South Coast AQMD

South Coast Air Quality Management District

Clean Fuels Program

2025 Annual Report & 2026 Plan Update

Technology Advancement Office

Leading the way to cleaner air

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- SunLine Transit Agency Zero-Emission Hydrogen Fuel Cell Bus
- Range Energy Battery Electric Transportation Refrigeration Unit
- Volvo VNR Class 8 Battery Electric Truck
- Volvo VNR Class 8 Battery Electric Truck
- Freightliner Class 8 Battery eCascadia Truck
- Voltu Motor Voltu3 Class3 Medium-Duty Work Truck
- UCI Vehicle-to-Home Technology Study
- BYD Battery Electric Yard Tractor

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EXECUTIVE SUMMARY

I. Introduction

The South Coast Air Quality Management District (South Coast AQMD) is the air pollution control agency for Orange County and the urban portions of Los Angeles, Riverside, and San Bernardino counties. This region—including the South Coast Air Basin (SCAB) and small portions of the Mojave Desert and Salton Sea Air Basins—has historically experienced the worst air quality in the nation due to its geography, meteorology, high population density, and associated emissions from mobile and stationary sources.

Established by Senate Bill (SB) 2297 (Rosenthal, 1988) (Chapter 1546), the Clean Fuels Program began as a five-year initiative to increase the use of clean fuels; subsequent legislation extended the Program and removed the sunset clause. That legislation also reaffirmed the existence of the Technology Advancement Office (TAO) to administer the Clean Fuels Program.

The Clean Fuels Program is central to achieving the significant nitrogen oxide (NOx) emissions reductions in the 2022 Air Quality Management Plan (AQMP) because it enables South Coast AQMD to fund Research, Development, Demonstration, and early Deployment (RDD&D) of clean fuels and transformative transportation technologies.

Funded by a $1 motor vehicle registration fee, the Program supports clean fuels and transportation technologies, including advancements in natural gas (NG); alternative and renewable fuel engines; battery-electric vehicles (BEVs); plug-in hybrid electric vehicles (PHEVs); hydrogen fuel cell vehicles (FCEVs); and related charging and fueling infrastructure. A core strategy is fostering public–private partnerships with industry, technology developers, academia, research institutions, and government agencies.

Since 1988, the Clean Fuels Program has leveraged over $273.4 million into nearly $1.75 billion in 1,586 contracts focused on clean technology RDD&D. Leveraging is based on executed contracts and total project costs as reported in the prior year's Clean Fuels Annual Report and Plan Update. Competitive state and federal grants have substantially increased leverage for many projects over the past decade.

Additional funding mechanisms include the Mobile Source Air Pollution Reduction Review Committee (MSRC) discretionary fund (Assembly Bill [AB] 2766), which develops annual Work Programs for project categories; Carl Moyer, Lower Emission School Bus, and Proposition 1B programs, which support on- and off-road emission reductions by incentivizing advanced technology deployment and installing supporting infrastructure.

As technologies reach commercialization (e.g., battery-electric trucks, BETs) or near commercialization (e.g., fuel cell electric trucks, FCETs), the Clean Fuels Program partners with major original equipment manufacturers (OEMs)—including Daimler Trucks North America, LLC (DTNA), Volvo Group North America, Hyundai Motor Company, and Peterbilt—to deploy at scale. These partnerships leverage OEMs' engineering, manufacturing, customer relationships, and financial resources to move advanced technologies from the laboratory to the field and into customers' hands—delivering the scale required to reduce emissions and attain National Ambient Air Quality Standards (NAAQS).

South Coast AQMD and partners lead technology development and commercialization to accelerate reductions in criteria and toxic air pollutants and help reduce greenhouse gas (GHG) emissions. The Program traditionally supports a portfolio spanning different Technology Readiness Levels (TRLs) to develop solutions across mobile sectors and enhance the region's chances of achieving NAAQS.

Per California Health & Safety Code (H&SC) §40448.5(e), the Clean Fuels Program considers factors such as: current and projected fuel costs and availability; the cost-effectiveness of emission reductions compared to other pollution control alternatives; the use of new pollution control technologies with traditional fuels; potential effects on public health, ambient air quality, and visibility; and other relevant factors. The Legislature provided flexibility to focus on a broad range of technology areas, including cleaner fuels, vehicles, equipment, emission controls, and infrastructure - supporting progress toward clean air goals.

California H&SC §40448.5.1 requires South Coast AQMD to prepare and submit a Clean Fuels Annual Report and Plan Update to the Legislative Analyst by March 31 each year. The Annual Report documents prior calendar year accomplishments; the Plan Update looks ahead to proposed projects for the next calendar year and adjusts the Program's technical emphasis.

II. Setting the Stage

The Clean Fuels Program strategy aligns with priority technology categories requiring significant emission reductions identified in the 2022 AQMP and with directives from the South Coast AQMD Governing Board to protect the health of nearly 18 million residents (~half of California's population) in SCAB.

The 2022 AQMP is the region's long-term blueprint for emission reductions across federal, state, and local jurisdictions. It encompasses stationary and mobile source emissions reductions via regulatory controls, incentive programs, co-benefits from climate programs, mobile source strategies, indirect source measures, and other innovative approaches to reduce emissions from federally regulated sources (e.g., aircraft, locomotives, ocean-going vessels).

The California Air Resources Board (CARB) 2022 State Implementation Plan (SIP) Strategy includes a revised mobile source strategy necessary for SCAB to meet the 2015 8-hour ozone standard of 70 parts per billion (ppb) by 2037. CARB's 2022 SIP Strategy requires rapid deployment of zero-emission (ZE) technologies. In 2025, Governor's Executive Order N-27-25 directs the continued adoption of ZE vehicles.

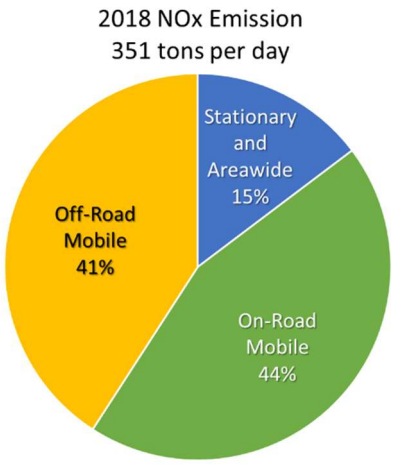

Figure 1: NOx Emissions by Source Category in SCAB (2018)

Ground-level ozone (a key component of photochemical smog) forms through reactions between NOx and volatile organic compound (VOC) emissions in sunlight. NOx emissions reduction is essential to improve ozone air quality and attain the ozone NAAQS in SCAB. In 2018, approximately 85 percent of NOx emissions were from mobile sources (see Figure 1). NOx and VOC emissions also drive secondary formation of PM2.5 (particles ≤2.5 micrometers).

The 2022 AQMP assumes the commercial adoption of current technologies and expedited development and commercialization of clean fuel mobile and stationary advanced technologies to achieve standards. It identifies the need for an 83 percent NOx reduction from 2018 levels and an additional 67 percent reduction in 2037 beyond already adopted measures to meet the 2015 8-hour ozone standard by 2037.

Most NOx emissions reductions come from mobile sources - both on- and off-road. SCAB is one of only two regions in the nation designated extreme nonattainment for the 2015 8-hour ozone NAAQS (along with California's San Joaquin Valley).

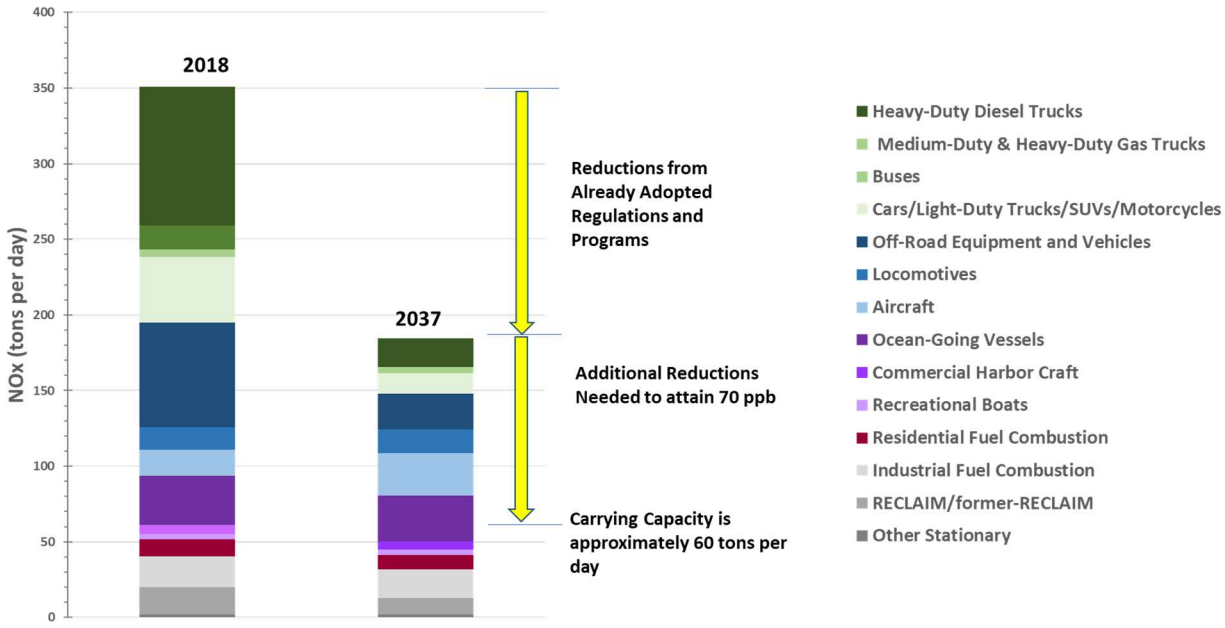

Figure 2: NOx Emissions and Reductions Required to Attain the 2015 Ozone Standard in 2037[1]

The 2022 AQMP shows the need for an economy-wide transition to ZE technologies where feasible, along with the CARB 2020 Mobile Source Strategy and low NOx technologies in other applications. New mobile source technologies must be developed, commercialized, and implemented widely to achieve these targets.

[1] South Coast AQMD 2022 AQMP. Chapter 4, p. 4-2, Figure 4-1. https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/final-2022-aqmp/07-ch4.pdf?sfvrsn=6

III. Clean Fuels Program

Established under California H&SC §40448.5, the Clean Fuels Program is a key mechanism to encourage and accelerate advancement and commercialization of clean fuels in stationary and mobile source technologies.

The Program funds projects across TRL 3–8 to cultivate a portfolio that achieves near- and long-term criteria pollutants and GHG emissions reductions and interfaces with incentive programs.

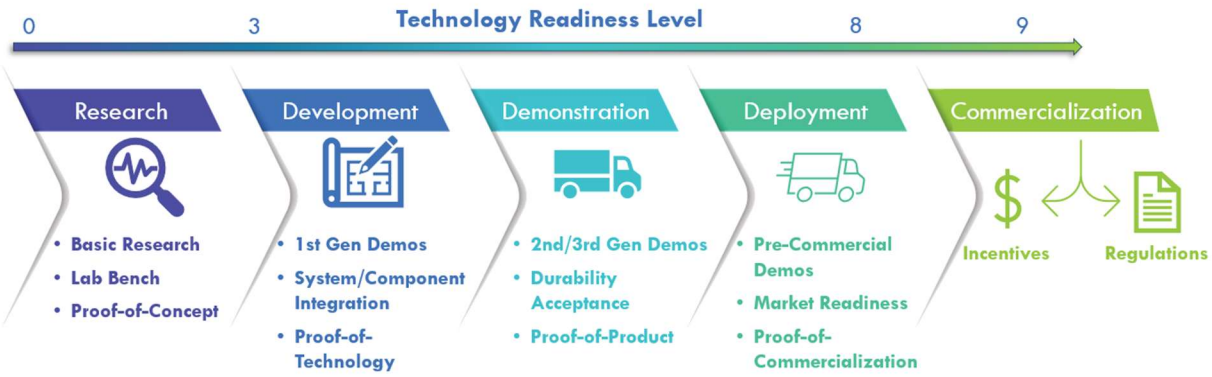

Figure 3: Technology Readiness Stages (TRL 3-8) of Clean Fuels Program

Each Annual Report and Plan Update is reviewed by two advisory groups:

- The Clean Fuels Advisory Group (mandated by SB 98, 1999)
- The Technology Advancement Advisory Group (created by the Governing Board in 1990)

These groups meet approximately every six months to provide expert analysis and feedback on potential projects and areas of focus; South Coast AQMD's Governing Board and other stakeholders also offer preliminary reviews and comments. In 2025, advisory groups met on January 30 and September 17.

IIIa. 2025 Annual Report

In calendar year (CY) 2025, the Clean Fuels Program executed 34 new and amended contracts.

- Table 2 (p. 31) shows funding partners in CY 2025
- Table 3 (p. 38) lists 16 RDD&D projects and 18 technology, assessment, outreach and sponsorship contracts (described in this report)

The Clean Fuels Program contributed almost $4.3 million, partnering with government, industry, academia, research institutions, and other stakeholders, resulting in nearly $43.8 million in total project costs.

Additionally, in CY 2025, the Program continued to leverage external opportunities, securing almost $42 million in new awards from federal, state, and local sources (Table 4, p. 40). Historical leverage averages $4 for every $1 in Clean Fuels funding; in 2025, the Program achieved $10 leveraged per $1 - a critical achievement given the funding magnitude identified in the 2022 AQMP for attaining NAAQS.

Projects and studies executed in 2025 spanned a diverse mix of advanced technologies across core areas:

- Hydrogen / Mobile Fuel Cell Technologies
- Electric / Hybrid Vehicle Technologies (including BE and hybrid trucks; ZE container transport technologies)
- Zero-Emission Infrastructure
- Stationary Clean Fuels Technologies (including microgrids and renewable systems)
- Health Impacts Studies
- Technology Assessment & Transfer / Outreach

Figure 6 (p. 33) shows the percentage distribution of executed agreements across these areas.

During CY 2025, South Coast AQMD supported projects from near-term to long-term RDD&D, enabling flexible co-funding and addressing SCAB's specific needs. Focus areas included:

- Significant battery-electric and hybrid-electric technologies and infrastructure for medium-duty (MD) and heavy-duty (HD) vehicles supporting transitions to near-zero (NZ) and ZE goods movement
- Development, demonstration, and deployment of large-displacement ultra-low-NOx engines
- Demonstration of hydrogen fuel cell MD/HD vehicles and infrastructure

In addition to the 34 executed contracts, 11 RDD&D projects/studies and 20 technology assessment & transfer contracts were completed in 2025 (see Table 5, p. 56). Appendix C provides two-page summaries of technical projects completed in 2025. As of January 1, 2026, there were 56 open contracts in the Clean Fuels Program (Appendix B lists open contracts by core technology).

Per California H&SC §40448.5.1(d), the Annual Report must be submitted to the state legislature by March 31, 2026, after Governing Board approval.

IIIb. 2026 Plan Update

The Clean Fuels Program undergoes annual re-evaluation to develop the Plan Update, based on technology progress and Agency priorities. The Program seeks to develop and deploy cost-effective clean fuel technologies via increased collaboration with OEMs to achieve large-scale deployment. Plan design balances sector needs with technology readiness, commercialization pathways, emission reduction potential (criteria pollutants and GHG), and co-funding opportunities.

South Coast AQMD remains committed to developing, demonstrating, and commercializing technologies that reduce NOx and toxic air contaminants (TACs) emissions - which often yield GHG and petroleum use reductions. These co-benefits have long supported successful public–private partnerships that leverage Clean Fuels funding.

Through extensive outreach and networking, the Agency identifies opportunities where Clean Fuels funding can significantly advance cleaner technologies in SCAB. Engagement includes state and federal collaboratives, industrial coalitions, and direct discussions with OEMs and technology providers regarding the state of technology and commercialization challenges. The Agency also regularly reviews unsolicited

proposals from OEMs and clean fuel developers. Potential development, demonstration, and certification projects emerging from these activities are included in the 2026 Plan Update.

Diesel trucks remain one of the largest NOx sources in SCAB. CARB estimates that ~60 percent of total on-road HD vehicle miles traveled in SCAB are from vehicles purchased outside California, underscoring a need for more stringent federal standards. The U.S. Environmental Protection Agency (U.S. EPA) adopted the final rule "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards" in December 2022, aligning in stringency with CARB's Omnibus Standard; in March 2024, EPA adopted two additional rules - the Phase 3 HD GHG standards and the light-duty (LD)/MD multi-pollutant standards for model year (MY) 2027 - emphasizing broad national adoption of ZE LD, MD, and HD vehicles. Several rules are being challenged, further elevating the importance of advancing ZE technologies.

The Warehouse Actions and Investments to Reduce Emissions (WAIRE) program, established under the Warehouse Indirect Source Rule (ISR), reduces NOx and diesel particulate matter (DPM) emissions from mobile sources attracted to warehouses. The San Pedro Bay Ports implemented a Clean Truck Fund to achieve ZE drayage trucks by 2035. Despite these efforts, the 2022 AQMP identifies additional NOx emissions reductions beyond adopted regulations still needed to meet ozone attainment deadlines.

In July 2024, the U.S. EPA awarded South Coast AQMD $500 million under the Climate Pollution Reduction Grants (CPRG) to implement INVEST CLEAN (Infrastructure, Vehicles, and Equipment Strategy for Climate, Equity, Air Quality, and National Competitiveness). INVEST CLEAN prioritizes emission reductions in goods movement due to substantial reductions in criteria and hazardous air pollutants, impacts on overburdened low-income communities, and opportunities to drive economic growth and job creation. This incentive funding ensures the Clean Fuels Program can continue advancing toward full commercialization through demonstrations and deployments.

While federal funding to deploy ZE vehicles and infrastructure has increased, federal support for university research has declined comparatively. South Coast AQMD will strengthen partnerships with local universities to conduct studies that assess technology advancements. Historically, Clean Fuels has funded studies focused on health impacts and fuel/emissions, demonstrating their value in achieving Program goals. If federal research funding continues to decline, South Coast AQMD will continue to identify and fund research opportunities that support technology advancement as part of the 2026 Plan Update.

Focus Areas (Next 5–10 Years)

The Plan Update will continue leveraging funds to develop, demonstrate, and commercialize technologies - from near-term to long-term - with significant emission reduction potential. Focus areas include:

- **Goods Movement & Ports:** ZE drayage trucks, cargo-handling equipment, and supporting infrastructure
- **Non-Exhaust Emissions:** Assessment of gaseous and particulate emissions from tire and brake wear
- **Engines & Powertrains:** Ultra-low-NOx engines; alternative/renewable gaseous and liquid fuels; high-efficiency large-displacement engines; ultra-low-emission renewable-fueled hybrid powertrains
- **Electric-Drive Platforms:** Fuel cell (FC), battery-electric (BE), plug-in hybrid, and non-plug-in hybrid technologies for MD/HD platforms

- **Charging & Hydrogen Infrastructure:** Ultra-fast, high-power charging for HD BEVs and similar rates for MD BEVs; high-flow fueling protocols and standards to improve hydrogen station health and reliability and expand HD hydrogen refueling
- **Portable Hydrogen Solutions:** Mobile/portable hydrogen refueling equipment to meet short-term needs and advance technology
- **Green Hydrogen & Ecosystems:** Green hydrogen production pathways and hydrogen ecosystems to reduce hydrogen costs and improve statewide station reliability and availability
- **Fuel & Emissions Studies:** Alternative fuel studies; advanced vehicle demonstration studies including non-exhaust emissions to optimize technology placement
- **Onboard Sensing:** Investigate near- and long-term benefits of onboard sensors for on- and off-road vehicles
- **Technology Transfer:** Apply proven on-road clean technologies to off-road applications
- **Health & PM Studies:** Evaluate and compare particulate matter and health impacts
- **Alternative Charging Solutions (ACS):** Low- and ZE ACS to support permanent electric vehicle (EV) charging and provide temporary backup power
- **Zero-Emission Microgrids:** Battery energy storage systems (BESS) and onsite clean power generation to support transportation electrification for goods movement and freight handling

Indicative Proposed Projects for 2026

South Coast AQMD proposes public–private partnerships to deploy Clean Fuels funding across a range of pre-commercial Clean Technology projects addressing the focus areas above. Indicative development/demonstration projects include:

<u>Development and deployment of ZE municipal fleet MD and HD trucks</u>

<u>Hydrogen Fuel-Cell Electric:</u>

- Class 8 drayage truck(s) (e.g., Toyota/Honda)
- Class 8 refuse truck(s) (e.g., Symbio)
- Class 7 delivery truck (e.g., RockeTruck)
- Class 6 Truck(s) in Utility, Service, Municipal, Delivery applications (e.g., Honda)
- Powertrain(s) (also, attached to BE tractor – hybrid system), scalable to transit buses, Class 7 drayage trucks
- Electric Power Take-Off (ePTO) with a hydrogen module to provide hydrogen to power on-board Fuel Cell(s) to generate electricity
- Mobile/Portable Refueler(s) for Off-Road Applications (e.g., Toyota Tsusho)
- Pilot Plant (e.g., PCC Hydrogen). Build a plant that reforms ethanol to produce between 300kg to over 20 tons per day without NOx emission production to deliver hydrogen to port applications to ensure low price, energy utilization and energy demand

Battery-Electric:

- Transport Refrigeration Unit (TRU) trailers (e.g., Range Energy, Nivalis Energy Systems)
- Class 8 Cement Truck (e.g., Volvo MACK)

Stationary / Microgrid Solutions:

- Linear generators for prime power and microgrid applications (e.g., GTI Energy, Hyliion)
- Charging microgrids using methanol reforming to produce electricity from hydrogen (e.g., Kaizen Clean Energy)

Indicative Research Partnerships:

South Coast AQMD will pursue collaborations with local and regional academic and research institutions for Clean Technology studies, including:

- Mobile battery-integrated EV chargers to accelerate MD/HD BEV deployment
- Battery swapping for MD/HD BEVs and equipment
- Secondary particulate matter (PM) formation from tire emissions
- On-road brake and tire wear PM and gaseous emissions using three trucks: LD BEV, Class 8 diesel, and Class 7 NG delivery
- Urban ammonia (NH_3) and nitrogen dioxide (NO_2) monitoring for on-road emission sources

CLEAN FUELS PROGRAM

2025 ANNUAL REPORT AND 2026 PLAN UPDATE

1.1. Background

The SCAB - comprising all of Orange County and the urban portions of Los Angeles, San Bernardino, and Riverside counties - experiences the worst air quality in the nation due to a combination of factors: a high vehicle population, high vehicle miles traveled (VMT), and geographic and atmospheric conditions favorable for photochemical oxidant (smog) formation. The South Coast AQMD's jurisdiction includes SCAB and small portions of the Mojave Desert and Salton Sea air basins, home to nearly 18 million residents (approximately half of California's population). Given these unique challenges, the California Legislature enabled South Coast AQMD to implement the Clean Fuels Program to accelerate the development, demonstration, and commercialization of clean fuels and advanced mobile-source technologies.

SB 2297 (Rosenthal, 1988) (Chapter 1546) established a five-year program to increase the use of clean fuels and created a funding source via a $1 motor vehicle registration surcharge. Subsequent legislation extended both the Program and the surcharge indefinitely, removing the sunset clause, and reaffirmed the existence of TAO to administer the Clean Fuels Program. The Program is an integral component of South Coast AQMD's strategy to achieve the significant NOx emissions reductions identified in the 2022 AQMP.

The California H&SC §40448.5(e) requires the Clean Fuels Program to consider, among other factors: current and projected economic costs and fuel availability; the cost-effectiveness of emission reductions from clean fuels compared with other pollution control alternatives; the use of new pollution control technologies with traditional fuels as an alternative means of reducing emissions; potential effects on public health, ambient air quality, and visibility; and other factors determined relevant by South Coast AQMD. The Legislature recognized the need for flexibility, enabling focus across a broad range of technology areas - cleaner fuels, vehicles, and infrastructure - to support continued progress toward clean air goals.

In 1999, the Legislature further amended the Clean Fuels Program. Under H&SC §40448.5.1(d), South Coast AQMD must submit an annual report to the Legislature on or before March 31 that includes:

- A description of core technologies considered critical to attaining and maintaining ambient air quality standards, and the efforts to overcome barriers to commercialization of those technologies.
- An analysis of the Clean Fuels Program's impact on the private sector and on research, development, and commercialization efforts by major automotive and energy firms, as determined by South Coast AQMD.
- A description of projects funded, including recipients, subcontractors, co-funding sources, matching state or federal funds, and the expected and actual results of each project advancing clean fuels technology and improving public health.
- The title and purpose of all projects undertaken pursuant to the Clean Fuels Program, the names of contractors and subcontractors, and the amount expended on each project.

- A summary of progress made toward the goals of the Clean Fuels Program.
- Funding priorities for the next year and relevant audit information for previous, current, and future years covered by the Program.

Also in 1999, SB 98 required annual updates to the Clean Fuels Program and a 30-day Public Notice to specified interested parties and the public prior to the annual public hearing at which the Governing Board considers action on the Clean Fuels Program. Accordingly, South Coast AQMD re-evaluates the Clean Fuels Program annually to develop a plan update based on reassessment of clean fuel technologies and direction from the Governing Board. Each year, the plan update targets projects that achieve near-term emission reductions necessary to meet health-based NAAQS.

Further, H&SC §40448.5.1(a)(2) requires South Coast AQMD to find that proposed programs and projects do not duplicate any other past or present program or project funded by CARB or other government and utility entities. This finding does not prohibit jointly funded programs or projects where duplication does not occur. Concurrent with adoption and approval of the Annual Report and Plan Update each year, the Governing Board considers TAO's efforts in the prior year to ensure no duplication and attests to that finding within its Resolution.

The following section describes the external expert panels that review the Clean Fuels Program each year.

1.2. Advisory Groups

In 1990, South Coast AQMD initiated an annual external review of its technology advancement program by a panel of experts. Over time - responding to Agency policies and legislative mandates - this process evolved into two external advisory groups that provide structured, ongoing guidance to the Clean Fuels Program.

Technology Advancement Advisory Group (TAAG)

The TAAG - one of six standing advisory groups within the South Coast AQMD Advisory Council - comprises stakeholders from industry, academia, regulatory agencies, the scientific community, and environmental non-governmental organizations (NGOs). TAAG's role is to:

- Coordinate the Clean Fuels Program with related local, state, and national activities;
- Review and assess the overall direction of the Program; and
- Identify new project areas and cost-sharing opportunities.

TAAG's charter calls for approximately 12 technical experts representing industry, academia, state agencies, the scientific community, and environmental interests.

Clean Fuels Advisory Group (CFAG)

Formed in 1999 pursuant to SB 98 (Alarcón), the CFAG is required under California H&SC §40448.5.1(c) to include 13 members with expertise in clean fuels technology and policy or public health, appointed from the scientific, academic, entrepreneurial, environmental, and public health communities. SB 98 further established conflict-of-interest safeguards prohibiting members from advocating expenditures for projects in which they have professional or economic interests.

CFAG's objectives are to review and recommend projects, plans, and reports prior to submittal of the required annual report to the South Coast AQMD Governing Board. Following CFAG's formation in 1999,

South Coast AQMD revisited TAAG's charter and membership to ensure that the two groups' functions complement one another.

Changes to CFAG composition are reviewed as needed by the South Coast AQMD Governing Board. Changes to TAAG membership are reviewed by the Governing Board's Technology Committee.

The Clean Fuels Program's review process now includes, at a minimum:

1. Two full-day retreats of both advisory groups, typically in the fall and winter;
2. Technical expert reviews beyond the advisory groups;
3. Technology forums or roundtables convening interested parties to discuss specific technology areas;
4. Review by the Technology Committee of the South Coast AQMD Governing Board;
5. A public hearing of the Annual Report and Plan Update before the full Governing Board, including adoption of the Resolution finding that proposed programs and projects do not duplicate any other past or present program or project funded by the state board or other government and utility entities, as required by the H&SC; and
6. Annual submittal of the Clean Fuels Program Annual Report and Plan Update to the Legislature by March 31.

1.3. Emissions Reduction Targets

The overall strategy of TAO's Clean Fuels Program is based on emission reduction technology needs identified through the AQMP process and South Coast AQMD Governing Board directives to protect the health of the approximately 18 million residents (nearly half the population of California) in SCAB. The 2022 AQMP is the long-term regional blueprint that relies on fair-share emission reductions from all jurisdictional levels (e.g., federal, state and local). The 2022 AQMP is composed of stationary and mobile source emission reductions from traditional regulatory control measures, incentive-based programs, projected co-benefits from climate change programs, mobile source strategies and emission reductions from federally regulated sources (e.g., aircraft, locomotives and ocean-going vessels). CARB's adopted 2022 SIP Strategy included a revised mobile source strategy required for SCAB to meet the 2015 8-hour ozone standard of 70 ppb by 2037. The adopted 2022 SIP Strategy for both mobile and stationary sources requires rapid deployment of ZE technologies to achieve air quality targets.

Ground level ozone (a key component of smog) is created by a chemical reaction between NOx and VOC emissions in sunlight. This is noteworthy because the primary driver for ozone formation in SCAB is NOx emissions, and mobile sources contribute approximately 85 percent of the NOx emissions in this region, as shown in Figure 1. Furthermore, NOx emissions, along with VOC emissions, also lead to the formation of PM2.5, including secondary organic aerosols (SOA).

The emission reductions and control measures in the 2022 AQMP rely on commercial adoption of a mix of currently available ZE technologies as well as the expedited development and commercialization of clean fuel mobile and stationary advanced technologies in SCAB to achieve air quality standards. Significant reductions are anticipated from implementation of advanced control technologies for on-road and off-road mobile sources. Air quality standards for ozone (70 ppb, 8-hour average) and fine particulate matter, promulgated by U.S. EPA, are projected to require additional long-term control measures for NOx and VOC. The 2022 AQMP identifies that 83 percent NOx emission reductions from the 2018 level and 67

percent additional reductions in 2037 beyond already adopted regulations and programs are necessary to meet the 2015 8-hour ozone standard by 2037. The majority of NOx emission reductions must come from mobile sources, including both on- and off-road sources. Notably, South Coast AQMD is currently one of only two regions in the nation designated as an extreme nonattainment area of the 2015 8-hour ozone NAAQS (the other region is California's San Joaquin Valley). As a result, the 2022 AQMP shows the need for economy-wide transition to ZE technologies where feasible, and low NOx emission technologies in other applications.

The need for advanced mobile source technologies and clean fuels is best illustrated by Figure 4 which identifies NOx emissions by source category in 2018 and 2037. NOx emission reductions identified in the 2022 AQMP will require the Clean Fuels Program to accelerate advancement of clean transportation technologies used as control strategies in the AQMP. Given this contribution, significant emission reductions from these sources are needed. 2022 AQMP mobile source strategies call for deploying cleaner technologies (both zero and near-zero emission, ZE/NZE) into fleets, requiring cleaner and renewable fuels, and ensuring continued clean performance in use. Federal actions are also required to address sources that are subject to federal regulations and beyond the regulatory authority of South Coast AQMD and CARB.

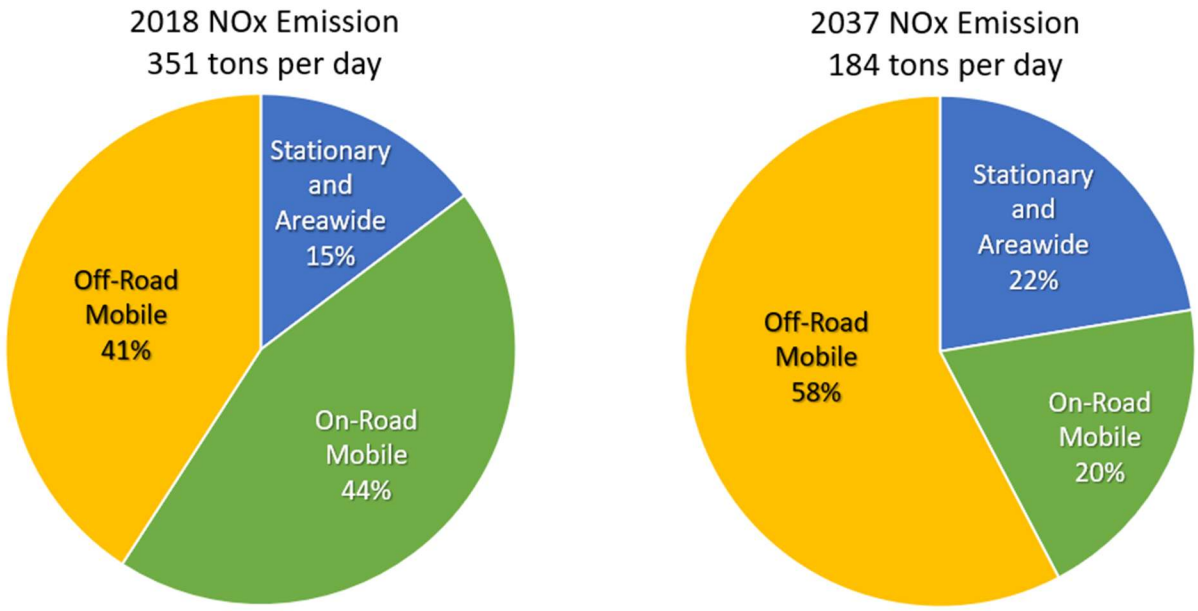

Figure 4: NOx Contribution Source Category in 2018 and 2037

Health studies further underscore the need to reduce NOx and TAC emissions. The South Coast AQMD Multiple Air Toxics Exposure Study (MATES) V (2021) - along with the four preceding MATES studies - assessed ambient air toxics levels, updated risk characterization, and evaluated concentration and risk gradients associated with selected sources. MATES VI is currently underway and will expand on the scope and findings of the prior MATES studies.

In summary, advanced, energy-efficient, and renewable technologies are essential - not only for attainment of air quality standards, but also to protect public health, reduce long-term dependence on petroleum-based fuels, and support a more sustainable energy future. Conventional strategies and traditional supply-and-consumption patterns must be retooled to achieve the NAAQS. To meet this need, the South Coast AQMD

Governing Board continues to aggressively implement the Clean Fuels Program and promote alternative fuels through TAO.

As technologies move toward commercialization - such as battery-electric and fuel-cell trucks - the Clean Fuels Program partners with major OEMs, including DTNA, Volvo Group North America, Hyundai Motor Company, PACCAR, and others, to deploy vehicles at scale. These partnerships enable the Program to leverage OEMs' research, product development, and financial resources to transition advanced technologies from the laboratory to the field and into customers' hands. OEMs possess the capacity to design, engineer, test, manufacture, market, distribute, and service quality products under trusted brands - the scale required to achieve emission reductions necessary to meet NAAQS.

As advanced technologies and cleaner fuels become commercial-ready, a concerted effort is required to bring them to market and onto roads. South Coast AQMD's Carl Moyer Program, together with the Volkswagen Mitigation Trust and the Community Air Protection Program (CAPP), help achieve these outcomes. These programs provide incentives that accelerate market penetration of technologies developed and demonstrated by the Clean Fuels Program. The synergy between the Clean Fuels Program and incentive programs positions South Coast AQMD as a leader in technology development and commercialization targeting reductions in criteria pollutants. Funding for RDD&D projects as well as on-/off-road incentive programs remains critical, given the magnitude of additional funding identified in the 2022 AQMP to achieve NAAQS.

Current federal and state regulatory efforts for on- and off-road vehicles and stationary equipment are expected to significantly reduce NOx emissions, yet additional measures are needed to meet the 2031 and 2037 ozone attainment deadlines. To support fleet turnover, the Clean Fuels Program emphasizes the commercialization and deployment of clean technologies - including ZE HD trucks, supporting ZE infrastructure, and planning studies that prioritize needs for the development of zero-emission trucks (ZETs) and infrastructure.

The following section provides an overview of the clean technology portfolio and implementation strategy for the Clean Fuels Program.

1.4. Clean Technology Development and Implementation

Over its 37-year lifetime, the Clean Fuels Program has encouraged projects that increase the use of clean-burning fuels and, in recent years, has shifted focus toward ZE technologies to further reduce emissions. Many technologies supported in the Program's early years are now being commercially deployed - including NZE NG Class 8 trucks, HD BEVs, and hydrogen fuel-cell electric transit buses—while others achieved success but were ultimately phased out (e.g., methanol buses and vehicles). Among the technologies supported by the Clean Fuels Program, several recently commercialized solutions now deliver emission reduction benefits through incentive programs, notably renewable natural gas (RNG)-fueled engines and ZETs.

OEM and Fleet Partnerships

The Clean Fuels Program partners with major OEMs - including DTNA, Volvo Group North America, Hyundai Motor Company, and others - and with large truck owner fleets such as Schneider National, Inc., NFI Industries, J.B. Hunt Transport, Inc., and others to deploy HD BETs and FCETs. These partnerships enable the Program to leverage OEMs' research, design, engineering, manufacturing, sales and service, and financial resources, moving advanced technologies from the laboratory to the field and into customers'

hands. OEMs have the capacity to develop advanced powertrains (battery-electric and fuel-cell electric), manufacture at scale, and support statewide sales through established distribution networks.

Technology Readiness and Portfolio

The Clean Fuels Program funds projects across TRL 3–8 to maintain a portfolio of technology choices and deliver both near-term and long-term emission-reduction benefits. Figure 3 outlines the technology readiness progression for development, demonstration, and early deployment projects during the pre-commercialization phase (funded by the Clean Fuels Program), and the relationship to incentive programs administered by TAO and regulatory implementation during the commercialization phase of clean vehicle technologies and equipment.

Despite the availability of several California incentive programs that support the deployment of commercially available cleaner technologies and help offset higher procurement costs, significant additional resources and technology development are still required for the region to achieve NAAQS. Several key emerging technologies - discussed in detail later - offer NOx and GHG emission reduction co-benefits while reducing reliance on vehicle purchase incentives.

Health Impact Research

Health impact studies are a core element of the Clean Fuels Program strategy. Evaluating the health impacts of air-pollution exposure helps assess source-specific impacts, guides policy and control strategies, and provides essential information to the public. Since the 1980s, South Coast AQMD has conducted five MATES campaigns, with MATES V completed in August 2021 and MATES VI currently underway. MATES uses comprehensive measurements, emissions inventory development, modeling, and health-risk assessment to estimate cancer and non-cancer chronic health risks due to exposure to air toxics across the South Coast AQMD jurisdiction. A summary of MATES findings is included in the Core Technology Areas section.

Updating MATES is a key Clean Fuels Program strategy. Planning for MATES VI began in 2023, with a monitoring campaign launched in June 2025; final data and dissemination of findings are expected between late 2027 and early 2028. This update will extend measurements, emission inventory, modeling, health-risk analysis, and trends analysis. Two near-road monitoring sites have been added, and an additional site at Mecca will provide data to determine air-toxic risk in the Coachella Valley for the first time in MATES.

1.5. Internal and External Sources of Funding Support

The Clean Fuels Program was established under California H&SC §§40448.5 and 40512 and Vehicle Code (VC) §9250.11. This legislation created revenue mechanisms from both mobile and stationary sources to support Program objectives and defined constraints on fund use. In 2008, these mechanisms were reauthorized under SB 1646 (Padilla), which removed the January 1, 2010 sunset and increased the administrative cap from 2.5 percent to 5 percent.

The Clean Fuels Program core funding mechanisms are the following:

- Mobile Sources (Department of Motor Vehicles [DMV] Surcharge):
  The Program is funded primarily through a $1 fee on motor vehicles registered within South Coast AQMD. Revenues collected from these vehicles must be used to support mobile-source projects.

- Stationary Sources (Emission Fee Surcharge):
  Stationary-source projects are funded by an emission fee surcharge on stationary sources emitting more than 250 tons of pollutants per year within South Coast AQMD.

Historically, these mechanisms generate approximately $13.5 million (mobile sources) and $350,000 (stationary sources) annually. For CY 2025, available funds were:

Funding Source	CY 2025 Amount
Mobile sources (DMV revenues)	$13,897,853
Stationary sources (emission fee surcharge)	$270,203

A defining feature of the Clean Fuels Program is its ability to leverage Clean Fuels funding through public–private partnerships with industry, technology developers, academic and research institutions, and government agencies. Leveraging is based on executed contracts and total project costs reported in the prior year's Clean Fuels Annual Report and Plan Update.

