

FUELING & *Financing*

Addressing the Urgent Challenges Facing Electric Heavy-Duty Vehicle Deployment

AUGUST 2024
Policy Report

Climate Change
and Business
Research Initiative



ABOUT THIS REPORT

This policy report is part of a series on how specific sectors of the business community can drive key climate change solutions and how policymakers can facilitate those solutions. Each report results from workshop convenings that include expert representatives from the business, academic, policy, and environmental sectors. The convenings and resulting policy reports are sponsored by Bank of America and produced by a partnership of UC Berkeley School of Law's Center for Law, Energy & the Environment (CLEE) and UCLA School of Law's Emmett Institute on Climate Change and the Environment.

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The Center for Law, Energy & the Environment (CLEE) channels the expertise and creativity of the Berkeley Law community into pragmatic policy solutions to environmental and energy challenges. CLEE works with government, business, and the nonprofit sector to help solve urgent problems requiring innovative, often interdisciplinary approaches. Drawing on the combined expertise of faculty, staff, and students across the University of California, Berkeley, CLEE strives to translate empirical findings into smart public policy solutions to better environmental and energy governance systems.

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AUTHORS

Ethan N. Elkind

DIRECTOR, CLIMATE PROGRAM
CENTER FOR LAW, ENERGY &
THE ENVIRONMENT

Shruti Sarode

CLIMATE CHANGE RESEARCH
FELLOW
CENTER FOR LAW, ENERGY &
THE ENVIRONMENT

Lidiya Kassahun

CLIMATE CHANGE RESEARCH
FELLOW (FORMER)
CENTER FOR LAW, ENERGY &
THE ENVIRONMENT

Additional contributions to the report were made by Cara Horowitz of UCLA School of Law. The authors also thank Enzo Cremers (UC Berkeley Class of 2024) for his contributions to the report through his role as a research assistant at CLEE.

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JULY 2023 CONVENING:

Simon Baker

DIRECTOR OF THE OFFICE OF DISTRIBUTED ENERGY RESOURCES, NATURAL GAS & RETAIL ENERGY RATES, CALIFORNIA PUBLIC UTILITIES COMMISSION

Analisa Bevan

ZERO EMISSION INFRASTRUCTURE SPECIALIST, CALIFORNIA AIR RESOURCES BOARD

Suncheth Bhat

CHIEF BUSINESS OFFICER, EV REALTY

Adam Browning

EXECUTIVE VICE PRESIDENT, FORUM MOBILITY

Morgan Caswell

MANAGER OF AIR QUALITY PRACTICES, PORT OF LONG BEACH

Michael Coates

PRINCIPAL PARTNER, MIGHTYCOMM

Anthony Harrison

HEAD OF POLICY AND COMMUNICATIONS, TERAWATT INFRASTRUCTURE

Marc Joseph

OF COUNSEL, ADAMS BROADWELL JOSEPH & CARDOZO

Dr. Aravind Kailas

ADVANCED TECHNOLOGY POLICY DIRECTOR, VOLVO GROUP

Lydia Krefta

DIRECTOR OF CLEAN ENERGY TRANSPORTATION, PG&E

Alex Nicholas

VICE PRESIDENT OF OPERATIONS, MHX

Guillermo Ortiz, Advocate

CLEAN VEHICLES, CLIMATE & CLEAN ENERGY PROGRAM, NRDC

Hannon Rasool

DIRECTOR OF THE FUELS AND TRANSPORTATION DIVISION, CALIFORNIA ENERGY COMMISSION

Nancy Ryan

PARTNER, E-MOBILITY ADVISORS

Andy Schwartz

SENIOR MANAGING POLICY ADVISOR, TESLA

Leuwam Tesfai

DEPUTY EXECUTIVE DIRECTOR FOR ENERGY AND CLIMATE POLICY, CALIFORNIA PUBLIC UTILITIES COMMISSION

OBSERVERS:

Paula Gruending

TRANSPORTATION ELECTRIFICATION SECTION LEAD, CALIFORNIA PUBLIC UTILITIES COMMISSION

Jennifer Kalafut

SENIOR MANAGER FOR ENERGY EFFICIENCY AND TRANSPORTATION ELECTRIFICATION, CALIFORNIA PUBLIC UTILITIES COMMISSION

Lucina Negrete

ASSISTANT DIVISION CHIEF OF THE MOBILE SOURCE CONTROL DIVISION, CALIFORNIA AIR RESOURCES BOARD

Michelle Orrock

CALIFORNIA GOVERNMENT AFFAIRS LEAD, BP AMERICA

JANUARY 2024 CONVENING:

Eleanor Bastian

PRINCIPAL PROGRAM MANAGER, WORLD WIDE OPERATIONS SUSTAINABILITY, AMAZON

Adam Browning

EXECUTIVE VICE PRESIDENT, FORUM MOBILITY

Michelle Buffington

VEHICLE PROGRAM SPECIALIST, MOBILE SOURCE CONTROL DIVISION, CALIFORNIA AIR RESOURCES BOARD

Jacqueline Torres

FORUM MOBILITY

Tim DeMoss

ENVIRONMENTAL AFFAIRS OFFICER, PORT OF LOS ANGELES (FMR)

Noelani Derrickson

SR. POLICY ADVISOR, NORTH AMERICA POLICY AND BUSINESS DEVELOPMENT, TESLA

Aaron R Dyer

SENIOR ADVISOR, PORTFOLIO PLANNING & INTEGRATION, SOCAL EDISON

Tom Fulks

FOUNDER AND PRINCIPAL, MIGHTYCOMM

Dr. Aravind Kailas

ADVANCED TECHNOLOGY POLICY DIRECTOR, VOLVO GROUP

Niki Okuk

DEPUTY DIRECTOR OF TRUCKS AND OFF-ROAD, CALSTART

Jeremy Orr

MANAGER, FLEET SUSTAINABILITY FUNDING & COMPLIANCE, US FOODS

Nicholas Raspanti

SENIOR DIRECTOR, BUSINESS DEVELOPMENT & POLICY, ZEEM SOLUTIONS

Annmarie Rodgers

CHIEF, COMPLIANCE ASSISTANCE AND OUTREACH BRANCH, CALIFORNIA AIR RESOURCES BOARD

Rebecca Saletta

DIRECTOR OF STRATEGIC PARTNERSHIPS, ZETI

Greg Sarvas

ELECTRIC TRANSPORTATION PROGRAM SUPERVISOR, POWER NEW BUSINESS & ELECTRIFICATION DIVISION, LOS ANGELES DEPARTMENT OF WATER AND POWER

Gia Vacin

DEPUTY DIRECTOR OF ZERO-EMISSION VEHICLE (ZEV) MARKET DEVELOPMENT, GOVERNOR'S OFFICE OF BUSINESS AND ECONOMIC DEVELOPMENT

Bill Watson

SALES MANAGER, ACCION OPPORTUNITY FUND

OBSERVERS:

Thomas Canepa

ROVER MOBILITY

Patrick Jean-Baptiste

ROVER MOBILITY

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Photo Credit: Tesla

I. EXECUTIVE SUMMARY

Heavy duty vehicles, such as large semi-trucks and buses, disproportionately contribute to harmful traditional air pollution that burdens primarily low-income and disadvantaged communities, while also emitting significant greenhouse gases that contribute to the destabilization of the Earth's climate.

Fortunately, zero-emission, electric versions of these vehicles are on the road today and increasingly becoming widely available (this report focuses specifically on battery electric trucks and not other technology options such as hydrogen). According to the Drive to Zero global database from the nonprofit CALSTART, 25 manufacturers of heavy-duty zero-emission electric vehicles as of 2024 collectively produced 42 different models.

While the upfront costs of these zero-emission vehicle models can be two to three times higher than their diesel counterparts, analysts expect them to be cost-competitive with fossil fuel-powered vehicles by next decade, given battery advancements. In addition, they offer significant operational benefits, including less maintenance and cheaper fuel costs. Furthermore, states like California currently offer sizable incentives and subsidies to offset the purchase price for certain buyers that meet eligibility requirements, subject to the availability of funds in the state budget.

California leads the nation with its Advanced Clean Truck regulation, which requires manufacturers to gradually increase the percentage of zero-emission vehicles in their medium- and heavy-duty truck sales. Additionally, the Advanced Clean Fleets regulation requires medium- and heavy-duty fleet owners to purchase an increasing percentage of zero-emission vehicles. However, without adequate charging infrastructure and private-sector financing, the state risks failing to meet these ambitious mandates.

The infrastructure needs are massive. The California Energy Commission estimates that the state will require 114,500 chargers by 2030 to support the anticipated 155,000 medium- and heavy-duty electric trucks and buses likely to be deployed in the state. By 2035, experts estimate that number will increase to almost 265,000 chargers (including for medium-duty vehicles, not the focus of this report). Yet the United States has

only about 5,000 charging stations currently equipped to serve heavy-duty vehicles, with only nine public fast charging stations capable of doing so, as of January 2024 (though more stations are coming on line, notably a May 2024 WattEV installation with three new “megawatt chargers” in Bakersfield).

In addition, vehicle purchases will require financial assistance in many instances. The current upfront cost of battery-powered vehicles is higher than their fossil-fueled counterparts, with an upfront cost premium estimated by some analysts to be 43% for class 6-7 trucks, 69% for non-tractor class 8 trucks, 86% for short-haul tractors, and 203% for long-haul tractors. While many observers expect the gap to disappear and battery-powered vehicles to become cheaper on a total cost of ownership basis by the next decade, many purchasers (particularly smaller fleets) will need significant financial assistance to make these purchases.

This charging infrastructure and vehicle purchasing and leasing will ultimately require a massive amount of private capital, largely in the form of lending from financiers. According to a Clean Freight Coalition study, electrifying the commercial fleets in the United States will require a cumulative, multi-decade investment of \$620 billion in charging infrastructure alone, as well as an additional \$370 billion for the grid networks to fully support the vehicle demand. While this report focuses specifically on California, which offers generous subsidies and incentives for both charging infrastructure and vehicle purchases, the state will need to maximally leverage private sector sources of funding to achieve its goals.

To address these twin needs of infrastructure and financing, UC Berkeley Law’s Center for Law, Energy and the Environment (CLEE) and the UCLA Law Emmett Institute on Climate Change and the Environment convened experts and stakeholders to help identify the most pressing barriers both to deploying more charging infrastructure and to unlocking more private financing for both electric vehicles and the infrastructure on which they rely, as well as the solutions to overcome those barriers. This report results from a literature review and two separate half-day workshops with a select group of stakeholders, including one on July 21, 2023 at UC Berkeley Law on charging infrastructure and one on January 19, 2024 on financing, held at the California Air Resources Board Southern California headquarters in Riverside, California.

