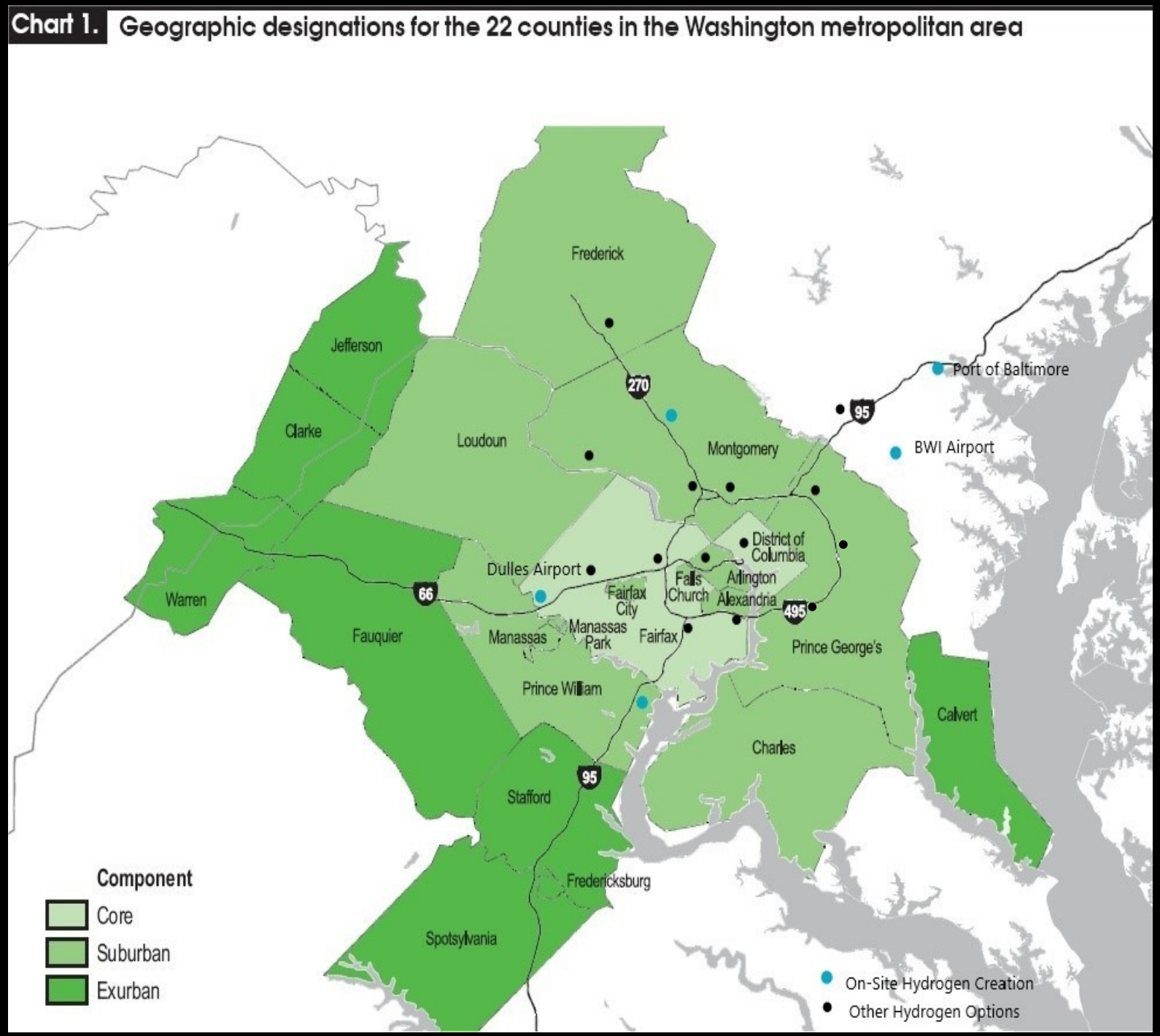

Business Model DMV Cluster

An approach to build the zero-emission DMV infrastructure needed to go from gasoline to green.

FCEV – UPDATE ON MARKET DEVELOPMENT

CALIFORNIA PERSPECTIVE

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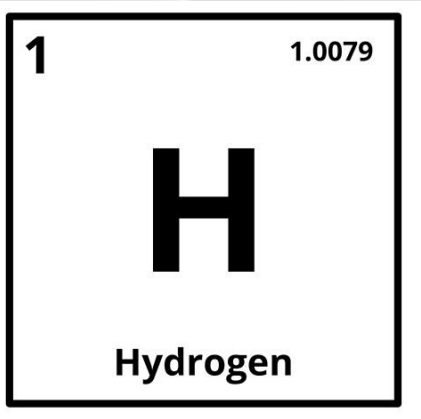
WHY IS HYDROGEN RELEVANT?