In 1998, South Coast AQMD launched the Carl Moyer Program. Together, the Clean Fuels Program and Carl Moyer Program (and subsequent incentive programs) create a unique synergy:

- Clean Fuels supports pre-commercial development, demonstration, and early deployment;
- Incentive programs provide market incentives that accelerate commercial adoption of technologies initially advanced through Clean Fuels.

This synergy enables South Coast AQMD to lead in technology development and commercialization targeting criteria-pollutant reductions. Since 1998, South Coast AQMD has implemented additional incentive programs - including Volkswagen Mitigation, Proposition 1B – Goods Movement, and CAPP - with cumulative funding exceeding $1 billion over the past five years (see Table 1).

Technology Type	Award Amount	NOx Reductions (tpy)	PM Reductions (tpy)
Zero Emission	$618M	239.7	11.5
Near-Zero Emission	$124M	153.7	1.5
Tier 3 to Tier 4 Final	$271M	1,524.5	36.1
Total	$1.01B	1,917.9	49.1

Includes funded projects from Carl Moyer, Proposition 1B, VW Mitigation Trust, and other Programs

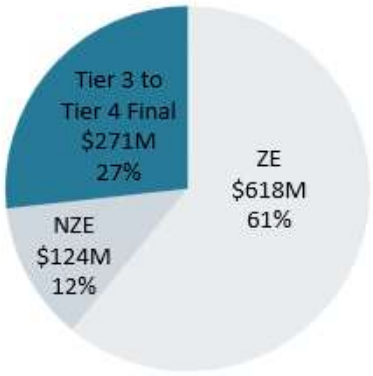

Table 1: Anticipated Emission Benefits from Incentive Programs (2021 – 2025)

Although the 2025 emission reductions may appear modest - about 4 percent of total on-road HD diesel reductions (1.69 tons per day [tpd] vs. 44.5 tpd) - increased infrastructure incentives and continued Clean Fuels Program support for the commercialization of clean technologies and equipment help ensure sustained emission reductions in SCAB.

Since 2017, there has been $462 million in AB 617 CAPP incentives, including $131 million awarded in 2024 for ZE equipment and supporting infrastructure in AB 617 communities - East Los Angeles/Boyle Heights/West Commerce, Southeast Los Angeles, San Bernardino/Muscoy, and Wilmington/Carson/West Long Beach. The 2022 AQMP also includes control measures to develop an indirect source regulation for the San Pedro Bay Ports and to strengthen fleet rules, leveraging incentives to accelerate emission reductions.

The Clean Fuels Program supplements its core funding with grants and cost-sharing contracts from multiple agencies on a project-specific basis. Historically, cooperative project-funding revenues have been received from CARB, California Energy Commission (CEC), U.S. EPA (including Diesel Emissions Reduction Act [DERA], Clean Air Technology Initiative [CATI], and Targeted Airshed Grant [TAG] programs), U.S. Department of Energy (DOE), and the U.S. Department of Transportation (DOT). These supplemental revenues depend largely on each originating agency's budget and planning cycles and the specific project or intended use of funds.

Table 4 (p. 40) lists federal, state, and other revenues totaling nearly $42 million awarded to South Coast AQMD in 2025 for projects that are part of the overall Clean Fuels Program RDD&D efforts - even where, for financial-tracking purposes, revenue is recognized in a special revenue fund other than the Clean Fuels Fund (Fund 31).

A final - and often most significant - indirect funding source is cost-sharing provided by private industry and other public and private organizations. Public–private partnerships with technology developers, academic and research institutions, and government agencies are a core strategy of the Clean Fuels Program. Historically, TAO has leveraged $4 of outside funding for every $1 of South Coast AQMD funding. Since 1988, the Program has leveraged nearly $273.4 million into over $1.75 billion in projects; in 2025, each $1 of Clean Fuels funds leveraged approximately $10 in outside funding. Through these partnerships, South Coast AQMD shares investment risk, accelerates technology development and commercial availability, increases end-user acceptance, reduces emissions from demonstration projects, and ultimately expands use of clean technologies in SCAB. While aggressively leveraging funds, South Coast AQMD continues to play a leadership role in technology development and commercialization, alongside its partners, to accelerate reductions in criteria pollutants emissions. Given the magnitude of additional funding needed - as identified in the 2022 AQMP - aggressively pursuing federal and state opportunities is more important than ever. The Clean Fuels Program also avoids duplicative efforts by coordinating and jointly funding projects with major agencies and organizations. Funding partners for 2025 are listed in Table 2 (p. 31).

Many technologies addressing SCAB's NOx emission reduction needs also align with the state's GHG emission reduction efforts. The U.S. EPA (2023) reported that the transportation sector accounted for 28 percent of U.S. GHG emissions. Because of these co-benefits, South Coast AQMD has successfully formed state partnerships and public–private collaborations to extensively leverage Clean Fuels funding.

1.6. Core Technology Areas

The SCAB faces air quality challenges from a wide variety of pollution sources. Given this diversity, there is no single technology or "silver bullet" that can solve all problems. Multiple technologies spanning a broad range of applications are required, and their full emission-reduction benefits will be realized on different commercialization and deployment timelines. Clean technologies and equipment are therefore paramount to improving air quality in the region.

To address this need, the Clean Fuels Program has established a broad range of Core Technology Areas, listed below and described throughout this document:

- Hydrogen / Mobile Fuel Cell Technologies
- Engine Systems / Technologies
- Electric / Hybrid Vehicle Technologies (including BE and hybrid-electric trucks and container transport technologies with ZE operations)
- Zero-Emission Infrastructure
- Fueling Infrastructure and Deployment
- Stationary Clean Fuels Technologies (including microgrids and renewables)
- Fuel and Emissions Studies
- Emissions Control Technologies
- Health Impacts Studies
- Technology Assessment and Transfer / Outreach

South Coast AQMD continually seeks to support the deployment of lower-emitting and ZE technologies. The Clean Fuels Program is shaped by two basic factors:

1. ZE and NZE technologies needed to achieve the NAAQS in SCAB; and
2. Available funding to support technology development and deployment, within the constraints of that funding.

South Coast AQMD strives to maintain a flexible program that can adapt to evolving technologies and the latest advancements, while balancing sector needs with technology readiness, emissions-reduction potential, and co-funding opportunities. Although the Clean Fuels Program is significant, national and international activities also influence technology-development trends; as such, the Program must remain nimble to leverage and accommodate changes in state, national, and international priorities.

While state and federal governments have devoted substantial attention to climate change, South Coast AQMD remains committed to developing, demonstrating, and commercializing ZE and NZE technologies. Fortunately, many technology sectors that address NOx emission reductions also deliver GHG emission reductions, creating co-benefits that have enabled strong state and federal partnerships. Even with leveraged funds, a key challenge is identifying projects and technologies where available funding can meaningfully accelerate progress toward cleaner air in SCAB.

To meet this challenge, South Coast AQMD employs broad outreach and networking and continues to innovate in these activities. Efforts include:

- Close involvement with state and federal collaboratives, public–private partnerships, and industrial coalitions;
- Issuance of Program Opportunity Notices (PONs) to solicit project ideas and concepts;
- Issuance of Request for Proposals (RFP) to solicit proposals from qualified respondents to design, develop and implement ZE and NZE technologies;
- Issuance of Requests for Information (RFIs) to assess the state of technologies and identify development and commercialization challenges; and
- Acceptance and review of unsolicited proposals from OEMs and clean-fuel technology developers in the absence of PONs and RFPs.

Historically, mobile-source projects have targeted low-emission developments in LD vehicles, transit buses, MD and HD trucks, and non-road applications. These efforts have focused on:

- Advancements in engine design, electric powertrains, and energy storage/conversion (e.g., FCs and batteries); and
- Implementation of clean fuels (e.g., NG, propane, hydrogen), including infrastructure development.

Stationary-source projects have included advanced low-NOx technologies and clean energy alternatives such as FCs, solar power, and other renewable and waste-energy systems.

In recent years, the focus has increasingly been on ZE and NZE technologies, with particular attention to MD and HD trucks to reduce mobile-source emissions, which constitute more than 80 percent of current NOx emissions in SCAB. While mobile sources include both on- and off-road vehicles as well as aircraft and ships, only the federal government has the authority to regulate emissions from aircraft and ships. South Coast AQMD is exploring opportunities to expand its authority to foster technology development for ship and locomotives related to goods movement.

In the absence of regulatory authority, South Coast AQMD leverages mitigation, state and federal funds, San Pedro Bay Ports funding, and industry partnerships to expand its portfolio of RDD&D pre-commercial projects to include locomotives, off-road equipment, marine vessels, and ocean-going vessels - demonstrating emission-reduction technologies in sectors where NOx emissions are increasing.

The 2022 AQMP includes five facility-based mobile-source measures, also known as indirect source measures. South Coast AQMD staff have been developing both voluntary and regulatory measures through an extensive public process. Unlike traditional regulations that focus on emissions from the facility, indirect source measures focus on emissions from vehicles associated with a facility.

- Warehouses: Newly established measures target emissions from trucks servicing warehouses.
- Ports: Measures concentrate on emissions from ships, trucks, locomotives, and cargo-handling equipment at the Ports.
- New Development / Redevelopment: Measures could aim to reduce emissions from construction equipment, particularly HD diesel earth-moving vehicles.

Projects from competitive solicitations, cooperative agency agreements, and unsolicited proposals are selected for co-funding. Criteria considered include:

- Emissions-reduction potential
- Technological innovation
- Potential to reduce costs and improve cost-effectiveness
- Contractor experience and capabilities
- Overall environmental impacts or benefits
- Commercialization and business-development potential
- Cost-sharing and partners
- Consistency with program goals and funding constraints

The core technology areas for South Coast AQMD programs that meet both funding constraints and the 2022 AQMP needs for achieving clean air are briefly described below.

1.6.1. Hydrogen / Mobile Fuel Cell Technologies

South Coast AQMD supports hydrogen fuel cell technologies as a core option within its technology portfolio and is committed to assisting state and federal programs to deploy LD, MD, and HD FCEVs.

Calendar Years 2014–2019 were pivotal for LD hydrogen FCEV introduction and consumer access:

- 2014: Hyundai introduced the Tucson FCEV, available via lease to interested individuals.
- 2015: Toyota and Hyundai commercialized LD FCEVs (Mirai and Tucson, respectively).
- 2016: Honda launched the Fuel Cell Electric Clarity passenger car; in mid-2024, Honda introduced the CR-V e:FCEV (plug-in hybrid hydrogen fuel cell electric vehicle).
- 2019: Hyundai's Nexo became the second FCEV offered for sale/lease in California.

Historically, Clean Fuels Program Fund support has covered LD FCEV leases for technology outreach at conferences and events in overburdened communities. While recent LD FCEV model availability has decreased, major OEMs remain committed to supporting FCEV introduction in the California market.

Fuel cells are well-suited to MD/HD applications where range, fast refueling, and high power/torque are critical and BE technologies may require further optimization to meet fleet needs.

Hydrogen Fuel Cell Partnership (H2FCP) vision and action plans highlight infrastructure scale-up needs:

- Vision 2030 (2018): Up to 1,000 refueling stations statewide, including about 200 HD stations to support approximately 70,000 FCETs by 2035.
- MD/HD Fuel Cell Electric Truck Action Plan (2016): Focused early on Class 4 parcel delivery and Class 8 drayage, with infrastructure development and progress metrics.

ARCHES (Alliance for Renewable Clean Hydrogen Energy Systems) recently issued an RFQ for Heavy-Duty Fuel Cell Electric Trucks, aiming to secure incentive agreements supporting the deployment

of approximately 5,000 FCETs, underscoring market demand and the role of hydrogen in meeting California's electrification goals.

The H2FCP Fuel Cell Electric Bus Road Map (2019) supports implementation of CARB's Innovative Clean Transit and Zero Emission Airport Shuttle regulations. Notable progress includes:

- SunLine Transit Agency (June 2020): U.S. EPA TAG; deployed six fuel cell electric buses, complementing an existing fleet of 26 fuel cell and four BE buses; upgraded to a 900 kilogram (kg)/day hydrogen station, capable of supporting up to 30 fuel cell buses.
- August 2021: Clean Fuels Program committed $531,166 to a $2 million project to develop and demonstrate two MD fuel cell transit buses at SunLine, with additional hydrogen fueling infrastructure support.

South Coast AQMD has established alliances with large OEMs to develop and deploy HD FCETs:

- Cummins (CEC/South Coast AQMD project): Development and demonstration of FC drayage trucks with next-generation FC modules, emphasizing packaging and innovative integration.
- Hyundai (U.S. EPA grants, 2021): Demonstration of Class 8 hydrogen FCETs with ranges up to 500 miles for regional and long-haul operations.
- U.S. EPA Award (2022): $5 million to develop and demonstrate six Class 8 FCETs, further expanding the hydrogen FC impact.

Despite limited station availability and high fuel prices, demonstrations indicate MD/HD FCETs are operationally viable under real-world conditions.

South Coast AQMD is actively pursuing strategies to reduce delivered hydrogen cost (e.g., large-scale stations and production facilities) and exploring longer-term FC powerplant technologies. Past and ongoing infrastructure support includes:

- Orange County Transportation Authority (OCTA) Liquid Hydrogen Station: Co-funded a station capable of fueling up to 60 fuel cell transit buses at OCTA.
- Zero and Near Zero-Emission Freight Facilities (ZANZEFF) Shore-to-Store: Clean Fuels Program co-funded CARB's ZANZEFF project, deploying 10 Toyota-Kenworth HD FCETs and installing three HD hydrogen stations in Wilmington, Long Beach, and Ontario.
- POLB HD Station: Co-funded CEC HD hydrogen refueling station by Shell Oil Products USA (Shell) at the Port of Long Beach (POLB), leased to Toyota Motor North America.

South Coast AQMD will continue providing funding for projects that develop and install hydrogen refueling infrastructure to serve retail fuel cell vehicles and MD/HD trucks and buses.

Key market and infrastructure challenges include:

1. Station Availability & Reliability
    a. Insufficient and uneven distribution of LD and HD hydrogen stations - including along truck and drayage routes is impacting fleet operations.

2. Permitting Time & Cost
    a. Complex and lengthy permitting processes increase capital costs and delay deployment of hydrogen refueling infrastructure.
3. Hydrogen Fuel Pricing
    a. High delivered hydrogen prices adversely affect the total cost of ownership (TCO), slowing fleet adoption and market growth.
    b. Cost reductions are essential for accelerated and sustainable ZE market adoption.

1.6.2. Engine Systems / Technologies

To achieve the emission reductions required for SCAB, HD trucking must transition to ZE technologies, consistent with CARB's 2022 Mobile Source Strategy and the 2022 AQMP. Recognizing the time needed to reach 100 percent ZE, the 2026 Plan Update supports a pragmatic pathway: aggressively scale ZE while deploying ultra-low-NOx internal combustion engine (ICE) platforms - powered by low-carbon-intensity fuels - to deliver near-term criteria pollutant and GHG emission reductions.

Progress in Ultra-Low-NOx ICE Platforms includes:

- NG Engines:
    - 2018: Cummins certified a 12-L low-NOx NG engine, expanding into more market sectors.
    - MY 2024: A more powerful 15-L NG engine became available, broadening HD applications.
- Diesel Technology:
    - Development and demonstrations show low-NOx diesel is viable. Research with Southwest Research Institute (SwRI) successfully achieved 0.02 g NOx/bhp-hr during regular diesel engine operation.
    - Lower-NOx diesel engines entered the market in 2024, with additional platforms anticipated in 2027, aligning with U.S. EPA and CARB rule phase-ins.

These ultra-low-NOx engines are expected to operate alongside BE, fuel cell electric, and NG platforms, providing immediate reductions while ZE technologies scale.

On March 29, 2024, U.S. EPA announced new GHG standards for HD vehicles (HD GHG Phase 3), effective June 21, 2024.

South Coast AQMD, with local, state, and federal partners, continues supporting development and demonstrations of alternative-fueled, low-emission HD engines using NG, RNG, hydrogen, renewable diesel, and other renewable/waste-stream fuels for trucks, transit and school buses, rail operations, and refuse/delivery vehicles—meeting or going below federal and state emission standards.

Hydrogen ICE: Bridge to FCs

- 2022: Cummins announced a hydrogen-powered ICE (H2-ICE) with low-NOx capabilities, targeting implementation in 2027.
- Near-term role: While fuel cells remain a core strategy for SCAB air quality goals, H2-ICE can serve as a bridge technology for on- and off-road applications, offering:
    - Utilization of existing engine platforms and service networks
    - Fuel quality insensitivity compared to some fuel cell systems
    - Compatibility with existing hydrogen production and distribution, accelerating station deployment that will later complement FCEVs

Continued research is required to achieve significant efficiency gains and emissions reductions (especially NOx under real-world duty cycles) in hydrogen combustion engines - including combustion strategies, aftertreatment optimization, and durability.

1.6.3. Electric / Hybrid Vehicle Technologies (including battery electric and hybrid electric trucks and container transport technologies with zero emission operations)

Achieving the emission reductions required in SCAB will depend on wide-scale transportation electrification. South Coast AQMD supports projects that address persistent market concerns - cost, battery life, all-electric range, and OEM commitment - and promotes integrated transportation systems that match EVs to real-world duty cycles (e.g., drayage, short regional haul, last-mile delivery).

Developing and deploying ZE goods movement and freight-handling technologies remains a top priority to support balanced, sustainable growth at the San Pedro Bay Ports and logistics facilities throughout SCAB.

In July 2024, South Coast AQMD received $500 million from the U.S. EPA under the CPRG for the project titled INVEST CLEAN which is currently underway. The project focuses on the electrification of the goods movement sector, providing significant funding for the installation of HD truck charging infrastructure in Southern California, with over 1,000 HD truck chargers expected over the next few years to accelerate deployment of BE HD trucks - complementing state-funded infrastructure programs.

INVEST CLEAN supports deployment of:

- ZE BEVs across HD Class 8 and MD Class 4–5 last-mile freight applications.
- ZE cargo handling equipment (CHE) (e.g., RTG cranes, yard trucks, forklifts, side handlers, top picks, reach stackers) to accelerate commercialization at warehouses, intermodal railyards, airports, ports, and freight facility centers.
- BE switcher locomotives to advance ZE yard operations and reduce localized emissions in freight corridors.

After decades of development and demonstrations, MD/HD BETs are now widely commercially available and eligible for incentives such as:

- Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project

- Carl Moyer Program
- Volkswagen Environmental Mitigation Trust
- CAPP funding

This incentive environment, combined with emerging technologies, is accelerating adoption across diverse fleet use cases. Emerging BE Technology include:

- Faster Charging for MD Work Trucks: Enables higher-duty cycles and greater payloads; supported by higher-voltage batteries, advanced chemistries, and vehicle-to-grid (V2G) capabilities.
- Battery-Swap Trucks: Offer rapid "refueling" compared to traditional fast charging - even megawatt-level charging - while potentially lowering grid demand and site footprint. Battery-swap ecosystems are expanding in overseas markets; for certain U.S. applications, swapping can be an alternative pathway to meet duty-cycle and infrastructure constraints.

Historically, HD hybrids were optimized for fuel economy. Under CARB and U.S. EPA regulations, new hybrid powertrains must co-optimize criteria emissions and fuel economy, meeting standards via the engine or as a combined system.

1.6.4. Zero Emission Infrastructure

Significant demonstration and commercialization efforts for ZE infrastructure are funded by the Clean Fuels Program alongside local, state, and federal programs. As the scale of hydrogen fuel cell and battery-electric vehicle/equipment deployments grows, ZE infrastructure has become an increasing focus of the Program - supporting large-scale demonstration and real-world deployment across the region.

To reflect this priority, ZE Infrastructure was established as a stand-alone category in the 2023 Plan Update, separate from Hydrogen/Fuel Cell and Electric/Hybrid Technologies. This structure enables targeted investment and clearer tracking of infrastructure projects that directly enable ZE operations (e.g., charging systems, hydrogen refueling, site readiness, and supporting energy systems), while maintaining programmatic alignment with broader technology development and fleet adoption goals.

1.6.4.1. Hydrogen Refueling Infrastructure

Retail-level hydrogen refueling stations require 18–36 months for permitting, construction, and commissioning, so advance planning is essential. While coordination with the California Division of Measurement Standards to establish standardized measurements for hydrogen fueling began in 2014, further efforts are needed to enable higher-volume retail sales - particularly in light of upcoming state and national ZE vehicle and infrastructure policy deadlines.

CARB's Low Carbon Fuel Standard (LCFS) provides incentives for producing and dispensing low carbon-intensity (CI) hydrogen for FCEVs, helping station operators remain solvent and offset operational costs, thereby reducing cost per kilogram to consumers. Although LCFS credit deflation and recent regulatory changes have contributed to elevated hydrogen prices, these incentives still support network expansion.

A deliberate, coordinated effort remains necessary to ensure future hydrogen refueling stations are designed with:

Siting flexibility for location constraints (e.g., ports and dense urban areas)

- Robust supply chains
- Fueling reliability comparable to gasoline and diesel stations

Today, the LD FCEV station network is insufficient to support the current vehicle population and future MD/HD FCEV growth, and carbon-neutral hydrogen supply remains a significant challenge.

Major Demonstrations & Infrastructure Investments include:

Shell / Equilon — POLB Tri-Generation & H2Freight (2019–2021)

- Award: $1.2M (Clean Fuels Program) for a 1,000 kg/day HD hydrogen station at POLB, using hydrogen produced by a tri-generation fuel cell on property leased by Toyota Motor North America.
- Status: Commissioned July 2021; Shell continues to operate and maintain the station for consumers, including Toyota and other committed fleet operators.

Port of Los Angeles (POLA) — Shore-to-Store (2019–2022)

- Total program: $83M (Clean Fuels commitment $1M).
- Deployments: 10 Toyota-Kenworth Class 8 FCETs; two large-capacity hydrogen stations in Wilmington and Ontario.
- Integration: Kenworth leveraged South Coast AQMD's Zero-Emission Cargo Transport (ZECT) II truck development; Toyota fuel cells integrated into Kenworth platforms.
- Fleets: UPS, Total Transportation Services, Southern Counties Express, Toyota Logistics Services (POLA, Port Hueneme), and fleets in Riverside County; most trucks completed the demonstration phase.

DOE H2@Scale — High-Flow Bus Protocol & Infrastructure Analyses (2021+)

- Frontier Energy (Mar 2021): DOE award to develop high-flow bus fueling protocols, with partners Southern California Gas Company (SoCalGas), Shell, National Laboratory of the Rockies (NLR, former National Renewable Energy Laboratory [NREL]).
- NLR / University of California, Davis (UCD): Grants to analyze HD hydrogen refueling needs in California and conduct a California Hydrogen Systems Analysis, aimed at bridging LD and HD infrastructure gaps as policies advance.
- Rationale: Station reliability is critical - LD station limitations slow adoption, and HD fueling disruptions directly impact operations, costs, and logistics. Improving equipment durability, maintenance practices, and uptime is a prerequisite for scale.

AB 8 & Station Reliability (CEC Funding)

- Requirement: AB 8 directs CEC to allocate $20M annually from the Alternative and Renewable Fuel and Vehicle Technology Program until ≥100 publicly accessible hydrogen stations operate in California.

- Status (2023): 66 open retail stations, with approximately 12 stations offline over 30 days, indicating ongoing reliability challenges.
- LD FCEV market: 2010–July 2025 cumulative LD FCEV sales/leases = 18,896; adoption remains constrained by infrastructure, fuel cost, supply, and market dynamics.
- Customer experience: South Coast AQMD co-funded the replacement/expansion of the Diamond Bar retail LD hydrogen station to improve user access.

Shell Station Closures & Partial Restarts (2024)

- Early 2024: Shell announced closure of all light-duty vehicle (LDV) hydrogen stations in California and a pause at three publicly accessible heavy-duty vehicle (HDV) stations.
- Current status: Stations have reopened for limited operation; public access remains limited. In contrast, when fuel supply is sufficient, operations such as NorCAL ZERO (30 FCETs out of Port of Oakland) are performing well.

South Coast AQMD has been involved in strategic partnerships & regional initiatives, including:

- H2FCP: South Coast AQMD works with H2FCP to improve reliability, standards, protocols, and green hydrogen pathways.
- Angeles Link: Participation in an initiative to build a dedicated hydrogen pipeline delivering clean hydrogen to SCAB.
- ARCHES (DOE-funded hub): California's effort to accelerate renewable hydrogen projects and infrastructure.
- Discussions with technology providers on new refueling approaches and expanded production of clean, renewable hydrogen.
- Deploying H2 stations through the incentive programs

1.6.4.2. Electric Charging Infrastructure

Continued advances in LD charging have accelerated the development of codes and standards for MD and HD infrastructure, including the Megawatt Charging System (MCS) for high-power charging. Utility programs - such as Southern California Edison (SCE)'s Charge Ready Transport and Los Angeles Department of Water and Power (LADWP)'s Commercial EV Charging Station Rebate - continue to support charging infrastructure deployment:

- LD Charging: Largely commercially available; the market is converging on North American Charging Standard (NACS) and Combined Charging System Combo 1 (CCS1).
- MD/HD Charging: Commercial deployments are available using CCS1 connectors; CCS1 remains the U.S. standard up to 350 kilowatt (kW) direct current (DC) for MD/HD applications.
- MCS (Charging Interface Initiative, CharIN): Released June 2022 for Class 6–8 EVs; designed for up to 3,000 A at up to 1,250 V (up to 3.75 MW [megawatt] DC). Not yet widely adopted, but poised to support depot and corridor fast charging.

- Additional Standards: Society of Automotive Engineers (SAE) J3068 for single-/three-phase alternating current (AC) charging, and Tesla's semi charging connector.

Installation complexity and costs for MD/HD infrastructure increase exponentially relative to LD due to higher power needs and extended utility interconnection timelines.

South Coast AQMD continues to seek state and federal funding to lead local and regional collaboratives that build out MD/HD charging networks. Examples of such collaboratives are included here:

- SCAG/CEC Electric Truck Research and Utilization Center (eTRUC): The Southern California Association of Governments (SCAG) is developing a six-county regional MD/HD charging and hydrogen refueling plan under CEC's eTRUC initiative, including detailed planning for the San Pedro Bay Ports and the I-710 corridor using advanced modeling and expanded data sources.
- Metro Commitment: Metro has committed $50 million to deploy HD BET charging between the San Pedro Bay Ports and along the I-710 corridor.
- South Coast AQMD Incentives: In 2023–2024, South Coast AQMD made > $200 million in Carl Moyer and CAPP funds available and partnered with public/private entities to build and expand the MD/HD charging and hydrogen refueling network. Additional proposals have been submitted to state and federal agencies to support BETs, off-road equipment, and long-haul truck electrification.
- Additional Opportunities: Funding exists under CARB, CEC, and U.S. EPA for HD electrification and climate pollution reduction.
- INVEST CLEAN (U.S. EPA CPRG Award): Focusing on goods-movement electrification, the INVEST CLEAN program allocates significant funding for heavy-duty truck charging in Southern California, with over 1,000 HD truck chargers expected over the next few years - complementing current state-funded infrastructure programs.

Deploying MD/HD charging infrastructure faces persistent barriers:

- High capital costs, permitting, and equipment certification
- Utility interconnection requirements and extended timelines
- Grid upgrade needs that require policy/process changes to streamline development

California Public Utilities Commission (CPUC) modeling and forecasting continue to be updated to reflect ACT, and ISR regulatory requirements, which mandate fleet transitions to BETs. Under current CPUC regulations, investor-owned utilities (IOUs) generally perform "just-in-time" grid upgrades; enabling advance upgrades in high-priority corridors - especially the I-710 freight route between the San Pedro Bay Ports and Inland Empire warehouses - will be critical.

For Class 8 trucks and similar battery-electric equipment, power demands are substantial. Many projects do not proceed due to inadequate local grid capacity. In response, the Clean Fuels Program is prioritizing microgrids and clean prime power (e.g., linear generators and fuel cells) to provide or supplement power for charging needs *(see Section 1.6.6: Stationary Clean Fuels Technology)*.

1.6.5. Fueling Infrastructure and Deployment

The Clean Fuels Program has historically provided funding to advance RNG infrastructure, including:

1. Upgrades and build-outs of public and private RNG fueling infrastructure.
2. Network expansion of public-access and fleet fueling RNG stations based on existing and anticipated vehicle populations.
3. Infrastructure readiness for transportation fuels with very low gaseous and GHG emissions.
4. Local production of clean, low-carbon-intensity renewable transportation fuels.

There are now commercial public-access RNG refueling stations across Southern California, and a portion of pipeline gas includes renewable content. Additionally, incentive funds have supported RNG infrastructure deployment.

While the Clean Fuels Program anticipates minimal new funding for RNG infrastructure in 2026, this standalone category is maintained to:

- Honor and support past investments and ensure continuity where needed.
- Sustain essential infrastructure in geographies or use cases where other incentive funding is absent or insufficient.
- Provide a transitional pathway that complements the Program's increasing emphasis on ZE technologies (with electric and hydrogen fueling covered in their respective categories).

A key enabler of alternative-fuel vehicle adoption is the availability and reliability of supporting refueling infrastructure:

- Gasoline and diesel networks are mature and ubiquitous.
- Alternative clean fuels - including alcohol-based fuels, propane, hydrogen, and electricity—remain less available or accessible.
- NG and RNG have become more readily available and cost-effective in certain markets, offering near-term emission reductions where ZE infrastructure is not yet feasible.

To realize emissions benefits, alternative fuels - especially those from renewable feedstocks - must be developed in tandem with growth in alternative-fuel vehicles.

1.6.6. Stationary Clean Fuels Technologies (including microgrids and renewables)

While stationary source NOx emissions are lower than mobile source NOx emissions in SCAB, there remain high-value applications where clean fuel technologies and process improvements can further reduce NOx, VOC, and PM emissions. Past projects demonstrate these benefits - for example, a local sanitation district retrofit of an existing biogas engine with digester gas cleanup and catalytic exhaust controls delivered significant reductions in NOx, VOC, and carbon monoxide (CO) emissions.

Stationary systems often operate in steady-state modes, enabling optimized engine calibrations, advanced aftertreatment, and the use of low- and zero-carbon fuels to maximize emission reductions.

Rapid growth in BEVs is catalyzing alternative energy storage and grid services that can support both transportation and stationary applications:

- V2G and Vehicle-to-Building (V2B) to provide peak shaving, backup, and resilience.
- Power-to-Gas (P2G) pathways to convert curtailed renewable electricity into hydrogen for storage and later use.
- Microgrid demonstrations and deployments to facilitate large-scale ZE vehicle/equipment infrastructure, site resilience, and managed charging.

Ongoing initiatives - such as University of California, Riverside (UCR)'s Sustainable Integrated Grid Initiative and University of California, Irvine (UCI)'s Advanced Energy and Power Program (both partially funded by South Coast AQMD) - assist in evaluating and validating these technologies for regional deployment. Given limited funding for low-emission stationary technology development, this category has historically been narrow in scope. To maximize air quality benefits, the Program prioritizes replacing higher-polluting fossil-fired power with clean, renewable energy resources or advanced ZE/NZE technologies, such as solar, energy storage, wind, geothermal, biomass conversion, and stationary fuel cells.

Stationary category coverage includes: boilers, heaters, gas turbines, linear generators, reciprocating engines, microgrids, and select renewables.

In 2023, the Clean Fuels Program funded UCI to study regional air quality and health impacts of hydrogen blends in commercial buildings and industrial applications as part of a CEC decarbonization award.

Introduced in 2019 as an alternative power generation technology, linear generators produce electricity by driving magnets through copper coils in a linear motion - distinct from traditional ICEs. Key attributes of this technology include:

- Lower-temperature thermochemical reaction, enabling lower emissions without add-on controls (e.g., Selective Catalytic Reduction, SCR).
- Fuel-agnostic operation: can utilize hydrogen, ammonia, biogas, and natural gas without physical modifications.
- Current deployments focus on stationary prime power; emergency backup applications are anticipated.

South Coast AQMD launched a linear generator demonstration with California State University, Long Beach (CSULB) to:

- Provide emissions insight across multiple fuels
- Demonstrate waste heat recovery
- Support peak shaving at the university
- Characterize criteria pollutants by fuel type and evaluate durability/robustness for a newly introduced linear generator fueled by natural gas

1.6.7. Fuel and Emissions Studies

Monitoring pollutants across SCAB is essential - particularly when linked to specific emission inventory sectors. This data highlights where additional emissions studies are needed to identify high-polluting sectors and quantify impacts from emerging technologies.

Over the past decade, South Coast AQMD funded emission studies assessing tailpipe impacts of biodiesel, renewable diesel, and ethanol-fueled LD/MD/HD vehicles, with a focus on criteria pollutants and GHG emissions. Findings indicate that biofuels, especially biodiesel in certain applications and duty cycles, can increase NOx emissions even as they reduce other criteria pollutants emissions - underscoring the need for fuel- and duty-cycle-specific assessments. Looking ahead, additional fuel and emissions studies on carbon-free fuels, such as hydrogen, are expected to inform deployment strategies and regulatory decisions.

The market share of gasoline direct injection (GDI) vehicles has grown rapidly - from about 4 percent of U.S. sales to an estimated 73 percent in 2023 (U.S. EPA). South Coast AQMD has funded studies investigating the physical and chemical composition of tailpipe emissions from GDI vehicles, including:

- Primary PM characterization
- SOA formation arising from gaseous and particulate emissions from NG and diesel HD vehicles

Results suggest that adding particulate filters on GDI vehicles can effectively control PM emissions. In 2024, the U.S. EPA adopted a new multi-pollutant standard for LD and MD vehicles beginning with MY 2027, which tightens PM standards and is expected to require particulate filters.

Recognizing the promise of linear generators as stationary clean fuel technologies, South Coast AQMD adopted Rule 1110.3 - Emissions from Linear Generators in 2023. The rule:

- Applies to natural-gas-fueled linear generators
- Sets emission standards for NOx, CO, and VOCs

Linear generators can operate on multiple fuels without hardware changes and tend to produce relatively low emissions. However, emissions data exist primarily for NG-fueled units; performance on hydrogen, ammonia, biogas, and other fuels remains to be systematically characterized. Additionally, given their recent market introduction, durability and robustness must be established through real-world testing.

Non-exhaust PM emissions - including brake wear, tire and road wear, clutch wear, and road dust resuspension - are gaining attention. These sources:

- Are not currently regulated due to measurement and control challenges
- Are projected to dominate traffic-related PM2.5 and PM10 (particles ≤10 micrometers) as exhaust emissions decline

The Clean Fuels Program supports MATES VI with projects studying ambient exposure from non-exhaust PM sources. Concurrent efforts at CARB and other institutions are working to quantify emission factors for non-exhaust PM emissions. South Coast AQMD is partnering with agencies to improve inventories and clarify contributions from these sources to overall PM emissions.

1.6.8. Emissions Control Technologies

This broad category covers technologies and systems that can be deployed on existing off-road mobile equipment, including aircraft, locomotives, marine vessels, farm and construction equipment, CHE, industrial equipment, and utility/lawn-and-garden equipment.

Off-road mobile technologies are often older, with uncontrolled or less stringently regulated in-use emissions compared to on-road applications. The primary regulatory authority for on-road and off-road retrofit regulations rests with the U.S. EPA and CARB, both of which are planning research to better characterize off-road emissions and identify effective controls.

Promising low-emission and clean fuel technologies proven in on-road sectors can be adapted to reduce emissions in off-road applications:

- Aftertreatment retrofits:
    - Particulate traps (diesel particulate filters, DPFs) and SCR systems can deliver immediate PM and NOx reductions, though retrofits may be challenged by space, visibility, and integration constraints on legacy off-road platforms.
- Alternative fuels:
    - NG, propane, hydrogen, and hydrogen-NG blends can reduce emissions where suitable engine platforms or dual-fuel conversions are feasible and warrant demonstration.
    - Reformulated gasoline, ethanol, biodiesel, and gas-to-liquid (GTL) fuels show potential when combined with advanced emissions controls and updated engine technologies.
- Emissions trade-off assessment:
    - Rigorous emissions assessments are essential, as controls aimed at reducing one pollutant may increase another (e.g., fuel-specific NOx vs. PM trade-offs).

Over recent decades, diesel emissions have been substantially reduced via:

- Cleaner fuels: RNG, hydrogen, biofuels, synthetic and low-carbon fuels integrated into engines.
- Advanced aftertreatment: Close-coupled catalysts, SCR, DPF, and electrically heated diesel exhaust fluid dosing strategies for improved low-temperature NOx control.
- Engine strategies: Cylinder deactivation and modern controls lowering emissions near-zero while improving efficiency.

PM and particle number (PN) emission concerns have grown for GDI-fueled LD vehicles and gaseous/gasoline-fueled MD/HD vehicles where particulate filters were historically absent. While relative PM levels may be below applicable standards, ultrafine PM and PN warrant assessment - especially given U.S. EPA's 2024 multi-pollutant standard for LD/MD vehicles (effective MY 2027), which tightens PM limits and is expected to require particulate filters on GDI platforms.

1.6.9. Health Impacts Studies

Monitoring pollutants across SCAB is essential - especially when focused on:

1. Specific sectors of the emissions inventory (to identify responsible technologies), and
2. Population exposure (to assess potential health risks).

Multiple studies indicate that sustained exposure to high levels of air pollution can cause irreversible damage to children's lungs, underscoring the need for additional emissions and health studies that (a) identify emissions from high-polluting sectors, and (b) quantify the resulting health effects.

As the region transitions to new fuels and transportation technologies, it is critical to understand how changes in fuel composition alter exhaust emissions and ambient air quality. This core technology area emphasizes health impact studies of vehicle exhaust, with a focus on NOx and PM2.5, alongside a detailed review of other potential toxic tailpipe emissions from alternative fuel and diesel engines. Prior work has shown in-use emissions for some HD diesel engines can be significantly higher than certification values, depending on the duty cycle, which reinforces the importance of real-world measurements.

Over the past decade, South Coast AQMD funded emissions studies to evaluate the tailpipe impacts of biodiesel, renewable diesel, and ethanol in LD/MD/HD vehicles, focusing on criteria pollutants and GHG emissions. Findings indicate:

- Biofuels - especially biodiesel under certain applications and duty cycles - can increase NOx emissions, even as they reduce other criteria pollutants emissions.
- These fuel-specific outcomes highlight the need for ongoing studies on carbon-free fuels (e.g., hydrogen) to fully characterize emissions and health implications.

In 2015, South Coast AQMD funded chamber studies (part of a 200-vehicle study) to investigate the toxicological potential of emissions from MD/HD vehicles, including ultrafine particles and vapor-phase substances. The studies examined whether volatile or semi-volatile organic compounds - even at lower mass emissions - could pose harmful health effects. Results indicated higher SOA emissions from compressed natural gas (CNG) vehicles compared to baseline, attributed to excess lube oil consumption, ammonia emissions, and the absence of particulate filters.

Since the late 1980s, South Coast AQMD has conducted five MATES campaigns, with MATES V completed in August 2021. MATES uses comprehensive measurements, modeling, and health-risk assessment methods to estimate cancer and non-cancer chronic health risks from air toxics across the jurisdiction.

Cancer risk is the expected number of additional cancers over a 70-year lifetime in a population of one million individuals if exposed to measured or modeled air toxics levels for 30 years.

Key MATES V findings include:

- Overall multi-pathway cancer risk declined by 54 percent compared to MATES IV.
- Diesel PM remains the primary risk driver, contributing 67 percent of overall multi-pathway cancer risk (population-weighted).

