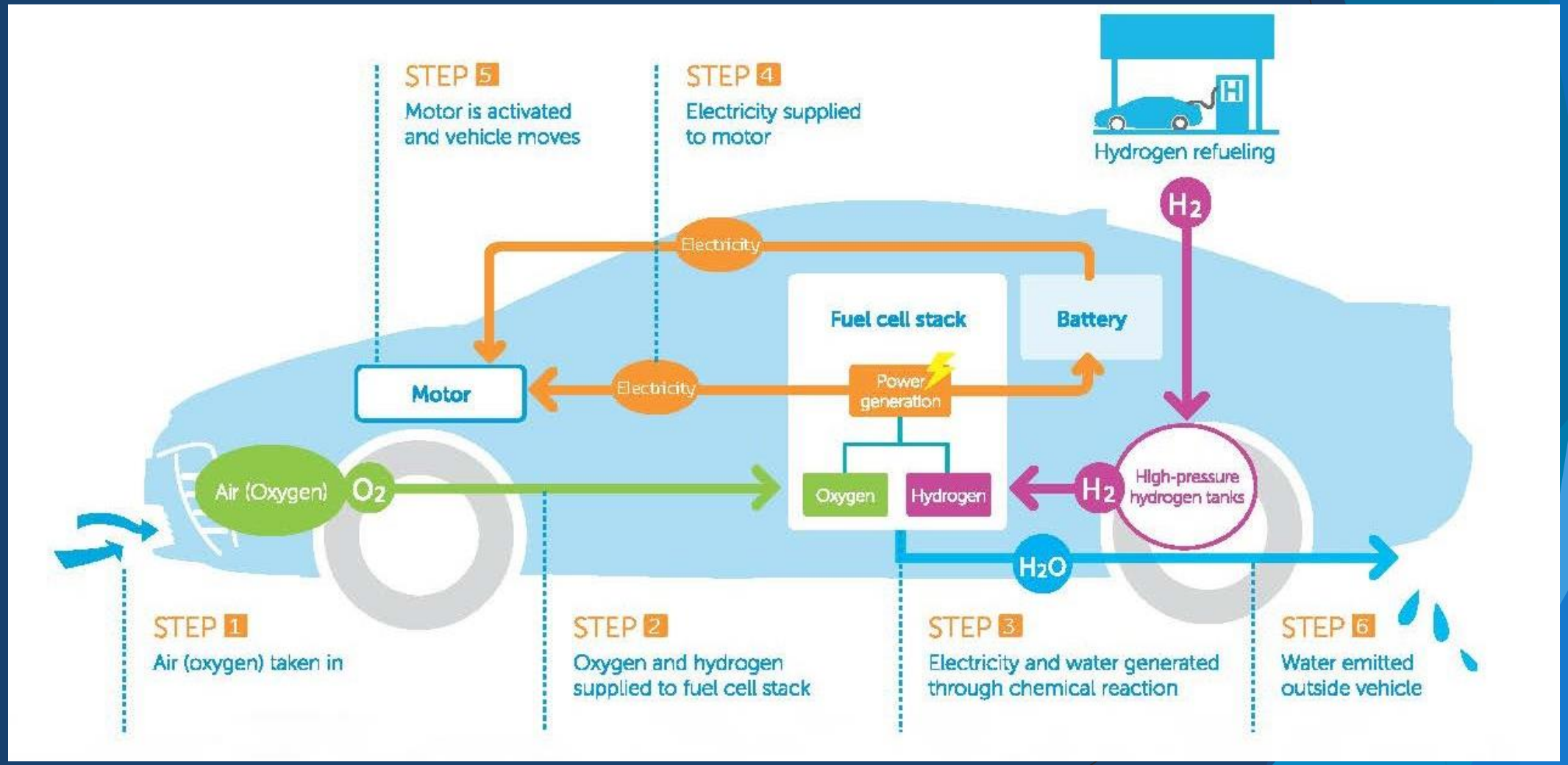
Fuel Cell

- Produces electric power through electrochemical reaction of hydrogen and oxygen

