

Medium/Heavy Duty & Marine Applications for Hydrogen and Fuel Cells in California

DOE H2 and FC Technical Advisory Committee
November 4, 2019

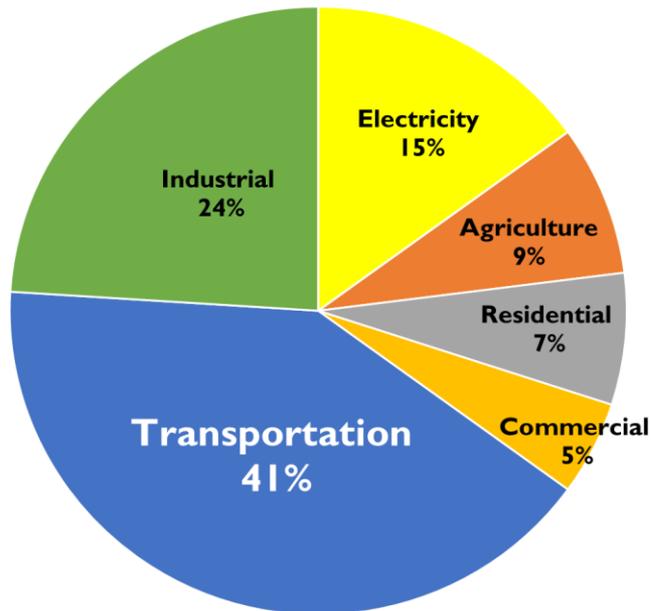
Leslie Goodbody

Air Resources Engineer
916.323.2961
leslie.goodbody@arb.ca.gov

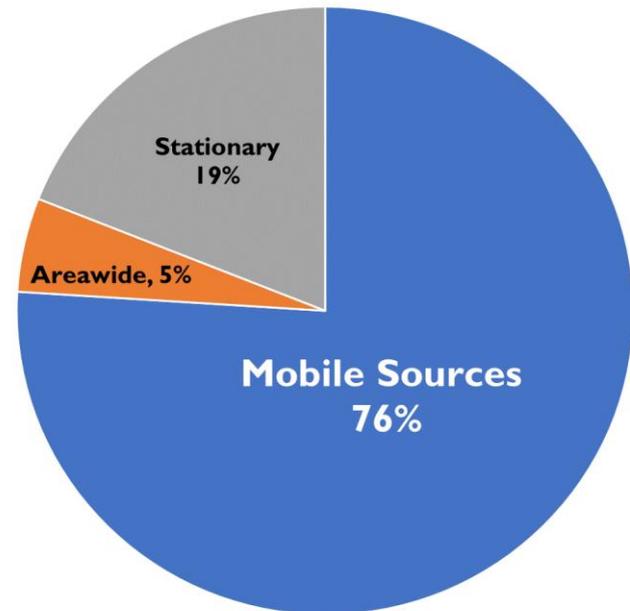


Transportation is the Largest Source of Emissions in CA

California GHG Emissions (2017)



California NOx Emissions (2017)

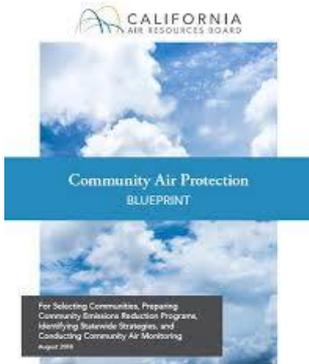


Cleaner Combustion Is Not The End Goal

Integrated approaches – Planning, Regulations, Investments

- **Planning:**
 - Coordination of statewide efforts between regions and agencies
 - Comprehensive and complementary measures
- **Regulations:**
 - Multi-pollutant approaches
 - Provide long-term market signals
- **Investments:**
 - Enhance markets with strategic public incentive and investment programs

Integrated Transportation Planning



Community Air Protection Blueprint

- Reduce exposure in communities most impacted by air pollution



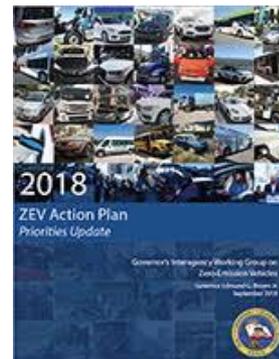
Climate Change Scoping Plan

- Strategy for achieving 2030 GHG target
- Strengthen existing major programs
- Further integrates efforts to reduce both GHGs and air pollution



