# Summary of Key Activities in California to Advance Electric Vehicle Charging Infrastructure Development

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## Introduction

Meeting the infrastructure needs to support the deployment of M/HD EVs is technically and economically feasible and happening in a growing EV market today. Substantial funds have been unlocked for infrastructure by the California Public Utility Commission (CPUC) and California Energy Commission (CEC) programs, recent laws (e.g., SB 350 and AB 841), CARB's Low Carbon Fuel Standard (LCFS), and others. Although much work remains, CARB can confidently adopt a robust ACF rule, knowing that agencies, industry, and other stakeholders are engaged in a comprehensive set of programs to meet the needs of M/HD EVs now, in the short-term, and in the years ahead.

## How Charging Occurs

The majority of California trucks are Class 2b-3 (62% or 1,040,000 of all trucks). These include commercial pick-up trucks, delivery vans and passenger vans. Most of these will charge at a "home base" overnight. This can be at a home garage, similar to a light-duty EV, or a depot location at a business. When there is a need for additional charging during the day, these vehicles can use the same public infrastructure as light-duty EVs: Level 2 chargers and public DC fast chargers (DCFCs).

According to CARB, most trucks average below 100 miles per day.[1] Class 4-8 and Class 7-8 tractors with daily routes less than 200 miles will primarily charge at private depots (home base or nearby single contract off-site charging stations) and may require higher-power DCFCs. In most cases, they too will be charged once a day, overnight at their depot.

Class 4-8 and Class 7-8 tractors with daily routes longer than 200 miles, will likely charge at depots and need access to DCFCs along their routes.[2] This is likely a small share of trucks. For example, CARB estimates that less than 40% of all Class 7-8 tractors travel more than 200 miles per day.[3] Once the in-process megawatt charging standard (MCS) is in place, Class 7-8 tractors will be able to complete a charge every 5-hours within the federally required 30-minute rest break for drivers (a driver can travel about 300 miles in 5-hours). Keep in mind, trucks with the battery capacity to travel beyond 300-miles on a single charge are coming in the near future.

[1] https://ww2.arb.ca.gov/sites/default/files/2020-02/200212presentation_ADA_1.pdf
[2] https://eta.lbl.gov/publications/california-semi-truck-electrification; https://caletc.com/assets/files/MHD-ForcastingWhitePaperFinal.pdf; https://caletc.com/assets/files/20200526-CalETCMHDEVForecasting-FinalDeliverable.pdf
[3] https://ww2.arb.ca.gov/sites/default/files/2020-02/200212presentation_ADA_1.pdf

## Transportation Electrification Planning

State agencies and the business community are actively planning for widespread EV adoption, rapid electric vehicle service equipment (EVSE or chargers) deployment, and grid integration to address gaps and maximize benefits.

The CEC leads the state's charging infrastructure planning and recently approved its first Electric Vehicle Charging Infrastructure Assessment report as required by AB 2127.[4] This report is required by law to be updated and published every two years. The report determines the light-duty and M/HD EV demand that will need to be served with charging infrastructure over the next several years. It uses CARB's Mobile Source Strategy projections of light-duty and M/HD EVs through 2030 and beyond to support Governor Newsom's Executive Order N-79-20. This order calls for

- All drayage trucks be zero emission by 2035.
- All light duty sales be ZEVs by 2035.
- All off-road vehicles be zero- emission by 2035.
- All other M/ HD vehicles be zero emission by 2045 where feasible.

Over the past two years, the CEC created and implemented a portfolio of sophisticated modeling tools to forecast charging needs for light-duty vehicles, M/HD vehicles, road trips, and transportation network vehicles (i.e., Uber and Lyft). The tools were built with partners, including the National Renewable Energy Laboratory (NREL) and Lawrence Berkeley National Lab (LBNL), and forecast what types of chargers are needed, where, and by when. To aid utilities in capacity planning, the CEC created the EVSE Deployment and Grid Evaluation Model (EDGE) modeling tool that uses charger forecasts to determine where the electric grid has adequate power capacity to support new chargers and where gaps exist, to inform advance planning.

