Summary of Available Zero-Emission Technologies and Funding Opportunities

Prepared by the Bay Area Air Quality Management District

June 2018

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Availability of Zero-Emission Technologies

The Bay Area Air Quality Management District (BAAQMD) recently assessed options for replacing diesel combustion vehicles and equipment with zero-emission technologies to help the San Francisco Bay Area region and other communities achieve the goal of "Diesel Free by 2033." This document provides a summary of the status of these technologies based on a literature review and BAAQMD staff's knowledge. Technology assessment reports from the California Air Resources Board (ARB) and the National Renewable Energy Laboratory are the primary sources of information used in this assessment[1].

Table 1 summarizes the status of zero-emission technologies for categories of equipment and vehicles that account for significant air pollution and greenhouse gases generated in the region. A technology readiness level of "commercially available" is assigned to categories that are readily available for purchase and have comparable costs to conventional technologies with or without incentives, "early commercialization" is assigned to technologies that are commercially available but have higher capital costs than similar conventional technologies due to low sales volumes, "demonstration phase" is a description of technologies that as of 2018 are being tested in very small quantities[2] and that may reach early or full commercialization level by 2033, and "not yet available" refers to categories of equipment and vehicles that have not yet been demonstrated and it is unknown when they will be commercialized.

Table 1: Summary of status of zero-emission technologies

Technology Readiness Level	Vehicle / Equipment Category
Commercially Available	Light-duty cars/SUVs
	Buses
	Cargo handling equipment
	Locomotives - switchers/yard goats
	Ocean going vessels (at berth)
	Transportation refrigeration units
	Medium-duty trucks
	Batteries for emergency or backup power (~5kW or shorter load durations)
	Fuel cell systems for emergency or backup power (~5-20kW)
Early Commercialization	Small construction equipment
	Batteries for emergency or backup power (>5kW)
Demonstration	Heavy-duty trucks
	Cargo handling equipment (container top/side picks)
Not Yet Available	Commercial harbor craft
	Large construction equipment
	Locomotive - line haul
	Ocean going vessels (at sea)

Buses

Buses are typically 35 to 45 ft. in length (or longer) and are primarily used to transport passengers[3]. Buses can range in size from small shuttles with

[1] https://www.arb.ca.gov/msprog/tech/tech.htm, https://www.nrel.gov/docs/fy14osti/60732.pdf
[2] https://www.arb.ca.gov/msprog/tech/techreport/ta_overview_v_4_3_2015_final_pdf.pdf
[3] https://law.justia.com/codes/california/2017/code-veh/division-1/section-233/

seating for 10 to 20 passengers, to school and transit buses that can seat 40 to 80 passengers, to articulated and double-decker buses that can carry over 200 passengers. In the Bay Area, most buses are propelled by an internal combustion engine (ICE) that burns diesel or compressed natural gas, or as a hybrid that operates on a combination of diesel fuel and batteries.

Battery electric buses are commercially available for use as transit, school, and shuttle buses[4, 5, 6]. Recent advancements in battery and wireless inductive charging technologies are also making wide adoption of battery electric buses more feasible and cost-effective. Other zero-emission bus technologies, including hydrogen fuel cells, are actively being tested and demonstrated in the Bay Area[7, 8]. Many Bay Area transit agencies have started to test or deploy zero-emission buses, such as the San Francisco Municipal Transportation Agency and San Mateo County Transit District, or SamTrans, who have committed to fully electrify bus fleets by 2035 and 2033, respectively[9, 10].

Light Duty Vehicles

Light-duty vehicles include motorcycles and four-wheeled passenger cars, i.e., sedans, crossovers, hatchbacks, vans, SUVs, and light-duty trucks that have a Gross Vehicle Weight Rating (GVWR) of 10,000 lbs. or less[11]. In the Bay Area, there are nearly six-million light-duty vehicles registered with more than 100,000 of these being zero-or near zero emissions. As of 2018, fully zero-emission battery electric cars are commercially available and the full lifecycle cost of ownership is nearly the same as conventional equivalent vehicles[12]. Multiple manufacturers (e.g., General Motors, Nissan, Tesla, Toyota, Volkswagen) offer at least one vehicle model, and more models are expected to come into the market in the coming years[13]. Light-duty hydrogen fuel cell cars, fully electric vans, and light-duty trucks are in the early commercialization stage but are expected to be commercially available within the next few years[14, 15, 16, 17].

Medium- and Heavy-Duty Trucks

Medium- and heavy-duty trucks are large motor vehicles that are primarily used to transport goods and equipment. Medium-duty trucks range in GVWR from 10,001 to 26,000 pounds (lbs.) and heavy-duty trucks have a GVWR of 26,001 lbs. and above. Medium- and heavy-duty trucks have historically been powered by diesel or natural gas internal combustion engines.

