



Session #13: The Rise of Hydrogen Fuel Cells in Transportation

December 01, 2022



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Format

- Q&A at the end
- Submit questions and comments to “Panelists”
- Scheduled for 2:00p-3:00p
- Handout
- Recording



The Rise of Hydrogen Fuel Cells in Transportation

December 01, 2022

2:00-2:05 **Rick Sapienza, NCCETC**--Introduction and Welcome

2:05-2:20 **Dr. Prabhu Rao, IVYS Energy**—Hydrogen’s Place in the Drive Zero Emissions Mobility

2:20-2:34 **Roland Cordero, Foothill Transit**—Foothill Transit’s Move into Hydrogen Fuel Cell Vehicles

2:34-2:48 **Jaimie Levin, Center for Transportation and the Environment**—Transforming the Heavy-Duty Transportation Sector to Zero

2:48-3:00 **Q&A**





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Introducing Our Speakers:



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Roland Cordero
Director of Maintenance & Vehicle Technology
Foothill Transit , West Covina CA
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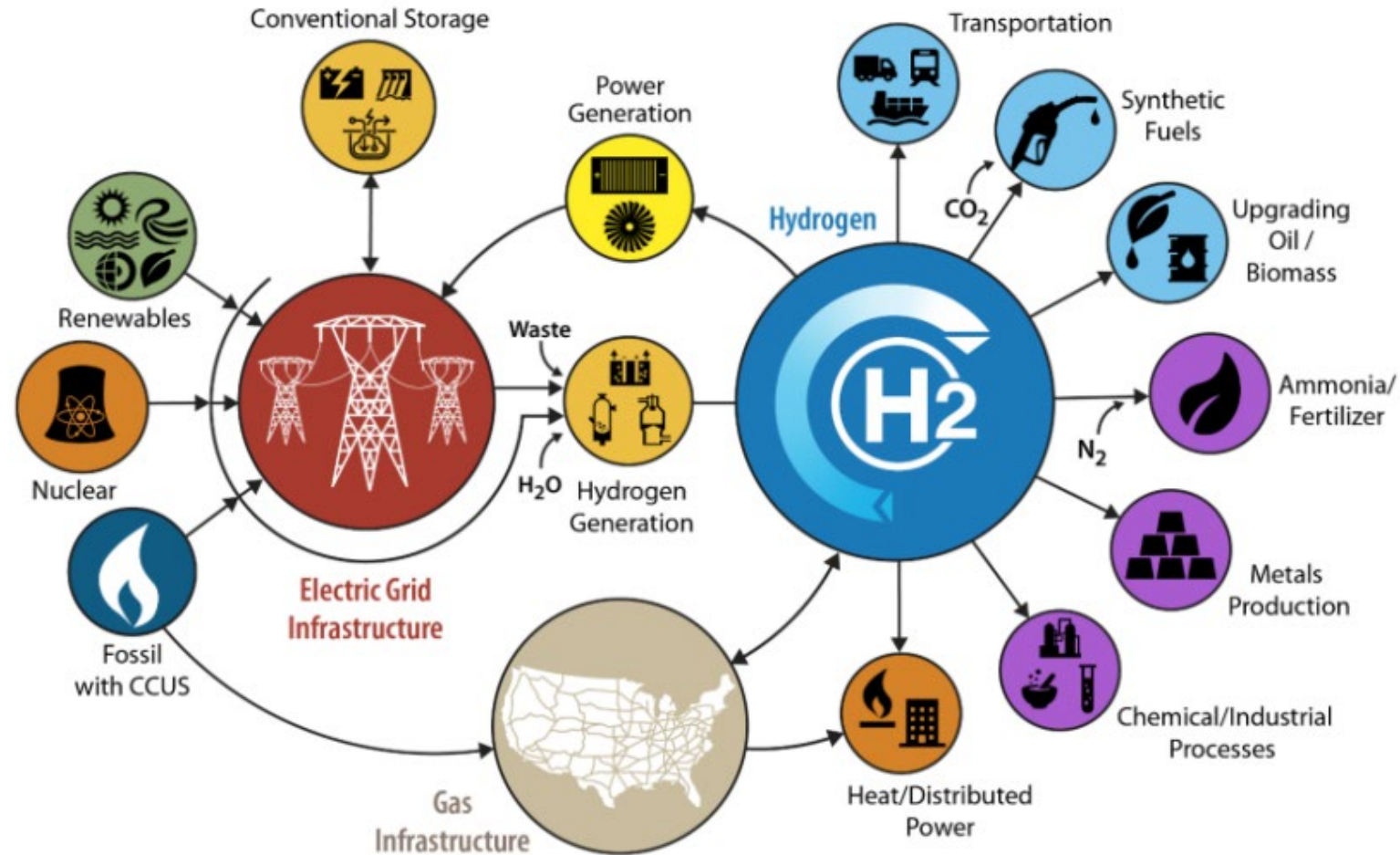
Jaimie Levin
Director West Coast Operations
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The Rise of Hydrogen Fuel Cells in Transportation
SFT Webinar Series
Dec 1, 2022

Hydrogen – What is all the excitement about?



Source: U.S. Department of Energy.

Hydrogen is the link between the power, gas and transportation energy infrastructure

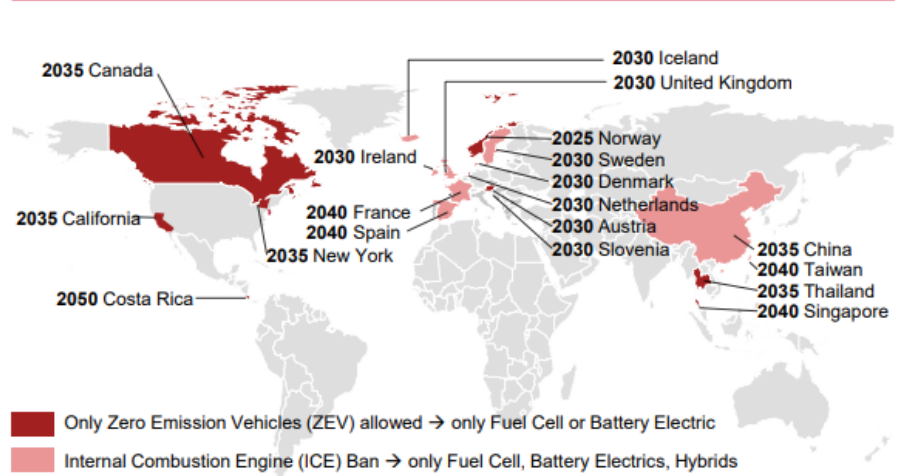




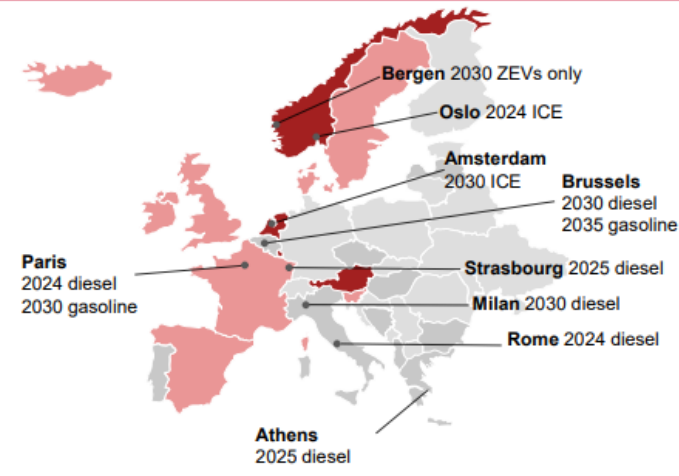
2. Analyst insights

Globally countries are committing to sustainability goals and planning to phase out new sales of pure ICE vehicles

