Hydrogen in California

H2 Economy Workshop

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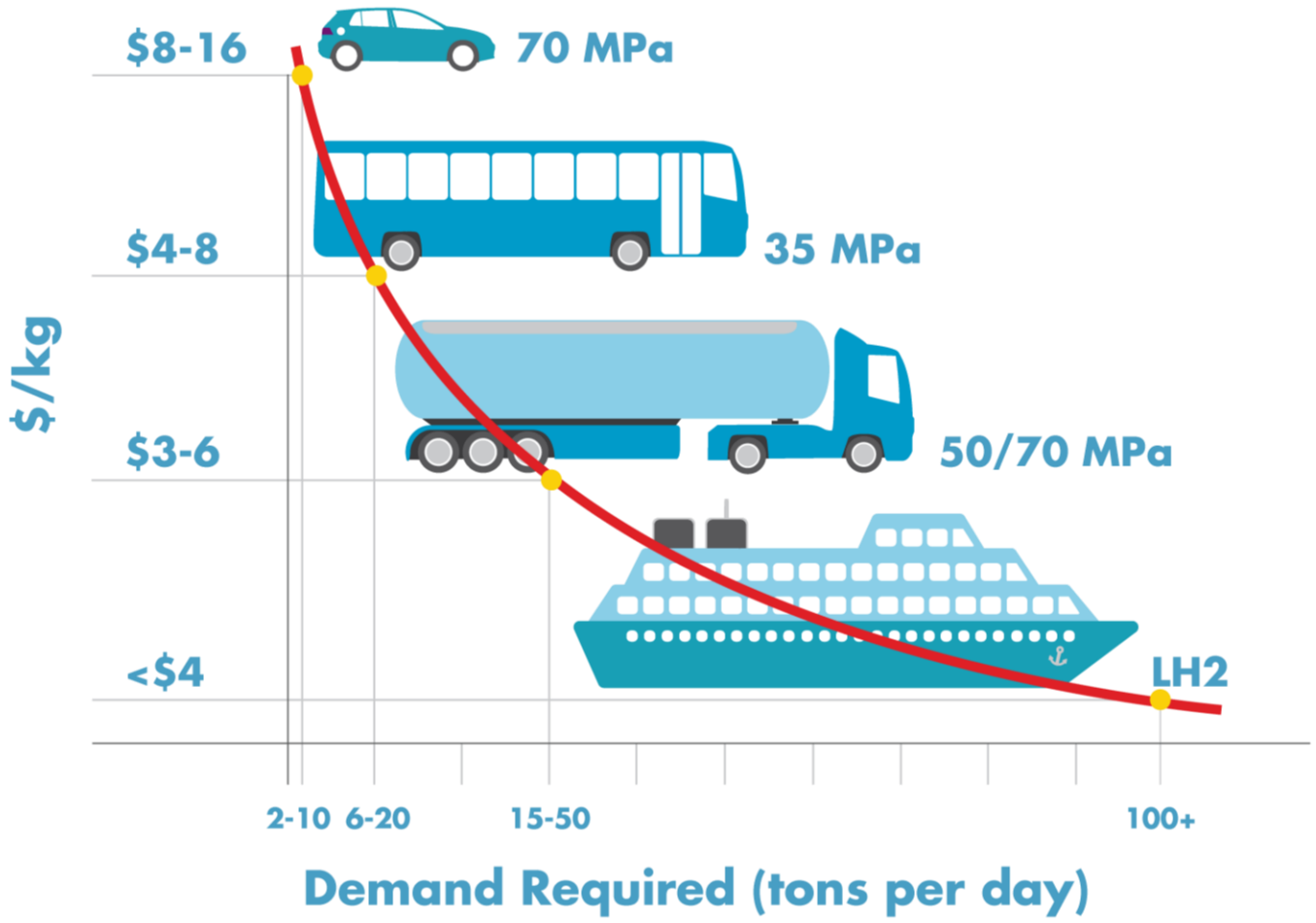
Shell Hydrogen Footprint Today