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4 https://www.arb.ca.gov/msprog/tech/techreport/bev_tech_report.pdf
5 https://www.californiahvip.org/eligible-technologies/#your-clean-vehicles
6 https://electrek.co/2018/05/07/all-electric-trucks-lion-electric/
7 http://www.actransit.org/environment/the-hyroad/
8 https://www.arb.ca.gov/msprog/tech/techreport/fc_tech_report.pdf
9 https://www.sfmta.com/press-releases/san-francisco-commits-all-electric-bus-fleet-2035
10 https://www.prnewswire.com/news-releases/samtrans-orders-10-proterra-catalyst-e2-buses-and-sets-a-100-percent-zero-emission-fleet-goal-by-2033-300613692.html
11 https://www.epa.gov/emission-standards-reference-guide/vehicle-weight-classifications-emission-standards-reference-guide
12 https://www.sciencedirect.com/science/article/pii/S030626191731526X?via%3Dihub
13 https://www.driveclean.ca.gov/
14 https://www.nissan.co.uk/vehicles/new-vehicles/e-nv200.html
15 http://www.businessinsider.com/electric-suvs-coming-to-market-soon-2018-4
16 http://workhorse.com/pickup/
17 https://www.arb.ca.gov/msprog/acc/mtr/appendix_c.pdf

Today, medium-duty battery electric delivery trucks are commercially available[18,19]. These trucks are well-suited for local applications as their typical 100-mile range allows the vehicle to return-to-base for refueling. Zero-emission technologies for other medium-duty applications and heavy-duty trucks are being developed and demonstrated with a limited number of models[20,21,22,23,24]. In California, specifically the Bay Area, several early tests and demonstrations of zero-emission medium- and heavy-duty trucks are being conducted, including battery electric delivery trucks operating in urban areas[25] and battery electric heavy-duty trucks operating in and around the Port of Oakland[26].

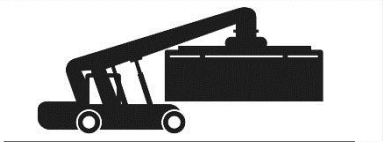
Many vehicle manufacturers, both those long established in the industry and new start-up companies, are developing zero-emission medium- and heavy-duty vehicles, and some are already producing vehicles at low volume[27]. Among the larger automotive companies, Daimler has announced that it expects to begin production on a fully electric heavy-duty truck in 2020[28].

Transport Refrigeration Units

A transport refrigeration unit (TRU) is defined as a refrigeration system powered by a diesel integral (inside housing) internal combustion engine designed to control the environment of temperature sensitive products that are transported in trucks and refrigerated trailers. TRUs may be capable of both cooling and heating. Zero-emission technologies (battery electric, plug-in electric, fuel cell, cryogenic, etc.) for TRU are commercially available; however, these options have specific infrastructure and operational requirements that need to be considered by fleet operators[29].

Mobile Cargo Handling Equipment

Mobile cargo handling equipment (CHE) is any mobile equipment used at ports, rail yards, and warehouse distribution centers to either handle freight or to perform other on-site activities, such as maintenance. Types of CHEs include yard trucks, top handlers, side handlers, reach stackers, forklifts, and gantry cranes, dozers, excavators, and loaders. In 2018, most CHEs, especially the larger vehicles, are powered by diesel internal combustion engines.



Today, there are several options for deploying zero-emission technologies for cargo handling equipment, such as automated electric equipment, electric rubber tired or rail mounted gantry (RTG or RMG) at container terminals, fuel cell and battery electric fork lifts, yard trucks at distribution centers, electric aircraft ground support equipment, battery electric belt

[18] https://www.arb.ca.gov/msprog/tech/techreport/ta_overview_v_4_3_2015_final_pdf.pdf
[19] https://electrek.co/2018/06/15/ups-fleet-1000-electric-vans-workhorse/
[20] https://www.californiahvip.org/eligible-technologies/#your-clean-vehicles
[21] https://www.californiahvip.org/vehicles/byd-6f-t7-class-6-cab-forward-truck/
[22] https://www.arb.ca.gov/msprog/tech/techreport/bev_tech_report.pdf
[23] https://www.californiahvip.org/vehicles/motiv-all-electric-powertrain-for-ford-f59-4/
[24] http://www.zenith-motors.com/wp-content/uploads/2013/05/Brochure122017.pdf
[25] http://www.cte.tv/wp-content/uploads/2018/05/ACT-BYD_Goodwill_press-release_FINAL1-1.pdf
[26] https://www.portofoakland.com/press-releases/port-oakland-first-battery-powered-truck-enters-fleet/
[27] https://www.trucks.com/2018/05/01/research-group-electric-truck-technology-advancing/
[28] https://www.theicct.org/sites/default/files/publications/Zero-emission-freight-trucks_ICCT-white-paper_26092017_vF.pdf
[29] https://www.arb.ca.gov/msprog/tech/techreport/tru_07292015.pdf

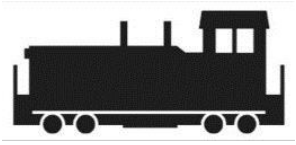
loader, electric baggage tug, are commercially available[30, 31, 32, 33]. Zero-emission technologies for container top/side picks currently are not commercially available[34, 35] although two electric container top picks are currently being demonstrated at the Port of Los Angles[36].

Construction & Earthmoving Equipment

Construction and earthmoving equipment refers to heavy-duty vehicles, specially designed to move, compact, haul, hoist, earth and other loose or bulk materials; and other types of construction equipment, such as bulldozers, graders, excavators, scrapers, loaders, trenchers, and backhoes[37]. In 2018, most of these vehicles and equipment are powered by diesel internal combustion engines.

Zero-emission technologies are in the early commercialization stage for smaller construction equipment[38,39,40]. The technology for providing full battery electric heavy-duty machinery will require further technological improvements as it has yet to meet parity with conventional powertrains[41].

