Appendix D: Long-Term Heavy-Duty Investment Strategy

Including Fiscal Year 2024–25 Three-Year Recommendations for Clean Transportation Incentives

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Executive Summary

The California Air Resources Board's (CARB's) Long-Term Heavy-Duty Investment Strategy (hereafter referred to as the "Strategy") serves as a roadmap for Low Carbon Transportation and Air Quality Improvement Program (AQIP) incentives (collectively known as Clean Transportation Incentives), specific to the heavy-duty (HD) transportation sector, to help achieve the State's climate change and air quality goals, and it also fulfills the requirements outlined in Senate Bill (SB) 1403 (Lara, Chapter 370, Statutes of 2018). Each year, CARB updates and refines its priorities for the technologies and project categories that merit investments to help the State reach its goals. CARB strives to maximize benefits for priority populations, and the projects funded by these investments include specific support to the communities most impacted by poor air quality. In addition, CARB has been shifting from broad purchase incentives to more targeted incentives for those who need them most, building on previous efforts to ensure that investments are equitably distributed.

The Strategy identifies priority focus areas and recommended levels of incentive funding. The levels of funding represent a critical down payment toward meeting these goals but do not approach the entire amount needed to achieve all of the State's goals, listed on pages 1-3 through 1-5 of the Fiscal Year (FY) 2024-25 Funding Plan for Clean Transportation Incentives. Emphasis is placed on the strategic use of State investments to incentivize the development and market expansion of clean HD vehicle and off-road equipment technologies – complementary to CARB's regulatory requirements. Regulations such as the Advanced Clean Fleets regulation are critical to achieve large-scale adoption of zero-emission (ZE) technologies in the heavy-duty sector, while incentives play an important complementary role to support early technology advancement and help meet the unique needs of small fleets and small businesses.

The Strategy also includes metrics to help assess the performance of Clean Transportation Incentives projects. These include targeted metrics that address ways to support healthy communities, grow the green economy, and encourage technology evolution.

Successful deployments of ZE truck and bus technologies from previous investments have been instrumental in advancing the on-road zero-emission vehicle (ZEV) market to where it is today, with a wide array of vehicles and equipment available on the commercial market. Recent investments in the development and demonstration of heavier and more specialized ZE off-road vehicles and equipment have resulted in a growing list of commercial products in the off-road sector. Continued commitment to these markets in the form of commercial incentives and funding for demonstration and pilot projects will play a critical role in meeting California's air quality and climate goals; promoting equity by ensuring that investments benefit the communities most impacted by poor air quality and provide assistance to small fleets and owner-operators; supporting high-quality jobs; and enhancing California's leadership role as an incubator and marketplace for clean, ZE technology.

Table D-1: Focused Recommendations for Clean Transportation Incentives Priorities[1]

Category	FY 2025–26	FY 2026–27	FY 2027–28
Demos and Pilots	$290–$450 Million ZE Line-Haul Rail, AT Aviation, AT Ocean-Going, ZE/Hybrid Marine, ZE Ag/Construction/Mining/Heavier CHE, Emergency and Heavy Specialty Equipment, Hydrogen and Off-Road ZE Ecosystems, Green Zones	$325–$515 Million ZE Line-Haul Rail, ZE Light Aviation, AT Heavy Aviation, AT Ocean-Going, ZE Marine, ZE Ag and Heavier Construction/Mining/CHE, Emergency and Heavy Specialty Equipment, Hydrogen and Off-Road ZE Ecosystems, Green Zones	$360–$480 Million ZE Line-Haul Rail, ZE Light Aviation, AT Heavy Aviation, AT Ocean-Going, ZE Marine, ZE Heavy Ag/Construction, ZE Extra-Specialty, Hydrogen and Off-Road ZE Ecosystems, Green Zones
Market Acceleration	$560–$610 Million ZE Construction and Heavier CHE, ZE Switcher Rail, ZE/Hybrid Marine, Heavy/Specialty ePTOs, ZE Long Haul Trucks, Temp. Fueling	$450–$545 Million ZE Construction/Mining and Heavier CHE, ZE Switcher Rail, ZE/Hybrid Marine, Heavy/Specialty ePTOs, ZE Long Haul Trucks, Temp. Fueling	$530–$830 Million ZE Ag and Heavier Construction/ Mining/CHE, ZE/Hybrid Marine, Emergency and Heavy Specialty Equipment
Market Equity	$640–$660 Million ZE Drayage/Small Fleets, ZE Forklifts, ZE School/Transit, Financing and Insurance Assistance, Secondary Market Support	$620–$655 Million ZE Drayage/Small Fleets, ZE Forklifts, ZE School/Transit, Financing and Insurance Assistance, Secondary Market Support	$260–$320 Million ZE Long Haul Trucks, ZE Drayage/Small Fleets, ZE Forklifts, ZE School/Transit, Secondary Market Support, ZE Switcher
Total Funding	$1,490–$1,720 Million*	$1,395–$1,715 Million*	$1,150–$1,630 Million*

*The vehicle and equipment types listed in the table above are a prioritized selection of the project types that CARB would invest in, given sufficient available funds. These focus areas are identified utilizing the strategy laid out in this document. This is not an exhaustive list of technologies or applications that Clean Transportation Incentives would fund, and total funding recommendations are not limited to existing appropriations.