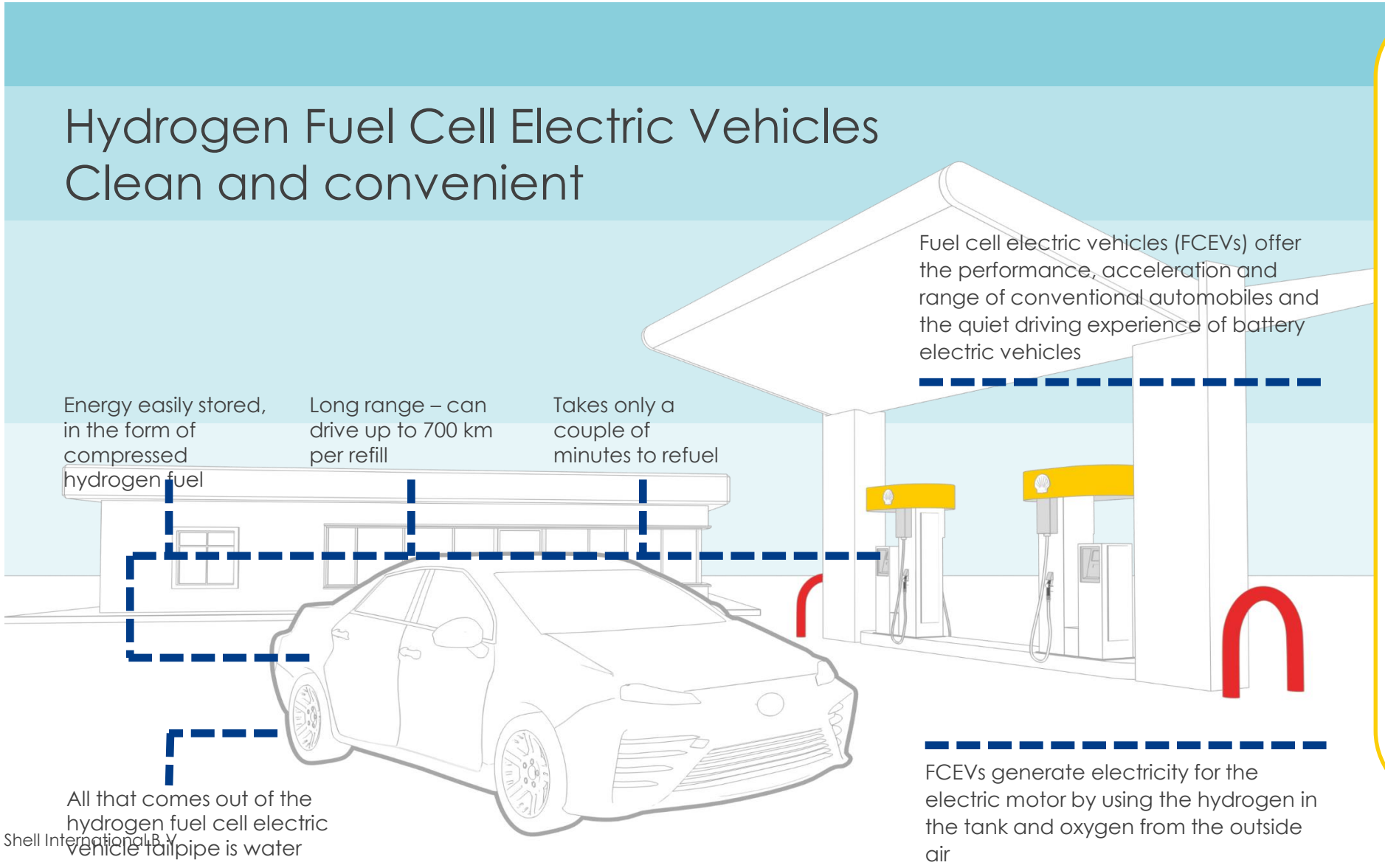
Shell has a vision to create Hydrogen hubs across mobility vectors, demand will drive down infrastructure cost



- Economies of scale will drive down infrastructure costs*; demand firmness will continue to drive innovation and economies of scope
- Lower levelized H_2 costs are opening the market for larger volume and scale opportunities, further reducing costs
- Standards and protocols for heavy duty systems are being defined currently
- The heaviest duty and longest haul vehicles will very likely need Liquid Hydrogen but we are not close to such demand levels yet

*Including capital costs for supply, distribution and compression/purification

Light Duty Mobility: Understand the Customer(s): Retail, Fleet, Public Policy



We understand the Light Duty (LD) and Retail customer for Fuel Cell Vehicles (FCV) well

We look forward to further developing understanding of the Medium Duty (MD) / Heavy Duty (HD) and Fleet customer :
Logistics operations

- Facilities operations
- Value drivers

There is a another customer who is critical to our success: public policy.