As of September 2020, there were nearly 67,000 Level 2 public and shared private charging stations including nearly 5,400 DCFCs.[5] Current funding from the CEC and utilities are expected to add 117,000 Level 2 charging stations and 4,100 DCFCs by 2025.[6] There are about 188,000 existing and projected chargers. The CEC estimates that an additional 61,000 Level 2 charging stations and 500 DCFCs are needed to achieve the light-duty vehicles 2025 goal of 250,000 charging stations, of which 10,000 are DCFCs.[7] These public charging stations could be used by some medium-duty EVs. The CEC predicts that 157,000 public and private chargers are required to support 180,000 M/HD EVs by 2030.[8] In 2021, the State Legislature approved a 3-year funding plan of $915 million for the CEC to administer in supporting the installation of thousands of additional charging stations.

The Electric Vehicle Charging Infrastructure Assessment report is vital because for the first time, it defines how many chargers of what type are needed by when and where. Armed with

[4] https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127
[5] https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127
[6] https://www.greentechmedia.com/articles/read/california-targets-384m-to-fill-gaps-in-electric-vehicle-charging-infrastructure
[7] https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127
[8] https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127

this detailed information, the investor-owned utilities (IOU) can begin planning to complete grid upgrades to support new chargers and can identify where to increase capacity in advance to avoid unnecessary installation delays. This data provides opportunities for IOUs to work with the CPUC, CEC, CARB and other state agencies to develop innovative financial support mechanisms beyond the traditional rate case to support charger installations. The publicly owned utilities (POUs) will also have access to this data for their territories to do detailed advance planning, budgeting, and implementation. Similarly, EV service providers (EVSPs) can use this data to plan for and leverage private capital to build charging stations. Several of these EVSPs are now publicly traded and have even greater access to significant capital.

*Additional planning efforts and activities:*

- The Transportation Electrification Partnership is a multi-year partnership among local, regional, and state stakeholders to accelerate transportation electrification and zero-emissions goods movement in the Greater Los Angeles region in advance of the 2028 Olympic and Paralympic Games. A key goal is to have nearly 200,000 charging stations installed to support people and goods movement by 2028 and 40% of drayage trucks to be zero-emission by the same year.
- The partnership between Los Angeles and LADWP is a good example of a city and publicly owned utility (POU) showing aggressive leadership installing charging infrastructure. Surpassing its 10,000 commercial electric vehicle charger goal two years early, Los Angeles now has 11,450 commercial electric vehicle chargers throughout the city, Mayor Eric Garcetti recently announced. This is the most of any city in the United States, according to Garcetti's office. The city's next goals are 25,000 by 2025 and 28,000 by 2028.[9]
- The San Pedro Ports are gaining experience from pilot projects to deploy infrastructure to support their 100% zero-emission ground equipment by 2030 and 100% zero-emission drayage by 2035 targets.
- A key objective of the M/HDV Alternative Fuel Infrastructure Strategic Development Plan, developed by the West Coast Collaborative M/HD Alternative Fuel Infrastructure Corridor Coalition, is to obtain funding to implement M/HD alternative fuel infrastructure in California, Oregon, and Washington.[10]
- Electric utilities in California, Oregon, and Washington are conducting a West Coast Clean Transit Corridor Initiative study to assess the M/HD EV charging infrastructure need along the 1,300-mile Interstate 5 corridor and interconnecting highways.[11]
- U.S. DOT plans to create 48 national EV charging corridors on highways covering 25,000 miles in 35 states.[12] In April 2021, the Biden administration released the report entitled "Federal Funding is Available For Electric Vehicle Charging Infrastructure On the National Highway System"[13] to help support this plan.

[9] https://www.thefourth-revolution.com/news/l-a-now-has-10000-commercial-electric-vehicle-charging-stations/
[10] https://www.westcoastcollaborative.org/files/sector-fuels/wcc-aficc-mhd-plan-exec-summary-2020-03-12.pdf
[11] https://westcoastcleantransit.com/#resources-section
[12] https://wwww.natso.com/topics/dot-to-establish-electric-vehicle-charging-corridors
[13] Federal Funding is Available For Electric Vehicle Charging Infrastructure on the National Highway System (dot.gov)

## Speeding up Charging Infrastructure Installation

Depending on the size, complexity, and availability of onsite power, building charging infrastructure can involve numerous parties and take several months to years to complete. Therefore, a key objective is to educate fleets on the need to begin business and charging infrastructure planning in partnership with their utility at the earliest point possible. Below are several efforts underway to accelerate charging infrastructure buildout.

