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

DOE H2 and FC Technical Advisory Committee
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Transportation is the Largest Source of Emissions in CA

California GHG Emissions (2017)

- Transportation: 41%
- Industrial: 24%
- Electricity: 15%
- Agriculture: 9%
- Residential: 7%
- Commercial: 5%

California NOx Emissions (2017)

- Mobile Sources: 76%
- Stationary: 19%
- Areawide: 5%

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](https://arb.ca.gov/msprog/ict/ict.htm)

**Zero-Emission Airport Shuttle** – fleet requirement
- Phased in fleet turnover beginning in 2027 (33%)
- Full implementation in 2035
- 2022 - Annual fleet reporting
- [https://ww2.arb.ca.gov/our-work/programs/zero-emission-airport-shuttle](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](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](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](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](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](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
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

<table>
<thead>
<tr>
<th>Battery Electric</th>
<th>Fuel Cell Electric</th>
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<tbody>
<tr>
<td>Kalmar &amp; Transpower</td>
<td>CNHTC* and Re-Fire</td>
</tr>
<tr>
<td>931 kW LiFePO₄ battery pack</td>
<td>56kW PEM fuel cell</td>
</tr>
<tr>
<td>70 kW charging station</td>
<td>Air Products mobile fueler</td>
</tr>
</tbody>
</table>

* 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
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](http://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](http://www.arb.ca.gov/msprog/cap/capfunds.htm)

<table>
<thead>
<tr>
<th>Bay Area AQMD Focus</th>
<th>San Joaquin Valley APCD Focus</th>
<th>South Coast AQMD Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Advanced technology at ports, including hybrid gantry cranes</td>
<td>• Agricultural equipment near farming communities</td>
<td>• Zero-emission and low-NOx trucks</td>
</tr>
<tr>
<td>• Zero-emission and low-NOx CNG school buses, and associated infrastructure</td>
<td>• Zero-emission school buses</td>
<td>• Off-road equipment, including construction and agricultural</td>
</tr>
<tr>
<td></td>
<td>• Locomotives</td>
<td>• Marine vessels</td>
</tr>
</tbody>
</table>
• 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 for Fuels Used in Light-, Medium- and Heavy Duty Applications

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

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

Regulations
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• 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
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• Fuel Cell Ferry Todd.Sterling@arb.ca.gov
• Shore-to-Store class 8 FCETs Ryan.Murano@arb.ca.gov

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