California – Shell Trident Project

<u>Reliability and Customer Service for Northern California:</u>

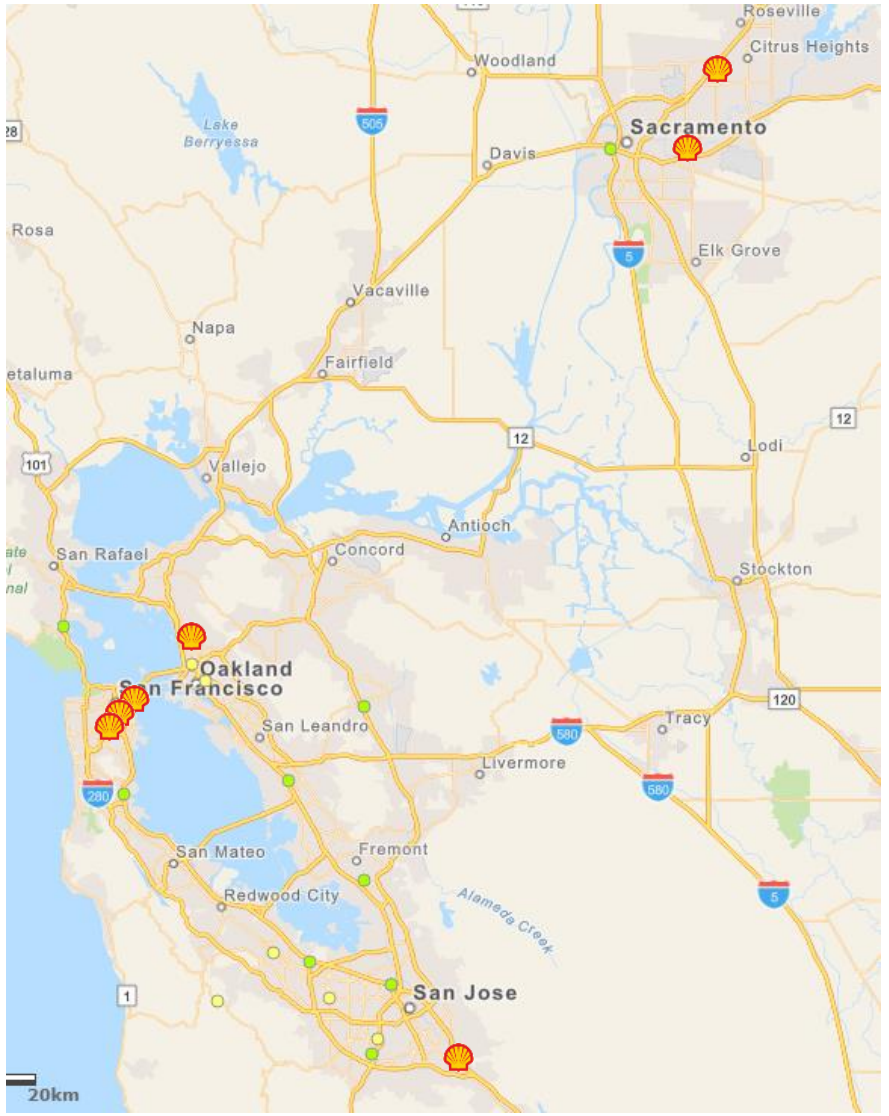
- 2x NEL H2 Station® CAR-200 at each location (redundancy)
- Two fueling positions with independent dispenser and POS
- Capacity to fuel 400 kg/day ~ serves up to 100 FCEVs/day
- Strategic, high-value locations within the Shell retail network
- Dispenser integrated under the canopy alongside other fuels

<u>Key Points:</u>

- First site, Citrus Heights, opened in 15 months (record)
- Highest dispensing capacity of any station in California at the time

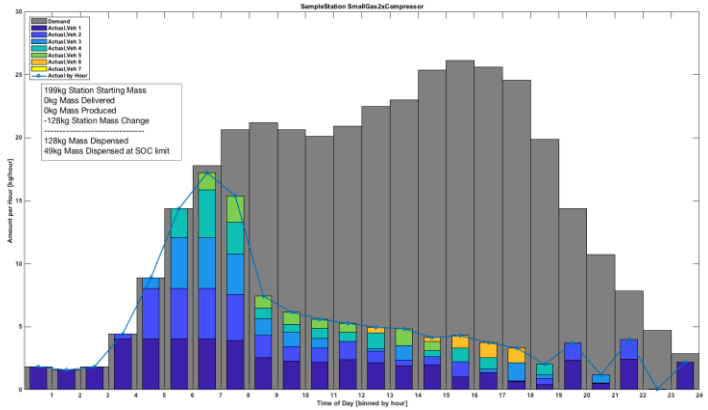
Project Participants:

Equipment Provider:

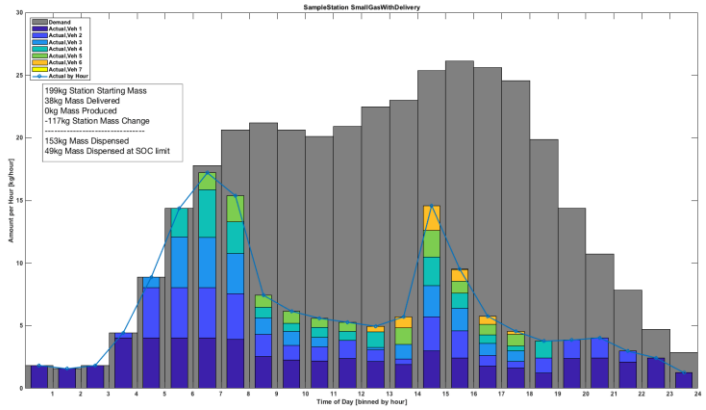


A Better Hydrogen infrastructure will enable a better customer experience

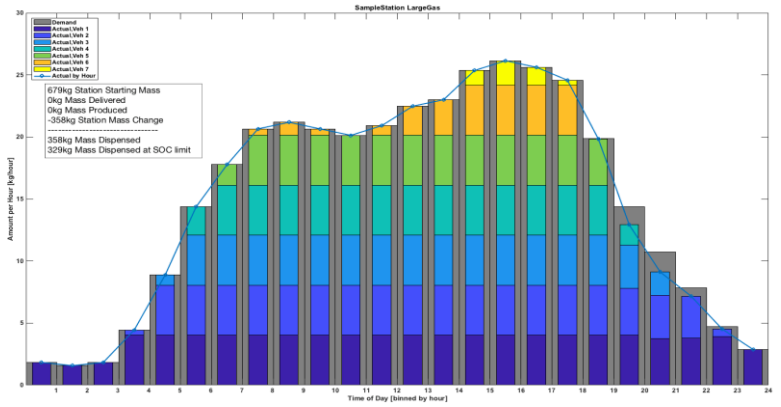
Existing Station: small, can't keep up with demand



