

CARB Heavy-Duty & Off-Road Hydrogen and Fuel Cell Activities

2019 DOE FCTO Annual Merit Review

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Innovative Clean Transit Rule

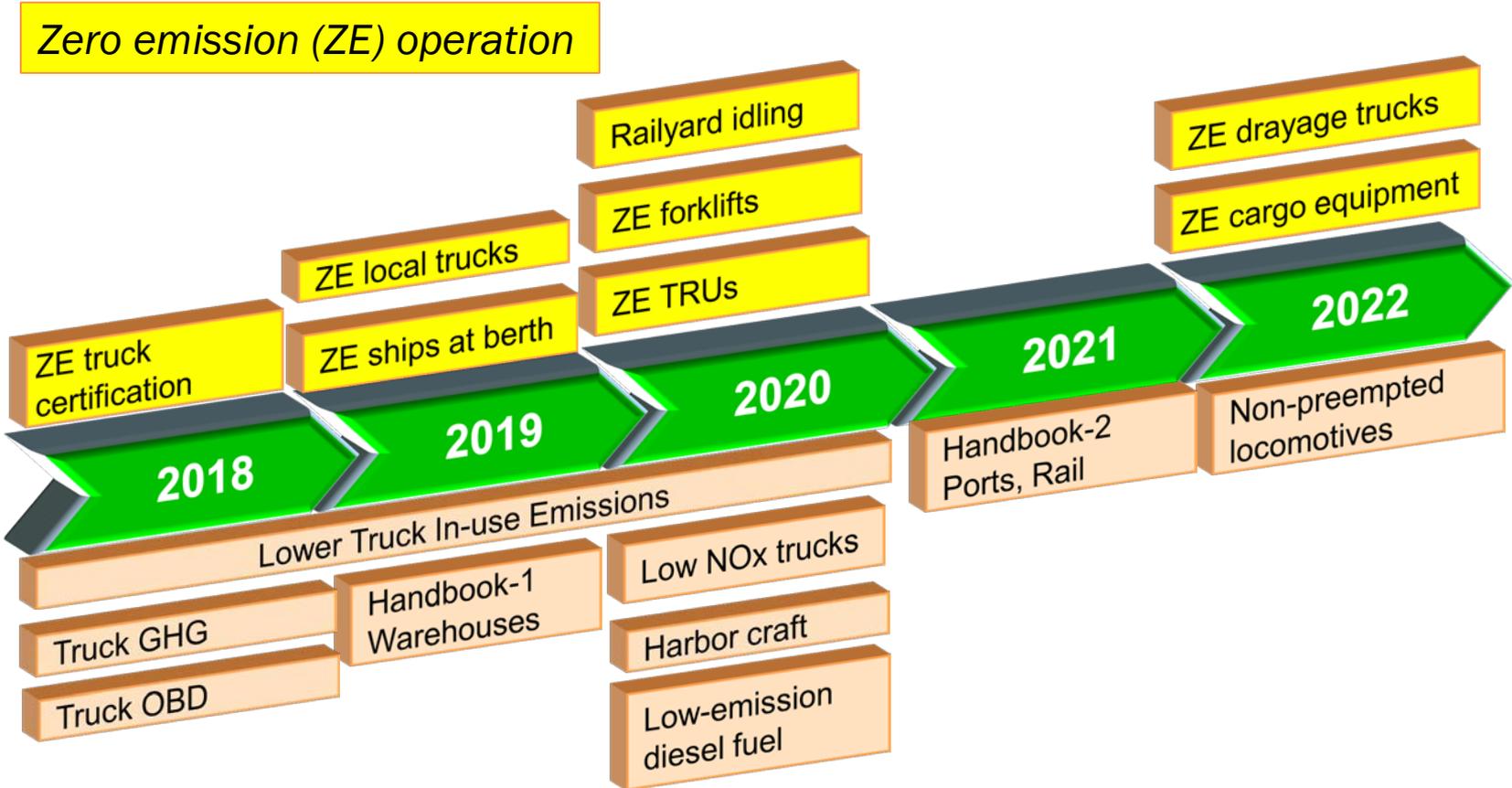
- Approved December 2018
- Zero-Emission Bus Roll-out Plans due:
 - Large transit agencies: June 30, 2020
 - Small transit agencies: June 30, 2023
- Early ZEB purchases count towards future compliance