- Population-weighted average air toxics cancer risk (SCAB): decreased from 997 per million (2012, MATES IV) to 455 per million (2018); in the Coachella Valley, decreased from 357 to 250 per million.
- Communities adjacent to Ports are in the top 96th percentile of air toxics cancer risk; the highest risk locations in 2018 included Los Angeles Airport (LAX), the San Pedro Bay Ports, and major goods movement corridors.
- At the ten MATES V monitoring sites - in areas disproportionately impacted and overburdened - cancer risk ranged from 585 to 842 per million, about 40 percent lower than 2012.
- Since 1998 (MATES II), diesel PM has been the largest contributor to air toxics cancer risk; in 2018 (MATES V), it accounted for approximately 50 percent of the risk.
- Chronic non-cancer risk was estimated for the first time in a MATES campaign, with hazard indices of 4.5 to 8 across the ten stations (a hazard index of 1 represents the highest concentrations at which no chronic health risks are expected).
- MATES V also conducted advanced air monitoring to characterize VOC emissions impacts from major refineries in SCAB on surrounding communities.

MATES VI (now underway) expands on prior campaigns by:

- Estimating exposure to brake wear particles and tire/road wear particles - including chemical composition from commercial LD/HD vehicle tires and brakes - to better attribute PM mass and gas-phase markers to these non-exhaust sources.
- Characterizing ambient ethylene oxide (EtO) contributions across SCAB, including a special study of secondary EtO formation from urban precursors (some from vehicular emissions).

These studies require specialized instrumentation and expertise (e.g., high-time-resolution monitors, chemical speciation, and advanced source apportionment techniques).

1.6.10. Technology Assessment and Transfer / Outreach

The Clean Fuels Program accelerates the development, demonstration, deployment, and adoption of innovative transportation technologies by:

- Assessing advanced technologies and retaining outside technical assistance to expedite low-emission and clean-fuel implementation;
- Coordinating with industry, academic partners, community organizations, and public agencies; and
- Educating end users through targeted outreach and technology transfer activities.

These efforts are essential to successful market adoption and ensure that technologies demonstrated through the Program achieve real-world emissions reductions at scale.

Technology Assessment & Technical Assistance:

- Conduct independent performance and readiness assessments for emerging and commercial technologies (e.g., ZE/NZE vehicles, fueling/charging, microgrids).
- Engage outside experts to support design reviews, safety, standards compliance, siting, and measurement & verification (M&V).
- Coordinate with other organizations to align demonstrations, avoid duplication, and maximize cost-share leverage.

Technology Transfer & Outreach:

- Support incentive programs that encourage the purchase of cleaner technologies.
- Co-sponsor and host technology-related conferences, workshops, showcases, and public outreach events.
- Disseminate information on advanced technologies to diverse audiences (residents in AB 617 or overburdened communities, local governments, funding agencies, technical audiences).

Community Engagement (AB 617/CAPP)

- Under AB 617 and CAPP, TAO conducts additional outreach in vulnerable and overburdened communities to:
    - Identify available ZE/NZE technologies, and
    - Connect residents and fleets to incentives that accelerate implementation.

Grant Integration

- Community and stakeholder outreach is embedded in grant proposals and projects funded/administered by the Clean Fuels Program to ensure local relevance, transparency, and feedback loops.

In past years, TAO staff hosted information booths to answer public questions and participated in discussion panels on ZE/NZE technologies at events including (not limited to):

- Annual International Onboard Sensing, Analysis, and Reporting Conference
- California Hydrogen Leadership Summit
- Real World Emissions Workshop
- Driving Mobility
- Electric & Hybrid Marine Technology Conference
- Hydrogen Village
- Irvine Clean Energy Conference
- Los Angeles Auto Show
- SoCal Electrified Drive Event (Orange County Auto Show)

- Clean Mobility Forum
- CoMotion LA

While the agency's Legislative, Public Affairs & Media Office leads education and awareness programs, TAO has co-sponsored and occasionally hosted technology-related events to complement agency efforts, including Technology Showcases at South Coast AQMD and the Advanced Clean Transportation (ACT) Expo. Programmatic outreach for TAO incentive programs include:

- INVEST CLEAN
- AB 617 Community Air Protection Programs
- Carl Moyer Program
- Proposition 1B – Goods Movement
- Volkswagen Environmental Mitigation Trust
- Replace Your Ride
- Commercial Electric Lawn & Garden Incentive and Exchange
- Residential lawn mower and residential EV charger rebate programs

CLEAN FUELS PROGRAM

2025 ANNUAL REPORT

2.1. Program Report Overview

This report summarizes progress of the Clean Fuels Program for CY 2025. The Program cost-shares projects to develop and demonstrate ZE/NZE and low-emission clean fuels and technologies that advance technology development and commercialization - not only for SCAB, but also for California and the nation. These projects are conducted through public–private partnerships with industry, technology developers, academic and research institutions, and local, state, and federal agencies.

This report also highlights achievements and summarizes project costs for CY 2025. Between January 1 and December 31, 2025, South Coast AQMD advanced the Program via RDD&D projects, with staff executing 34 new contracts/agreements (see Table 3, p. 38) that support clean fuels and advanced ZE/NZE and low-emission technologies. The Clean Fuels Program contribution to these projects was nearly $4.3 million in cost-share, with total project costs of almost $43.8 million, reflecting a leveraging ratio of approximately 10:1.

Projects initiated in CY 2025 address a wide range of issues and employ a diverse technology mix, delivering near-term emission reductions while enabling long-term planning. This report provides information on:

- External funding support received into the Clean Fuels Fund as cost-share for contracts executed during the period; and
- Funding support awarded to South Coast AQMD for projects that fall within the scope of the Clean Fuels Program's RDD&D efforts but may be recognized in another special revenue fund for financial tracking purposes (see Table 4, p. 40).

In CY 2025, South Coast AQMD was awarded nearly $42 million from multiple sources, including:

- CARB and CEC's joint Advanced Technology Demonstration and Pilot Projects (ATDPP) solicitation for the Strategic Pathways for Extended Electric Drayage (SPEED) project to deploy Volvo Class 8 battery-electric trucks and truck chargers in Southern California;
- U.S. EPA CATI grant to deploy zero-emission commercial workboats; and
- DOE Congressional Direct Spending Request to deploy marine shore-side charging infrastructure.

More detail on this financial summary is provided in Section 2.3 of this report.

South Coast AQMD will continue pursuing federal, state, and private funding opportunities during CY 2026 to amplify leverage, while acknowledging that support for promising technologies is not contingent on external cost-sharing. South Coast AQMD remains committed to a leadership role in developing advanced technologies that reduce criteria pollutants in SCAB.

2.2. Barriers, Scope, Impact, and RDD&D

2.2.1. Overcoming Barriers

Commercializing and implementing advanced technologies entails a range of challenges and barriers. Bringing new, clean technologies to market requires a coordinated approach that combines real-world demonstrations, education, outreach, regulatory drivers, and incentives. To realize maximum emissions benefits, technologies must achieve widespread deployment and user acceptance. Manufacturers must overcome both technical and market barriers to build competitive, sustainable businesses. These barriers include project-specific constraints as well as broader, cross-cutting technology challenges.

Technology Implementation Barriers	Project-Specific Issues
• Viable commercialization path	• Identifying committed demonstration sites
• Technology price/performance parity with convention technology	• Overall project cost and cost-share using public funds
• Consumer acceptance	• Securing charging or fuel infrastructure
• Fuel availability/convenience issues	• Identifying and resolving real and perceived safety issues
• Certification, safety and regulatory barriers	• Quantifying actual emissions benefits
• Quantifying emissions benefits	• Viability of technology providers
• Sustainability of market and technology	
• Supporting infrastructure	

Beyond technical and market hurdles, other barriers include shrinking research budgets, infrastructure and energy uncertainties and risks, sensitivity to multimedia environmental impacts, and the ongoing need to balance environmental objectives with economic constraints. South Coast AQMD addresses these challenges by building public–private partnerships with key stakeholders - industry, end users, and government agencies - that have a direct stake in developing and commercializing clean technologies. Inclusive partnerships that engage all key stakeholders are essential to move advanced technologies from development to commercialization.

Each stakeholder contributes more than funding:

- Industry: Provides production expertise and the operational experience needed to ensure compatibility with real-world process requirements.
- Academic and research institutions: Contribute current technology knowledge, testing proficiency, and independent evaluation to validate performance and inform design improvements.
- Governmental and regulatory agencies: Offer guidance in identifying high-impact sources for emissions reductions; assist with permitting and compliance; coordinate infrastructure needs; facilitate standards development; and support outreach.

There is substantial synergy in developing technologies that advance the shared goals of public and private entities across environment, energy, and transportation - accelerating progress while managing risk and improving cost-effectiveness.

2.2.2. Scope and Benefits

Because overcoming commercialization barriers can take significant time and capital, manufacturers and end users are often reluctant to assume the pre-commercial risk of developing advanced technologies. The Clean Fuels Program accelerates commercialization by co-funding RDD&D projects - sharing risk with technology developers and eventual users to de-risk emerging technologies and speed their path to market.

Figure 5 provides a conceptual overview of the breadth of the Clean Fuels Program. As described in the Core Technology Areas section, the Program funds multiple stages of technology projects to (1) maintain a portfolio of emissions-reduction technologies and (2) deliver near-term and long-term emission benefits. The Clean Fuels Program typically supports projects across TRLs 3–8, bridging development, demonstration, and early deployment on the path to commercialization.

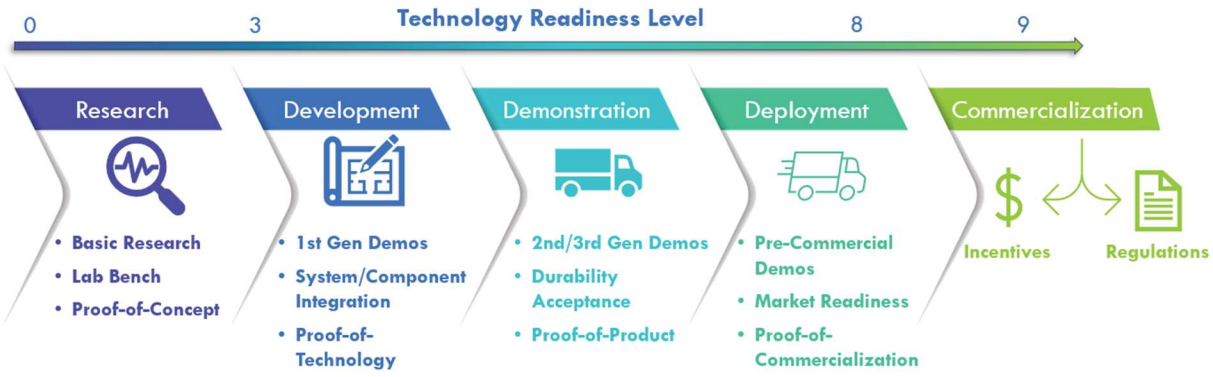

Figure 5: Technology Readiness Stages 3-8 of Clean Fuels Program

Because advanced technology RDD&D projects are pre-commercial and often span multiple years, their emission benefits can be difficult to quantify: full reductions may materialize in the future, or be superseded if superior technologies emerge. Nevertheless, the impacts and benefits of the Clean Fuels Program are evidenced by a selective list of sponsored projects that have resulted in commercial products or accelerated advanced technologies. As a partial estimate of Program impacts, emission benefits from South Coast AQMD's own incentive programs for near-zero, zero-emission, and off-road categories are summarized in Table 1 (p. 7).

Near-Zero-NOx Engine Commercialization (HD Vehicles)

- Cummins Westport, Inc. (CWI): Development and certification of near-zero-NOx NG 8.9L and 12L engines (0.02 g/bhp-hr).
- SwRI: Development of a near-zero-NOx HD diesel engine.
- CNG hybrid-electric drayage trucks under DOE ZECT II, CARB Greenhouse Gas Reduction Fund (GGRF), and demonstration projects with DOE/NLR/CEC.

Hydrogen Fuel-Cell Vehicle Advancement (MD/HD)

- Kenworth range-extended fuel-cell electric drayage truck project.
- SunLine Transit Agency advanced fuel-cell bus project.

- United Parcel Service (UPS) demonstration of fuel-cell delivery trucks.
- Kenworth, TransPower, US Hybrid, Cummins: Fuel-cell drayage truck projects under ZECT II.
- Hyundai Class 8 fuel-cell truck development and demonstration projects.

Battery-Electric Vehicle Advancement (MD/HD)

- Early BETs as part of CARB GGRF Zero Emission Drayage Truck (ZEDT), ZECT I, and ZECT II.
- Volvo Low Impact Green Heavy Transport Solutions (LIGHTS) and Switch-On projects: Pilot deployments of Volvo Class 8 BETs.
- DNTA: Innovation Fleet, Customer Experience, and Zero-Emission BET Delivery Truck projects.
- Joint Electric Truck Scaling Initiative (JETSI): A follow-on large-scale deployment with two fleets of 50 Class 8 BETs each.

South Coast AQMD played a leading or major role in advancing these technologies. Their benefits could not have been achieved without collective stakeholder engagement - manufacturers, end users, and government - working together to overcome technology, market, and project-specific barriers at every stage of the RDD&D process.

2.2.3. Strategy and Impact

In addition to the feedback and input described in the Advisory Groups section, South Coast AQMD actively pursues additional partners through participation in working groups, committees, partnerships, councils, and task forces. This engagement has enabled close coordination of the Clean Fuels Program with state and federal organizations - including CARB, CEC, U.S. EPA, DOE, DOT, and several national laboratories—as well as with regional and industry stakeholders.

Coordination also extends to the AB 2766 Discretionary Fund Program administered by the MSRC; local air districts such as the Bay Area AQMD (BAAQMD), Sacramento Metropolitan AQMD (SMAQMD), San Diego Air Pollution Control District (San Diego APCD), and San Joaquin Valley Air Pollution Control District (SJVAPCD); the National Association of Fleet Administrators (NAFA); major local transit districts; local utilities including SoCalGas, SCE, and LADWP; national laboratories (e.g., NLR); the San Pedro Bay Ports; and universities with research facilities, including the University of California campuses at Berkeley, Davis, Irvine, Los Angeles, and Riverside, and West Virginia University. The list of organizations with which South Coast AQMD coordinates research and development also includes entities specified in H&SC §40448.5.1(a)(2).

South Coast AQMD holds periodic meetings with several organizations to review and coordinate program and project plans. For example, staff meet with CARB to review research and development plans, discuss mutual interests, avoid duplication, and identify cost-sharing opportunities. Additional periodic meetings are held with industry-oriented R&D organizations, including (but not limited to) the California Hydrogen Business Council (CHBC), H2FCP, California Stationary Fuel Cell Collaborative, Clean Energy Institute (CEI), Electric Power Research Institute (EPRI), Veloz, the Los Angeles Cleantech Incubator (LACI) Regional Transportation Partnership, and the West Coast Collaborative. These coordination efforts have resulted in multiple cosponsored projects.

Descriptions of key contracts executed in CY 2025 are provided in Section 2.3. Most projects are cosponsored by various funding organizations and include active OEM involvement - partnerships essential to address commercialization barriers and accelerate implementation of advanced technologies.

Table 2 (below) lists funding agency partners and manufacturers actively involved in South Coast AQMD projects during this reporting period. Importantly, many additional technology developers, small manufacturers, and project partners - critical to the success of the Clean Fuels Program - are identified in the detailed 2025 Project Summaries by Core Technology Areas contained within this report, as well as in Table 4 (p. 40), which lists federal, state, and local funding awarded to South Coast AQMD in CY 2025 for RDD&D projects (which will likely result in executed contracts in CY 2026).

Table 2: South Coast AQMD Funding Partners in CY 2025

Balboa Island Ferry, Inc.	Range Energy, Inc.
California Air Resources Board	City of Riverside
California Energy Commission	Sikand SITI-Center and ECST
CALSTART	TravelCenters of America, LLC
Electric Power Research Institute	U.S. Environmental Protection Agency
MHX Solutions, LLC	University of California, Irvine
Mobile Source Air Pollution Reduction Review Committee	University of California, Riverside
Southern California Association of Governments	Voltu Motor, Inc.
Southern California Edison	Volvo Technology of America, LLC

2.3. Funding & Financial Summary

The Clean Fuels Program supports clean fuels and technologies that show the greatest promise for reducing emissions, promoting energy diversity, and, in the long term, providing cost-effective alternatives to current technologies. To address the wide variety of pollution sources in SCAB - and the need for reductions now and into the future - South Coast AQMD utilizes revenue from the $1 motor vehicle registration fee (see Internal and External Sources of Funding Support, p. 6) to fund a diverse portfolio of projects. This approach expands technology choices with the potential for different commercialization timelines, enabling both near-term and long-term emission-reduction benefits.

Given the evolving nature of technology and changing market conditions, the portfolio reflected here is a snapshot in time, as approved by the South Coast AQMD Governing Board.

As projects are approved by the Governing Board and executed as contracts over the course of the year, financials may change to reflect updated information provided during contract negotiations. Accordingly, the following represents the status of the Clean Fuels Fund as of December 31, 2025.

2.3.1. Funding Commitments by Core Technology Areas – Executed Contracts in 2025:

South Coast AQMD continued to successfully leverage public funds with outside investment to advance clean air technologies. Between January 1 and December 31, 2025, the Agency executed or amended a total of 34 contracts/agreements - comprising 16 RDD&D projects and 18 technology transfer and outreach contracts that support clean fuels (see Table 3, p. 38). The distribution of funds by technology area is shown graphically in Figure 6 (below). This broad suite of investments reflects South Coast AQMD's commitment to researching, developing, demonstrating, and deploying technology solutions with near-term and longer-term emission-reduction potential.

CY 2025 Project Commitments and Total Costs

- South Coast AQMD Clean Fuels Fund Contribution: $4,268,029
- Total Cost of Clean Fuels Projects: $43,760,557

Traditionally, the South Coast AQMD Governing Board approves annual transfers from the Clean Fuels Fund to the General Fund for Program administration. Beginning in FY 2017, this transfer has been handled through the annual budget process. When the Governing Board approved South Coast AQMD's FY 2025–26 Budget on May 2, 2025, it included $1 million from the Clean Fuels Fund recognized in TAO's budget for technical assistance, workshops, conferences, co-sponsorships, outreach activities, and related postage, supplies, and miscellaneous costs.

Only funds committed by December 31, 2025 are included in this report. Any portion of the Clean Fuels Fund not spent by the end of FY 2025–26 (June 30, 2026) will be returned to the Clean Fuels Fund.

For CY 2025 executed and amended Clean Fuels contracts, the average South Coast AQMD contribution was leveraged at approximately $10 of outside investment for every $1 of Clean Fuels funding. While the typical historical leveraging is $4:$1, the 2025 portfolio includes several significant contracts - in both funding and impact - that are expected to advance development and commercialization of clean transportation technologies (see Table 3, p. 38).

During 2025, distribution of funds for South Coast AQMD newly executed contracts, and contract amendments, totaling nearly $4.3 million in additional Clean Fuels Program funding, is shown in Figure 6.

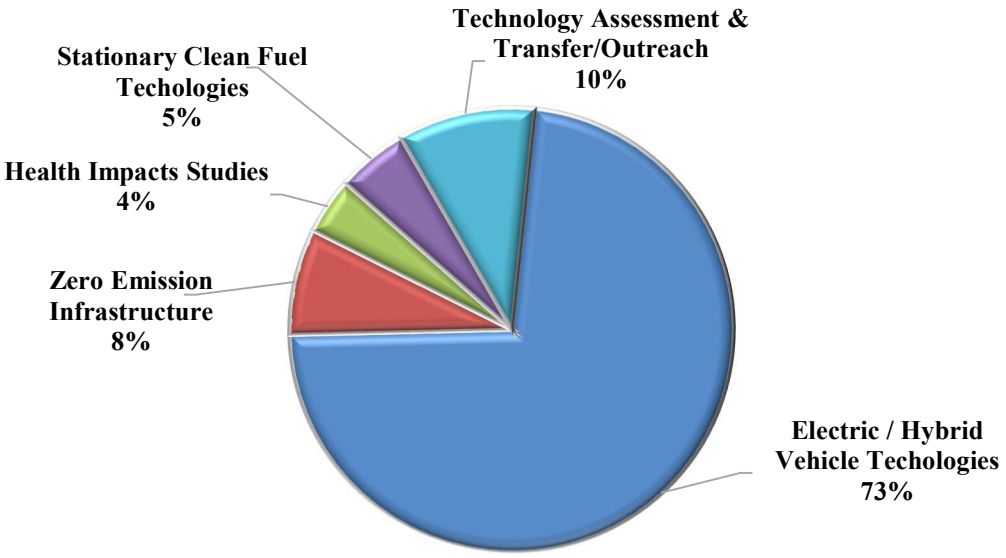

Figure 6: Distribution of Funds for Executed Clean Fuels Projects CY 2025 ($4.3M)

Additionally, South Coast AQMD continued to pursue funding opportunities and, in CY 2025, secured nearly $42 million for RDD&D projects (see Table 4, p. 40). As of January 1, 2026, there were 56 open Clean Fuels Fund contracts; Appendix B lists these contracts by core technology area.

2.3.2. Review of Audit Findings

State law requires an annual financial audit following the close of each South Coast AQMD fiscal year. The audit is performed by an independent Certified Public Accountant selected through a competitive bid process. For the fiscal year ended June 30, 2025, the firm LSL, LLP conducted the audit and issued an unmodified opinion on South Coast AQMD's Annual Comprehensive Financial Report - the highest level of assurance obtainable. Notably, South Coast AQMD has consistently achieved this rating on all prior annual financial audits. The audit identified no adverse internal control weaknesses related to South Coast AQMD's financial statements, which include the Clean Fuels Program revenue and expenditures.

2.3.3. Highlighted Executed and/or Amended Contracts in RDD&D

Two examples of the impact of South Coast AQMD's research and development coordination efforts in CY 2025 include:

Electrification of Balboa Island Ferries and Installation of Supporting Charging Infrastructure

The Balboa Island Ferry (BIF) provides a vital transportation and tourism link between Balboa Island and the Balboa Peninsula in Newport Beach, California. The operator owns and runs three identical vintage wooden ferries built in the 1950s, carrying approximately 1.5 million passengers and 350,000 vehicles annually. As a unique ferry operator in California, converting these diesel-powered ferries to ZE propulsion will demonstrate the feasibility of ZE ferry powertrains for similarly unique operators and help remove barriers to ZE adoption in the marine sector.

Project Scope

South Coast AQMD is partnering with BIF to:

- Replace three diesel ferries equipped with 2010 Tier II marine engines with electric propulsion systems; and
- Install up to four chargers to support vessel charging.

Upon completion, BIF intends to become California's first operator with an all-ZE, 100 percent BE ferry fleet. This project advances technology integration and incorporates ZE technologies into off-road fleets.

Equity and Planning Alignment

The project supports county-level planning goals by improving socially equitable and environmentally sustainable transportation options, including service to overburdened communities and connectivity between communities and places of work.

Expected Benefits

- The three BE ferries will displace the direct use of 8,395 gallons of diesel fuel annually in local communities.
- Ferry operations avoid approximately 350,000 vehicle trips and carry approximately 1.5 million pedestrians annually, reducing local traffic demand and avoiding vehicle-based air pollutant emissions.

Workforce and Outreach

BIF will work with project partners to document workforce training efforts and conduct outreach, supporting the safe operation, maintenance, and community acceptance of ZE ferry technologies.

Figure 7: Balboa Island Ferries

JETSI: The Schneider Case Study

Project Overview

The Schneider JETSI project deployed 50 HD BETs at Schneider National, Inc.'s South El Monte facility as part of California's JETSI. Involving 20 organizations and supported by $66.5 million in funding from the CARB and CEC, the project aimed to demonstrate ZE drayage at scale and significantly reduce GHG emissions.

Site Energization and Infrastructure

Schneider experienced significant delays in energizing the site due to infrastructure planning challenges:

- The originally planned electric vehicle supply equipment (EVSE) was discontinued, requiring a pivot to new charger technology.
- Schneider's site specifications (designed for the initial chargers) needed updates, and the new chargers required Underwriters Laboratories (UL) certification.
- Schneider reconvened site planning with Black & Veatch (design consultant) and SCE (local utility).
- Los Angeles County permitting delays extended through May 2023, to ensure the revised infrastructure plan met requirements.

Figure 8: Schneider South El Monte Facility

By June 2023, Schneider installed four Power Electronics NB Stations, each 1.2 MW (total 4.8 MW) managing four ultrafast dual-port chargers per station (8 ports per station; 32 ports total), capable of concurrent charging for 32 BETs.

Vehicle Delivery, Duty Cycle, and Training

Truck Deployment and Operations

- DTNA delivered 50 Freightliner eCascadia BETs on schedule, enabling timely commissioning and deployment.
- Schneider operates BETs around the clock, with typical daily mileage of 150–270 miles per shift.
- A single truck may run two ~10-hour shifts per day with charging between shifts as required.

Driver Training

- Drivers acclimated to BETs quickly, completing online training focused on operations and efficiency.
- Drivers were paired with Velocity (local DTNA dealer) driver-training engineers for on-the-road feedback.

Operational Performance

- Drivers typically operated BETs 7–12 hours/day, covering 150–200 miles.
- During longer night shifts (250–280 miles), drivers often swapped trucks mid-shift to complete routes within battery limits—necessitating strategic scheduling.
- Observed idling times were 40–60 percent, at 3–4 kilowatt-hour (kWh)/hour energy draw.

Figure 9: HD BETs Deployed by Schneider

- BET efficiency measured 2.0–2.2 kWh/mile, equating to 16.9–18.7 miles per diesel gallon equivalent (MPDGE) - approximately 3× more efficient than baseline diesel trucks.
- Heating, ventilation, and air conditioning (HVAC) loads had minimal impact on energy draw during operation, including night heating; analysis continues under varying conditions.

Charging Operations and Costs

- Schneider provided a baseline facility operational energy (excluding charging) for Jan–Dec 2024 of 185,991 kWh (0.186 gigawatt-hour [GWh]).
- From Nov 2023–Oct 2024, total facility energy (including BET charging) reached 10.4 GWh - nearly 60× the baseline.

Schneider meters vehicle charging separately and qualifies for SCE's TOU-EV-9 rate option based on peak demand. SCE waived or significantly reduced many facility demand charges for Schneider through 2027.

Cost Profile and Optimization

- For 50 trucks, total charging cost (including ramp-up) was $1.65 million.
- Time-of-Use (TOU) charges accounted for about 94 percent of overall costs; demand charges were approximately 0.1 percent, reflecting utility concessions.
- Early on (September 2023), charging skewed on-peak; over time, charging shifted to mid-peak, off-peak, and super-off-peak, with off-peak costs dominating later months.
- Despite optimization, utility expenses increased by about 44.4 percent year-over-year, underscoring the value of demand-management solutions (e.g., behind-the-meter storage) to mitigate long-term electricity costs.

User Acceptance and Reliability

- Initial range anxiety decreased as drivers gained confidence; many returned to base at approximately 20 percent state-of-charge (SOC) after nearly180 miles.
- For longer routes, drivers planned mid-day returns to swap trucks.

- Fleet managers actively redirected drivers to alternate charging locations if SOC approached lower thresholds.
- Schneider reports intermittent active fault codes, being addressed with DTNA.
- Overall driver feedback is highly positive: ride quality, lack of engine noise, and ease of steering are frequently cited.

Maintenance Costs

- Limited maintenance data was available due to the fleet's recent deployment.
- The first five BETs were analyzed against baseline diesel trucks.
- Diesel maintenance averaged $0.11–$0.18/mile; BETs ranged $0.03–$0.35/mile, with no single BET maintenance event over $500.
- Variability likely reflects limited maintenance events and differences in distance operated during the early period.

Environmental Impact

- Over a 12-year average lifetime, the 50-vehicle fleet is expected to avoid approximately 29.6 million kg carbon dioxide (CO_2) emissions.
- Additional approximate emission reductions: 29,515 kg NOx, 285.64 kg PM2.5, 273.29 kg PM10, and 279.48 kg Sulfur Oxides (SOx)—contributing to improved air quality in SCAB, where drayage emissions have historically been significant.

Opportunities to Further Reduce Costs and Emissions

- On-site solar generation can offset grid usage, especially during peak periods when carbon intensity is highest.
- BESS can optimize charging schedules, reduce demand charges, and enhance resilience.
- Integrating distributed energy resources (DERs) enables Schneider to maximize fleet sustainability and improve long-term operational efficiency.

Conclusion and Key Lessons

Schneider's BET deployment demonstrates that battery-electric trucks can meet drayage duty cycles with significant efficiency gains over diesel. However, infrastructure delays, interoperability, maintenance-related downtime, and equipment costs present hurdles requiring adaptive planning and close coordination among vendors, utilities, and project partners.

Key lessons include:

- Start infrastructure planning early and design for charger technology flexibility and UL certification timelines.
- Implement proactive maintenance strategies in collaboration with OEMs and dealers.
- Optimize charging to off-peak TOU windows and consider BESS for demand management.

- Maintain robust operational planning, flexible funding strategies, and ongoing collaboration to scale zero-emission truck deployments effectively.

Snapshot of Key Metrics

Category	Metric
Trucks deployed	50 Freightliner eCascadia BETs
Charger infrastructure	4 × 1.2 MW NB Stations (32 ports total)
Annual baseline (non-charging) energy	185,991 kWh (0.186 GWh)
Total energy incl. charging (Nov ’23–Oct ’24)	10.4 GWh (~60× baseline)
Total charging cost (ramp-up included)	$1.65 million
Cost composition	~94 percent TOU; ~0.1 percent demand
BET efficiency	2.0–2.2 kWh/mile (16.9–18.7 MPDGE)
Maintenance costs (early data)	BETs: $0.03–$0.35/mile; Diesel: $0.11–$0.18/mile
Lifetime (12-yr) GHG reduction	~29.6 million kg CO_2
Criteria pollutant reductions	~29,515 kg NOx; ~286 kg PM2.5; ~273 kg PM10; ~279 kg SOx

2.3.4. Project Funding Detail and Contract Summaries by Core Technology Areas – Executed and/or Amended Contracts in 2025:

Table 3 provides a summary of the 34 new and continuing contracts/agreements, projects, and studies funded by South Coast AQMD in CY 2025, including South Coast AQMD’s Clean Fuels Program authorized funding and partner co-funding.

Table 3: Contracts Executed or Amended (w/$) between January 1 & December 31, 2025

Contract	Contractor	Project Title	Start Term	End Term	South Coast AQMD $	Project Total $
Hydrogen / Mobile Fuel Cell Technologies and Infrastructure						
25207	FirstElement Fuel Inc	License Agreement to Operate and Maintain Publicly Accessible Hydrogen Fueling Station at South Coast AQMD's Diamond Bar HQs	05/29/25	05/28/28	0	0
Electric / Hybrid Vehicle Technologies and Related Infrastructure						
22177	Daimler Trucks North America LLC	Deploy Class 8 Battery Electric Trucks and Charging Infrastructure	06/16/22	12/31/26	0	300,000
22247	NFI Interactive Logistics LLC	Deploy Class 8 Battery Electric Trucks, Charging Infrastructure and Distributed Energy Resource Technologies	12/15/22	12/31/26	0	455,247

Table 3: Contracts Executed or Amended (w/$) between January 1 & December 31, 2025 (cont'd)

Contract	Contractor	Project Title	Start Term	End Term	South Coast AQMD $	Project Total $
23072	CALSTART	Charging Infrastructure Data Collection, Fleet Case Studies, Analysis and Reporting for Deployment of 100 Commercial Class 8 Battery Electric Trucks	03/08/23	12/31/26	0	48,785
23090	Electric Power Research Institute	Deployment of 100 Commercial Class 8 Battery Electric Trucks	09/10/21	12/31/26	0	39,000
24267	Electric Power Research Institute	Develop and Demonstrate Megawatt Fast Charging for Battery Electric Trucks	01/14/25	01/13/27	1,500,000	19,326,774
25115	Volvo Technology of America LLC	Develop and Demonstrate Battery-Electric Excavator and Wheel Loader	02/04/25	08/31/26	0	2,140,270
25146	Voltu Motor Inc	Develop, Demonstrate and Deploy 10 Ford F350 Class 2B/3 Medium-Duty Work Trucks	06/10/25	12/31/26	300,000	2,200,000
25149	Greenwealth Energy Solutions Inc	EV Hardware and Software Installation and Maintenance at South Coast AQMD HQ	06/06/25	12/05/32	653,248	723,248
25185	Range Energy Inc	Demonstration of Zero-Emission Transport Refrigeration Unit with Electric-Powered Trailer for Heavy-Duty Vehicles	09/10/25	09/09/26	111,180	741,200
26049	Balboa Island Ferry	Electrification of Ferries and Installation of Supporting Charging Infrastructure	12/31/25	06/30/27	250,000	11,484,790
Transfer	Various	Support the Residential EV Charging Incentive Program	09/05/25	12/31/25	200,000	200,000
Transfer	Various	Lease of Three Electric Vehicles	01/01/25	12/31/25	99,794	99,794
Zero Emission Infrastructure						
25076	GenCell Inc	Demonstrate Off-Grid Electrical Fast Charging Solution to Support UCLA's Electric Fleet	01/07/25	11/04/25	30,000	1,187,092
25124	University of California Riverside	CHARGE-OPT: Accelerating Electrification of Medium- and Heavy-Duty Trucks in Southern California with Data-Driven Planning Platforms for Charging Networks, Truck Fleets, and Power Systems	04/16/25	04/15/27	300,000	600,000
Health Impacts Studies						
25147	University of California Riverside	Ethylene Oxide Sources Study	06/10/25	12/09/26	176,956	176,956
Stationary Clean Fuels Technologies						
25154	University of California Irvine	Investigate the Impact of Vehicle-to-Home Technology on Regional Air Quality	06/06/25	06/05/27	220,548	370,548

Table 3: Contracts Executed or Amended (w/$) between January 1 & December 31, 2025 (cont'd)

Contract	Contractor	Project Title	Start Term	End Term	South Coast AQMD $	Project Total $
Technology Assessment and Transfer / Outreach						
25132	California State University Los Angeles	Cosponsor California State University, Los Angeles in the Battery Workforce Challenge	04/02/25	10/01/26	150,000	650,000
Various	Various	Cosponsor 20 Conferences, Workshops & Events plus 4 Memberships	01/01/25	12/31/25	276,303	3,016,853

Table 4 summarizes all revenues awarded to South Coast AQMD in the reporting CY to support TAO's RDD&D activities, irrespective of fund recognition (e.g., Clean Fuels Fund) or pass-through contract execution status.

Table 4: Summary of Federal, State and Local Funding Awarded or Recognized in CY 2025 for Technology Demonstration Projects

Awarding Entity or Program	Award (*) or Governing Board Date	Purpose	Contractors	Award Total / Fund
CARB ATDPP program	06/06/25	SPEED Project to Deploy Class 8 Battery Electric Trucks and Truck Chargers in Southern California	Various	$22,000,000 Fund 67
CEC ATDPP program	06/06/25	SPEED project to Deploy Class 8 Battery Electric Trucks and Truck Chargers in Southern California	Various	$19,295,211 Fund 67
U.S. EPA CATI Grant	12/5/25	Deploy Zero-Emission Commercial Workboats	Pacific Towing LLC City of Los Angeles, Department of Recreation and Parks	$150,000 Fund 83
U.S. Department of Energy Congressional Direct Spending Request	12/5/25	Deploy Marine Shore-Side Charging Infrastructure	Harbor Breeze Cruises	$500,000 Fund 83
				$41,945,211

The summaries that follow describe contracts executed or amended (affecting dollars) in CY 2025. They are presented in the order shown in Table 3, organized by category and contract number. Pursuant to California H&SC §40448.5.1(d), each project summary includes:

- Project title
- Contractor(s) and, if known at the time of writing, key subcontractors or project partners
- South Coast AQMD cost-share, cosponsors, and their respective contributions
- Contract term
- Project description

2.3.4.1. Hydrogen / Mobile Fuel Cell Technologies

25207: License Agreement to Operate and Maintain Publicly Accessible Hydrogen Fueling Station at South Coast AQMD's Diamond Bar HQs

Contractor: FirstElement Fuel Inc	South Coast AQMD Cost-Share	$ 0
Term: 05/29/25 – 05/28/28	Total Cost:	$ 0

South Coast AQMD has operated a hydrogen refueling station at its Diamond Bar headquarters for nearly two decades. The station was originally one of eight in California funded by a CEC award to Air Products and Chemicals, Inc. (APCI). Over time, the station has experienced aging infrastructure issues and increasing operational downtime, limiting dispensing capacity and impacting fleet and public access.

FirstElement Fuel, Inc. (FEF) was awarded a $42.6 million grant by the CEC to develop a statewide network of 46 high-performance hydrogen fueling stations, which includes replacing and expanding the South Coast AQMD headquarters station. The enhanced station is planned to include telematics integration to manage fueling data, improve station operations, and optimize vehicle throughput.

South Coast AQMD's current contract with APCI expires on July 31, 2026, and is currently operating on a month-to-month extension. To ensure continuity of service and to meet regulatory and funding timelines, a three-year license agreement with FEF was signed that will:

- Authorize FEF to assume day-to-day operational responsibilities of the existing station at the current site; and
- Serve as a prerequisite for CEC approval of the larger station replacement project.

2.3.4.2. Electric / Hybrid Vehicle Technologies (including battery electric and hybrid electric trucks and container transport technologies with zero emission operations)

22177: Deploy Class 8 Battery Electric Trucks and Charging Infrastructure

Contractor: Daimler Trucks North America LLC	South Coast AQMD Cost-Share	$ 0
	CARB (received as pass-through funds into Fund 67)	300,000
Term: 06/16/22 – 12/31/26	Total Cost:	$ 300,000

DTNA's project is part of the South Coast AQMD Governing Board–approved JETSI initiative, co-sponsored by CARB, CEC, POLB, POLA, and the MSRC. The program totals $74 million under GFO-20-606, the Zero-Emission Drayage Truck and Infrastructure Pilot Project. Within that budget, South Coast AQMD is contributing $5.6 million in cost-share.

At Schneider's South El Monte site, the project deployed 50 Class 8 BETs operating in and around overburdened communities, as well as EVSE and/or DER, including 16 DC fast chargers rated at 350 kW with CCS1 connectors.

The latest 2025 modification extends the project period and adds an additional $300,000 from CARB administrative funds to further expand the project scope.

22247: Deploy Class 8 Battery Electric Trucks, Charging Infrastructure and Distributed Energy Resource Technologies

Contractor: NFI Interactive Logistics LLC	South Coast AQMD Cost-Share	$ 0
	Cosponsors:	
	CARB (received as pass-through funds into Fund 67)	455,247
Term: 12/15/22 – 12/31/26	Total Cost:	$ 455,247

The NFI project is part of the South Coast AQMD Governing Board–approved JETSI initiative, co-sponsored by CARB, CEC, POLB, POLA, and the MSRC. The program totals $74 million under GFO-20-606, the Zero-Emission Drayage Truck and Infrastructure Pilot Project. Within that budget, South Coast AQMD is contributing $5.6 million in cost share.

At NFI's Ontario site, the project will deploy:

- 50 Class 8 BETs operating in and around overburdened communities;
- 38 DC fast chargers rated at 175 kW and/or 350 kW with CCS1 connectors;
- 1 MW of solar generation; and
- 5 megawatt-hour (MWh) of battery energy storage.

The latest 2025 modification extends the project period and adds an additional $455,247 from CARB administrative funds to offset increased project costs.

23072: Charging Infrastructure Data Collection, Fleet Case Studies, Analysis and Reporting for Deployment of 100 Commercial Class 8 Battery Electric Trucks

Contractor: CALSTART	South Coast AQMD Cost-Share	$ 0
	Cosponsors:	
	CEC (received as pass-through funds into Fund 67)	48,785
Term: 03/08/23 – 12/31/26	Total Cost:	$ 48,785

The CALSTART project is part of the South Coast AQMD Governing Board–approved JETSI initiative, co-sponsored by CARB, CEC, POLB, POLA, and the MSRC. The program totals $74 million under GFO-20-606, the Zero-Emission Drayage Truck and Infrastructure Pilot Project. Within that budget, South Coast AQMD is contributing $5.6 million in cost share.

CALSTART's primary responsibilities include EVSE data collection, start-up reporting, and fleet case studies. The latest 2025 modification extends the project period and adds $48,785 from CEC administrative funds to support additional data-collection periods.