- The Governor's Office of Business and Economic Development (GO-Biz) Zero-Emission Vehicle Market Development Strategy outlines how state agencies and key stakeholders can move together with the scale and speed required to reach the state's ZEV targets, including building a robust charging network.[14] For more information on G0-Biz's programs to support EVs and charging infrastructure go to: https://business.ca.gov/industries/zero-emission-vehicles/.
- Per AB 1236, cities and counties must adopt an ordinance that creates a consistent statewide permitting process for EV charging infrastructure. However, compliance has varied, in part due to a lack of awareness. To improve compliance, GO-BIZ released a permitting guidebook in 2019, shares best practices, hosts public workshops, and is mapping and scoring each jurisdiction. Importantly, the compliance score helps inform funding awards from the On-Road Heavy-Duty Voucher Incentive Program.
- Per SB 1000, local municipalities that serve disadvantaged communities, as defined by California statute, must integrate environmental justice into their General Plan, which the Office of Planning and Research recommends include air quality goals and policies to promote zero-emission fleet and technology deployment and transportation system investments.[15] The CEC completed its first report required for this program. For more information, see: TN238717_20210707T142344_Presentation - SB 1000 Staff Workshop 2021-07-08.pdf.
- The CEC's planning, particularly through the AB 2127 Electric Vehicle Charging Infrastructure Assessment process, will help in several ways:
    - Informing long-term, phased planning by utilities and private EVSPs to enable the coordination of multiple charger installations and multiple subprojects simultaneously. This is time- and cost-effective, and a departure from the common "one-off" small projects that can be inefficient and slow.
    - By predetermining where power capacity gaps exist, informed utilities can do advance "least regrets" upgrades to their distribution infrastructure and potentially save months to years of time in installing chargers.
- The Los Angeles County Board of Supervisors approved the creation of a Zero Emission Infrastructure Plan that, among other things, sets the goal of installing 60,000 new EV chargers by 2025 and 70,000 by 2035.[16]

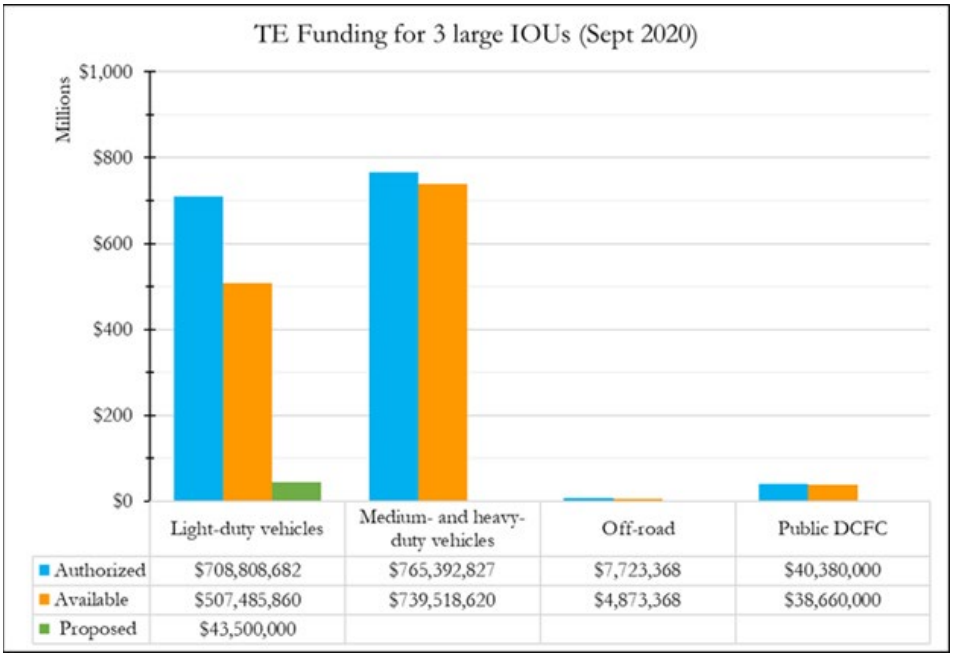
In addition to current actions underway, our coalition is proposing that the ACF rule require fleets to submit ZEV transition plans that include EVSE plans in coordination with their utilities to accelerate infrastructure deployment. This is modeled on the plans required in the Innovative Clean Transit rule that, utilities claim, have helped considerably.