Planned ICE - Registration Bans and ZEV only allowances around the world*



European Cities which are planning an ICE - vehicle phase out*



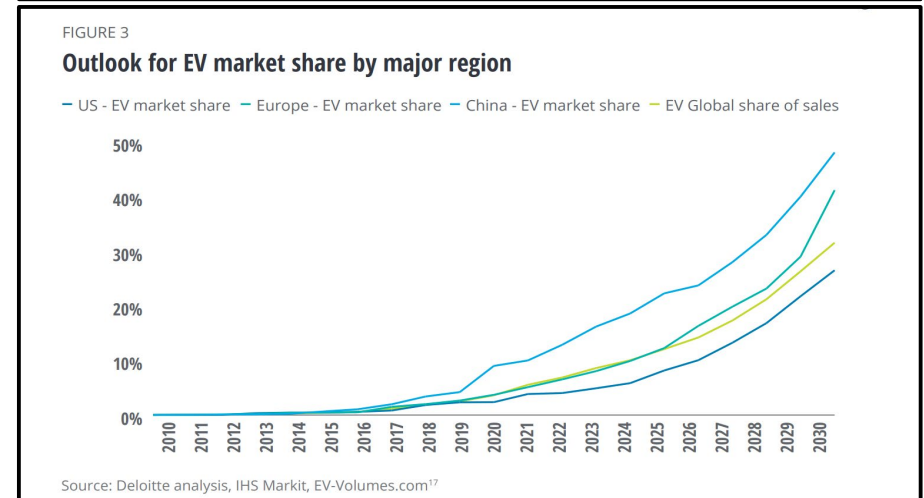
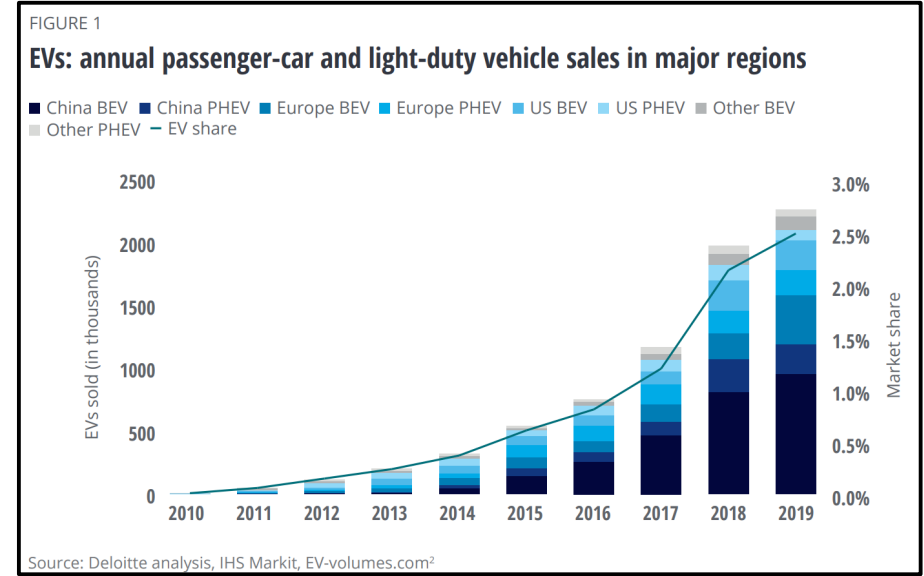
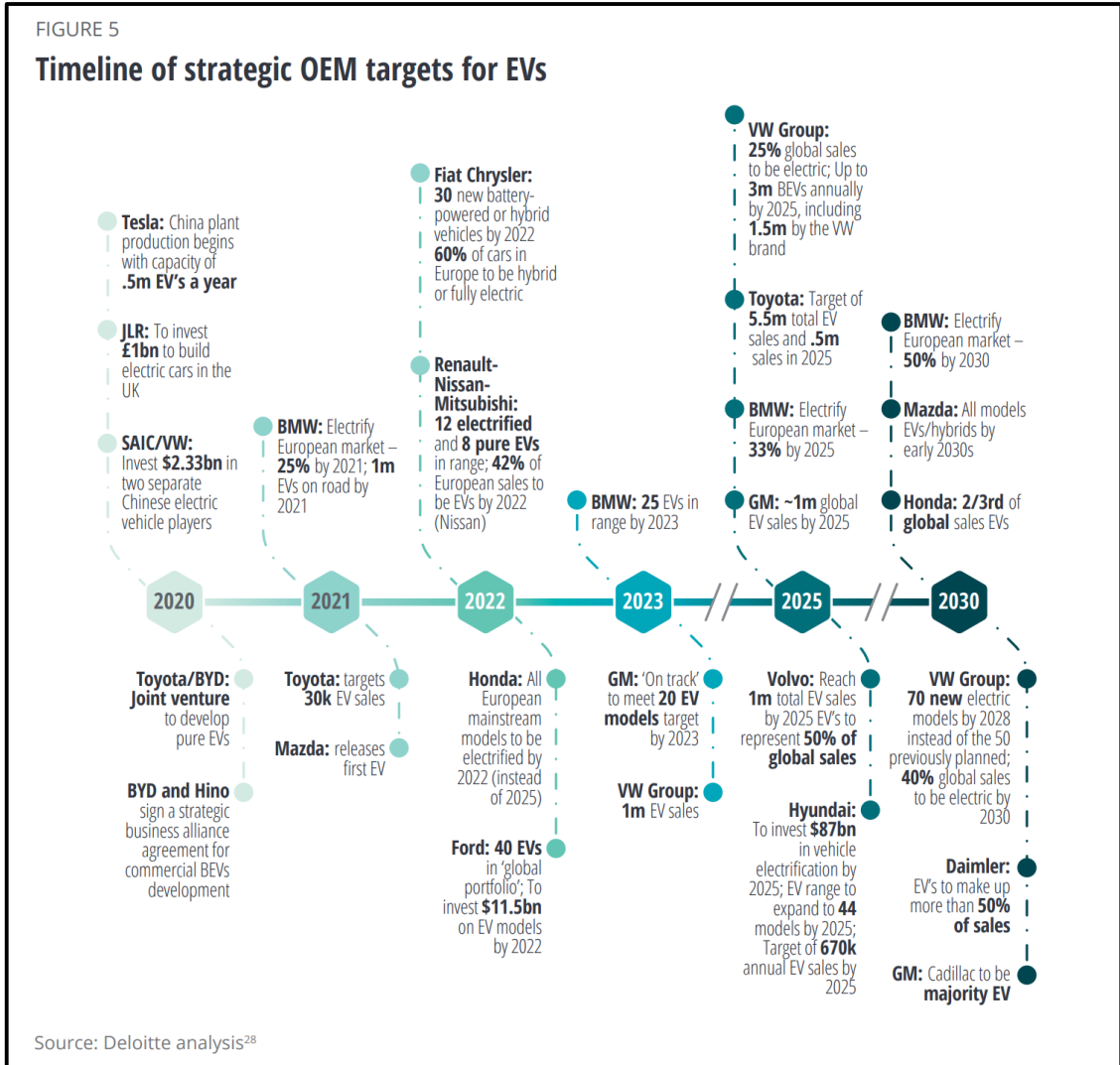
19 | National and sub-national governments **worldwide** set a target to ban Internal Combustion Engines or allow only Zero Emission Vehicles