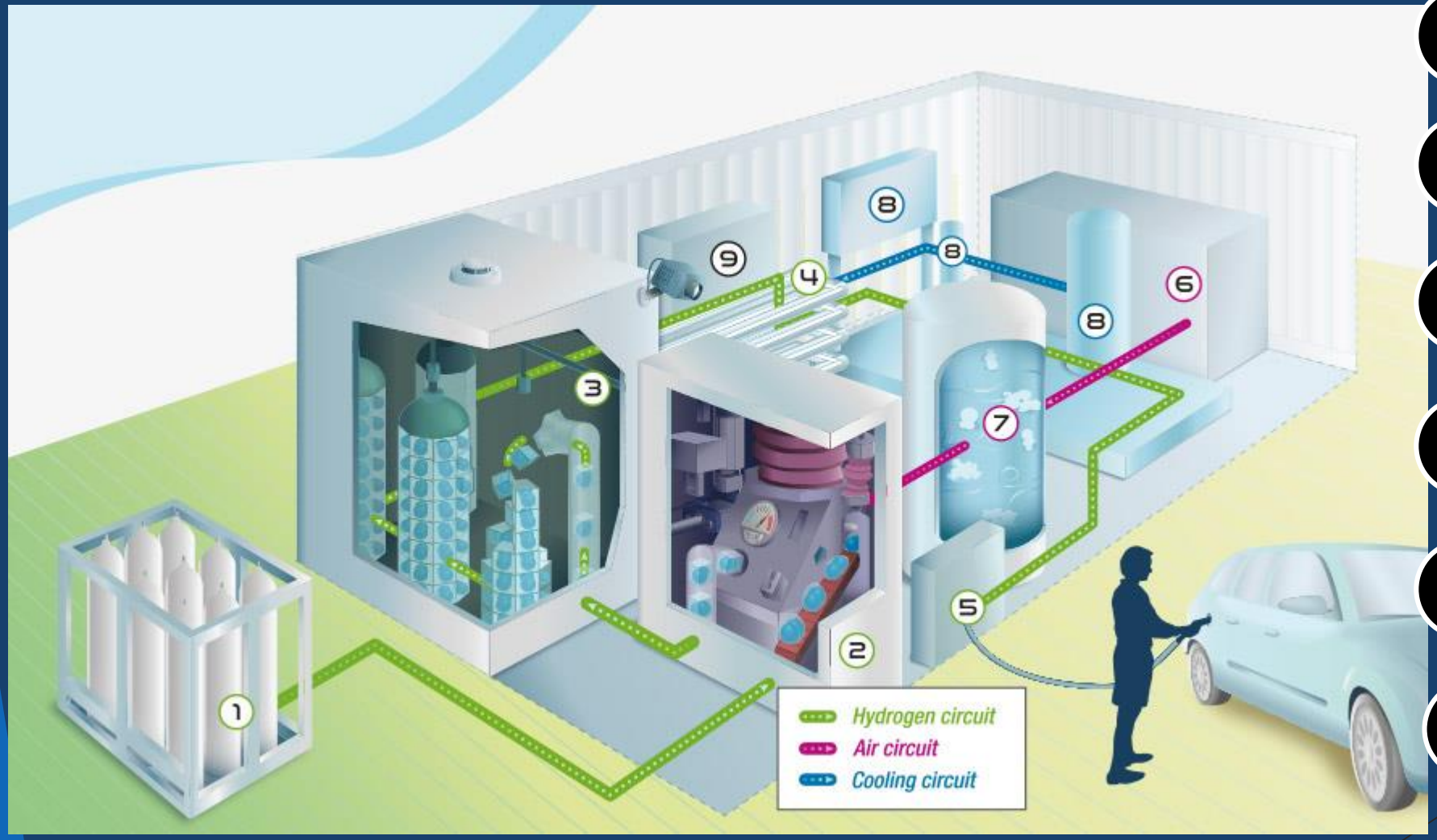
Fuel Cell Stack + Hydrogen Supply

- Replaces the battery in electric drive systems

How Fuel Cell Electric Vehicles Work



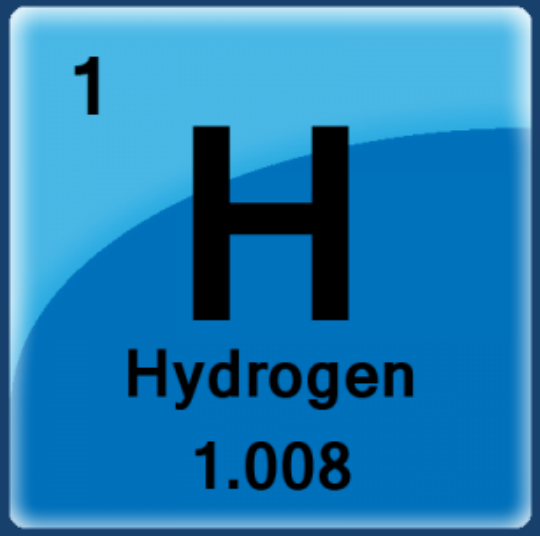
Hydrogen Fueling Station – Behind the Wall



1. H2 Supply
2. Compression
3. H2 Storage
4. Temp Control
5. Dispensing
6. - 9. Auxiliary Equipment

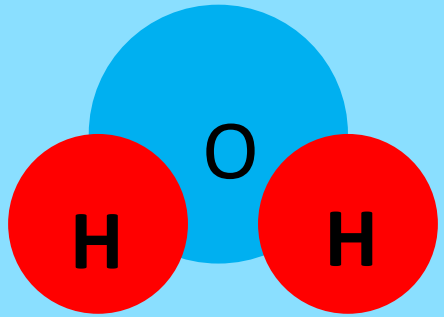
Fuel Cells – Used in Many Applications Today

Introduction to Hydrogen



Hydrogen is:

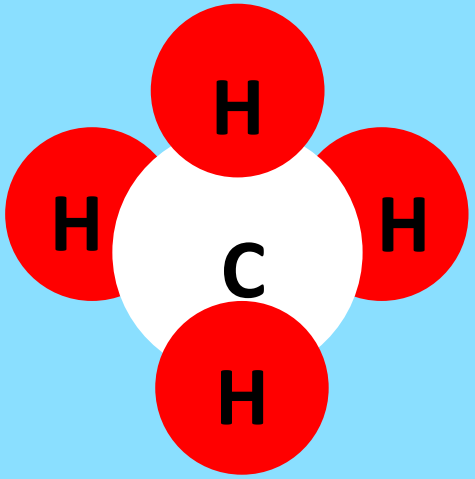
- Odorless, colorless, and tasteless
- Non-toxic and non-poisonous
- Lighter than other fuels
- Flames have low radiant heat
- Wide flammability range
- Low risk of asphyxiation