Locomotives



A locomotive is a self-propelled vehicle used to push or pull trains, and the combination of locomotive(s) pulling freight or passenger railcars forms a train. Most of the freight and passenger locomotives in the Bay Area are powered by a diesel-electric system whereby an internal combustion engine that is fueled by diesel drives an electrical generator or alternator, which in turn powers electric motor(s) that drive the wheels[42].

While electric train and rail technology is commercially available, it would currently be cost prohibitive to widely deploy this technology for long haul freight and passenger use. Therefore, in the near-term, the most technologically feasible and cost-effective advanced technology available to reduce toxic and criteria pollutant emissions is the installation of a compact aftertreatment system (e.g., combination of Selective Catalytic Reduction and Diesel Oxidation Catalysts) onto new and remanufactured diesel-electric freight interstate line haul locomotives. Emissions in communities that are disproportionally impacted by diesel emissions can be further reduced by augmenting this control equipment with a combination of on-board batteries and geo-fencing technologies.

Zero-emission technologies are commercially available for switch (yard) operations (e.g., a railway electrification system that provides power through overhead or third line power line). Battery electric technologies are also being tested for switch (yard) locomotives in other parts of the United States[43].

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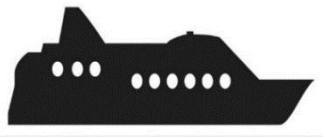
[30] https://www.arb.ca.gov/msprog/tech/techreport/che_tech_report.pdf
[31] https://orangeev.com/
[32] https://www.californiahvip.org/eligible-technologies/#your-clean-vehicles
[33] https://www.arb.ca.gov/msprog/tech/techreport/ta_overview_v_4_3_2015_final_pdf.pdf
[34] https://blog.hyster.eu/see-hyster-talk-zero-emissions-container-handling/
[35] https://www.joc.com/regulation-policy/la-lb-officials-say-zero-emissions-cargo-equipment-viable-2030_20180504.html
[36] https://www.portoflosangeles.org/Board/2017/October%202017/101917_Regular_Agenda_Item_6_Transmittal_1.pdf
[37] https://www.slideshare.net/SagarRadadiya/construction-equipments-introduction-and-classification
[38] https://www.zeecrane.com/
[39] https://www.volvoce.com/global/en/news-and-events/news-and-press-releases/volvo-ce-unveils-100-percent-electric-compact-excavator-prototype/
[40] http://www.kramer-online.com/en/discover-kramer/zero-emission/the-kramer-5055e/
[41] http://network.bellona.org/content/uploads/sites/3/2018/06/ZEC-Report-1.pdf
[42] https://www.arb.ca.gov/msprog/tech/techreport/final_rail_tech_assessment_11282016.pdf

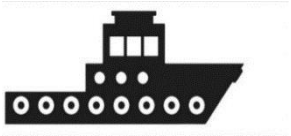
Ocean-Going Vessels

Ocean-going vessels (OGV) are large vessels designed for deep water navigation. Types of OGVs include large cargo vessels such as container vessels, tankers, bulk carriers, and car carriers, as well as passenger cruise vessels. These vessels transport containerized cargo, bulk items such as vehicles, cement, and coke, liquids such as oil and petrochemicals, and passengers. OGV propulsion (main) engines are primarily fueled by residual fuel oil and auxiliary engines that are mainly powered by diesel fuel. The majority of vessels that visit California ports are foreign-flagged vessels[44].



As of 2018, technologies (e.g., shore-side power, fuel cells, and emissions capture and control systems) are commercially available that enable vessels at dockside to achieve zero and near-zero emissions. Other than nuclear power, no other zero-emissions technology has been developed for vessels at sea[45]; however, an all-electric autonomous container ship is being planned in Norway[46].

Commercial Harbor Craft



Commercial harbor craft means any private, commercial, government, or military marine vessel including, but not limited to, passenger ferries, excursion vessels, tugboats, ocean-going tugboats, towboats, push-boats, crew and supply vessels, pilot vessels, fishing vessels, research vessels, U.S. Coast Guard vessels, hovercraft, emergency response harbor craft, and barge vessels that do not otherwise meet the definition of ocean-going or recreational vessels[47]. Nearly all commercial harbor craft vessels are powered by diesel fuel.

While no zero-emission technologies are commercially available for harbor craft, dedicated battery electric systems are being developed for larger ships but have not yet been adopted for commercial harbor craft. Also, several demonstration and early commercialization projects are underway including a zero-emission hydrogen fuel cell ferry project funded by the ARB with funding from the "California Climate Investments" (CCI) program[48] that is being administered by the BAAQMD in partnership with Golden Gate Zero Emission Marine Inc. Another demonstration project funded by US Environmental Protection Agency (USEPA) will convert an existing ferry to full electric in Alabama. Proton Exchange Membrane or Polymer Electrolyte Membrane (PEMFC) systems have been used in harbor craft demonstrations in New York[49], electric ferries are being built and operated in Norway[50,51], and a hybrid tugboat has been demonstrated at the Ports of Los Angeles and Long Beach[52].

