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

DOE H2 and FC Technical Advisory Committee
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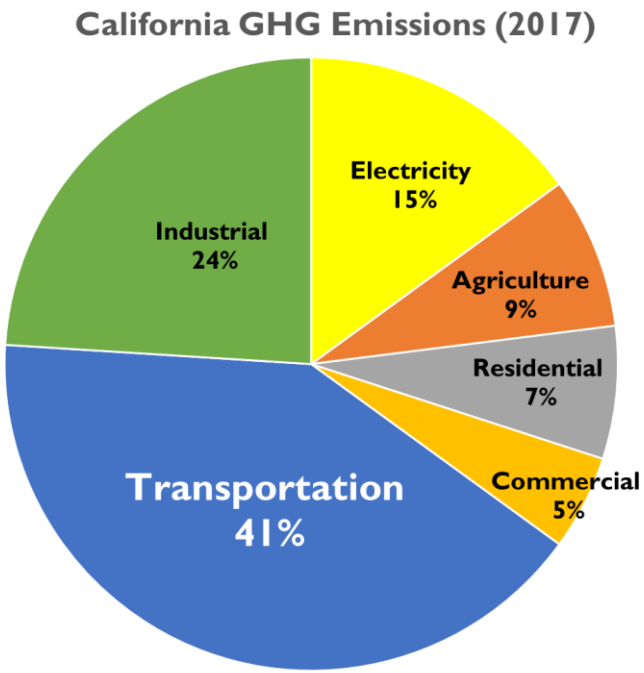
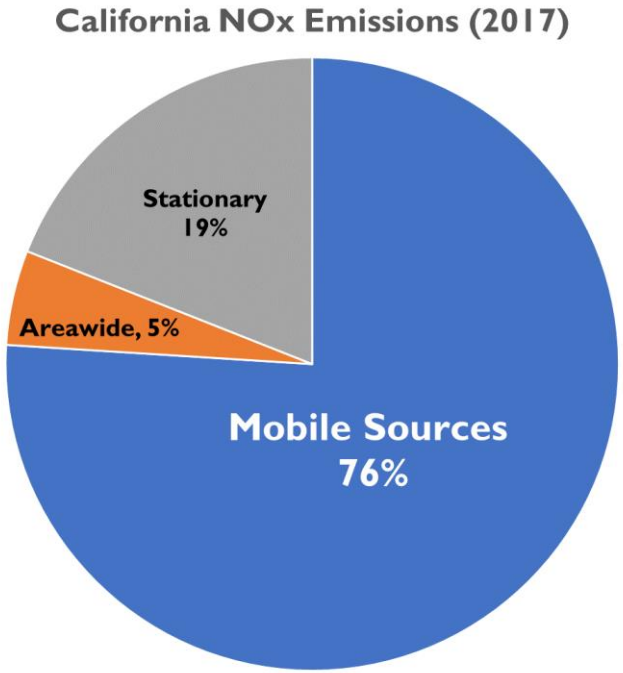
CALIFORNIA
AIR RESOURCES BOARD

Transportation is the Largest Source of Emissions in CA



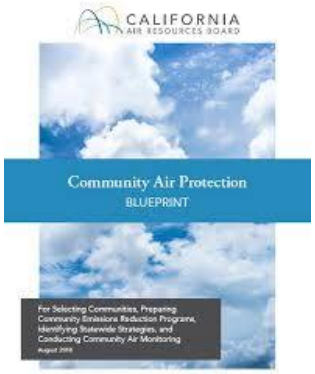


Cleaner Combustion Is Not The End Goal

Integrated approaches – Planning, Regulations, Investments

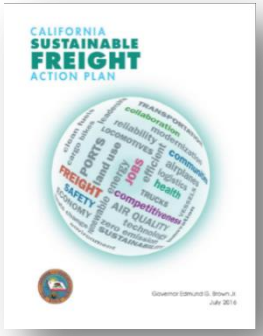
- Planning:
  - Coordination of statewide efforts between regions and agencies
  - Comprehensive and complementary measures
- Regulations:
  - Multi-pollutant approaches
  - Provide long-term market signals
- Investments:
  - Enhance markets with strategic public incentive and investment programs