Others Solution: require mid day delivery to manage demand



Next generation stations solution: better station performance can serve full demand



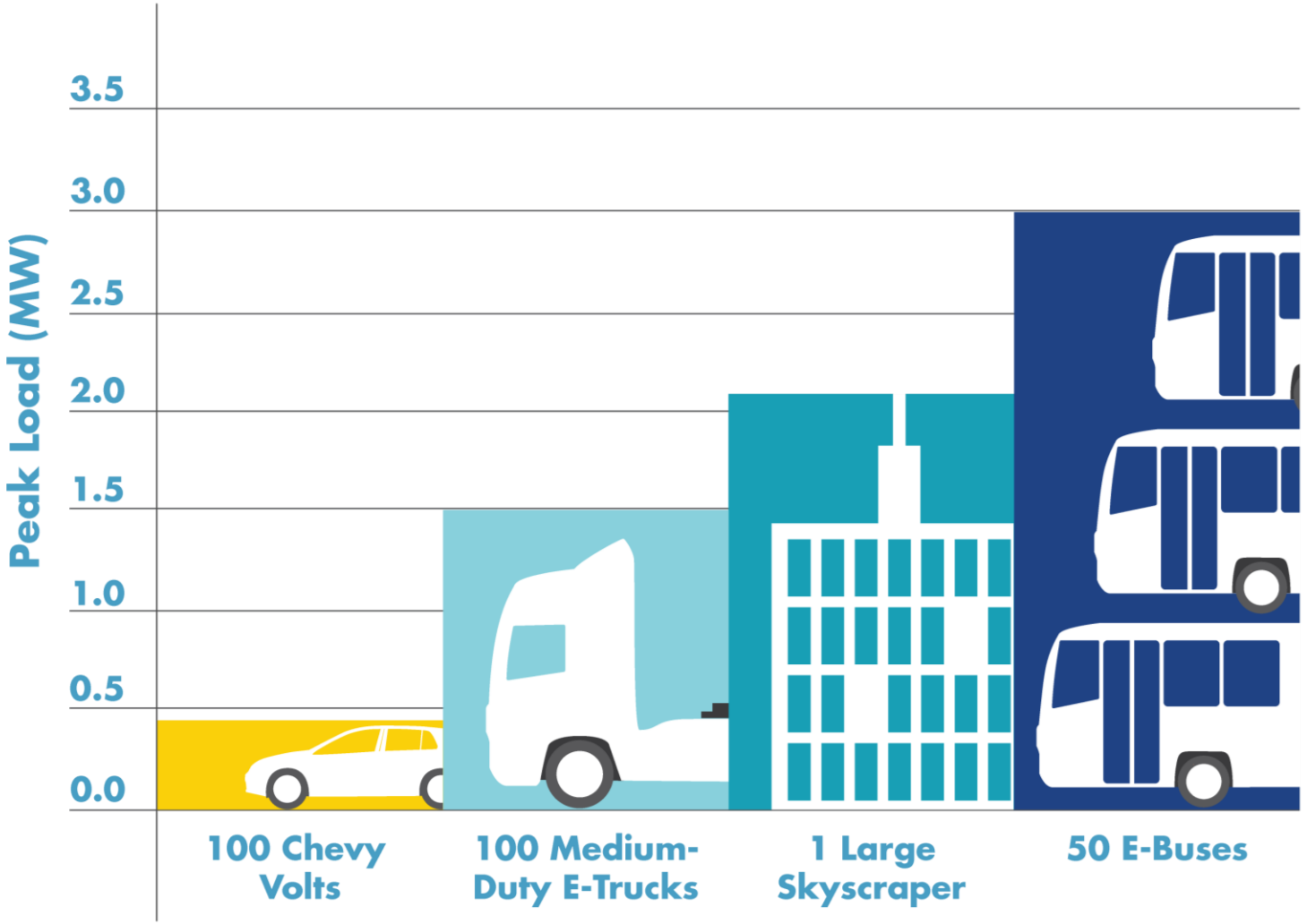
A systematic approach to not only the station, but also the distribution logistics and production enable better performance of a retail station and helps bring hydrogen mobility down the cost curve.

Shell is participating in the ZANZEF programme funded by CEC, CARB and SCAQMD with the intent to structure clean operations for future goods movement

Shell Site development at Wilmington

- 2 Hydrogen Refueling Stations at 1 Tonne/Day in Port of LA;
- 1 station at Port of LB, operated by Shell for Toyota
- Capex $8mln/station;
- Capcapacity utilisation expected in year 4 of project
- Reduction of GHG by 500 tonnes over duration of project

Why FCEV for HD? Infrastructure, Scaling, and Power Demand of EVs



- The peak load at the substation level is challenged by a B-EV fleet
- Volt charge rate 3.3 kw, truck 15 kw, bus 60kw (4-6 hours to full charge for a ~80 mile bus, much large for 300 mile buses)
- Peak HRS load for 50 FCETs is 100-200 kw for compression and cooling,
  - H2 equivalent of 7MW of power compared to BET charging

Refueling Network: Coordinated for Coverage and Capacity
Heavy-Duty based on freight corridors