Hydrogen from Water

Electrolysis

Uses electricity to split the molecule



Hydrogen from Natural Gas

Reforming

Uses heat + catalytic reaction to split the molecule

Hydrogen – the Pathway to Renewable

The Hydrogen Production Transition

Fossil Fuel Sources

Natural Gas Pipeline

Reformation

H_2

Renewable Power Sources

Electric Grid

Water Electrolysis

Transportation Fuel

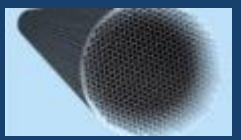
Storage

Traditional Markets

Traditional Markets

Refining

Fertilizers



Pipelines & New Storage Technologies

—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

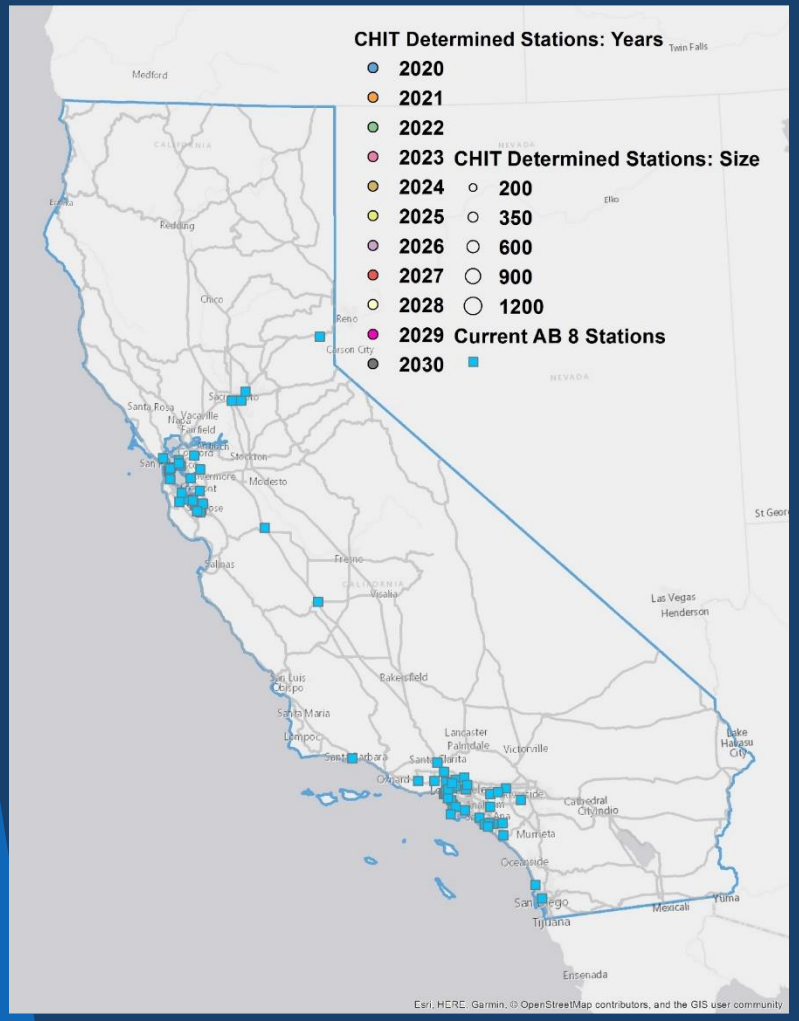
and

1,000,000 fuel cell vehicles

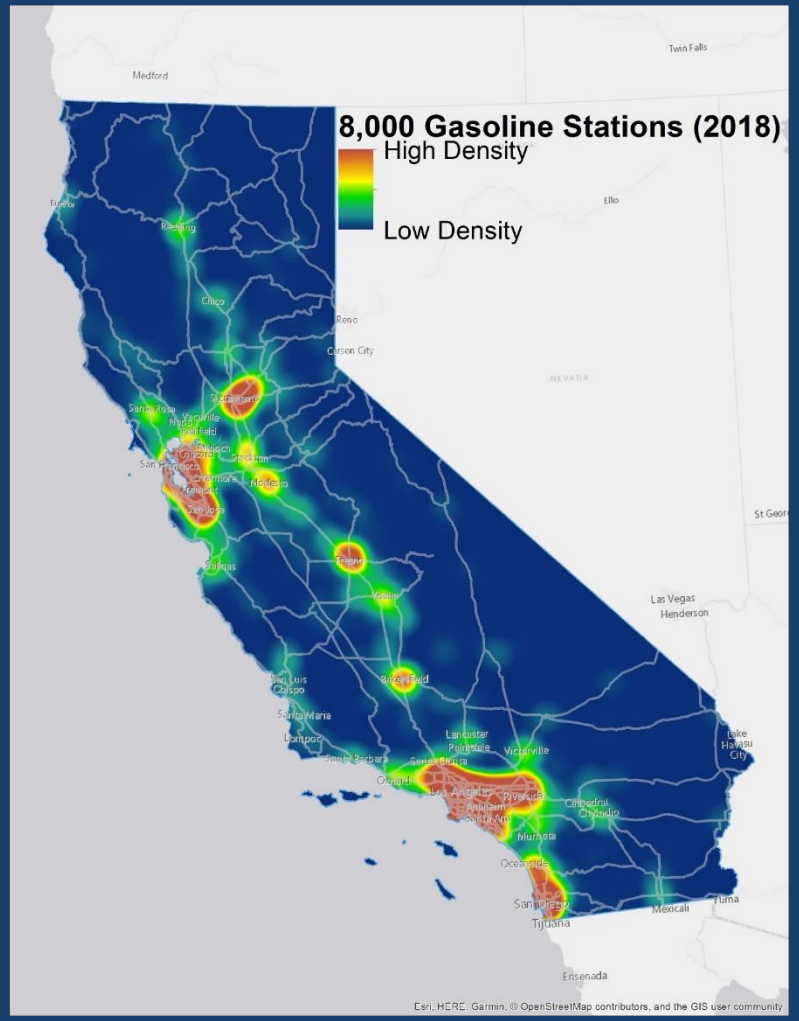
by **2030**

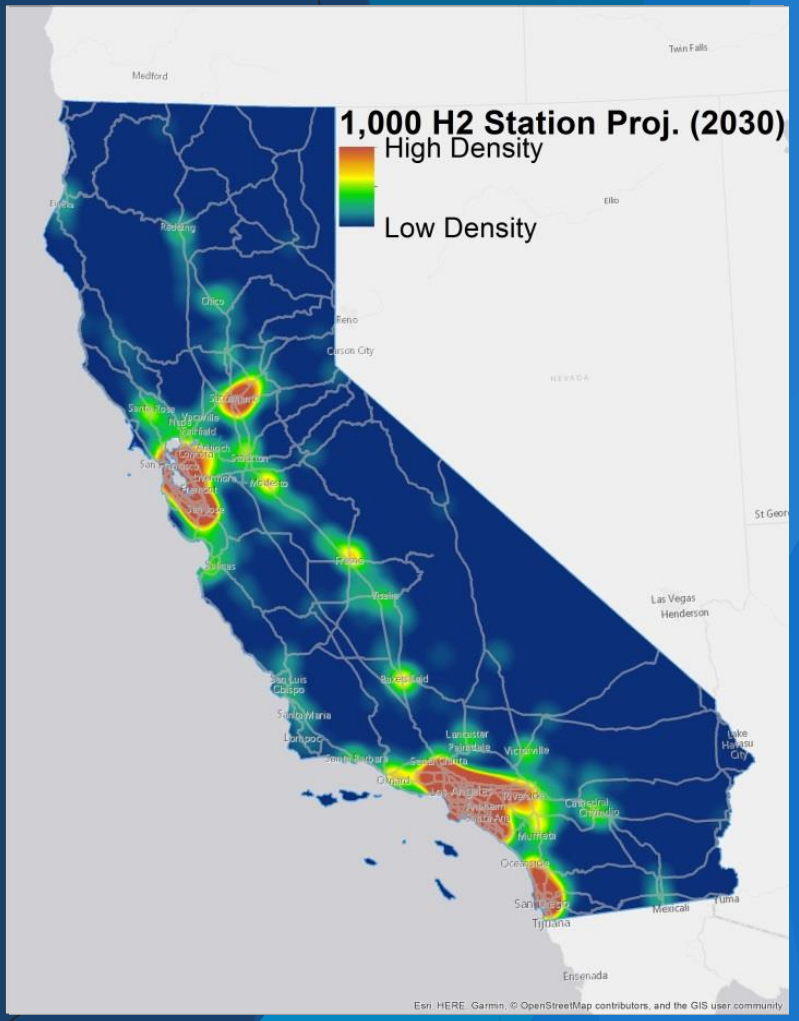