TOP BARRIERS AND SOLUTIONS FOR HEAVY-DUTY CHARGING DEPLOYMENT

BARRIER 1: INSUFFICIENT COORDINATION AMONG STATE AGENCIES

SOLUTIONS

The Governor’s Office could:

- Create an executive level “charging working group” or “czar” with the Governor’s authority to ensure coordination and hold accountable state agencies responsible for the deployment of charging infrastructure to support the heavy-duty vehicle sector

- Task the charging working group or czar with holding semi-annual meetings among agency leaders to ensure transparency and accountability on infrastructure deployment progress
- Require the state agency working group leaders to make the data on deployment progress publicly available
- Require state agencies that fund or finance charging infrastructure to coordinate with each other and with the legislature if necessary to ensure synchronization of available public funding and financing for charging infrastructure
- Appoint or empower an existing “strike team” or leader within the Governor’s Office who can help solve private-sector permitting and zoning challenges and then scale those solutions statewide

BARRIER 2: SLOW UTILITY PLANNING AND DEPLOYMENT OF HEAVY-DUTY ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

SOLUTIONS

The Legislature and California Public Utilities Commission could:

- Require utilities to be more transparent about sources of energization and approval delays, potentially through ongoing proceedings on this issue
- Mandate utilities to improve data transparency to facilitate charger deployment and reduce inefficiencies in capacity planning
- Require utilities to build a tool with the California Energy Commission that combines energization plans and feasibility to identify optimal charger installation sites, and to publish that information online for public viewing.
- Encourage or require utilities to build an equipment bank for needed charging and grid infrastructure (e.g. transformers) to avoid construction delays
- Encourage or require the utilities to hire and dedicate more utility employees in the job classifications needed to design and upgrade the charging infrastructure and grid deployment, as well as contract out when necessary to address staffing shortages
- Authorize a “balancing account” to help utilities fund grid upgrades for heavy-duty charging infrastructure sooner
- Direct investor-owned utilities to prioritize charging infrastructure investments in areas that serve regulated fleets and truckmakers, and receive financial assurances and contracting support from developers to minimize ratepayer risk

Utilities could expand existing efforts to educate heavy-duty fleet managers in the electric vehicle transition and the needed front- and behind-the-meter infrastructure

The California Department of Transportation (Caltrans) could offer bulk permits to utilities over a set time to encourage system-wide grid upgrades needed for charging depots

The California Energy Commission could establish an entity to process and disseminate data on optimal charging locations for planning processes

BARRIER 3: LACK OF NON-RATEPAYER FUNDING FOR GRID UPGRADES TO SUPPORT HEAVY-DUTY CHARGING INFRASTRUCTURE

SOLUTIONS

The California Air Resources Board could accelerate heavy-duty electric vehicle charging infrastructure deployment via the Fast-Charging Infrastructure pathway under the state's low carbon fuel standard

Utilities and state leaders could seek federal funds for grid upgrades, given the continued escalation of electricity rates in California

The California Legislature could:

- Pay for grid upgrades through the general fund or non-traditional sources of existing funding, such as via transportation infrastructure investments
- Incorporate grid needs in any proposed climate bond

TOP BARRIERS AND SOLUTIONS FOR FINANCING HEAVY-DUTY VEHICLES AND CHARGING INFRASTRUCTURE

BARRIER 1: RIGID PUBLIC PROGRAM DESIGN CAN INHIBIT PRIVATE SECTOR LENDING

SOLUTIONS

The California Legislature and Air Resources Board could:

- Modify Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) funding to ensure more targeted uptake by fleets more readily able to electrify
- Streamline and accelerate incentive payment processing times
- Reduce the state sales tax to make zero-emission heavy-duty vehicle models more competitive on upfront costs with diesel versions
- Continue to encourage other states to develop similar incentive programs and ensure equity and inclusion in their program design

- Modify scrapping requirements to facilitate incentive uptake and more zero-emission heavy-duty vehicle miles
- Boost funding for mobile charging as a solution when grid connections are not feasible or would take too long

The federal government could reduce the federal excise tax to make zero-emission models more competitive on upfront price with diesel versions.

BARRIER 2: INVESTORS, LENDERS AND PURCHASERS LACK INFORMATION ON ELECTRIC TRUCKS

SOLUTIONS

The California Air Resources Board, Energy Commission, and Governor’s Office of Business and Economic Development (GO-Biz) could develop educational materials for the investor community on heavy-duty electric vehicles and associated infrastructure

Nonprofit leaders and private-sector investors could share heavy-duty electric vehicle data and assessments with the broader investment community to facilitate more lending

The California Infrastructure and Economic Development Bank (IBank) and Air Resources Board could facilitate private-sector lending for heavy-duty electric vehicles and associated infrastructure.

Large, established private sector companies could participate more meaningfully in this transition by launching funds for heavy-duty electric vehicles and associated infrastructure to educate and attract other lenders

BARRIER 3: LACK OF RESIDUAL VEHICLE VALUE DATA AND SECONDARY MARKET

SOLUTIONS

The California Legislature and Air Resources Board could:

- Modify the HVIP incentive to provide a residual value guarantee with a fixed “floor” resale purchase price for heavy-duty electric vehicles, to encourage fleet purchasers to re-sell the vehicles to smaller operators
- Modify incentives to encourage truck makers to lower prices on sales and leases
- Seek to expand the out-of-state market for heavy-duty electric vehicles in order to increase supply and decrease prices

The California IBank or Legislature could expand and expedite loan loss reserve programs to offset investor and insurer concerns about the residual value of used vehicles.

The California Energy Commission and Air Resources Board could estimate resale values of heavy-duty electric vehicles based on data from used batteries in the light-duty sector

The California Legislature, IBank, or Air Resources Board could create a backstop reinsurance program to cover any losses from low residual values

The following sections of the report detail these solutions and an overview of the issue in more depth.



II. INTRODUCTION: ELECTRIC HEAVY-DUTY VEHICLES ADDRESS CLIMATE CHANGE AND AIR POLLUTION, YET REQUIRE INCREASED FINANCIAL SUPPORT

Transportation is the largest source of greenhouse gas emissions in the United States, making up 29 percent of all emissions.

According to the U.S. Environmental Protection Agency's (EPA) greenhouse gas inventory, medium- and heavy-duty vehicles (MHDVs) account for one-third of carbon dioxide emissions from on-road vehicles and will need to achieve substantial emission reductions by 2030 and reach near-zero emissions by 2050 to meet California and U.S. climate goals.¹ According to the California Air Resource Board's inventory of greenhouse gas emissions, heavy-duty trucking (such as semi-trucks and buses) was responsible for over 30 million megatons of greenhouse gas emissions in 2021, or approximately 10% of statewide emissions.²

Heavy-duty trucks are also the largest contributor to mobile source emissions of nitrogen oxides (NO_x), which reacts in the atmosphere to form ground-level ozone, or smog, as well as particulate matter, carbon monoxide, and air toxics.³ Pollution from heavy-duty vehicles powered by diesel engines causes major public health challenges. Long-term exposure to diesel exhaust has been linked to lung cancer, stroke, heart disease, pulmonary disease, chronic respiratory illnesses, asthma, bronchitis, and other adverse health effects. In 2015, transportation tailpipe emissions in general were associated with 385,000 premature deaths globally from ambient fine particulate matter (PM 2.5) and ozone pollution, equivalent to a societal cost of nearly 1 trillion dollars per year.⁴ Diesel engines emit a mix of air pollutants, including diesel particulate matter (DPM). Scientists estimate that about 70% of total known cancer risk related to air toxics in California is attributable to DPM. Based on 2012 estimates of statewide exposure, researchers estimate that DPM increases statewide cancer risk by 520 new cases of cancer per million residents exposed over a lifetime.⁵

Additionally, while the impacts of climate change and air pollution affect all Californians, residents in disadvantaged and low-income communities face the most severe impacts, as the pollution is disproportionately emitted among lower-income and ra-

cially marginalized communities.⁶ Low-income communities therefore stand to gain the most in monetized health benefits per capita from increased adoption of more electric vehicles.⁷

Deploying more zero-emission heavy-duty vehicles would address this pollution and help California achieve both its climate and equity goals. The state is actively pursuing both battery electric vehicles (BEVs) and hydrogen fuel cells as complementary zero-emission technologies. As noted previously, this report focuses on BEVs. These vehicles produce zero tailpipe emissions during operation, significantly reducing air pollutants and improving air quality. Additionally, battery-electric vehicles are 3.5 times more energy efficient than conventional diesel vehicles when driving at highway speeds for different weight classes, vehicle types, and duty cycles. At lower speeds, where traditional diesel engines waste a lot of energy idling and coasting, BEVs are 5 to 7 times more efficient.⁸ And while the electricity to power them is in part generated by fossil sources (mainly gas), California’s grid is required by Senate Bill 100 (De León, 2018) to be carbon-free by 2045.

ELECTRIC HEAVY DUTY TRUCK TECHNOLOGIES AND COST

Heavy-duty trucks are vehicles with a gross weight above 26,001 pounds, divided into class 7 (up to 33,000 lbs) and class 8 (above 33,000 lbs). Class 7 vehicles include box, refuse, and tow trucks, while class 8 includes dump trucks, cement mixers, and tractor units for hauling semi-trailers.



Figure 1: Federal Highway Administration's Vehicle Weight Classification- Class 7 and 8.⁹

At the end of 2023, California had 753 Department of Motor Vehicle-registered (DMV) zero-emission heavy-duty electric trucks on the road, comprised of 369 tractor trucks, 359 chassis and cabs, 21 terminal tractors (tractors used within ports), 3 refuse trucks, and 1 flatbed truck.¹⁰ Manufacturers with deployed heavy-duty zero-emission vehicles include Freightliner Trucks (a subsidiary of Daimler Truck), Volvo Trucks, Volvo-owned Mack Trucks, BYD Auto, Tesla, Orange EV, Nikola, Hyundai, Kalmar Industries, Peterbilt Motors, Kenworth Trucks, and International Trucks, among others. As of 2024, the Drive to Zero global database from CALSTART listed 25 manufacturers of heavy-duty zero-emission vehicles that collectively produced 42 different models.¹¹

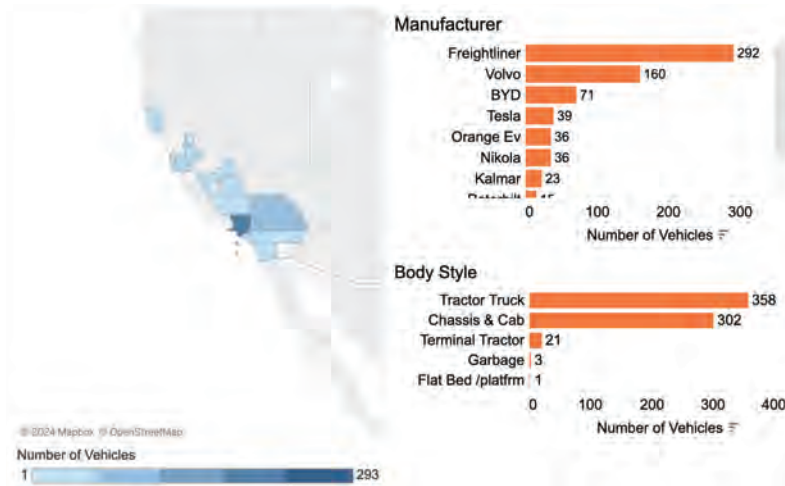


Figure 2: Screenshot of Heavy-Duty ZEV Truck Population in California through 2023 from the California Energy Commission database.¹²

The current upfront cost of these vehicles is higher than their fossil-fueled counterparts. Analysis conducted by the International Council on Clean Transportation (ICCT) demonstrated that the upfront cost premium associated with battery electrification is 43% for class 6-7 trucks, 69% for non-tractor class 8 trucks, 86% for short-haul tractors, and 203% for long-haul tractors.¹³ Some convening participants expect the gap to eventually disappear, although they noted that the market has not seen meaningful cost declines over the past three years. As truck costs decrease, battery-powered vehicles will ultimately be cheaper on a total cost of ownership basis by the next decade.

Table 1 depicts a summary of cost estimates for diesel and battery electric trucks for 2022, 2025 and 2040, as forecasted by ICCT based on data from the years 2020 and 2021 that cover mostly U.S. and a few international sources. Although some convening participants described prices for battery electric trucks as being nearly 60% higher than the prices shown in the table below, truck pricing between manufacturers and purchasers is ultimately confidential information, and no comprehensive public information is available to demonstrate this price discrepancy or data. Regardless, high truck pricing represents a significant though potentially short-term barrier for the U.S. market.