Sustainable Freight Action Plan (2030 targets)

- Increase freight system efficiency by 25%
- 100,000 ZEVs and equipment



ZEV Action Plan

- 1.5 million ZEVs by 2025
- Expand charging/fueling
- Leverage national markets
- Government to lead by example



Mobile Source Strategy (2031 NOx targets)

- Zero-emission everywhere possible (on-road and off-road)
- Near zero everywhere else



Heavy-Duty Vehicle and Port/Marine Regulations

Adopted and Pending On-Road ZEV Regulations

Innovative Clean Transit – fleet requirement

- Starting in 2023 – 25% of annual new bus purchase must be ZEBs (large TAs), 100% by 2029 (all TAs)
- ZEB Roll-Out Plans due June 2020 for large TAs, June 2023 for small
- Early purchase counts toward future compliance
- <https://arb.ca.gov/msprog/ict/ict.htm>



Zero-Emission Airport Shuttle – fleet requirement

- Phased in fleet turn-over beginning in 2027 (33%)
- Full implementation in 2035
- 2022- Annual fleet reporting
- <https://ww2.arb.ca.gov/our-work/programs/zero-emission-airport-shuttle>

Zero-Emission Powertrain Certification – manufacturer requirement

- Required for medium and heavy duty vehicles model year 2026 and later
- Support advanced-technology measures and ensure performance and reliability
- <https://ww2.arb.ca.gov/our-work/programs/zero-emission-powertrain-certification>



Advanced Clean Trucks (Pending) - manufacturer requirement

- Manufacturer ZE truck sales requirement for 2024-2030 MY
- Large companies and fleets must report on vehicle operations and trucking service contracts
- Board hearing December 12-13, 2019, final vote in spring 2020
- <https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks>

Pending Freight and Marine Regulations



Ocean-Going Vessels at Berth – Reducing emissions at berth

- Amend regulation to require more visits, vessel types, and ports
- Hold ports, terminals and tech providers accountable
- Solutions include shore power and emissions capture & control
- Board date: December 5, 2019
- <https://ww3.arb.ca.gov/ports/shorepower/shorepower.htm>

Commercial Harbor Craft

- Focus on cleaner combustion for in-use and new engines
- Support introduction of zero-emission technologies wherever possible
- Next public meetings: late 2019
- <https://ww2.arb.ca.gov/our-work/programs/commercial-harbor-craft>



Cargo Handling Equipment

- Focus on Transition to full zero-emission technologies
- Phase-in anticipated to begin in 2026+
- Next public meetings: TBD
- <https://ww2.arb.ca.gov/our-work/programs/cargo-handling-equipment>



Incentive Funding

Demonstration Projects

Greenhouse Gas Reduction Fund

Funded Hydrogen and Fuel Cell Projects

10 of 30 projects (\$112M) awarded since FY 2014-15 involve hydrogen and fuel cell technology

- SunLine Transit, 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 HD 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



GGRF Demonstration Project

Zero-Emission Hydrogen Ferry

- Funding: \$3M grant, \$5.5M total
- Water-Go-Round Fuel cell ferry
 - 22 knot top speed
 - Up to 84 passengers
 - BOE Systems: 2x 100kW electric motors
 - Hydrogenics: three 120kw fuel cell
 - H₂: 242 kg on-board H₂ at 250 bar
 - 100 kW Li-ion battery
 - 350 bar tube trailer at dock



GOLDEN GATE
ZERO
EMISSION MARINE



Sandia
National
Laboratories

Cap and Trade
Dollars at Work



GGRF Demonstration Project

Zero-Emission Hydrogen Ferry

The *Water-Go-Round* will be on the water in early 2020 and will operate for at least 3 months in trials

Planned uses during the trial:

- Commuter ferry
- Excursion/tour boat
- Research/survey vessel
- Package/freight delivery
- Crew boat



GGRF Demonstration Project

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 November 2019
- Stations complete September 2020



GGRF Demonstration Project

Fuel Cell Hybrid Electric Top Loader

- Funding: \$6.5M grant, \$8.8M total
- Electric top loader demonstration
 - Hyster-Yale – build and integrate
 - Nuvera – two 45kW fuel cell engines
 - WAVE – 250kW wireless charging system
- Mobile refueler to provide hydrogen
- Fenix Marine Services will operate the top loader in Port of LA
- Project complete: Spring 2021



GGRF Demonstration Projects

Commercialization of POLB Off-Road Technology (C-Port)