Integrated Transportation Planning



Community Air Protection Blueprint

- Reduce exposure in communities most impacted by air pollution



Sustainable Freight Action Plan (2030 targets)

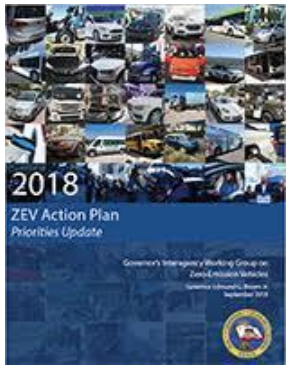
- Increase freight system efficiency by 25%
- 100,000 ZEVs and equipment

Mobile Source Strategy (2031 NOx targets)

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

Climate Change Scoping Plan

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



ZEV Action Plan

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

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 | Bay Ship & Yacht Co. | BAE Systems | Hydrogenics: Shift Power | Energize Your World | Red and White Fleet: San Francisco Cruises | Sandia National Laboratories | California Climate Investments: 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

Cap and Trade Dollars at Work

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

THE PORT OF LOS ANGELES · TOYOTA · Shell · The Port OF Hueneme · ups · South Coast AQMD

CALIFORNIA CLIMATE INVESTMENTS
Cap and Trade Dollars at Work

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

CTE CENTER FOR TRANSPORTATION AND THE ENVIRONMENT
HYSTER-YALE GROUP
NUVERA®
WAVE Wireless Advanced Vehicle Electrification
FENIX MARINE SERVICES
CALIFORNIA CLIMATE INVESTMENTS Cap and Trade Dollars at Work

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

California Climate Investments
Cap and Trade Dollars at Work

The Port of Long Beach · Academy of Global Logistics · ILWU · Green Education, Inc. · Grant Farm · KALMAR · Air Products · South Coast AQMD · Taylor · BYD · CNHTC · SSA Marine, A Carrix Enterprise · Long Beach Container Terminal · SINOTRUK · TETRA TECH

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

California VW Mitigation Trust

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

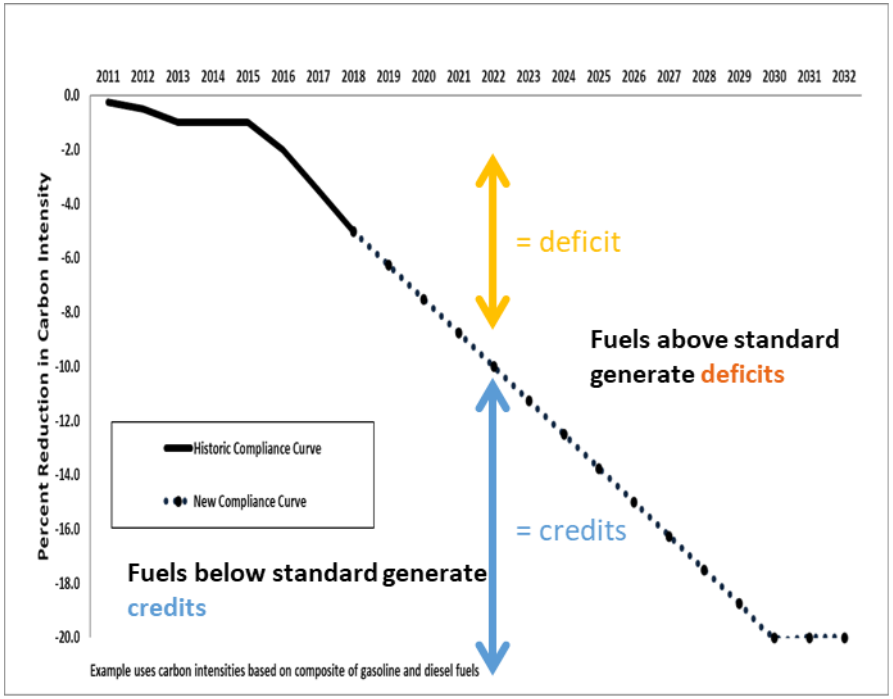
Community Air Protection (CAP) Incentives

- $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
• Advanced technology at ports, including hybrid gantry cranes • Zero-emission and low-NOx CNG school buses, and associated infrastructure	• Agricultural equipment near farming communities • Zero-emission school buses • Locomotives	• 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

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- 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