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[43] https://www.arb.ca.gov/msprog/tech/techreport/final_rail_tech_assessment_11282016.pdf
[44] https://www.arb.ca.gov/msprog/tech/techreport/ogv_tech_report.pdf
[45] https://www.arb.ca.gov/msprog/tech/techreport/ogv_tech_report.pdf
[46] https://newatlas.com/autonomous-electric-shipping-container-vessel/49477/
[47] https://govt.westlaw.com/calregs/Document/I0FD137A0A3C111E0BACCB30E82542E24?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=%28sc.Default%29&bhcp=1
[48] www.arb.ca.gov/ccifundingguidelines
[49] https://www.arb.ca.gov/msprog/tech/techreport/draft_chc_technology_assessment.pdf
[50] https://www.workboat.com/news/shipbuilding/alabama-looks-first-u-s-electric-ferry/
[51] https://electrek.co/2018/03/05/all-electric-ferries-battery-packs/
[52] https://www.arb.ca.gov/newsrel/2010/hybridtug.htm

Stationary Engines

According to the BAAQMD emissions inventory, there are approximately 7,600 stationary diesel engines registered in the Bay Area. Although particulate matter emissions from stationary diesel engines are typically higher than on-road diesel sources, the facilities using them are generally not required to upgrade to cleaner equipment. This is because many engines predate the BAAQMD's permitting rules or because the equipment is meant for emergency or backup power and the hours in which it can operate outside of an emergency are extremely limited. For example, off-road diesel engines are generally exempt from fuel formulation requirements (such as sulfur content) and exhaust gas aftertreatment. However, there are alternatives to stationary diesel engines that are cost-competitive, especially when paired with financing and incentives.

Hydrogen fuel cells are a cost-competitive alternative to diesel engines for 5-10kW loads, especially when paired with currently available federal tax incentives. Batteries are appropriate alternatives for smaller or portable applications, particularly ones with lower power draws (~5kW) and shorter load durations (~8 hours); see Table 2 below.

While there are some cost-competitive zero emissions options in the lower kW range, it should be noted that most backup generators currently registered with the BAAQMD (92%) operate in the 35kW range and above. These generators are expected to become a more viable option for larger back-up applications within the next 15 years due to improved energy efficiency and management practices as well as lower costs for more reliable and energy dense batteries. This may also be accelerated when batteries are teamed with renewable power solutions and regulations requiring carbon pricing or market-based carbon control programs such as California's AB32 Cap-and-Trade Program.

Table 2: Estimated Annual Cost of Ownership for Backup Generator Equipment in the 4 to 6kW Range

Load Duration *For power loads in 4-6kW range*	*Diesel*	*Fuel Cell System w/ Federal Tax Incentive*	*Battery*	*Incentives*
8 hours 30-50kWh	$120/ kWh	$115/kWh	$160/kWh	Leverage existing federal tax incentives for fuel cells; Consider offering incentives for batteries
3 days 200-400kWh	$16/ kWh	$17/kWh	$90/kWh	Leverage existing federal tax incentives for fuel cells; Support R&D for reducing battery costs and increasing lifetimes
1 week 700-1000kWh	$6/ kWh	$9/kWh	$80/kWh	Not yet cost-effective to replace diesel for heavy demands; Support R&D for reducing battery costs and increasing lifetimes

Cost-competitive with diesel Cost-competitive with additional incentives R&D is recommended

Cost of ownership includes permitting and installation costs, annual maintenance costs, and annual fuel costs in backup scenarios. Source data: *Backup Power Cost of Ownership Analysis and Incumbent Technology Comparison*, National Renewable Energy Laboratory, September 2014.

Upcoming California Regulations Requiring Zero-Emission Technology

Mobile source vehicle and equipment emissions are regulated by the ARB and the USEPA. The following is a brief listing of categories of mobile sources that are being targeted for new regulatory requirements by ARB:

- Zero-emissions cargo handling equipment regulation for ARB Board consideration in 2022, with potential starting date of 2026
- Trucks: Advanced Clean Truck Rule (formerly last mile delivery rule) to be considered in 2019 and zero-emission drayage truck regulation to be developed for ARB Board consideration in 2022 (with 2026-2028 starting date)
- Commercial Harbor Craft at Seaports amendments for ARB Board consideration in 2020, with a potential starting date of 2023
- Zero-emission transportation refrigeration unit regulation for ARB Board consideration in 2019, with a potential starting date of 2020+
- School & Transit Buses
- Freight Facilities

Commitments to Adopt Zero-Emission Technologies and Reduce Petroleum Consumption Around the World

In California, the following zero-emission technology and petroleum goals have been identified by Governor Brown and other State and local agencies:

- Governor Brown identified reducing petroleum use in cars and trucks in 2015 by up to 50 percent by 2030 as one of the key climate change strategy pillars that are needed to reduce emissions to meet the 2030 greenhouse gas emissions target[53].
- In 2012, Governor Brown issued Executive Order B-16-12 directing state government to help accelerate the market for zero-emission vehicles (ZEVs) in California and sets targets for adoption of 1.5 million ZEVs in California by 2025.
- Assembly Bill 739 requires that 30% of newly purchased vehicles by state agencies be zero-emission by 2030[54].
- The California Sustainable Freight Action Plan has identified a goal of transitioning to zero-emission technology by deploying over 100,000 freight vehicles and equipment capable of zero-emission operation and maximizing near-zero emission freight vehicles and equipment powered by renewable energy by 2030[55].
- ARB is in the process of proposing a goal of achieving a zero-emission transit system by 2040[56] and a goal of replacing existing diesel airport ground support equipment with zero-emission equipment by 2032[57].
- The Bay Area Plug-In Electric Vehicle Readiness Plan (2013) adopted goals of 110,000 EVs on Bay Area roads by 2020 and 250,000 EVs by 2025. The BAAQMD's 2017 Clean Air Plan has set a longer-term goal of 90% of the Bay Area fleet being zero-emission by 2050.