[1] Acronym key: advanced technology (AT), battery electric (BE), cargo handling equipment (CHE), electric power take-off (ePTO), hydrogen fuel cell (FC)

Introduction

California has invested billions of dollars to date with the goal of accelerating the development and adoption of the cleanest available technologies. These investments further California's work toward improving community sustainability, reducing overall carbon emissions and criteria air pollutants, and reducing exposure to toxic air contaminants. Meeting the State's goal of carbon neutrality by 2045 can help reduce the adverse impacts of climate change and provide Californians healthier air to breathe. Making the transition equitably requires repairing the harms caused by decades of discriminatory transportation, land use, and housing practices and building more inclusive and equitable places that prioritize providing vulnerable communities with opportunities to thrive.

Medium- and heavy-duty vehicles[2] and off-road equipment continue to be the largest source of criteria pollutants, including diesel particulate matter (PM), a toxic air contaminant directly linked to adverse health impacts. Reducing HD emissions, especially with ZEV technology, is a key element of this Strategy.

The Strategy serves as a roadmap for how CARB plans to invest its Low Carbon Transportation and AQIP funding (collectively known as Clean Transportation Incentives) on a variety of HD on- and off-road technologies. Included in this document is a discussion on the overall CARB incentive funding portfolio and the critical role that Low Carbon Transportation and AQIP play in complementing regulations and increasing adoption of ZE technology. This document also details a strategy for investing these funds, which includes continuing support for previous investments and focusing those investments where they will be most impactful.

California continues to lead the way in fostering the development of ZE technologies and improving their equitable distribution. CARB is working closely with other agencies to support sector-wide clean HD technology adoption, for example through its efforts with the California Energy Commission (CEC) to support the deployment of ZE infrastructure. CARB also continues its history of building a broad suite of regulatory actions to reduce emissions from the transportation sector, including the Advanced Clean Fleets (ACF) and companion Advanced Clean Trucks (ACT) regulations, the Innovative Clean Transit (ICT) regulation, the ZE Forklift regulation, Commercial Harbor Craft Regulation, and the Ocean-Going Vessels at Berth regulation – complemented by a comprehensive incentive portfolio that supports technologies from the pre-commercial phase all the way through legacy fleet turnover.

In addition to the regulations mentioned above and the statutory drivers detailed in the FY 2024-25 Funding Plan for Clean Transportation Incentives, several other CARB-produced documents help guide CARB investments. Most notably, the Mobile Source Strategy and

[2] On-road medium- and heavy-duty vehicles encompasses all non-light-duty vehicles from class 2b through class 8 (8,501 pounds gross vehicle weight rating or higher). Together with off-road equipment, this is referred to collectively as heavy-duty, or HD.

the California Sustainable Freight Action Plan provide a key focus with specific strategies relevant to the HD vehicle and off-road sectors. The Mobile Source Strategy is the State's integrated plan that identified the level of need for cleaner mobile source technologies needed to achieve California's many air quality, climate, and community risk reduction goals.[3] The California Sustainable Freight Action Plan is designed to integrate investments, policies, and programs across several State agencies to help realize a singular vision for California's freight transport system.[4] Additional key guiding documents include the California State Implementation Plans (SIPs), the 2017 Climate Change Scoping Plan, the 2016 ZEV Action Plan, the ZEV Market Development Strategy, the Cap-and-Trade Auction Proceeds Investment Plan, the California Sustainable Communities and Climate Protection Act 2018 Progress Report, and the SB 350 Low Income Barriers Study, Part B: Overcoming Barriers to Clean Transportation Access to Low Income Residents.

Every year, the content, structure, and format of the Strategy evolve to reflect current conditions. This year's document makes several changes from previous years, in part due to the continuing shift of CARB investment priorities from driving technology advancement to helping to achieve equity. Much of the technology described in the Strategy – particularly in the on-road space – has already advanced to the point where it no longer needs to be updated and included here. In the off-road space, however, there are still opportunities to achieve further advances in technology. Accordingly, much of the discussion on technology status focuses on the off-road sector for this year's Strategy.

Background

This document represents the eighth update of the Strategy; the first iteration was developed as a companion document to the FY 2017–18 Funding Plan. The following year, the legislature defined the Strategy in statute. Senate Bill (SB) 1403 (Lara, Chapter 370, Statutes of 2018) directed CARB to produce annually a three-year investment strategy for Low Carbon Transportation and AQIP investments, beginning with FY 2019–20, along with Three-Year Recommendations for Clean Transportation Incentives , appearing in this document as Table D-1 and Table D-2. According to statute, the Strategy must:

- Describe the role of public investments in supporting the demonstration and deployment of advanced HD and off-road technologies;
- Provide an assessment of the investment needed from Low Carbon Transportation and AQIP funds;
- Describe CARB's portfolio of investments; and

[3] CARB. *2020 Mobile Source Strategy*. *https://ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy*

[4] *California Sustainable Freight Action Plan*. July 2016. *https://ww2.arb.ca.gov/sites/default/files/2019-10/CSFAP_FINAL_07272016.pdf*

- Include a report on the State's school bus fleet in consultation with CEC, providing information related to milestones achieved by the State's school bus incentive programs and the projected need for funding, taking into consideration the State's school bus inventory, turnover, and useful life (Appendix E of the Funding Plan).