A Path to California's Hydrogen Goals

Currently Funded Stations



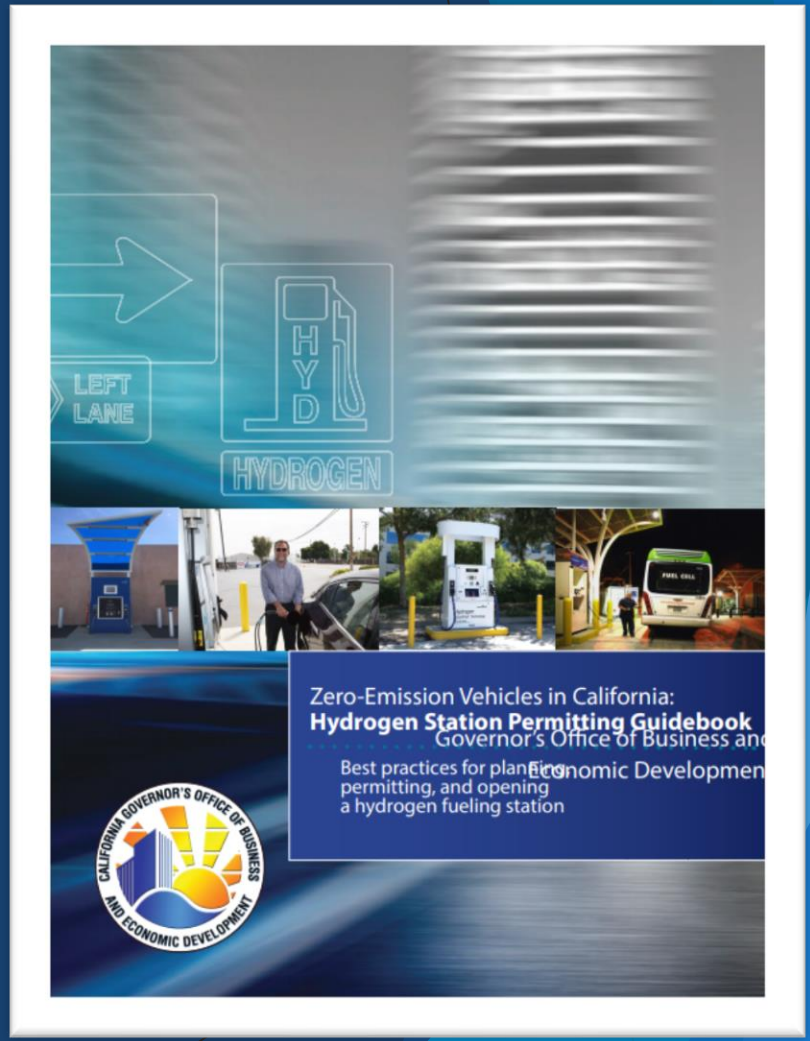
Growth of H2 Infrastructure Statewide

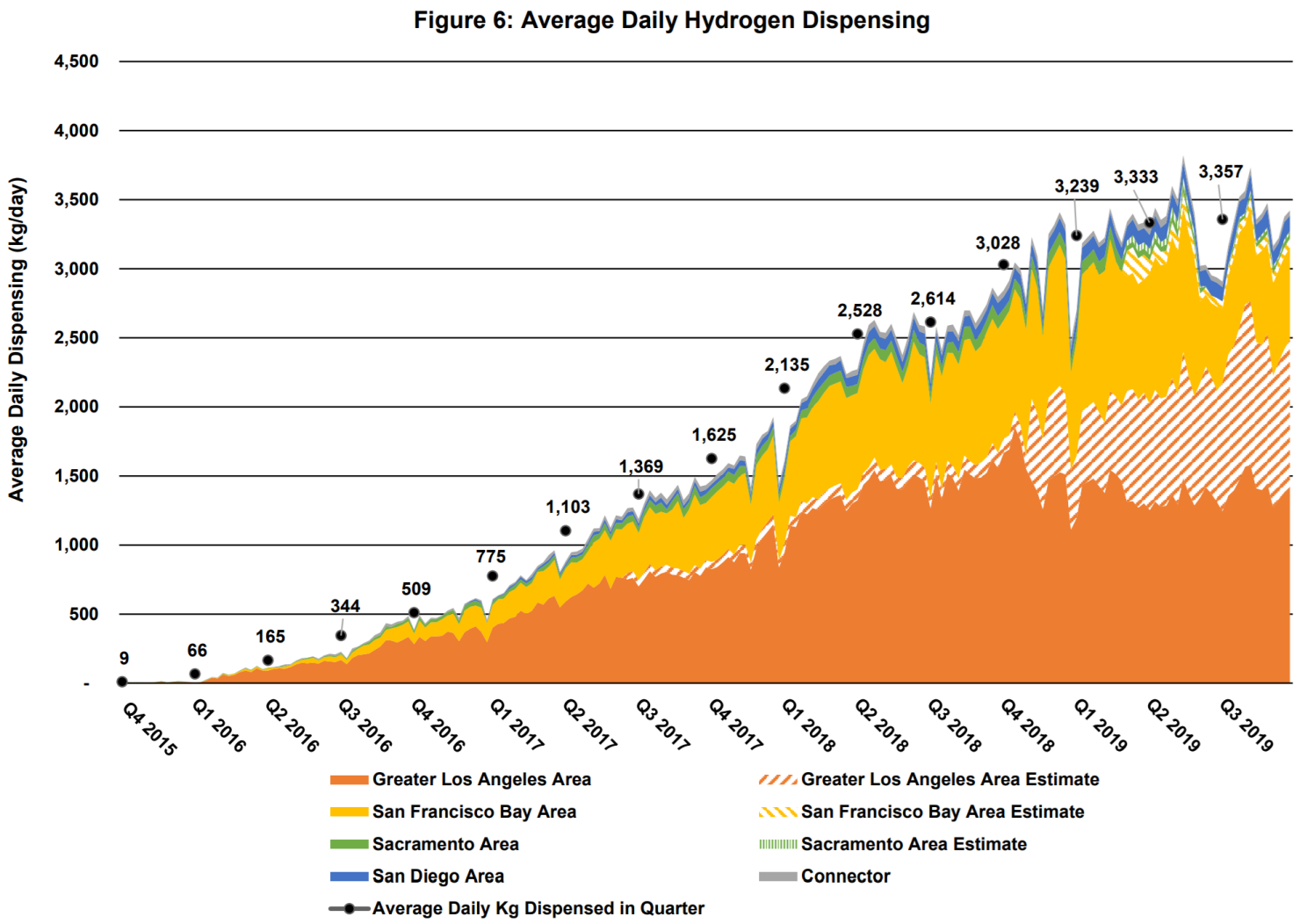




1st Hydrogen Station Permitting Guidebook

- 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?”





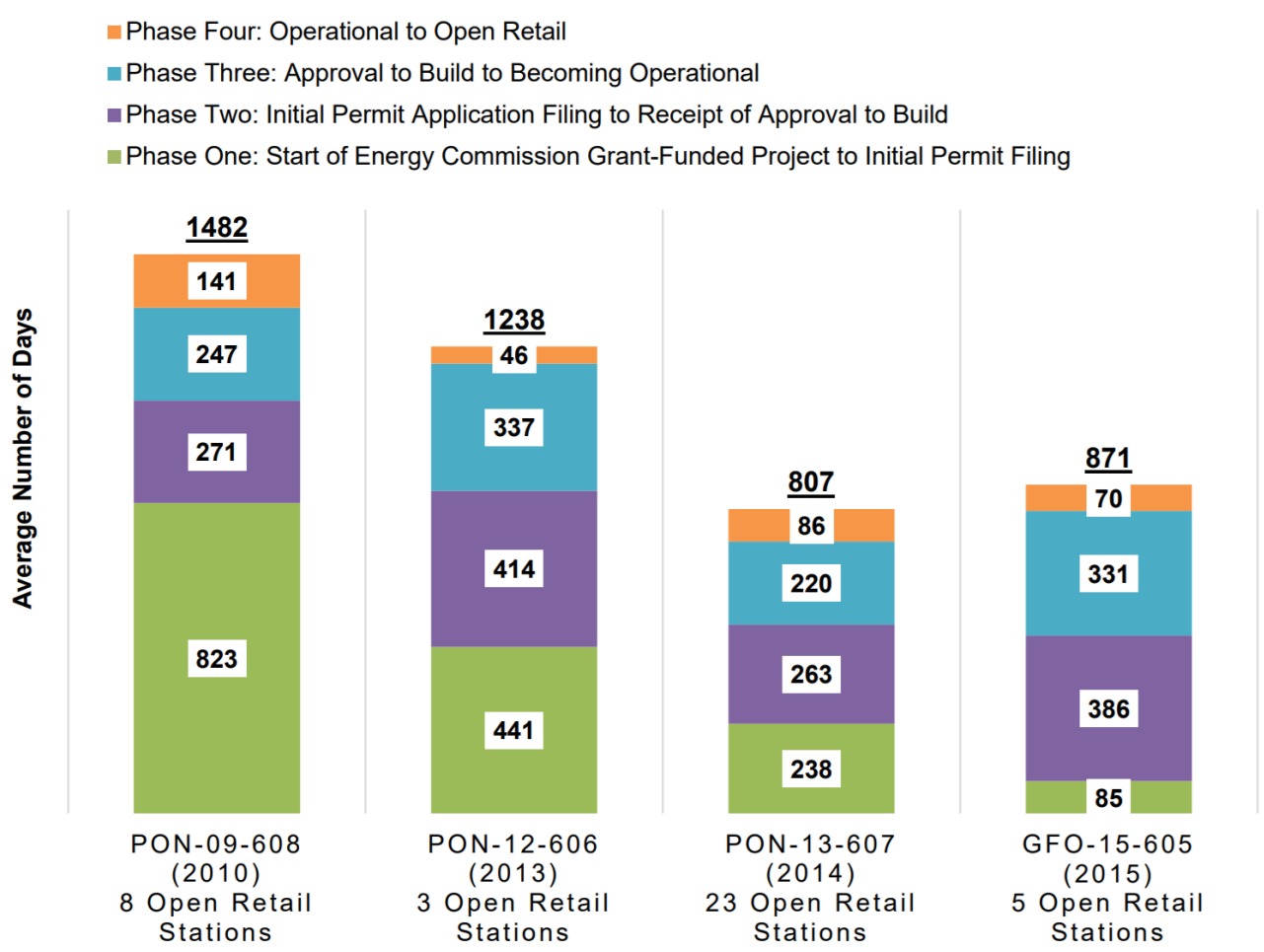
Can we make the market work?