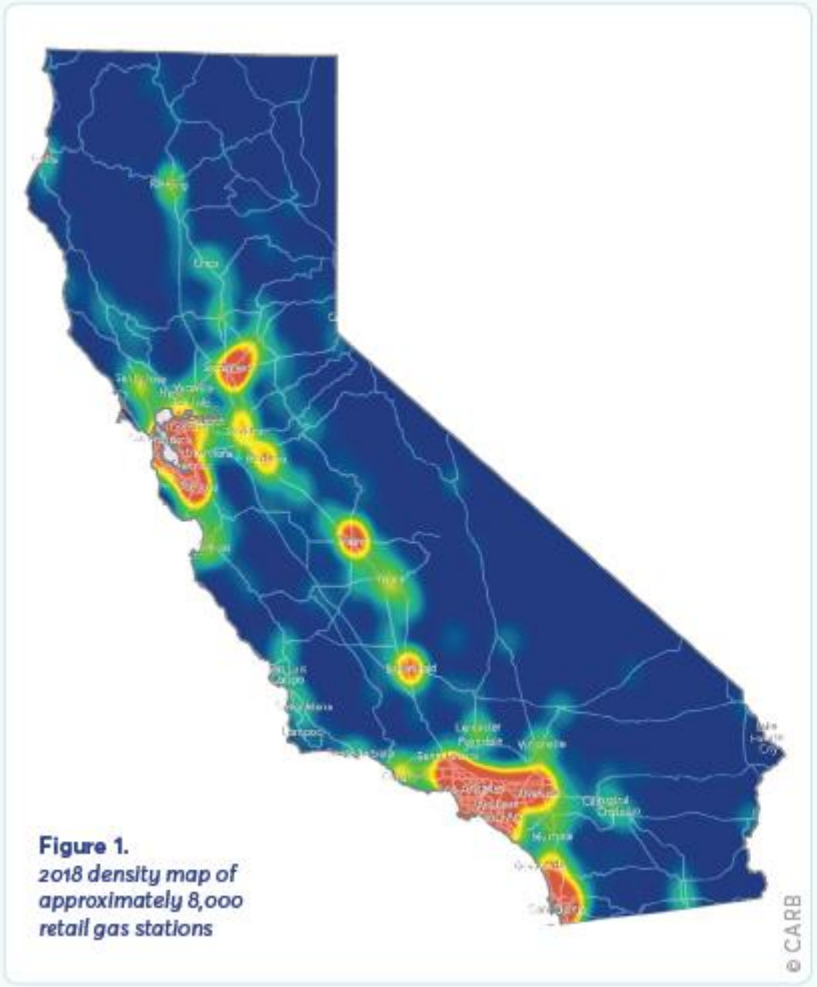


Figure 1.
2018 density map of approximately 8,000 retail gas stations

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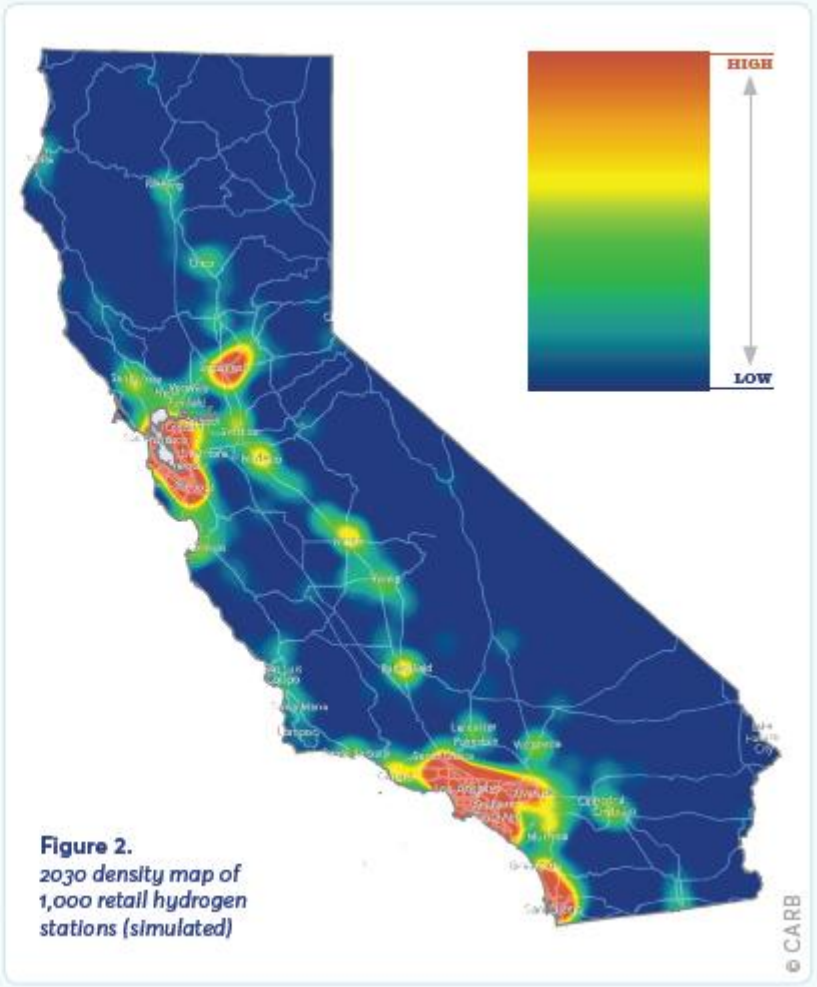