23090: Deployment of 100 Commercial Class 8 Battery Electric Trucks

Contractor: Electric Power Research Institute	South Coast AQMD Cost-Share	$ 0
	Cosponsors:	
	CEC (received as pass-through funds into Fund 67)	39,000
Term: 09/10/21 – 12/31/26	Total Cost:	$ 39,000

The EPRI project is part of the South Coast AQMD Governing Board–approved JETSI initiative, co-sponsored by CARB, CEC, POLB, POLA, and the MSRC. The program totals $74 million under GFO-20-606, the Zero-Emission Drayage Truck and Infrastructure Pilot Project. Within that budget, South Coast AQMD is contributing $5.6 million in cost share.

EPRI's primary responsibilities include EVSE data collection and enhanced analysis of Class 8 BETs and charging operations across both participating fleets.

The latest 2025 modification extends the project period and adds $39,000 from CEC administrative funds to support additional data-collection periods.

24267: Develop and Demonstrate Megawatt Fast Charging for Battery Electric Trucks

Contractor: Electric Power Research Institute	South Coast AQMD Cost-Share	$ 1,500,000
	Cosponsors:	
	CEC	12,999,155
	EPRI	2,195,019
	Travel Centers of America	889,625
	SCAG	577,270
	SCE	500,000
	MHX Solutions	500,000
	Momentum	100,000
	InTech Energy Inc	65,705
Term: 01/14/25 – 01/13/27	Total Cost:	$ 19,326,774

Led by EPRI, in partnership with CALSTART under the eTRUC, and funded by the CEC's Electric Program Investment Charge, this project aims to accelerate the commercialization of megawatt-scale fast charging for Class 7 and BETs. It will extend vehicle range, reduce charging time to under 10 minutes for approximately 100 miles of added range, and advance ZE freight corridors through a "Community First" approach that integrates industry, government, academia, and local communities.

The project will:

- Develop high-efficiency, high-power charging systems;
- Establish an open-access testing center in Southern California to foster innovation;
- Pilot deployments of at least two public high-power charging sites along vital corridors; and
- Scale knowledge transfer via an interactive website, a comprehensive best-practices guidebook with practical tools, and public events.

Together, these efforts will support commercial adoption and pave the way for scalable ZE charging infrastructure.

25115: Develop & Demonstrate Battery-Electric Excavator & Wheel Loader

Contractor: Volvo Technology of America LLC	South Coast AQMD Cost-Share	$ 0
	Cosponsors:	
	US EPA FY18 TAG	1,296,387
	Volvo Technology of America LLC	843,883
Term: 02/04/25 – 08/31/26	Total Cost:	$ 2,140,270

Volvo partnered with South Coast AQMD to develop and demonstrate two prototype Volvo battery-electric off-road machines - a compact excavator and a wheel loader. The project's purpose is to accelerate the deployment of ZE technologies for off-road mobile equipment, reducing harmful diesel emissions, petroleum consumption, and greenhouse gases in SCAB.

The completed demonstration phase tested both machines in real-world applications with identified customers at selected sites across SCAB and produced conclusions and recommendations to support a successful commercial launch of the electric models.

In the final phase, the project will use remaining demonstration funds to deploy additional electric equipment models validated during testing. To expedite North American market adoption, the project will offer point-of-sale purchase incentives to early technology adopters - similar to CARB's Clean Off-Road Equipment Voucher Incentive Project (CORE). Because some proposed equipment is currently excluded from CORE due to horsepower limits, this project serves as the only voucher incentive presently available for those models.

The intention is to deploy up to 13 BE machines and fully utilize the remaining funds. A CY 2025 modification extends the project period to allow all units to be deployed.

25146: Develop, Demonstrate and Deploy 10 Ford F350 Class 2B/3 Medium-Duty Work Trucks

Contractor: Voltu Motor Inc	South Coast AQMD Cost-Share	$ 300,000
	Cosponsors:	
	City of Riverside	1,200,000
	Voltu Motor Inc	380,000
	MSRC	300,000
	UCR	20,000
Term: 06/10/25 – 12/31/26	Total Cost:	$ 2,200,000

Voltu will develop, demonstrate, and deploy 10 MD Class 3 BETs to modernize the City of Riverside's services fleet. Voltu is a technology company that has developed a complete powertrain system and vehicle-integration technology, poised to bring cutting-edge EV capability to the work-truck market by addressing a critical gap in these truck classes.

Voltu's proprietary powertrain will be assembled and integrated on a Ford F-350 chassis, designed and equipped to meet the performance demands of municipal service applications.

Vehicle specifications:

- Drivetrain: 4-wheel drive (dual motor)
- Torque: 827 lb-ft
- Peak power: 600 hp
- Range: Over 300 miles (EPA estimate)
- Towing capacity: Over 16,000 lb

Charging compatibility:

- Capable of Level 3 DC fast charging and Level 3 AC-to-DC charging (Voltu's patented approach)
- Supports NACS and CCS1 connectors

This project will accelerate commercial adoption of zero-emission medium-duty trucks in municipal fleets and help modernize city services with high-performance, reliable, and versatile battery-electric work trucks.

25149: EV Hardware and Software Installation and Maintenance at South Coast AQMD HQ

Contractor: Greenwealth Energy Solutions Inc	South Coast AQMD Cost-Share	$ 653,248
	Cosponsors:	
	CALSTART	70,000
Term: 06/06/25 – 12/05/32	Total Cost:	$ 723,248

This project replaced 55 Level 2 charging stations - 16 single-port and 39 dual-port - at the South Coast AQMD headquarters, capable of concurrently charging 94 LD EVs and PHEVs. The replacement of the public charging network included recycling the old EVSE, upgrading data-communications equipment, and providing staff with an online dashboard and network-control capabilities.

The project also includes a seven-year service warranty and support to ensure charger-network maintenance and uptime.

25185: Demonstration of Zero-Emission Transport Refrigeration Unit with Electric-Powered Trailer for Heavy-Duty Vehicles

Contractor: Range Energy Inc	South Coast AQMD Cost-Share	$ 111,180
	Cosponsors:	
	Range Energy Inc	348,400
	Nuvve Holding Co	122,000
	SJVAPCD	111,180
	Thermo King LLC	62,000
Term: 09/10/25 – 09/09/26	Total Cost:	$ 741,200

TRUs maintain appropriate temperatures for goods during freight transport - for example, moving food from cold-storage warehouses to grocery stores. Most TRUs are powered by small diesel engines and mounted to insulated trailers to keep items cold or frozen. TRUs are a significant contributor to community air pollution and local health impacts, especially along major transportation corridors such as the San Joaquin Valley and SCAB.

Range Energy, in collaboration with TRU and EVSE suppliers, will partner with a local fleet operating in SCAB to conduct an end-to-end demonstration of BE TRU and electric-powered trailer technology.

The project aims to demonstrate - and quantify - the community, commercial, and financial benefits of deploying BE TRU trailer technology in local fleet operations.

26049: Electrification of Ferris and Installation of Supporting Charging Infrastructure

Contractor: Balboa Island Ferry	South Coast AQMD Cost-Share	$ 250,000
	Cosponsors:	
	Balboa Island Ferry	1,793,848
	Carl Moyer Program	1,776,546
	CARB (received as pass-through funds into Fund 83)	7,664,396
Term: 12/31/25 – 06/30/27	Total Cost:	$12,117,942

BIF is a transportation and tourism link between Balboa Island and the Balboa Peninsula in Newport Beach, California. The operator owns and runs three identical vintage wooden ferries, originally built in the 1950s, carrying approximately 1.5 million passengers and 350,000 cars annually. As a unique ferry operator in California, transitioning from diesel-powered vessels to ZE propulsion will demonstrate the feasibility of ZE ferry powertrains for niche operators like BIF and help remove barriers to ZE adoption in the marine sector.

Project partnership and scope:

- South Coast AQMD is partnering with BIF to replace three diesel ferries (equipped with 2010 Tier II marine engines) with BE propulsion.
- Install up to four shore-side chargers to support reliable vessel charging operations.

Outcomes and benefits:

- Enable BIF to become California's first operator with an all-ZE, 100 percent BE ferry fleet.
- Advance ZE marine technologies and help integrate ZE solutions into off-road fleets.
- Reduce local air pollution and GHG emissions while maintaining essential community mobility and tourism services.

Together, this project showcases a replicable pathway for small and unique ferry operators to transition to ZE propulsion, supporting cleaner air and resilient, modernized maritime operations.

Transfer: Support the Residential EV Charging Incentive Program

Contractor: Various	South Coast AQMD Cost-Share	$ 200,000
Term: 09/05/25 – 12/31/25	Total Cost:	$ 200,000

The Residential EV Charging Incentive Program provides rebates to buy down the cost of hard-wired residential Level 2 (240V) chargers. The program is administered on a first-come, first-served basis for low-income, income-qualified residents and offers up to $500 per rebate. Since 2015, funding has supported over 400 chargers. These additional funds will continue the program year-round.

Transfer: Lease of Three Electric Vehicles

Contractor: Various	South Coast AQMD Cost-Share	$ 99,794
Term: 01/01/25 – 12/31/25	Total Cost:	$ 99,794

South Coast AQMD's TAO showcases emerging clean-fuel technologies to public and private organizations, enabling potential purchasers to familiarize themselves with available low-emission solutions and encouraging market adoption. This effort supports and promotes the development and deployment of cleaner technologies across the region.

This transfer covers the lease of three EVs to facilitate demonstrations and outreach activities.

2.3.4.3. Zero Emission Infrastructure

25076: Demonstrate Off-Grid Electrical Fast Charging Solution to Support University of California, Los Angeles (UCLA)'s Electric Fleet

Contractor: GenCell Inc	South Coast AQMD Cost-Share	$ 30,000
Term: 01/07/25 – 11/04/25	Total Cost:	$ 1,187,092

This project aimed to develop and demonstrate an off-grid fast-charging solution to support UCLA in meeting its sustainability goals and reducing environmental impacts through fleet electrification.

As an interim off-grid charging approach, UCLA - in partnership with GenCell, Inc.—planned to install a hydrogen fuel cell system (GenCell EVOX) to power two direct-current fast chargers (DCFCs). The EVOX system was designed to include integrated battery energy storage to enhance resiliency and provide additional charging capacity.

25124: CHARGE-OPT: Accelerating Electrification of Medium- and Heavy-Duty Trucks in Southern California with Data-Driven Planning Platforms for Charging Networks, Truck Fleets, and Power Systems

Contractor: University of California Riverside	South Coast AQMD Cost-Share	$ 300,000
	Cosponsors:	
	UCR	150,000
	AmpTrans Inc	150,000
Term: 04/16/25 – 04/15/27	Total Cost:	$ 600,000

This project aims to accelerate the electrification of medium- and heavy-duty trucks in Southern California by developing and deploying CHARGE-OPT, a web-based, data-driven planning platform that addresses key barriers - including fragmented data, uncoordinated infrastructure planning, and uncertainty in grid readiness.

CHARGE-OPT will provide an integrated optimization platform to support coordinated decision-making among charging-station developers, fleet owners, regulators, and electric utilities by analyzing truck operations, charging-infrastructure needs, policy scenarios, and power-system constraints.

The platform will be built using large-scale spatio-temporal data and advanced optimization models, deployed on secure cloud servers, and made freely available for analyses within Los Angeles, San Bernardino, Riverside, and Orange Counties.

2.3.4.4. Stationary Clean Fuels Technologies (including microgrids and renewables)

25154: Investigate the Impact of Vehicle-to-Home Technology on Regional Air Quality

Contractor: University of California Irvine	South Coast AQMD Cost-Share	$ 220,548
	Cosponsors:	
	UCI	$150,000
Term: 06/06/25 – 06/05/27	Total Cost:	$ 370,548

This project will analyze energy-use reductions across multiple vehicle-to-home (V2H) use cases and evaluate V2H's ability to shave peak demand in 2030, 2035, and 2045. It will quantify reductions in NOx and PM2.5 emissions, translate these into air-quality improvements and health benefits for SCAB, and assess V2H as a resilient backup power resource during grid outages - serving as an alternative to combustion backup generators. The analysis will leverage findings from a South Coast AQMD project that evaluated the air-quality impacts of backup generators in the Basin.

In addition, the project will develop policy guidelines and recommendations to support responsible and scalable V2H deployment.

(UCI has assumed the $150,000 funding portion that was originally proposed by the DOE).

2.3.4.5. Health Impacts Studies

25147: Ethylene Oxide Sources Study

Contractor: University of California Riverside	South Coast AQMD Cost-Share	$ 176,956
Term: 06/10/25 – 12/09/26	Total Cost:	$ 176,956

EtO is a human carcinogen, and its ambient and workplace concentrations have received considerable attention since the 2016 release of an updated unit risk factor indicating a one-in-a-million lifetime cancer risk at 0.11 parts per thousand (ppt). Data from focused air quality studies and the National Air Toxics Trends Stations (NATTS) network show seasonal variation in EtO, with higher concentrations in warmer months - suggesting a possible role for photochemical processes in its secondary formation. If secondary production is significant, South Coast AQMD must understand the chemical mechanisms and precursor species to inform effective controls.

In May 2024, South Coast AQMD loaned a Picarro cavity ring-down (CRD) analyzer to UCR, to investigate EtO production from ambient air. Preliminary data indicated that secondary formation may be important and mobile source precursors might have a role, laying the groundwork for a more comprehensive study.

Building on these findings, the current effort will investigate secondary EtO formation using one of South Coast AQMD's newly purchased Aerodyne Tunable Infrared Laser Direct Absorption Spectroscopy (TILDAS) analyzers. Compared with the Picarro CRD, the TILDAS offers higher detection sensitivity and faster response, improving measurement accuracy and enabling rapid switching between experimental conditions to better resolve formation pathways and precursor dynamics.

2.3.4.6. Technology Assessment and Transfer / Outreach

25132: Cosponsor California State University, Los Angeles in the Battery Workforce Challenge

Contractor: California State University Los Angeles	South Coast AQMD Cost-Share	$ 150,000
	Cosponsors:	
	Sikand SITI-Center and ECST	500,000
Term: 04/02/25 – 10/01/26	Total Cost:	$ 650,000

Launched in 2023 by the DOE and Stellantis, the Battery Workforce Challenge is a three-year engineering competition aimed at advancing EV technology. The program challenges universities and their partners to design, build, test, and integrate advanced EV battery packs into a Stellantis vehicle. California State University, Los Angeles is one of 12 universities nationwide selected to participate.

The design and development of advanced batteries are critical to electrifying the transportation sector, and this program will prepare and train the next generation of engineers and technicians to meet the growing demand for EVs. Participating students gain the hands-on experience and skills needed to become highly capable engineers driving battery innovation.

Various: Cosponsor 20 Conferences, Workshops & Events plus 4 Memberships

Contractor: Various	South Coast AQMD Cost-Share	$ 276,303
	Cosponsors:	
	Various	2,740,550
Term: 01/01/25 – 12/31/25	Total Cost:	$ 3,016,853

South Coast AQMD regularly participates in, hosts, and co-sponsors conferences, workshops, and other events to advance clean-air, clean-fuel, and transportation-innovation initiatives. In CY 2025, South Coast AQMD provided funding for 20 conferences, workshops, and events, including:

- Clean Fuels Advisory Group Retreats
- International Onboard Sensing, Analysis, and Reporting Conference
- Real-World Emissions Workshop
- Tire Emissions & Sustainability USA Conference
- California Science & Engineering Fair
- Asilomar Conference on Resilient Transportation Transitions
- Southern California Chinese-American Environmental Protection Association Convention
- Inaugural Hydrogen Engine Conference
- Zero-Emission Ride and Drive
- California Hydrogen Leadership Summit

- Greater Riverside Chambers of Commerce Infrastructure Summit
- Port Electrification US Conference
- Sustain SoCal Driving Mobility 12 Symposium
- California Summit - Driving Progress Toward 2030
- Transportation Electrification Conference
- Advanced Clean Transportation Conference & Expo
- Sustain SoCal Energy Event
- SoCal Electrified Drive Event
- Gordon Research Conference and Seminar on Atmospheric Chemistry
- CoMotion LA

Additionally, in CY 2025, South Coast AQMD renewed four memberships to support ongoing collaboration and thought leadership:

- CALSTART - a nonprofit working nationally and internationally with businesses and governments to develop clean, efficient transportation solutions.
- CHBC - a membership-based trade association that educates the public and policymakers on the benefits of hydrogen and advances policy positions that support hydrogen commercialization in the energy and transportation sectors to achieve California's climate, air-quality, and decarbonization goals.
- H2FCP - an industry-government collaboration aimed at expanding the market for FCEVs and supporting a zero-emission, energy-diverse future.
- CEI at UCI - a recognized leader in sustainable energy that addresses the broad utilization of energy resources from a systems perspective and the nexus of electric power generation, transportation, infrastructure, and the environment.

2.4. Progress and Results

Given the large number and diversity of emission sources contributing to air quality problems in SCAB, there is no single technology or "silver bullet" that can address the region's challenges. A portfolio of technologies is required to achieve the emission reductions needed to meet the 2023 and upcoming 2032 air quality standards, as well as the state's 2050 climate goals. Accordingly, South Coast AQMD continues to support a wide range of advanced technologies, addressing both the diversity of sources and the timelines to commercialization.

Projects co-funded by South Coast AQMD's Clean Fuels Program include emission reduction demonstrations for mobile and stationary sources, although legislative requirements limit the use of available Clean Fuels funds primarily to on-road mobile sources. These funded projects not only accelerate development, demonstration, and commercialization of zero- and near-zero-emission technologies and fuels, but also demonstrate technical viability to technology providers, end users, and policymakers.

In the early years, mobile source projects funded by the Clean Fuels Program targeted low-emission technology developments in automobiles, transit buses, MD and HD trucks, and off-road applications. Over

the last several years, the focus has shifted largely to ZE technologies for MD and HD trucks, particularly in the goods movement and freight handling sectors.

2.4.1. Highlighted Completed Contracts in RDD&D

Selected projects completed in 2025 which represent a range of key technologies from near-term to long-term are highlighted below:

Switch-On: Develop and Deploy Heavy-Duty Battery Electric Vehicles (Volvo Group North America, LLC.)

Project Overview

The Switch-On project conducted a large-scale demonstration and early commercial deployment of ZE freight trucks in SCAB. The deployment included 70 BE Class 7 and Class 8 trucks across eight freight fleets, supported by charging infrastructure installation, operational data collection, and stakeholder outreach.

Real-World Operations

Deployed vehicles accumulated approximately 1.9 million revenue miles, demonstrating successful real-world operation of BETs in drayage and regional distribution service. For suitable duty cycles, utilization levels were comparable to diesel counterparts, validating technical and operational feasibility at fleet scale.

Quantified Emission Benefits (Annualized)

- NOx: 2.833 tons reduced
- PM2.5: 0.005 tons reduced
- CO_2: 2,872 tons avoided

These emission reductions contribute to improved air quality in freight-impacted areas and overburdened communities.

Fleet & Driver Feedback

Feedback was overwhelmingly positive:

- Over 90 percent of drivers reported smooth adaptation to electric trucks, citing reduced noise, improved air quality, and enhanced driving comfort.
- Fleet managers reported growing confidence in vehicle reliability, operational performance, and emerging energy-cost benefits as operational experience increased.

Conclusions & Impact

The Switch-On project demonstrates the technical and operational viability of ZE freight trucks at scale and advances early commercialization, while reducing emissions and community exposure in freight-impacted and disadvantaged communities.

Figure 10: ZE Freight Truck

Development and Demonstration of Electric-Powered Trailer for Heavy-Duty Vehicles (Range Energy, Inc.)

This project comprised two main activities:

1. Prototype Build: Development of the Electric Trailer **(**eTrailer) System.
2. Operational Demonstration: Real-world deployment within a beverage distribution fleet in SCAB.

The build phase spanned 12+ months across 2023–2024, primarily at Range Energy's facility in Mountain View, California. The demonstration occurred in Downey, California, at a warehouse operated by a large beverage distribution fleet during October–November 2024. The warehouse served as the charging location and the starting/ending point for demonstration routes.

A performance evaluation phase ran throughout the demonstration and post-demonstration, concluding in July 2025. The Project is now complete, and the final report is on file with South Coast AQMD.

The prototype eTrailer is built on a conventional 53-ft dry van and integrates the following key components:

- Energy Module: 192 kWh battery.

Figure 11: Range Energy eTrailer

- Drive Module: 250 kW electric axle providing propulsion assistance and regenerative braking.
- Smart Sensors: Control and optimize the level of propulsion assistance.
- Base Trailer: Standard 53-ft dry van platform for system integration.

During the demonstration, the diesel tractor towing the eTrailer was equipped with:

- On-board Sensing, Analysis, and Reporting (OSAR) devices.
- Portable Emissions Monitoring System (PEMS) instrumentation provided by UCR, College of Engineering-Center for Environmental Research & Technology.

Demonstration & Evaluation Results

The demonstration indicated that a large beverage fleet operator can meaningfully:

1. Improve diesel fuel efficiency of in-use tractors
    a. From 7.28 miles per gallon (mpg, baseline) to 10.3 mpg on representative routes.
2. Reduce emissions attributable to diesel fleet operations
    a. Observed reductions in some instances: up to 49 percent for PM and 17 percent for NOx, with promising outcomes for cold starts.

Additional positive findings included:

- Charging feasibility: The eTrailer was successfully charged using existing warehouse power, without costly infrastructure upgrades.
- Operational readiness: Training and day-to-day operation for eTrailer users proved straightforward and effective.

Applications & Follow-On Work

The eTrailer has real-world applications for both dry van and refrigerated trailers. South Coast AQMD and Range Energy have initiated a follow-on demonstration to assess the financial and operational feasibility of deploying the eTrailer in refrigerated distribution fleet operations in SCAB.

Range Energy anticipates that economic and emissions benefits may be greater in refrigerated applications than in dry van use, given that most TRUs currently operate with diesel motors.

Market Opportunity & Commercialization Outlook

- There are over five million dry van and refrigerated trailers in use nationwide, with hundreds of thousands operating in California.
- None of these trailers currently use a system like the eTrailer demonstrated in this project.
- This presents a significant opportunity for fleet operators to reduce diesel fuel consumption and emissions at scale.

Range Energy is preparing for scaled commercialization in 2026, enabling a ramp-up period to establish manufacturing, service, and continuous improvement infrastructure for the eTrailer system.

Timeline Summary

- 2023–2024: Prototype build (12+ months), Mountain View, CA.
- Oct–Nov 2024: Demonstration, Downey, CA (warehouse charging and route operations).
- Through July 2025: Performance evaluation (during and post-demonstration).
- Commercialization Target: 2026.

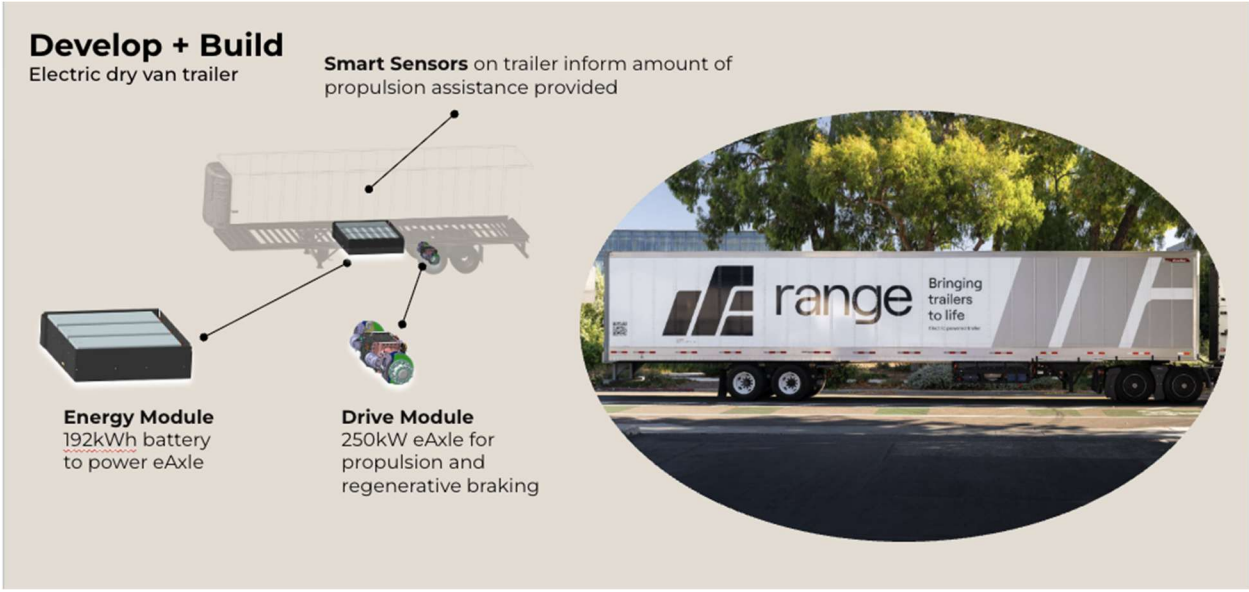

Figure 12: Range Energy eTrailer System

2.4.2. Contracts by Core Technology Area Completed in 2025

Table 5 provides a list of 31 projects and contracts completed by South Coast AQMD in CY 2025. Summaries of the completed technical projects are included in Appendix C.

Table 5: Contracts Completed or Closed between January 1 & December 31, 2025

Contract	Contractor	Project Title	Date
Hydrogen / Mobile Fuel Cell Technologies and Infrastructure			
21313	SunLine Transit Agency	Deployment of Zero-Emission Fuel Cell Transit Buses	Dec 2025
21372	University of California Irvine	California Hydrogen Systems Analysis	Jun 2025
Zero Emission Infrastructure			
25076†	GenCell Inc	Demonstrate Off-Grid Electrical Fast Charging Solution to Support UCLA's Electric Fleet	Nov 2025
Electric and Hybrid Electric Technologies and Infrastructure			
18232	Hyster-Yale Group Inc	Electric Top-Pick Development, Integration & Demonstration	Feb 2025
19166	Phoenix Cars LLC DBA Phoenix Motorcars	Battery Electric Shuttle Bus Replacement Project	Apr 2025
19464	West Basin Container Terminal LLC	Battery Electric Yard Tractor Replacement Project	Feb 2025
21153	Volvo Group North America LLC	Switch-On: Develop and Deploy Heavy-Duty Battery Electric Vehicles	Nov 2025
23103†	San Bernardino County DBA Arrowhead Regional Medical Center	Deployment of Zero Emission Mobile Clinics	Apr 2025
24101†	Odyne Systems LLC	Develop and Demonstrate an Electric Power Take-Off System on a Zero-Emission Battery Electric Medium-Duty Truck Chassis	Jun 2025
24123	Range Energy Inc	Development and Demonstration of Electric Powered Trailer for Heavy-Duty Vehicles	Jun 2025
24318	University of California Riverside	Evaluation of Electric Powered Trailer for Heavy-Duty Vehicles	Dec 2025
Technology Assessment and Transfer / Outreach			
20085†	CALSTART Inc	Technical Assistance for Development & Demonstration of Infrastructure and Mobile Source Applications	Nov 2025
25077†	Coordinating Research Council Inc	Cosponsor the 35th Real World Emissions Workshop	Jul 2025
25098†	TRC Environmental Corporation	Cosponsor the 2025 California Hydrogen Leadership Summit	Jul 2025
25105†	CALSTART Inc	Cosponsor the CALSTART 2025 Member Symposium	Mar 2025
25107†	Emissions Analytics LLC	Cosponsor the Tire Emissions and Sustainability USA 2025 Conference	Jul 2025
25138†	University of California Davis	Cosponsor the Asilomar 2025 Conference on Resilient Transportation Transitions	Oct 2025
25139†	University of California Riverside	Cosponsor the 14th Annual International OSAR Conference	Jul 2025

Table 5: Contracts Completed or Closed between January 1 & December 31, 2025 (cont'd)

Contract	Contractor	Project Title	Date
Technology Assessment and Transfer / Outreach (cont'd)			
25141†	Southern California Chinese American Environmental Protection Association	Cosponsor the 2025 Southern California Chinese American Environmental Protection Association Annual Convention	Apr 2025
25148†	University of California Riverside	Cosponsor the 2025 Inaugural Hydrogen Engine Conference	Jul 2025
25158†	Harbor Trucking Association	Cosponsor Zero Emission Ride and Drive 2025	May 2025
25163†	CALSTART Inc	Cosponsor the 12th California Summit Driving Progress Towards 2030	May 2025
25167†	The Institute of Electrical and Electronics Engineers Inc	Cosponsor the ITEC+2025 IEEE Transportation Electrification Conference	Aug 2025
25179†	TRC Environmental Corporation	Cosponsor ACT Expo 2025	Jul 2025
25198†	Greater Riverside Chambers of Commerce	Cosponsor the Greater Riverside Chambers of Commerce Infrastructure Summit	Jun 2025
25209†	India Infrastructure Publishing	Cosponsor the 3rd Annual Port Electrification US Conference	Jul 2025
25220†	Sustain SoCal	Cosponsor the Driving Mobility 12 Conference	Jul 2025
26032†	Orange County Automobile Dealerships Association	Cosponsor the 2025 SoCal Electrified Ride Experience at OC Auto Show	Oct 2025
26040†	Gordon Research Conferences	Cosponsor the 2025 Gordon Research Conference and Seminar on Atmospheric Chemistry	Sept 2025
26043†	CoMotion Inc	Cosponsor the 2025 CoMotion LA Event	Dec 2025
26054†	Sustain SoCal	Cosponsor the 2025 16th Annual Energy Event	Nov 2025

†Two-page summary reports (as provided in Appendix C) are not required for level-of-effort technical assistance contracts, leases or co-sponsorships; or reports were unavailable at time of printing this report.

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CLEAN FUELS PROGRAM

2026 PLAN UPDATE

3.1. Clean Fuels Program - 2026 Plan Overview

The Clean Fuels Program has evolved over time and continues to fund a broad portfolio of technologies spanning near-term and long-term implementation. Planning for the Program is a continuous activity that must remain flexible to address emerging technologies and capitalize on advances in research, technology, and data. Each year, South Coast AQMD re-evaluates the Program and develops a Plan informed by current clean-fuel technology assessments and the direction of the South Coast AQMD Governing Board.

The 2026 Plan targets several projects to achieve near-term emission reductions needed for the South Coast to meet health-based NAAQS. The Plan includes cost-share projects to develop and demonstrate ZE/NZE, and low-emission clean fuels and technologies that advance development and commercialization - benefiting not only SCAB but also California and the nation.

Consistent with prior years, proposed 2026 projects will be carried out through public-private partnerships among:

- Industry and technology developers
- Academic and research institutions
- Local, state, and federal agencies

To continue advancing zero-emission technologies - particularly hydrogen fuel cell electric (HFCE) technologies and hydrogen supply infrastructure - the Clean Fuels Program may exercise flexibility in cost-share expectations, recognizing limited state and federal funding in this area.

3.2. 2026 Program Plan for Core Technology Areas

The 2026 Plan funds RDD&D of advanced, pre-commercial technologies spanning near-term to long-term to address critical air quality and deployment challenges in SCAB. The Plan remains flexible to incorporate new technologies, control measures identified in the 2022 AQMP, evolving research, and emerging data.

The Program addresses key challenges, including:

1. Federal Standards Compliance: Support implementation of federal requirements, including the more stringent 8-hour ozone standard of 70 ppb promulgated by the U.S. EPA in late 2015.
2. New Technology Measures: Accelerate development of technologies nearing commercialization and deploy commercially ready technologies to achieve near-term emission reductions.
3. Zero-Emission Infrastructure: Develop and deploy EV charging infrastructure, assess grid readiness, and advance alternative charging solutions to support EV deployment.
4. Hydrogen Ecosystem Reliability: Improve hydrogen refueling station reliability and availability, support alternative hydrogen production pathways, and deploy mobile hydrogen refueling where needed.

The 2026 Plan maintains a sufficiently flexible portfolio to respond to:

- New control measures and strategies identified in the 2022 AQMP
- Dynamically evolving technologies with high emission reduction potential
- New research findings and operational data

Project objectives span near-term to long-term across previously defined core technology areas. The Clean Fuels Program concentrates on applied development, demonstration, deployment and commercialization, rather than fundamental research.

Focus on increasing utilization of clean technologies in conventional applications, delivering immediate and scalable emission reductions. Barriers such as higher upfront costs, limited refueling/charging infrastructure, and behavior change requirements can impede adoption - even when benefits are significant.

    - Government incentives help offset upfront costs and reduce risk, accelerating uptake.
    - Building stakeholder confidence in long-term viability and cost-effectiveness is essential.

- Field Demonstrations (Near- to Mid-Term):

  Provide real-world performance evidence, surface end-user issues ahead of commercial introduction, and establish preliminary emissions reduction potential. Demonstrations are crucial to de-risking technologies and informing certification pathways.

- Technology Development & Pilots (Mid- to Long-Term):

  Typically two or more years in duration, often requiring long-term performance verification through field demonstrations and large-scale pilot deployments prior to certification and commercialization.

  Projects may include higher-risk, emerging technologies with substantial emission-reduction potential.

- Mature Clean Fuel Technologies (On-going):

  Some clean fuel vehicle technologies are technically mature but constrained by higher costs and the need for supporting charging/refueling infrastructure - especially for fuels with higher production costs. Targeted incentives and infrastructure investments remain pivotal for expanded deployment.

The Program aims to fund viable projects across ten core technology areas with the greatest potential to achieve the NAAQS:

1. Hydrogen & Mobile Fuel Cell Technologies
2. Engine Systems & Technologies
3. Electric & Hybrid Vehicle Technologies (including battery-electric and hybrid-electric trucks and container transport technologies enabling zero-emission operations)
4. Zero-Emission Infrastructure
5. Fueling Infrastructure & Deployment
6. Stationary Clean Fuels Technologies (including microgrids and renewables)

7. Fuel & Emissions Studies
8. Emissions Control Technologies
9. Health Impacts Studies
10. Technology Assessment & Transfer / Outreach

Within these core technology areas, South Coast AQMD will actively leverage Program funds with public-private partnerships - including industry, technology developers, academic and research institutions, and local, state, and federal agencies - to expedite demonstrations and deployments across SCAB.

Many core areas are interdependent and synergistic:

- An HD vehicle - such as a transit bus or drayage truck - may use a hybrid-electric drivetrain with a fuel cell operating on hydrogen or an ICE operating on an alternative fuel as a range extender, with overlapping hybrid system components.
- A hydrogen-powered engine may utilize an NG HD vehicle (NG, gaseous fuel) and require compressed tank storage, sharing combustion and fuel storage components across platforms.

Program priorities may shift during the year to:

- Maintain a diverse, flexible portfolio
- Leverage cost-sharing opportunities with state and federal partners or other entities
- Address specific technology issues affecting residents within South Coast AQMD's jurisdiction

AB 617 CAPP - signed by the California Governor in 2017 - supports emission reduction actions and provides incentive funding for designated AB 617 communities. The six AB 617 communities within the South Coast region establish funding priorities in their Community Emission Reduction Plans (CERPs). The Program will retain additional flexibility to develop strategies and technologies tailored to these overburdened communities.

In 2026, the focus remains aligned with the control measures identified in the 2022 AQMP, subject to the availability of suitable projects. The categories identified above are responsive to current air quality challenges and technology advancement opportunities, ensuring continued progress toward NAAQS attainment.

3.2.1. Hydrogen / Mobile Fuel Cell Technologies

Hydrogen and mobile fuel cell technologies have been a focus of the Clean Fuels Program for over a decade. While notable progress has been made - particularly in LD, transit bus, and Class 8 applications - the primary constraint to widespread viability remains the installation, reliability, and operation of hydrogen refueling stations. In parallel, hydrogen fuel cell powertrains require further advancement and scaling for MD, HD, and select on- and off-road mobile applications where longer range and faster fueling are essential.

Industry headwinds - such as the recent bankruptcy and wind-down of Nikola and Hyzon - underscore the importance of partnering with additional fuel cell OEMs to support larger-scale deployment of Class 8 FC trucks. These market developments also highlight the need to research, fund, and accelerate the buildout of

reliable hydrogen refueling infrastructure. Station reliability and network availability challenges have contributed to higher delivered hydrogen costs, dampening OEM interest in expanding these technologies.

In 2026, the Clean Fuels Program will focus on scaling Class 8 hydrogen FC truck deployments and expanding/refining supporting hydrogen refueling infrastructure to enable durable, cost-effective operations.

Medium-Duty & Specialized Vehicle Opportunities

Several OEMs have proposed Class 6 hydrogen FC trucks aimed at the MD market to support the transition to ZE commercial transportation. Another OEM has proposed an HFCE refuse collection vehicle, targeting commercial-scale production to decarbonize refuse fleets in California.

While refuse vehicle technology maturation is critical, mass adoption will depend on cost-effective, reliable hydrogen supply. Beyond vehicle development, the crucial hurdle is access to low-cost hydrogen delivered through a reliable network. To address this, Utility, a company specializing in hydrogen production from biogases (e.g., landfill gas, wastewater gas, dairy gas), is developing hydrogen production facilities at landfills within SCAB, where landfill gas is currently flared. These projects could both reduce emissions and lower hydrogen costs, strengthening the economic case for HFCE deployments.

Stationary & Mobile Fuel Cell Power

FCs are also being advanced for stationary power generation in prime and backup applications. RockeTruck is developing and demonstrating a mobile FC trailer capable of continuously producing 35 kW of power for 48 hours, utilizing the Honda Clarity FC. The project is designed to:

- Provide emergency charging capability in remote locations or during grid outages
- Charge stranded vehicles that have lost their state of charge
- Serve as a mobile, flexible resource to support critical operations

These mobile and stationary solutions complement transportation deployments by broadening hydrogen's utility across the energy ecosystem.

Potential Project Categories

The 2026 Plan Update identifies priority opportunities and pre-commercial demonstrations to advance OEM FCEVs and supporting infrastructure. Future projects may include:

1. Hydrogen R&D to Support Innovative Fueling Solutions

   Develop and demonstrate research that advances innovative, cost-effective, and reliable fueling solutions for HFCE vehicles, including:

   a. Station reliability improvements (redundancy, diagnostics, and maintenance best practices)

   b. Network availability and resiliency (backup supply, mobile refueling units)

   c. Alternative hydrogen production pathways (biogas-derived hydrogen; co-location at landfills and wastewater facilities)

   d. Dispensing advancements (faster fueling protocols for MD/HD duty cycles; improved thermal management)

e. Data and standards (performance baselines, real-world duty cycle analytics, interoperability and codes/standards support)

2. MD and HD FCEV Demonstrations

Develop and demonstrate MD and HD FCEV platforms in real-world fleets to accelerate certification and commercialization, including:

a. Class 6 medium-duty applications (urban delivery, vocational)

b. Class 8 long-haul and regional haul trucks (high-utilization corridors and depot-based operations)

c. Vocational vehicles (e.g., refuse collection, drayage, construction)

d. Integrated ecosystem pilots (vehicle + station + supply chain + maintenance/training)

e. Cost-share models and incentives to offset higher upfront costs and catalyze early deployments

3.2.2. Engine Systems/Technologies

The 2026 Plan Update continues to support cleaner engines and hybrid powertrains for the HD sector while accelerating the transition to ZE technologies. Near-term engine projects will focus on development, demonstration, and emissions verification/certification of platforms that can deliver immediate emission reductions, complementing longer-term ZE deployment.

Aggressive GHG emission reduction targets set by CARB and the U.S. EPA have renewed interest in low- and zero-carbon alternative fuels for high-power/torque applications - most notably the H2-ICE. While fuel-source GHG emission reduction benefits are straightforward to estimate, it is crucial to evaluate criteria pollutant emissions under real-world duty cycles and over useful lifetimes to ensure that both criteria pollutants and GHG emissions are reduced in practice.

Renewable and alternative fuels provide a pragmatic pathway for HD truck and rail sectors to meet decarbonization goals while ZE technologies address challenges related to cost, range, and infrastructure. “Drop-in” fuels, such as renewable diesel, enable fleet operators to use existing diesel engines and fueling infrastructure without costly modifications or downtime, protecting major fleet investments and delivering near-term emissions benefits.

This transitional strategy complements ongoing development of battery-electric and HFCE platforms by reducing fleet emissions now, while ZE technologies continue to scale.