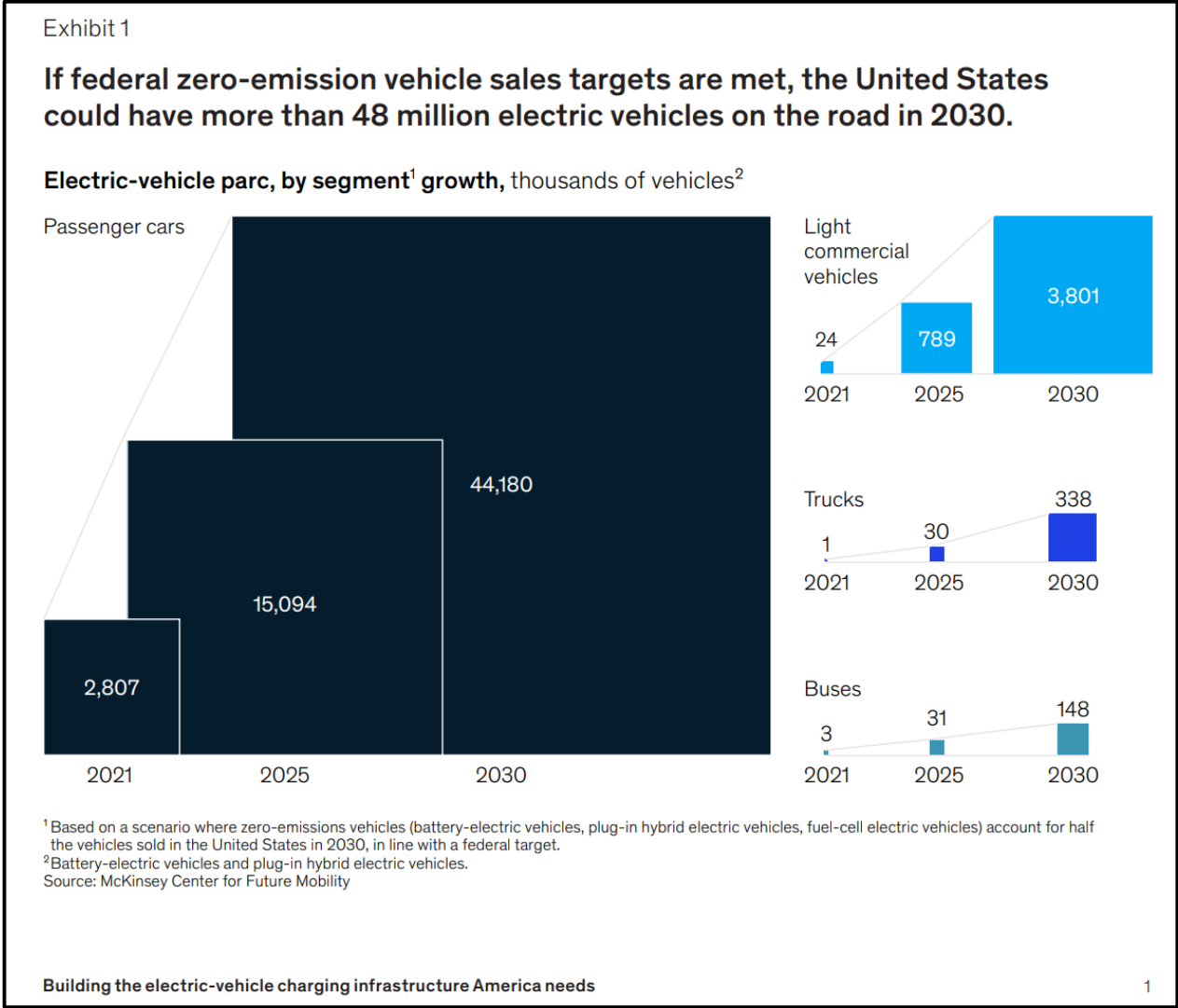
9 | Countries within **Europe** have already announced a ban on the internal combustion engine and/ or certain types of fuel



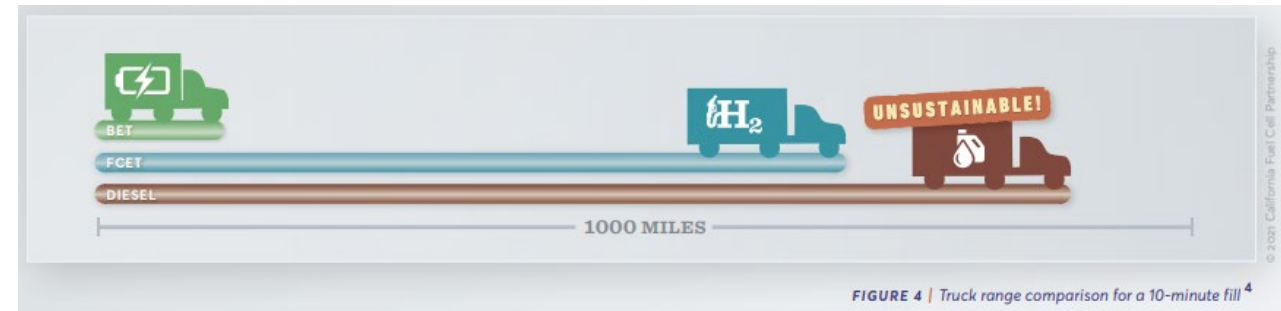
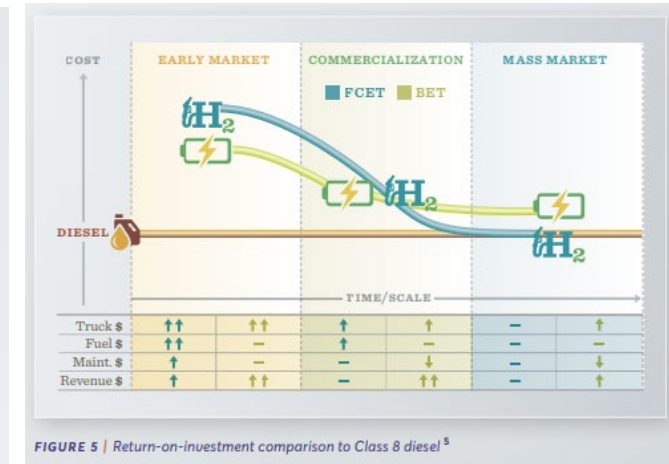
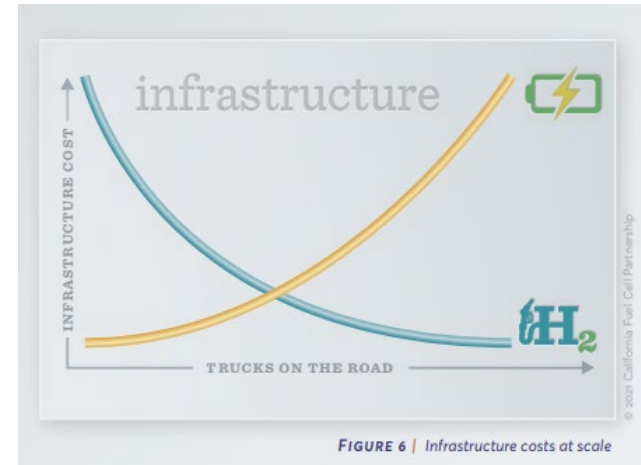
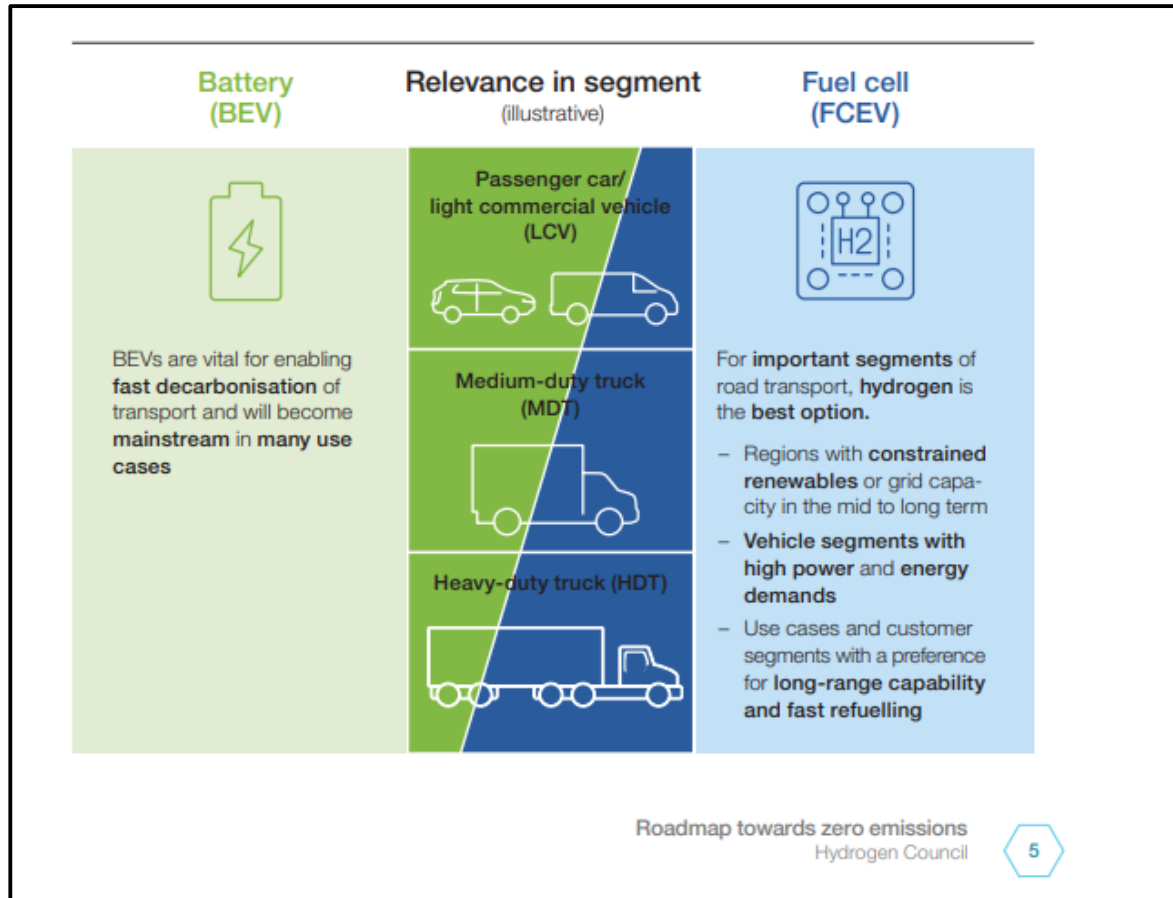
March to Zero Emission Mobility