Figure 2.
2030 density map of 1,000 retail hydrogen stations (simulated)

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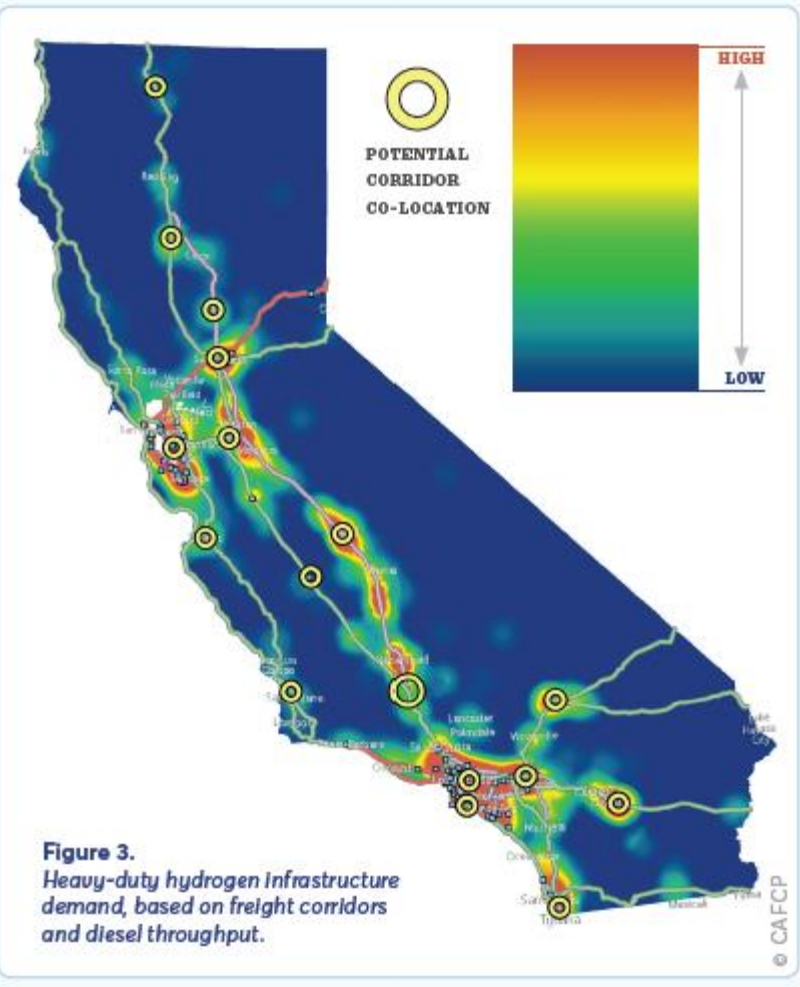

Figure 3.
Heavy-duty hydrogen infrastructure demand, based on freight corridors and diesel throughput.

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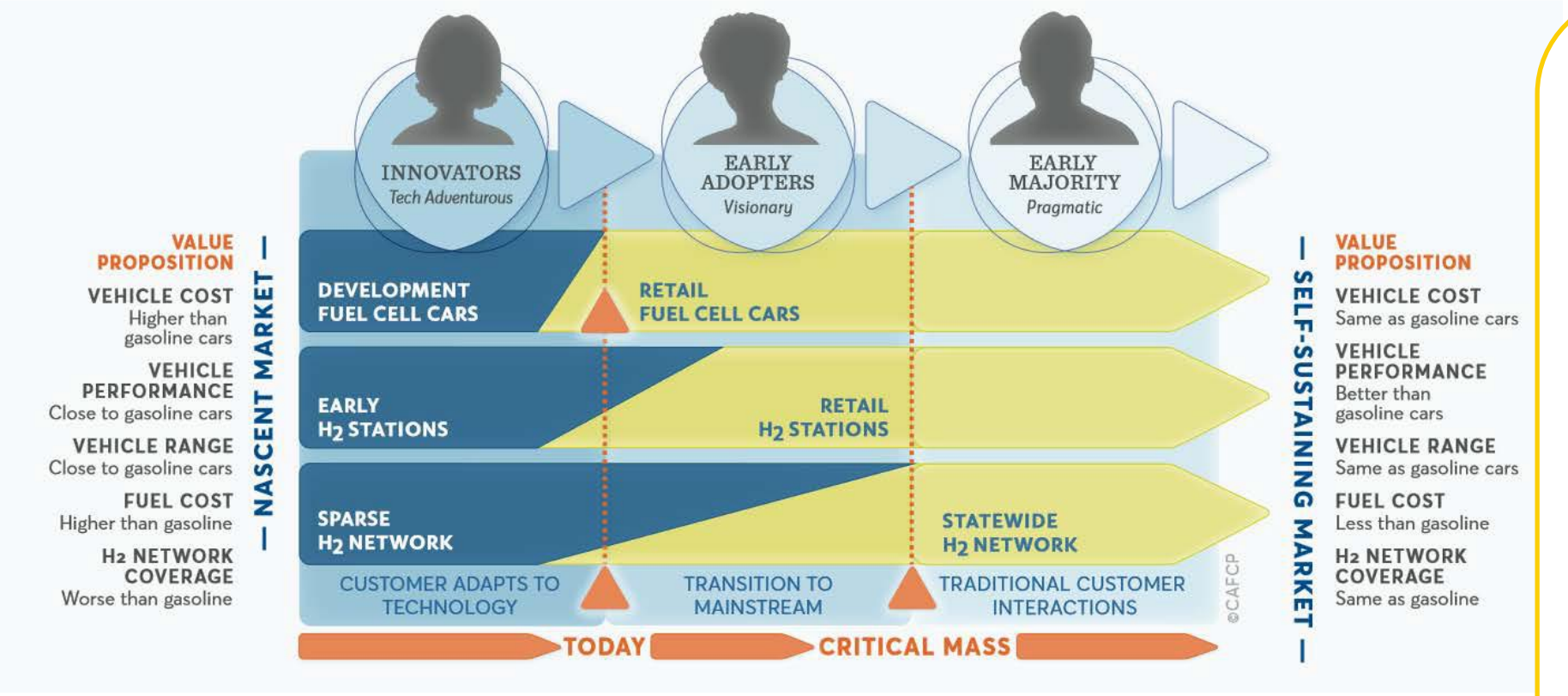
- Consider: tethered fleets, variable logistics optimizations and driver-owned fleets, multi-purpose station design, etc.