AN IMPORTANT WIDELY AVAILABLE FUEL

- Hydrogen also has the highest energy density of any common fuel by weight (about three times more than gasoline)
- Hydrogen is by far the most abundant element in the universe, totaling 73% of all mass. Hydrogen exists on Earth in compounds, like water.
- 10 million metric tons of hydrogen are currently produced in the U.S. 70% of this hydrogen is used in the petroleum refining industry and 20% goes into fertilizer production.



ENVIRONMENTAL BENEFITS

- Hydrogen used in fuel cells generates zero GHG emissions and criteria pollutants.
- Hydrogen-based synthetic fuels, hydrogen combustion engines, and blending hydrogen into existing fuels can also reduce or eliminate emissions across a variety of applications.

ADVANTAGES AS AN ENERGY CARRIER

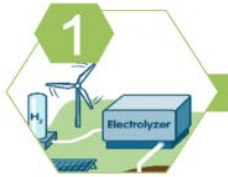
- For transportation: Fast refueling, long range, no change in fueling behavior, supports heavy duty drive cycles, can replace diesel with same performance and behavior, little impacted by environmental factors
- For stationary power: Large scale, long term energy storage possible, transportable, easily scalable
- For production: Can be produced from a vast variety of domestic resources, allows for energy independence

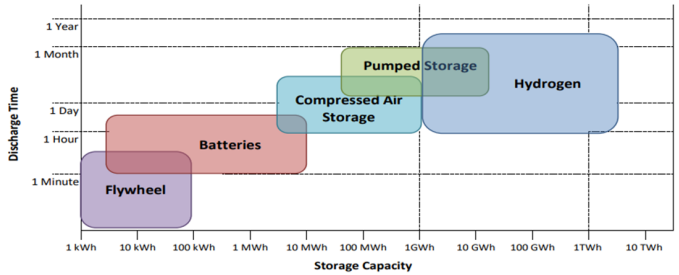
WHAT CAN IT DO? - SEVEN ROLES IN THE ENERGY TRANSITION

Enable the renewable energy system → Decarbonize end uses

Enable **large-scale renewables integration** and **power generation**

1





Distribute energy across sectors and regions

2

3

Act as a **buffer** to increase system resilience

4

Decarbonize **transportation**

5

Decarbonize **industry energy** use

6

Help decarbonize **building heating and power**

7

Serve as **feedstock,** using captured carbon

LA DWP

ladwp.com

SOURCE: Hydrogen Council

FUEL CELL ELECTRIC VEHICLES

Toyota Mirai (2nd Generation) Range: 420 miles
MSRP: $49,500

Honda Clarity FCEV (1st Generation) Range: 360 miles
MSRP: $59,485

Hyundai Nexo (2nd Generation) Range: 380 miles MSRP: $58,935
Hyundai announced FCEV option for every vehicle by 2028

HYDROGEN FUELING STATIONS DEVELOPMENTS

Lake Forest (2016): 1dispenser, 1 car ~120 kg capacity - fully refuel 22 cars

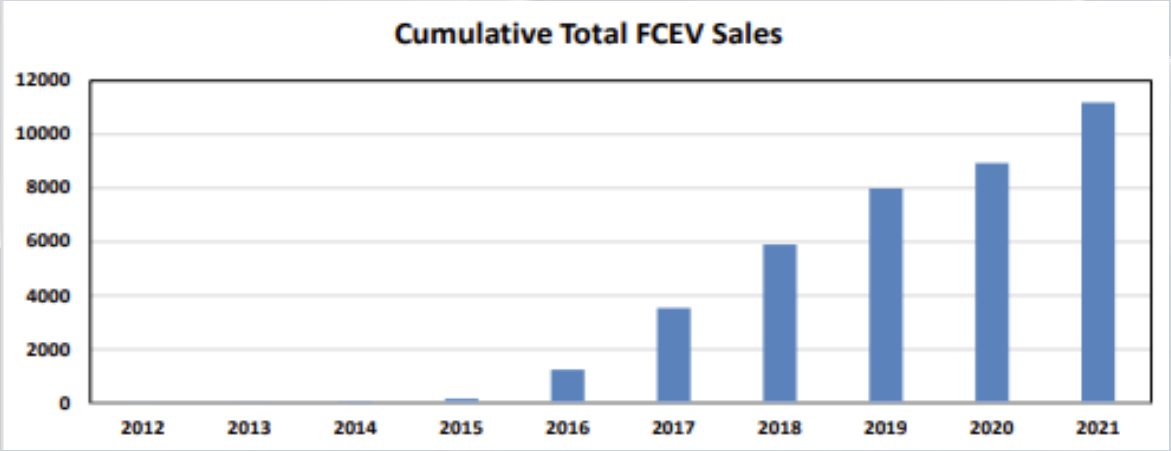
2014 Grant Awards (PON-13-607): 28 stations receive $46M = **$1.6M per station** (average capacity 120kg)
2020 Grant Awards (GFO-19-602): 114 stations receive $115M = **$1M of grant funding per station** (average capacity 1000+kg)