<u>Potential Project Categories</u>

1. Develop and Demonstrate Advanced Vehicle Technologies to Achieve Ultra-Low Emissions

Scope may include:

a. H2-ICE trucks (on-road): duty-cycle-matched demonstrations; comparative emissions testing (NOx, PM, CO, hydrocarbon [HC]); fuel economy and GHG analyses (well-to-wheel).

b. Hybrid HD powertrains: parallel/series hybrids, engine downsizing with electrified assist; regenerative braking for vocational duty cycles (drayage, refuse, construction).

c. Aftertreatment optimization: advanced catalysts and controls tuned for alternative fuels; durability and in-use compliance verification.

d. M&V: PEMS, life-cycle assessments, and certification-aligned testing to support commercialization.

3.2.3. Electric / Hybrid Vehicle Technologies (including battery electric and hybrid electric trucks and container transport technologies with zero emission operations)

The 2026 Plan Update continues to advance BE and hybrid-electric powertrains across LD, MD, and HD segments to fully transition to ZE technologies. Near-term engine projects will develop and demonstrate battery-electric technology on conventional on-road vehicles and expand into new areas that require focused attention, including:

- Battery-powered trailers
- ePTO systems for jobsite power or TRUs
- BEVs for vocational/specialty applications

Vocational/Specialty BEV Demonstration

A representative vocational/specialty BEV project will develop and demonstrate a Class 8 BEV vocational truck (e.g., cement truck), a particularly challenging application. The demonstration will evaluate economic viability and technical feasibility in real-world use, with a focus on:

- Operational performance, range, and charging experiences
- TCO
- Emissions reductions

Cement trucks have heavy loads, mixed routes, limited charging infrastructure, high payload demand, and additional hardware (e.g., chutes, conveyors, water tanks) with potential continuous ePTO demand for mixer operation. These factors require large onboard energy, creating trade-offs among range, package space, battery weight, maximum payload, and cost, which complicate BEV integration for cement fleets.

CARB is developing requirements to transition diesel-powered TRUs to ZE technologies. CARB's 2022 TRU Technology Assessment identified potential pathways to reduce emissions from trailer-mounted TRUs, including BE TRU models paired with electric-powered trailers. The Assessment notes that electric-powered trailer technology - including regenerative braking and axle generation - can help address power requirements and duty-cycle challenges associated with ZE BE TRUs.

South Coast AQMD will pursue public-private partnerships to develop and conduct end-to-end demonstrations of battery-powered TRUs integrated with electric-powered trailer technology. Successful demonstrations will support commercial development and wide-scale deployment of ZE TRU technology in the HD truck sector and inform CARB's ZE TRU rulemaking.

Potential Project Categories

To enable expedited, widespread use of pre-commercial and commercial BE and hybrid-electric vehicles in SCAB, the Plan identifies the following project categories:

1. Develop and Demonstrate MD and HD On-Road BEVs and Equipment *(including trailers, ePTO systems, and vocational/specialty applications)*, including:

    a. Vocational BEVs: Class 8 cement/mixer trucks; refuse, utility, and construction applications with continuous or high-power ePTO requirements.

    b. Battery-powered trailers: Integrated energy modules, regenerative braking, and axle generation to support TRUs and route efficiency.

    c. Charging solutions: Depot, opportunity, and jobsite charging; managed charging strategies matched to duty cycles and payload constraints.

    d. Performance & TCO verification: Range, payload impacts, duty-cycle energy use, maintenance, and emissions outcomes.

2. Demonstrate LD BEVs and PHEVs, including:

    a. Fleet deployments to validate utilization, charging behavior, and grid impacts.

    b. Comparative assessments of BEVs vs. PHEVs for specific use cases (e.g., municipal, service, and low-mileage fleets).

    c. Real-world emissions and cost analyses to accelerate adoption and inform procurement decisions.

3.2.4. Zero Emission Infrastructure

3.2.4.1. Hydrogen Refueling Infrastructure

FCs have diverse applications across both on-road and off-road equipment. However, off-road operations generally lack access to fixed hydrogen fueling stations. Installing on-site hydrogen refueling can be cost-prohibitive and often not feasible in land-constrained environments such as port complexes and similar facilities. In these scenarios, mobile hydrogen refueling stations can provide the necessary fueling support to enable adoption of fuel cell-powered off-road equipment while avoiding expensive permanent infrastructure.

The Clean Fuels Program has partnered with Toyota Tsusho America, Inc. (TAI) to develop and demonstrate a fuel cell-powered mobile hydrogen refueler addressing these off-road constraints. The mobile refueler will supply hydrogen to FC-powered CHE at POLA.

- Objectives:
    - Evaluate technical requirements for mobile hydrogen fueling (capacity, refueling rates, reliability, safety).
    - Assess economic viability of mobile refueling within port operations, including utilization, logistics, and TCO.
- Schedule: Project commencement is anticipated in Q1 2026.

This demonstration will generate practical insights to inform broader deployment of mobile/temporary fueling solutions in land-constrained and high-throughput environments.

Potential Project Categories

To lead the demonstration and deployment of hydrogen fueling infrastructure, the 2026 Plan identifies future project concepts such as:

1. Develop and Demonstrate Hydrogen Production and Fueling Stations
    a. Distributed and hub-based production (including low-carbon pathways).
    b. Station design for HD duty cycles, redundancy, and uptime targets.
    c. Integration with fleet operations, safety, and codes/standards.
2. Develop and Demonstrate Mobile/Temporary Gaseous and Liquid Hydrogen Refueling Infrastructure
    a. Mobile refuelers for off-road and temporary on-road deployments.
    b. Gaseous and liquid configurations matched to duty-cycle needs (flow rates, storage, siting).
    c. Rapid deployment models to bridge infrastructure gaps and support early fleet adoption.

3.2.4.2. Electric Charging Infrastructure

South Coast AQMD continues to invest - through incentive programs - in BE charging infrastructure and enabling technologies to accelerate the transition to clean, zero-emission vehicles (ZEVs) across SCAB. Supported systems include charging stations, energy storage, and related technologies that collectively enable reliable EV and truck operations.

Common hurdles to charging infrastructure deployment include:

- Insufficient grid capacity
- Grid reliability constraints
- Regulatory and interconnection complexities

These barriers frequently lead to delays, cost escalations, and prolonged project timelines for fleets and site hosts.

Where delays are driven by grid complexities, linear generators have emerged as a flexible prime-power and EV charging solution - particularly for microgrid applications. Linear generators produce electricity by

moving magnets through copper coils in a linear motion and can operate on hydrogen, NG, and biogas, offering multi-fuel flexibility.

South Coast AQMD has partnered with GTI Energy and CSULB to evaluate emissions, efficiency, and performance of a linear generator across multiple fuels. This work will inform suitability, deployment conditions, and operational best practices for near-term charging needs.

Planning & Grid Analysis Tools

To support upcoming infrastructure funding and complex siting decisions, there is a growing need for technical planning and grid analysis tools that help fleet owners, regulatory agencies, and developers understand capacity constraints and plan efficiently. The Clean Fuels Program has had:

- Partnership with universities to develop a technical planning data platform for MD/HD ZEV infrastructure deployment, including criteria and benefits analyses for Southern California.
- Ongoing discussions with research entities to expand fleet and grid analysis tools in support of ISRs and forthcoming infrastructure grant solicitations.

South Coast AQMD is considering proposals to fund battery-integrated EV chargers and battery-powered microgrids as intermediate solutions - particularly in areas lacking sufficient grid capacity for immediate DC fast-charger interconnection or where customers face lengthy interconnection timelines.

Evaluation scope will include additional operational benefits:

- Reduced grid demand through peak shaving and load management
- Increased renewable self-consumption (e.g., solar + storage pairing)
- Emergency charging and remote deployment capability
- Improved route optimization and operational resilience for MD/HD EVs
- Fleet-aligned charging strategies to maintain payloads, uptime, and TCO targets

Potential Project Categories

To lead the demonstration and deployment of hydrogen fueling and charging infrastructure, the Plan identifies the following project categories:

1. Develop and Demonstrate Mobile MCS Infrastructure

   Focus: Mobile, high-power charging solutions for BE MD/HD trucks, enabling rapid deployment at depots, ports, and along key corridors while grid upgrades are pending.

2. Develop and Demonstrate Innovative Charging Solutions for Grid Support

   Focus: Integrated storage-backed charging, microgrids, managed charging, and vehicle-to-everything (V2X) capabilities to enhance reliability, lower operational costs, and mitigate grid constraints.

3.2.5. Fueling Infrastructure and Deployment

While the Program's emphasis has steadily shifted toward ZE technologies, the 2026 Plan Update continues to identify high-value opportunities for fueling infrastructure and low-emission generation to support near-term reliability and resilience across SCAB. This includes:

- Maintaining existing renewable fueling infrastructure;
- Demonstrating low-emission generation technologies that can serve as prime or backup power; and
- Bridging deployment gaps where grid constraints delay ZE charging projects.

Linear generators are low-emission power systems that generate electricity by driving magnets in a linear motion. They are fuel-agnostic - capable of operating on NG and renewable fuels (e.g., biogas) - and are increasingly utilized in microgrids where grid support is limited or interconnections are delayed.

The Clean Fuels Program has partnered with CSULB launch a project to provide emissions insights for a linear generator operating across multiple fuels, including performance and efficiency characterization.

The Clean Fuels Program will fund an additional project to characterize criteria pollutant emissions under different fuels and evaluate durability and robustness of a newly introduced linear generator fueled by NG and renewable fuels.

These demonstrations will inform deployment conditions, operational practices, and cost-effectiveness for near-term resilience solutions—especially for sites awaiting permanent ZE infrastructure.

Potential Project Categories

To lead the demonstration and deployment of fueling infrastructure and renewable fuel technologies, future projects may include:

1. Demonstrate Low-Emission Engine/Generation Technology
    a. Prime and backup applications supporting depot operations, charging hubs, and critical facilities.
    b. Fuel-flexible platforms (e.g., NG and renewable fuels) with verified emissions and efficiency.
2. Develop, Maintain, and Expand Renewable Fuel Infrastructure
    a. Preserve and enhance existing renewable fueling networks to ensure reliability and access.
    b. Targeted upgrades and resilience measures aligned with high-utilization corridors and hubs.
3. Demonstrate Renewable Transportation Fuel Production and Distribution Technologies
    a. Pilot production pathways and logistics for renewable fuels, including integration with fleet operations.
    b. M&V for criteria pollutant and GHG benefits across the supply chain.

3.2.6. Stationary Clean Fuel Technologies (including microgrids and renewables)

While much of the Program's emphasis has shifted to ZE technologies, low-emission generator-powered microgrids and battery-powered microgrids are increasingly popular for:

- BEV charging
- Building electrification
- Backup power and load shifting

These solutions are being explored to provide both prime and backup power where grid capacity and interconnection timelines pose challenges.

Linear generators have emerged as a low-emission alternative to ICE for prime power and microgrid applications. They generate electricity by driving magnets in a linear motion through copper coils and can operate on multiple fuels, including RNG, hydrogen, and propane, making them fuel-flexible and well-suited to constrained or transitional sites.

South Coast AQMD staff are evaluating a proposal from a new linear generator manufacturer to conduct comprehensive emissions testing of their platform. The project will:

- Characterize criteria pollutant emissions across multiple fuels (RNG, hydrogen, propane)
- Test durability and robustness under real-world operating conditions, including varied loads and ambient temperatures
- Deliver insights on emission performance, efficiency, and operational suitability for clean energy microgrid applications

Results would inform deployment best practices, M&V protocols, and technology selection for near-term resilience while ZE infrastructure scales.

Potential Project Categories

To lead demonstration and deployment of resilient, low-emission power solutions, future projects may include:

1. Develop and Demonstrate Microgrids with Photovoltaic/FC/Battery Storage Energy Management
    a. Integrated PV + FC + battery systems with advanced energy management for depots, buildings, and EV charging hubs
    b. Use cases: peak shaving, islanded operation, backup and emergency response
2. Develop and Demonstrate ZE/NZE Energy Generation Alternatives
    a. Fuel-flexible prime/backup generation (e.g., linear generators, fuel cells) verified for criteria pollutants and GHG performance
    b. Rapid-deploy solutions to bridge grid constraints and support BEV charging reliability

3.2.7. Fuel and Emissions Studies

In recent years, the Clean Fuels Program has supported studies aligned with MATES. With MATES VI currently underway, South Coast AQMD staff propose to pursue additional emissions studies - such as investigations into secondary PM formation from tires and urban ammonia (NH_3) monitoring near potential sources like freight corridors - to help update NH_3 emissions inventories and provide community-level data for pollutants of concern across SCAB.

In 2026, there will be a continued need for the Clean Fuels Program to focus on fuels and emissions studies that complement technology demonstrations and inform regulatory decisions:

1. In-Use Emission Studies for Advanced Technology Vehicle Demonstrations (including non-exhaust emissions)
    a. Characterize in-use emissions for advanced technology deployments (e.g., ZE/NZE platforms), explicitly including non-exhaust PM (e.g., tire wear).
    b. Utilize PEMS and supplemental sensors to capture real-world duty cycles, ambient conditions, and seasonal variability.
    c. Link emissions outcomes to operational data (routing, loads, speeds, charging/fueling profiles).
2. Emission Studies on Biofuels, Alternative Fuels, and Related Environmental Impacts
    a. Evaluate criteria pollutants and air toxics associated with biofuels and alternative fuels under representative operating conditions.
    b. Include well-to-wheel/ life-cycle considerations where feasible to contextualize GHG and criteria pollutant impacts.
    c. Identify co-benefits and potential tradeoffs to inform fleet procurement and policy development.
3. Identify & Demonstrate In-Use Fleet Emission Reduction Technologies and Opportunities
    a. Assess retrofit and operational strategies (e.g., aftertreatment optimization, managed charging/fueling, route planning) that yield near-term emissions reductions.
    b. Conduct pilot demonstrations with robust M&V to validate scalability, cost-effectiveness, and community benefits.

<u>Potential Project Categories</u>

The 2026 Plan Update identifies key opportunities to continue advancing fuels and emissions research:

1. Conduct In-Use Emission Studies for Advanced Technology Vehicle Demonstrations (including non-exhaust emissions)
2. Conduct Emission Studies on Biofuels, Alternative Fuels, and Other Related Environmental Impacts
3. Identify and Demonstrate In-Use Fleet Emission Reduction Technologies and Opportunities

3.2.8. Emission Control Technologies

South Coast AQMD will continue funding studies to mitigate emissions from ICEs and assess impacts from emerging technologies. On-board emissions sensors have been identified by CARB and other agencies as reliable tools for in-use emissions compliance. When combined with global positioning systems (GPS), cellular connectivity, weather, traffic, and online air-quality models, real-time data can enable advanced operational strategies such as geofencing and eco-routing, consistent with approaches outlined in CARB's 2022 SIP Strategy.

In parallel, on-route remote sensing technologies show promise for measuring truck emissions non-intrusively by capturing pollutants in the exhaust plume of passing vehicles. These systems enable large-scale, cost-effective data collection to identify high emitters, characterize real-world emission profiles across engine/fuel configurations, inform emissions inventories, and support fleet modernization programs. Technology pathways include:

On-Board Sensor-Based Monitoring:

- Capabilities: Continuous emission proxies (e.g., NOx sensors), on-board diagnostics (OBD)/engine data, GPS, and telematics for in-use compliance verification and operational optimization.
- Use Cases:
    - Compliance: Detect deviations from emissions controls and trigger corrective actions.
    - Geofencing & Eco-routing: Dynamically route/operate vehicles to reduce emissions in sensitive corridors and AB 617 communities.
    - Predictive maintenance: Early detection of aftertreatment degradation (e.g., SCR/DPF performance).
    - Certification support: Complement PEMS campaigns with long-duration datasets across seasons and duty cycles.

On-Route Remote Sensing:

- Capabilities: Non-intrusive measurement of NOx, CO, HC, opacity/PM proxies, and other pollutants from passing vehicles at high-throughput locations.
- Use Cases:
    - High-emitter identification for targeted outreach and enforcement.
    - Real-world emissions profiling by vehicle class, engine tech, fuel type, and age.
    - Inventory refinement and validation of policy impacts (e.g., retrofit programs, fuel transitions).
    - Program evaluation for modernization initiatives and indirect source rules.

Potential Project Categories

1. Develop and Demonstrate On-Board Sensor-Based Emissions Monitoring Methodology

   Objectives:

   a. Design and validate an end-to-end methodology integrating on-board sensors, telematics, and analytics for in-use compliance and operational emissions reduction.

   b. Align with PEMS protocols and develop correlation frameworks between sensor proxies and measured emissions.

      Scope elements:

      - Multi-fleet pilots across MD/HD duty cycles and corridors.
      - Data fusion (GPS, traffic, meteorology, load, route characteristics).
      - Geofencing rulesets and eco-routing strategies to reduce emissions in hot spots.
      - M&V plans, quality assurance/quality control (QA/QC) procedures, and privacy-preserving data governance.

2. Remote Sensing Technology for Measuring Truck Emissions

   Objectives:

   a. Deploy remote sensing at freight corridors, ports, and high-volume arterials to measure truck emissions at scale.

   b. Identify high emitters, estimate fleet distributions, and refine emissions inventories.

      Scope elements:

      - Multi-site deployments with continuous operation and standardized calibration.
      - Source attribution using license-plate/vehicle class lookups (consistent with privacy and regulatory requirements).
      - Integration with AB 617 community priorities to quantify local benefits.
      - Reporting frameworks for policy, program evaluation, and fleet engagement.

3.2.9. Health Impacts Studies

In 2020, $PM_{2.5}$ and PM_{10} peak values exceeded federal NAAQS at one or more routine monitoring stations within SCAB; PM_{10} also exceeded federal standards in the Coachella Valley. The 2022 AQMP noted that the Basin does not meet the 2012 annual $PM_{2.5}$ NAAQS, and that portions of South Coast AQMD's jurisdiction attain the 1987 PM_{10} 24-hour NAAQS after removing exceptional events.

At that time, multiple studies reported correlations between elevated ambient particulate matter and adverse health impacts across the United States and internationally. Additional, Basin-specific studies can provide updated insights—similar to past health impact studies - informing policy, prioritization, and community interventions.

To address ongoing PM and NOx emission challenges, the 2026 Plan Update may include the following study categories:

1. PM and NOx Impacts Studies
    a. Characterize ambient concentrations, hot spots, and temporal trends for $PM_{2.5}$, PM_{10}, and NOx.
    b. Evaluate source contributions (on-road, non-road, industrial, secondary formation) and meteorological influences.
    c. Assess potential exposure disparities and environmental justice implications.
2. Fenceline Monitoring
    a. Deploy fenceline monitors near industrial facilities, freight corridors, and other potential sources to capture near-source variability.
    b. Integrate continuous monitoring with targeted sampling for speciation (e.g., elemental carbon, metals, ammonia, organic fractions).
3. Health Impacts Studies
    a. Link ambient and fenceline data to health indicators (e.g., respiratory and cardiovascular outcomes), leveraging community-level datasets.
    b. Explore relationships between short-term peaks, long-term exposure, and susceptible populations, including AB 617 communities.

Potential Project Categories

1. Conduct In-Use Emission Studies for Advanced Technology Vehicle Demonstrations (including non-exhaust emissions)
2. Conduct Emission Studies on Biofuels, Alternative Fuels, and Other Related Environmental Impacts
3. Identify and Demonstrate In-Use Fleet Emission Reduction Technologies and Opportunities
4. Fenceline Monitoring and Health Impact Assessments for PM and NOx emissions

3.2.10. Technology Assessment and Transfer/Outreach

South Coast AQMD will continue to accelerate the transition to clean, ZE transportation by funding RDD&D of transformative technologies and providing incentive funding to speed fleet turnover across on-road and off-road sectors. Equally essential are technology transfer and outreach activities that bridge innovation and adoption - supporting procurement decisions, workforce readiness, and community awareness so that demonstrated technologies achieve real-world deployment at scale. Core activities include:

- Funding & Incentives: Competitive grants and incentive programs that de-risk early adoption and support deployment of LD/MD/HD vehicles, infrastructure, and enabling technologies.
- Technology Transfer & Knowledge Sharing: Co-sponsoring and hosting conferences, workshops, and technical roundtables; publishing guidance, case studies, and data summaries to inform fleets, agencies, and community stakeholders.

- Outreach & Engagement: Tailored communications and community/stakeholder outreach embedded in grant proposals and funded projects - ensuring local relevance, transparency, and feedback loops.
- Workforce Development: Training for operators, technicians, and first responders to build the skills necessary for safe, reliable operation of advanced transportation and infrastructure systems.

Potential Project Categories

1. Assess and Support Advanced Technologies, Disseminate Information, and Support Workforce Training
2. Support Implementation of Clean Fuels Incentives and Demonstration Projects

3.3. Target Funding Allocations to Core Technology Areas

Figure 13 presents the potential funding allocations of available Clean Fuels Program funds for CY 2026, based on South Coast AQMD projected program costs of $31.4 million across all potential projects. Actual CY 2026 expenditures are expected to be less than the projected total, since not all projects will materialize.

Target allocations reflect:

- A balance of technology priorities across core areas
- Technical challenges and opportunities discussed in this Plan
- Near-term vs. long-term benefits, aligned with available funding constraints

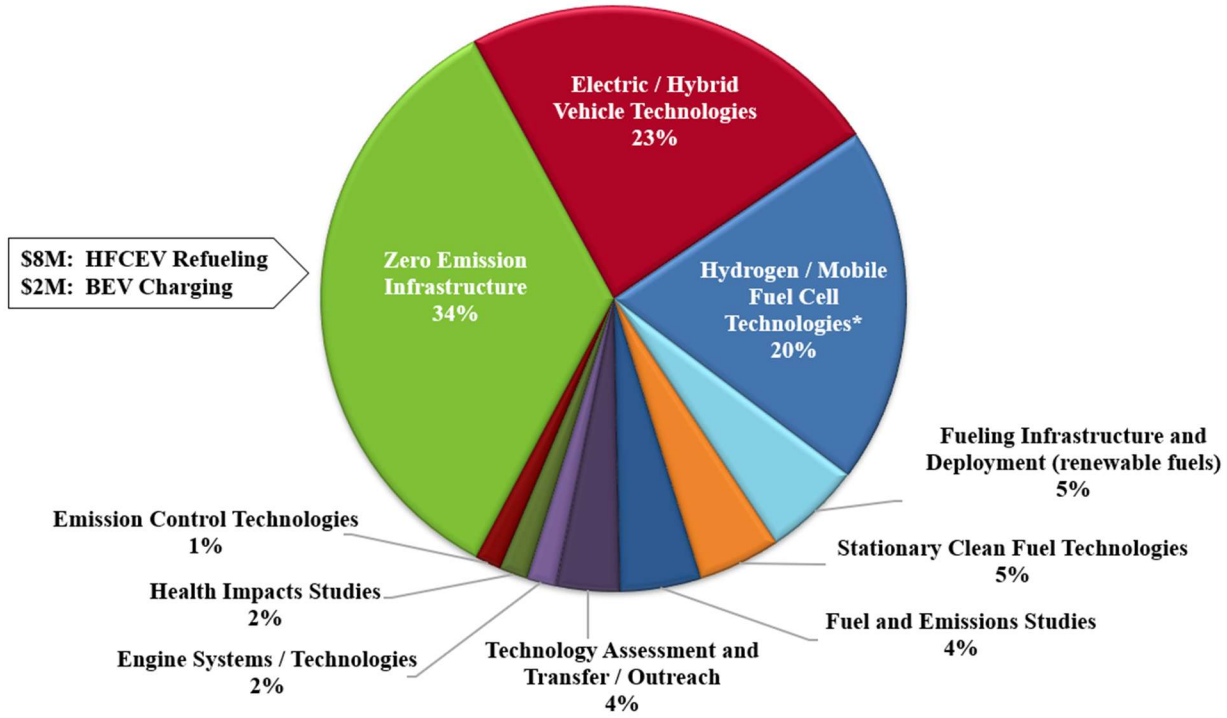
While cost-effectiveness of emission reductions is one of several factors in funding decisions, the Legislature provides flexibility to prioritize technologies with higher cost-effectiveness when necessary to help South Coast AQMD meet the NAAQS.

The 2022 AQMP calls for accelerated deployment of ZE technologies wherever feasible to achieve the 2015 8-hour ozone NAAQS. The associated CARB 2020 Mobile Source Strategy underscores the need for rapid implementation of ZE transportation.

Specific contract awards throughout 2026 will be based on:

- The proposed allocation represented in Figure 13
- The quality of proposals received
- Evaluation against standardized criteria (e.g., emissions benefits, technical merit, readiness, cost-effectiveness, equity and community impacts, leveraging potential)
- South Coast AQMD Governing Board approval

Where appropriate, Clean Fuels Program projects may utilize the MSRC discretionary fund, contingent on project types and alignment with the MSRC's annual Work Program.



* Additional Hydrogen FCE Technology projects through other grant funding sources

Figure 13: Projected Cost Distribution for Potential Clean Fuels Program Projects in 2026 ($31.4M)

3.4. Potential Projects

This section presents proposed projects for 2026, organized by program areas and described in further detail consistent with the South Coast AQMD budget, priorities, and the best available state-of-technology. Although not required, the Plan also includes projects that may be funded by other revenue sources - such as state and federal grants and incentive programs (e.g., AB 617 CAPP, Volkswagen Environmental Mitigation Trust, and Carl Moyer).

Table 6 (p. 77) summarizes potential projects and the distribution of South Coast AQMD costs in 2026. The funding allocation continues the emphasis on development and demonstration of ZE/NZE technologies, including infrastructure to support vehicles and off-road equipment.

For the 2026 Plan Update, there is a continued focus on ZE technologies, including funding for:

- Hydrogen/fuel cell technologies
- Electric/hybrid vehicle technologies
- Zero-emission infrastructure (now presented as a separate category, reflecting its growing importance and formerly included within hydrogen/fuel cell and electric/hybrid technologies)

Consistent with the shift from NZE to ZE technology, there are significant decreases in funding for RNG infrastructure and engine systems/technologies to prioritize ZE vehicles and infrastructure for future projects in 2026, including:

- HD ZE BE and FC Trucks

  Deployments for various applications, including vocational vehicles.

- ZE Infrastructure Development, Demonstration, Deployment, and Planning

  Including ACS solutions (automated charging solutions), ultra-fast, high-power charging for HD battery-electric vehicles, permanent EV charging infrastructure, and temporary backup power generation for all vehicle classifications.

- Microgrids and Low-/ZE Power Generation Demonstrations

  To support ZE infrastructure and improve site reliability and resilience.

- Fuel & Emissions Studies

  Exploring alternative fuels, identifying optimal placement of transportation technologies, and assessing gaseous and particulate emissions (e.g., tire and brake wear).

As in prior years, funding allocations align with South Coast AQMD's FY 2025–26 Goals and Priority Objectives, including supporting the development of cleaner advanced technologies. Overall, the Clean Fuels Program is designed to:

- Maintain a broad portfolio of technologies
- Complement state and federal efforts
- Maximize leveraging and synergies across technology areas

Once fully developed, each proposed project will be presented to the South Coast AQMD Governing Board for approval prior to contract initiation. This Plan Update reflects:

- Technology maturity and readiness
- Identified contractors and project teams
- Participating host sites and fleets
- Secured cost-sharing
- Other necessary factors for timely and successful implementation

Recommendations to the Governing Board will include:

- Technology descriptions and applications
- Proposed scope of work
- Capabilities of selected contractor(s)
- Expected costs and project benefits

  (as required by H&SC 40448.5.1.(a)(1))

Based on communications with all organizations specified in H&SC 40448.5.1.(a)(2) and a review of their programs, the projects proposed in this Plan do not appear to duplicate any past or present projects.

3.4.1. Funding Summary of Potential Projects

This section contains information for each of the potential projects, summarized in Table 6.

Proposed Project: Descriptive title and a designation for future reference.

Expected South Coast AQMD Cost: Estimated proposed South Coast AQMD cost-share as required by H&SC 40448.5.1.(a)(1).

Expected Total Cost: The estimated total project cost, including South Coast AQMD's cost-share and the cost-share of outside organizations, is expected to be required to complete the proposed project. This indicates how much South Coast AQMD public funds are leveraged through its cooperative efforts.

Description of Technology and Application: Brief summary of the proposed technology to be developed and demonstrated, including expected vehicles, equipment, fuels, or processes that could benefit.

Potential Air Quality Benefits: Brief discussion of expected benefits of the proposed project, including anticipated contribution towards meeting the goals of the 2022 AQMP, as required by H&SC 40448.5.1.(a)(1). In general, the most important benefits of any technology research, development and demonstration program are not necessarily realized in the near-term. Demonstration projects are generally intended to be proof-of-concept for an advanced technology in a real-world application. While emission benefits, for example, will be achieved from the demonstration, true benefits will be seen over a longer term, as a successfully demonstrated technology is eventually commercialized and implemented on a wide scale.

Table 6: Summary of Potential Projects for 2026

Proposed Project	Expected SCAQMD Cost $	Expected Total Cost $
Hydrogen/Mobile Fuel Cell Technologies		
Develop and Demonstrate Hydrogen Research to Support Innovative Technology Solutions for Fueling Fuel Cell Vehicles	200,000	900,000
Develop and Demonstrate MD and HD Fuel Cell Vehicles	6,000,000	16,050,000
Subtotal	$6,200,000	$16,950,000
Engine Systems/Technologies		
Develop and Demonstrate Advanced Gaseous- and Liquid-Fueled MD and HD Engines and Vehicle Technologies to Achieve Ultra-Low Emissions	500,000	2,000,000
Subtotal	$500,000	$2,000,000
Electric / Hybrid Vehicle Technologies		
Develop and Demonstrate MD and HD On-Road Battery Electric Vehicles and Equipment	7,250,000	106,400,000
Demonstrate Light-Duty Battery Electric Vehicles and Plug-In Hybrid Vehicles	120,000	120,000
Subtotal	$7,370,000	$106,520,000
Fueling Infrastructure and Deployment (renewable fuels)		
Demonstrate Low-Emission Engine/Generation Technology	1,000,000	2,000,000
Develop, Maintain and Expand Renewable Fuel Infrastructure	300,000	1,000,000
Demonstrate Renewable Transportation Fuel Production and Distribution Technologies	400,000	1,500,000
Subtotal	$1,700,000	$4,500,000
Zero Emission Infrastructure		
Develop and Demonstrate Hydrogen Production and Fueling Stations	8,625,000	42,198,750
Develop and Demonstrate Innovative Charging Solutions for Grid Support	1,150,000	12,297,548
Develop and Demonstrate Mobile Fast Charging Off-Grid Infrastructure	1,000,000	4,000,000
Subtotal	$10,775,000	$58,496,298
Stationary Clean Fuel Technologies		
Develop and Demonstrate Microgrids with Photovoltaic/Fuel Cell/Battery Storage/Energy Management	1,000,000	4,000,000
Develop and Demonstrate Zero or Near-Zero Emission Energy Generation Alternatives	430,000	2,000,000
Subtotal	$1,430,000	$6,000,000

Table 6: Summary of Potential Projects for 2026 (cont'd)

Proposed Project	Expected SCAQMD Cost $	Expected Total Cost $
Fuel and Emissions Studies		
Conduct In-Use Emission Studies for Advanced Technology Vehicle Demonstrations	500,000	500,000
Conduct Emission Studies on Biofuels, Alternative Fuels and Other Related Environmental Impacts	500,000	1,500,000
Identify and Demonstrate In-Use Fleet Emission Reduction Technologies and Opportunities	400,000	1,500,000
Subtotal	$1,400,000	$3,500,000
Emission Control Technologies		
Onboard Sensors for On-Road/Off-Road Vehicles	250,000	1,000,000
Integration of On-Road Technologies in Off-Road Applications	200,000	1,000,000
Subtotal	$450,000	$2,000,000
Health Impacts Studies		
Conduct Studies for Particulate Matter Impacts, Fenceline Monitoring, and Health Impacts	500,000	500,000
Subtotal	500,000	500,000
Technology Assessment and Transfer/Outreach		
Assess and Support Advanced Technologies and Disseminate Information	750,000	2,000,000
Support Implementation of Clean Fuels Incentives and Demonstration Projects	350,000	400,000
Subtotal	$1,100,000	$2,400,000
TOTALS FOR POTENTIAL PROJECTS	**$ 31,425,000**	**$202,866,298**

3.4.2. Technical Summaries of Potential Projects

3.4.2.1. Hydrogen / Mobile Fuel Cell Technologies and Infrastructure

Proposed Project: Develop and Demonstrate Hydrogen Research to Support Innovative Technology Solutions for Fueling Fuel Cell Vehicles

Expected South Coast AQMD Cost: $200,000

Expected Total Cost: $900,000

Description of Technology and Application:

California has been the lead for hydrogen infrastructure and fuel cell vehicle (FCV) deployment. This leadership has advanced a hydrogen network that is not duplicated anywhere in the U.S. and is unique worldwide for its focus on providing a retail fueling experience. In addition, the advancements have identified many lessons learned for hydrogen infrastructure development, deployment and operation. Other interested states and countries are using California's experience as a model case, making success in California paramount to enabling market acceleration and uptake in the U.S. U.S. leadership for hydrogen technologies is rooted in California, a location for implementing many DOE H2@Scale pathways, such as reducing curtailment and stranded resources, reducing petroleum use and emissions, and developing and creating jobs. The technical research capability of the national laboratories can be used to assist California in decisions and evaluations, as well as to verify solutions to problems impacting the industry. Because these challenges cannot be addressed by one agency or one laboratory, in 2018, a hydrogen research consortium was organized to combine and collaborate. Moreover, in 2022, California announced its intention to develop a renewable hydrogen hub as a part of the DOE announcement for an $8B funding opportunity to establish up to ten regional hydrogen hubs to build self-sustaining hydrogen economies of producers and infrastructure in the nation. The Governor's Office of Business and Economic Development (GO-Biz) established the ARCHES to unite critical public and private stakeholders to build the framework for a California renewable, clean hydrogen hub.

The California Hydrogen Infrastructure Research Consortium as a part of H2@Scale effort focuses on top research needs and priorities to address near-term problems and support California's continued leadership in innovative hydrogen technology solutions needed for fueling FCEVs. South Coast AQMD assisted California Hydrogen Infrastructure Research Consortium tasks through Clean Fuel program over the last couple of years. The tasks completed through the consortium included design considerations and risk analysis for HD hydrogen fueling stations, design concepts for a HD fueling performance test device, a model to evaluate the dispensing capacity of HD hydrogen stations, and review of station design concepts.

Also, South Coast AQMD past collaboration with UCD Institute of Transportation was published in 2023, California Hydrogen Analysis Project: The Future Role of Hydrogen in a Carbon-Neutral California, which evaluated the current hydrogen policies and their impact on carbon-neutral transportation by 2050 with data analysis and modeling support of current hydrogen resources. These efforts are complemented by projects undertaken and supported by the H2FCP and its members over the last few years such as the H2 Fuel Cell Electric Trucks, A Vision for Freight Movement in California – and Beyond document released in July 2021 establishing a vision for 70,000 Class 8 FC trucks supported by 200 hydrogen fueling stations by 2035, including barriers that need to be overcome, CARB's Advanced Clean Truck Regulation adopted in June 2020, and anticipated adoption of the Advanced Clean Fleets Regulation in 2022.

These efforts are complemented by projects undertaken and supported by the H2FCP and its members over the last few years such as the H2 Fuel Cell Electric Trucks, A Vision for Freight Movement in California – and Beyond document released in July 2021 establishing a vision for 70,000 Class 8 FC trucks supported by 200 hydrogen fueling stations by 2035, including barriers that need to be overcome, CARB's Advanced Clean Truck Regulation adopted in June 2020, and anticipated adoption of the Advanced Clean Fleets Regulation in 2022.This project area would enable co-funding support for additional or follow on mutually agreed technical tasks with the California Hydrogen Infrastructure Research Consortium members, the H2FCP, UCD, UCI, ARCHES, as well as other collaborative efforts that may be undertaken to advance hydrogen infrastructure technologies including the upcoming hydrogen hubs efforts.

Potential Air Quality Benefits:

The 2022 AQMP identifies the use of alternative fuels and zero emission transportation technologies as necessary to lower NOx and VOC emissions to meet federal air quality standards. One of the major advantages of FCEVs is the fact that they use hydrogen, a fuel that can be domestically produced from a variety of resources such as NG (including biogas), electricity (stationary turbine technology, solar or wind), and biomass. The technology and means to produce hydrogen fuel to support FCEVs are available but require optimization to achieve a broad market scale. The deployment of large numbers of FCEVs, which is one strategy to attain air quality goals, requires a well-planned and robust hydrogen fueling infrastructure network. These South Coast AQMD projects, with significant additional funding from other governmental and private entities, will work towards providing the necessary hydrogen production and fueling infrastructure network for our region.

Proposed Project: Develop and Demonstrate MD and HD Fuel Cell Vehicles

Expected South Coast AQMD Cost: $6,000,000

Expected Total Cost: $16,050,000

Description of Technology and Application:

This proposed project would support evaluation, including demonstrating promising FC technologies for applications using direct hydrogen with proton exchange membrane (PEM) fuel cell technology. Battery dominant FC hybrids are another potential technology that can reduce costs and enhance the performance of FCEVs.

The California ZEV Action Plan specifies actions to help deploy an increasing number of ZEVs, including MD and HD ZEVs. CARB's Advanced Clean Truck and Fleet and Innovative Clean Transit Bus Regulations will also increase the deployment of MD and HD FCVs. Fleets are useful demonstration sites because economies of scale exist in central fueling, training skilled personnel to operate and maintain FCVs, monitoring and collecting data on vehicle performance, and OEM technical and customer support. In some cases, MD and HD FCVs could leverage the growing network of hydrogen stations and provide an early base load of fuel consumption until the number of LD FCVs grows. These vehicles could include hybrid-electric vehicles powered by FCs and equipped with batteries capable of charging from the grid and even supplying power to the grid.

In 2012, the DOE awarded South Coast AQMD funds to demonstrate ZECT technologies. In 2015, the DOE awarded South Coast AQMD additional funds to develop and demonstrate additional fuel cell truck platforms and vehicles under ZECT II. Both ZECT I and ZECT II enabled the largest strides in the TRL of hybrid, BE, and FC HD trucks on the overall vehicle design and architecture. The FC drayage truck's TRL before this project was at a strong Level 4 with several proof-of-concept vehicles constructed, and it has advanced the TRL to Level 7 with ZECT II. The Clean Fuels Program cost-shared the demonstration of transit buses at OCTA which was completed in September 2021. In 2020, the U.S. EPA TAG Program awarded South Coast AQMD six FC transit buses to be deployed at SunLine Transit which were also cost-shared by the Clean Fuels Program, Subsequently, in 2022 and 2023, the U.S. EPA awarded South Coast AQMD two additional grants for development and demonstration FC trucks that will also be cost-shared by Clean Fuels Program.

This category may include projects in the following applications:

On-Road:	**Off-Road:**
• Transit Buses	• Vehicle Auxiliary Power Units
• Shuttle Buses	• Construction Equipment
• MD & HD Trucks	• Lawn and Garden Equipment
• Specificality trucks such as refuse	• Cargo Handling Equipment

Potential Air Quality Benefits:

The 2022 AQMP identifies the need to implement ZEVs. South Coast AQMD adopted fleet regulations that require public and some private fleets within SCAB to acquire alternatively fueled vehicles when making new purchases. CARB is revising the Advanced Clean Fleets for adoption in 2022 to impose 100 percent ZE vehicle fleet targets for last mile delivery, drayage and public fleets in 2035. In the future, such vehicles could be powered by ZE FCs operating on hydrogen fuel. The proposed projects have the potential to accelerate

the commercial viability of FCEVs. Expected immediate benefits include the establishment of ZE/NZE proof-of-concept vehicles in numerous applications. Over the longer term, the proposed projects could help foster wide-scale implementation of FCEVs in SCAB. The proposed projects could also lead to significant fuel economy improvements, manufacturing innovations and the creation of high-tech jobs in Southern California, besides realizing the air quality benefits projected in the AQMP as well as GHG reductions. Currently, the trucks in the ZECT II project have a targeted range of 150 miles. Future projects would include extending the range of the FCVs up to 400 miles and demonstrating improvements in the reliability and durability of powertrain and hydrogen storage systems. For FC transit buses, projects are being proposed that reduce the cost of the FC bus to less than $1 million through advanced technologies for the FC stack, higher density and lower cost batteries, and increased production volumes.