March to Zero Emission Mobility



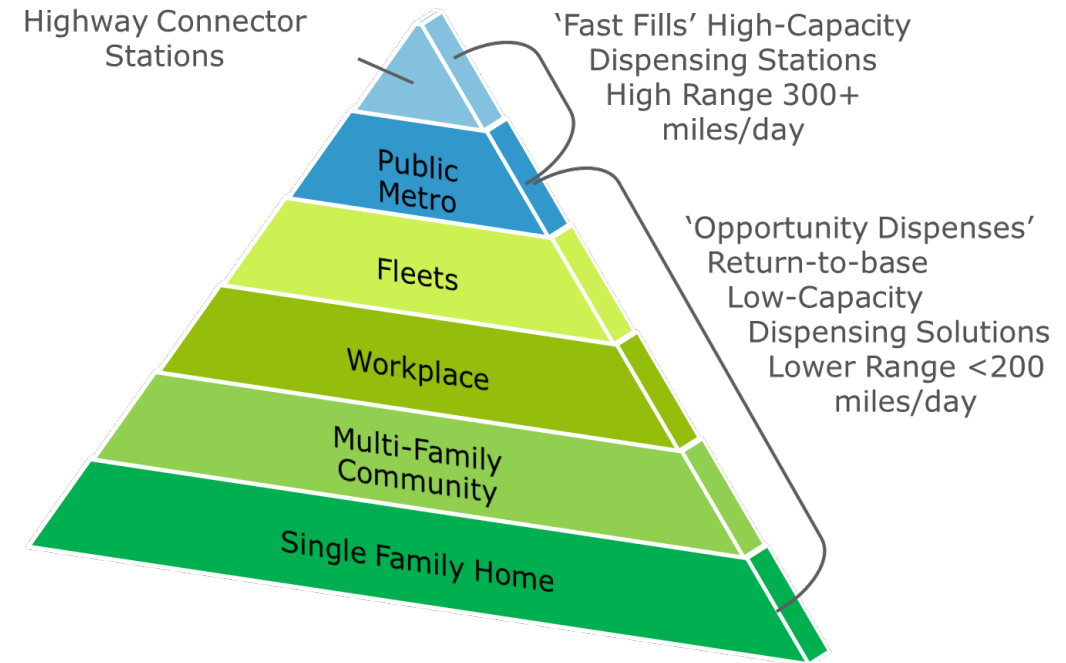
March to Zero Emission Mobility- "AND" Solution



Fuel Cells have a role in the MDT and HDT truck and bus markets



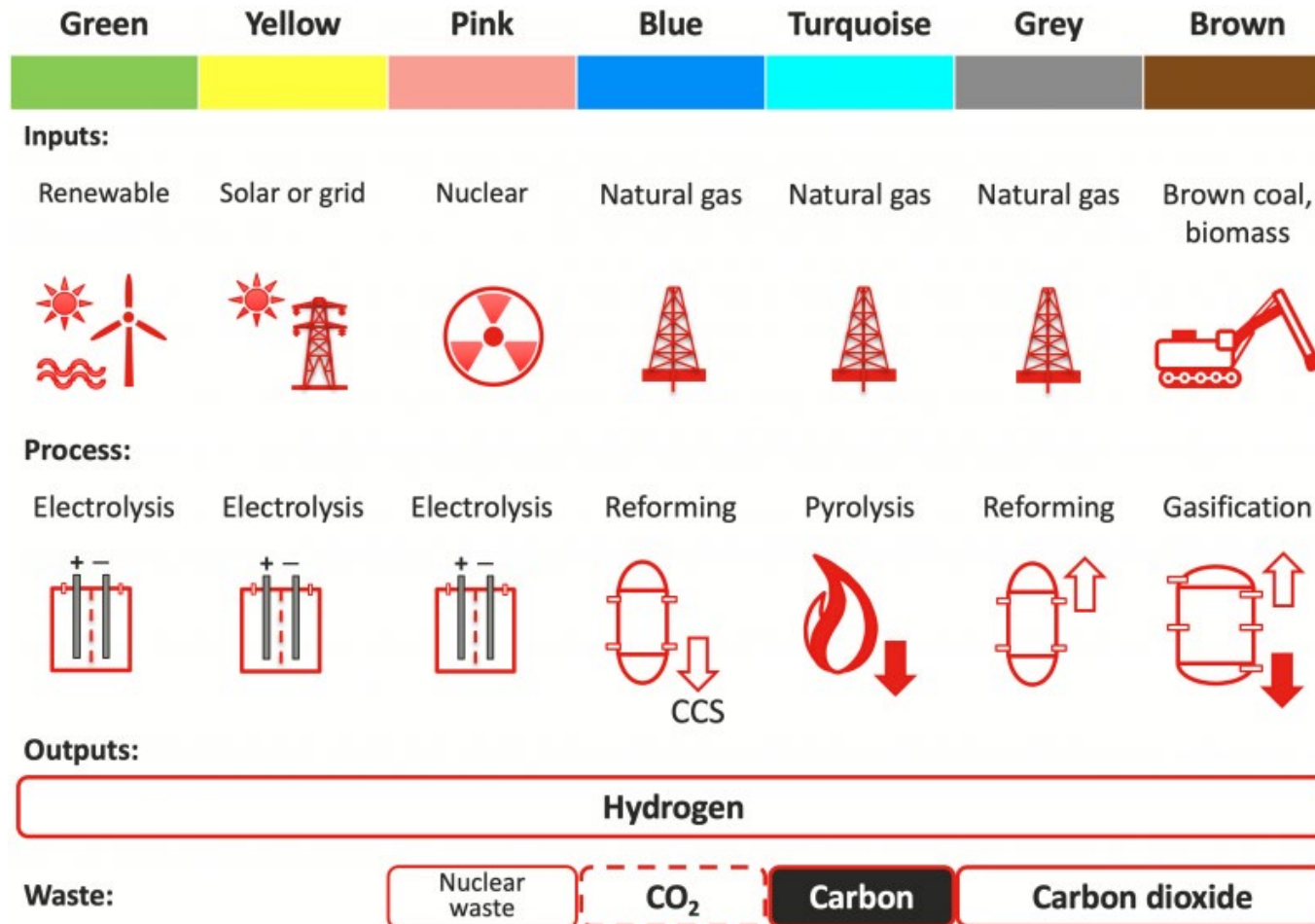
E-Infrastructure will be Rate-Limiting



A synchronized launch of infrastructure and fleets provides the most practical business solution