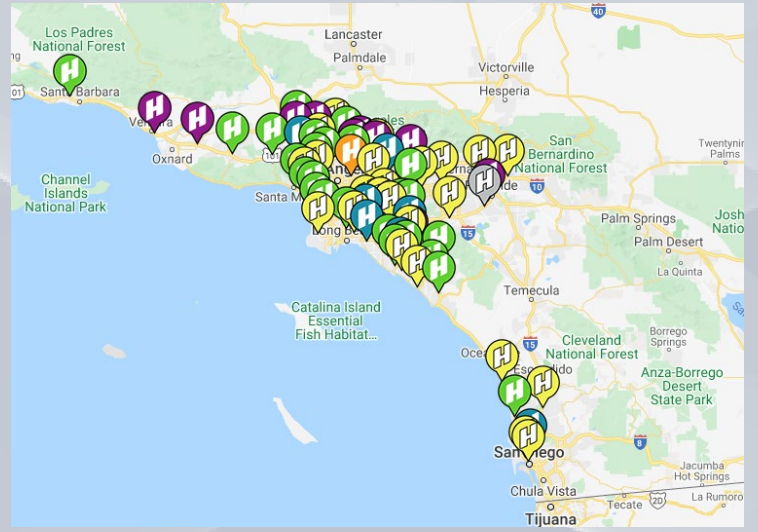
Oakland (2019): 2 dispensers, 2 cars ~ 800 kg capacity – fully refuel 145 cars

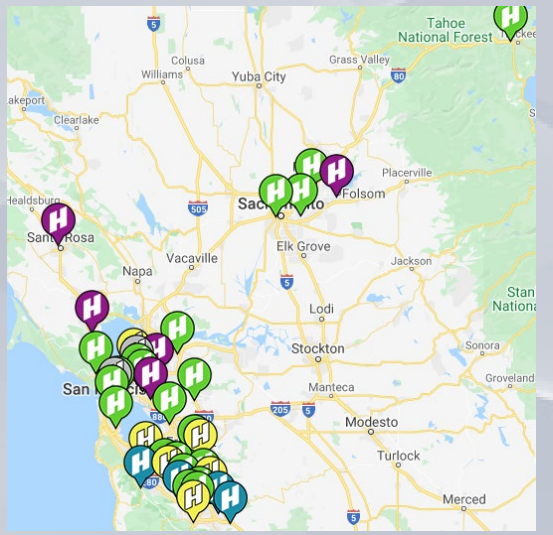
Sunnyvale (2021): 4 dispensers, 4 cars ~ 1600 kg capacity
- fully refuel 290 cars

CALIFORNIA FCEV ADOPTION & STATION DEPLOYMENT

Numbers as of September 1, 2021	Total
FCEVs—Fuel cell cars sold and leased in US*	11,187
FCEBs—Fuel cell buses in operation in California	**48**
Fuel cell buses in development in California	38
Hydrogen stations available in California**	48
Retail hydrogen stations in *construction* in California***	10
Retail hydrogen stations in *permitting* in California***	30
Retail hydrogen stations *proposed* in California***	15
Retail hydrogen stations *funded*, but not in development in California***	72
Total retail hydrogen stations in development in California***	**127**
2021 ARB AB8 Report expects 100 stations operational by 2023	
Retail truck hydrogen stations in construction in California	4
Retail truck hydrogen stations *funded*, but not in development in California****	5