The Role of Incentives and CARB Portfolio of Heavy-Duty Funding

In its ongoing effort to reduce criteria and climate pollutant emissions from the transportation sector, California has allocated billions of dollars to a multitude of programs, with different but complementary goals. CARB's portfolio emphasizes technology advancement, the accelerated deployment of ZE HD vehicles and off-road equipment, turnover of the legacy fleet, and equitably distributed investments. These efforts to incentivize clean technologies complement CARB's regulatory efforts that ensure these technologies are deployed in strategic and impactful ways that support the State's climate and low-carbon transportation goals.

CARB's incentive programs work hand-in-hand with its regulatory programs to accelerate the reduction of HD emissions. Incentives can play an important role in each stage of the commercialization pathway. At the earliest stage, incentives to demonstrate pre-commercial technologies help bring them to market and prepare for future regulatory requirements. Early investments in emerging solutions de-risks technology providers to bring them to market sooner. Once commercialized, incentives help to drive early adopter purchase decisions by reducing incremental costs and supporting vehicle and equipment cost reductions over time by building manufacturer economies of scale. As regulatory requirements approach, CARB's incentive strategy shifts toward providing financial and other assistance for smaller businesses that face unique challenges switching to ZEVs. In some incentive programs, limited incentives remain available once regulations are in effect for generating emission reductions beyond what is required by the regulations.

CARB administers a portfolio of incentive programs, each with its own statutory requirements or policy goals, and often specializing in specific commercialization stages. Technologies progress across the commercialization pathway, and often transition to the next program in the funding succession, and eventually away from incentives completely as they become more established in the market.

Clean Transportation Incentives projects can help to rapidly advance technology to meet California's long-term climate, air quality, and community protection goals. These project types fund advanced technologies in their early stages, starting with demonstration and pilot projects and continuing through the early stages of commercialization, and generally do not require scrappage. Low Carbon Transportation and AQIP funds play a growing role in assisting small businesses to successfully deploy the cleanest available technologies.

As a technology reaches market scale, other programs within CARB's portfolio play a primary role, such as the Carl Moyer Memorial Air Quality Standards Attainment Program

(Moyer), the Volkswagen (VW) Mitigation Trust, Community Air Protection Program (CAPP), and Funding Agricultural Replacement Measure for Emission Reductions (FARMER). These programs focus on achieving cost-effective emission reductions, especially in disadvantaged communities (DACs), that are not otherwise required by law. These programs tend to focus on turning over the existing fleet at an accelerated pace and often require additional measures such as scrappage. Scrappage programs provide additional emission benefits because an older, polluting vehicle must be taken off the road as a condition for funding a clean replacement.

CARB will continue to coordinate its overall investment strategy across the broader portfolio of incentive programs, both within the agency and with other local, state, and federal partners. State and air district programs complement CARB's work with vehicles and other project elements. As a key example, infrastructure investments by CEC (for example through the EnerGIIZE program[5]), transportation agencies, and utilities help to support the deployment of ZE trucks, buses, and off-road equipment. The Inflation Reduction Act of 2022 provides federal funding that complements CARB and other State agency programs. The federal Infrastructure Investment and Jobs Act also provides funding, particularly for transportation infrastructure projects.

With multiple goals guiding State action on clean HD vehicles and off-road equipment, maintaining multiple programs with different but complementary objectives is necessary. CARB's portfolio of programs is designed to achieve emissions reductions and emphasizes community protection, with investments focused on priority populations.

[5] EnergIIZE (Energy Infrastructure Incentives for Zero-Emission) Commercial Vehicles Project. *https://www.energiize.org/*

Programmatic Metrics for Clean Transportation Incentives

In addition to identifying priority focus areas and recommending levels of incentive funding, this document also includes metrics to help assess the performance of Clean Transportation Incentives projects in meeting the requirements of SB 1403. CARB has identified three broad categories that define success for these programs with some overlap between the three: (1) Supporting Healthy Communities, (2) Growing the Green Economy, and (3) Encouraging Technology Evolution.

CARB continues to work with stakeholders for input on metrics to refine and improve how we measure the success of our Clean Transportation Incentives projects. These metrics have historically focused solely on data from the Clean Truck and Bus Voucher Incentive Project (HVIP) and the Clean Off-Road Equipment Voucher Incentive Project (CORE). Additional data is now available from other incentive programs, including CARB's Advanced Technology Demonstration and Pilot Projects, and is incorporated into the Strategy as available. All programmatic metrics shown in this year's Strategy have been updated with data through April 30, 2024.