Hydrogen Production – Colors

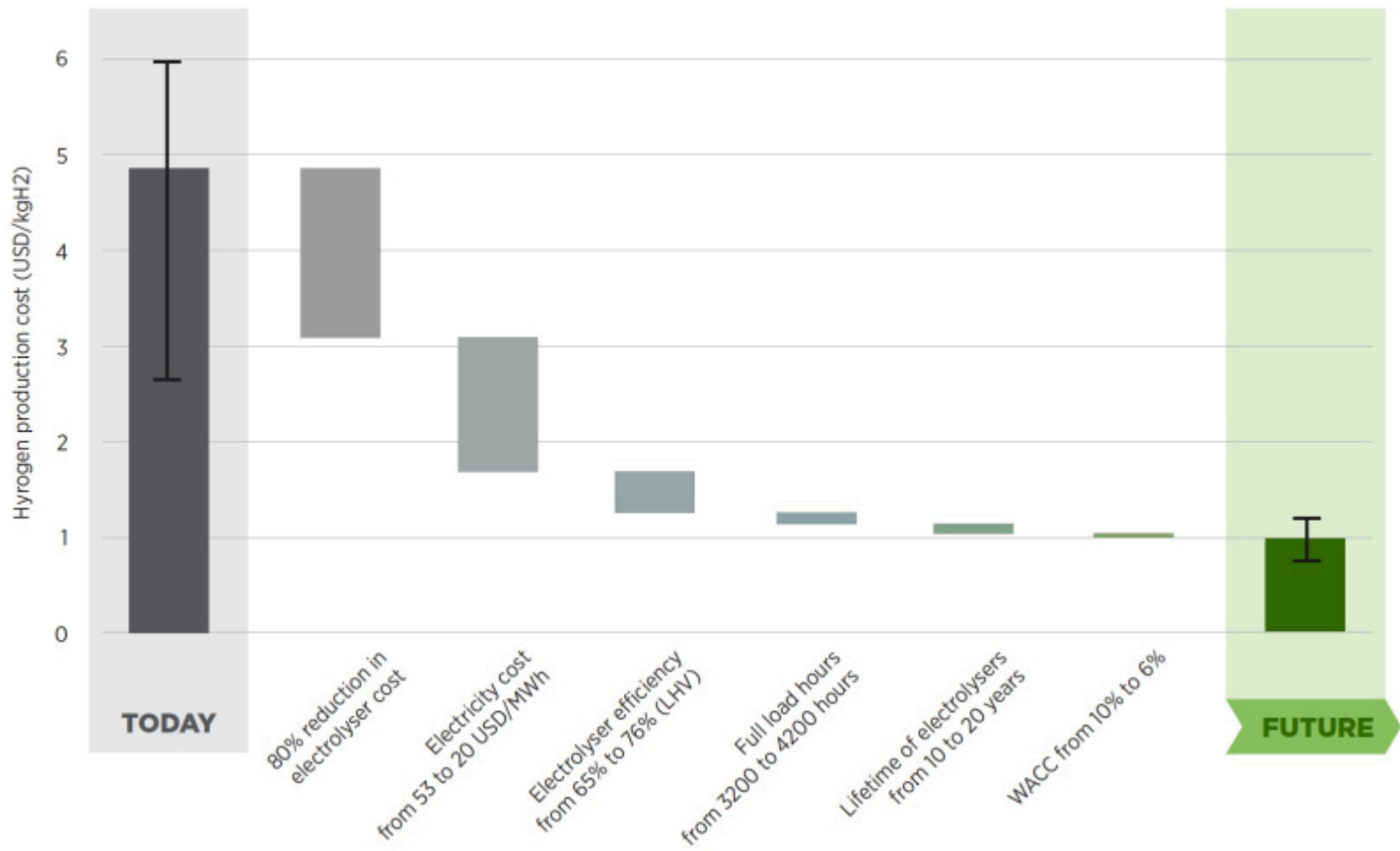


<https://broadleaf.com.au/resource-material/the-colour-of-hydrogen/>

Important to understand this – incentives based on the ‘renewable’ content of the Hydrogen



Green Hydrogen – Cost Roadmap



A combination of cost reductions in electricity and electrolysers, combined with increased efficiency and operating lifetime, can deliver 80% reduction in green hydrogen cost. Source: IRENA

\$1/kg of H2 will be a disruptive change in the markets



E-Mobility – Other Considerations



Fleet's provide an Enabling Entry Point



- Transition Roadmaps – it is a journey so plan for it
- Optionality – ability to change or course correct
- Resiliency – what is the back up?
- Hybridization – both vehicles and infrastructure



Transit & HD Truck Market

Both Battery (BEV) and Hydrogen (FCEV) have a Role – Hybrids



*The future of e-fuels infrastructure is a **Hybrid Hydrogen and Charging Station** that leverages the benefits of each technology to maximize environmental benefits while enhancing value to the customer*



Location
Boston, MA

Application
Hyundai Nexo FCV / Ioniq BEV

Green Hydrogen
Rooftop solar / energy storage



www.ivysinc.com
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Foothill Transit's Zero-Emissions Journey

Roland M. Cordero
Director of Maintenance and Vehicle Technology



Foothill Transit

About Foothill Transit

- Pomona and San Gabriel Valleys (eastern Los Angeles County)
- 327 sq. mi service area, 1.5m service pop.
- 12.6 Million boarding's per year, 43,000/day
- 36 local and express routes.
- 328 CNG buses, 31 electric buses.
- Innovation is part of our core mission.



We're going all electric by 2030!



LET'S CLEAR THE AIR

Foothill Transit has led the charge in sustainable transportation for years. It's why we were the **FIRST IN THE COUNTRY** to put fast-charge electric buses on the roads. It's why we consistently monitor and measure the environmental impact of everything we do. And it's why we're committed to operating a **100% ELECTRIC BUS FLEET BY 2030**. Because we believe in guilt-free trips. In exploring the earth - not exploiting it. And that with your help, we can make **SAVING OUR PLANET** as simple as going for a ride.



BEB Experience

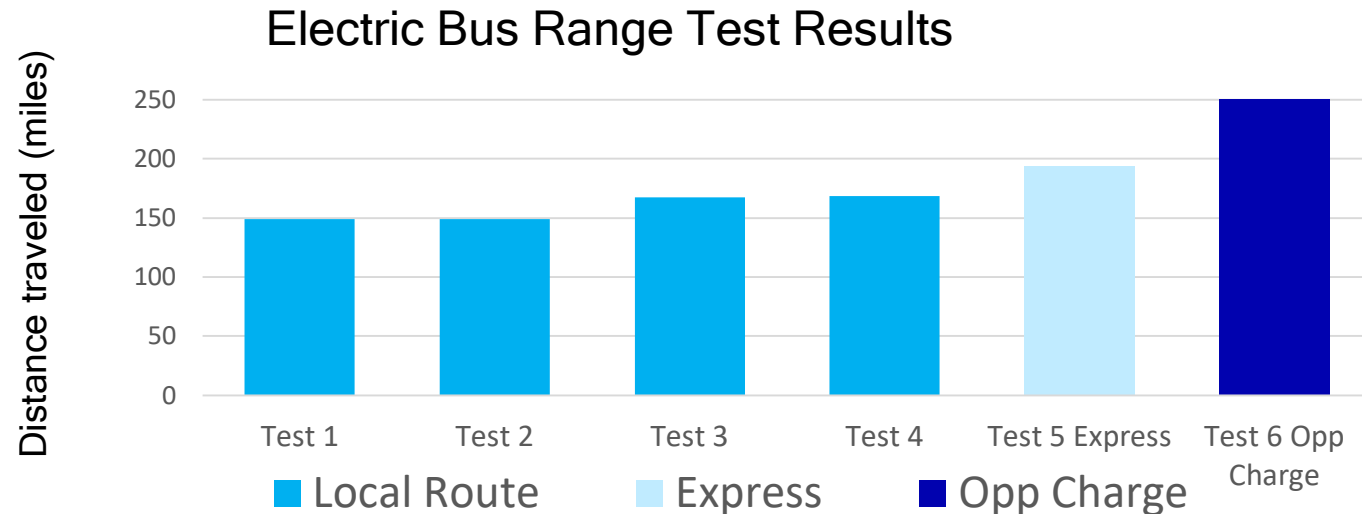
- 12 years experience
- Limited Range
- Demanding charging requirements
- Operational impacts
- High cost of in-route chargers
- High cost of technology parts



Foothill Transit

BEB Range Testing

- Four tests on local routes average 159 mile range
- Results varied from 149 to 168 miles.
- Express line test, 194 miles
- Opportunity charge, 250 miles
- Battery level 100% -> 10%





Existing and Future Depot Operational Assessment

- \$120 M to electrify entire fleet
- Not one to one bus replacement
- Buses will be charged when returning to the depot.
 - Overnight charging will be the bottleneck in the future
 - Charged buses will move to parking area and another bus will be charged
- Only electrify 60% of bus routes



Battery Electric Bus and Fuel Cell Electric Bus Fleet Comparison

Credits and Incentives

BEB Rebates & Incentives

LCFS credit revenue at \$100 / Ton

HVIP Rebate; \$120,000 / BEB

SCE 50% charger rebate

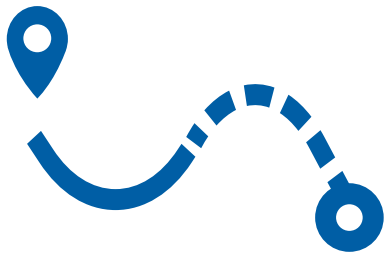
FCEB Rebates & Incentives

LCFS credit revenue

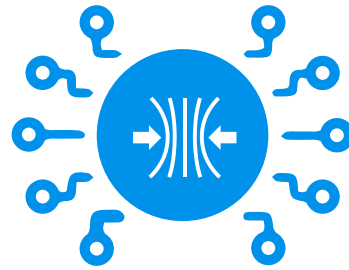
HVIP Rebate; \$270,000/ FCEB

Fuel rebates (N/A)

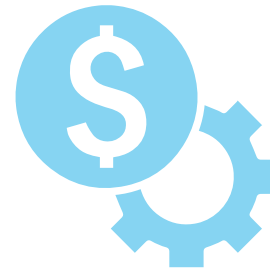
Why Fuel Cell?