Year	ZEB Percentage of Annual Total New Bus Purchases	
	Large Transit Agency	Small Transit Agency
2023	25%	-
2024	25%	-
2025	25%	-
2026	50%	25%
2027	50%	25%
2028	50%	25%
2029 & after	100%	100%



<https://arb.ca.gov/msprog/ict/ict.htm>

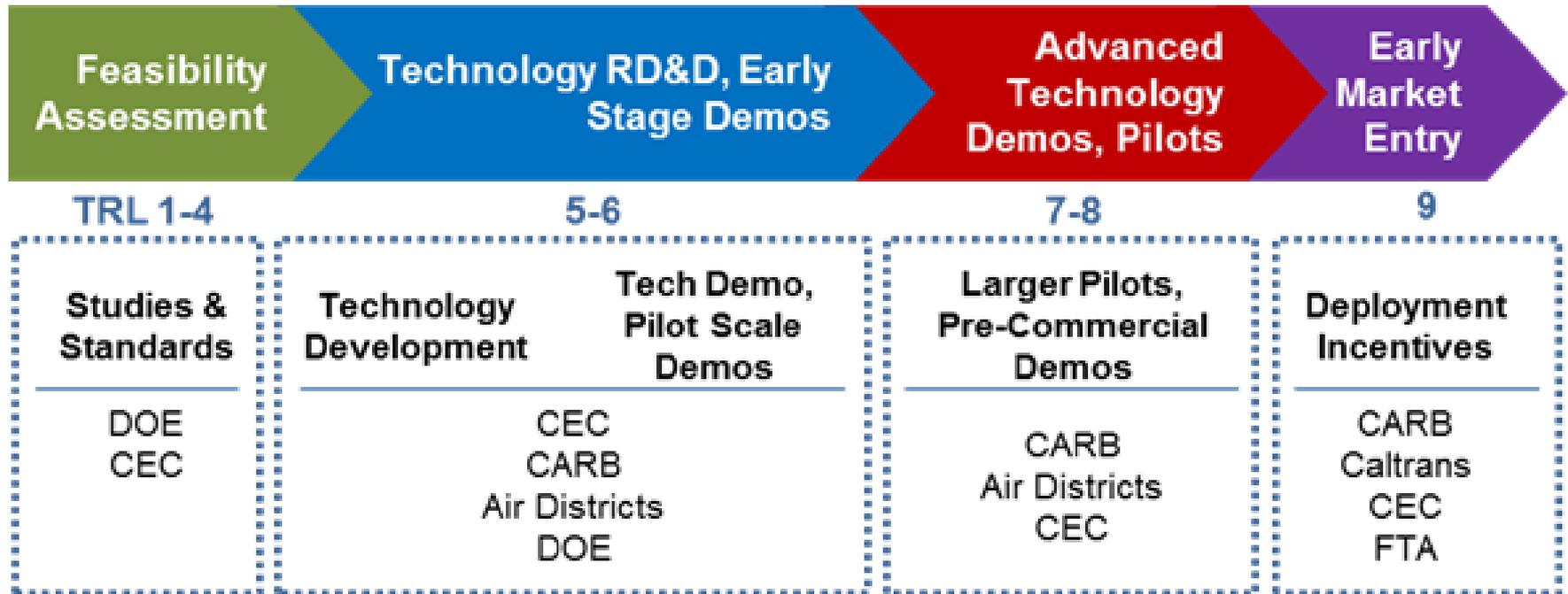
New CARB Rules to Cut Pollution from Freight



Lower emissions

Timeline shows Board consideration

Investing to Advance Technology



- Incentives accelerate technology advancement and reward early adopters ahead of pending regulations
- Regulations complement incentives
- Focus on disadvantaged communities

Clean Technology Vouchers

Hybrid and Zero-Emission Voucher Incentive Project (HVIP)