Truck Class	DIESEL			BATTERY ELECTRIC		
	2022	2025	2040	2022	2025	2040
Class 6-7 Rigid Truck	\$111,000	\$112,000	117,000	\$159,000	\$135,000	\$89,000
Class 8 Rigid Truck	\$158,000	\$161,000	162,000	\$270,000	\$228,000	\$150,000
Class 8 Short-Haul Tractor	\$150,000	\$151,000	157,000	\$279,000	\$233,000	\$148,000
Class 8 Long-Haul Tractor	\$168,000	\$171,000	178,000	\$515,000	\$410,000	\$216,000

*Table 1: ICCT Purchase Cost Estimates for 2022 and Forecast for 2025 and 2040 for Diesel vs. Battery-Electric, Classes 6-8.*¹⁴

Ultimately, ICCT estimated that battery electric trucks will achieve retail cost parity with their diesel alternatives before 2030 for class 6-7 rigid trucks and before 2040 for class 8 rigid trucks and short-haul trailers. Beneficially for battery electric heavy-duty vehicle owners, fuel and operations and maintenance costs are already lower for these vehicles when compared to their fossil-powered counterparts. Furthermore, experts predict these operations and maintenance costs will decrease in the near future as developers deploy more charging infrastructure, construct more maintenance facilities, and train more mechanics. In 2022, the total cost of ownership for a battery-electric long-haul class 8 truck in California was \$2.50 per mile, 21% higher than its diesel counterpart. However, ICCT analysis showed that by 2030, the cost of owning a battery-electric truck should drop to \$1.90 per mile, achieving parity with diesel vehicles on a total cost basis.¹⁵

CURRENT STATUS OF HEAVY-DUTY VEHICLE CHARGING TECHNOLOGY AND DEPLOYMENT

Charging of battery-electric heavy-duty vehicles predominately comes in two forms – alternating current (AC) level 2 charging and direct current (DC) fast charging. Level 2 charging is appropriate for most light-duty vehicle charging scenarios, but it can take up to 80-100 hours to fully charge a 600-kWh heavy duty battery, meaning it is only suitable for short-range route trucks.¹⁶ Conversely, DC fast chargers span from 50 kW to 350 kW. As a point of reference, a 100 kW DC fast charger can charge a 600-kWh electric truck in six hours. Some participants noted that the majority of class 8 vehicles on the market currently accept roughly 250-270 kilowatts of charging power, and analysts expect the vehicles to increase their accepted capacity going forward.

The Megawatt Charging System (MCS) represents the highest-power charging connector available for large battery electric vehicles like trucks. Developed by CharIn and the National Renewable Energy Laboratory,¹⁷ MCS has the ability to recharge heavy-duty electric trucks in about 30 minutes, which helps address the need for quick charging in heavy-duty transportation. WattEV opened the first electric truck charging depot in the United States in Bakersfield, California in May 2024. It uses the Megawatt Charge System and is capable of delivering up to 1.2 megawatts of power, currently the highest-speed charger available in the US.¹⁸

CALIFORNIA’S POLICIES AND PROGRAMS TO BOOST HEAVY DUTY ZERO-EMISSION VEHICLES

California policies actively promote and require the use of heavy duty zero-emission vehicles. State laws require California to achieve net zero greenhouse gas emissions as soon as possible, but no later than 2045, and achieve and maintain net negative greenhouse gas emissions thereafter.¹⁹ In furtherance of these targets, the state has developed numerous regulatory and incentive programs to help deploy more heavy-duty zero-emission vehicles.

Some key policies include:

POLICY	DESCRIPTION
<p>ADVANCED CLEAN TRUCK (ACT) REGULATION</p>	<p>This regulation represents the California Air Resources Board’s (CARB) signature rule to address emissions from trucks and buses. It requires manufacturers to gradually increase the percentage of zero-emission vehicles in their sales of medium- and heavy-duty trucks. This first-in-the-nation regulation aims to accelerate the adoption of cleaner technologies in the freight and transit sectors.²⁰</p>
<p>ADVANCED CLEAN FLEETS (ACF) REGULATION</p>	<p>This rule builds on the Advanced Clean Truck rule’s manufacturer sales mandate and requires medium- and heavy-duty fleet owners to purchase an increasing percentage of zero-emission vehicles.²¹ The regulation applies to fleets performing drayage operations (transporting shipping containers by truck to their final destination), those owned by state, local, and federal government agencies, and “high priority” fleets, defined as entities that own, operate, or direct at least one vehicle in California and that have either \$50 million or more in gross annual revenues, or that own, operate, or have common ownership or control of a total of 50 or more vehicles (excluding light-duty package delivery vehicles).²² As of June 2024, seventeen states sued to block the ACF rule while it awaits a waiver from the United States Environmental Protection Agency.</p>
<p>ZERO-EMISSION VEHICLE (ZEV) MANDATE</p>	<p>The Air Resources Board’s zero-emission vehicle mandate, which requires vehicle manufacturers to produce a certain percentage of zero-emission vehicles, includes heavy-duty vehicles as part of the total vehicle sales. This mandate further encourages automakers that also sell light- and medium-duty vehicles to develop and deploy heavy-duty zero-emission vehicles.</p>
<p>OMNIBUS REGULATION</p>	<p>CARB’s Heavy-Duty Engine and Vehicle Omnibus Regulation (Omnibus Regulation) is a set of emission standards for heavy-duty truck engines that went into effect in December 2021. The regulation aims to reduce nitrogen oxides (NOx) emissions from these engines, which are a major contributor to air pollution in California. The regulation applies to model years 2024–2031 and requires a 90% reduction in NOx emissions from heavy-duty on-road engines compared to existing standards, phased in from 2024–2031. The standards for 2024 model year engines are more stringent than previous California and current federal standards.²³</p>

POLICY	DESCRIPTION
<p>LOW CARBON FUEL STANDARD (LCFS)</p>	<p>This standard is a market-based regulatory program that incentivizes the use of low-carbon and renewable fuels, including electricity. Heavy-duty zero-emission vehicles benefit from the low carbon fuel standard because it assigns a carbon intensity score to different fuels and mandates fuel providers to either reduce the carbon intensity of fuels that do not meet the standard or purchase credits from lower-carbon fuel providers, potentially increasing the cost of fossil fuel relative to cleaner alternatives like electricity.²⁴ The low carbon fuel standard also provides important incentives for transit agencies, which are leaders in the adoption of heavy-duty electric vehicles.</p> <p>In a current rulemaking update, CARB is proposing several changes to LCFS to accelerate the carbon intensity (CI) reduction goals for fuels in the state, specifically to tighten the 2030 carbon intensity reduction targets from 20% to 30%, along with a one-time 5% reduction of the carbon intensity benchmark in 2025. As a part of this amendment, CARB is also proposing new credits for the construction of fast charging infrastructure or hydrogen refueling infrastructure for zero-emission vehicles.²⁵</p>
<p>CALIFORNIA SUSTAINABLE FREIGHT ACTION PLAN</p>	<p>This plan provides a high-level vision and broad direction to the Governor for state agencies to utilize when developing specific investments, policies, and programs related to the freight transport system that serves California’s transportation, environmental, and economic interests.²⁶ The plan proposes actions on how the state can move closer to its zero-emission vehicle deployment goals.</p>

Table 2: Key policies and programs in California to boost heavy duty zero-emission vehicles

In addition to the above policies, California also provides various financial incentives to offset the purchase price of zero-emission heavy-duty vehicles. These incentives include rebates, grants, and low-interest loans for individuals and businesses investing in zero-emission trucks and buses. For example, the California Air Resource Board funds the On-Road Heavy Duty Voucher Incentive Program through the Carl Moyer Programs,²⁷ which provide grants for cleaner-than-required engines, equipment and emission-reduction technologies.

The Air Resource Board also incentivizes the purchase of eligible commercially available zero-emission, hybrid, or cleanest combustion technologies through point-of-purchase price reductions through its Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP).²⁸ HVIP’s primary objective is to accelerate the commercialization of cleaner, low-carbon hybrid and electric trucks and buses. In fiscal year 2022-23, the board allocated \$250 million in funding for the HVIP Program, providing rebates ranging from \$20,000 to \$240,000 per vehicle, depending on a variety of factors like vehicle type, manufacturer, vehicle size, and more. HVIP provides point-of-sale vouchers for zero-emission vehicles. These vouchers are applied at the time of purchase, reducing the upfront cost for buyers. Since its inception in 2009, the HVIP has pro-

vided support for over 12,100 clean-fuel vehicles, as of April 2024. Of these vehicles, 58% have been deployed in pollution-burdened communities. More than 2,000 fleets actively participate in the program, with each vehicle costing on average 21% off the original purchase price.²⁹ Through HVIP, the Ports of Long Beach and Los Angeles will make \$60 million in Clean Truck Fund Rate funding available for vouchers toward the purchase of zero-emission, Class 8 drayage trucks that operate at the San Pedro Bay ports complex.³⁰

On the federal level, the Inflation Reduction Act allocated \$1 billion to support the transition to clean heavy-duty vehicles. The U.S. Environmental Protection Agency (EPA) oversees and administers the Clean Heavy Duty Vehicles program. It aims to reduce pollution from heavy duty vehicles and further environmental justice in communities disproportionately affected by pollution.

URGENT NEED FOR HEAVY-DUTY ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

Heavy-duty electric vehicles have unique charging needs, distinct from those of light-duty vehicles. Because these vehicles feature large batteries and often operate daily with substantial driving miles, operators require high-powered charging to fully recharge batteries. Charging can occur at a truck depot overnight or between shifts (depot charging) or in the middle of a journey to extend range (en-route charging). In addition, because these are commercial vehicles, time spent charging is potentially time spent not making critical deliveries or finishing routes, which costs money for an industry in which many small operators may have slim profit margins.

Many fleet operators may be reluctant to purchase or lease an electric heavy-duty vehicle if they do not have access to fast, convenient and affordable charging. The deployment need is significant. The California Energy Commission estimated that the state will need 114,500 chargers (not necessarily accounting for chargers with multiple charge cords that can charge more than one vehicle at once) by 2030 to support the anticipated 155,000 medium- and heavy-duty electric trucks and buses likely to be deployed, of which 109,000 will be depot chargers while 5,500 will be en-route. By 2035, when the state forecasts deployment of 377,000 medium- and heavy-duty trucks and buses, experts estimate that the state will need 256,000 depot chargers and 8,500 en-route chargers.³¹ In addition, the Truck and Engine Manufacturers Association reported that the United States has only about 5,000 charging stations equipped to serve heavy-duty vehicles. And among those, the U.S. Department of Energy stated that only 9 public fast charging stations are capable of serving heavy trucks, as of January 2024.³² As previously mentioned, WattEV opened a public charging facility in May 2024 in Bakersfield that features 15 single-cord 240kW direct-current chargers, plus three 1,200kW rapid megawatt chargers, all drawing power from the site's solar array.³³

Although the state is lacking the necessary infrastructure, various agencies and private sector entities have begun investing in deployment. For example, in February 2024, the California Energy Commission approved a \$1.9 billion investment plan that accelerates deployment of infrastructure for light, medium, and heavy-duty zero-emission vehicles (ZEV) across California.³⁴ The commission's 2023-2024 Investment Plan allocated \$1.15 billion for medium- and heavy-duty ZEV infrastructure. This allocation includes \$47.6 million of Clean Transportation Program funding for medium- and heavy-duty ZEV

infrastructure in Fiscal Year 2023–2024. These funds will support the deployment of ZEV drayage trucks, school buses, transit buses, and other medium- and heavy-duty vehicles within the state. Since the first Clean Transportation Program Investment Plan was released in 2009, the commission has invested more than \$1.8 billion in projects supporting zero-emission vehicle infrastructure, alternative fuels, and advanced vehicle technologies. This figure includes both the base Clean Transportation Program funds and recent general funds. One of the key highlights of this investment includes awarding 120 projects, providing more than \$97 million in infrastructure incentives through the nation’s first commercial vehicle fleet incentive project titled Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles (EnergIIZE Commercial Vehicles). This project will accelerate the deployment of electric and hydrogen infrastructure needed to fuel zero-emission trucks, buses, and equipment. The multiyear project includes a requirement that 60 percent of funds support low-income and disadvantaged communities.³⁵

Heavy-duty electric vehicle charging will require not just the chargers themselves but grid infrastructure upgrades to supply the power, as well as real estate with parking availability to allow vehicles such as trucks to charge overnight or between shifts. As this infrastructure requires careful planning and time to be installed, public and private sector leaders will need to act immediately to ensure the infrastructure build-out does not hamper this transition.