Vehicle Range



System
Resiliency



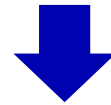
Infrastructure
Cost



Vehicle
Fueling Process

Current Plans

Proof of Concept (Line 486 deployment)



Resiliency – Fleet Mix



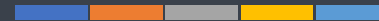
Lifecycle Cost Comparison vs. BEB



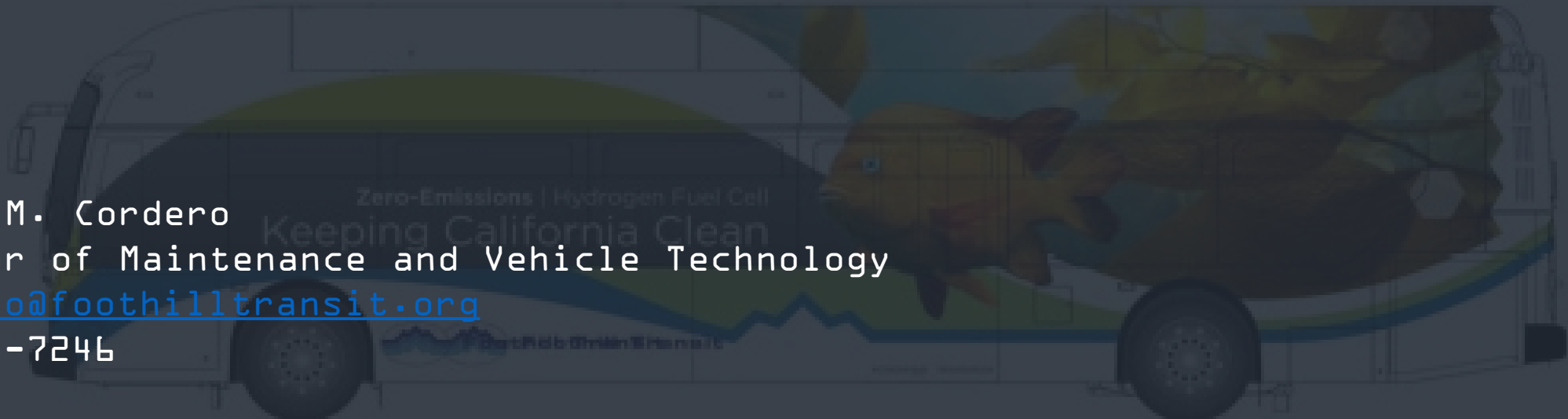


Foothill Transit

THANK YOU



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Hydrogen Fuel Cell Deployments Transforming The Heavy-Duty Transportation Sector to ZERO



Jaimie Levin

Director of West Coast Operations
Center for Transportation & the Environment



About CTE



- **Who We Are: 501(3)(c) non-profit** engineering and planning firm
- **Our Focus: Zero-Emission** Transportation Technologies
- **Our Mission:** Improve the **health of our communities and the planet**
- **Portfolio - >\$800 million; 117 Active Projects** totaling over **\$316 million**
- **National Presence**
Atlanta, Berkeley, Los Angeles, Minneapolis/St. Paul

100 CTE Members



Leadership Circle Members



Members

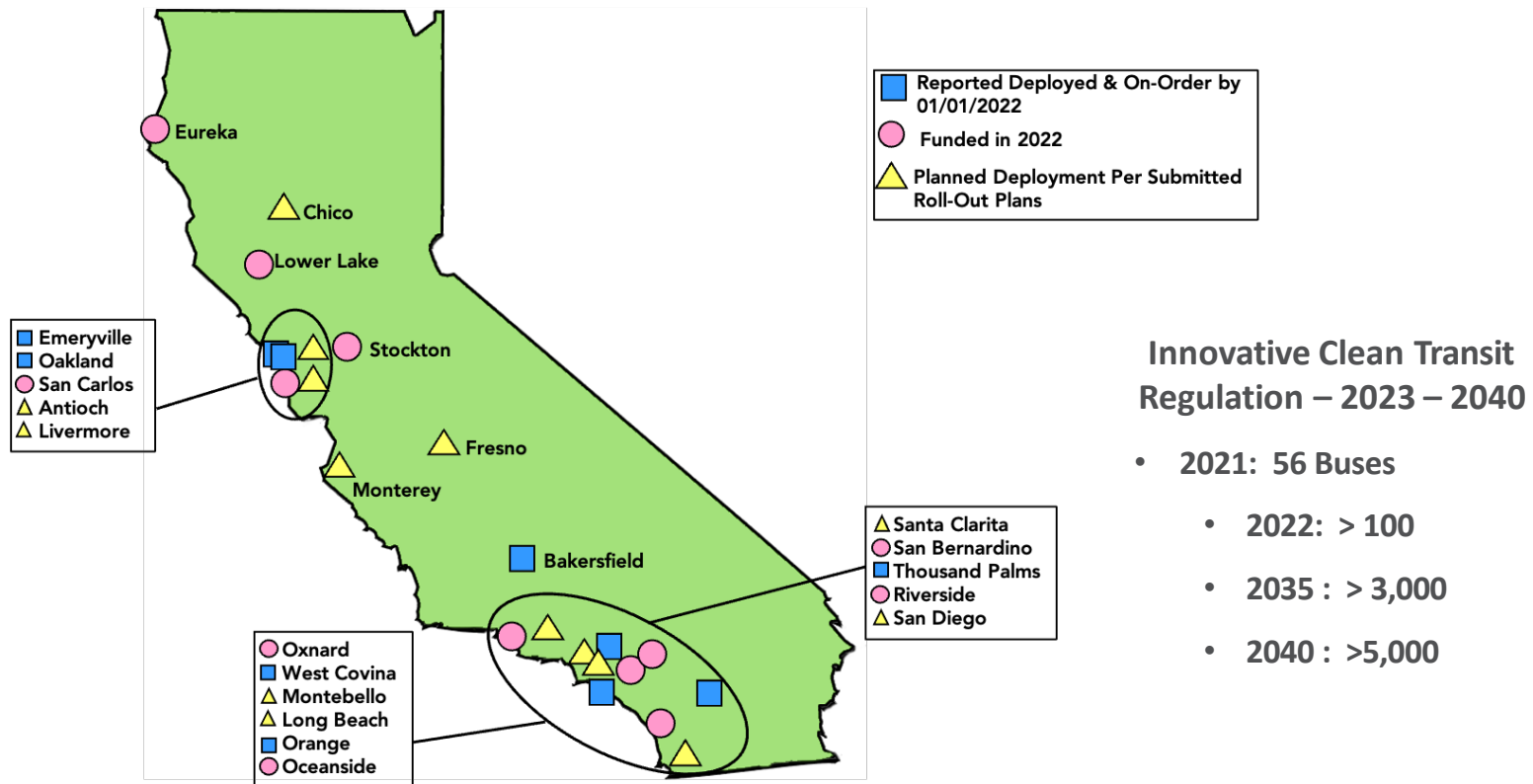


Fuel Cell Electric and H₂ Projects

- Class 6 UPS Trucks
- Class 8 Trucks
- Marine Cargo Top Loader
- 40' and 60' Transit Buses
- HD and LD H₂ Stations