"Yes!"

H2 Station Development Time

- Local permitting = 333 days, on average (purple bar)
- #1 Lesson?
  - Communication is key

Figure 11: Average Number of Days Spent on Station Development



Source: CEC

Today's Stations

Today, scale is the key to market acceleration

2020 Hydrogen Station Permitting Guidebook

Part 1. Setting the Stage

Part 2. The Hydrogen and Fuel Cell Electric Vehicle Ecosystem

Part 3. Station Development Process

Part 4. Additional Topics

Part 5. Looking Forward

Part 6. Additional Resources

We're Here to Help

- Education
- Connecting with other jurisdictions
- Safety

Contact us with your questions!

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Hydrogen Infrastructure

Funding for hydrogen fueling infrastructure in California

KEITH MALONE | PUBLIC AFFAIRS

March 10, 2020

CaFCP Members

— 20 years of collaboration —

February 2020

Northern CA Hydrogen Stations

Retail: Open

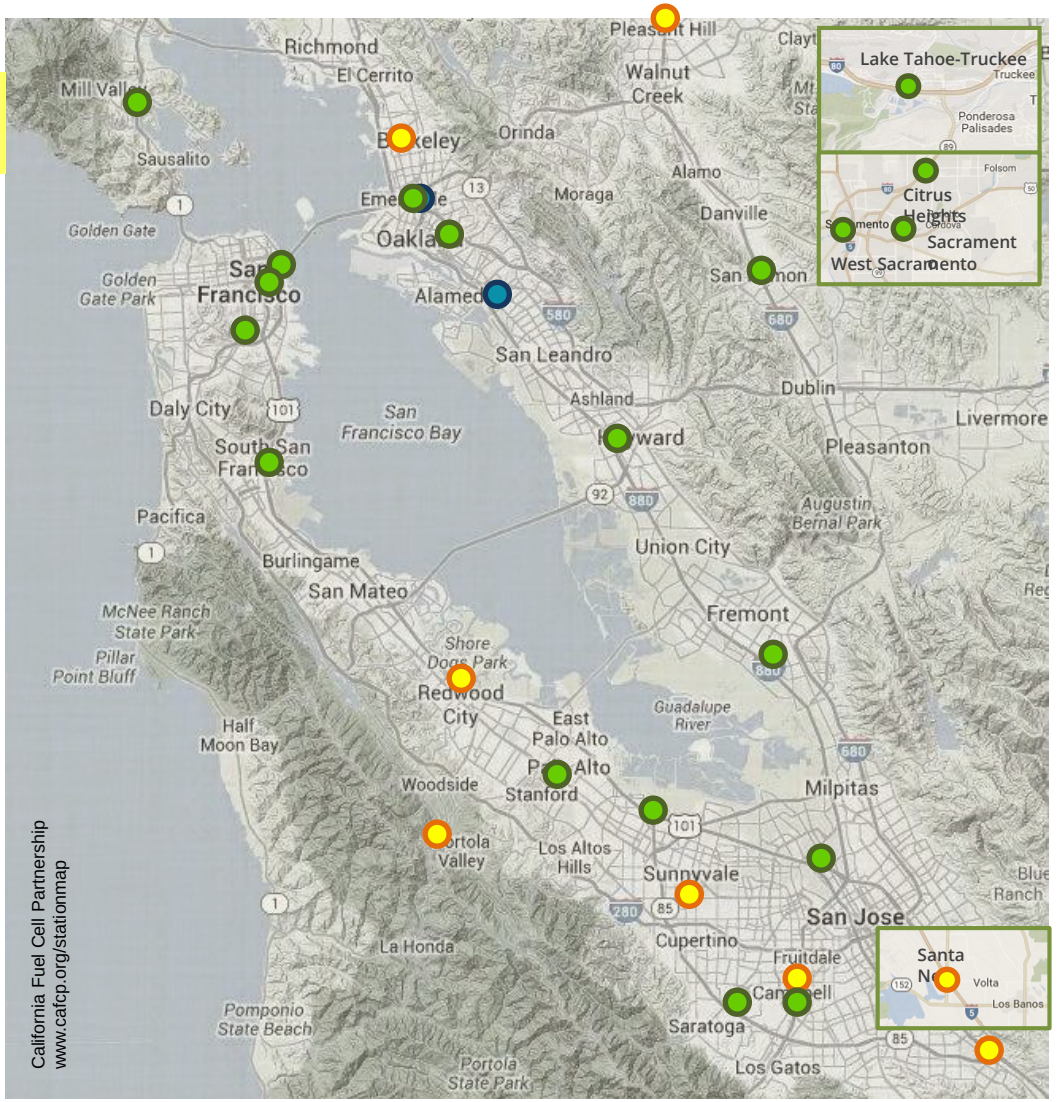
Campbell - Winchester Blvd
Citrus Heights
Emeryville
Fremont
Hayward
Mill Valley
Mountain View
Oakland - Grand Ave
Palo Alto
Sacramento
San Francisco - Harrison St
San Francisco - Mission St
San Francisco - Third St
San Jose
San Ramon
Saratoga
South San Francisco
Lake Tahoe-Truckee
West Sacramento