California Fuel Cell Partnership Vision: the California Fuel Cell Revolution

Advancing California's Economic, Social & Environmental Priorities



- **Transition**: from grant funding to market-based policy that enable scale and encourage private
- **Accelerate:** customer value proposition to increase adoption of fuel cell electric vehicles
- **Amplify:** Trucks, Grid Integration, and Low-Carbon Hydrogen Supply

Policy Objective: activate the market (with a profit motive) to encourage new entrants – vehicle makers and infrastructure developers – and encourage customer adoption.

The California Fuel Cell Partnership Vision for 1 million FCV and 1,000 HRS in 2030 would require an accelerated pace:

- From current pace of approximately 10 HRS/year to a pace of 80 HRS/year.
- From current pace of approximately 1,500 vehicles per year to a pace of 90,000 FCV/year.

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Questions and Answers

Hydrogen Electric mobility is relevant for heavy duty operators

- The high specific energy density of compressed hydrogen
- The ability to pump significant energy in a short time (high power flux)
- High efficiency of the power train (the “fuel cell”) and high recyclability
- Ability to have low cost hydrogen today, close to diesel parity.
- Ability to generate “greened” hydrogen from bio-gas or green power

1 kg H2 → 11.2 Nm^3 H2 → 33.3 kWhr (LHV)

High mass energy density → 1kg H2 = 3.77 L gasoline =3.5 L diesel

Low volume energy density → 1 Nm^3 H2 = 0.34 L gasoline =0.31 L diesel

Hydrogen production from water electrolysis (5kWhr/Nm^3 H2; 55kWhr/kg H2)

Power: 1 MW electrolsyer → 200Nm^3 H2 → 18 kg/hr H2

Energy: ~55 kWhr → 1 kg H2 → 10 L demineralised water

Power Production from a hydrogen PEM fuel cell/H2 and O2 inputs: 1kg H2 → 16kWhr

Light Duty vehicle Energy Efficiency Ratio (EER = 1.9)

H2 tank	H2 consump-tion	Driving range	Annual driving distance	Annual H2 consumption
5 kg	1 kg/100km	500km	15,000km	150kg

Heavy Duty vehicle Energy Efficiency Ratio (EER = 1.2)

H2 tank	H2 consump-tion	Driving range	Annual driving distance	Annual H2 consumption
35 kg	8kg/100km	350 km	60,000km	5000kg

Comprehensive Policy Framework for CA Hydrogen Market Activation

POLICY ACTIONS TO ACTIVATE THE MARKET

1.) Multi-Year Program of Station Development and Investment for Market Confidence
- ✓ Semi-Annual ARFVTP Grant Funding for more than 100 HRS as per AB8
- ✓ Multi-Year Public Funding Program (e.g., structure ARFVTP in Multi-Year GFO)
- • Re-authorize AB-8 for beyond 200 HRS