[53] https://www.arb.ca.gov/cc/pillars/pillars.htm#factsheets
[54] https://www.arb.ca.gov/msprog/actruck/mtg/180531presentation.pdf
[55] http://dot.ca.gov/hq/tpp/offices/ogm/cs_freight_action_plan/Documents/CSFAP_Main%20Document_FINAL_07272016.pdf
[56] https://arb.ca.gov/msprog/ict/meeting/mt180611/180611presentation.pdf
[57] https://www.arb.ca.gov/msprog/offroad/gse/presentationjune6.pdf

- The San Pedro Bay Ports Clean Air Action Plan 2017 requires that, beginning in 2035, all trucks entering the port must be zero-emission or pay a fee[58].

The following map and Table 3 show petroleum reduction commitments made around the world.

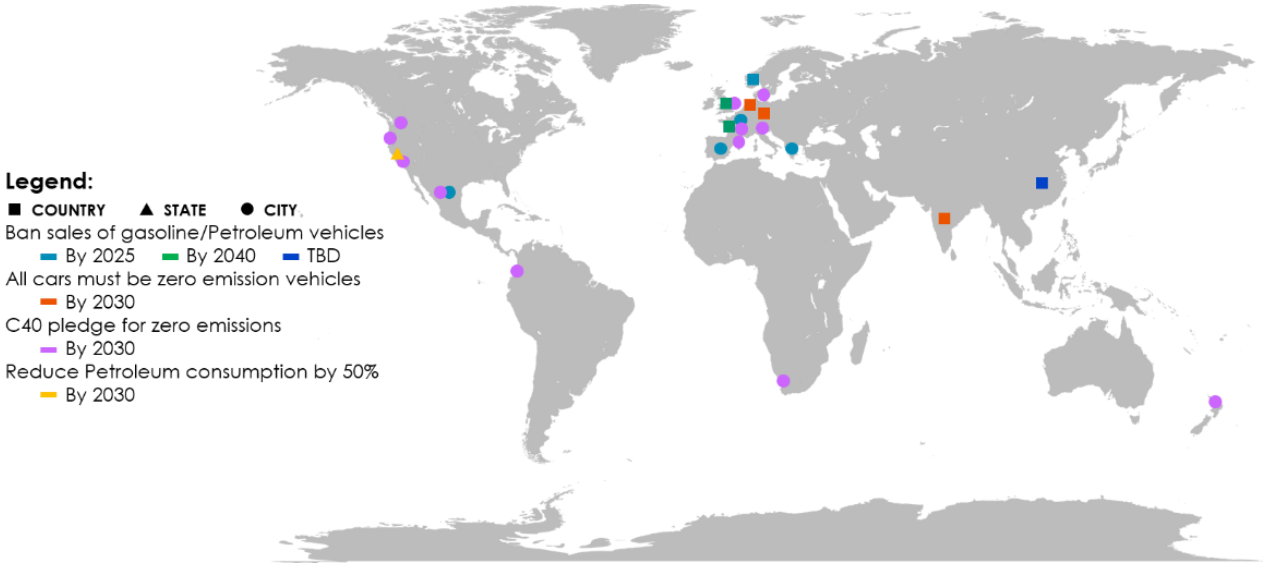

Table 3 – Commitments to Petroleum Reduction

Date	Country/State/City	Commitment
2025	**Norway, Madrid, Athens**	Ban sales of petroleum-fueled vehicles by 2025
	Paris, Mexico City	Ban sales of petroleum-fueled vehicles by 2025;
		C40 Pledge*
2030	**Netherlands, Germany, India**	All cars must be ZEVs by 2030
	London, Los Angeles, Copenhagen, Barcelona, Quito, Vancouver, Cape Town, Seattle, Auckland, Milan	C40 Pledge*
	California	Reduce petroleum consumption by 50% by 2030
2040	**France, Britain**	Ban sales of petroleum-fueled vehicles by 2040
TBD	**China**	Ban sales of petroleum-fueled vehicles by date TBD

*C40 Pledge to transition to "Fossil-Fuel-Free Streets" by: 1) procuring, with our partners, only zero-emission buses from 2025 and 2) ensuring a major area of our city is zero emission by 2030[59].

[58] https://www.arb.ca.gov/msprog/actruck/mtg/180531presentation.pdf
[59] http://c40-production-images.s3.amazonaws.com/other_uploads/images/1418_Fossil_Fuel_Free_Streets_Declaration.original.pdf?1508742654

Attachment A: Funding Opportunities for Zero-Emission Vehicles and Fueling Infrastructure

California Emissions Reduction Funding

This section summarizes funding opportunities that are currently available in most parts of California to help transition to zero-emission vehicles, equipment, and infrastructure.