POLICY	DESCRIPTION
<p>NATIONAL ZERO-EMISSION FREIGHT CORRIDOR STRATEGY</p>	<p>Developed by the Joint Office of Energy and Transportation and U.S. Department of Energy (DOE), in collaboration with the Department of Transportation (DOT) and the Environmental Protection Agency (EPA), and released in March 2024, the strategy will guide the deployment of zero-emission medium- and heavy-duty vehicle (ZE-MHDV) charging and hydrogen fueling infrastructure from 2024 to 2040. The strategy is designed to meet growing market demands by targeting public investment to amplify private sector momentum, focus utility and regulatory energy planning, align industry activity, and improve air quality in local communities heavily impacted by diesel emissions.³⁶</p>
<p>CHARGING AND FUELING INFRASTRUCTURE (CFI) DISCRETIONARY GRANT PROGRAM</p>	<p>The U.S. Department of Transportation’s (DOT) Charging and Fueling Infrastructure (CFI) Grant Program offers \$2.5 billion over 5 years in funding to deploy publicly accessible electric vehicle charging infrastructure in urban and rural communities, as well as along Alternative Fuel Corridors.³⁷ The federal Bipartisan Infrastructure Bill of 2021 created the program and made metropolitan planning organizations, public authorities, and governments eligible to receive the funding.</p>

POLICY	DESCRIPTION
<p>CLEAN TRANSPORTATION PROGRAM</p>	<p>The California Energy Commission offers \$100 million annually for projects that support the transition to zero-emission vehicles and their infrastructure. Through the Clean Transportation Program, the Commission is investing in projects throughout California that accelerate advancement and adoption of medium- and heavy-duty vehicles and charging infrastructure for these vehicles. For fiscal year 2023–2024, the energy commission’s proposed funding allocation is \$47.6 million in Clean Transportation Program dollars to the medium- and heavy-duty sectors, in addition to \$218.5 million from the Greenhouse Gas Reduction Fund and the \$125 million in Proposition 98 general funds. This funding is intended to meet the growing needs of charging and hydrogen fueling infrastructure for medium- and heavy-duty ZEVs. A significant portion is directed by the state budget to specific sectors, such as drayage trucks.³⁸</p>
<p>SENATE BILL 671 (GONZALEZ) CLEAN FREIGHT CORRIDOR ASSESSMENT</p>	<p>SB 671 requires the California Transportation Commission (CTC) to collaborate with relevant state agencies to develop a Clean Freight Corridor Assessment. The assessment will develop clean freight guidelines and consider alternative fueling infrastructure, road safety and congestion for onboarding cleaner emission freight vehicles for the five most polluting freight corridors in California. The criteria developed through the Clean Freight Assessment will also be incorporated into the guidelines and funding programs of the contributing state agencies to make a systemic shift toward implementing California’s freight planning.</p>

Table 3. Federal and State Electric Vehicle Charging Policies and Programs

URGENT NEED FOR HEAVY-DUTY ELECTRIC VEHICLE FINANCING

As noted above, zero-emission heavy duty vehicle sales, particularly within the heavy-duty truck sector like Class 8, remain limited primarily due to the high upfront costs and associated challenges such as battery weight, charging time, and range limitations. For example, an ICCT study estimated that class 8 zero-emission short-haul tractor trucks⁴⁰ cost \$279,000 in 2022, whereas the traditional internal combustion engine-version is priced at \$150,000.⁴¹ While analysts expect light-duty electric vehicles to reach cost parity with their fossil fuel-powered counterparts sooner, heavy-duty trucks face additional hurdles given their larger battery size. However, as discussed above, experts project that this cost disparity will diminish by the decade’s end as production volumes increase and battery costs decline.

Given this current upfront price gap, increasing access to financing for zero-emission heavy-duty trucks will be critical to catalyzing the transition to a cleaner transportation sector, mitigating greenhouse gas emissions, and improving air quality. Equally important is securing the necessary funding for the extensive charging infrastructure required to support these vehicles. According to a Clean Freight Coalition study, electrifying the commercial fleets in the United States would require a cumulative multi-decade

investment of \$620 billion in charging infrastructure (including the chargers, site infrastructure, and electric service upgrade), as well as an additional \$370 billion for the grid networks to fully support the vehicle demand.⁴² As a result, policy makers will need to develop programs that encourage more private-sector financing to meet these investment needs.

DEVELOPING SOLUTIONS TO THE CHARGING AND FINANCING NEED

Given the scale and urgency of the need to deploy more heavy-duty zero-emission vehicles and associated infrastructure and catalyze sufficient financing for the vehicles and infrastructure, UC Berkeley Law's Center for Law, Energy and the Environment (CLEE) and the UCLA Law Emmett Institute on Climate Change and the Environment convened experts and stakeholders to help identify the most pressing barriers both to deploying more charging infrastructure and to unlocking more private financing for both the vehicles and the infrastructure. These two needs were independently identified by stakeholders and policy makers as the most pressing for the law school centers to address. CLEE and the Emmett Institute then undertook a literature review and convened two half-day workshops with a select group of stakeholders to inform the policy recommendations presented in this analysis.

First, on July 21, 2023, the law schools organized a small-group, expert convening at UC Berkeley Law to identify the key opportunities to boost deployment of charging infrastructure for heavy-duty electric vehicles in California, entitled "Heavy Duty Vehicle Charging Infrastructure: Policy Solutions to Increase Deployment." This convening was attended by state leaders, industry representatives, environmental advocates, and other stakeholders, who identified the key public and private sector actions that could facilitate greater deployment of this charging infrastructure to meet California's heavy-duty vehicle zero-emission goals. Then on January 19, 2024, the law schools organized a second convening entitled "Financing Heavy Duty Zero-Emission Vehicles Policy Solutions to Increase Access" (see acknowledgements for the list of both convening participants). That convening took place at the California Air Resources Board's Southern California headquarters in Riverside, California. It served as a platform for experts both in the private and public sectors to identify major barriers hindering the financing of zero-emission heavy-duty electric vehicles and associated infrastructure and to brainstorm potential solutions to overcome these challenges. The following sections summarize and combine the key findings from those two discussions.



III. VISION FOR IDEAL CHARGING INFRASTRUCTURE DEPLOYMENT FOR HEAVY DUTY ELECTRIC VEHICLES

During the first convening in July 2023, participants outlined a comprehensive vision for the successful deployment of heavy-duty charging infrastructure by 2035, encompassing several key principles:

Coordinated Deployment: participants emphasized the need for coordinated efforts across government agencies, private industry, and all stakeholders. This coordination would streamline the deployment of heavy-duty electric vehicle charging infrastructure to minimize cost and maximize benefits. All stakeholders would have a clear understanding of targets and deployment plans and would be able to contribute to meeting the shared vision.

Grid Reliability and Resilience: the charging deployment would draw energy from a reliable and resilient grid. Participants highlighted the need for the electrical grid to provide dependable power for chargers of all scales, while also being resilient to the increased impacts of climate change.

Affordability: the cost of electricity would be low and predictable on a day-to-day basis, making it more competitive compared to fossil fuel alternatives. Additionally, the price and location of charging would minimize the need for drivers and operators to design routes around off-peak charging times, while the burden of scaling the needed grid infrastructure would not disproportionately fall on residential and lower-income ratepayers.

Equity and Community Benefits: in deploying the infrastructure, policy makers and industry leaders would address and prioritize the needs of disadvantaged communities. Because much of the needed charging infrastructure, particularly logistics hubs, are located within or surrounded by disadvantaged communities, electrification of freight in these communities will significantly reduce air pollution impacts. Participants also envisioned that this transition would occur without further burdening these communities with increased traffic.

Local Workforce Development: participants envisioned local workers building the infrastructure, providing opportunities for training and education to contribute to the development of a skilled workforce. Policy makers and industry would minimize job losses associated with this energy transition, with fossil fuel workers having access to retraining programs to support the deployment of heavy-duty charging infrastructure instead.



Photo Credit: Matt Petit

IV. BOOSTING THE DEPLOYMENT OF CHARGING INFRASTRUCTURE FOR HEAVY-DUTY ELECTRIC VEHICLES: BARRIERS & SOLUTIONS

Participants at the July 2023 convening identified and ranked three priority barriers hindering the attainment of their vision for ideal infrastructure deployment. They then developed a list of solutions to overcome each barrier, described in the following section.

BARRIER 1: INSUFFICIENT COORDINATION AMONG STATE AGENCIES THAT LEADS TO UNSYNCHRONIZED, INEFFICIENT, AND COMPLEX DEPLOYMENT PROCESSES

Numerous state agencies play crucial roles in planning, permitting and funding the deployment of charging infrastructure for heavy-duty electric vehicles, ranging from the California Department of Transportation (Caltrans) to the California Public Utilities Commission. Each of these agencies has its own programs and personnel dedicated to this deployment. However, participants noted that these agency efforts are too-often fragmented and lack coordination, leading to slower infrastructure deployment. The problem becomes more acute given that electric trucks can be delivered in less than 4-6 months, while utility upgrades may take 18-24 months or longer.⁴³

Moreover, many agency and legislative funding allocation timelines are not synchronized, exacerbating the challenges of efficient deployment. Participants particularly emphasized the lack of a holistic electrification charging plan across agencies, with no agency having ultimate responsibility for leading these public-sector efforts. The result is irregular availability of grants and uncoordinated permitting that lead to delays and added complexity for all stakeholders, stretching deployment timelines and increasing developer costs. It also leads to the ineffective use of funds, as each agency carries out its own implementation plan. In addition to the lack of interagency coordination, private sector entities face several permitting challenges in deploying heavy-duty charging infrastructure, including lengthy and complex approval processes and restrictive zoning and other land use regulations. Addressing these challenges requires streamlined processes, better interagency coordination, clear guidelines, and robust stakeholder engagement to facilitate the timely deployment of heavy-duty charging infrastructure.

SOLUTIONS

The Governor could create an executive-level “charging working group” or “czar” with the Governor’s authority to ensure coordination and hold accountable state agencies responsible for deployment of charging infrastructure to support the heavy-duty vehicle sector

The Governor could create and empower with enforcement authority over key agencies a collaborative “Charging Working Group” or “czar” that could efficiently coordinate the agencies in their work to deploy needed infrastructure. The working group or czar could potentially build on the infrastructure strike team already created by Governor Newsom’s executive order in May 2023.⁴⁴ This leadership could also potentially come from Senate Bill 934 (Gonzalez), pending in the California Legislature as of June 2024.⁴⁵ That bill would create a “Zero-Emission Freight Central Delivery Team” jointly convened by the California Transportation Commission and the Energy Commission, with representatives from various state agencies, in order to ensure statewide coordination of zero-emission freight infrastructure planning and implementation. Ultimately, the working group leader could designate key ownership and leadership roles among lead commissioners from pivotal agencies such as the California Public Utilities Commission (PUC), Energy Commission (CEC), Air Resources Board (CARB), Department of Transportation (Caltrans), and other relevant authorities. These designated leaders would form the core of the working group, convening regularly to evaluate progress, establish priorities, and pinpoint follow-up action required to facilitate deployment.

The Governor could task the working group or czar with holding semi-annual meetings among agency leaders to ensure transparency and accountability on infrastructure deployment progress

The governor could charge the working group with organizing semi-annual symposiums where principal leaders would report to all stakeholders, providing transparency and accountability and a comprehensive overview of advancements made toward the state’s infrastructure deployment goals for the heavy-duty sector. This platform would not only facilitate information dissemination but also foster a collaborative approach towards overcoming challenges and optimizing resources. The working group or czar could play a pivotal role in ensuring consistency and coordination across existing planning processes at agencies like the public utilities and energy commissions, including Integrated Resource Planning (IRP), Distribution Resource Planning (DRP), and Transportation Priorities Planning (TPP), as well as demand forecasts and Integrated Energy Policy Report (IEPR).