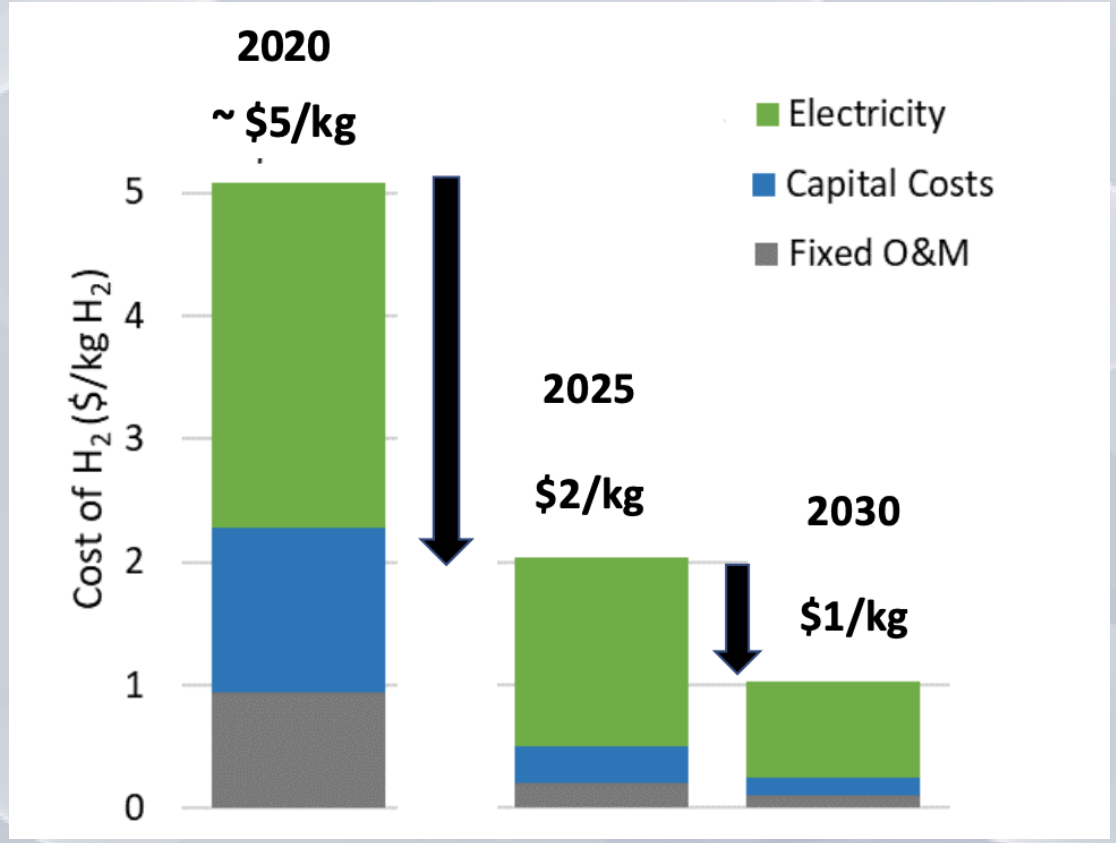


"private industry had previously begun development on 8 stations without any request of State grant funds and an additional 15 stations have since been announced through fully private financing (for a total of 23 stations planned or under development with fully private financing)."
https://ww2.arb.ca.gov/resources/documents/annual-hydrogen-evaluation