Summary of Incentive Accomplishments

94+ MILLION

MILES TRAVELED

There were 94,793,650 zero-emission miles traveled in California by HVIP-funded vehicles between 2010 and 2024.

989+ THOUSAND

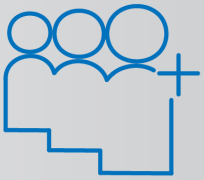
EQUIPMENT RUNTIME

CORE-funded zero-emission off-road equipment has been used for 989,077 hours in California between 2020 and 2024.

36+ THOUSAND

JOBS CREATED

The incentive dollars spent through HVIP and CORE have created over 10,000 jobs and spurred over 26,000 jobs from private investment, totaling over 36,000 jobs.



Supporting Healthy Communities

An essential part of CARB's mission is to protect the health of Californians from the harmful effects of air pollution – particularly for priority populations that are disproportionately impacted. To date, 51% of vouchers (HVIP and CORE combined) have funded vehicles and equipment deployed in disadvantaged and low-income communities. Those vehicles have traveled more than 353 million cleaner-than-diesel miles in disadvantaged communities (DACs), as defined by CalEnviroScreen,[6] which amounts to approximately 79% of all cleaner-than-diesel miles traveled in California by funded vehicles. This includes more than 94 million zero-emission miles in California logged by funded ZEVs.

Equity is a key factor for CARB to consider when creating and implementing incentive programs. Tracking voucher incentives received by public and small fleets enables accountability to CARB's goals for supporting the fleets in greatest need of assistance. Between 2021–2024, 57% of all HVIP vouchers went to public or small private fleets[7], and in 2024 alone, that group received 81% of HVIP vouchers.

[6] California Communities Environmental Health Screening Tool (CalEnviroScreen) 4.0. *https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40*

[7] Small private fleets are defined by HVIP as those with 20 or fewer medium- and heavy-duty vehicles and less than $15 million in annual revenue.

51
PERCENT

VOUCHERS IN PRIORITY POPULATION AREAS

Fifty-one percent of vouchers (HVIP and CORE combined) have funded vehicles and equipment deployed in priority population areas, as identified by California Climate Investments.

353
MILLION

DAC MILES TRAVELED

HVIP-funded vehicles have traveled approximately 353 million miles in DACs, as identified in CalEnviroScreen.

63
PERCENT

SMALL AND PUBLIC FLEET SUPPORT

Sixty-three percent of FY 2021-2024 HVIP vouchers were given to public or small fleets (private entities with <$10 million annual revenue or fewer than 50 employees).

Industry Example

Small Fleets Make Big Moves

Small fleets make up the majority of California's trucking fleets – approximately 99% of fleets operating Class 2b–8 vehicles have fewer than 50 trucks. These fleets face unique challenges adopting ZEVs, and CARB has increasingly focused its investments on helping these fleets.

- In 2022, CARB launched the Innovative Small e-Fleet Pilot Project, which provides operational and financial flexibility to small fleets looking to incorporate ZEVs into their business.
- Concurrently, CARB created Cal Fleet Advisor, a free technical assistance program for California fleets.
- Furthermore, HVIP recently doubled voucher amounts for public and nonprofit fleets with 20 or fewer medium- and heavy-duty vehicles, and for private fleets of the same size with less than $15 million in annual revenue.

Providing these resources and voucher enhancements has greatly increased the participation of small fleets in HVIP. Since 2021, the number of vouchers requested by small fleets has increased each year, with more than 700 vouchers given to small fleets in 2023 alone – accounting for approximately 63% of all vouchers that year. The percentage of vouchers given to small fleets is up to 81% so far in 2024. Cal Fleet Advisor continues to assist small fleets in their journey to ZE, with nearly 500 small fleets receiving assistance through the program.

By addressing the unique barriers small fleets face, CARB is paving the way for a more sustainable and equitable transportation future. An increased focus on supporting smaller fleets' adoption of ZE technology in California will help the state achieve its emissions reduction goals while ensuring that all fleets can benefit from the total cost savings of operating zero emission technologies, and that communities benefit.

Growing the Green Economy

CARB's investments are intended to create additional economic benefits where possible. Consistent funding for clean technology projects helps to attract clean tech manufacturing to California and the United States, bringing high-quality jobs and fostering the development of a valuable industry. The HVIP and CORE catalogs now offer 447 models from 114 different original equipment manufacturers (OEMs). Since 2010, HVIP and CORE have funded over $1.6 billion toward the purchase of 15,390 vehicles or equipment, with approximately $400 million of that funding happening in the past year. To date, 15% of HVIP vouchers and 32% of CORE vouchers have gone to OEMs with manufacturing facilities in California.

$1.6+ BILLION

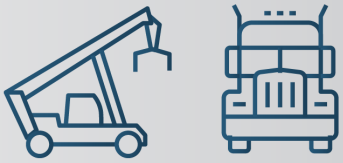
VEHICLE PURCHASE

HVIP and CORE have funded $1.6 billion toward the purchase of 15,390 clean vehicles and equipment since 2010.