The state agency working group leaders could make the data on deployment progress publicly available

The working group or czar could prioritize guaranteeing the timely availability of chargers and grid upgrades in accordance with established goals, along with strategic planning to align infrastructure development with the projected timelines in order to avoid delays that might impede progress. To enhance data management and accessibility (as well as transparency and accountability), the working group could establish an online repository of data and information on deployment progress to date, potentially through the California Energy Commission’s beta dashboard displaying all medium- and heavy-duty zero-emission vehicle charging stations in development in California.⁴⁶ This

repository could serve as a comprehensive resource, housing granular workstreams, workshops, and relevant data, making information readily available to the public. This commitment to transparency would not only foster accountability but also encourage collaboration and engagement from stakeholders.

State agencies responsible for funding or financing charging infrastructure could coordinate with each other and with the legislature if necessary to ensure synchronization of available public funding and financing for charging infrastructure

Multiple agencies play a role in allocating funds to heavy-duty electric vehicle charging infrastructure, including the California Air Resources Board, Energy Commission, Public Utilities Commission, Caltrans and others. However, participants noted that these agencies and the timelines they set are not always synchronized, which results in challenges lining up enough funds and financing to deploy necessary infrastructure. The agencies could better coordinate with each other and with the legislature if necessary (if programs and timelines are statutorily determined) to strategically streamline and time financial resources, avoiding fragmentation and maximizing the impact of grants. The availability of grants like the Charging and Fueling Infrastructure Discretionary Grant Program is a key component in facilitating the development of heavy-duty charging infrastructure. These grants serve as crucial financial incentives that can significantly alleviate the economic burden faced by stakeholders involved in the deployment of such infrastructure. However, the effective utilization of these grants necessitates a well-coordinated approach to ensure their optimal impact. This coordination work could potentially happen through the aforementioned “Zero-Emission Freight Central Delivery Team” that would be jointly convened by the California Transportation Commission and the Energy Commission, under Senate Bill 934 (Gonzalez), under debate as of June 2024.

The Governor could empower an existing “strike team” or leader within the Governor’s Office who can help solve private-sector permitting and zoning challenges and then scale those solutions statewide

The envisioned team or czar, empowered by the Governor to direct efforts at key state agencies, could identify, analyze, and resolve permitting challenges faced by private sector entities involved in deploying heavy-duty charging infrastructure. Building on the existing infrastructure strike team, including for charging installations, promulgated by the aforementioned executive order,⁴⁷ the strike team or leader could initiate the effort by compiling a comprehensive list of challenges that individual developers or companies are encountering during the permitting process and then appointing a responsible individual to navigate and resolve each challenge. This effort could include convening a public-private quarterly working group, where stakeholders from multiple sectors convene to discuss challenges, share insights, and collectively strategize solutions. To further enhance collaboration and industry engagement, the Governor could establish a specialized “E-Truck Regulation Advisory Committee” within this framework, providing a targeted platform for addressing regulatory concerns specific to heavy-duty charging. The strike team could also ensure transparency and real-time tracking of progress via an online dashboard, such as the one developed pursuant to the recommendation above on the charging working group. This dashboard could identify priority transmission and distribution (T&D) upgrades necessary to support heavy-duty vehicle charging. The site could also regularly update data related to indicators of progress,

providing stakeholders with a visual representation of the advancements made in addressing infrastructure challenges. This initiative could also be incorporated into the convenings mentioned above, in which a dedicated session would involve a progress report and discussions on progress, barriers, and solutions deployed.

BARRIER 2: CHALLENGES WITH UTILITY COORDINATION, DATA TRANSPARENCY, AND ENERGIZATION DELAYS

Utilities are critical to the needed and urgent deployment of charging infrastructure, since they supply the grid infrastructure to power the chargers. Yet participants noted that lack of utility data and transparency can lead to higher risk and uncertainty with charging infrastructure investment. Interconnection or energization delays, which involve getting a project linked into and powered by the grid, can lead to otherwise completed projects awaiting connection to operate. For example, developer-reported timelines for energization for DC fast chargers range from six months to more than two years.⁴⁸ Further approval delays by the utility can stretch construction timelines, as well as increase uncertainty for investors, who typically need to see charging infrastructure generate revenue quickly.

At the same time, a lack of comprehensive and frequent data in areas such as capacity or energization forecasts makes project planning challenging and imprecise. Coming from many different sources, the data on such metrics as charging demand patterns, utility infrastructure, energization and grid capacity are often of varying quality and formats, requiring significant data analysis. The data gaps can inadvertently lead developers to invest in areas that lack sufficient infrastructure or to miss areas with newly available grid capacity.

Furthermore, smaller-scale charging infrastructure projects can face significant additional cost barriers if developers are responsible for paying for disproportionately large grid upgrades. For example, purchasing transformers and switchgear on a per-project basis can lead to higher costs and longer lead times, for both the purchaser and the developer. To assist and accelerate the transition, utilities and regulators will have to adapt their permitting and data practices, as well as play a more active role in deploying both behind-the-meter and in-front infrastructure.

SOLUTIONS

The Legislature or California Public Utilities Commission could utilize current proceedings to require utilities to be more transparent about sources of energization and approval delays

Senate Bill 410 (Becker, Chapter 394, 2023) and Assembly Bill 50 (Wood, Chapter 317, 2023) required the public utilities commission to establish reasonable and maximum energization time periods, along with a procedure for customers to report delays, among other requirements. In response, the commission opened a new proceeding in January 2024 to implement these goals.⁴⁹ The public utilities commission could utilize this proceeding to mandate utilities enhance transparency of the sources of energization or approval delays associated with heavy-duty electric vehicle charging projects. Commissioners could require utilities to provide clearer insights into the timelines and factors causing delays in the approval process. This transparency could

in turn help address uncertainties that hinder capital investment and streamline the overall deployment of the relevant infrastructure. Specifically, policy makers could require investor-owned utilities (IOUs) to incorporate reporting mechanisms into the Rule 29 tariff, which seeks to reduce the cost and simplify the process of providing charging infrastructure for commercial, industrial, and/or multi-family electric vehicle charging station projects.⁵⁰ By mandating a reporting obligation, policy makers would necessitate investor-owned utilities to submit detailed information to the public utilities commission (or governing boards, in the case of municipal utilities and cooperatives) regarding energization timelines and any encountered delays. Such a reporting requirement could establish a more transparent and accountable system, facilitating a better understanding of the sources and drivers of delays for developers in the approval and energization phases.

Furthermore, to foster a collaborative approach, commission or utility leaders could organize workshops under the Rule 29 tariff. These workshops would provide a platform for utilities to engage with regulatory authorities, stakeholders, and the broader community. Through these workshops, utilities could share insights into challenges faced during the approval process, discuss strategies for minimizing delays, and collectively work towards solutions. This collaborative effort would ensure that policy makers and industry leaders consider diverse perspectives, leading to more effective decision-making.

The California Public Utilities Commission or Legislature could require utilities to improve data transparency to facilitate charger deployment and reduce inefficiencies in capacity planning

The commission or legislature could require utilities to improve the transparency of data related to charger deployment. While the commission and utilities are already working on updating Interconnection Capacity Analysis (ICA) maps,⁵¹ they only update monthly and not for every circuit. Instead, policy makers could require a more comprehensive and frequent updating mechanism, ensuring that data accuracy is actionable and reflective of the dynamic charging landscape. Participants noted that the current energization capacity analysis mapping process, designed with distributed energy resources (DERs) in mind, lacks a customer-centric focus. Therefore, a more user-friendly, comprehensive effort could help developers more efficiently site and invest in the needed charging infrastructure. In addition, some participants suggested that the public utilities commission could facilitate this data transparency through the existing proceeding on modernizing the electric grid for a “High Distributed Energy Resources (DER) Future,” begun in July 2021.⁵²

The California Legislature or Public Utilities Commission could require utilities to work with the California Energy Commission to build a tool that combines energization plans and feasibility to identify optimal charger installation sites, and to publish that information online for public viewing

A robust and comprehensive tool could combine detailed energization plans with feasibility assessments, providing stakeholders with valuable insights into the optimal locations for heavy-duty charging infrastructure. This integration could ensure that the chosen locations not only align with energization plans but also consider factors like grid capacity, utility infrastructure, demand patterns and site suitability that are crucial

for successful implementation. The public utilities commission could also introduce incentive programs to spur utilities to provide accurate and timely data collection.

Furthermore, the legislature could mandate private-sector data collection, ensuring a comprehensive and standardized approach across the industry. The key types of private-sector data that could be essential in building effective charging infrastructure include charging demand patterns (peak usage times, daily patterns, and seasonal variations), geospatial data (including maps, satellite imagery, and land use data, which helps identify suitable locations), utility infrastructure data, grid capacity and load data, and real estate and zoning information. Some participants also want improved transparency on the service agreements needed for charging, as well as the energization needed to enable bidirectional charging, in which the vehicles can discharge electricity while connected for charging, in order to provide grid services and electricity supply. Ultimately, legislation could require utilities to make the data available in usable and real-time formats, potentially updated weekly or monthly.

The California Energy Commission could be a logical agency to host this tool with utility data, rather than relying on disparate utilities to build their own tools. The energy commission could house the data within its existing “EVSE Deployment and Grid Evaluation (EDGE) Tool,” which seeks to inform charging deployment efforts and associated grid planning via access to related data. However, the tool currently has access only to limited utility data for primary distribution circuits through 2025 and does not have access to any secondary distribution grid data.⁵³

Alternatively, the legislature could require investor-owned utilities to build a platform or map to share the utility data, with the potential advantage that they could accomplish this task sooner than a state agency. The legislature would need to ensure adequate monitoring and enforcement to ensure the utilities meet the timelines and accessibility needs.

The California Energy Commission could establish an entity to process and disseminate data on optimal charging locations for planning processes

The California Energy Commission could create an entity to process and collect the data described above, such as detailed energization plans, feasibility assessments, and utility infrastructure, and make it available for planning processes related to the optimal locations for heavy-duty charging infrastructure. By centralizing data collection and making it available for planning processes, this entity could streamline the information-sharing process, fostering a collaborative environment for efficient decision-making. The energy commission could potentially incorporate this work through its existing “Electric Vehicle Charging Infrastructure Assessment” under Assembly Bill 2127 (Ting, 2018),⁵⁴ or through the aforementioned “Zero-Emission Freight Central Delivery Team” that would be jointly convened by the California Transportation Commission and the Energy Commission, under the pending SB 934.

The California Public Utilities Commission could encourage or require utilities to build an equipment bank for needed charging and grid infrastructure (e.g. transformers) to avoid construction delays

With regulator or legislative encouragement or mandates through firm timelines for utilities on improving energization processes, utilities could explore the possibility

of pre-purchasing transformers or switchgears, which are often customer-purchased and site-specific items necessary for charger installations. To implement this solution effectively, utilities would need a robust forecasting system to anticipate the demand for heavy-duty charging infrastructure. This forecast could involve a meticulous process of assessing, approving, and continuously tracking pre-order volumes. By integrating forecasting mechanisms, utilities can proactively align their pre-buying capabilities with the evolving needs of the charging infrastructure landscape. Furthermore, these advanced purchases could tie into the above-mentioned industry information sharing initiatives with the California Energy Commission and Public Utilities Commission. Collaborative efforts to share data and insights with these regulatory bodies could enhance the accuracy of forecasting models and ensure that utilities have enough information to justify pre-purchasing this distribution grid equipment.