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

Battery Electric	Fuel Cell Electric
Kalmar & Transpower	CNHTC* and Re-Fire
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)

- Long Beach Container Terminal will deploy yard trucks at Port of Long Beach (POLB), Pier E
- Project complete: Spring 2020



GGRF Future Demonstration Funding

Fiscal Year 2019-2020 Heavy-Duty Investments

- Proposed \$40 million allocation for competitive projects:
 - Zero-emission drayage truck pilot (\$20M)
 - Large-scale deployments of 50+ zero-emission drayage trucks at one or two fleets
 - Ships-at-berth bonnet system (\$10M)
 - Capture and treat criteria pollutant emissions from OGVs at ports
 - Inducement prize (\$10M)
 - Compete to achieve technological goal in winner-takes-all format
- CARB to consider adopting FY 2019-20 Funding Plan at October Board meeting (Oct. 24)
- Proposed Funding Plan available at www.arb.ca.gov/aqip





Incentive Programs

Commercial and Other Incentives

Clean Technology Vouchers

Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)

- Established in 2010: ~7,500 vouchers issued through 6/30/19
- Wait list now with new funding available in January 2020
- Zero-emission trucks and buses; ePTOs and plug-in hybrids
- Up to \$300K for fuel cell truck or bus
- First fuel cell bus voucher delivered in March 2019
- CaliforniaHVIP.org



Clean Off-Road Equipment Voucher Incentive Project (CORE)

- Launched this year
- Finalizing Implementation Manual
- Zero-emission cargo handling equipment, rail car movers, TRUs
- More info: www.CaliforniaCORE.org



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 - \$65M first installment
 2. **\$90M** for Zero-emission Class 8 freight and port drayage - \$27M first installment
 3. **\$60M** for Combustion Freight/Marine (competitive) - \$30M first installment
 4. **\$70M** for Zero-emission Freight/Marine (competitive) - \$35M first installment
 5. **\$5M** each for light duty H2 Infrastructure and LD charging infrastructure
- Funding available statewide starting this fall
- ww2.arb.ca.gov/vwmitigationtrust



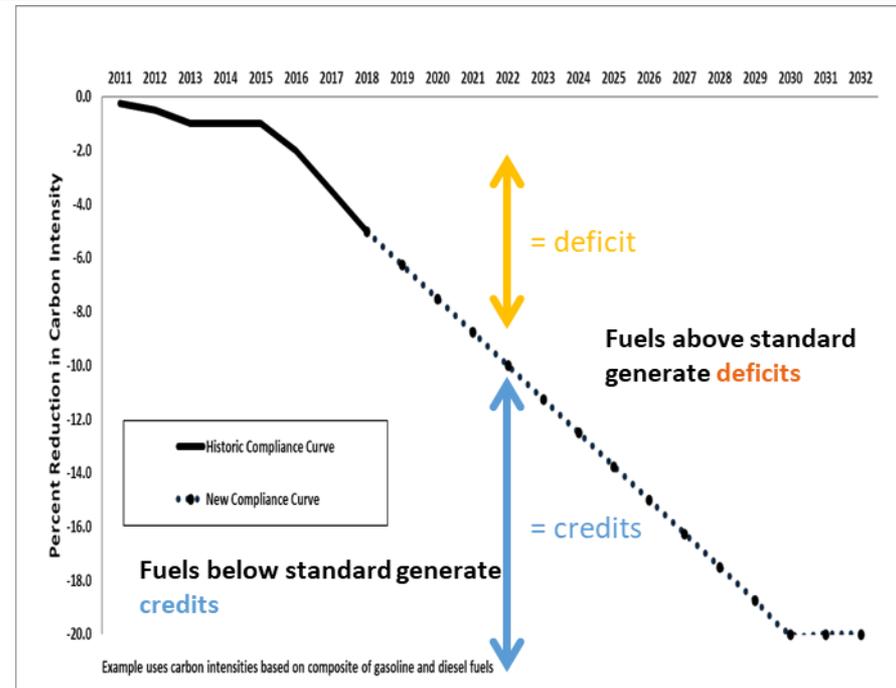
Community Air Protection (CAP) Incentives

- \$740M appropriated since 2017 to support AB 617
 - Air districts fund projects according to priorities and concerns identified by community members
 - Includes mobile and stationary sources
 - *CAP Incentives 2019 Guidelines* approved in May 2019, and additional options coming soon
 - www.arb.ca.gov/msprog/cap/capfunds.htm