447 MODELS

MANUFACTURERS

There are 114 HVIP- and/or CORE-eligible manufacturers offering 447 vehicle or equipment models.



$4.4 BILLION

TOTAL INVESTMENT

Additional public and private spending toward these purchases totaled $4.4 billion—over $3 for every $1 of voucher investment. Leveraged private spending represents purchases redirected from traditional technologies to clean technologies.

Encouraging Technology Evolution

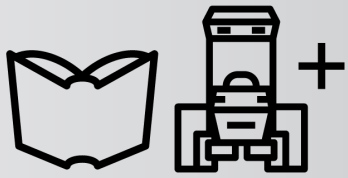
Clean technologies for some demanding applications, such as ocean-going vessels and aviation, are not yet available at commercial scale. CARB investments can help to spur the development, improvement, and commercialization of needed advanced technologies in for demanding applications. Specifically, demonstration and pilot projects will help advance ZE and other emission-reducing technologies for demanding applications and provide opportunities for innovative solutions to achieve emission reductions. To date there has been $436 million encumbered for demonstration and pilot projects, with $424 million of that benefitting priority populations. These 34 projects have collectively produced more than 750 vehicles and equipment – many of them world firsts – from a battery-electric freight locomotive and fuel cell passenger ferry to large-scale deployments of zero-emission trucks.

Feedback from those purchasing and operating advanced technology vehicles and equipment is valuable for understanding fleet attitudes and perceptions of new vehicle technology from early adopters. One of the best indicators of satisfaction is when a fleet that participated in an incentive project continues to express interest in or procure additional advanced technology vehicles or equipment. Surveys this year found that 84% of HVIP survey respondents indicated that they plan to purchase additional HD ZEVs within the next five years.

123
MODELS

CORE NEW TECHNOLOGY

Since July 2023, 123 new off-road equipment models or model-year updates have been added to CORE's catalog.



84
PERCENT

FUTURE ZEV PURCHASES

Eighty-four percent of HVIP voucher recipients surveyed plan to purchase additional medium- and heavy-duty zero-emissions vehicles within the next five years.

While current criteria for monitoring success across the three metric categories provide valuable feedback on the effectiveness of CARB investments, there are additional benefits that are not yet reflected. CARB will continue to work with stakeholders to solicit, develop, refine, and implement additional metrics that better communicate the full range of benefits accruing from Clean Transportation Incentives.

Technology and Market Status Updates

Assessing the technology and market readiness of key ZE vehicle and equipment platforms is an important part of ensuring the long-term effectiveness of this Strategy, tracking progress toward goals, and helping to set priorities for funding. Fundamentally, Clean Transportation Incentive funding is tasked with achieving greenhouse gas (GHG) reductions and other co-benefits through strategic investments in advanced technologies, with the end goal of broader market acceptance and greater equity. This Strategy takes a two-pronged approach, beginning with technology readiness and then assessing market readiness. Technology readiness refers to the ability of a platform to perform comparably to conventional counterparts and is a general assessment of the status of a vehicle or piece of equipment on the path to commercialization. In this process, the technology moves from the pre-commercial demonstration stage to larger scale early commercial deployments in the pilot stage, and finally to a stage of full commercial availability. This is complemented by market readiness: the market and economic factors that can potentially affect the success and uptake of what would otherwise be a technologically advanced, commercially viable platform. The goal of tracking technology and market readiness is to provide better-informed directional guidance on where technology platforms are in terms of technology readiness for the market and determining how best to help facilitate further adoption. This approach allows CARB to formulate more nuanced and effective funding recommendations and priorities.

In recent years, both on- and off-road clean technology platforms have made significant progress along the commercialization arc. For on-road technology platforms, every major OEM and several start-ups now have ZE models available for fleets to purchase, demonstrating commercial readiness, manufacturer confidence, and increased market acceptance. The same can be said for many smaller off-road technology platforms, such as lighter versions of forklifts, wheel loaders, and excavators. Heavier off-road technologies that are used in demanding applications such as mining, rail, agriculture, and construction will benefit from further technological advancements aided by investments in the form of demonstration and pilot projects. Deployments of such equipment in Europe and Asia may accelerate the arrival of similar products in the United States. Projects focused on demanding applications may include creating a more favorable ecosystem for hydrogen, additional deployments of commercial harbor craft, large-scale agricultural electrification, and initial explorations of advanced aviation propulsion technologies.

In the past year, there have been steady technology improvements among several ZE equipment platforms, specifically rail locomotives, telehandlers and cranes/materials handlers in construction, heavy airport ground support equipment (GSE) such as pushback tractors and aircraft tugs, and various types of commercial harbor craft such as ferries and tugs. Earlier this year, the Port of San Diego received a battery-electric tugboat, the first of its kind in the United States. A new ZE locomotive project began in 2024, with a hydrogen fuel cell locomotive in San Bernardino being tested by the San Bernardino County Transportation Authority. The South Coast Air Quality Management District (SCAQMD) is

demonstrating a battery-electric twin roller compactor for construction in the Coachella Valley. In addition to these projects, there are many more ZE off-road pilots and demos taking place all over California. These projects involving an array of off-road platforms underscore CARB's commitment to encouraging technological innovation and continued development of ZE technology in demanding applications.