[14] https://business.ca.gov/industries/zero-emission-vehicles/zev-strategy/
[15] https://opr.ca.gov/docs/20200706-GPG_Chapter_4_EJ.pdf, page 16.
[16] https://hahn.lacounty.gov/zero-emission-infrastructure

## Paying for Infrastructure

Utility Funded Programs

The three largest electric IOUs in California that serve roughly three-quarters of the state, are approved to collectively invest over $700 million in M/HD charging infrastructure by 2024. Over $760M is approved for light duty charging infrastructure including level 2 funding for fleets, workplaces, multi-unit dwellings and public destination centers and over $40M for public DCFCs (see CPUC's chart below on spending for light-, medium- and heavy-duty charging infrastructure). The M/HD charging funds support about 8,000 to 21,000 chargers at about 2,000 sites. In many cases, more than one electric truck can use a charger each day. After this initial investment, the IOUs may seek approval for additional tranches of funding in future proposals for the CPUC, with increasing need driven in part by the ICT and ACT rules and upcoming ACF rule. The CPUC recently released a proposed decision which would allow the IOUs to invest up to an additional $80 million each through a streamlined advice letter process to support additional charging infrastructure as needed to support California's increasingly ambitions M/HD vehicle electrification goals.[17] A significant amount of this funding is for utility-side of the meter investments (e.g., transformer and distribution system upgrades needed to service the customer's property), but AB 841 (enacted 2020) changes that to make these investments part of a utilities' responsibility in the normal course of business. This change should significantly reduce the customer's cost of installing infrastructure at a typical site, improve certainty for independent market participants, and provide a foundation upon which other utility or state programs can facilitate the build out of transportation electrification infrastructure.




| | Light-duty vehicles | Medium- and heavy-duty vehicles | Off-road | Public DCFC |
|---|---|---|---|---|
| Authorized | $708,808,682 | $765,392,827 | $7,723,368 | $40,380,000 |
| Available | $507,485,860 | $739,518,620 | $4,873,368 | $38,660,000 |
| Proposed | $43,500,000 | | | |

[17] https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M386/K637/386637996.PDF

- *Pacific Gas & Electric*: make-ready infrastructure and charging station rebates approved for M/HD EVs and forklifts[18] at $236.3 million for at least 640 sites. The approved investment is through 2023. An additional $7.3 million is approved for three pilot projects.[19]
- *Southern California Edison*: make-ready infrastructure and charging station rebates for M/HD EVs and forklifts approved at $342.6 million for at least 870 sites.[20] An additional $4 million pilot program is approved for transit bus infrastructure. The approved investment is through mid-2024.
- *San Diego Gas & Electric*: make-ready infrastructure and charging station rebates for M/HD EVs and forklifts approved at $107 million for about 300-600 sites. The approved investment is through 2024. An additional $11 million is approved for four pilot projects.[21]
- In five to seven years, the three IOUs will have millions of dollars in LCFS holdback funds to spend on projects, including drayage electrification and electric transportation projects in rural areas and disadvantaged communities.

Public Owned Utilities (POUs) supply roughly a quarter of California's population and load and are developing their own M/HD programs. For example, large POUs such as the Los Angeles Department of Water and Power ($15 million to the Port of Los Angeles over five years and $13 million spent on commercial chargers) and the Sacramento Municipal Utility District have programs to support M/HD charging infrastructure.

Publicly Funded Programs

- In July 2021, Governor Newsom approved the new state budget. "Totaling $2.7 billion in 2021-22, and $3.9 billion over three years, the ZEV investments in the Budget not only push progress in each market pillar, but increase private sector confidence and enable increased participation in the market, allowing the zero-emission industry to capitalize on scale."[22] Included in this budget is $915 million dedicated for charging infrastructure for light and MHD vehicles over the next three years to dramatically accelerate the pace and scale of the infrastructure needed to support ZEVs.
- The CEC recently announced a major new program entitled the "Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles" or the "EnergIIZE Commercial Vehicles" program. It is designed to help M/HD ZE fleet and truck owners with the planning and funding of their fueling infrastructure needs. It is being initially funded with $50 million for this year but is intended to extend for many years in the future with additional annual contributions. CALSTART will administer the program and it is expected to open for business this fall. [23]
- Through 2023, the CEC's Clean Transportation Program offers almost $130 million for M/HD ZEVs and EVSE and $82 million for light-duty EVs and EVSE infrastructure. The program also provides about $2.5 million/year for workforce development.