- Established in 2010: Over 6,800 vouchers and \$326M committed (3/1/19)
- Transit, school and shuttle buses; utility and delivery trucks (zero-emission, hybrid and low NOx)
- Up to \$300K for FC truck or bus plus \$100K/bus for station
- First fuel cell bus voucher delivered in March 2019
- CaliforniaHVIP.org

Clean Off-Road Equipment Voucher Incentive Project (CORE)

- Initiated in 2018
- Zero-emission yard trucks, large forklifts, ground support equipment, TRUs and rubber tire gantry cranes
- Funding available later in 2019



Volkswagen Mitigation Trust

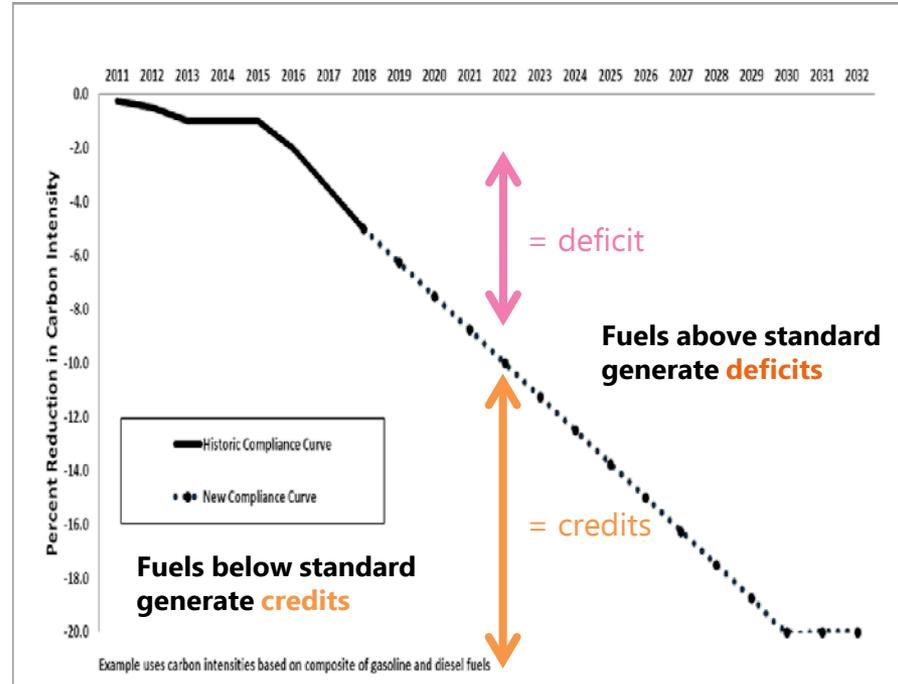
- California's allocation: **\$423 million**
- Approved Beneficiary Mitigation Plan details 5 funding categories, 4 are open to hydrogen & fuel cell technology:
 1. **\$130M** for Zero-emission transit, school and shuttle buses (up to \$400,000 for a FCEB)
 2. **\$90M** for Zero-emission Class 8 freight and port drayage (up to \$200,000 for a FCET)
 3. **\$70M** for Zero-emission freight/marine (competitive)
 4. **\$5M** for light duty H2 infrastructure
- Funding available statewide starting this summer
- ww2.arb.ca.gov/vwmitigationtrust



Low Carbon Fuel Standard (LCFS)

- Reduce carbon intensity (CI) of transportation fuel 20% by 2030
- Fuel providers can opt-into LCFS to generate credits for using lower-carbon fuels
- Credits have monetary value and can be traded in the LCFS market.
- For more information:

<https://www.arb.ca.gov/fuels/lcfs/lcfs.htm>



Bus/Fuel Type	Example CI ⁽¹⁾	Annual Credit Value ⁽²⁾
FCEB using H2 from generic LCFS lookup table pathway	120	\$8,702
FCEB & H2 from zero-CI electrolysis	10	\$24,949

1. CIs shown are for illustrative purposes and subject to change.
2. Based on 6.5 mi/kg FCB fuel efficiency, \$200/MT LCFS credit value, and 40,000 mi/year