- Carl Moyer Program (CMP): The CMP is a state-funded program offering grants to owners of heavy-duty vehicles and equipment, including trucks, buses, agricultural and marine equipment, and locomotives, to reduce air pollution from heavy-duty engines. Engine owners must operate CMP-funded vehicles and equipment within the BAAQMD's jurisdictional boundaries, and priority is given to projects that reduce emissions in impacted communities. More information can be found at www.baaqmd.gov/moyer.
- Community Health Protection Grant (AB134/617): AB 617 directed the California Air Resources Board, in conjunction with local air districts, to establish the Community Air Protection Program. AB 134 appropriated $250 million from the Greenhouse Gas Reduction Fund to reduce mobile emissions in communities most affected by air pollution. The Bay Area has been allocated $50 million of these funds for emission reduction projects. These funds will be used to implement projects under the Carl Moyer Program, and optionally under the Proposition 1B Goods Movement Emission Reduction Program. More information can be found at http://www.baaqmd.gov/plans-and-climate/community-health-protection-program/grant-program.
- California Climate Investments (CCI) and Greenhouse Gas Reduction Fund (GGRF): CCI is a statewide initiative that puts billions of Cap-and-Trade dollars, established by AB 1532 and SB 535 through the GGRF, to work by reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment—particularly in disadvantaged communities, low-income communities, and low-income households. More information can be found at https://ww2.arb.ca.gov/our-work/programs/california-climate-investments.
- California Clean Vehicle Rebate Project (CVRP): GGRF is the primary funding source for the CVRP, which promotes clean vehicle adoption in California by offering rebates of up to $7,000 for the purchase or lease of new, eligible zero-emission vehicles, including electric, plug-in hybrid electric and fuel cell vehicles. More information about this program can be found at: https://cleanvehiclerebate.org/eng/about-cvrp.
- Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP): The HVIP was formed by the California Air Resources Board as a result of the Air Quality Improvement Program following the passing of the California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007 (AB 118, Statutes of 2007, Chapter 750). HVIP offers point-of-sale incentives for clean trucks and buses. More information can be found at https://www.californiahvip.org/about/#why-clean-vehicles.
- Enhanced Fleet Modernization Program (EFMP): The EFMP) is a voluntary car retirement (scrap) and replacement incentive program. The goal of the program is to incentivize lower-income California motorists to scrap their older, high-emitting cars and replace them with newer, cleaner and more fuel-efficient cars. The EFMP Plus-Up Program for the Bay Area is currently under development. More information can be found at: https://www.arb.ca.gov/msprog/aqip/efmp/efmp.htm.

- Volkswagen (VW) Settlement Funds:
    - Electrify America: The settlement requires VW to invest $800 million in Zero-Emission Vehicle (ZEV) projects in California and more information about this program can be found at: https://www.electrifyamerica.com/.
    - Environmental Mitigation Trust (Trust): The settlement allocates about $423 million from an Environmental Mitigation Trust (Trust) to California. The Trust will provide focus fund on "scrap and replace" projects for the heavy-duty sector, including on-road freight trucks, transit and shuttle buses, school buses, forklifts, and port cargo handling equipment, commercial marine vessels, and freight switcher locomotives.

  More information can be found at https://www.arb.ca.gov/msprog/vw_info/vsi/vsi.htm.

- California Energy Commission (CEC): The CEC's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) invests in the energy innovation pipeline for the development and deployment of alternative and renewable fuels and advantage transportation technologies to help meet the state's goals of reducing greenhouse gas emissions and petroleum dependence in the transportation sector. More information can be found at http://www.energy.ca.gov/contracts/transportation.html.

San Francisco Bay Area

- Local Sources: Local sources of funding in the Bay Area include the Transportation Fund for Clean Air (TFCA), which collect revenue from a $4 surcharge fee on vehicles registered in the Bay Area to fund cost-effective clean air vehicle and trip reduction projects that reduce on-road motor vehicle emissions within the BAAQMD's jurisdiction. More information can be found at: http://www.baaqmd.gov/grant-funding/funding-sources.

- Pacific Gas & Electric (PG&E) Funds:
    - PG&E provides $500 clean fuel rebates to customers with EVs (more information at https://www.pge.com/en_US/residential/solar-and-vehicles/options/clean-vehicles/electric/clean-fuel-rebate-for-electric-vehicles.page?WT.mc_id=Vanity_cleanfuelrebate-ev.
    - PG&E also launched the EV Charge Network program to accelerate California's transition to a clean transportation future by offering electric vehicle charger installation. More information can be found at https://www.pge.com/en_US/business/solar-and-vehicles/your-options/clean-vehicles/charging-stations/ev-charge-network.page.

Federal Funding Sources

- Environmental Protection Agency's (EPA) Diesel Emissions Reduction Act (DERA) Program: The EPA's DERA Program provides support for projects that protect human health and improve air quality by reducing harmful emissions from diesel engines. More information can be found at https://www.epa.gov/cleandiesel.

- Federal Highway Administration's (FHWA) Congestion Mitigation and Air Quality Program (CMAQ): Administered by the FHWA, the CMAQ supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. More information can be found at https://www.fhwa.dot.gov/environment/air_quality/cmaq/.

Attachment B: Financing Opportunities for Zero-Emission Alternatives to Stationary Diesel Engines

This section summarizes some of the financing opportunities that are currently available to businesses and agencies to help transition to zero-emission alternatives to stationary diesel engines.

San Francisco Bay Area

- Pacific Gas & Electric Energy Efficiency Financing: PG&E provides interest-free loans with on-bill financing to commercial customers to adopt new, energy-efficient equipment. Eligible project types include lighting, heating, ventilation and air conditioning (HVAC), electric motors, refrigeration, food service equipment and water pumps. Loans range from $5,000 to $100,000, and up to $250,000 for government agencies. More information can be found at: https://www.pge.com/en_US/business/save-energy-money/financing/energy-efficiency-financing/energy-efficiency-financing.page.