[18] The three IOUs' expenditures on forklifts are limited to 10%. A site may have both electric trucks and electric forklifts.
[19] For Idle Reduction pilot (25 charge ports under construction), for infrastructure for EV School Bus pilot, and the Medium/Heavy Duty Fleet Customer Demonstration.
[20] SCE also completed two pilots at the Port of Long Beach (cranes and yard trucks).
[21] For a Port Electrification pilot, Green Shuttle pilot, School Bus pilot, and Fleet Delivery pilot.
[22] http://www.ebudget.ca.gov/2021-22/pdf/Enacted/BudgetSummary/ClimateChange.pdf ; Page 109
[23] https://www.energy.ca.gov/news/2021-04/energy-commission-announces-nations-first-incentive-project-zero-emission-truck

- CARB's LCFS program was recently enhanced with its Fast Charging Infrastructure (FCI) Program[24] to incentivize DCFC deployments at public locations.
- CARB's Low Carbon Transportation Program funds several competitive grant programs that may pay for infrastructure. In FY 2019-2020, $40 million was allocated for the Heavy-Duty Demonstration and Pilot Projects, another $14 million for several smaller programs, as well as a portion of the one-time $135 million for the FARMER program.
- CARB's Community Air Protection Program expanded to include M/HD charging infrastructure when the legislature appropriated an additional $245 million in FY 2018-19. This adds to the original $250 million one-time appropriation.
- California air district grants include funding for M/HD infrastructure but vary annually. For example, the South Coast Air Quality Management District provides about $2-4 million/year.
- The Carl Moyer Memorial Air Quality Standards Attainment Program is expected to provide about $94 million/year to fund on- and off-road clean transportation projects. Funds may be used for HD infrastructure in addition to vehicles.
- At least $7.5 billion is currently being considered by Congress in the bipartisan infrastructure deal to pay for 500,000 chargers nationwide. More funding is being considered in the proposed $3.5 trillion reconciliation bill.
- Separate incentives for truck purchases help ensure other funding sources can focus on infrastructure. Vehicle purchase programs include the Volkswagen Environmental Mitigation Trust, Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), and the $7,500 federal tax credit for Class 2b-3 EVs.[25]

Public-Private Funded Partnership Programs

- TravelCenters of America (TA) is the largest "Travel Center" or truck stop company in the nation with 270 locations. It has just secured a $4 million grant with the California Energy Commission to participate in an innovative industry test project for medium- and heavy-duty vehicle (MDHD) electrification. The project will integrate publicly accessible medium and heavy-duty fast chargers with solar PV, battery storage, and a hydrogen fuel cell to power opportunity and overnight charging for fleets at the TA Travel Center in Ontario, California. This project will demonstrate bi-directional energy flow (V2G), backup power resilience, integration with distributed energy resources and cost-effective charging. [26] TA recently announced the creation of a new business unit, eTA, to advance sustainable energy efforts including EV charging at its locations.[27]
- Sysco Riverside, Inc. also received a $4 million grant to deploy a modular distributed energy resource system including onsite solar PV generation, a battery energy storage system, and an advanced energy management system. This project will power 40 new electric heavy-duty trucks and charging infrastructure at Sysco's Riverside distribution warehouse, helping accelerate market adoption.[28]

[24] https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting
[25] Unless the manufacturer reaches the 200,000-unit cap.
[26] https://www.energy.ca.gov/sites/default/files/2021-05/2021-06-09-Agenda_ADA.pdf
[27] https://www.ta-petro.com/newsroom/travelcenters-of-america-enhances-commitment--to-sustainability-and-alternative-energy
[28] https://www.energy.ca.gov/sites/default/files/2021-05/2021-06-09-Agenda_ADA.pdf

- Electrify America designated the Wilmington and West Long Beach Project as the winners of the Green City Grant of $25 million for EVSE. Mayor Eric Garcetti celebrated this investment to develop Zero Emission Vehicle (ZEV) infrastructure to help meet the zero emission transportation targets for heavy duty trucks and public transit buses laid out in his Green New Deal and the Port's Clean Air Action Plan (CAAP).[29]