H2 and Fuel Cell Pilot and Demonstration Projects

- Greenhouse Gas Reduction Funds for Low Carbon Transportation
 - 10 of 30 projects (\$112M) awarded since FY 2014-15 involve hydrogen and fuel cell technology
 - SunLine, AC Transit and Orange County Transit
 - 25 FECBs and 3 hydrogen stations/or upgrades
 - 10 Class 8 trucks – Kenworth/Toyota – Port of Los Angeles
 - 2 large capacity Shell hydrogen stations in Wilmington and Ontario
 - 5 Class 8 plug-in hybrid fuel cell trucks
 - 19 fuel cell delivery vans – 2 projects with UPS
 - Fuel Cell Ferry – Golden Gate Marine
 - 2 fuel cell 242,000 lb. capacity yard trucks
 - Electric top loader with fuel cell and wireless charging
 - Fuel cell yard truck and battery yard truck: side-by-side comparison



Pilot Commercial Deployment Projects

SunLine FCEBs & On-Site Hydrogen Generation

- Funding: \$12.6M grant, \$17.8M total
- Thousand Palms, Coachella Valley
- 5 NewFlyer Xcelsior® XHE40 Buses
 - 40' FCEBs, standard propulsion system
 - Ballard FCveloCity-HD 85kw modules
- Nel Hydrogen Production/Fueling Station
 - Modular PEM electrolyzer
 - 900 kg/day, 350 bar – 30 buses
 - Complete turnkey solution
- Buses delivered January 2019
- Station complete August 2019



Pilot Commercial Deployment Projects

Fuel Cell Electric Bus Commercialization Consortium

- Funding: \$22.3M grant, \$45.5M total
- 20 NewFlyer Xcelsior® XHE40 Buses

10 buses to Orange County (Southern CA)	10 buses to AC Transit (SF Bay Area)
Trillium/Air Products <ul style="list-style-type: none"> • Delivered LH2 • 1,750 kg/day - up to 50 buses • Service bay upgrade • Commissioning in May 2019 	Messer, LLC – Station upgrade <ul style="list-style-type: none"> • Delivered LH2 • 1,050 kg/day – up to 30 buses • Commissioning in Dec. 2019
First 2 buses accepted, all buses to be deployed in June 2019	



Demonstration Projects

Port of Los Angeles Shore-to-Store

- Funding: \$41.1M grant, \$82.5M total
- 10 hydrogen fuel cell Class 8 trucks
 - Kenworth truck w/ Toyota FC technology
 - 60 kg on-board storage
 - Developed in partnership with California Energy Commission, DOE and SCAQMD
- Two large-capacity H2 refueling stations
 - Wilmington and Ontario, California
 - Delivered gas, 1500 kg/day capacity, 700 bar
- First truck delivered summer 2019
- Stations complete spring 2020



Demonstration Projects

Fast Track Fuel Cell Truck

- Funding: \$5.1M grant, \$6.8M total
- 5 plug-in hybrid fuel cell electric Class 8 trucks
 - 3 trucks – update existing EV Navistar chassis, Hydrogenics fuel cells
 - 2 trucks – Peterbilt glider, Loop Energy fuel cells
- Drop-and-swap mobile tube trailers and chargers at Port of LA and Fontana
- Demonstration partners: TTSI and Daylight Transport
- Project complete: Spring 2020



Demonstration Projects

Fuel Cell Hybrid Electric Delivery Van

- Funding: \$4.3M grant, \$9.5M total
- UPS in Ontario and surrounding areas
- 15 FC hybrid delivery vans
 - Retrofitting existing UPS vans
 - Based on prototype built in partnership with DOE and CEC
 - Integration by Unique Electric Solutions
 - Hydrogenics 30kw fuel cell engines
- Goal: develop fuel cell retrofit kit
- Complete: Spring 2021