As ZE vehicles and equipment achieve technology readiness, more widespread adoption becomes dependent on achieving a sufficient level of market readiness. Market and economic factors are key to ensuring the ultimate success of technologically advanced, commercially viable vehicle or equipment platforms. In recent years, substantial advancements have been made to help reduce or eliminate market barriers for on-road vehicles. The ZEVs available today can meet a diverse range of duty cycles and operational demands and are well-positioned for broader adoption. To achieve this broader adoption, regulations play a pivotal role. Regulations can require OEMs to manufacture and sell an increasing number of ZEVs each year and ensure larger fleets purchase them, helping meet the State's climate and air quality goals.

To foster an inclusive and equitable shift to ZE technology, support for small fleets and those in priority communities will still be needed. This includes targeted incentives, technical assistance programs, and additional wrap-around support specifically designed to mitigate the unique challenges faced by these groups. Expanding the resources available to fleets continues to be a priority for CARB. Resources such as a used ZEV voucher program, temporary charging assistance, and others will be investigated further to understand their feasibility and benefits. By focusing on equity, CARB can help to create a more just and sustainable transportation ecosystem that ensures no fleet gets left behind and the most impacted communities, that have been hit the hardest by the ongoing use of fossil fuels, receive public health benefits.

Industry Example

San Diego Welcomes America's First Battery-Electric Tugboat

The maritime industry plays a vital role in regional commerce and the global economy, contributing around 3% of the world's greenhouse gas emissions. However, unique duty-cycle demands and design criteria make decarbonization and emission reduction a greater challenge. Decreasing emissions will require a combined effort from vessel operators, shipyards, engineers, and all levels of government. By focusing on commercial harbor craft, it is possible to bring cleaner technology closer to shore and the communities most impacted by maritime pollution.

In March 2024, the first all-electric tugboat in the United States arrived at the Port of San Diego. The eWolf, a battery-electric harbor tugboat capable of zero-emission operations, owned and operated by Crowley Maritime Corporation, is replacing a traditional diesel tugboat and is predicted to save 3,200 metric tons CO2e in the first 10 years of operation. This is an important step in creating cleaner air for the port-adjacent communities and for Crowley to meet their commitment to be net-zero carbon by 2050. The battery-electric tugboat received funding from several public entities, including the San Diego Air Pollution Control District, U.S. Environmental Protection Agency (EPA), and the Department of Transportation's Maritime Administration.

As the eWolf begins operating this year, the aim is that it is seen as a viable solution for more ports in California. The immediate benefits of reduced air and noise pollution are important for Crowley, the Port of San Diego, and California as they work toward a cleaner future for commercial harbor craft.

Priorities for Clean Transportation Incentives

Each year, the Strategy includes an updated assessment of projected funding needs and recommended priority investment areas for Clean Transportation Incentives.

Priorities guiding this year's update include:

- A growing focus on ensuring equitable access to and disbursement of public funds;
- Supporting advancement of additional off-road categories to prepare for future regulations; and
- Signaling to technology providers and other market participants California's interest in accelerating the arrival of advanced technologies in demanding applications like ocean-going vessels and aviation.

Other key updates to this year's priorities include:

- A new third year that is characterized by a narrowing of scope as more technologies graduate out of our incentive programs and we focus on demanding applications and equity.
- Relative to demanding applications, there is a new abbreviation – AT, which stands for Advanced Technology – before these most challenging applications to represent non-ZE solutions. AT represents true steppingstones to ZE in demanding applications, not just cleaner combustion, renewable fuels, or conventional hybrids. Examples may include hydrogen turbine hybrids in aviation, ZE-capable hybrids in marine, or other solutions.
- The addition of Hydrogen Ecosystems, representing large-scale production and use of hydrogen by an array of vehicle and equipment types, similar to or possibly in conjunction with the Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES) hydrogen hub project.
- Similarly, Off-Road ZE Ecosystems have been added that include demonstrating scale deployments of many technology types like ZE transport refrigeration units (TRUs) and gensets.
- CARB also signals its intent to explore new ideas of how to support secondary markets for clean technology and help small fleets with financing and insurance assistance.

It is important to note that the levels of funding recommended do not represent the total funding necessary to support the technologies needed. Rather, these amounts are guided in part by an assessment of OEM and supplier capacity for producing a meaningful number of demonstration and pilot projects during the three-year investment strategy timeframe. These recommendations are designed to ensure that State funds are focused on the technologies that need to advance in commercialization over the next three years in order to impact 2030 and 2050 outcomes while also providing benefits today. If additional resources were to become available, the increased funding could help spur manufacturers

to increase production capacity and provide additional fleet support, training, and infrastructure.

Industry Example

Temporary Charging for Faster Deployment

As utilities and the electrical supply chain work to keep pace with rapidly accelerating electric vehicle (EV) deployments, fleets are seeking interim charging solutions that enable them to take delivery of EVs even before grid infrastructure to the site is upgraded or permanent chargers are installed. Temporary or mobile charging is a solution that has come to market in recent years with multiple manufacturers offering commercial products. This technology can help fleets get EVs in operation sooner than otherwise possible and can even be used in situations where permanent infrastructure may not be feasible.