Fuel Cell Bus Deployments in California



Innovative Clean Transit Regulation – 2023 – 2040

- 2021: 56 Buses
 - 2022: > 100
 - 2035 : > 3,000
 - 2040 : >5,000

NorCAL ZERO Project – \$54 million

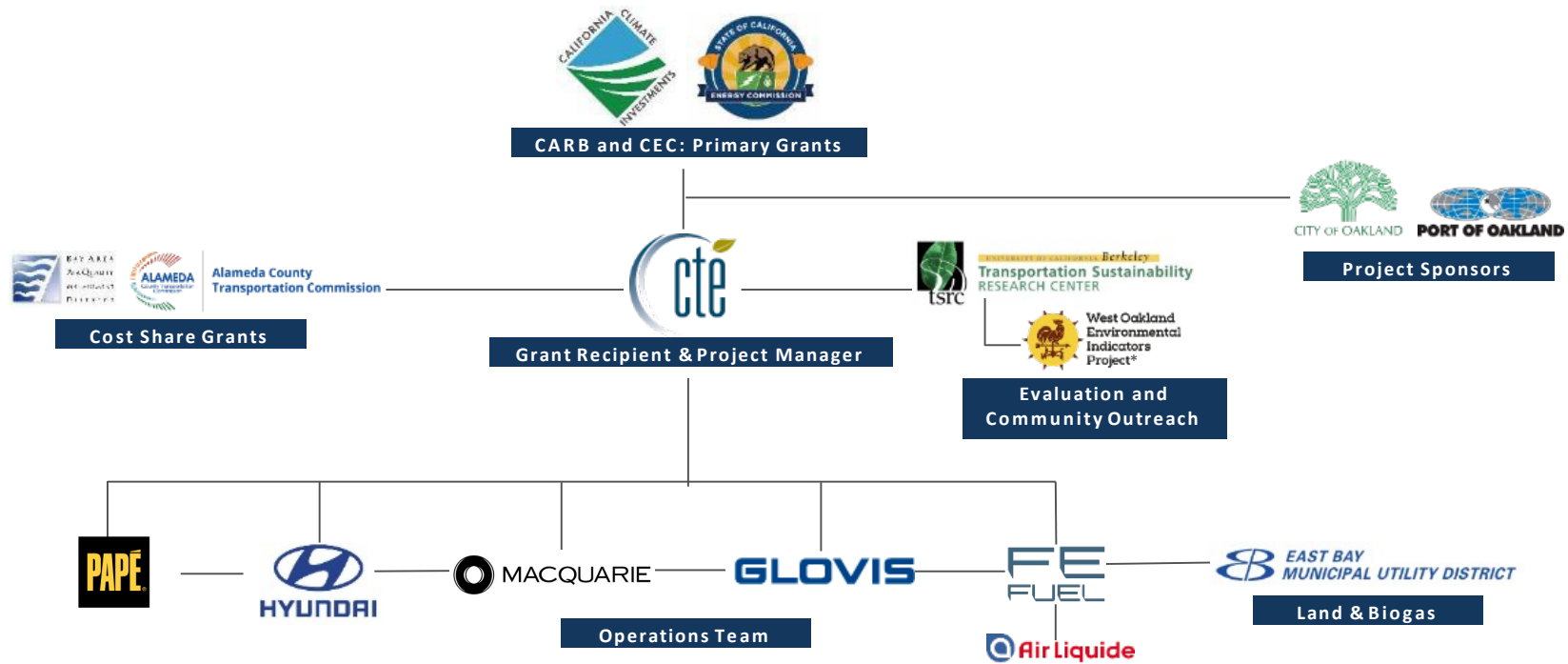


- **Goal: To Demonstrate Commercial Viability of FCETs to Fleet Operators**
- **30 Fuel Cell Electric, Class 8 Drayage Trucks Operating from Port of Oakland**
 - Range of up to 500 miles
- **Hydrogen Fueling Station @ EBMUD in Oakland**
 - 10- to 20-minute 60 kg fills; Up to 60 trucks
- **Service and Repair Facility: Papé KW in San Leandro**
 - Local Workforce

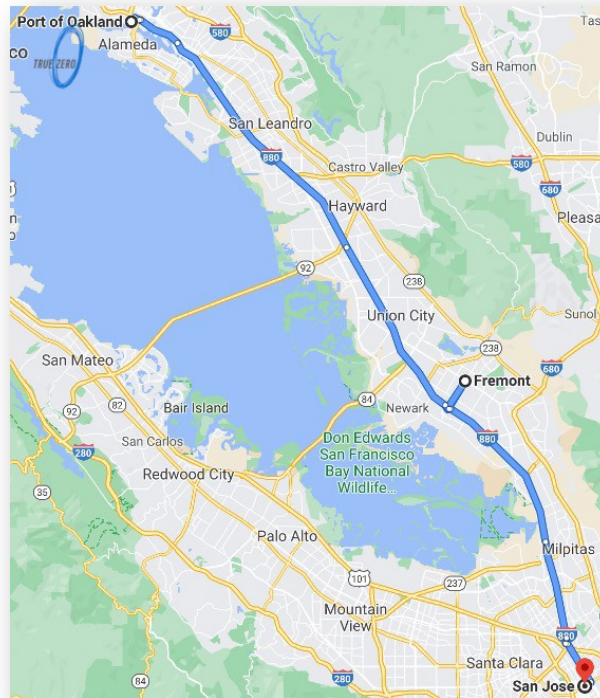
Date	Milestone
June 15, 2023	Trucks fully deployed
June 14, 2024	Conclude 1-Year Performance Evaluation
June 14, 2029	Six Years of Truck Service



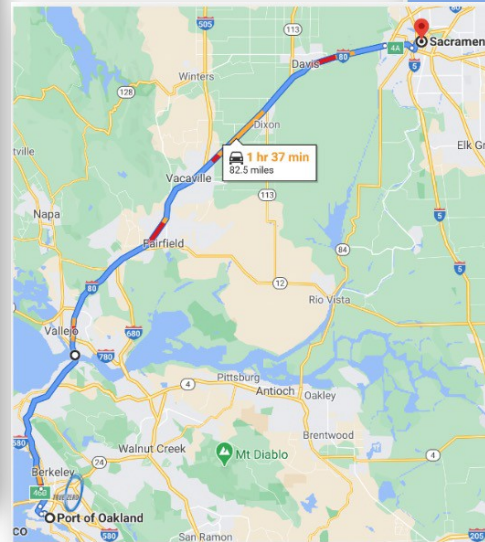
NorCAL ZERO Project Team – 16



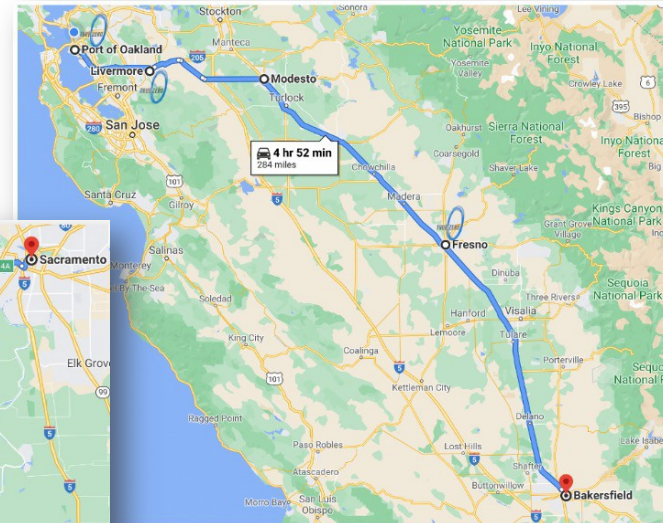
Truck Duty Cycle



Bay Area



Sacramento



Central Valley

Fuel Cell Electric Truck Benefits



Fuel cells are the perfect fit for heavy duty trucks & long driving distances

HYUNDAI

Refueling Time
Just 8 - 12 min
(20 min US truck target)

Range
Up to 500 miles for US 6x4 tractor
About 250 miles
Swiss 4x2 Cargo
No big impact
by low ambient temperatures

Payload
Similar to Diesel
*Expected weight difference
BE Vs FCE truck +4 ton (+8,800 lbs.)