The California Public Utilities Commission could encourage or require the utilities in to hire more utility employees in the job classifications needed to design and upgrade the grid deployment, as well as contract out when necessary to address staffing shortages

To address the potential shortage of skilled employees at the utilities, which in turn can delay approvals and needed grid upgrades, regulators could encourage or require utilities to hire and train more individuals equipped with the skills needed to design, construct and maintain a robust grid infrastructure for heavy-duty charging, such as through setting firm timelines on energization processes. In addition, the commission could allow and encourage utilities to contract out engineering work to qualified contractors to alleviate workflow bottlenecks and charging infrastructure installation delays caused by staffing shortages. This workforce is essential for meeting the evolving demands of the electric vehicle infrastructure landscape.

The California Public Utilities Commission could direct investor-owned utilities to prioritize charging infrastructure investments in areas that serve regulated fleets and truckmakers and receive financial assurances and contracting support from developers to minimize ratepayer risk

Utilities could prioritize investment in projects that serve fleets obligated to comply with the advanced clean fleets rule) and truckmakers who must comply with the advanced clean trucks regulation. Some participants noted that utilities might otherwise be reluctant to invest ratepayer funds in these projects if the demand has not yet materialized or they would be concerned about accusations of favoritism for prioritizing these projects over others. Yet given the regulatory obligations, these projects could be sound investments with de facto regulatory guarantees of need. As a result, the public utilities commission could adopt a rule requiring utilities to accept from charging depot developers in these priority areas cash bonds or deposits to provide assurance to a utility otherwise unwilling to risk investor or ratepayer funds on a new, unfamiliar type of project or customer. This upfront, third party assurance and contribution could in turn avoid costly delays by the utility conducting a lengthy financial due diligence process with no fixed end date. It could also eliminate a reason for a utility to deny or unduly delay service connection requests. Furthermore, the commission could adopt a rule to allow charging depot developers in these priority areas to pay for qualified contract planning work ordinarily performed by a utility, when the utility lacks the resources or qualified staff to conduct this work, which would cause delays that are not the fault of the customer. The developer could pay

the utility to hire the contractor or hire a contractor directly, upon timely approval by the utility. The utility could then pay the developer back through discounted rates over a set period of time.

Utilities could bolster existing efforts to educate heavy-duty fleet managers in the electric vehicle transition and the needed front- and behind-the-meter infrastructure

Utilities such as Pacific Gas & Electric (PG&E) and Southern California Edison have existing programs to help educate fleet managers on how to install the necessary charging infrastructure to electrify their vehicles.⁵⁵ These fleet managers are crucial to the widespread adoption of heavy-duty electric vehicles. As a result, utilities could bolster this outreach to educate more of them about the technology and related charging and grid needs. These educational initiatives could encompass a broad spectrum, including the essential aspects of transitioning to electric vehicles, understanding front-of-the-meter infrastructure requirements, and (where applicable) delving into the nuances of behind-the-meter infrastructure. Such education efforts can encompass a variety of media, including workshops, seminars, and informational materials tailored to the specific needs and challenges faced by fleet managers. By providing comprehensive and accessible information, utilities can empower fleet managers to make informed decisions to navigate the installation of heavy-duty electric vehicle chargers.

The California Department of Transportation (Caltrans) could offer bulk permits to utilities over a set time to encourage system-wide grid upgrades needed for charging depots

Participants noted that Caltrans currently provides utilities with permits for grid upgrades needed for charging installations on a one-at-a-time basis within or through Caltrans-owned property. Instead, the agency could provide utilities with bulk permits with different time-scale options, such as issuing permits for extended periods, like one or two years. The shift to bulk permits on varying time scales could create a more efficient permitting process and allow utilities to plan for a more extended timeframe, reducing costs and administrative overhead, and streamlining project timelines for heavy-duty charging infrastructure installations.

The California Public Utilities Commission and Legislature could authorize a “balancing account” to help both investor-owned and municipal utilities fund grid upgrades for heavy-duty charging infrastructure sooner

The California Public Utilities Commission (CPUC) could use the aforementioned Senate Bill 410 (Becker, 2023) proceeding to authorize the establishment of a “balancing account” mechanism to expedite the funding of grid upgrades specifically tailored for heavy-duty vehicle charging. In October 2023, Governor Newsom signed SB 410 to direct the commission to set average and target time periods for grid connections and upgrades.⁵⁶ As of June 2024 the proceeding is underway.⁵⁷ If the commission moves expeditiously, this proceeding could help provide investor-owned utilities with a dedicated fund that they can utilize to accelerate the implementation of necessary grid upgrades to support the deployment of heavy-duty charging infrastructure. This expenditure would come with an oversight and reasonableness review, providing a safeguard to maintain fiscal responsibility and ensure prudent use of the allocated resources. For municipal utilities not subject to California Public Utilities Commission

jurisdiction, the legislature could establish such an account, potentially through the California Energy Commission or Treasurer's Office.

BARRIER 3: NEED FOR NON-RATEPAYER FUNDING FOR UTILITIES

According to a study commissioned by California regulators, California's big three investor-owned utilities will need to invest up to \$50 billion by 2035 to build out the distribution grids needed to handle the rapid scaling of heavy duty charging infrastructure.⁵⁸ Participants believed that passing these costs to ratepayers would be politically infeasible, especially during a period when electricity rates are already increasing rapidly, largely due to wildfire mitigation costs. As a result, developers, advocates and policymakers will need to augment utility spending on charging-related infrastructure with state and federal funding while making it easier for utilities to spend existing ratepayer dollars more efficiently.

SOLUTIONS

The California Air Resources Board could accelerate heavy-duty electric vehicle charging infrastructure deployment via the Fast-Charging Infrastructure pathway under the state's low carbon fuel standard

Participants at the convening discussed the importance of ensuring funding for non-grid charging infrastructure. The California Air Resources Board developed the low carbon fuel standard (LCFS) program, which requires fuel providers to reduce the carbon content of their fuel or buy credits from low- or zero-carbon fuel providers who have excess credits (for more information on this program, please refer to table 2). The board designed the program to incentivize low carbon transportation fuels, and participants noted that it could serve as a powerful financial incentive to drive investments in heavy duty electric vehicle charging infrastructure without relying on ratepayer dollars. Currently, approximately 80% of the \$3-to-4 billion in annual low carbon fuel standard revenues support biogas and biofuels providers (biofuels).⁵⁹ These funds are overseen by the Air Resources Board, which requires them to be spent for specific purposes that align with regulatory requirements.⁶⁰

Participants suggested that the board could instead align low carbon fuel standard funds more directly with the state's zero-emission vehicle goals and allocate more dollars for electric vehicle charging infrastructure through a more robust "Fast Charging Infrastructure" program. This program provides credits based on the installed capacity of chargers, rather than purely on the electricity usage at those sites.⁶¹ Participants noted that this program has proven successful for light duty vehicles, and the board is currently considering expanding it to heavy duty charging via the new proposed amendments to the low carbon fuel standard.⁶² These new amendments would allow heavy duty charging infrastructure installations to generate credits in the low carbon fuel standard market based on the installed capacity of the chargers, thereby generating additional revenue for those chargers and improving their return on investment. If the program is sufficiently flexible and robust, it would help alleviate utilization risk in the early years of the electric truck market and encourage developers to build more of this infrastructure. Participants also observed that higher credit prices will be needed in order to attract private capital and meet state goals, which could argue in favor of the board tightening the carbon targets in the low carbon fuel standard. Because the

state is short several billions of dollars of investment in non-grid infrastructure for the state to reach its electrification goals, this approach could help leverage non-ratepayer funds to finance heavy-duty charging installation.

Utilities and state leaders could seek federal funds for grid upgrades, given the continued escalation of electricity rates in California

As electricity rates continue to escalate due to multiple factors, California policy makers and utility leaders could increase efforts to seek non-ratepayer sources of funding. Utilities and state agencies could jointly explore federal funding avenues in particular as a means to fill the financial gap hindering deployment of heavy-duty electric vehicle charging infrastructure. By actively seeking support from the Department of Transportation (DOT) or other federal agencies, these stakeholders could secure resources that they can dedicate to upgrading the grid infrastructure. For example, the department offers programs like Charging and Fueling Infrastructure (CFI) Discretionary Grant Program. This program provides competitive grants for electric vehicle charging and alternative-fueling infrastructure projects. It recently awarded \$623 million to fund 47 charging projects in 22 states and Puerto Rico, including the construction of approximately 7,500 charging ports, although utilities are not eligible to apply.⁶³ For more information on federal and state electric vehicle charging policies and programs, please refer to table 3.

The California Legislature could pay for grid upgrades through the general fund or non-traditional sources of existing funding, such as via transportation infrastructure investments

Given rising electricity rates, the legislature could consider financing the necessary grid upgrades directly from the general fund or greenhouse gas reduction fund (GGRF, funded by proceeds from the state's cap-and-trade auction proceeds), particularly when sufficient budget funds exist to allocate. Some of these expenses could be recouped from ratepayer funds, such as public financing of new transmission lines. This approach capitalizes on the economic advantages of public financing, which is often considerably more cost-effective than relying solely on utility finance, potentially alleviating the financial burden on ratepayers. The state could also establish a dedicated revenue stream earmarked specifically for funding solutions to challenges associated with heavy-duty charging infrastructure. Finally, the state could explore dedicating existing funding for highway and other infrastructure expansion, as well as potentially public health funds, to support charging station infrastructure investments, given the tie to public health benefits and co-location with existing transportation networks, such as truck charging stations along highways.

State leaders could incorporate grid needs in a proposed climate bond

State leaders have the opportunity to incorporate grid needs into any proposed "climate bond" presented to voters by advocates or the legislature. Such a state bond could create a financial mechanism to support essential infrastructure projects like heavy-duty vehicle charging, while aligning with broader climate and environmental goals. In July 2024, the legislature passed climate bond legislation via Senate Bill 867 (Allen), for inclusion on the November ballot. However, if passed by the voters, it would only allocate funds for light-duty electric vehicle charging and none for heavy-duty truck charging or grid upgrades. Future bonds, however, could address these gaps by including funding for heavy-duty charging infrastructure.



Photo Credit: Matt Petit

V. VISION FOR FINANCING ELECTRIC HEAVY DUTY VEHICLES AND CHARGING INFRASTRUCTURE

During the January 2024 Riverside convening, participants described key elements of a vision for ideal financing of zero-emission heavy duty vehicles and associated infrastructure.

Maximize Public Dollars to Leverage Private Dollars: participants envisioned that any public funds for vehicles and infrastructure fully leverage private sources of capital and be distributed promptly to recipients with reduced bureaucratic barriers that might hinder access. In particular, investment from the private sector and environmental, social, and governance (ESG) lenders in zero-emission heavy-duty vehicles could provide a robust source of support.

Program Flexibility and Accessibility: policy makers would develop flexible programs and interventions that consider the evolving nature of zero-emission heavy-duty vehicle technologies and overall market dynamics.

Thriving Secondary Market: participants envisioned a thriving secondary market for zero-emission heavy-duty vehicles with competitive residual value compared to new fossil-fueled vehicles. This growth in the secondary market would eventually attract lenders, resulting in lower lease payments and higher resale values.

Zero Emission Heavy Duty Vehicles Reaching Cost Parity with Diesel Counterparts: the cost of heavy-duty electric vehicles is expected to achieve parity with traditional internal combustion engine (ICE) trucks by 2030.⁶⁴ As this cost gap diminishes, participants envisioned that the existing public incentives for electric heavy-duty vehicles will eventually phase out.

Addressing Barriers to Infrastructure Deployment: deployment barriers such as complicated permitting, long delays on grid energization, and other site-specific challenges would be fixed comprehensively to allow financing to flow.

Inclusive Program Design and Implementation: the transition to zero-emission heavy-duty vehicles would be inclusive and actively involve local communities during the program design and implementation. In addition, these heavy-duty electric vehicle technologies would become more accessible to underserved communities to ensure economic and environmental justice and create green jobs.