3.4.2.2. Engine Systems / Technologies

Proposed Project: Develop and Demonstrate Advanced Gaseous- and Liquid-Fueled MD and HD Engines and Vehicle Technologies to Achieve Ultra-Low Emissions

Expected South Coast AQMD Cost: $500,000

Expected Total Cost: $2,000,000

Description of Technology and Application:

The objective of this proposed project would be to support development and certification of near-commercial prototype low emission MD and HD gaseous- and liquid-fueled engine technologies, as well as integration and demonstration of these technologies in on-road vehicles. The NOx emissions target for this project area is 0.02 grams per brake horsepower hour (g/bhp-hr) or lower and the PM emissions target is below 0.01 g/bhp-hr. This effort is expected to result in several projects, including:

- demonstration of advanced engines in MD and HD vehicles and high horsepower and long haul applications;
- field demonstrations of advanced engine technologies in various fleets operating with different classes of vehicles;
- development and demonstration of ultra-low emission renewable fueled hybrid powertrain technology; and
- development and demonstration of optimized engine systems for use with low- and zero carbon alternative fuels such as hydrogen.

Anticipated fuels for these projects include but are not limited to alternative fuels (fossil fuel-based and RNG, propane, hydrogen blends, ethanol, electric and hybrid), conventional and alternative diesel fuels, ultra-low sulfur diesel, renewable diesel, dimethyl ether and gas-to-liquid fuels. There has been significantly more interest as well as a mandate requiring the use of renewable fuels across all sectors due to CARB's LCFS. Projects listed under Fuel/Emissions Studies will assess the emissions impact of renewable fuels on past and future optimized combustion technologies. Several key diesel engine development projects that have demonstrated the ability to achieve 0.02 g/bhp-hr NOx under all conditions are near the on-road truck demonstration stage. Truck integration and packaging are another critical step towards commercialization. Prototype trucks are typically placed in revenue service to collect real-world performance data as well as end user feedback for production engines. Furthermore, with the new in-use and low-load emissions requirements within the CARB and the U.S. EPA low NOx regulations, we expect these new generation of ultra-low emission engines to comply with the low emissions standard for their full useful life.

Moreover, as incentive funding shifts away as clean combustion technologies reach full commercial readiness, development of cost-effective technologies that do not rely on incentives are key to drive additional market penetration and emissions reduction. South Coast AQMD is closely monitoring low emission ICE availability and ensuring the lowest possible emissions ICEs are being deployed in our region. Due to the slow fleet turn over, the legacy 2010+ diesel fleet will remain in service well into the 2030s and beyond, especially for the high-powered applications. Thus, continued development of cost-effective low emission engine technologies is key to reduce the impact of legacy fleets in our region.

Potential Air Quality Benefits:

This project is intended to reduce HD engine particulate emissions by over 90 percent compared to current diesel technology. The key to future engine system project success are emissions, cost-effectiveness and availability of future incentives. This project is expected to lead to increased availability of low emission alternative fuel HD engines. Fleets can use the engines and vehicles emerging from this project to comply with South Coast AQMD fleet regulations and towards compliance of the 2022 AQMP control measures.

3.4.2.3. Electric / Hybrid Vehicle Technologies (including battery electric and hybrid electric trucks and container transport technologies with zero emission operations)

Proposed Project: Develop and Demonstrate MD and HD On-Road Battery Electric Vehicles and Equipment

Expected South Coast AQMD Cost: $7,250,000

Expected Total Cost: $106,400,000

Description of Technology and Application:

MD and HD vehicles only make up 5 percent of vehicles in the U.S. and drive 11 percent of all vehicle miles traveled each year and yet are responsible for more than 30 percent of all the fuel burned annually[2,3,4]. As presented in the 2022 AQMP, MD and HD vehicles are the largest source of NOx emissions in SCAB. Electric and hybrid technologies have been widely implemented in the LD sector with commercial offerings by most of the automobile manufacturers. Significant emission reductions are needed for MD and HD vehicles and off-road equipment, exacerbated by low turnover of these vehicles by fleets and high incremental costs for battery and hybrid electric vehicles and equipment compared to conventional-fueled vehicles and equipment.

Vehicle categories to be considered for potential or future demonstration and deployment projects include drayage/freight/regional haul trucks, utility trucks, last mile delivery vans, shuttle buses, transit buses, waste haulers and other municipal vehicles, construction equipment, cranes and other off-road equipment such as yard tractors, forklifts, top handlers, and rubber tired gantry (RTG) cranes. Innovations that may be considered for demonstration and deployment include advancements in the auxiliary power unit; and battery-dominant plug-in hybrid systems utilizing off-peak charging, with advanced battery technologies including alternative chemistries, design, and management systems. Alternative fuels are preferred in these projects, e.g., natural gas, especially from renewable sources, liquefied petroleum gas (LPG), hydrogen, GTL and hydrogen-natural gas blends, but conventional fuels such as gasoline, renewable diesel, or even modified biodiesel may be considered if emission benefits can be demonstrated as equivalent or superior to alternative fuels. Both new designs and retrofit technologies and related charging infrastructure will be considered.

MD and HD EV technology has seen rapid early successes as both on-road vehicles and off-road equipment are transitioning increasingly towards ZE technologies. New and emerging EV technologies including higher power charging, new battery chemistry, and specialty/vocational EV development. This category also includes battery swap technologies and well as electrified trailer technologies.

This project category will develop and demonstrate the following:

- various EVs and equipment;
- studies for anticipated costs for EVs and equipment;
- customer interest and preferences for these alternatives;

[2] https://www.bts.gov/content/number-us-aircraft-vehicles-vessels-and-other-conveyances

[3] https://www.bts.gov/content/us-vehicle-miles

[4] https://www.bts.gov/content/fuel-consumption-mode-transportation

- new innovative technology such as higher power charging, new battery technology/chemistry, electrified trailers, and battery-swap technologies;
- BE and hybrid-electric MD and HD vehicles (e.g., drayage/freight/regional haul trucks, utility trucks, delivery vans, shuttle buses, transit buses, waste haulers); and
- development and demonstration of BE off-road equipment, (e.g., BE off-road cargo handling such as yard tractors, forklifts and top-handlers, and construction equipment).

Potential Air Quality Benefits:

The 2022 AQMP identifies ZE/NZE vehicles as a key attainment strategy. Plug-in hybrid electric technologies have the potential to achieve NZE while retaining the range capabilities of conventional-fueled vehicles, a key factor expected to enhance broader consumer acceptance. Given the variety of EV systems under development, it is critical to determine actual emission reductions and performance metrics compared to conventional-fueled vehicles. Successful demonstration of optimized prototypes would promise to enhance the deployment of ZE/NZE technologies.

Expected benefits include establishing criteria for emission evaluations, performance requirements, and customer acceptability of the technology. This will help both regulatory agencies and OEMs to expedite introduction of ZE/NZE vehicles in SCAB, which is a high priority of the 2022 AQMP.

Proposed Project: Demonstrate Light-Duty Battery Electric Vehicles and Plug-In Hybrid Vehicles

Expected South Coast AQMD Cost: $120,000

Expected Total Cost: $120,000

Description of Technology and Application:

South Coast AQMD has included BEVs and PHEVs in its demonstration fleet since developing early conversion vehicles. At the headquarters, South Coast AQMD installed 94 Level 2 EV charging ports and a DC fast charger to support public and workplace charging as a means of educational outreach regarding BEV and PHEV technology. Additionally, 30 networked Level 2 fleet chargers were added through the SCE Charge Ready Fleet program in 2020. In 2025, South Coast AQMD is in the process of updating the Level 2 chargers to the latest standards.

LD BEVs and PHEVs are now widely available and continuously improving with the latest technology, safety, features, and reliability. Some OEMs have proposed vehicle-to-home concepts using BEVs as backup power solutions. As a result, the Clean Fuels Program will continue to evaluate commercially available LD PHEVs and BEVs.

Potential Air Quality Benefits:

The 2022 AQMP identifies the need to implement LD EVs. South Coast AQMD's adopted fleet regulations require public and some private fleets within SCAB to acquire alternatively fueled vehicles when making new purchases. In the future, such vehicles could be powered by BEVs. The proposed projects can potentially accelerate the commercial viability of BEVs and PHEVs. Expected immediate benefits include the deployment of ZEVs in South Coast AQMD's demonstration fleet. Over the longer term, the proposed projects could help foster wide-scale implementation of ZEVs in SCAB. The proposed projects could also lead to significant fuel economy improvements, manufacturing innovations and the creation of high-tech jobs in Southern California, besides realizing the air quality benefits projected in the 2022 AQMP.

3.4.2.4. Zero Emission Infrastructure

Proposed Project: Develop and Demonstrate Hydrogen Production and Fueling Stations

Expected South Coast AQMD Cost: $8,625,000

Expected Total Cost: $42,198,750

Description of Technology and Application:

Alternative fuels, such as hydrogen and the use of advanced technologies, such as FCEVs, are necessary to meet future clean air standards. A key element in the widespread acceptance and increased use of alternative fuel vehicles is the development of a reliable and robust infrastructure to support the fueling of vehicles, cost-effective production and distribution and clean utilization of these new fuels.

A challenge to the entry and acceptance of direct-hydrogen FCVs is the limited number and scale of hydrogen fueling and production sites. This project would support developing and demonstrating hydrogen fueling technologies with a focus on MD/HD fueling infrastructure. Proposed projects would address:

Fleet and Commercial Fueling Stations: Further expansion of the hydrogen fueling network to both on- and off-road equipment, based on retail models, providing renewable generation, adoption of standardized measurements for hydrogen fueling, other strategic fueling locations, dispensing pressures that support ZEV deployment.

Energy Stations: Multiple-use energy stations that can produce hydrogen for FCVs or stationary power generation are considered enabling technology and potentially cost-competitive with large-scale reforming. System efficiency, emissions, hydrogen throughput, hydrogen purity, and system economics will be monitored to optimize strategies for hydrogen fueling infrastructure deployment, producing power and hydrogen from renewable feedstocks (e.g., biomass, digester gas), and storing hydrogen on a larger scale.

Innovative Fueling Appliances: Home or small scale fueling/charging or portable refueling solutions are an attractive advancement for alternative clean fuels for potential applications. This project would evaluate an innovative hydrogen refueler for cost, compactness, performance, durability, emission characteristics, ease of assembly and disassembly, maintenance and operations. Other issues such as setbacks, building permits, building code compliance and UL ratings for safety would also be evaluated.

Innovative Hydrogen Production: new and innovation pathways to provide local production of renewable hydrogen. This could either align or supplement California hydrogen hub effort. The production could also include efforts such as a dedicated hydrogen pipeline similar to CNG.

CARB projections for on-road FCEVs counts are now 30,800 in 2024 and 61,000 in 2027 in California[5] and the majority of these do not include MD and HD vehicles deployed in SCAB. To meet demand, the number of hydrogen fueling infrastructures needs to be significantly increased and become more reliable in terms of uptime and supply. South Coast AQMD will seek additional funding from CEC and CARB to construct and operate hydrogen fueling stations and take advantage of funding opportunities that may arise soon with the California hydrogen hub application and others, such as the anticipated adoption of the Advanced Clean

[5] California Air Resources Board. *2021 Annual Evaluation of Fuel Cell Vehicle Deployment & Hydrogen Fuel Station Network Development* (AB 8 Report). September 2021.

Fleets Regulation. FirstElement Fuel was awarded a CEC grant to replace and expand the LD station at the South Coast AQMD Headquarters which will be cost-shared by Clean Fuel. Another technology that can assist on-road and off-road hydrogen equipment fueling is the mobile refueling. CEC also awarded Zero Emission Industries (ZEI) to develop, build, and demonstrate a first-of-its-kind liquid hydrogen bunkering and dispensing system. This novel system will capture and re-use hydrogen boil-off gas, increasing system efficiency and financial viability while allowing for flexible deployment that follows relevant land-based and marine codes and standards. This project will also be cost-shared by the Clean Fuels program.

Potential Air Quality Benefits:

The 2022 AQMP identifies using alternative clean fuels in mobile sources as a key attainment strategy. Under AQMP goals, the South Coast AQMD has several fleet rules in effect that require public and certain private fleets to purchase clean-burning alternative-fueled vehicles when adding or replacing vehicles to their vehicle fleets. The Warehouse ISR also requires certain warehouse owners and operators to comply with the rule through preapproved actions, such as by operating clean fuel vehicle technologies. FCEVs constitute some of the cleanest alternative-fuel vehicles today. Since hydrogen is a key fuel for FCEVs, this project would address some of the barriers faced by hydrogen as a fuel with a focus on MD/HD infrastructure and thus assist in accelerating its acceptance and ultimate commercialization. In addition to supporting the immediate deployment of the demonstration fleet, expanding the hydrogen fuel infrastructure should contribute to the market acceptance of FC technologies in the long run, leading to substantial reductions in NOx, VOC, CO, PM and toxic compound emissions from vehicles.

Proposed Project: Develop and Demonstrate Innovative Charging Solutions for Grid Support

Expected South Coast AQMD Cost: $1,150,000

Expected Total Cost: $12,297,548

Description of Technology and Application:

The South Coast AQMD has been involved in the development and demonstration of BEVs and has transitioned to deployment phase. Over the past few years, several OEMs have commercialized BE MD and HD models. As the number of BEVs increases, the site peak demand increases and often faces long delays in getting sufficient grid capacity. Development and demonstration of innovative charging solutions for providing prime power while the grid capacity is added as well as backup power is now in high demand. Traditional off-grid power generation using ICE generators are often not preferred and does not fit within the funding guidelines. Innovative charging solutions that combine with the advantages of renewable fuel sources could yield major benefits, potentially even lower emissions compared to traditional grid power.

This project category is to apply advanced and innovative power generation technologies to identify best fit low and ZE electric generation solution for BEV charging, and to demonstrate their viability, reliability, and durability, gauge market preparedness, evaluate costs relative to traditional grid power and ICE-based generators. The use of alternative charging solutions and generation (i.e., solar, linear generators) could support a large-scale deployment of BETs and charging infrastructure at a single fleet location where energy storage is optimized for grid reliability and to offset electricity demand charges.

South Coast AQMD is also actively pursuing development of ACS to support temporary power charging as well as providing power during grid outage events. These innovative charging solutions ranging from mobile battery packs, hydrogen FC generators, combustion of renewable fuels, as well as temporary installations of chargers via existing electrical systems, different than permanent infrastructure, which requires long term planning as well as permitting of the site and equipment, ACS systems are mobile and can often deployed quickly and falls under backup generator category for permitting, or local building department for electrical permitting. ACS technologies can also provide power for off-road equipment which also requires mobile charging.

Linear generators were introduced in 2010s and provide an alternative technology for low emission power generation applications. Unlike traditional ICEs, linear generators produce electricity by driving magnets through copper coils in a linear motion. A unique feature of linear generators is that the thermochemical reaction takes place at lower temperatures than ICE, which results in lower emissions without add-on control devices (e.g., selective catalytic reduction). Linear generators are modular in their design, rapidly dispatchable, and have the ability to run on fuels such as hydrogen, ammonia, NG, and biogas, making them a viable alternative charging solution for microgrid applications.

Similar category also includes sections of the Stationary Clean Fuel Technologies that are not directly supporting BEVs.

Potential Air Quality Benefits:

Certification of BE and hybrid EVs and engines and their integration into SCAB's transportation sector is a high priority under the 2022 AQMP. This project is expected to further efforts to develop innovative charging technologies that could aid in the deployment of MD and HD trucks, buses, off-road equipment, and other applications. Benefits will include proof of concept for new technologies, diversification of transportation fuels and lower emissions of criteria, toxic pollutants and GHG.

Proposed Project: Develop and Demonstrate Mobile Fast Charging Off-Grid Infrastructure

Expected South Coast AQMD Cost: $1,000,000

Expected Total Cost: $4,000,000

Description of Technology and Application:

There is a critical need to address gaps in EV charging infrastructure availability. Forty-one percent of the 3,916,106[6] EVs sold in the U.S. since 2010 were in California, and of those sales in California, almost half (44 percent) of Clean Vehicle Rebate Project[7] rebates issued as of July 2023 were for vehicles in the South Coast AQMD jurisdiction. In addition, the California ZEV Action Plan, which was updated in 2018, calls for 5 million ZEVs and supporting infrastructure by 2030.

There are separate challenges associated with infrastructure for LD EVs versus MD and HD EVs, which are on opposite ends of the commercialization spectrum. LD EVs and charging infrastructure have long been commercially available with an SAE J1772 connector standard for Level 1 and Level 2 charging as well as CCS1/NACS connector for public fast charging. Despite that, the availability and costs of infrastructure deployment still remain the main challenges for LD EVs.

MD and HD EVs are becoming more commercially available, with multiple OEMs supplying Class 4 through Class 8 battery electric vehicles. Standards for charging infrastructure to support MD and HD EVs have generally been with the CCS1 connector in North America, although Tesla has adopted a different connector for their semi-trucks. A separate MCS connector is under development by CharIN for Class 6 -8 EVs for charging up to 4.5 MW DC. There is also an agreed upon SAE J3068 connector standard for single-phase and three-phase AC charging. The challenges and costs of installing MD and HD charging infrastructure have exponentially increased compared to LD infrastructure. Further, innovative solutions must be explored and demonstrated for off-road mobile applications where a fixed charging solution is not yet feasible. Another emerging technology is the popularity of battery-swap trucks and its swap stations in other markets, but those are still in very early stages in the U.S.

Alongside various federal and state incentive funds for charging infrastructure, the Clean Fuels Program will continue to support:

- deployment of a network of DC fast charging infrastructure and rapidly expand the existing network of public EV charging stations including DERs;
- deployment of DC fast charging infrastructure in conjunction with energy storage and/or solar to support large scale deployments of 50 or more BETs at a single fleet location;
- charging infrastructure and innovative systems (i.e., solar or battery swap) to support MD and HD vehicle and off-road equipment demonstration and deployment projects;
- regional planning/grid studies for MD/HD charging;
- development of MD/HD charging infrastructure solutions that provide easier installation through reduced grid reliance and increased resiliency;

[6] https://www.veloz.org/ev-market-report/. Q2 2023 data uploaded on 8/2/23.

[7] https://cleanvehiclerebate.org/eng/rebate-statistics

- development of ACS solutions that provide prime power for temporary solutions charging and or mobile backup power;
- investigation of fast charging impacts on battery life;
- development of intelligent transportation system strategies for cargo containers; and
- development of freight load-balancing strategies as well as to conduct market analysis for ZE HD trucks in goods movement.

Potential Air Quality Benefits:

The 2022 AQMP identifies zero emission vehicles as a key attainment strategy. MD/HD infrastructure is currently a limiting factor to deploying BETs for many fleets. This proposed project category will reduce PM pollution along major roadways through the expansion of the public EV charging infrastructure network by allowing drivers to shift away from conventional-fueled vehicles to battery and FC EVs. In addition, this project will assist in achieving improved fuel economy and lower tailpipe emissions, further helping the region to achieve NAAQS and protect public health. Expected benefits include the establishment of criteria for emission evaluations, performance requirements and customer acceptability of the technology. This will help both regulatory agencies and OEMs to expedite introduction of ZEVs in SCAB, which is a high priority of the 2022 AQMP.

3.4.2.5. Fueling Infrastructure and Deployment (renewable fuels)

Proposed Project: Demonstrate Low-Emission Engine/Generation Technology

Expected South Coast AQMD Cost: $1,000,000

Expected Total Cost: $2,000,000

Description of Technology and Application:

Natural gas vehicles (NGVs) have been very successful in reducing emissions in SCAB due to the deployment by fleet owners and operators of HD vehicles utilizing this fuel. This technology category seeks to support the expansion of OEMs producing engines or systems certified to the lowest optional NOx standard or NZE and useable in a wide variety of MD and HD applications, including Class 6 vehicles such as school buses and in passenger and goods delivery vans, Class 7 vehicles such as transit buses, waste haulers, street sweepers, sewer-vector trucks, dump trucks, concrete mixers, commercial box trucks, Class 8 tractors used in goods movement and drayage operations, and off-road equipment such as construction vehicles and yard hostlers.

Hydrogen fueled ICEs start to gain more attention as a few major advantages exist with this technology. Comparing with the FC electric technology, hydrogen ICE can work at a lower level of fuel purity and costs significantly less upfront. It is also expected to be more reliable as it is largely based on today's engine technology. The increase in hydrogen ICE can also be a driving force for the FC application by increasing the consumption of hydrogen fuel in the transportation sector. Efforts have been made to optimize tailpipe NOx and PM emissions, while GHG emissions are nearly zero.

Potential Air Quality Benefits:

Gaseous fueled vehicles have inherently lower engine criteria pollutant emissions relative to conventionally fueled vehicles, especially older diesel-powered vehicles. The deployment of NZE vehicles would significantly further emission reductions relative to the state's current regulatory requirements. Incentivizing the development and demonstration of NZE vehicles in private and public fleets, goods movement applications, and transit buses will help reduce local emissions and emissions exposure to nearby residents. NG and hydrogen vehicles can also have lower GHG emissions, help address national energy security objectives and reduce biomass waste produced from such feedstocks. Deployment of additional NZE vehicles is consistent with the 2022 AQMP goal to reduce criteria pollutants. When fueled by RNG and renewable hydrogen, it supports California's objectives of reducing GHGs and carbon intensity of the state's transportation fuel supply, as well as the federal government's objective of increasing domestically produced alternative transportation fuels.

Proposed Project: Develop, Maintain and Expand Renewable Fuel Infrastructure

Expected South Coast AQMD Cost: $300,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

This project supports the development, maintenance and expansion of renewable fuel fueling infrastructure in strategic locations throughout SCAB, including the Ports, and advancing technologies and station design to improve fueling and fueling efficiencies of HDVs. This category supports broader deployment of NZE HD vehicles and implementation of South Coast AQMD's fleet rules. In addition, as existing NG and hydrogen fueling infrastructure begins to age or has been placed in demanding usage, components will deteriorate. This project offers facilities the opportunity to replace worn-out equipment or to upgrade existing fueling and/or garage and maintenance equipment to provide increased fueling capacity to public agencies, private fleets and school districts.

Potential Air Quality Benefits:

The 2022 AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. HD NGVs have significantly lower emissions than their diesel counterparts and represent one of the cleanest ICE-powered vehicles available today. The project has the potential to significantly reduce the installation and operating costs of NGV fueling infrastructure and improve vehicle fueling times through improved fueling system designs and high-flow nozzles. New or improved NGV infrastructure helps facilitate hydrogen refueling infrastructure. Increased exposure and fleet and consumer acceptance of renewable fuel vehicles will lead to significant and direct reductions in NOx, VOC, CO, PM and toxic compound mobile source emissions. Such increased penetration of NGVs and other renewable fuel vehicles will provide direct emission reductions of NOx, VOC, CO, PM and air toxic compounds throughout SCAB.

Proposed Project: Demonstrate Renewable Transportation Fuel Production and Distribution Technologies

Expected South Coast AQMD Cost: $400,000

Expected Total Cost: $1,500,000

Description of Technology and Application:

The transportation sector represents a significant source of criteria pollution in SCAB. Clean, alternative fuel-powered transportation is a necessary component for this region to meet NAAQS. Alternative fuels produced from renewable sources such as waste biomass help further efforts associated with landfill and waste diversion, GHG reduction, energy diversity and petroleum dependency. Locally produced renewable fuels further reduce concerns associated with out-of-state production and transmission of fuel and help support the local economy. Renewable fuels recognized as a transportation fuel under the state's LCFS program and the federal government's Renewable Fuel Standard program can provide financial incentives, including reduced fuel price and operational costs, which act as incentives to purchase and deploy alternative or renewable energy powered vehicles.

This project category will consider development and demonstration of technologies for the production and use of renewable transportation fuels such as RNG, renewable diesel, and renewable hydrogen. These renewable fuels can be converted from various waste biomass feed stocks, including municipal solid wastes, green waste, and biosolids produced at wastewater treatment facilities generated from anaerobic digestion, gasification, and pyrolysis. Transport of fuels can include mobile refueling but also dedicated pipeline for long distance and high-volume transport. For example, at POLA, a mobile hydrogen refueler is currently being demonstrated. This mobile refueler is powered by a hydrogen fueled FC truck and has the capability of hauling 247 kg of hydrogen. The purpose of this mobile hydrogen refueler is to provide hydrogen fuel to support ZE equipment operating at the port.

The main objectives of this project are to investigate, develop and demonstrate:

- commercially viable methods for converting renewable feed stocks into CNG, liquefied natural gas (LNG), hydrogen or diesel (e.g., production from biomass);
- economic small-scale NG and hydrogen liquefaction technologies;
- utilization of various feed stocks locally available;
- commercialize incentives for fleets to site, install and use renewable refueling facilities; and
- pipeline interconnection in the local gas grid to supply users.

Potential Air Quality Benefits:

The 2022 AQMP relies on a significant increase in the penetration of ZE/NZE vehicles in SCAB to attain the NAAQS by 2037. This project would help develop renewable transportation fuel production and distribution facilities to improve local production and use of renewable fuels to help reduce transportation costs and losses as well as reduce total operating costs of ZE/NZE vehicles to be competitive with comparable diesel fueled vehicles. Such advances in production and use are expected to lead to greater infrastructure development. Additionally, this project could support the state's goal of redirecting biomass waste for local fuel production and reduce GHGs associated with these waste biomass feedstocks.

3.4.2.6. Stationary Clean Fuel Technologies (including microgrids and renewables)

Proposed Project: Develop and Demonstrate Microgrids with Photovoltaic/Fuel Cell/Battery Storage Energy Management

Expected South Coast AQMD Cost: $1,000,000

Expected Total Cost: $4,000,000

Description of Technology and Application:

Large deployments of ZE Class 8 BETs each carrying 300+ kWh of battery-stored energy or fuel cell trucks (FCTs) carrying 30-50 kg of hydrogen will require costly infrastructure that creates a barrier for some fleets to adopt ZE technologies. Many fleet operators lease their facilities, making it impossible to recoup the capital expenditure of EV or hydrogen infrastructure in a short period. To comply with existing and upcoming regulatory requirements, fleets must navigate challenges installing and maintaining charging and/or fueling infrastructure. Microgrids can be instrumental in meeting the challenge of cost-effectively providing large amounts of energy for EV charging or hydrogen generation to support ZEV charging and fueling. Additionally, suppose the microgrid equipment is owned by a third party and energy is sold to the fleet through a power purchase agreement. In that case, the financial challenge of large capital investment can be avoided by the fleets.

A microgrid is a group of interconnected loads and DERs within clearly defined electrical boundaries that act as a single controllable entity concerning the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected and island-mode. Microgrids can work synergistically with the utility grid to provide power for ZEV fueling by managing when energy from the grid is used during off-peak hours when it is the least expensive. Then during peak demand periods, the microgrid would use energy from battery storage or onsite generation. Most technologies that make up microgrids include photovoltaic, FCs, battery storage, along with hardware and software for the energy management system (EMS). When grid service is interrupted, the microgrid can disconnect from and continue to operate as an energy island independent from the grid. Ensuring an uninterrupted power source is an important consideration for fleets. If the microgrid is connected to the fleet's logistics and telematics systems, additional benefits in infrastructure cost and battery life for BETs can be realized. If the EMS is fed information on the route a truck is planning to travel, it can charge the vehicle with enough energy for the trip so the truck will operate within the desired 20-80 percent SOC of the battery having the least amount of impact to battery life. Additionally, if the EMS is connected to the logistics system, it can plan charging schedules with 150 kW or lower power chargers which will have less impact on battery life than 350+ kW chargers and lower charging costs.

Electricity demand for electric and FC HD trucks is substantial. For a 100-vehicle fleet of BETs with 300 kWh batteries, 30 MW hours/day of electricity would be required to charge these BETs. The hydrogen requirement for a 100-vehicle fleet of FCTs is 2,000 kg/day. Microgrids can provide energy for EV and hydrogen infrastructure to enable large ZEV deployments and make charging and fueling economical and reliable.

Several pilot projects are being discussed with microgrid developers and fleets that involve various configurations of microgrid technologies and different business models. Proposed projects would include development and demonstration of microgrids utilizing various types of renewable and zero and or low

emitting onsite generation (fuel cell tri-generation, power to gas, photovoltaic, wind), energy storage, connectivity to logistics systems, V2G and V2B technologies. Projects demonstrating different business models will be considered, such as projects involving a separate entity owning some or all the microgrid equipment and engaging in a power purchase agreement to provide energy to fleets transitioning to ZETs. Proposed projects would partner with truck OEMs and their major customers, such as large- and medium-sized fleets looking at microgrid solutions for their operations in SCAB.

Potential Air Quality Benefits:

Microgrids can provide grid resilience and potentially support large deployments of ZE MD and HD trucks that are necessary to meet the AQMP target of 83 percent NOx emission reductions from the 2018 level and 67 percent additional reductions in 2037 beyond already adopted regulations and programs by 2037. Both renewable and zero emitting power generation technologies that make up a microgrid can provide a well-to-wheel ZE pathway for transporting goods. Projects could potentially reduce a significant class of NOx and CO emissions over the assumptions in the 2022 AQMP and further enhance South Coast AQMD's ability to enforce full-time compliance.

Proposed Project: Develop and Demonstrate Zero or Near-Zero-Emission Energy Generation Alternatives

Expected South Coast AQMD Cost: $430,000

Expected Total Cost: $2,000,000

Description of Technology and Application:

This project aims to support the development and demonstration of clean energy and renewable alternatives in stationary applications. The technologies to be considered include thermal, photovoltaic and other solar energy technologies; wind energy systems; energy storage potentially including V2G or V2B functionalities for alternative energy storage; biomass conversion; and other renewable energy and recycling technologies. Innovative solar technologies, such as solar thermal air conditioning and photovoltaic-integrated roof shingles, are particularly interesting. Also, in the agricultural sections of SCAB, wind technologies could potentially be applied to drive large electric motor-driven pumps to replace highly polluting diesel pumps. Besides renewable technologies, electrolyzer technology could be used to generate hydrogen as a clean fuel. Hydrogen, when used in ICEs, can potentially reduce tail-pipe emissions of NOx, while emissions in fuel cells are reduced to zero.

This project is expected to result in pilot-scale ZE/NZE energy production demonstrations, scale-up process design and cost analysis, overall environmental impact analysis and projections for ultimate clean fuel costs and availability. This project is expected to result in several projects addressing technological advancements in these technologies that may improve performance and efficiency, potentially reduce capital and operating costs, enhance the quality of RNG generated from renewable sources for injection into NG pipelines, improve reliability and identify markets that could expedite implementation of successful technologies. One example of near-zero technology is the linear generator. This technology was introduced in 2019 and unlike traditional internal combustion engines, linear generators produce electricity by driving magnets through copper coils in a linear motion. This reaction takes place at much lower temperatures than ICEs, which result in lower emissions without the need for add-on emission control devices such as catalysts. In addition, linear generators are fuel agnostic and can switch between fuels like hydrogen, NG, ammonia, and biogas.

Potential Air Quality Benefits:

The 2022 AQMP identifies that the development and implementation of non-polluting power generation could gain maximum air quality benefits. Polluting fossil fuel-fired electric power generation needs to be replaced with clean, renewable energy resources or other advanced ZE technologies, such as hydrogen FCs, particularly in a distributed generation context to help provide grid resiliency as the transportation sector becomes more reliant on electricity.

This project is expected to accelerate implementation of advanced ZE/NZE energy sources. Expected benefits include directly reducing emissions by displacement of fossil generation; proof-of-concept and potential viability for ZE power generation systems; increased exposure and user acceptance of the new technology; reduced fossil fuel usage; and potential for increased use, once successfully demonstrated, with resulting emission benefits, through expedited implementation. These technologies would also have a substantial influence on reducing GHG emissions.

3.4.2.7. Fuel and Emissions Studies

Proposed Project: Conduct In-Use Emission Studies for Advanced Technology Vehicle Demonstrations that include non-exhaust emissions

Expected South Coast AQMD Cost: $500,000

Expected Total Cost: $500,000

Description of Technology and Application:

Hybrid electric, plug-in electric hybrid and BE and FC EVs will all play a role in the future of transportation. Each of these transportation technologies have attributes that could provide unique benefits to different transportation sectors. Identifying optimal placement of each transportation technology will provide the co-benefits of maximizing environmental benefits and return on investment.

As the new CARB and U.S. EPA low-NOx regulations focus on addressing the gap between in-use and certification values, staff expects the in-use emissions from new engines to perform closer to certification values, but there are still a significant population of the diesel legacy fleet expected to remain in service well into the 2030s. There is always a need to better assess real world truck emissions, fuel economy, and activity from engines, hybrid powertrains and zero carbon combustion technologies for continued technology improvements and verification of emission reductions.

This project would review and potentially coordinate application specific drive cycles for specific applications. Potential emission reductions and fossil fuel displacement for each technology in a specific application would be quantified on a full-cycle basis. This information could be used to develop a theoretical database of potential environmental benefits of different transportation technologies when deployed in specific applications. This duty-cycle requirement, often based on traditional vehicles, is used for planning purposes for building MD and HD public ZEV fueling stations, similar to the approaches provided for NLR's fleet DNA database. Furthermore, the creation and standardization of test cycles, like the chassis dyno-based cycle, can be used to evaluate efficiency of ZEVs and direct comparisons with baseline ICE vehicles.

Another project would be characterization of intermediate volatility organic compound (IVOC) emissions, which is critical in assessing ozone and SOA precursor production rates. Diesel vehicle exhaust and unburned diesel fuel are major sources and contribute to formation of urban ozone and SOA, which is an important component of PM2.5. NGVs are also a concern due to lack of particulate filters, however the actual impact based on current and projected vehicle populations needs to be further studied. Another emerging PM emissions of interest non-tailpipe emissions from brake and tire wear. CARB estimates PM from non-tailpipe sources already exceeded traditional sources and increases with VMT. CARB has introduced a series of projects to assess the emission factor for brake- and tire-wear emissions. South Coast AQMD also expects new fuels and emission studies projects to support the research needed for MATES VI study.

Potential Air Quality Benefits:

Development of an emissions reduction database for various application specific transportation technologies would assist in targeted deployment of new transportation technologies. This database coupled with application specific vehicle miles traveled and population data would assist in intelligently deploying advanced technology vehicles to attain the maximum environmental benefit. These two data streams would allow vehicle technologies to be matched to an application that is best suited to the specific technology, as

well as selecting applications that are substantial enough to provide significant environmental benefits. Demonstration of a quantifiable reduction in operating cost through intelligent deployment of vehicles will also accelerate commercial adoption of various technologies. Accelerated adoption of lower emitting vehicles will further assist goals in the 2022 AQMP.

Proposed Project: Conduct Emission Studies on Biofuels, Alternative Fuels and Other Related Environmental Impacts

Expected South Coast AQMD Cost: $500,000

Expected Total Cost: $1,500,000

Description of Technology and Application:

The use of renewable fuels such as biofuels can be an important strategy to reduce petroleum dependency, air pollution and GHG emissions and help with California's aggressive GHG reduction goals. Biofuels are receiving increased attention due to national support and state activities resulting from SB 32, AB 1007 and the LCFS. With an anticipated increase in renewable fuel use, it is the objective of this project to further analyze these fuels to better understand their benefits and impacts not only on GHGs but also air pollution and associated health effects.

In various diesel engine studies, replacement of petroleum diesel fuel with renewable fuel has demonstrated reduced PM, CO and air toxics emissions. Renewable fuel also has the potential to reduce GHG emissions if made from renewable feedstocks such as soy and canola. However, certain blends of biodiesel can increase NOx emissions for some engines and duty cycles, which exacerbates ozone and PM2.5 challenges faced in SCAB. In addition, despite recent advancements in toxicological research in the air pollution field, the relationship between biodiesel particle composition and associated health effects is still not completely understood.

Ethanol is another biofuel that is gaining increased national media and state regulatory attention. CARB's reformulated gasoline regulation increases ethanol content to 10 percent as a means to increase the number of renewable fuels in the state. Ethanol has been demonstrated in various emission studies to reduce PM, CO and toxic emissions. South Coast AQMD also has been monitoring efforts in using ethanol as a primary fuel for MD and HD applications in optimized engine systems that allows both criteria and GHG reductions which could be another pathway for reducing emissions due to abundance of ethanol from the LD sector.

CARB adopted a regulation on commercialization of alternative diesel fuels, including biodiesel and renewable diesel, while noting that biodiesel in older HD vehicles can increase NOx. The need for emerging alternative diesel fuels for HD trucks and transit buses is also being studied. Researchers have proposed evaluating the emissions impact of RNG and other NG blends such as renewable hydrogen or pure hydrogen.

To address these concerns on potential health effects associated with alternative fuels and fuel blends, this project will investigate physical and chemical composition and associated health effects of tailpipe PM emissions from LD to HD vehicles burning biofuels to ensure public health is not adversely impacted by broader use of these fuels. This project also supports future studies to identify mitigation measures to reduce NOx emissions from biofuels. Additionally, a study of well-to-wheel emissions from for the extraction and use of shale gas might be considered.

The Power-to-Gas concept as well as demand for additional green hydrogen supply has renewed interest in hydrogen-fossil fuel blends as well as pure hydrogen for use in both ICE and other combustion sources. Hydrogen fueled ICEs were studied heavily in the early 2000s and results have shown significant possible criteria emission reductions with optimized engine calibration though any new hydrogen ICE will need to comply to the latest emission standard.

To evaluate contribution of meteorological factors to high ozone and PM2.5 episodes occurring in SCAB, mainly as a result of higher summer temperatures and increased air stagnation following droughts, a comprehensive study is necessary to evaluate trends of meteorological factors that may adversely impact air quality in SCAB to support efforts such as the MATES VI. The study will assist in better understanding potential impact of recent weather trends on criteria pollutant emissions and developing more effective strategies for improving air quality in the future.

Potential Air Quality Benefits:

If renewable diesel, biodiesel and biodiesel blends can be demonstrated to reduce air pollutant emissions with the ability to mitigate NOx impacts, this technology will become a viable strategy in meeting air pollutant standards as well as the goals of SB 32 and the LCFS. The use of biodiesel is an important effort for a sustainable energy future. Emission studies are critical to understanding emission benefits and any tradeoffs (NOx impacts) that may result from using this alternative fuel. With reliable information on the emissions from using biodiesel and biodiesel blends, this can ensure the use of biodiesel without creating additional NOx emissions. Additionally, understanding meteorological factors on criteria pollutant emissions may help identify mitigation strategies, possibly through targeted advanced transportation deployment.

Proposed Project: Identify and Demonstrate In-Use Fleet Emission Reduction Technologies and Opportunities

Expected South Coast AQMD Cost: $400,000

Expected Total Cost: $1,500,000

Description of Technology and Application:

New technologies, such as alternative fueled HD engines, are extremely effective at reducing emissions because they are designed to meet the most stringent emissions standards while maintaining vehicle performance. In addition, many new vehicles are now equipped with telematics enabling motorists to obtain transportation information such as road conditions to avoid excessive idling and track information about vehicle maintenance needs, repair history, tire pressure and fuel economy. Telematics have been shown to reduce emissions from new vehicles through various vehicle usage optimization strategies. Unfortunately, many in-use fleets lack telematic systems, particularly HD engines in trucks, buses, construction equipment, locomotives, commercial harbor craft and CHE, and have fairly long working lifetimes (up to 20 years due to remanufacturing in some cases). Even LD vehicles routinely have lifetimes exceeding 200,000 miles and 10 years. The in-use fleets, especially the oldest vehicles, are responsible for the majority of emissions. In the last few years, real-time emissions and fuel economy data reporting along with telematics has been demonstrated with large fleets as fleet management tools to identify high emitters and increase operational efficiency. Similar efforts have already been proposed by CARB as part of the Heavy-Duty Inspection and Maintenance (HD I/M) regulation. Moreover, the same telematic systems are being installed on ZETs where fleet and charging management are important. Cloud-based fleet management concepts are being proposed by researchers to maximize range and air quality benefits of ZETs.