Xcient

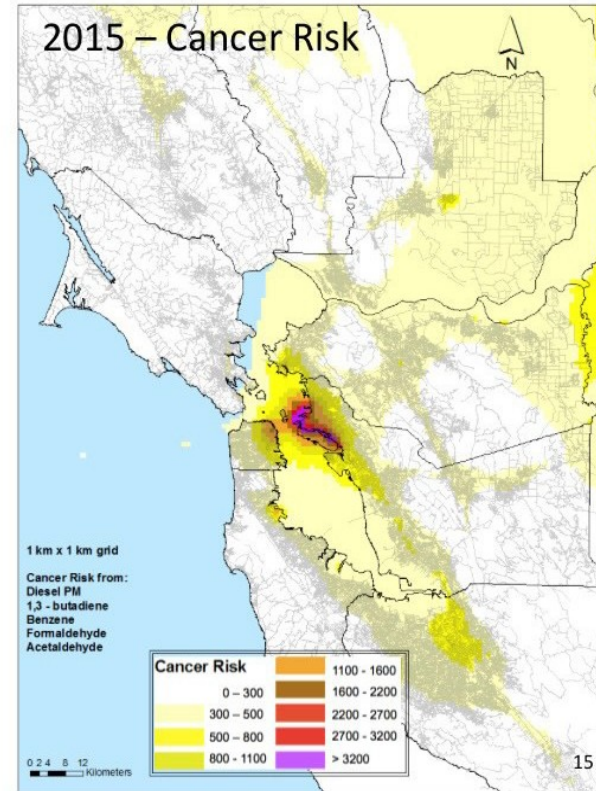
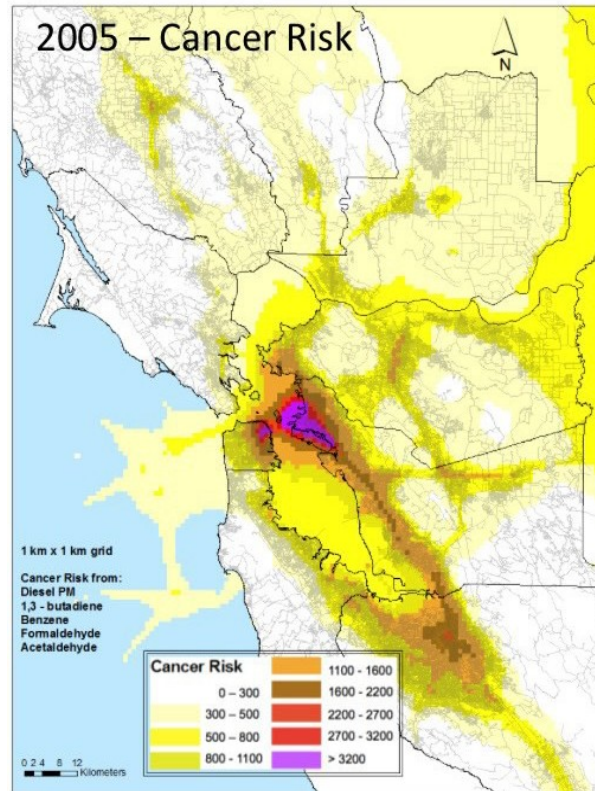
Hydrogen Sourcing



- 54% Renewable Feedstock and Carbon Intensity of Zero
- Fuel Cells are Agnostic to The Sources of Hydrogen
- Ultimate Goal: 100% Renewable and Carbon Intensity of Zero
- Fuel Cell Trucks will play a key role in distribution of fuel



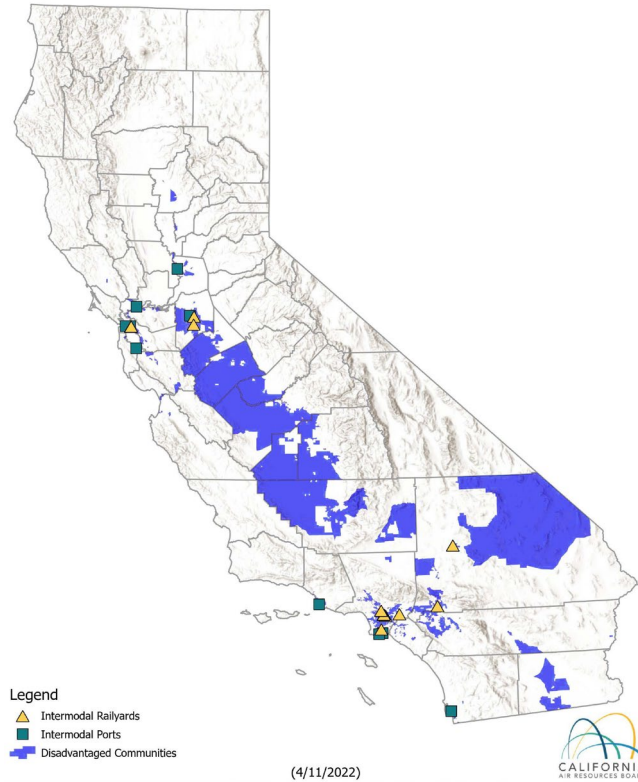
Benefits to Disadvantaged Communities



Class 8 Truck Deployments



Intermodal Ports and Railyards in California

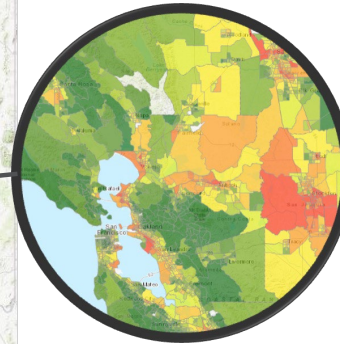
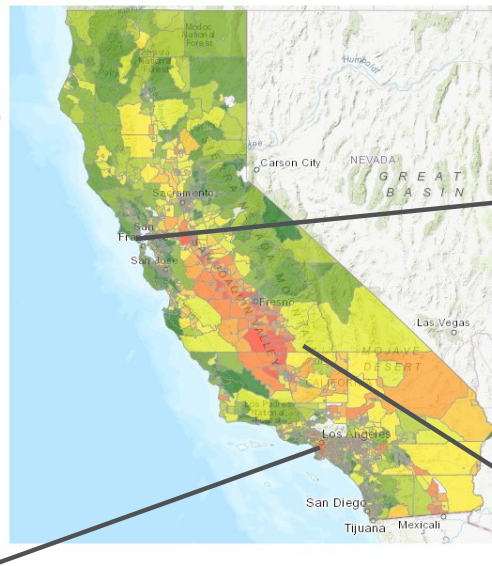
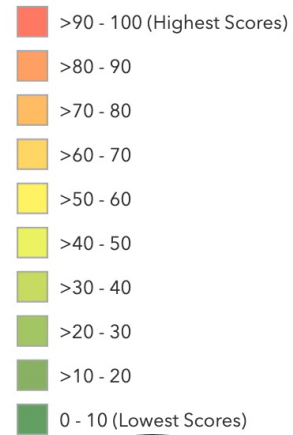


Benefits to Disadvantaged Communities

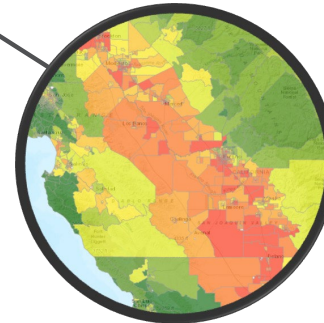


Overall Percentile

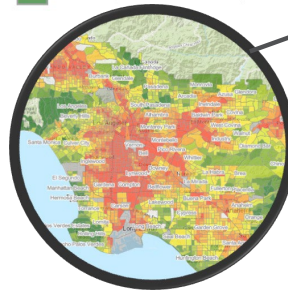
CalEnviroScreen 4.0 Results



Bay Area: I-80/580



Central Valley: I-5



Southern California: I-10

Swiss Deployment



- 46 Trucks in 2021
- More than 3 Million Zero Emission Miles
- Very Low Downtime
- 1,600 units deployed by 2025



California ZEV Goals



“To meet the ambitious goals set by Governor Newsom in **Executive Order N-79-20** to transition all medium- and heavy-duty trucks in California to zero-emission vehicles in the next 15 to 25 years.”

2035 – 100% Truck Sales will be Zero Emission

2035 – 100% of In-Service Drayage Trucks will be Zero Emission

2045 – 100% of In-Service MD/HD Trucks will be Zero Emission

Transit – 100% of In-Service Transit Buses will be Zero Emission

Advanced Clean Truck Rule



Advanced Clean Trucks (ACT)

- Manufacturers must sell ZEVs as a percentage of sales*
- Approved June 2020
- Begins with 2024 model year
- Credit for sales start in 2021
- Minimum tractor sales
- Flexibility to shift sales between categories
- One-time fleet reporting

Model Year (MY)	Class 2b-3	Class 4-8	Class 7-8 Tractors
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%
2033	45%	65%	40%
2034	50%	70%	40%
2035+	55%	75%	40%



*Partial credit for near-zero emissions vehicles (NZEVs). NZEVs are plug-in hybrids with minimum all electric range

Proposed Drayage Truck Regulation

- Require Class 7-8 drayage trucks operating at California's seaports and intermodal railyards to be Zero-Emission Vehicles (ZEVs) by 2035
- Includes a phased-in approach for drayage trucks beginning in 2024



Key Industry Challenges & Opportunities



- **Lack of Commercially Available FCEV Options:**
 - *Investment in trucks/port/off-road vehicle demonstrations*
- **Lack of Available Refueling Infrastructure:**
 - *Investment in refueling infrastructure to support larger vehicle deployments*
- **High TCO:**
 - *Scaling vehicle, fuel production*
- **Technology Readiness:**
 - *Range improvements, weight reductions*





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