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



February 2020

Southern CA Hydrogen Stations

Retail: Open

Anaheim
Cal State LA
Costa Mesa
Del Mar
Diamond Bar
Fairfax-LA
Harris Ranch
Hollywood
La Cañada Flintridge
Lake Forest
Lawndale
LAX
Long Beach
Playa Del Rey
San Juan Capistrano
*Santa Barbara
Santa Monica - Cloverfield Blvd
South Pasadena
Thousand Oaks
Torrance
UC Irvine
Woodland Hills

Heavy Duty: Bus

Santa Ana - OCTA
*Thousand Palms - SunLine Transit

Heavy Duty: Truck

Long Beach – Port of Long Beach
Ontario
Wilmington

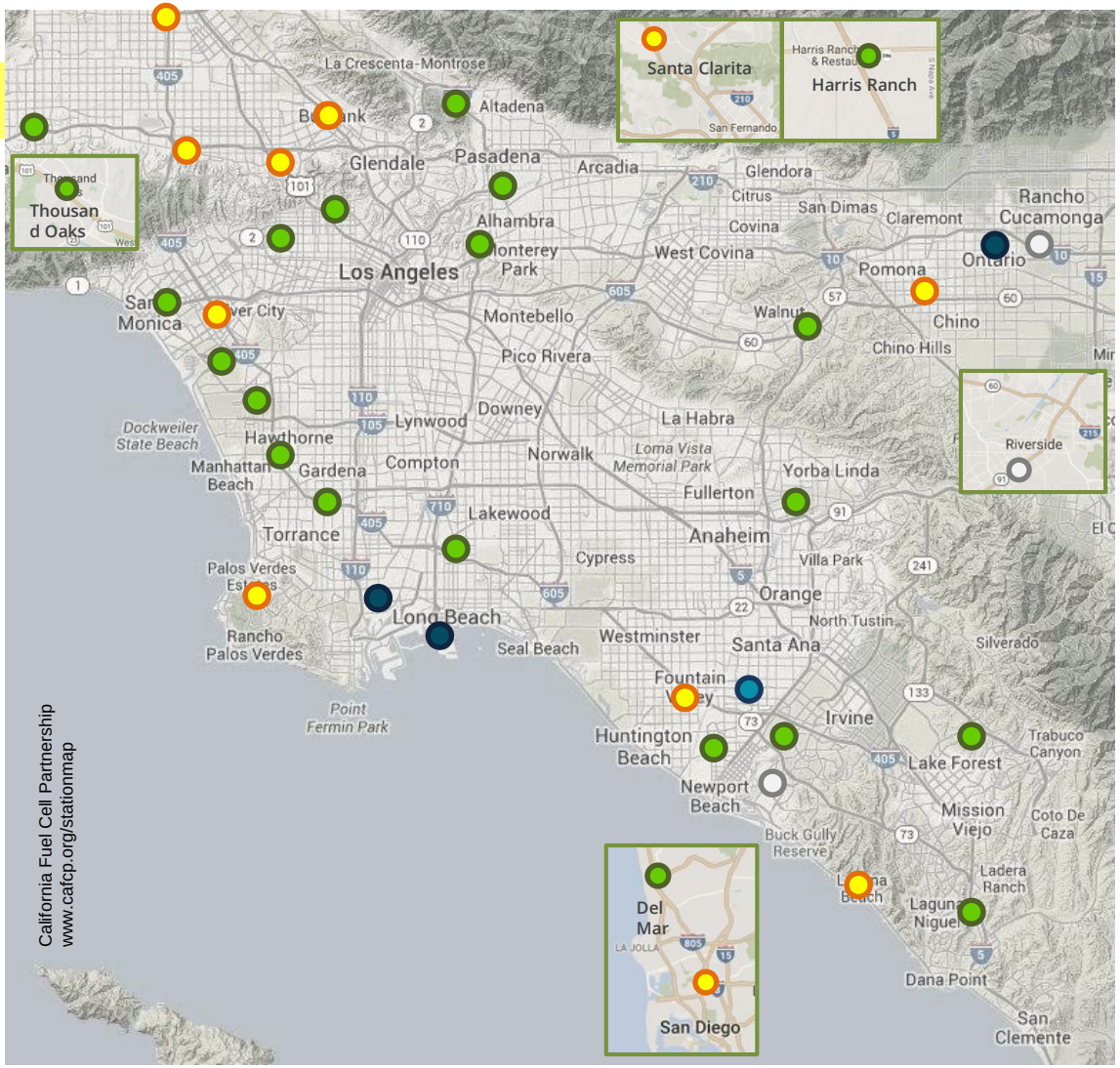
Retail: In Development

Burbank (upgrade)
Chino
Culver City
Fountain Valley
Laguna Beach
Mission Hills
Rancho Palos Verdes
San Diego
Santa Clarita
Sherman Oaks
Studio City

Not Operational

Newport Beach
Ontario
Riverside

*Not shown on map



By the Numbers
in California

Numbers as of March 1, 2020	Total
***FCEVs—Fuel cell cars sold and leased in US**	8,225
FCEBs—Fuel cell buses in operation in California	42
Retail hydrogen stations open in California	**44**
Fuel cell buses in development in California	7
Fuel cell shuttles in development in California	4
**Retail hydrogen stations in development in California	18