In March 2024, CARB started a temporary charging pilot – funded through HVIP for purchasers in Standard HVIP, ISEF, and the Drayage set-aside – to test the feasibility of temporary refueling, allowing fleets to evaluate performance, cost, and scalability in real-world conditions. The pilot will collect operational and anecdotal data on how temporary charging fits with different duty cycles, vehicle types, and depot locations. The project will place four zero-emission chargers with different fleets and keep them at the fleet locations until permanent charging infrastructure is completed (up to two years).

The first two mobile chargers were placed with a drayage fleet – 4Gen Logistics – in July of 2024. One charger is at 4Gen's depot at the Port of Long Beach and the other at 4Gen's depot in Rialto, the two end-points of 4Gen's operations. 4Gen will submit reports that will include both telematic data (energy used, charging times) and anecdotal info (user experiences, downtimes) with the first report expected to be submitted in September 2024.

A third mobile charger will be delivered to Loomis Security in Hayward this fall. The final mobile charger will be placed with drayage firm Quick Container and the team is currently evaluating several different mobile charging options to best match Quick's operations.

CARB will monitor the results of the temporary charging pilot project and continue investigating this and other innovative solutions to accelerate the deployment of HD ZEVs.

Focus on Small Fleet Support

Across its portfolio of investments, CARB is intentionally shifting the focus of incentives toward helping a greater number of small businesses. With ACF going into effect for drayage and large on-road fleets, CARB is directing its resources to undercapitalized small fleets in greatest need of assistance to ensure equitable access to ZE technology. Small fleets are eligible for larger HVIP incentives, along with innovative incentive options available through the Innovative Small e-Fleet Pilot Project (ISEF). Similarly, CORE will prioritize funding for small businesses as well. Changes to program eligibility and voucher amounts will be reflected in the Funding Plan and individual program implementation manuals.

Clean Transportation Incentives Three-Year Investment Recommendations

The Strategy includes a set of funding recommendations that function as a snapshot in time, incorporating a rolling three-year funding horizon. This year's update to the Strategy builds on the funding levels identified in the FY 2023–24 report, addresses FY 2025–26 and FY 2026–27, and adds a new third year, FY 2027–28. CARB has reevaluated and updated the projected levels of investment needed to move technologies toward meeting State goals over the new three-year funding period.

The recommended levels of funding have been developed around a central core of established priorities and updated priorities identified in the discussion above. For example, continuing to support hydrogen fuel cell technologies will be important to advancing those vehicle and equipment platforms that have the potential to considerably extend the range of operations for ZE technologies, including new off-road sectors. Building on further development of ZE ecosystems helps to demonstrate success of these technologies to perform at a more expansive facility, corridor, or community deployment levels. While many prior demonstrations and pilots have focused on deployments in port environments, newer projects have also been conducted at railyards and distribution centers. Ongoing demonstrations of ZE rail and marine technologies have already shown great potential for further deployment. The application of ZE technologies in the areas of large construction and agricultural equipment are expected to follow and benefit from earlier on-road technologies and they are now ready for further development. Looking forward, CARB will continue to apply an equity overlay to all of these investments that looks at ways to target funding to small fleets, priority populations, and underserved communities.

The aggregated results of these funding projections are shown in Table D-2. The table summarizes key focus areas grouped by project type: Demonstrations and Pilots, intended to accelerate the technological and market readiness of included platforms; Market Acceleration, projects that reduce upfront costs to increase market volumes and drive early-adopter uptake; and Market Equity, a category that includes innovative solutions for small fleets and focuses on benefits to priority populations. The priorities table frames the range of investments ideally needed each year over the course of the next three fiscal years. Both low and high funding levels are shown to suggest the range of investment needed to

maintain progress. At the lower funding levels, not all of the priorities can be achieved. The higher levels represent aggressive levels of investment sufficient to drive all of the identified priorities, potentially allowing additional applications within a pathway to advance.

These recommendations focus on creating the critical technology capability and product mix needed to meet the State's goals, without fully and completely funding those projects and pieces of equipment needed for meeting the goals. As has been highlighted in prior Strategy documents and by way of input from public meetings, the need for incentives geared toward meeting California's GHG and air quality goals continues to exceed the recommended funding levels shown here.