California Funding Programs

- California Hub for Energy Efficiency Financing (CHEEF): CHEEF is a program of the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA). CHEEF's energy efficiency financing pilot programs offer loans and credit enhancements for eligible energy projects for residential (single-family and affordable multifamily units), small business, and commercial customers (including for-profit, non-profit, and government entities of any size). At least 70% of the financed amount must go towards energy efficiency or demand response measures. Up to 30% of the financed amount may fund non-energy efficiency improvements. More information can be found at https://www.thecheef.com/commercial.
- California Infrastructure and Economic Development Bank (IBank):
    - California Lending for Energy and Environmental Needs (CLEEN): CLEEN is a program of the IBank which provides financing, including direct loans and publicly-offered tax-exempt bonds, to help meet the state's goals for greenhouse gas reduction, water conservation, and environmental preservation. MUSH (municipalities, utilities, schools, and hospitals) are eligible for loans ranging between $500,000 and $30 million for projects spanning energy generation, energy conservation, and energy storage. More information can be found at: http://www.ibank.ca.gov/cleen-center/.
    - Small Business Loan Guarantee Program (SBLGP): SBLGP is a program of the California Infrastructure and Economic Development Bank (IBank) which provides loan guarantees of up to $2.5 million or up to 80% of the loan amount to small businesses that experience barriers to capital access. Loan funds can be used for a variety of business-related purposes including construction, expansion, and disaster relief. More information can be found at: http://www.ibank.ca.gov/small-business-finance-center/.
- Self-**Generation Incentive Program (SGIP)**: The California Public Utilities Commission's SGIP program offers rebates to commercial and residential customers for installing distributed energy systems such as stationary engines, fuel cells, and energy storage systems. For example, incentives for battery systems can be as high as $400 per kWh. More information can be found at: http://www.cpuc.ca.gov/sgip/.

Federal Programs

- Rural Energy for America Program (REAP): USDA's REAP program provides agricultural producers and small businesses located in eligible rural areas with guaranteed loan financing and grant funding for renewable energy systems or energy efficiency improvements. More information can be found at: https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency.
- Property Assessed Clean Energy (PACE): PACE financing programs provide loans to commercial and residential property owners to cover upfront costs of installing energy efficiency and renewable energy improvements, including energy generation with renewable fuels. Loans are repaid through property tax assessments over 5 to 25 years. PACE programs are currently available in 35 states. More information can be found at: https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs.

Attachment C: Zero-Emission Trucks and Buses Available in California Eligible for Hybrid Voucher (HVIP) funding from Air Resources Board

Category	OEM	Model
Bus	Blue Bird	Blue Bird Electric Powered All American School Bus
	Blue Bird	Blue Bird Electric Powered Vision School Bus 4x2 Configuration
	BYD Motors	BYD C10 45' All-Electric Coach Bus
	BYD Motors	BYD C6 23' All-Electric Coach Bus
	BYD Motors	BYD K11 60' Articulated All-Electric Transit Bus
	BYD Motors	BYD K7M 30' All-Electric Transit Bus
	BYD Motors	BYD K9 40' All-Electric Transit Bus
	BYD Motors	BYD K9S 35' All-Electric Transit Bus
	Complete Coach Works	Complete Coach Works Zero Emission Propulsion System
	Lion Bus	eLion School Bus Type C, 4x2 All-Electric
	Gillig	Gillig 29' ePlus Battery Electric Low Floor Bus
	Gillig	Gillig 35' ePlus Battery Electric Low Floor Bus
	Gillig	Gillig 40' ePlus Battery Electric Low Floor Bus
	Motiv Power Systems	Motiv EPIC 6 on Ford F59 Platform School Bus - 5 Battery
	Motiv Power Systems	Motiv EPIC 6 on Ford F59 Platform School Bus - 6 Battery
	New Flyer	New Flyer Xcelsior 35' All-Electric Transit Bus
	Proterra	Proterra 35' Catalyst XR+
Bus, School Bus	GreenPower	GreenPower SYNAPSE 72 All-Electric School Bus
	Motiv Power Systems	Motiv EPIC 4 Dearborn on Ford E450 Platform School Bus
Shuttle Buses	GreenPower	GreenPower EV Star All-Electric Min-eBus
	GreenPower	GreenPower SYNAPSE All-Electric Shuttle Bus
	Motiv Power Systems	Motiv All-Electric Powertrain for Ford E450
	Phoenix	Phoenix Motor Cars ZEUS 300 Shuttle Bus
	GreenPower	GreenPower EV250 30' All-Electric Bus
	GreenPower	GreenPower EV350 40' All Electric Bus
	GreenPower	GreenPower EV550 45' All-Electric Double Decker Transit Bus
Shuttle Buses	New Flyer	New Flyer 60' Xcelsior All-Electric Transit Bus
	New Flyer	New Flyer Xcelsior 40' All-Electric Transit Bus
	Proterra	Proterra 35' Catalyst E2
	Proterra	Proterra 35' Catalyst FC
	Proterra	Proterra 35' Catalyst FC+
	Proterra	Proterra 35' Catalyst XR
	Proterra	Proterra 40' Catalyst E2
	Proterra	Proterra 40' Catalyst E2 Max
	Proterra	Proterra 40' Catalyst E2+