This project category is to investigate near-term emission control technologies that can be cost-effectively applied to reduce emissions from the in-use fleet. The first part of the project is to identify and conduct proof-of-concept demonstrations of feasible candidate technologies, such as:

- remote sensing for HD vehicles including license plate recognition systems;
- annual testing or for high mileage vehicles (>100,000 miles);
- replace or upgrade emission control systems at 100,000-mile intervals;
- on-board emission diagnostics with remote notification;
- low-cost test equipment for monitoring and identifying high emitters;
- intelligent transportation system such as fleet management tools, dashboards and localized traffic policies;
- electrical auxiliary power unit replacements;
- development, deployment and demonstration of smart vehicle telematic systems;
- fleet and charger management concepts; and
- low-cost emissions sensor development.

Potential Air Quality Benefits:

Many of the technologies identified can be applied to LD and HD vehicles to identify and subsequently remedy high-emitting vehicles in the current fleet inventory. Estimates suggest that 5 percent of existing fleets account for up to 80 percent of the emissions. Identification of higher emitting vehicles would assist

with demand-side strategies, where higher emitting vehicles have correspondingly higher registration charges. Identification and replacement of high-emitting vehicles have been identified in the CERPs from multiple AB 617 communities as a high priority for residents living in these communities, particularly as HD trucks frequently travel on residential streets to bypass traffic on freeways surrounding these overburdened communities.

3.4.2.8. Emission Control Technologies

Proposed Project: Onboard Sensors for On-Road/Off-Road Vehicles

Expected South Coast AQMD Cost: $250,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

New HD on-road vehicles represent one of the largest categories in the NOx emissions inventory in SCAB. The 2022 AQMP identifies that 83 percent NOx emission reductions from the 2018 level and 67 percent additional reductions beyond already adopted regulations and programs are necessary to meet the 2015 8-hour ozone standard by 2037. Previous in-use emission studies, including studies funded by the South Coast AQMD, have shown significantly higher NOx emissions from on-road HD vehicles than the certification limit under certain in-use operations, such as low power duty cycles. In CARB's adopted HD On-Road "Omnibus" Low NOx regulation, in addition to the lower certification values, there is a low load test cycle and revisions to the not-to-exceed compliance tests. NOx sensor data reporting is also introduced where the vehicle computer is required to store a past period of emissions data to ensure real-world emission reductions are realized over various duty cycles, especially those low power duty cycles in urban areas. An alternative proposed new methodology is to continuously measure real-time emissions from trucks with onboard sensors. Both industry, government and regulators are looking to use sensors to better monitor emissions compliance and leverage the real-time data from sensors to enable advances concepts such as geofencing. CARB's newly adopted HD I/M rules address in-use emissions from the older legacy fleets and also has onboard sensors as one of the emission testing methods.

This project category is to investigate near term and long-term benefits from onboard sensors to understand in-use emissions better and reduce emissions from the advanced management concept. Potential projects are to identify and conduct proof-of-concept demonstrations of feasible candidate technologies, such as:

- laboratory evaluation/verification of new and baseline sensors;
- development and evaluation of next generation sensors, including real-time on-route remote testing;
- development of algorithms to extract sensor information into a mass-based metric;
- demonstrate feasibility to monitor emissions compliance using sensors;
- identify low-cost option for cost and benefit analysis;
- demonstrate sensors on NG and other mobile sources such as LD, off-highway and commercial harbor craft; and
- development, deployment and demonstration of smart energy/emissions management systems.

Potential Air Quality Benefits:

The proposed research projects will assist the trucking industry to monitor emissions, using sensors as one of the design platform options and identify freight routes which result in lower emissions. Reduction of NOx and PM emissions from mobile sources is imperative for SCAB to achieve NAAQS and protect public health.

Proposed Project: Integration of On-Road Technologies in Off-Road Applications

Expected South Coast AQMD Cost: $200,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

On-road HD engines have demonstrated progress in meeting increasingly stringent federal and state requirements. New HD engines have progressed from 2 g/bhp-hr NOx in 2004 to 0.2 g/bhp-hr NOx in 2010, which is an order of magnitude decrease in just six years. Off-road engines, however, have considerably higher emissions limits depending on engine size. For example, Tier 3 standards for HD engines require only 3 g/bhp-hr NOx. There are apparent opportunities to implement cleaner on-road technologies in off-road applications. There is also an opportunity to replace existing engines in both on-road and off-road applications with the cleanest available technology. Current regulations don't usually require repowering (engine replacement) or remanufacturing to meet cleaner emission standards as engines are retired. Unfortunately, this does not take advantage of recently developed clean technologies.

Exhaust gas cleanup strategies, such as EGR, SCR, DPF, electrostatic precipitators, baghouses and scrubbers, have been used successfully for many years on stationary sources. The exhaust from the combustion source is routed to the cleaning technology, which typically requires a large footprint for implementation. This large footprint has made installation of such technologies on some mobile sources prohibitive. However, in cases where the mobile source is required to idle for long periods of time, it may be more effective to route emissions from the mobile source to a stationary device to clean the exhaust stream.

Projects in this category will include utilizing proven clean technologies in novel applications, such as:

- demonstrating certified LNG and CNG on-road engines as well as other clean alternative fuels such as hydrogen in off-road applications including yard hostlers, locomotives, commercial harbor craft, gantry cranes, waste haulers and construction equipment;
- implementing lower emission engines requirement in repower applications for both on-road and off-road applications; and
- applying stationary best available control technologies, such as EGR, SCR, scrubbers, DPF, baghouses and electrostatic precipitators, to appropriate on- and off-road applications, such as idling locomotives, commercial harbor craft at dock and HD line-haul trucks at weigh stations.

Potential Air Quality Benefits:

Transfer of mature emission control technologies, such as certified engines and SCR, to the off-road and retrofit sectors offers high potential for immediate emission reductions. Further development and demonstration of these technologies will assist in regulatory efforts which could require such technologies and retrofits.

3.4.2.9. Health Impacts Studies

Proposed Project: Conduct Studies for Particulate Matter Impacts, Fenceline Monitoring, and Health Impacts

Expected South Coast AQMD Cost: $500,000

Expected Total Cost: $500,000

Description of Technology and Application:

Reducing diesel exhaust from vehicles has become a high priority in SCAB since CARB identified the particulate phase of diesel exhaust as a surrogate for all toxic air contaminants emitted from diesel exhaust. Additionally, health studies indicate that ultrafine particulate matter (UPM) may be more toxic on a per-mass basis than other fractions. Several control technologies have been introduced and others are under development. Recent studies have shown that control technologies applied to mobile sources have been effective in reducing the mass of particulates emitted. However, there is also evidence that UPM on and near roadways has increased, even while the mass of particulates has decreased. To have a better understanding of changes in ultrafine particulate emissions from the application of new technologies and health effects of these emissions, an evaluation and comparison of UPM and potential impacts on community exposure, particularly in overburdened communities, is needed. In this project, measurements and chemical composition of UPM will be done, as well as studies conducted from HD vehicles to measure, evaluate and compare UPM, polycyclic aromatic hydrocarbon (PAH) and other relevant toxic emissions from different types of fuels such as gasoline, CNG, low-sulfur diesel, biofuels and others. This project needs to be closely coordinated with development of technologies for alternative fuels, aftertreatment technologies, and new engine development to determine health benefits of such technologies.

In addition to UPM, facilities, buildings, structures, or highways which attract mobile sources of pollution are considered "indirect" sources. Ambient and saturation air monitoring near sources such as ports, airports, rail yards, freight/logistics distribution centers and freeways is important to identify emissions exposure to surrounding communities and provide data to assess health impacts. This could include the study of indirect sources such as warehouses which are impacted by South Coast AQMD's Indirect Source Regulations. This project category would identify areas of interest and conduct ambient air monitoring, emissions monitoring, analyze data and assess potential health impacts from mobile sources. These projects would need to be at least one year in duration to properly assess air quality impacts in surrounding communities.

Lastly, previous studies of ambient levels of toxic air contaminants, such as the MATES studies, have found that diesel exhaust is the major contributor to health risk from air toxics. Analyses of DPM in ambient samples have been based on measurements of elemental carbon. While the bulk of particulate elemental carbon in SCAB is thought to be from combustion of diesel fuels, it is not a unique tracer for diesel exhaust. This project category would also include other related factors, such as toxicity assessment based on age, source (HD, LD engines) and composition (semi-volatile or non-volatile fractions) to better understand health effects and potential community exposure, particularly in overburdened communities. Additionally, early identification of new health issues could be of considerable value and could be undertaken in this project category.

Potential Air Quality Benefits:

The 2022 AQMP for SCAB relies on significant penetration of low emission vehicles to attain federal clean air standards. Reduction of PM emissions from combustion of diesel and other fuels is a major priority in achieving these standards. This project would help to better understand the nature and number of UPM generated by different types of fuels and advanced control technologies as well as provide information on potential health effects of UPM. Such an understanding is important to assess the emission reduction potentials and health benefits of these technologies. In turn, this will have a direct effect on the policy and regulatory actions for commercial implementation of alternative fuel vehicles in SCAB. The proposed monitoring project will assist in evaluation of adverse public health impacts associated with mobile sources. The information will be useful in (a) determining whether indirect sources have a relatively higher impact on residents living in close proximity, particularly in overburdened communities; and (b) providing guidance to develop some area-specific control strategies in the future should it be necessary. The results of the health impact study will provide a more robust, scientifically sound estimate of ambient levels of DPM as well as levels of PM from other significant combustion sources, including gasoline and diesel generated VOCs. This will allow a better estimation of potential exposure and health effects from toxic air contaminants from diesel exhaust in SCAB. This information in turn can be used to determine health benefits of promoting clean fuel technologies.

3.4.2.10. Technology Assessment and Transfer/Outreach

Proposed Project: Assess and Support Advanced Technologies and Disseminate Information

Expected South Coast AQMD Cost: $750,000

Expected Total Cost: $2,000,000

Description of Project:

This project supports assessment of clean fuels and advanced technologies, progress towards commercialization and dissemination of information on demonstrated technologies. The objective of this project is to expedite transfer of technology developed from TAO projects to the public domain, industry, regulatory agencies and the scientific community. This project is a fundamental element in South Coast AQMD's outreach efforts by coordinating activities with other organizations to expedite implementation of advanced engines and clean fuels technologies.

This project may include the following:

- technical review and assessment of technologies, projects and proposals;
- support for ACS and ZE charging and fueling infrastructure;
- advanced technology curriculum development, mentoring and outreach to local schools;
- emission studies and assessments of ZE/NZE alternatives;
- preparation of reports, presentations at conferences for technical and non-technical audiences, meeting funding agency/grant requirements and improving public relations by conducting public outreach on successful clean technology demonstration and deployment projects;
- participation in and coordination of workshops and various meetings;
- support for training programs related to fleet operation, maintenance and fueling of alternative fuel vehicles and equipment;
- publication of technical papers as well as reports and bulletins; and
- dissemination of information, including website development and updates.

These objectives will be achieved by consulting with industry, scientific, health, medical and regulatory experts and co-sponsoring related conferences and organizations, resulting in multiple contracts. In addition, an ongoing outreach campaign will be conducted to encourage decision-makers to voluntarily switch to alternatively fueled vehicles and train operators to purchase, operate and maintain these vehicles/equipment and associated infrastructure.

Potential Air Quality Benefits:

As the Clean Fuels Program transitions increasingly to ZE vehicle, equipment and infrastructure technologies, there will continue to be challenges in assisting fleets and others to successfully make this transition. The benefits of highlighting challenges, lessons learned, and success stories in the use of ZE/NZE vehicles, equipment and infrastructure can expedite acceptance and commercialization of these technologies. In addition, projects that support workforce training and professional development will prepare and train the next generation of engineers and technicians to handle the increased demand of EVs. The emission reduction benefits will contribute to the goals of the 2022 AQMP.

Proposed Project: Support Implementation of Clean Fuels Incentives and Demonstration Projects

Expected South Coast AQMD Cost: $350,000

Expected Total Cost: $400,000

Description of Project:

This project supports implementation of incentive programs, including state and federal grant programs, Carl Moyer, Prop 1B, VW, VIP, CAPP, lower emission school bus, Replace Your Ride, and South Coast AQMD residential EV charger rebate program. Implementation support includes application review, funds allocation, equipment owner reports collection, documentation to CARB, verification of vehicle operation, and other support as needed. Information dissemination is critical to successfully implementing coordinated and comprehensive incentive programs. Outreach will be directed to vehicle OEMs, dealers, individuals and fleets.

Potential Air Quality Benefits:

South Coast AQMD will provide matching funds to implement several key incentive programs to reduce emissions in SCAB. The benefit of highlighting ZE vehicle, equipment and infrastructure incentives is to expedite acceptance and commercialization of advanced technologies. Future emission reduction benefits will contribute to the goals of the 2022 AQMP. Carl Moyer, Prop 1B, VW, VIP, CAPP, and lower emission school bus incentive programs can reduce large amounts of NOx and PM emissions, and toxic air contaminants in SCAB.

Appendix A

South Coast AQMD Advisory Groups

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Technology Advancement Advisory Group[1]

Dr. Aaron Katzenstein, Chair	South Coast AQMD
Rosalie Barcinas	Southern California Edison
*Julie Burbridge	California Energy Commission
*Jessie Denver	Governor's Office of Business and Economic Development
Dr. Michael Kleinman	University of California Irvine
*Paul Lin	Southern California Gas Company
Dr. Matt Miyasato	Independent Consultant
George Payba	Los Angeles Department of Water and Power
David Pettit	Natural Resources Defense Council
Dr. Leela Rao	Port of Long Beach
Dr. Bill Robertson	California Air Resources Board
Dr. Laura Verduzco	Chevron Corporation
Sam Wilson	Union of Concerned Scientists

*Newly appointed member

[1] Members as of February 20, 2026

SB 98 Clean Fuels Advisory Group[2]

Dr. Aaron Katzenstein, Chair	South Coast AQMD
Marcus Alexander	Electric Power Research Institute
Keith Brandis	Volvo Group
*Matthew Forrest	Daimler Truck North America
Dr. Mridul Gautam	West Virginia University, Adjunct Professor, & University of Nevada-Reno
Vacant	*TBD from scientific, academic, entrepreneurial, environmental, and public health communities*
Dr. Petros Ioannou	University of Southern California Center for Advanced Transportation Technologies
Yassamin Kavezade	California Building Decarbonization Coalition
Dr. Wayne Miller	University of California, Riverside, College of Engineering, Center for Environmental Research and Technology
David Park	Hydrogen Fuel Cell Partnership
Dr. Scott Samuelsen	University of California, Irvine, Combustion Laboratory/National Fuel Cell Research Center
Tom Swenson	Cummins, Inc.
Dr. John Wall	Independent Consultant
Vacant	*TBD from scientific, academic, entrepreneurial, environmental, and public health communities*

*Newly appointed member

[2] Members as of March 6, 2026

Appendix B

Open Clean Fuels Contracts as of January 1, 2026

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Contract	Contractor	Project Title	Start Term	End Term	South Coast AQMD $	Project Total $
Electric / Hybrid Electric Technologies and Infrastructure						
18287	Evgo Services LLC	Charging Station and Premises Agreement for Installation of One DCFC at SCAQMD Headquarters	06/27/18	06/26/28	0	0
20296	Daimler Trucks North America LLC	Deploy Zero Emission Electric Delivery Trucks	05/27/21	03/31/26	0	12,310,000
22036	University of California Riverside	Energy-Efficient Routing for Electric Trucks	09/06/22	12/31/26	99,500	99,500
22120	Los Angeles Cleantech Incubator	Conduct Stakeholder Outreach and ZEV Workforce Plan	03/24/22	12/31/26	95,000	155,000
22177	Daimler Trucks North America LLC	Deploy Class 8 Battery Electric Trucks and Charging Infrastructure	06/16/22	12/31/26	447,638	27,073,593
22247	NFI Interactive Logistics LLC	Deploy Class 8 Battery Electric Trucks, Charging Infrastructure and Distributed Energy Resource Technologies	12/15/22	12/31/26	4,547,126	35,078,329
23072	CALSTART	Charging Related Data Collection, Fleet Analysis and Reporting for Deployment of 100 Commercial Class 8 Battery Electric Trucks	03/08/23	12/31/26	98,582	246,367
23090	Electric Power Research Institute	Deployment of 100 Commercial Class 8 Battery Electric Trucks	03/19/24	12/31/26	109,638	209,588
24267	Electric Power Research Institute	Develop and Demonstrate Megawatt Fast Charging for Battery Electric Trucks	01/14/25	01/13/27	1,500,000	19,326,774
25115	Volvo Technology of America LLC	Develop and Demonstrate Battery-Electric Excavator and Wheel Loader	02/4/25	08/31/26	0	2,140,270
25146	Voltu Motor Inc	Develop, Demonstrate and Deploy 10 Ford F350 Class 2B/3 Medium-Duty Work Trucks	06/10/25	12/31/26	300,000	2,200,000
25149	Greenwealth Energy Solutions Inc	EV Hardware and Software Installation and Maintenance at South Coast AQMD HQ	06/06/25	12/05/32	653,248	723,248
25185	Range Energy Inc	Demonstration of Zero-Emission Transport Refrigeration Unit with Electric-Powered Trailer for Heavy-Duty Vehicles	09/10/25	09/09/26	111,180	741,200
26049	Balboa Island Ferry	Electrification of Balboa Island Ferries and Installation of Supporting Charging Infrastructure	12/31/25	06/30/27	250,000	11,484,790
Emissions Control Technologies						
23059	University of California Riverside	Study of Emissions and Air Quality Impact from Goods Movement Operations in Southern California Communities	12/27/22	6/30/27	500,000	3,610,000

Contract	Contractor	Project Title	Start Term	End Term	South Coast AQMD $	Project Total $
Fuel / Emission Studies						
24033	University of California Irvine	Conduct a Study of Air Quality Impacts of Hydrogen in End-Use Appliances for Commercial Buildings and Industrial Applications	03/13/24	04/30/26	80,000	3,405,000
Fueling Infrastructure and Deployment (NG / RNG)						
18336	ABC Unified School District	FY2017-18 Alternative Fuel School Bus Replacement Program (3 CNG Buses)	10/05/18	11/30/34	117,900	676,500
18337	Alta Loma School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (2 CNG Buses)	10/05/18	11/30/34	78,600	423,000
18344	Bellflower Unified School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (1 CNG Bus)	09/07/18	11/30/34	39,300	225,500
18346	Chaffey Joint Union High School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (6 CNG Buses)	10/05/18	11/30/34	235,800	1,269,000
18348	Cypress School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (1 CNG Bus)	09/07/18	11/30/34	39,300	211,500
18349	Downey Unified School District	FY 2017-18 alternative Fuel School Bus Replacement Program (4 CNG Buses)	09/14/18	11/30/36	157,200	902,000
18350	Fountain Valley School District	FY2017-18 Alternative Fuel School Bus Replacement Program (1 CNG Bus)	09/07/18	11/30/34	39,300	211,500
18351	Fullerton Joint Union High School District	FY2017-18 Alternative Fuel School Bus Replacement Program (4 CNG Buses)	10/05/18	11/30/34	157,200	846,000
18354	Hemet Unified School District	FY2017-18 Alternative Fuel School Bus Replacement Program (5 CNG Buses)	10/05/18	11/30/34	196,500	1,127,500
18355	Huntington Beach Union High School District	FY2017-18 Alternative Fuel School Bus Replacement Program (15 CNG Buses)	10/05/18	11/30/34	589,500	3,382,500
18363	Orange Unified School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (1 CNG Bus)	09/14/18	11/30/34	39,300	225,500
18364	Placentia-Yorba Linda Unified School District	FY2017-18 Alternative Fuel School Bus Replacement Program (6 CNG Buses)	10/05/18	11/30/34	235,800	1,353,000
18365	Pupil Transportation Cooperative	FY 2017-18 Alternative Fuel School Bus Replacement Program (5 CNG Buses)	10/05/18	11/30/34	196,500	1,127,500
18367	Rialto Unified School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (13 CNG Buses)	10/05/18	11/30/34	510,900	2,931,500
18368	Rim Of The World Unified School District	FY2017-18 Alternative Fuel School Bus Replacement Program (3 CNG Buses)	10/05/18	11/30/34	117,900	676,500
18369	Rowland Unified School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (3 CNG Buses & 1 Propane Bus)	11/02/18	11/30/34	117,900	770,000

Contract	Contractor	Project Title	Start Term	End Term	South Coast AQMD $	Project Total $
Fueling Infrastructure and Deployment (NG / RNG) (cont'd)						
18370	San Jacinto Unified School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (2 CNG Buses)	09/14/18	11/30/34	78,600	451,000
18374	Upland Unified School District	FY 2017-18 Alternative Fuel School Bus Replacement Program (4 CNG Buses)	10/12/18	11/30/34	157,200	902,000
20178	Whittier Union High School District	FY 2017-18 Alternative Fuel School Bus Replacement Program	02/21/20	11/30/34	196,500	1,052,500
Health Impacts Studies						
25147	University of California Riverside	Ethylene Oxide Sources Study	06/10/25	12/09/26	176,956	176,956
Hydrogen and Mobile Fuel Cell Technologies and Infrastructure						
15150	Air Products and Chemicals Inc	Install/Upgrade Eight H2 Fueling Stations throughout SCAG (including SCAQMD's HQs H2 station)	10/10/14	07/31/26	643,750	16,979,189
15611	Ontario CNG Station Inc	Installation of Ontario Renewable Hydrogen Fueling Station	07/10/15	07/31/26	200,000	2,510,000
20033	Port of Long Beach	Sustainable Terminals Accelerating Regional Transportation (START) Phase I	06/04/21	06/30/26	500,000	105,013,765
22084	A-1 Alternative Fuel Systems	Develop and Demonstrate Hydrogen Fuel Cell Medium-Duty Buses	01/19/22	04/30/26	531,166	2,086,608
24166	Zero Emission Industries Inc	Development of a Portable Liquid Hydrogen Fueling System	06/27/24	04/30/26	1,175,000	7,168,750
24235	Air Products and Chemicals Inc	License Agreement to Operate and Maintain Publicly Accessible Hydrogen Fueling Station at SCAQMD's Diamond Bar HQs	04/10/24	07/31/26	0	0
25207	FirstElement Fuel Inc	License Agreement to Operate and Maintain Publicly Accessible Hydrogen Fueling Station at SCAQMD's Diamond Bar HQs	05/29/25	05/28/28	0	0
Stationary Sources - Clean Fuels						
24035	RockeTruck Inc	Develop and Demonstrate Hydrogen Fuel Cell Mobile Power Generation System	05/10/24	09/30/26	200,000	4,617,067
25154	University of California Irvine	Investigate the Impact of Vehicle-to-Home Technology on Regional Air Quality	06/06/25	06/05/27	220,548	370,548
Zero Emission Infrastructure						
24131	University of California Riverside	Regional Medium- and Heavy-Duty Zero Emission Vehicle Infrastructure Analysis	05/10/24	05/31/26	150,000	300,000

Contract	Contractor	Project Title	Start Term	End Term	South Coast AQMD $	Project Total $
Zero Emission Infrastructure (cont'd)						
25124	University of California Riverside	CHARGE-OPT: Accelerating Electrification of Medium- and Heavy-Duty Trucks in Southern California with Data-Driven Planning Platforms for Charging Networks, Truck Fleets, and Power Systems	04/16/25	04/15/27	300,000	600.000
Technology Assessments and Transfer / Outreach						
09252	JWM Consulting Service	Technical Assistance with Review and Assessment of Advanced Technologies, Heavy-Duty Engines and Conventional and Alternative Fuels	12/20/08	06/30/26	30,000	30,000
12376	University of California Riverside	Technical Assistance with Alternative Fuels, Biofuels, Emissions Testing, and Zero-Emission Transportation Technology	06/01/14	05/31/26	300,000	300,000
19302	Hydrogen Ventures	Technical Assistance with Hydrogen Infrastructure and Related Projects	04/24/19	04/23/27	50,0000	50,000
20265	Eastern Research Group	Technical Assistance with Heavy-Duty Vehicle Emissions Testing, Analyses & Engine Development & Applications	06/17/20	06/30/26	50,000	50,000
22096	AEE Solutions LLC	Technical Assistance with Heavy-Duty Vehicle Emission Testing, Test Methods and Analysis of Real-World Activity Data	11/08/21	11/07/27	100,000	100,000
22273	Green Paradigm Consulting Inc	Technical Assistance with Alternative Fuels, Evs, Charging & Infrastructure and Renewable Energy	04/22/22	04/02/26	200,000	200,000
22274	Gladstein, Neandross & Associates LLC	Technical Assistance with Alternative Fuels & Fueling Infrastructure, Emissions Analysis & On-Road Sources	05/05/22	04/02/26	300,000	300,000
24173	Integra Environmental Consulting Services Inc	Technical Assistance to Support Technology Advancement Office Mobile Source Incentive and Technology Demonstration Programs	05/01/24	04/30/26	75,000	75,000
25132	California State University Los Angeles	Cosponsor California State University, Los Angeles in the Battery Workforce Challenge	04/02/25	10/01/26	150,000	650,000

Appendix C

Final Reports for 2025

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South Coast AQMD Contract #21313 **December 2025**

Deployment of Zero Emission Fuel Cell Transit Buses

Contractor
SunLine Transit Agency

Cosponsors
South Coast AQMD
U.S. EPA

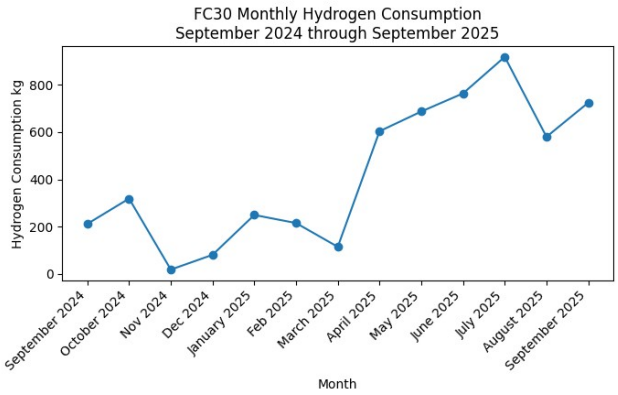
Project Officer
Maryam Hajbabaei

Background
The SunLine Transit Agency Fuel Cell Bus Deployment Project was funded by the U.S. EPA Targeted Airshed Grant Program and the South Coast AQMD. The project supports both state and federal mandates to reduce criteria air pollutants, greenhouse gas emissions, and reliance on fossil fuel in the South Coast Air Basin. Under this agreement, SunLine procured and deployed six zero emission fuel cell electric buses (FCEB), replacing six 2008-2009 compressed natural gas (CNG) buses, and committed to collecting a minimum of one year of performance data for each vehicle. The project directly benefits overburdened communities in Riverside County and advances the commercialization and adoption of hydrogen-powered transit technology in California.

Project Objective
The objectives were to procure six New Flyer XHE40 fuel cell electric buses, replace six end-of-life CNG buses and complete U.S. EPA compliant scrappage, commission and deploy the buses into fixed-route service, conduct a minimum twelve months of performance data collection for each bus, analyze operational performance and hydrogen consumption data, and prepare quarterly and final reports. All goals and objectives were successfully achieved.

Technology Description
Each bus features a Ballard FCveloCity HD 100 kilowatt fuel cell system, a Siemens ELFA electric hybrid drive, and a 100 kilowatt hour lithium iron phosphate battery pack. Hydrogen is stored in 38 kilograms of Type 3 composite cylinders at 350 bar, providing an expected range of 250 to 300 miles per day. All propulsion, energy storage, and hybrid systems are liquid cooled and integrated for regenerative braking, power optimization, and fast fill refueling per SAE J2601 two fueling protocols. The buses produce zero tailpipe emissions of nitrogen oxides (NOx), volatile organic compounds (VOC), carbon monoxide (CO), particulate matter (PM), and greenhouse gases (GHG).

Status
All six buses were delivered, commissioned, and placed into revenue service. FC25 - FC29 completed their twelve-month performance data collection periods. FC30 entered service on September 23, 2024, and completed data collection on September 30, 2025. During early deployment, FC30 experienced commissioning and software related issues resulting in temporary out-of-service periods. These were resolved through New Flyer and Ballard warranty support and system updates, leading to improved availability over time. All quarterly reports, and the draft final report have been completed. All six buses remain in active revenue service.



Results

The project demonstrated the operational feasibility of hydrogen fuel cell buses in fixed route transit service. Hydrogen consumption, availability, and maintenance performance were tracked throughout the demonstration period. Reliability improved over time, particularly for FC30 after early software and hardware adjustments were completed. Preventive and corrective maintenance, fueling patterns, and operational performance were documented through quarterly reporting and the final dataset.

Benefits

Replacement of six CNG buses with zero emission FCEBs eliminates approximately 0.66 tons per year of NOx and approximately 480 metric tons of carbon dioxide (CO2) equivalent based on typical heavy duty CNG bus duty cycles of approximately 50,000 miles per year per bus. The deployment delivers zero tailpipe emissions of criteria air pollutants and GHG, directly benefiting overburdened communities in the South Coast Air Basin. The project reduces NOx, PM, ozone forming emissions compared to the replaced CNG fleet while also reducing fossil fuel use. The results support the California zero emission bus mandates and long-term hydrogen transit deployment.

Project Costs

The total project cost was $6,759,910, with $5,953,706 payable under the contract, including U.S. EPA funding of $5,748,785 and South Coast AQMD funding of $204,921, and SunLine cost share of $806,204. The contract reflects per bus costs of $936,312.83 for each of the first five buses and $1,091,480.65 for the sixth bus.

Commercialization and Applications

SunLine will continue operating all six buses for their full twelve-year service life. Data from this project supports fleet transition planning, hydrogen infrastructure development, and replication of hydrogen transit systems by other agencies. The project provides a validated pathway for large scale zero emission bus deployment in California and beyond.

South Coast AQMD Contract #21372 **June 2025**

California Hydrogen Systems Analysis Project

Contractor
University of California, Davis

Cosponsors
H2 Study Advisory Board - 6 energy providers, 3 automakers, 2 foundations, 4 government agencies

Project Officer
Maryam Hajbabaei

Background
The University of California, Davis (UC Davis), Institute of Transportation Studies is continuing their multidisciplinary research consortium that brings together the world's leading automotive manufacturers, energy companies and government agencies with multi-disciplinary researchers to understand the critical factors and dynamics necessary to transition to a sustainable transportation system by means of exploring the difficult technical, economic and behavioral questions required to inform industry planning and government policy. Through this research program, the California Hydrogen Systems Analysis project builds on and updates existing work on carbon neutral hydrogen systems, which is extensive, but represents a single cohesive analysis and plan for the state.

The study includes hydrogen's role in transportation, with all light-, medium-, and heavy-duty vehicles, as well as its use in industry and role as an emerging energy storage option for intermittent electric power. UC Davis, Institute of Transportation Studies has several analytical tools and models in development that support this very detailed study of these dynamics, and for the rollout of a hydrogen system over the next 30 years.

This project builds on South Coast AQMD's long history of support for the Sustainable Transportation & Energy Pathways consortium-based research programs on Fuel Cell Vehicle Modeling (1998-2002), Hydrogen Pathways (2003-2006), Sustainable Transportation Energy Pathways (2007-10), Next STEPs (2011 – 2014) and STEPs+ (2015-2018).

Project Objective
As a Program Sponsor, South Coast AQMD's representation on the project Advisory Board provided feedback on draft reports and attendance at monthly meetings. The explicit objectives of the Program are to: 1) analyze and model hydrogen's role in a carbon neutral system of transportation, industry and energy storage through 2050 in California and beyond; 2) assess existing policies to identify gaps over the next 5-10 years; and 3) study the role of hydrogen storage and other forms of storage including vehicle-to-grid (V2G) and power-to-gas (P2G) in grid serving both fuel cell and battery electric vehicles

Status
The California Hydrogen Systems Analysis Project was completed in February 2023, with a final report released in April 2023.

Results
Hydrogen system development, and its planning, have reached a critical point in California. The role of transportation will be central in determining hydrogen demand in future years and in particular, the role of fuel cell vehicles, both light-duty and medium/heavy duty, will be important in that regard. Our modeling research has many findings, as detailed in the report. Some of these include:

- **Transportation can lead.** A hydrogen system development led by strong demand growth in transportation (especially light-duty and medium/heavy-duty road vehicles) can support the development of a medium-scale supply and distribution system by 2030. At a scale of 300–500 tons per day, possible by 2030, this should be sufficient to cut hydrogen costs and prices toward their long term potential. Industry can also play an important role, but such projects typically require

large individual times and with long lead times, and may require lower hydrogen prices to trigger investments than transportation does.

● **Transportation is scalable.** Growth in light-duty and medium/heavy-duty fuel cell vehicles can be done rapidly and incrementally, with infrastructure such as stations added in parallel.

● **Strong early investment is needed.** In the early years of developing hydrogen systems for transportation, many refueling stations were needed to ensure adequate coverage so drivers can reliably find fuel as they make journeys. This can mean generally low utilization of stations and challenging station economics. This in turn may require policies to ensure that profitability can be achieved.

● **Existing gasoline/diesel fueling stations should provide a solid base** for creating hydrogen stations, at least through 2030. Converting or augmenting existing stations can be easier than starting with "greenfield" sites and can provide excellent locations.

● **Hydrogen will likely be delivered to stations.** Hydrogen could be produced on site at refueling stations but requires space for electrolytic (or SMR) systems, sufficient storage on site, and purchase of electrolyzers and use of retail electricity. In general, large-scale production from remote sites, selected based on scaling potential, renewable resource availability and hydrogen production cost, appears likely to be far cheaper than on-site production, especially for renewable (electrolytic and biomass-based) hydrogen; but the market must reach a certain size to support the development of large production sites.

● **Liquid hydrogen may play an important role.** Liquid hydrogen production/storage/station systems have significant advantages over gaseous systems, even if used to fuel gaseous storage on board vehicles. One of the biggest advantages is the speed of refueling vehicles with liquid-based technologies. Another is the density of storage made possible with liquids. A third is the lower cost and larger volumes of liquid tanker trucks than gaseous tube trailers for delivering hydrogen to stations. However, liquid systems involve significantly higher conversion and storage losses than gaseous systems and may be more expensive, especially at small volumes.

● **Hydrogen availability and price will be critical.** The market share of fuel cell vehicles will depend on the retail price of hydrogen, the availability of stations, and the availability and price of fuel cell vehicles.

Benefits

The successful transportation market development of hydrogen vehicles and supporting systems will provide important benefits for Southern California. These include air quality benefits, as fuel cell vehicles replace gasoline cars and diesel trucks; climate pollutant reductions compared to these vehicles, and potential job benefits (not assessed in this report). A key point is that there is a need for hydrogen uptake in transportation because electric vehicles may not be able to serve the entire light-duty or medium- / heavy-duty vehicle markets. This is speculative but there is reason to believe that light-duty electric vehicles may struggle to capture 100% of that market, and particularly that electric trucks will struggle to capture 100% of that market, and that fuel cell vehicles and hydrogen will be needed. We estimate anywhere from 5-20% market share for hydrogen light-duty vehicles and 30-80% market share for hydrogen trucks in our scenarios, leading to large hydrogen demands and significant emissions reductions. These are in line with our expectations at project start, though high hydrogen use from low numbers of vehicles, and the ability to build a broader market off this, are new findings.

Project Costs

As budgeted, South Coast AQMD contributed $50,000 toward the California Hydrogen Systems Analysis Project. The project was supported by other industry and government sponsorships, and the total support of $550,000 in co-funding was provided by funders including, but not limited to Aramco, California Energy Commission, General Motors, Honda, Hyundai, Leighty Foundation, Shell, Southern California Gas and Toyota.

South Coast AQMD Contract #18232 **February 2025**

Electric Top Pick Development, Integration and Demonstration

Contractors

Hyster-Yale Materials Handling (HYMH)
Wave Charging
Calstart

Co-Sponsors

South Coast AQMD
California Energy Commission (CEC)

Project Officer

Joseph Lopat

Background

Mobile sources used in goods movement and powered with conventional fossil fuels contribute a large portion of nitrogen oxide (NOx) and particulate matter (PM) emissions in the South Coast Air Basin (Basin) and create an adverse impact on air quality and public health, particularly in Environmental Justice communities adjacent to the San Pedro Bay Ports - Port of Los Angeles (POLA) and Port of Long Beach (POLB), that are disproportionately impacted by goods movement operations and activities. In order to mitigate these port-related emissions, and further reduce petroleum usage, CEC & South Coast AQMD strongly supported accelerated deployment of zero- and near zero-emission technologies in cargo transport and handling operations.

Project Objective

HYMH worked with its existing prototype for modular electrified power systems to scale such technology and to validate and demonstrate a pre-pilot Hyster® J1150HD-CH electric container handler – known as a Top Pick Handler. Together with project partner WAVE Charging and CALSTART, a demonstration of this prototype was planned for POLA's APM Terminals (APM). Demonstration intended to support diesel like performance of the zero-emission op pick supported by opportunity charging powered by wireless charging technology supplied by WAVE and improve emissions impacts understanding from a real-life case.

Technology Description

During the project, an emission baseline was created on T4F diesel version of Top Pick. A prototype Top Pick was designed, assembled, and tested at a HYMH test site.

Figure 2: Top pick during assembly and test

WAVE's wireless charger was produced and was ready for installation on the Top Pick prototype. Electrical infrastructure at the Port test site was prepared for installing WAVE's wireless charger.

Figure 1: WAVE parts delivered to installation site

However, the project did not advance to the demonstration phase due to unforeseen challenges and changed circumstances experienced during the project.

Results

The project showed that HYMH zero-emission Top Pick can have the same performance and productivity as a diesel equivalent. Knowledge gained through this project has accelerated development of zero-emission cargo handling equipment (CHE), and support and engagement with end customer has led to future market for these innovative products.

Benefits

Based on the emission baseline study that was performed by the University of California on T4F diesel equivalent of Top Pick at one of the terminals at POLA which averaged around 1.34 gallons per hour, significant emissions reduction of carbon dioxide (CO2), carbon monoxide (CO), non-methane hydrocarbons (NMHC), methane (CH4), total hydrocarbons (THC), Soot, PM and NOx would be resulted when same operations are performed using zero emission equivalent.

Project Costs

The project budget and the actual project costs are shown in the table below.

Project Partners	CEC + SCAQMD Funds	Contractor Match share	Total project cost
South Coast AQMD	$287,806		$287,806
CEC	$1,949,524	$404,258	$2,353,782
WAVE		$652,926	$652,926
Others (HYMH Minor Sub-contractors)		$99,302	$99,302
Total Project Cost	**$2,237,330**	**$1,156,486**	**$3,393,816**

Commercialization and Applications

With the help of this project, HYMH was able to learn from many challenges encountered regarding technology, software development and hardware component selection. As a result, additional prototype and test trucks using updated technology, components and design elements have been produced. These trucks are then the basis for commercial offerings which will be available on the market in 2026 and 2027. The purpose of the project was to expedite commercial availability of zero-emissions products into cargo-handling applications. For HYMH, this project enabled bringing zero-emissions products to market more quickly, offering customers additional alternatives to achieve their sustainability objectives.

South Coast AQMD Contract #19166 **April 2025**

Battery-Electric Shuttle Bus Replacement Project

Contractor
PhoenixEV (formerly Phoenix Motorcars)

Cosponsors
U.S. EPA

Project Officer
Berj Der Boghossian

Background
The U.S. EPA Targeted Airshed Grant (TAG) was awarded to PhoenixEV (formerly Phoenix Motorcars) for the replacement of 29 diesel and gasoline airport shuttle buses with new, battery-electric buses manufactured by PhoenixEV and associated charging infrastructure. Airport shuttle bus fleets typically operate on short, congested loops with high idle times and stop-and-go traffic, which are ideal conditions for battery-electric vehicles. The buses were equipped with electric drivetrain technology which delivered up to 110 miles per charge. This U.S. EPA TAG grant required all replaced diesel and gasoline vehicles to be removed from service and scrapped to ensure there are no more tailpipe emissions.