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

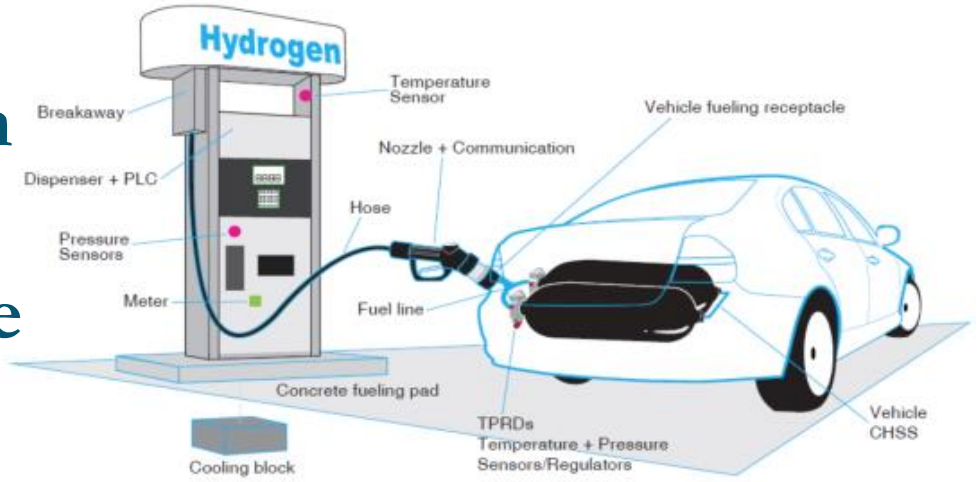
- 400 miles
- 5 passengers

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

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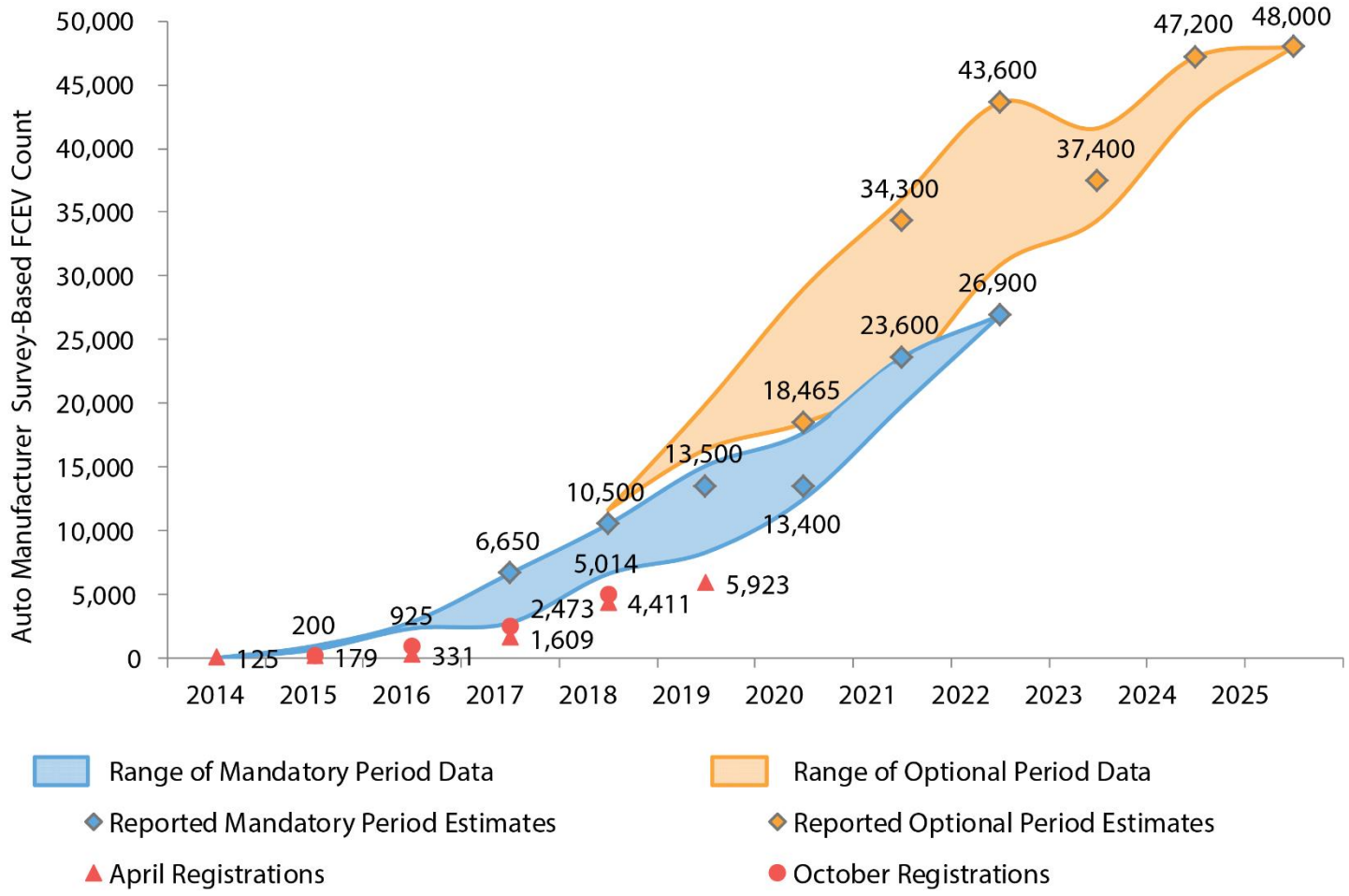
CARB annual survey: Automaker projections for fuel cell vehicles



Source: Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development, 2019

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
https://www.sciencedirect.com/science/article/pii/S0360319919307505?via%3Dihub

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 opportuninties
  - Utilized for selecting grant awardees

Automaker letter to stakeholders
https://cafcp.org/sites/default/files/CaFCP-OEM-2019-Priority-Station-Location-Announcement_Final.pdf
California Hydrogen Infrastructure Tool
http://californiaarb.maps.arcgis.com/apps/webappviewer/index.html?id=f2bc784715984f3cb2905dbc4a0391b6

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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

Trucks and other heavy duty vehicles

"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

Hydrogen Council

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.

GLOBAL CLIMATE ACTION SUMMIT

Hydrogen Council

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