VI. HEAVY-DUTY VEHICLE AND CHARGING INFRASTRUCTURE FINANCING: BARRIERS & SOLUTIONS

Participants at the January 2024 convening identified and ranked the three priority barriers hindering the financing of electric heavy-duty vehicles and the associated charging infrastructure. They then developed a list of solutions to overcome each barrier, described in the following section.

BARRIER 1: RIGID PUBLIC PROGRAM DESIGN THAT CAN INHIBIT PRIVATE SECTOR LENDING

A number of participants described the state-level programs that offer funding and financing as often too rigid and inflexible to encourage uptake and leverage sufficient private sources of capital, due to lengthy bureaucratic processes. Some also noted a misalignment between contract and grant timelines that can affect access to public funding and incentives. Restrictive program criteria can further compound these issues, such as fleet size limitations on incentive dollars. These restrictions can impact adoption by failing to support large businesses that can otherwise afford to transition their entire fleets to electric heavy-duty vehicles. These early-adopter fleets could otherwise help scale the market for heavy-duty electric vehicles, bringing down their cost over time and helping to launch a secondary market with cheaper used vehicles for smaller, less-resourced fleets. Furthermore, a number of participants cited high insurance costs as hindering adoption, primarily due to the newness of the technology and lack of historical price and performance data available to insurers, yet state incentives often fail to take into account those costs (and insurers fail to take into account the price of the vehicles after incentives).

SOLUTIONS

The California Legislature and Air Resources Board could modify HVIP incentives to ensure more targeted uptake by fleets more readily able to electrify

The California Air Resource Board could amend existing incentive programs like the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) by expanding eligibility criteria and accommodating emerging technologies. For example, the

Legislature could expand HVIP to include incentives for the development of charging infrastructure or emerging technologies such as vehicle-to-grid integration and vehicle sharing platforms that can help further reduce emissions and improve efficiency. As a model that could be expanded to include more funding programs at a bigger scale, the board and the California Energy Commission coordinate on funding HVIP with the energy commission's EnergyIIIZE grant program, which provides reimbursement-style grants to infrastructure projects that deploy charging for heavy-duty commercial fleets.⁶⁵ HVIP could also better account and compensate for higher insurance costs for electric heavy-duty vehicles compared to diesel counterparts, due to insurers lacking data on how the technology performs over a sufficient amount of time and failing to value the vehicle based on post-incentive prices.

Some participants expressed a desire for the board to delete the current limits on the number of vehicles and fleet size eligible for HVIP, perhaps coupled with a limit on the number of vouchers per year per company to protect funds from being dominated by a few large companies (although California Energy Commission funding is still available to large fleets). The goal would be to encourage uptake by companies that are well positioned to electrify their fleets and are already required to do so by regulation, in order to encourage them to go beyond their compliance obligations. Funding could be limited only to those vehicles in the fleet that exceed regulatory obligations, to avoid reserving funds primarily for companies that may not be as well suited to convert their fleets, even with the financial assistance. Many companies may otherwise be less motivated to convert their fleets quickly, if they are not directly regulated by the Advanced Clean Trucks or Advanced Clean Fleets rules.

In addition, participants wanted the California Air Resources Board to eliminate the restrictions on funding being tied to truck classification. Because HVIP vouchers provide more funding for vehicles with higher gross vehicle weight rating (GVWR), regardless of electric range, participants described the perverse result that a customer with a Class 6 truck with a 80kWh battery and 80 miles of range might receive double the voucher as a customer with a Class 4 truck with 120kWh of battery and 150 miles of range, simply because the higher truck classification merits more dollars. The incentives could instead be tied to the value of fossil-miles that can be displaced or perhaps more simply to the size of the electric drivetrain.

Finally, a number of participants wanted any new incentive programs developed by the state to not necessarily follow HVIP rules, given what they deemed to be overly-restrictive criteria. New programs could instead seek new ways of encouraging adoption rather than replicate a model that has confounded some industry members in certain cases.

The California Air Resources Board and Energy Commission could streamline and accelerate incentive payment processing times

Incentive recipients often face uncertainties regarding payment timing, which significantly impacts their operational activities. To address these issues, agencies like the California Air Resources Board and Energy Commission that offer incentives and direct payment could streamline their processes by simplifying grant application and approval procedures. This streamlining could include reducing the number of approval layers, minimizing paperwork, and expediting compliance checks that often slow down the payment process. By implementing more straightforward payment procedures,

regulators could reduce administrative burdens for incentive recipients. Additionally, agencies could explore efficient digital payment mechanisms to ensure timely payment and reimbursements.

Participants also complained that current payment of incentives often takes too long and does not match with the expenditure timing, creating a cash flow gap. They noted that this delay is a common challenge with many large state grants, such as HVIP and Carl Moyer.⁶⁶ In some cases, it can take months after approval and truck delivery before the state can process the incentive payment. According to participants, this lag is forcing difficult conversations between truck manufacturers and truck purchasers about which party should bear the risk of the delayed incentive payment. While HVIP pays dealerships directly and not the customer, some companies such as Tesla do not have dealerships, while Carl Moyer by contrast pays the customer directly. Instead, some participants wanted a “Finance Direct Pay” model in which the incentive check could be co-signed directly to the customer’s financing partner. This modification would effectively reduce the amount of the loan that the customer would have to take to cover the timing gap, because the lenders could then expect the state’s check with less delay and third-party processing time.

The California Legislature, Governor’s Office, Air Resources Board and Energy Commission could continue to encourage other states to develop similar incentive programs and ensure equity and inclusion in their program design

Given that many trucking routes cross state lines and that major fleets operate in multiple states, California leaders could continue to encourage other states to adopt similar and expanded incentives for heavy-duty electric vehicles, building on outreach that state leaders conduct with other states to replicate funding programs and coordinate on initiatives like multi-state charging corridors for electric trucks. California leaders could help ensure that other states learn from the state’s experience in developing their own programs. This work is particularly important for supporting interstate fleet operators, whether or not their trucks cross state lines, as they may want to replicate electric operations in other jurisdictions. State leaders could also continue to encourage other states to include equity in their program design, such as by actively engaging community-based organizations and environmental justice groups in disadvantaged communities to ensure that the benefits of zero-emission truck programs are distributed to residents of disadvantaged communities, as is already occurring in jurisdictions like Washington State and Mexico. Of note, some participants objected to how HVIP and other programs currently address equity, with a focus on supporting smaller fleets rather than overall emission reductions in disadvantaged communities, which may entail lifting restrictions on supporting larger fleets which in some cases might be responsible for disproportionately large amounts of localized pollution. Regardless of the approach, the California Air Resources Board could bolster efforts to share best practices and align efforts more generally across regions.

The Federal Government and California Legislature could reduce excise and sales taxes to make zero-emission models more competitive on upfront price with diesel versions

Participants described the challenge of bridging the upfront price gap between zero-emission and diesel-fueled heavy-duty vehicles, with new Class 8 rigid diesel trucks costing roughly \$158,000 but new Class 8 rigid electric trucks priced around \$270,000

(see Table 1). Although the price gap will decrease and operating cost savings can help reduce total cost of ownership over time, some participants wanted Congress (or California leaders to petition Congress) to amend the federal excise tax to reduce it for zero-emission heavy-duty vehicles, at least temporarily until prices decrease. They also wanted the California Legislature to reduce sales taxes on new zero-emission models, in order to remove a disincentive for truck operators to buy new zero-emission models.

The California Air Resources Board could modify scrapping requirements to facilitate incentive uptake and more zero-emission heavy-duty vehicle miles

Current state scrapping regulations, such as the Carl Moyer program, provide incentive payments in exchange for the early retirement of older and more polluting vehicles, particularly diesel trucks. But these scrapping regulations can create perverse difficulties. Some fleet operators expressed concern that if they scrap an older truck but then have problems operating the replacement zero-emission heavy-duty vehicles, they will lose money due to long down times in the repair shop. Eliminating the need to have already exchanged their back-up vehicle in order to claim the grant funding would provide these operators greater confidence and operational resilience as they undertake the transition to heavy duty vehicles. Thus, participants wanted the scrapping requirements eliminated but not the incentive payments, provided applicants can meet other conditions that would guarantee the emission reductions envisioned by the incentive program. For example, regulators could ensure and enforce retirement of displaced fossil vehicles via other methods, such as odometer and telematic reporting, which could prevent the operator from selling an old diesel-powered vehicle to another fleet that will continue to operate it. By eliminating the current scrapping requirements, policy makers could help heavy-duty vehicle operators more easily bundle Carl Moyer incentives with HVIP.

The California Air Resources Board, Public Utilities Commission, Energy Commission and Legislature could boost funding for mobile charging

Certain charging locations for fleets may need more power sooner than the utility can provide it. In that instance, fleet operators or developers may need to begin building their charging installation with temporary energy and charging solutions, in order to keep their electric vehicles fueled and fleet in compliance with state regulations. The state or utilities could provide funding or incentives to install mobile or temporary charging solutions, such as through batteries that can discharge into the vehicles. The state's self-generating incentive program (SGIP),⁶⁷ for example, supports energy storage systems but only when they are permanently tied to the grid, along with other restrictions. These provisions could make a temporary or mobile charging system ineligible (though federal Inflation Reduction Act incentives would still apply). As a result, state leaders could modify eligibility for this program to account for the need.

BARRIER 2: INVESTORS, LENDERS AND PURCHASERS LACK INFORMATION ON ELECTRIC TRUCKS

Investors, financial institutions, and other private sector lenders often lack awareness about heavy-duty electric vehicles, leading to an unfounded overestimation of risks and underestimation of return on investment. Furthermore, within ESG lenders, clean transportation investments are relatively limited compared to investments in solar,

wind, and energy sectors. Additionally, major financial institutions typically refrain from providing funding to small fleet owners or individual entities, as such lenders do not align with the institution's target audience or business model.

At the same time, some smaller fleet owners may view heavy-duty electric vehicles as not a feasible solution to decarbonizing their vehicles and may explore alternative technologies such as hydrogen instead. They may express concern about the high initial costs of heavy-duty electric vehicles and the availability of critical minerals, leading them to postpone their adoption and wait for advancements in alternative technologies.

As a result, many investors and fleet owners need education on heavy-duty electric vehicle technologies, charging times, battery reliability, transition mineral availability and recyclability, and total cost of ownership. The target audiences for education on heavy-duty electric vehicles could include fleet operators, investors, and the private sector in general to dispel misinformation surrounding heavy-duty electric vehicles. Furthermore, certain lenders may be more inclined to fund riskier or emerging technology investments, emphasizing the need for policy makers and advocates to try to align risk levels with the preferences and capacities of different lenders.

SOLUTIONS

The California Air Resources Board, Energy Commission, and Governor's Office of Business and Economic Development (GO-Biz) could develop educational materials for the investor community on heavy-duty electric vehicles and associated infrastructure

The Air Resources Board, Energy Commission and GO-Biz could all develop comprehensive educational materials, such as factsheets that are tailored to specific financial stakeholders, including investors, lenders, financial institutions, and fleet operators. This outreach work could build off the air resources board's "ZEV TruckStop" informational website, which contains basic information about zero-emission vehicles.⁶⁸ These materials would highlight the environmental, economic, and social benefits of electric heavy-duty vehicles to dispel myths or address the lack of awareness about the state of the technology and its deployment status. In addition, agency leaders could organize or sponsor workshops, webinars, and seminars to provide in-depth information on zero-emission heavy-duty vehicles to respond to common misconceptions and concerns raised by investors and lenders. Collaboration with industry experts and research institutions could then enable the agency to provide credible and up-to-date information on technological advancements, market trends, and regulatory developments in the sector. Moreover, the agency could establish partnerships with financial media outlets and industry publications to disseminate educational content and raise awareness among a broader audience of potential investors and lenders. The California Pollution Control Financing Authority could also conduct this outreach in the process of educating potential recipients about the new "Zero-Emission Truck Loan Pilot Project," a loan-loss reserve system open to qualified small trucking fleets with 20 or fewer vehicles purchasing new or used Class 2b through Class 8 zero-emission vehicles. The authority operates this program in partnership with the California Air Resources Board.⁶⁹

To supplement Air Resources Board outreach, the Energy Commission could conduct research to assess the economic viability and environmental benefits of the vehicles,

producing or co-authoring reports and case studies to inform investors and lenders about the potential returns on investment. By communicating the results of various funded demonstration projects and pilot initiatives, commission staff could document the performance and reliability of the vehicles in real-world settings, addressing typical investor concerns about technology readiness and operational feasibility.