	Proterra	Proterra 40' Catalyst FC
	Proterra	Proterra 40' Catalyst FC+
	Proterra	Proterra 40' Catalyst XR
	Proterra	Proterra 40' Catalyst XR+
Bus, Truck	Motiv Power Systems	Motiv All-Electric Powertrain for Ford F59
	Motiv Power Systems	Motiv All-Electric Powertrain for Ford F59 Starcraft e-Quest XL School Bus
	Motiv Power Systems	Motiv All-Electric Powertrain for Ford F59 Starcraft e-Quest XL School Bus
Delivery	Chanje	Chanje V8070 All-Electric Panel Van
	Workhorse Group	Workhorse 4x2 E-100 All-Electric Step Van
	Zenith Motors	Zenith Motors Electric Cargo Van
Delivery, Truck	BYD Motors	BYD T5 Class 5 Cab-Forward Delivery Truck
	Motiv Power Systems	Motiv All-Electric Powertrain for Ford F59
Refuse	BYD Motors	BYD T9M Class 8 Refuse Truck
Shuttle Bus	Zenith Motors	Zenith Motors Electric Passenger Van
Terminal Truck	BYD Motors	BYD Q1M Electric Yard Tractor
	Orange EV	Orange EV T-Series 4x2 Terminal Truck Conversion of Kalmar Ottawa Truck, Extended Duty (N)
	Orange EV	Orange EV T-Series 4x2 Terminal Truck Extended Duty (N)
Terminal Truck, Truck	BYD Motors	BYD Q3M (8TT) Class 8 Battery-Electric Tractor Trailer
	Orange EV	Orange EV T-Series 4x2 Terminal Standard Duty
	Orange EV	Orange EV T-Series 4x2 Terminal Truck Conversion of Kalmar Ottawa Truck Standard Duty
Truck	BYD Motors	BYD T7 Class 6 Cab-Forward Truck
	Chanje	Chanje V8100 All-Electric Panel Van
	Lightning Systems	Lightning Systems Ford Transit 350HD with LightningElectric Drivetrain
	Phoenix	Phoenix Motor Cars ZEUS Electric Flat Bed Truck
Utility with Electric Power Take-off	Altec Industries, Inc	Altec 12E8 JEMS ePTO with Exportable Power
	Altec Industries, Inc	Altec JEMS 1820 and 18E20 ePTO

Attachment D: Availability of Mobile Source Zero-Emission Technologies

Availability	Vehicle/Equipment	References	Notes
Commercially Available	 Light-Duty Cars/SUVs	https://www.arb.ca.gov/msprog/acc/mtr/appendix_c.pdf	
	 Buses	https://www.arb.ca.gov/msprog/tech/techreport/bev_tech_report.pdf	
	 Cargo Handling Equipment	https://www.arb.ca.gov/msprog/tech/techreport/che_tech_report.pdf	Not available for container top/side picks
	 Locomotives: Switchers/Yard Goats, Passenger	https://www.arb.ca.gov/msprog/tech/techreport/final_rail_tech_assessment_11282016.pdf	Catenary and electrified third rail technologies are available
	 Ocean Going Vessels at Berth	https://www.arb.ca.gov/msprog/tech/techreport/ogv_tech_report.pdf	Shorepower, Bonnet
	 Transportation Refrigeration Unit (TRUs)	https://www.arb.ca.gov/msprog/tech/techreport/tru_07292015.pdf	
	 Medium-Duty Trucks	https://www.arb.ca.gov/msprog/tech/techreport/bev_tech_report.pdf	Delivery trucks are commercially available

Availability	Vehicle/Equipment	References	Notes
Early Commercialization	 Small Construction Equipment	http://network.bellona.org/content/uploads/sites/3/2018/06/ZEC-Report-1.pdf, http://www.kramer-online.com/en/discover-kramer/zero-emission/the-kramer-5055e/,	Available by 2020
Demonstration	 Heavy-Duty Trucks	https://www.arb.ca.gov/msprog/tech/techreport/bev_tech_report.pdf	Available by 2020
	 Commercial Harbor Craft	https://www.arb.ca.gov/msprog/tech/techreport/draft_chc_technology_assessment.pdf	Demonstration project in Bay Area 2018-2019 to demonstrate zero-emissions hydrogen fuel cell ferry
	 Container Top/Side Picks	https://www.joc.com/regulation-policy/la-lb-officials-say-zero-emissions-cargo-equipment-viable-2030_20180504.html ; https://www.portoflosangeles.org/Board/2017/October%202017/101917_Regular_Agenda_Item_6_Transmittal_1.pdf	Battery electric top picks demonstrated in Los Angeles
Not Yet Available	 Large Construction Equipment	http://network.bellona.org/content/uploads/sites/3/2018/06/ZEC-Report-1.pdf	
	 Ocean Going Vessels at Sea	https://www.arb.ca.gov/msprog/tech/techreport/ogv_tech_report.pdf	Vessel speed reduction is available; all-electric autonomous container ship to be built in Norway
	 Locomotive - Line Haul	https://www.arb.ca.gov/msprog/tech/techreport/final_rail_tech_assessment_11282016.pdf	No technologies are available other than catenary or 3rd rail electrification that are too costly to deploy