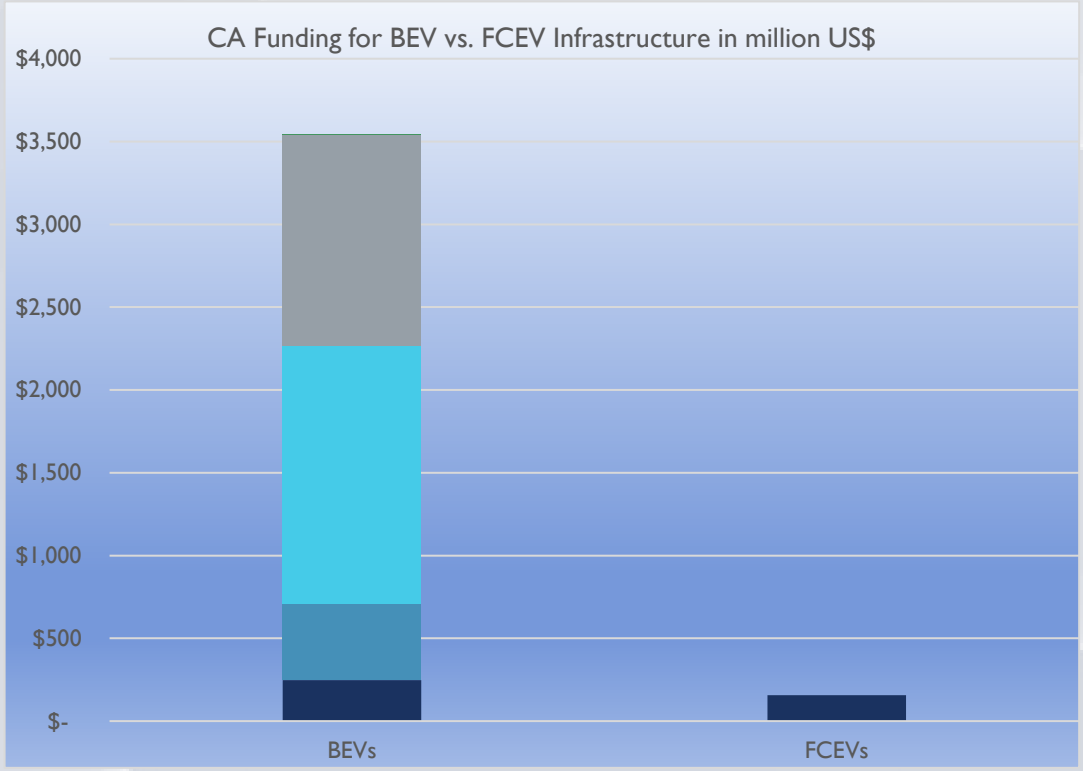
https://cafcp.org/by_the_numbers

FUEL COST (CA)

- New stations sell hydrogen at $13.11 per kilogram including taxes * 5.6 kg = $73.42 today for 420 mile range (Mirai)
- $4.40 per gallon at 27 mpg for new gas car for 420 miles = $68.44
- 90% of hydrogen dispensed in California for transportation is **renewably sourced** due to CA's LCFS program without any bans of production pathways
- DOE Hydrogen Shot Program seeks to reduce hydrogen cost from $5kg today to $2/kg by 2025 and $1/kg by 2030



2020 INFRASTRUCTURE FUNDING



FUNDING SOURCE	DATE/TIME FRAME	BATTERY EVs		FUEL CELL EVs
Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) and Clean Transportation Funding (CTP)	Total ARFVTP and CTP funding since 2005 to date based on fuel type (electricity or hydrogen)[1]	$188 m LD $58 m MD & HD		$169.4 m LD $30.1 m HD
Electrify America (VW Settlement)	1st, 2nd, and 3rd of four Zero-Emission Vehicle Investment Plans (ZIP)[2]	$184 m Cycle 1 $153 m Cycle 2 $127 m Cycle 3		$0
Public Utilities Commission	May 2021[3]	**authorized** $752 m LD $733 m MD/HD $25 m off-road $44 m DCFC	**available** $522 m LD $694 m MD/HD $20 m off-road $43 m DCFC	$0
Utilities	Ongoing	Rebates and credits to customers[4]		None
TOTAL FUNDING		**$3,543 million**		**$200 million**

Meanwhile , the California Air Resources Board determined that an additional $300M in the next few years will lead to self sufficiency in the market, effectively allowing a business case for hydrogen in which no additional government funding is necessary.

https://ww2.arb.ca.gov/sites/default/files/2020-11/ab_8_self_sufficiency_report_draft_ac.pdf

POLICY SUPPORT FOR ZERO EMISSION OPTIONS

	CA - BEV	MD – BEV	Federal - BEV
Infrastructure Grants	Yes	Yes	Yes
Infrastructure Tax Credits/Rebates	Yes	Yes	Yes
Rate Basing Infrastructure	Yes	Yes	N/A
Vehicle Purchase Tax Credit/Rebate	Yes	No	Yes*
Fuel Sales Tax Exemption	Yes	Yes	N/A
Utility Rebates	Yes	Yes	N/A

	CA - FCEV	MD – FCEV	Federal - FCEV
Infrastructure Grants	Yes	No**	No
Infrastructure Tax Credits/Rebates	No	No	No**
Rate Basing Infrastructure	No	No	N/A
Vehicle Purchase Tax Credit/Rebate	Yes	No	Yes
Fuel Sales Tax Exemption	No	No	N/A
Utility Rebates	No	No	N/A