Project Objective
The project's primary environmental objective was to eliminate tailpipe emissions from participating fleets, directly supporting federal and state clean air goals. Specifically, the project aimed to reduce cumulative emissions of nitrogen oxide (NOx), particulate matter ≤ 2.5 microns ($PM_{2.5}$), carbon monoxide (CO), and carbon dioxide (CO_2) over the service life of the replacement vehicles. These reductions are critical for helping the region meet National Ambient Air Quality Standards (NAAQS), comply with the California State Implementation Plan (SIP), and mitigate public health burdens in surrounding communities, especially those historically overexposed to transportation related air pollution.

Technology Description
PhoenixEV specializes in the electrification of shuttle buses and offers a range of electric vehicles. The buses deployed in this project were the ZEUS Z400 battery-electric shuttle buses featuring fully electric drivetrains that produce zero tailpipe emissions. They are equipped with 105 kWh of battery capacity, have a range of 110 miles per charge, and are built onto Ford E-450 chassis.

Status
This project aimed to replace 29 diesel and gasoline airport shuttle buses. Ultimately, 18 battery-electric shuttle buses were delivered, deployed across six fleet operators, and are now in service. The new buses replaced internal-combustion shuttles primarily used on high-frequency airport loop routes characterized by high annual mileage and significant idling, and they feature fully electric drivetrains with zero tailpipe emissions.

The project encountered several unforeseen challenges, including COVID-19–related supply-chain disruptions, manufacturing delays, and changes to incentive program funding. As a result, the project was unable to replace an additional 11 internal-combustion shuttle buses, falling short of the original target of 29 total replacements.

Despite some operational and reporting challenges, the project achieved its primary objectives of delivering zero emission shuttle buses and quantifying associated emission reductions.

Results

As part of the original proposal, PhoenixEV was to deploy 29 vehicles to seven fleets who met the program's eligibility requirements. Ultimately, 18 vehicles were deployed to six fleets. These 18 older, higher emitting shuttle buses were permanently destroyed, directly preventing them from returning to the roads and ensuring that the emissions reductions associated with their replacement were fully realized. This process not only secured the environmental benefits of the project but also reinforced the integrity of the program by guaranteeing replacement of high polluting vehicles with zero-emission alternatives.

The older, higher emitting vehicles were replaced with PhoenixEV ZEUS Z400 battery electric shuttle buses. The shuttle buses are designed for opportunity charging throughout the day, allowing operators to extend range during service breaks and maintain reliable, full day operations. These vehicles were also deployed to meet the same operational demands as the original diesel and gasoline units while eliminating fuel combustion and associated emissions, directly supporting the project's air quality improvement goals.

During post-deployment monitoring and interviews, shuttle bus drivers reported smoother acceleration, lower fatigue, and no range-related issues. Maintenance staff noted reduced servicing requirements and adapted to new EV systems after training. Fleets reported improved rider satisfaction with passengers noticing quieter and more pleasant rides. Participating fleets leveraged positive feedback in marketing and expressed interest in future EV procurement.

Overall, this project successfully demonstrated the viability of electric shuttle deployment in one of the nation's most polluted and congested areas and proved it will lead to larger scale deployment of the technology at the airports and beyond. By addressing operational, financial, and infrastructure barriers, it offers a scalable model for future zero-emission fleet transitions. Beyond vehicle replacement, the project strengthened fleet confidence in electrification, demonstrated EV reliability in continuous airport operations, and established a foundation for broader adoption of clean transportation in other high impact corridors.

Benefits

This project contributed to the qualitative estimated health benefits by reducing emissions of harmful air pollutants such as NOx (3.6 tons per year), $PM_{2.5}$ (0.3 tons per year), hydrocarbons (HC, 0.6 tons per year), CO (2.6 tons per year), and CO_2 (739.1 tons per year). These reductions are associated with improved respiratory health and decreased localized exposure to harmful pollutants in communities already experiencing environmental burdens.

Project Costs

PhoenixEV received a total of $1,447,101 in reimbursements from the US EPA grant funding for their work on the replacement of, ultimately, 18 of the planned 29 shuttle buses, leading to the reduction of harmful vehicle emissions.

Coupled with the purchases of these 18 shuttle buses, California's Clean Truck and Bus Voucher Incentive Project (HVIP) funding totaling $1,220,978 was leveraged to cover more costs. Additionally, PhoenixEV's out-of-pocket cost-share totaled $1,876,008.87.

Combined, the total cost of this project, including US EPA funding, leveraged HVIP funding, and PhoenixEV out-of-pocket cost-share, was $4,544,087.87. This total fell short of the projected cost at the start of the project due to the 11 shuttle buses that were not delivered.

Commercialization and Applications

This project offers a scalable model for future zero-emission fleet transitions. Positive feedback from fleet operators, shuttle bus drivers, maintenance staff, and passengers all strengthen confidence in fleet electrification. With manufacturers like PhoenixEV providing the vehicle supply, broader adoption of clean, zero-emission transportation is feasible.

South Coast AQMD Contract #19464 **February 2025**

Battery Electric Yard Tractor Replacement Project

Contractor
West Basin Container Terminal, LLC

Cosponsors
U.S. EPA

Port of Los Angeles

Project Officer
Sam Cao

Background
The U.S. EPA's Targeted Airshed Grant (TAG), awarded West Basin Container Terminal (WBCT) for the purchasing 10 battery-electric yard tractors built by BYD. The yard tractors were integrated with Wireless Advanced Vehicle Electrification (WAVE) vehicle-side inductive charging pads. Awarded separately, The City of Los Angeles Harbor Department (Port of Los Angeles, Port, POLA, Harbor Department) under grant agreement ARV-17-049 with the California Energy Commission (CEC) is conducting the Zero Emission Freight Vehicle Advanced Infrastructure Demonstration (AID) Project. The project team designed, installed, and demonstrated wireless inductive charging infrastructure, designed and manufactured by WAVE, including 10 base chargers and 2 opportunity chargers. A peak shaving battery energy storage system (BESS), designed and manufactured by Schneider Electric, was installed and integrated with the system to support operation of the zero-emission (ZE) yard tractors at POLA's WBCT site.

Project Objective
Mobile sources in goods movement sectors make up the large portion of NOx and PM2.5 emissions in the South Coast Air Basin and cargo handling equipment have been identified as one of the most significant sources with adverse impact on air quality and public health, particularly in Environmental Justice (EJ) communities adjacent to the Ports of Los Angeles and Long Beach that are disproportionately impacted by goods movement operations and activities, and resultant emissions of ozone precursors, toxic air contaminants and greenhouse gases. In order to mitigate these port-related emissions, South Coast AQMD strongly supports accelerated deployment of zero and near zero emission technologies in cargo transport and handling operations, including electric yard tractors. Both Ports of Los Angeles and Long Beach have also supported these technologies pursuant to a Zero Emission Technologies Roadmap with an established plan for technologies to pursue to advance zero emission technology development.

Technology Description
WBCT has elected to deploy BYD battery electric yard tractors with 218 kWh of battery capacity. BYD is a global manufacturer of electric vehicles and components with financial resources, technology, and organizational support to design, refine, and manufacture world class products. BYD has already achieved wide-scale commercialization of battery electric buses and taxis. BYD manufactures every major component, starting with the batteries and battery management system (BMS), as well as inverters and traction motors. This vertical integration enables seamless communication between these components, improving operational efficiency and reliability. The key component is the battery technology developed by BYD, estimated to last for more than 10 years, with minimal degradation. The CEC AID project allowed the 10 BYD battery-electric yard tractors to be integrated with the WAVE inductive charging system and charging will be provided by 10 inductive charging pads at the main equipment corral and

additional 2 opportunity charging pads near the break station. The charging system will also be equipped with 1MWh battery storage system.

Status

The project involved the replacement of 10 liquefied petroleum gas (LPG) yard trucks with battery electric yard trucks. The project has been successfully completed, with all 10 electric tractors now in operation. The old LPG units have been fully decommissioned and scrapped, and scrappage reports have been generated to document the process. Additionally, monitoring data was collected throughout the project to support emissions tracking and reporting.

Results

The goal of this portion of the demonstration project was to better understand the activity, performance, and emissions benefits of the battery-electric yard tractors. The in-service yard tractors were monitored for nearly 30 months between June 16, 2022 and December 4, 2024.

The average hours of use for the yard tractors were 3.4 hours a day, with a range from 2.5 to 4.5 hours per day for individual yard tractors. The average daily distance traveled for all the yard tractors was 25.3 miles, with a range from approximately 16.6 to 35 miles for individual yard tractors. The average daily speed over all the yard tractors was 7.6 mph, with a range from about 6.8 to 8.4 mph for individual yard tractors.

The average daily operational energy discharge over all the yard tractors was 52 kWh, with a range from 46 to 66 kWh for individual yard tractors. The average daily energy discharge in terms of state of charge (SOC) percent used over all the yard tractors was 27.8 percent, with a range from 21 to 35 percent for individual yard tractors.

The average charging energy input per charging event was 219.4 kWh, with a range for the individual yard tractors from 211.4 to 234.8 kWh.

The average charge duration was 2.1 hours over all yard tractors, with a range from 1.9 to 2.3 hours for the individual yard tractors. The SOC percentage charged was 34 percent over all yard tractors, with a range from 19 to 52 percent for the individual yard tractors.

The AID team is encouraged by the data analysis and operational efficiency of the equipment, though currently minimal. Even with the limited operational hours, the yard tractors seem able to match the duty cycle of the diesel counterparts and operate for two full shifts with an opportunity charge in between.

Benefits

The project has contributed to several qualitative estimated health benefits by reducing emissions of harmful air pollutants such as nitrogen oxides (9.519 tons per year NOx), particulate matter (0.969 tons per year PM), and diesel fuel saved (93,740 gallons per year). These reductions are associated with improved respiratory health and decreased exposure to pollution-related illnesses in the EJ communities.

Project Costs

In terms of project partner participation, WBCT received a combined award amount of $1,915,454.55 for their contribution to accelerate deployment of zero emission cargo handling equipment to reduce harmful diesel emissions, petroleum consumption and greenhouse gases in EJ communities along the goods movement corridors that are impacted by heavy diesel truck traffic and the associated air pollution. Additionally, BYD Motors LLC was paid $3,010,000.00 for providing 10 electric yard tractors with WAVE charging equipment.

Commercialization and Applications

The project was disseminated through various platforms, including a public relations event hosted by the POLA for the final commissioning of the wireless charging site. This event included a project update on the Ports America website showcasing this project as part of a larger enterprise wide decarbonization road map, which will significantly increase public awareness of the project's impact.

South Coast AQMD Contract #21153 **November 2025**

Switch-On: Develop and Deploy Seventy Heavy-Duty Battery Electric Vehicles

Contractor
Volvo Trucks North America

Cosponsors
U.S. EPA
South Coast AQMD
Volvo Trucks North America
Eight leading freight delivery fleets

Project Officer
Fan Xu, Ph.D.

Background
Heavy-duty (HD) diesel freight distribution trucking operations contribute to air pollution in the South Coast Air Basin (Basin) and low-income and overburdened communities are disproportionately impacted with high diesel exhaust emissions. Battery electric trucks (BETs) provide significant emission reductions of nitrogen oxide (NOx), particulate matter ≤2.5 microns (PM2.5), greenhouse gas (GHG) and other pollutants in applications that consume the greatest volume of diesel in the country and are considered as an important measure to meet air quality standards in nonattainment areas and improve air quality in the Basin.

Project Objective
Funded by U.S. EPA and South Coast AQMD, Volvo Trucks North America (Volvo), a major HD manufacturer of Class 7 and 8 trucks, implemented a revolutionary project, Switch-On, to realize market penetration of HD electric trucks in Southern California and to support the expansion throughout the nation. The deployment scale was a more aggressive step compared to smaller pilot-scale demonstrations and a large amount of data was collected and analyzed from a range of fleets with different operations and routes.

Partnering with 8 leading freight delivery fleets, Volvo deployed 70 HD Class 7 and 8 zero emission BETs, Volvo VNR Electric, traveling between warehouses, freight facilities, and customer delivery sites. The trucks operated in the Basin to demonstrate the operational and emissions reduction performance in real-world use. Truck and energy utilization data were collected and analyzed over a 12-month plus period. Fleet management and driver surveys were implemented to learn about user fleet experiences.

Technology Description
The Volvo VNR Electric platform has a common electric powertrain that is configurable as a day cab tractor or rigid truck. It has two battery energy capacity ratings (265 and 565 kWh) and multiple axle configuration options (4x2, 6x2, and 6x4), which allow fleets to tailor their Class 7 and 8 applications by balancing vehicle capability with route requirements and cost (Figure 1).

Figure 1. Switch-On Volvo VNR Electric trucks charging

Status
The project consisted of the following elements:

Truck specifications/build/delivery – Volvo worked with each fleet to develop specifications to meet route/operational needs, build, and deliver trucks to customers through its dealer network. Trucks were delivered between Q4 2022 and Q1 2024.
Charging infrastructure installations – Fleets developed charging infrastructure requirements and installed charging equipment. A total of 21 new chargers were installed.
Operation data collection/survey – Vehicle operational data were collected using telematics, as well as charging infrastructure usage data. Fleet manager and driver surveys were conducted. The data collection was completed in June 2024.

Results
Volvo successfully navigated initial delays with fleet recruiting and COVID-related supply chain issues (vehicles and charging infrastructure) to deliver all 70 trucks to the 8 fleets. Fleets' BET utilization increased during the project period, driven by factors including charging infrastructure availability and reliability and increased fleet/driver confidence in the trucks' ability to meet the routes.

Volvo collected robust vehicle-level telematics data positional and operational data (e.g., odometer reading, GPS coordinates, powertrain status, battery state-of-charge). The data were analyzed to determine the vehicle- and fleet-level utilization. The Switch-On trucks operated 94% of the miles in the South Coast AQMD territory. Fleets' use metrics varied due to various factors including, the number of participating trucks, routes served, and charging station reliability. Table 1 summarizes the fleet-level results.

Table 1. Summary of Switch-On Project fleet-level utilization

Name	Number of Vehicles	Total Miles Traveled (Through 2025 Q2)	Total Energy Used (kWh)	Average Miles Traveled (Through 2025 Q2)	Average Energy Used (kWh)	Estimated Average Annual Miles*
Fleet A	35	454,404	576,655	12,983	16,476	15,354
Fleet B	4	53,683	68,126	13,421	17,031	9,260
Fleet C	10	489,406	621,074	48,941	62,107	44,458
Fleet D	10	729,276	925,477	72,928	92,548	35,133
Fleet E	3	122,363	155,283	40,788	51,761	23,995
Fleet F	3	14,263	18,100	4,754	6,033	1,209
Fleet G	2	29,818	37,840	14,909	18,920	7,748
Fleet H	3	52,614	66,769	17,538	22,256	13,702

*Projected annual mileage per vehicle based on data from 2025 Q1 and 2025 Q2.

Some of the trucks equipped with the lower 265 kWh capacity battery had challenges meeting their routes' requirements due to the limited usable driving range (≤100 miles). The trucks with the higher 565 kWh capacity battery met the fleets' route requirements. The charging infrastructure that most fleets installed did not allow for data collection, so energy use was estimated from vehicle telematics data.

The U.S. EPA Diesel Emissions Quantifier tool was used to estimate the vehicle tailpipe emissions savings using the full implementation usage data. The results are shown in Table 2.

Table 2. Estimated Project Avoided Emissions and Fuel Use, Switch-On Project (annual, 10-year lifetime)

Timeframe	NOx (short tons)	PM2.5 (short tons)	HC (short tons)	CO (short tons)	CO2 (short tons)	Diesel (gallons)
Annual	2.83	0.005	0.064	2.30	2,872	255,290
Lifetime	28.33	0.047	0.638	23.00	28,720	2,552,900

To learn about user fleet experiences, two unique surveys collecting feedback from drivers and fleet managers were developed and distributed digitally. A series of structured questions were developed in the following categories: 1) Operational Impacts & Energy Efficiency; 2) Truck Operation, Handling, & Payload; 3) Training, Education, & Onboarding; and 4) Comfort, Health Benefits, & Overall Satisfaction. The results for all the fleets were generally positive, but some challenge areas were identified.

Benefits

BETs are a very effective tool to reduce NOx, PM2.5, GHG and other criteria emissions to help meet air quality standards in nonattainment areas. The broader scale emissions will continue to decrease as the grid continues to transition to low-/no-GHG and other emissions.

The project showed the Volvo VNR Electric trucks can meet freight distribution fleets' properly selected routes (load, distance, speeds). Only some routes for fleets operating the lower battery capacity could not be met, highlighting the need to properly match the routes and technology. Higher battery capacity and/or high-power midday opportunity charging will increase the freight distribution industry fleet route coverage.

Project Costs

Project costs in the table below show the contribution by organization and project element.

Organization	Element	Funding	Funding
USEPA	Trucks	$19,460,000	$19,460,000
South Coast AQMD	Chargers (Cost Share)	$784,355	$1,034,355
South Coast AQMD	Monitoring, Reporting and Data Collection	$200,000	
South Coast AQMD	Final Reporting	$50,000	
Volvo	Trucks (Cost Share)	$2,809,168	$12,395,356
Fleet partners	Trucks (Cost Share)	$8,322,628	
Fleet partners	Chargers (Cost Share)	$1,263,560	
TOTAL		**$32,889,712**	

Commercialization and Applications

The Volvo Switch-On trucks were early commercial trucks available to customers across North America. This project and Volvo's broader electric truck commercialization across North America and worldwide show that electric trucks are a viable solution. In line with Volvo's standard approach, adequate analysis of routes and duty cycles should be done to properly identify routes that are suited to electric trucks characteristics (driving range, load capacity, dwell times for charging [overnight, midday], areas of operation,) and economic factors (annual miles driven, electric tariff/rate available during charging times, reduced maintenance cost) for maximum benefits.

Projected improvements in battery performance and decreasing costs will lower vehicle cost, extend driving range, enhance energy efficiency, and increase cost effectiveness. These improvements will broaden the range of duty cycles and applications where electric trucks can displace diesel trucks while also matching or surpassing the total cost of operation over diesel trucks.

The project also highlighted that charging infrastructure capabilities and reliability are of equal importance as the trucks' capabilities and reliability. Anticipated improvements in devices and services will support fleets' electrification decisions and accelerate deployment timelines.

South Coast AQMD Contract #24123 **June 2025**

Development and Demonstration of Electric-PoweredTrailer for Heavy-Duty Vehicles

Contractor
Range Energy Inc. (“Range”)

Co-Sponsors
South Coast AQMD

Project Officer
Sam Cao

Background
This South Coast AQMD’s Clean Fuels Program was established to further the deployment of clean transportation technologies that reduce harmful emissions and help attain air quality standards. The Clean Fuels Program supported the build and demonstration of the Range electric-powered trailer (electric trailer) in commercial fleet operations. Use of heavy-duty class 8 trucks with electric trailers provides an opportunity to reduce emissions from goods movement activities throughout the South Coast Air Basin (Basin). Electric trailers use standard interfaces to connect with diesel or electric tractors without retrofitting. Electric trailers provide propulsion assistance and regenerative braking, which result in fuel savings and emissions reduction. Electric trailers are also expected to extend the range of zero-emission trucks through propulsion assistance.

Project Objective
The main project objectives were to: (1) build a prototype electric trailer with a system that provides propulsion assistance, regenerative braking, and power source capabilities through the operation of an on-board battery and electric axle; (2) demonstrate the electric trailer in live operations of a beverage distribution fleet in the Basin; and (3) assess operations results, including fuel consumption and emissions performance.

Technology Description
The prototype electric trailer is comprised of the following key components: (1) an energy module with a 192 kWh battery; (2) a drive module with a 250 kW electric axle to provide propulsion assistance and regenerative braking; (3) smart sensors to inform the amount of propulsion assistance provided by the system; and (4) a conventional 53’ dry van trailer on which the energy module, drive module, and sensors were installed. During the demonstration, the diesel tractor towing the electric trailer was outfitted with on-board sensing analysis and reporting (OSAR) devices and a predictive emissions monitoring system (PEMS) provided by University of California, Riverside, College of Engineering-Center for Environmental Research and Technology (UCR/CE-CERT).

Status
The build portion of the project required development over the course of more than twelve months in 2023 and 2024. The demonstration portion of the project occurred in Downey, California, at a beverage distribution fleet facility during October and November 2024. The performance evaluation portion of this project occurred throughout the demonstration and afterwards, through July 2025. This project has been completed, and the final report is on file with South Coast AQMD.

Results
The demonstration indicated that a large beverage fleet operator meaningfully improved the diesel fuel efficiency of its in-use diesel tractors (e.g., from a baseline of 7.28 mpg to 10.3 mpg on representative routes). During the demonstration, fleet tractors towing the electric trailer consumed about 269.1 gallons of diesel fuel over a total of 2,750 miles traveled. The average diesel fuel cost during the demonstration was ~$5.00 per gallon. As a result, a total of ~$1,345.50 was spent on diesel fuel (269.1 gallons x $5.00 per gallon). The baseline mpg for the fleet was 7.28 mpg. Accordingly, the fleet operator would have spent ~$1,888.73 on diesel fuel over the same 2,750 miles traveled during the demonstration if an electric trailer was not used ((2,750 miles / 7.28 mpg) x $5.00 per gallon). Reviewing diesel fuel

costs only, the fleet operators saved $543.23 by using the electric trailer. Presented differently, during the demonstration, 108.6 gallons of diesel fuel were saved (not consumed) by using the electric trailer. Additional fuel savings potential is available in the future after resolving end user operations issues. The demonstration also observed a reduction in emissions attributable to diesel fleet operations (e.g., in some instances -49% for PM and -17% for NOx, with promising outcomes for cold starts). Other positive results of the demonstration included confirming the ability to charge the electric trailer using existing warehouse power without making costly charging infrastructure upgrades as well as confirming the ease of training and operation of electric trailer users. While the demonstration results are certainly positive, we also recognized the challenge of evaluating fuel efficiency and emissions reduction benefits from operating innovative technologies in real operations. Accordingly, future demonstrations and evaluations will be beneficial to advance and refine helpful new technologies, such as the electric trailer. This project would not have been possible without the support of South Coast AQMD, UCR/CE-CERT, and a beverage distribution fleet based in Downey, California.

Benefits

The project demonstrated that electric trailer use in a trucking fleet is a potential, additional option for operators to incorporate a practical electrification solution into their commercial operations. Electric trailers offer the potential benefits of costs savings through increase in diesel fuel efficiency/decrease in diesel fuel consumption by the tractor, corresponding emissions reductions, and lower maintenance cost associated with the use of regenerative braking through use of the electric trailer's electric axle. Additional validation is required, but qualitative observations during the demonstration and testing indicate a meaningful potential for increasing safety benefits with the use of a tractor and electric trailer. Moreover, the electric trailer presents a commercial vehicle electrification option that may be deployed without significant utility side infrastructure upgrades or installation of fast charging, electric vehicle supply equipment because of longer dwell times that trailers have in operations relative to tractors or other commercial vehicles. A 480V 3-phase charger using existing facility circuits may be used to charge the electric trailer. Use of electric trailers presents a practical pathway for fleet operators to reduce emissions from trucking operations as they would be incentivized to deploy this technology to secure diesel fuel savings. The use of electric trailers would be especially compelling to fleet operators if such use was coupled with South Coast AQMD programs that separately incentivize adoption of electric equipment, such as the Warehouse Actions and Investments to Reduce Emissions Program administered by South Coast AQMD.

Project Costs

The total anticipated project cost forecasted at the start of the project was $4,242,000, which was comprised of $500,000 in South Coast AQMD funds and $3,742,000 in recipient in-kind match. The project was on budget throughout its lifetime. There was some cost savings realized during the electric trailer build process relating to refining parts requirements, which resulted in actual recipient in-kind match amounting to $3,687,144.

Commercialization and Applications

The electric trailer has real world potential applications on dry van and refrigerated trailers. Indeed, South Coast AQMD and Range are undertaking a follow-on demonstration to understand the financial and operations feasibility of using an electric trailer in refrigerated distribution fleet operations in the Basin. Range anticipates that the economic, and related emissions, benefits of operating the electric trailer in refrigerated operations will be greater than those potentially realizable for dry van applications because most transport refrigeration units also operate using a diesel motor. There are over five million dry van and refrigerated trailers in use in the United States, with hundreds of thousands of those trailers being used in California alone. None of those trailers use an electric trailer system like the one that was demonstrated in this project. There is a meaningful opportunity for fleet operators to reduce diesel fuel consumption and emissions meaningfully. Range is preparing for scaled commercialization of its electric trailer system in 2026, which will provide a ramp up period to allow the company to establish the needed infrastructure to commercialize, maintain, and improve the electric trailer system in the coming years.

South Coast AQMD Contract #24318 **December 2025**

Evaluation of Electric-Powered Trailer for Heavy-Duty Vehicles

Contractor

University of California, Riverside (UCR)

Co-Sponsors

South Coast AQMD

Project Officer

Dr. Tanfeng (Sam) Cao

Background

This study evaluated the feasibility and benefits of a battery-powered trailer assist system using federally approved measurement methods, supplemented with additional complementary approaches. The assessment compared regulated emissions from a baseline truck operating on standard routes with those from the same truck operating on the same routes with the same trailer providing propulsion assistance in hybrid mode and no assistance in conventional mode. Testing employed 40 Code of Federal Regulations (CFR) Part 1065, approved portable emission measurement systems (PEMS) methods and UCR's low-cost on-board sensing system. PEMS testing was conducted for one day on each mode, while OSAR collected continuous data over a month-long demonstration across two vehicles where load and conditions were changing.

Project Objective

The goal of this project is to evaluate real-world feasibility and benefit of the Range Energy battery power trailer assist system on diesel conventional trucks. To achieve this, UCR conducted activity data logging, in-use emissions testing, and long-term measurements using UCR's newly developed OSAR system (On-board Sensing Analysis and Reporting). The results are intended to inform stakeholders about the energy-saving potential of this trailer-assist technology. This evaluation also considers how certified engines perform under real-world, off-cycle conditions while using advanced technologies to reduce emissions.

Technology Description

This e-trailer consisted of two main activities: (1) building the prototype eTrailer (denoted as the hybrid vehicle) and (2) demonstrating that eTrailer in the operations of a beverage distribution fleet in the South Coast Air Basin. The build portion of the Project required extensive development over the course of 12+ months, with most development activities occurring at Range Energy's facility in Mountain View, California. The demonstration portion of the Project was based in Downey, California, at a warehouse operated by a large beverage distribution fleet. That warehouse served as the charging location for the eTrailer as well as the starting and ending points for demonstration routes.

Four commercial Class 8 heavy-duty trucks were used for emissions testing. All were Freightliner Cascadia models equipped with Detroit Diesel engines. Two trucks were operated under normal in-service conditions through the participating Reyes fleet, while the other two were operated by Range Energy. The model years ranged from 2017 to 2022, with engine displacements between 12.8 and 14.2 liters. An additional older 2016 vehicle was included to investigate the potential for higher particulate matter (PM) emissions and to quantify the PM reduction benefit of the trailer system, since previous tests showed very low tailpipe PM levels that the OSAR system could not reliably measure. Unfortunately, even this rented 2016 truck exhibited very low PM emissions, falling below the detection limits of both the OSAR system and the supplementary micro-soot sensor.

All vehicles were equipped with standard emissions-control technologies, including a diesel oxidation catalyst (DOC) for carbon monoxide (CO) and total hydrocarbons (THC), a diesel particulate filter (DPF) for PM, and a selective catalytic reduction (SCR) system for nitrogen oxide (NO_x). In-cylinder NO_x was further managed using exhaust gas recirculation (EGR). Odometer readings at the start of testing ranged from 47,422 to 584,456 miles.

Status

This project was completed successfully in May 2025. Comprehensive data analysis was completed in November 2025.

Results

The largest observed carbon dioxide (CO_2) reduction, over 50%, occurred during controlled A/B testing with the same truck, trailer, and load. This reduction is substantially higher than the 28% average observed during in-service operation and slightly above the overall average reduction of 43%. Cold-start and warm-start segments showed smaller benefits, with reductions of approximately 25% and 30%, respectively. All CO_2 emission differences were statistically significant for the MY 2022 vehicle, the in-service 2017 fleet vehicle, and the MY 2016 vehicle once a single outlier data point was removed for the MY 2016 vehicle. Overall, the hybrid trailer assist system appears capable of improving fuel economy by roughly 25–50%, with controlled-route comparisons showing an average improvement of 43%, see Fig 1.

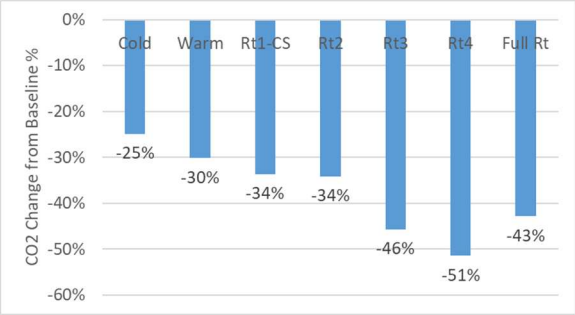


Fig. 1: CO2 emissions percent change

NO_x emissions measured with the OSAR system and both PEMS tests for the late-model (2022) and older (2016) vehicles were very low and ranged between 3 g/mi (0.75 g/hp-hr) measured by the OSAR system to as low as 0.2 g/mi (0.05 g/hp-hr) measured by PEMS. It is important to note that some results may show NOx emissions rates exceeding certification standards. This should not be interpreted as a certification failure but rather as a demonstration of the differences between standardized certification duty cycles and real-world in-use conditions.

The observed mean differences in NO_x and PM emissions between the conventional and the hybrid tests were not statistically significant, indicating that the hybrid trailer system neither increased nor decreased these emissions relative to the conventional configuration. Other pollutants, including NO_2, CO, and hydrocarbon (HC), were also not statistically significant due to low concentrations and relatively large variability, see Fig 2 and 3.

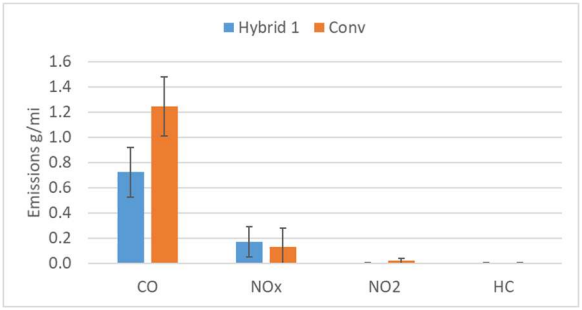


Fig. 2: NOx emissions comparison

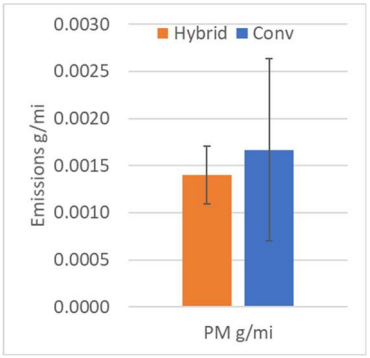


Fig. 3: PM emissions comparison

Benefits

In this study, we assessed a hybrid trailer assist system appears capable of improving fuel economy by roughly 25–50%, with controlled-route comparisons showing an average improvement of 43%. The hybrid trailer system neither increased nor decreased these emissions relative to the conventional configuration. With low load SCR performance being introduced into the market by 2027, it is possible that NOx emissions maybe reduced with hybridizing. To fully evaluate potential NO_x reductions, testing under laboratory-grade conditions with high-precision analyzers may be necessary

Project Costs

	SCAQMD
Testing & Reporting	$50,000

Commercialization and Applications

A hybrid trailer assist system appears capable of improving fuel economy by roughly 25–50%, with controlled-route comparisons showing an average improvement of 43% for the reductions of harmful pollutants and GHG emissions.

Appendix D

List of Acronyms

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LIST OF ACRONYMS

AB—Assembly Bill
AC—alternative current
ACF—Advanced Clean Fleets Regulation
ACS—alternative charging solution
ACT—advanced clean transportation, Advanced Clean Trucks Regulation
AID—Zero Emission Freight Vehicle Advanced Infrastructure Demonstration Project
APCD—Air Pollution Control District
APCI—Air Products and Chemicals, Inc.
APM—APM Terminals
AQMD—Air Quality Management District
AQMP—Air Quality Management Plan
ARCHES—Alliance for Renewable Clean Hydrogen Energy Systems
ATDPP—Advanced Technology Demonstration and Pilot Projects
BAAQMD—Bay Area Air Quality Management District
BE—battery electric
BESS— battery energy storage system
BET—battery electric tractor / battery electric truck
BEV—battery electric vehicle
BIF—Balboa Island Ferry
BMS—battery management system
CAPP—Community Air Protection Program
CARB—California Air Resources Board
CATI—Clean Air Technology Initiative
CCS1—combined charging system combo 1
CEC—California Energy Commission
CEI—Clean Energy Institute
CERP—Community Emission Reduction Plan
CE-CERT—College of Engineering/Center for Environmental Research & Technology
CFAG—Clean Fuels Advisory Group
CFR—code of Federal regulations
CH4—methane
CharIN—Charging Interface Initiative
CHBC—California Hydrogen Business Council
CHE—cargo handling equipment
CI—carbon-intensity
CNG—compressed natural gas
CO—carbon monoxide
CO_2—carbon dioxide
CORE—Clean Off-Road Equipment Voucher Incentive Project
CPRG—Climate Pollution Reduction Grants
CPUC—California Public Utilities Commission
CRD—cavity ring-down
CSULB—California State University, Long Beach
CWI—Cummins Westport, Inc.
CY—calendar year
DC—direct current
DER—distributed energy resource
DERA—Diesel Emissions Reduction Act
DMV—Department of Motor Vehicles
DOC—diesel oxidation catalyst
DOE—Department of Energy
DOT—Department of Transportation
DPF—diesel particulate filter
DPM—diesel particulate matter
DTNA—Daimler Trucks North America LLC
EGR—exhaust gas recirculation
EJ—environmental justice
EMS—energy management system
EPRI—Electric Power Research Institute
ePTO—electric power take-off
EtO—ethylene oxide
eTrailer—electric trailer
eTRUC—Electric Truck Research and Utilization Center
EV—electric vehicle
EVSE—electric vehicle supply equipment
FC—fuel cell
FCET—fuel cell electric truck
FCEV—fuel cell electric vehicle
FCT—fuel cell truck
FCV—fuel cell vehicle
FEF—FirstElement Fuel, Inc.
FY—fiscal year
g/bhp-hr—grams per brake horsepower hour
GDI—gasoline direct injection
GGRF—Greenhouse Gas Reduction Relief Fund
GHG—greenhouse gas
Go-Biz—Governor's Office of Business and Economic Development
GPS—global positioning system
GTL—gas to liquid
H2—hydrogen
H2FCP—Hydrogen Fuel Cell Partnership
H2-ICE—hydrogen internal combustion engine
H&SC—California Health and Safety Code
HC—hydrocarbon
HD—heavy duty
HD BET—heavy-duty battery electric truck
HD I/M—heavy-duty inspection and maintenance
HDV—heavy-duty vehicle
HFCE—hydrogen fuel cell electric
HVAC—heating, ventilation, and air conditioning
ICE—internal combustion engine
INVEST CLEAN—Infrastructure, Vehicles, and Equipment Strategy for Climate, Equity, Air Quality, and National Competitiveness
IOU—investor-owned utilities
ISR—Indirect Source Rule
IVOC—intermediate volatility organic compound

LIST OF ACRONYMS (cont'd)

JETSI—Joint Electric Truck Scaling Initiative
kg—kilogram
kW—kilowatt
kWh—kilowatt-hour
LACI—Los Angeles Cleantech Incubator
LADWP—Los Angeles Department of Water and Power
LAX—Los Angeles Airport
LCFS—Low Carbon Fuel Standard
LD—light-duty
LDV—light-duty vehicle
LIGHTS—Low Impact Green Heavy Transport Solutions
LNG—liquefied natural gas
LPG—liquefied petroleum gas or propane
M&V—measurement & verification
MATES—Multiple Air Toxics Exposure Study
MCS—megawatt charging system
MD—medium duty
MD/HD— medium- and heavy-duty
mpg—miles per gallon
MPDGE—miles per diesel gallon equivalent
MSRC—Mobile Source Air Pollution Reduction Review Committee
MW—megawatt
MWh—megawatt hour
MY—model year
NAAQS—national ambient air quality standards
NACS—North American Charging Standard
NAFA—National Association of Fleet Administrators
NATTS—National Air Toxics Trends Stations
NG— natural gas
NGV—natural gas vehicle
NGO—non-governmental organization
NH3—ammonia
NLR—National Laboratory of the Rockies
NMHC—non-methane hydrocarbons
NO_2—nitrogen dioxide
NOx—nitrogen oxide
NREL—National Renewables Energy Laboratory
NZ—near zero
NZE—near zero emission
OBD—on-board diagnostics
OCTA—Orange County Transit Authority
OEM—original equipment manufacturer
OSAR—Onboard Sensing, Analysis and Reporting
P2G—power-to-gas
PAH—polycyclic aromatic hydrocarbons
PEM—proton exchange membrane
PEMS—predictive emissions monitoring system, portable emissions measurement system
PHEV—plug-in hybrid vehicle
PM—particulate matter / permanent magnet
PM2.5—particulate matter ≤ 2.5 microns
PM10—particulate matter ≤ 10 microns
PN—particle number
POLA—Port of Los Angeles
POLB—Port of Long Beach
PON—Program Opportunity Notice
ppb—parts per billion
ppt—parts per thousand
QA/QC—quality assurance / quality control
R&D—research and development
RDD&D (or RD3)—research, development, demonstration and deployment
RFI—Request for Information
RFP—Request for Proposal
RNG—renewable natural gas
RTG—rubber tire gantry
SAE—Society of Automotive Engineers
SB—Senate Bill
SCAB—South Coast Air Basin or "Basin"
SCAG—Southern California Association of Governments
SCAQMD—South Coast Air Quality Management District
SCE—Southern California Edison Company
SCR—selective catalytic reduction
San Diego APCD—San Diego Air Pollution Control District
Shell—Shell Oil Products USA
SIP—State Implementation Plan
SJVAPCD—San Joaquin Valley Air Pollution Control District
SMAQMD—Sacramento Metropolitan Air Quality Management District
SOA—secondary organic aerosol
SOC—state-of-charge
SoCalGas—Southern California Gas Company (A Sempra Energy Utility)
South Coast AQMD—South Coast Air Quality Management District
SOx—sulfur oxides
SPEED—Strategic Pathways for Extended Electric Drayage
SwRI—Southwest Research Institute
TAAG—Technology Advancement Advisory Group
TAC—toxic air contaminants
TAI—Toyota Tsusho America, Inc.
TAO—Technology Advancement Office
TCO—total cost of ownership
THC—total hydrocarbons
TILDAS—Tunable Infrared Laser Direct Absorption Spectroscopy
TOU—time-of-use
tpd—tons per day
TRL—technology readiness level

LIST OF ACRONYMS (cont'd)

TRU—transportation refrigeration unit
U.S.—United States
U.S. EPA—United States Environmental Protection Agency
UCD—University of California, Davis
UCI—University of California, Irvine
UCLA—University of California, Los Angeles
UCR—University of California, Riverside
UCR/CE-CERT—UCR/College of Engineering/Center for Environmental Research & Technology
UL—Underwriters Laboratories
UPM—ultrafine particulate matter
UPS—United Postal Service
V2B—vehicle-to-building
V2G—vehicle-to-grid
V2H—vehicle-to-home
V2X—vehicle-to-everything
VC—Vehicle Code
VMT—vehicle miles traveled
VOC—volatile organic compounds
WAIRE—Warehouse Actions and Investments to Reduce Emissions Program
WAVE—wireless advanced vehicle electrification
WBCT—West Basin Container Terminal, LLC
ZANZEFF—Zero and Near Zero Emission Freight Facilities
ZE—zero emission
ZECT—Zero Emission Cargo Transport
ZEDT—Zero Emission Drayage Truck
ZET—zero emission truck
ZEV—zero emissions vehicle

South Coast Air Quality Management District

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