Table D-2: Focused Recommendations for Clean Transportation Incentives Priorities

Category	FY 2025–26	FY 2026–27	FY 2027–28
Demos and Pilots	$290–$450 Million ZE Line-Haul Rail, AT Aviation, AT Ocean-Going, ZE/Hybrid Marine, ZE Ag/Construction/Mining/Heavier CHE, Emergency and Heavy Specialty Equipment, Hydrogen and Off-Road ZE Ecosystems, Green Zones	$325–$515 Million ZE Line-Haul Rail, ZE Light Aviation, AT Heavy Aviation, AT Ocean-Going, ZE Marine, ZE Ag and Heavier Construction/Mining/CHE, Emergency and Heavy Specialty Equipment, Hydrogen and Off-Road ZE Ecosystems, Green Zones	$360–$480 Million ZE Line-Haul Rail, ZE Light Aviation, AT Heavy Aviation, AT Ocean-Going, ZE Marine, ZE Heavy Ag/Construction, ZE Extra-Specialty, Hydrogen and Off-Road ZE Ecosystems, Green Zones
Market Acceleration	$560–$610 Million ZE Construction and Heavier CHE, ZE Switcher Rail, ZE/Hybrid Marine, Heavy/Specialty ePTOs, ZE Long Haul Trucks, Temp. Fueling	$450–$545 Million ZE Construction/Mining and Heavier CHE, ZE Switcher Rail, ZE/Hybrid Marine, Heavy/Specialty ePTOs, ZE Long Haul Trucks, Temp. Fueling	$530–$830 Million ZE Ag and Heavier Construction/ Mining/CHE, ZE/Hybrid Marine, Emergency and Heavy Specialty Equipment
Market Equity	$640–$660 Million ZE Drayage/Small Fleets, ZE Forklifts, ZE School/Transit, Financing and Insurance Assistance, Secondary Market Support	$620–$655 Million ZE Drayage/Small Fleets, ZE Forklifts, ZE School/Transit, Financing and Insurance Assistance, Secondary Market Support	$260–$320 Million ZE Long Haul Trucks, ZE Drayage/Small Fleets, ZE Forklifts, ZE School/Transit, Secondary Market Support, ZE Switcher
Total Funding	$1,490–$1,720 Million*	$1,395–$1,715 Million*	$1,150–$1,630 Million*

*The vehicle and equipment types listed in the table above are a prioritized selection of the project types that CARB would invest in, given sufficient available funds. These focus areas are identified utilizing the strategy laid out in this document. This is not an exhaustive list of technologies or applications that Clean Transportation Incentives would fund, and total funding recommendations is reflective of ideal appropriations and are not limited to existing appropriations.

Conclusion

As CARB's roadmap for investing Low Carbon Transportation and AQIP funding on HD on- and off-road technologies, the Heavy-Duty Investment Strategy helps to ensure that CARB's overall incentive funding portfolio focuses those investments where they will be most impactful. California has allocated billions of dollars to a variety of programs, with different but complementary goals. These investments emphasize technology advancement, the accelerated deployment of ZE HD vehicles and off-road equipment, turnover of the legacy fleet, and equitably distributed investments. Ultimately, they incentivize clean technologies that complement CARB's regulatory efforts to ensure these technologies are deployed in strategic and impactful ways that support the State's climate and air quality goals.

This Strategy includes key focus areas and frames the range of investments ideally needed each year over the course of the next three fiscal years. However, the need for incentives geared toward meeting California's climate and air quality goals continues to exceed the recommended funding levels shown in this document. These recommendations are designed to ensure that State funds are focused on the technologies that need to advance in commercialization over the next three years to impact 2030 and 2050 outcomes while also providing benefits today. If additional resources were to become available, the increased funding could help spur increased production capacity and provide additional fleet support, training, and infrastructure.

CARB will continue to coordinate its overall investment strategy across the broader portfolio of incentive programs, both within the agency and with other local, state, and federal partners. In order to foster an inclusive and equitable shift to ZE technology, support for small fleets and those in priority communities has become a primary focus. This includes targeted incentives, technical assistance programs, and additional wrap-around support specifically designed to mitigate the unique challenges faced by these groups. This focus on equity will help to create a more just and sustainable transportation ecosystem that ensures no fleet or community gets left behind and the state's priority populations receive public health benefits.

Acronym List

ACF – Advanced Clean Fleets

ACT – Advanced Clean Trucks

AQIP – Air Quality Improvement Program

AT – Advanced Technology

CAPP – Community Air Protection Program

CARB – California Air Resources Board

CEC – California Energy Commission

CHE – Cargo Handling Equipment

CORE – Clean Off-Road Equipment Voucher Incentive Project

DAC – Disadvantaged Community

EnergIIZE – Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles Project

EPA – U.S. Environmental Protection Agency

ePTO – Electric Power Takeoff

FARMER – Funding Agricultural Replacement Measures for Emission Reductions

FC – Fuel Cell

FY – Fiscal Year

GHG – Greenhouse Gas

GSE – Ground Support Equipment

HD – Heavy-Duty

HVIP – Hybrid and Zero-Emission Voucher Incentive Project

ICT – Innovative Clean Transit

IRA – Inflation Reduction Act

ISEF – Innovative Small e-Fleet Pilot Project

MD – Medium-Duty

Moyer – Carl Moyer Memorial Air Quality Standards Attainment Program

OEM – Original Equipment Manufacturer

PM – Particulate Matter

SB – Senate Bill

SIP – State Implementation Plan

TRU – Transport Refrigeration Unit

VW – Volkswagen

ZE – Zero-Emission

ZEV – Zero-Emission Vehicle