The University of Texas at Austin

Center for Electromechanics

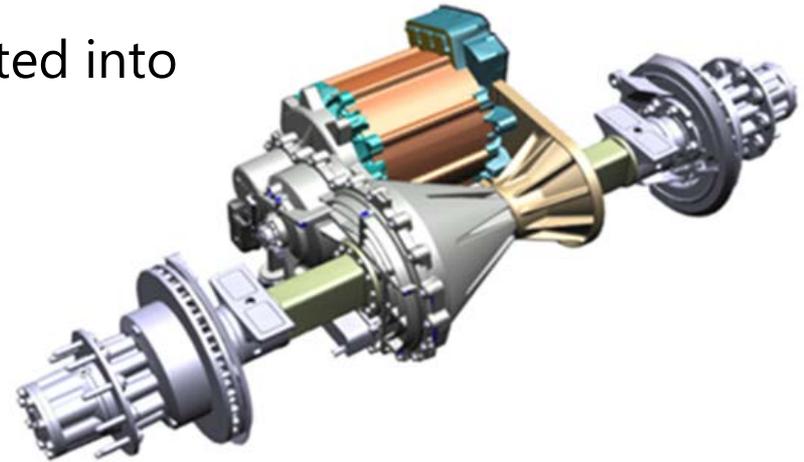
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Demonstration Projects

Next Generation Fuel Cell Delivery Van

- Funding: \$5.8M grant, \$11.7M total
- UPS in Ontario and surrounding areas
- 4 FC hybrid electric delivery vans
 - Linamar - Gen 2.0 eAxle design integrated into new Ford F-59 chassis
 - Ballard - 30kw fuel cell engines
- Goal: develop FC retrofit kit
- Complete: Spring 2021



Demonstration Projects

Zero-Emission Hydrogen Ferry

- Funding: \$3M grant, \$5.5M total
- Fuel cell ferry – 22 knots top speed and up to 84 passengers
 - BAE Systems – electric propulsion system
 - Hydrogenics – three 120kw fuel cells
 - On-board H2 storage for 2 days of operation
 - Air Liquide - 350 bar tube trailer at dock
- Ferry operational in September 2019
- Project complete in Spring 2020.



Demonstration Projects

Fuel Cell Hybrid Electric Top Loader

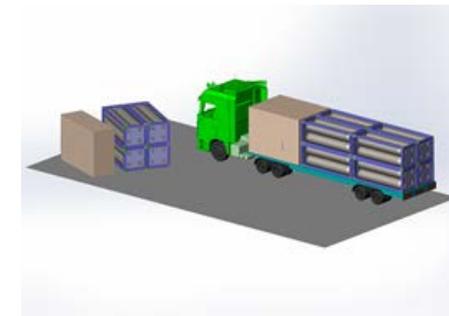
- Funding: \$6.5M grant, \$15.4M total
- Electric top loader demonstration
 - Hyster-Yale – build and integrate
 - Nuvera – two 45kW fuel cell engines
 - WAVE – two 250kW wireless charging systems
- Mobile refueler to provide hydrogen
- Fenix Marine Services will operate yard trucks in Port of LA
- Project complete: Spring 2020



Demonstration Projects

Hybrid Fuel Cell Yard Truck

- Funding: \$5.8M grant, \$12.1M total
- 2 hybrid fuel cell 242,000 lb capacity yard trucks
 - BAE Systems powertrain-270hp, 3800 ft-lb torque
 - Ballard FCveloCity-HD 85kw fuel cell modules
 - 20 kg on-board H2 storage @ 350 bar
- HTEC stationary-placed mobile tube trailer
 - 400 kg storage at 450 bar
 - 2 kg/min dispensing
- TraPac will operate yard trucks in Port of LA
- Project complete: Spring 2021



Demonstration Projects

Port of Long Beach Off-Road Technology Demonstration

- Funding: \$5.3M grant, \$8.3M total
- 3 battery electric top handlers (Taylor and BYD)
- Electric yard truck side-by-side comparison

Battery Electric	Fuel Cell Electric
Kalmar & Transpower	CNHTC* and Loop Energy
931 kW LiFePO ₄ battery pack	56kW PEM fuel cell
70 kW charging station	Air Products mobile fueler

* China National Heavy Duty Truck Group Co. (CNHTC)

- SSA Marine will deploy yard trucks at Pier E in Port of Long Beach
- Project complete: Spring 2020