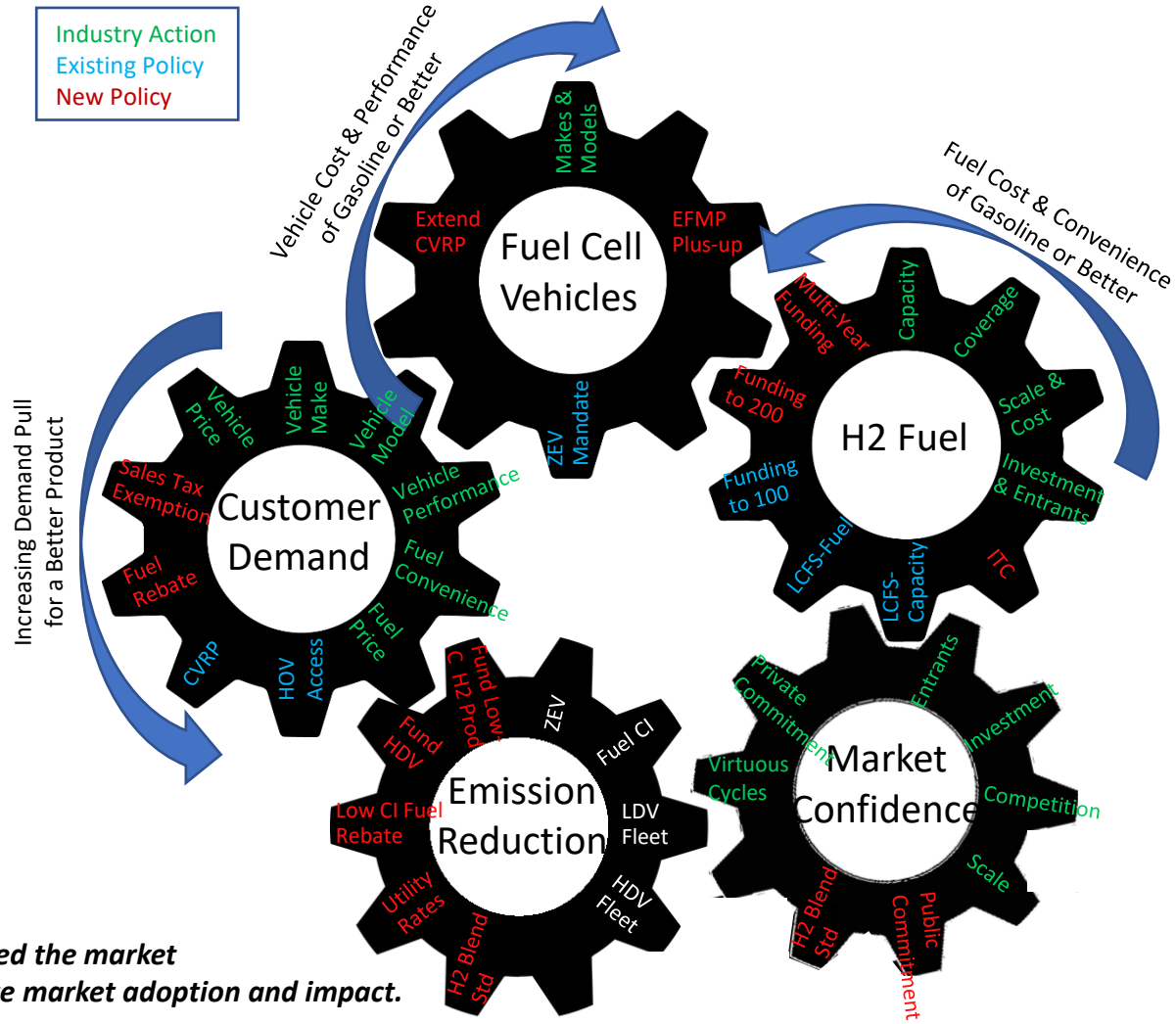
2.) Viable Market Conditions for Investment to Accelerate and Scale for Impact
- ✓ LCFS Fuel Credits with EER at 2.5 (or greater as vehicle efficiency improves)
- • Investment Tax Credit for H2 Infrastructure Investment (Stations, Production, Distribution)
- • Clean Hydrogen Blending Standard in Natural Gas (analog to Renewable Portfolio Standard)

3.) Increase and Accelerate Customer Value Proposition to Support Adoption
- ✓ Zero-Emission Vehicle (ZEV) Mandate
- ✓ Clean Vehicle Rebate Program (CVRP)
- • Continue and Increase Customer Incentives
  - • Continue CVRP, increase with larger incentive (fill federal tax credit gap)
  - ✓ Continue HOV Lane access
  - • [Activate EFMP Plus-Up program]
- • Sales Tax Exemption for Hydrogen Fuel (with sunset) and Station Equipment (in CAETFA program – probably needs broader push, the program needs more money)
- • Fuel Rebate to offset market price of fuel to parity now (customer adoption)

4.) Guide Development from the Start for Maximum Social Benefit
- ✓ LCFS Capacity Credits to Accelerate Station Capacity and Incentivize Decarbonization
- • Put 2030 carbon free in statute (and ensure definitions work for industry and enviros)
- • Electric Utility Rate Structures for Electrolysis as Demand Response Asset, Grid Storage Tech.
- • Fuel Rebate to offset higher cost of zero-carbon supply (zero-carbon from start)
- • Fund Heavy-Duty vehicles and stations to accelerate with bridge to Total Cost of Ownership

5.) Principles
- • Equal (proportional) funding for ZEV Infrastructure (Hydrogen, BEV)
- • Harmonize across policies for level playing field

Picking up Speed in the Gears of the Hydrogen Fuel Cell Revolution to Hasten a Tipping Point with Virtuous Cycles – Lean In on Confidence



Have one Carrot (CVRP, ARFVTP) and one Stick (ZEV, LCFS) each for Vehicle, Fuel that have created the market
Adding policy supports in each area is now needed to pivot toward commerciality and accelerate market adoption and impact.