Bay Area AQMD Focus	San Joaquin Valley APCD Focus	South Coast AQMD Focus
<ul style="list-style-type: none"> • Advanced technology at ports, including hybrid gantry cranes • Zero-emission and low-NOx CNG school buses, and associated infrastructure 	<ul style="list-style-type: none"> • Agricultural equipment near farming communities • Zero-emission school buses • Locomotives 	<ul style="list-style-type: none"> • Zero-emission and low-NOx trucks • Off-road equipment, including construction and agricultural • Marine vessels
www.baaqmd.gov/community-health/community-health-protection-program	community.valleyair.org/	www.aqmd.gov/ab617

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
- Two key inputs affect amount of credits earned per MJ of fuel
 - Carbon intensity (CI) of fuel relative to displacement fuel
 - Efficiency of equipment relative to baseline (EER) – need data to support developing EERs for HD fuel cell powered equipment.



- For more information:
<https://www.arb.ca.gov/fuels/lcfs/lcfs.htm>

EER Values used in LCFS Credit Calculations

EER Values for Fuels Used in Light-, Medium- and Heavy Duty Applications

Fuel/Vehicle Combination	EER Values Relative To Displacement Fuel	Displacement Fuel
Gasoline (including 6% and 10% ethanol blends) Used In Gasoline Vehicles or 85% Ethanol/15% Gasoline Blends Used In Flexible Fuel Vehicles	1	Gasoline
Electricity Used in a Battery Electric or Plug-In Hybrid Electric Vehicle	3.4	Gasoline
On-Road Electric Motorcycle	4.4	Gasoline
Hydrogen Used in a Fuel Cell Vehicle	2.5	Gasoline
Diesel Fuel or Biomass-Based Diesel Blends Used in A Diesel Vehicle	1	Diesel
Electricity Used in a Battery Electric (BEV) or Plug-In Hybrid Electric (PHEV) Heavy-Duty Truck or Bus	5	Diesel
Electricity Used in a Fixed Guideway or Heavy Rail	4.6	Diesel
Electricity Used in a Fixed Guideway or Light Rail	3.3	Diesel
Electricity Used in a Trolley Bus, Cable Car, or Street Car	3.1	Diesel
Electricity Used in Forklifts	3.8	Diesel
eTRU	3.4	Diesel
eCHE	2.7	Diesel
eOGV	2.6	Diesel
Hydrogen Used in a Heavy-Duty Fuel Cell Vehicle	1.9	Diesel
Hydrogen Used in a Fuel Cell Forklift	2.1	Diesel

Source: Credit value calculator at ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

Contacts

Regulations

- Innovative Clean Transit
Shirin.Barfjani@arb.ca.gov
- ZE Airport Shuttle Bus
Anthony.Poggi@arb.ca.gov
- Zero-Emission Powertrain Certification
David.Eiges@arb.ca.gov
- Advance Clean Trucks
Paul.Arneja@arb.ca.gov
- Ocean Going Vessels at Berth
Angela.Csondes@arb.ca.gov
- Commercial Harbor Craft and Cargo Handling Equipment
David.Quiros@arb.ca.gov

Demonstration Projects

- General info and FY 2019-10 funding
Earl.Landberg@arb.ca.gov

- Fuel Cell Top Loader and C-Port projects
Nathan.Dean@arb.ca.gov
- Fuel Cell Ferry
Todd.Sterling@arb.ca.gov
- Shore-to-Store class 8 FCETs
Ryan.Murano@arb.ca.gov

Other Incentive Programs

- AB 617 Community Air Protection
Kyle.Goff@arb.ca.gov
- LCFS General
Arpit.Soni@arb.ca.gov
- LCFS Hydrogen EERs
Jordan.Ramalingam@arb.ca.gov

VW Mitigation Trust

- Zero-Emission Freight Marine, Chengfeng Wang
cwang@baaqmd.gov

- Zero-Emission Class 8 Freight and Port Drayage Trucks
vwfunds@aqmd.gov
www.aqmd.gov/vw
Hotline: 833-894-7267

HVIP: CaliforniaHVIP.org

- info@Californiahvip.org for general questions
- Patrick.Chen@arb.ca.gov for vehicle eligibility evaluation

CORE: CaliforniaCORE.org

- Niki Okuk,
nokuk@calstart.org for general questions
- Matthew.Diener@arb.ca.gov for equipment eligibility evaluation