*capped

**capped at too low a level to provide an incentive

POLICY RECOMMENDATIONS FOR MARYLAND

Stations:

- Development of a comprehensive Low Carbon Fuel Standard program modeled after CA's LCFS program
- Rate Base Hydrogen Infrastructure For Gas Utilities
  - Hydrogen Blending or Dedicated Hydrogen Pipeline Conversion
  - Hydrogen Infrastructure for LD, MD and HD Fueling
- Create State Tax Credits for Hydrogen Fueling Infrastructure
- Create limited funding program for initial infrastructure rollout to develop core fueling station network
- Remove Sales Tax from Hydrogen Fuel

Vehicles

- Waive the Excise Tax for ZEV Purchases
- Adopt FCEV Bulk Purchase programs
  - (e.g. FCE Bus Program for Transit Agencies, FCE Truck Program for HD Fleets, FCEV Program for LD State Fleets)

Hydrogen Production

- Offer Wholesale Access Rates to Hydrogen production via electrolysis
- Incentivize Renewable Hydrogen Production via Tax Credit or Renewable Gas Standard (RGS)
- Incorporate Hydrogen and Long Duration Energy Storage in State Energy Planning (RPS/DER)

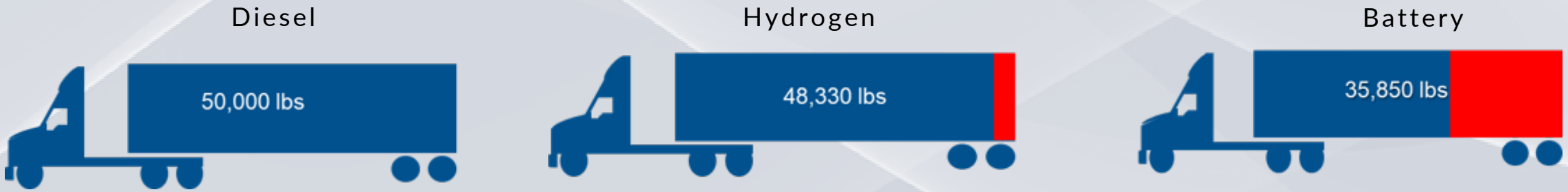
ADDITIONAL SLIDES

FUEL CELL ELECTRIC TRUCKS

One significant advantage of fuel cell trucks in comparison to battery-powered is the weight of the fuel itself.

A fuel cell for long-haul truck loses about 1,000 pounds of cargo capacity compared to a diesel engine (assuming a maximum weight of 80,000 pounds).

A battery to power a long-haul truck (even with a battery mass of 4 kg/kWh, which has yet to be achieved for heavy-duty vehicles) would lose around 5,000 pounds of capacity. With current battery masses, the capacity loss would be closer to 10,000 or 15,000 pounds.



Source: Walker, Clean Air Task Force – Zero Carbon Fuels, May 2021.

FUEL CELL ELECTRIC TRUCKS

Toyota Kenworth FCET (T680)

Cummins FCET

Hyundai FCET (XCIENT)

Mercedes-Benz FCET (GenH2)

PACCAR FCET

HYZON FCET

OTHER FUEL CELL ELECTRIC VEHICLE OPTIONS

BMW iX5

Hyzon Class 2-3 FCEV

Sierra Northern Railway H2 Switcher Locomotive

CMB.TECH Hydrogen Excavator

Hydrogen FCEV Ferry Boat (SeaChange)

ZeroAvia Fuel Cell Electric Plane

REFERENCES AND FURTHER READING

- Many of the slides are sourced from the CHBC 2021 Hydrogen Industry Slide Deck: www.californiahydrogen.org
- FCEV Sales, FCEB, & Hydrogen Station Data - https://cafcp.org/by_the_numbers
- 2021 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development: https://ww2.arb.ca.gov/sites/default/files/2021-09/2021_AB-8_FINAL.pdf
- 2020 Hydrogen Station Network Self-Sufficiency Analysis per Assembly Bill 8: https://ww2.arb.ca.gov/sites/default/files/2020-11/ab_8_self_sufficiency_report_draft_ac.pdf
- Path To Hydrogen Competitiveness: A Cost Perspective: https://hydrogencouncil.com/en/path-to-hydrogen-competitiveness-a-cost-perspective/
- 2021 Hydrogen Decarbonization Pathways: https://hydrogencouncil.com/en/hydrogen-decarbonization-pathways/