Nonprofit leaders and private-sector investors could share heavy-duty electric vehicle data and assessments with the broader investment community to facilitate more lending

Nonprofits and other entities that interface with the investment community and serve as trusted messengers, such as Ceres, could engage institutional investors, asset managers, and financial institutions to promote heavy-duty electric vehicles and related infrastructure as a viable sustainable investment opportunity, either through direct lending products for vehicle or infrastructure purchases or investment in companies providing these services. They could partner with regional chambers of commerce to co-organize investment summits and roundtable discussions, providing a platform for direct engagement with potential investors.

They will need to communicate to these investors that fleet operators need financing not just for the vehicles but also for infrastructure and maintenance costs. Many large leasing companies provide a full suite of fleet services to their customers, yet this same service is not in effect for heavy-duty electric vehicle fleets at a broad enough scale without significantly more financing. Furthermore, these messengers can communicate that fleets will often need synchronous funding for the charging infrastructure. Adding this infrastructure into the financing package could potentially help offset risk for institutional investors, given the slower depreciation rate of charging compared to vehicles. This type of infrastructure investment might also seem more familiar to current sustainable investors who already support solar and wind farms, which are more similar to charging than mobile vehicles. These trusted messengers could help educate and work with lenders to help them become more familiar with the technologies and gain experience with these large vehicles.

In addition, these entities could partner with state agencies such as the California Air Resources Board and Energy Commission to co-organize investor briefings, roundtable discussions, and stakeholder dialogues focused on the opportunities for investing in electric heavy-duty vehicles. They could facilitate knowledge-sharing and collaboration among a diverse range of financial stakeholders. These kinds of discussions could offer valuable insights and guidance to investors and lenders interested in supporting clean transportation initiatives.

The California Infrastructure and Economic Development Bank and Air Resources Board could facilitate private-sector lending for heavy-duty electric vehicles and associated infrastructure

The California Infrastructure and Economic Development Bank (IBank) could partner with a private sector lender to facilitate these transactions, with the California Air Resources Board potentially augmenting with incentive dollars. As a possible model or source of financing, the IBank collaborates with Climate Tech Finance, a program of the Bay Area Air Quality Management District (BAAQMD), to vet and underwrite loans issued by community and commercial banks in support of greenhouse gas emis-

sion-reducing technology development and adoption.⁷⁰ This financing source could potentially expand to assist heavy-duty electric vehicles, with proper outreach and education efforts directed both toward lenders and applicants. For example, if a business received an 80 percent loan guarantee through this program, the Air Resources Board and other agencies could potentially help fund the other 20 percent through existing incentives or funding programs. Similarly, Southern California Edison and California Capital Access Programs (CalCap) plan to unveil a pilot-stage loan loss reserve program that can contribute 20 percent of the cost of the vehicles, which could contribute to this private-sector approach.⁷¹

Large, established private-sector companies could participate more meaningfully in this transition by launching funds for heavy-duty electric vehicles and associated infrastructure to educate and attract other lenders

Large companies with an interest in supporting and expanding heavy-duty electric vehicles and associated infrastructures could launch a fund to help finance this deployment. Potentially modeled on a recent airline-created fund to invest in sustainable aviation fuel, private sector industry leaders could develop a fund exclusively to finance deployment and also educate lenders about the opportunities.⁷²

BARRIER III: LACK OF RESIDUAL VEHICLE VALUE DATA AND SECONDARY MARKET

The lack of a strong and relatively inexpensive secondary market for heavy-duty electric vehicles, combined with the absence of reliable residual value data, poses a significant challenge for lenders that inhibits financing for new vehicles. Residual value data are crucial for lenders to assess the value of the vehicles as collateral for loans or leases, and the absence of such data for heavy-duty electric vehicles makes it challenging for buyers or lessors to secure financing. The data are also needed for insurers, who base their policies in part on expected resale values and otherwise price those policies higher than on diesel alternatives, according to some participants. Moreover, without residual value data, investors and fleet operators may hesitate to buy or sell heavy-duty electric vehicles, further constraining the secondary market. Participants noted that over the next two years, more resale data will become available as some of the first generation of roughly 500 electric heavy-duty vehicles are resold. However, until that point, this lack of a secondary market increases uncertainty in investment decisions for private sector stakeholders. As an added challenge, concerns about battery safety and warranty issues could persist among resale purchasers, influencing investment decisions in the secondary market for heavy-duty electric vehicles.

SOLUTIONS

The California Legislature or Air Resources Board could modify the HVIP incentive to provide a residual value guarantee with a fixed “floor” resale purchase price for heavy-duty electric vehicles, to encourage fleet purchasers to re-sell the vehicles to smaller operators

Such a “fixed floor” would provide financiers with the certainty they need to price the residual value into their lease. As the amount of incentives available for big fleets decreases, participants noted that purchasers could consider the residual values of

the vehicles as a financial reassurance. A fixed floor resale price could encourage more fleets to make the transition, which would also help spur the secondary market and allow less-expensive used vehicles to become available on the market sooner for smaller companies and operators. Typically, participants noted that many fleets tend to put their vehicles on the used market after three years of operation. Participants observed that as incentives and therefore new vehicle sales decrease, the state is missing opportunities to transition more expensive new vehicles to the cheaper used market and therefore the development of a robust secondary market. Instead, the state legislature or Air Resources Board could modify the HVIP and other incentive programs to increase the available upfront incentive amount, provided the recipients agree to a fixed sales price after three years of ownership, with the additional requirement that they sell the vehicle to a smaller operator (noting that this would create additional administrative burdens on the board to track resale transactions). The buyer would therefore be willing to accept the risk and potential monetary loss of selling the vehicle at a relatively low fixed price (or even lower, depending on market conditions) in exchange for higher upfront incentives. By doing so, the state could potentially support deployment of used vehicles among smaller fleets that would not otherwise receive incentives for the vehicles.

The California Air Resources Board could modify incentives to encourage truckmakers to lower prices on sales and leases

In order to encourage manufacturers to bring down electric vehicle truck prices, the legislature or board could modify incentives like HVIP to determine eligibility based on the price of the vehicles, similar to how federal tax credits for light duty electric vehicles operate. If incentives are available only for vehicles below a certain price (and not for vehicles above that price), automakers may be encouraged to set prices not to exceed that incentive price threshold, in order to encourage more sales among buyers who rely on the incentive to be able to afford the vehicle. Over time, these incentive price thresholds could decrease, potentially placing downward pressure on vehicle pricing as automakers aim to reach more customers by ensuring their vehicles are priced low enough to qualify for incentives. Lower vehicle prices would translate into more sales and California being better positioned to achieve its heavy-duty vehicle decarbonization goals. For example, in early years, regulators could limit HVIP eligibility to trucks that cost no more than \$450,000. In subsequent years, they could reduce the price eligibility threshold to vehicles that cost no more than \$430,000 (i.e. \$20,000 less), declining to vehicles at \$390,000 in the next year and so forth, based on projected decreases in battery costs. In addition, as mentioned previously, policy makers could tie the incentive to the size of the battery on a kilowatt hour (kWh) basis, as was done with some solar incentives, or to the range of the vehicle, coupled with a maximum incentive per project to avoid a single vehicle utilizing too many incentive dollars. As a result of such changes, truckmakers would have an incentive to lower the price of their vehicles and potentially improve vehicle efficiency, in order to ensure customers could access the incentive.

The California IBank or Legislature could expand and expedite loan loss reserve programs to offset investor and insurer concerns about the residual value of used vehicles

Loan loss reserve programs allocate money to a reserve account for a lender, in order to help the lender lower their credit standards and lend to customers of lesser credit

value. In the context of heavy-duty vehicles, this kind of program could help smaller operators buy zero-emission models by compensating for the lack of residual value market data. As mentioned, Southern California Edison and California Capital Access Programs (CalCap) plan to unveil a pilot-stage loan loss reserve program that can contribute 20 percent of the cost of the vehicles. Also as discussed, the California Air Resources Board and Pollution Control Financing Authority launched the “Zero-Emission Truck Loan Pilot Project,” a loan-loss reserve system open to fleets with 20 or fewer vehicles. These and other such programs, such as potentially a new one created by the California IBank or legislature, could specifically address the lack of data on residual values by backstopping loans and allowing lenders to offer more generous financing terms without needing resale value assurance. However, participants noted that these programs need more funding and an accelerated timeline for a full-scale launch.

The California Energy Commission and Air Resources Board could estimate resale values of heavy-duty electric vehicles based on data from used batteries in the light-duty sector

Although resale data are scant in the context of heavy-duty vehicles, the same batteries but in a smaller package currently power millions of light-duty vehicles, which have been on the road in California and other places around the world for more than a decade. Using accepted modeling techniques, the California Energy Commission or Air Resources Board could potentially extrapolate and estimate the battery conditions and likely resale value of used heavy-duty electric vehicles after a given amount and type of usage. This information could underlie incentives, loan-loss reserves, insurance, and other programs to address the residual value information gap facing lenders.

The California Legislature, IBank, or Air Resources Board could create a backstop reinsurance program to cover any losses from low residual values

Residual value insurance in this context would reimburse lenders in the event that resale value is lower than investors expected. The state could create a backstop reinsurance program using public funds for this purpose, based potentially on resale data from the light-duty sector.

The California Legislature and Air Resources Board, as well as advocates, could seek to expand the out-of-state market for heavy-duty electric vehicles in order to increase supply and decrease prices

While California has pioneered the adoption and deployment of zero-emission heavy-duty trucks, other states are still in the early stages of adoption, resulting in a limited secondary market for heavy-duty electric vehicles. However, by leveraging platforms like the National Governors Association, the Air Resources Board and other state leaders and advocates can share best practices and highlight the importance of transitioning to cleaner transportation. As more states begin adopting zero-emission truck regulations and introduce incentives, the secondary market for these vehicles can expand nationwide, offering greater opportunities beyond California’s borders.



VII. CONCLUSION: HEAVY-DUTY CHARGING INFRASTRUCTURE AND FINANCING SUPPORT NEEDED FOR A SUCCESSFUL TRANSITION

Electric heavy-duty vehicles are here and projected to become cost-competitive with diesel counterparts in the next decade. The technology is already proven and scaling rapidly among the light-duty sector. But success in the heavy-duty vehicle sector is not similarly assured, unless the charging infrastructure and robust financing for these vehicles are available for fleets that want to or have to make this transition. The solutions contained in this report can offer a path for state policymakers to ensure that decarbonizing heavy-duty vehicles for equity, climate and economic reasons is ultimately feasible. But without urgent action on infrastructure and financing, the state risks failing in this endeavor, at least at a time scale necessary to address the exigencies of both climate action and air pollution. Yet if California is successful, the state will once again serve as a blueprint for other states and ultimately nations around the world seeking to emulate a transition to a cleaner and more economical future for heavy-duty vehicles.



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Center for Law, Energy
& the Environment (CLEE)
UC Berkeley School of Law
1995 University Avenue, Suite 460
Berkeley, CA 94720-7200

clee.berkeley.edu

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Emmett Institute on Climate
Change and the Environment
UCLA School of Law
405 Hilgard Avenue
Los Angeles, CA 90095

law.ucla.edu/emmett