Privately Funded Programs

- Charging Station Providers/Operators for light-duty EVs and M/HDVs, such as Siemens, ABB, Greenlots (Shell), Electrify America, Black & Veatch, Burns & McDonald, Trillium, Love's, ENELx, and Power Flex are continuing to leverage private capital to install private and public charging stations throughout the state. For example, Electrify America installed charging stations at 400 stations nationally, with another 220 in process, and plans to install a total of approximately 800 stations with about 3,500 chargers by 2022. Recent installations include stations with high-power 350 kW chargers.
- The National Association of Truck Stop Operators (NATSO) launched a National Highway Charging Collaborative to extend EV charging to every corner of the nation. Over the next decade, the Collaborative will leverage $1 billion in capital to deploy charging at more than 4,000 travel plazas and fuel stops that serve highway travelers and rural communities by 2030. In its first year, the public-private collaborative funded more than 150 DC fast charging spots in at least eight states, including California, Florida, Iowa, Missouri and Washington.[30]
- Many electric truck makers and dealers have financing divisions or subsidiaries and many of these will finance not only the trucks but also their infrastructure costs through leases and other methods. Three examples include Volvo Trucks of North America, Daimler and Peterbilt. These companies can also help truck customers take full advantage of all available incentive programs.
- Daimler recently announced the completion of the first Heavy Duty Truck Charging Plaza at their location in Portland, Oregon.[31] It will serve as a commercially utilized and demonstration site with several chargers including nine megawatt charger system (MCS) chargers. They will also be operating solar and storage in integration with charging operations.
- Some conventional gasoline/diesel and alternative fuel providers like Trillium are beginning to add EVSE to their existing national network of fueling stations.

## Charging Standards

The de facto charging standard used by nearly all light duty vehicles and most newer M/HD vehicles in the US is the combined charging system (CCS) type 1. This is used on all new cars produced in the US with the exception of Tesla. CARB is working on a rule to require all carmakers to use the CCS type 1 charger standard. The CCS standard can fuel a vehicle using AC current, for example, from a garage at up to 19 kW, or DC current from a DCFC at up to 350 kW.

[29] https://media.electrifyamerica.com/en-us/releases/148
[30] https://www.natsoaltfuels.com/EVCharging.php
[31] https://daimler-trucksnorthamerica.com/PressDetail/daimler-trucks-north-america-portland-general-2021-04-21

The megawatt charging system (MCS) standard, which is currently in the process of being finalized by the end of this year, will have the capability of going up to 4.5 mW to support charging for very large batteries such as might be in Class 8 semi-trucks with 500 miles of range.[32] This new standard could allow these trucks to re-charge their batteries within 30 minutes. It will also support ships, aircraft and other industrial applications.

Connectivity, payment, smart charging, and other standards also exist and are being enhanced. The CEC is currently considering regulations to require new public charging stations to use these standards, among other improvements.

## Electricity Costs

Significant savings in fuel costs is one of the biggest benefits of electric transportation. A key factor in producing those savings is that electric drive trains are about 4-5 times more efficient than combustion engines. According to CARB, an EV package delivery truck owner can save $4,000/year in fuel costs compared to a similar internal combustion engine (ICE) vehicle. With a local drayage truck, the annual savings can be $9,000.[33] A recent analysis using real-world driving data for two CA fleets (NFI and Schneider) found that switching from diesel to electric for the combined fleets of 92 vehicles could save a total of $1,300,000 per year in annual fuel costs – a 44% savings. [34]

The IOUs have implemented new tariff or electricity rate plans to lower costs for M/HDVs. Each of these IOUs has implemented programs to lower demand charges. For example, customers charging on PG&E's reformed commercial EV rate will save about 30-50 percent on their monthly bills compared to previous commercial rates. The savings are enhanced by the value of CARB's LCFS credits. CARB's analysis shows that in the two examples above, with LCFS credits added, the savings for the package delivery truck can be $8,400/year and $27,900/year for the EV drayage truck.[35] In some cases, the savings from lower costs for electricity plus the LCFS credit values can pay for all or even more than fueling costs, freeing up excess revenue for other operating expenses.

LCFS credits go to the owners of the charging equipment, tenants of the property where charging occurs, to a designated aggregator or a charging network provider. The value of these non-residential credits is substantial: roughly $0.16/kWh for light- and medium-duty trucks and $0.22/kWh for heavy duty trucks at recent credit prices. New proposals are being considered by state agencies to use these future revenue streams to help fleets obtain low-cost loans to finance the electric trucks and charging infrastructure (e.g., loan loss reserve type financing for small fleets especially).

[32] https://www.charin.global/technology/mcs/
[33] https://ww2.arb.ca.gov/sites/default/files/2021-02/210302acfpres_ADA.pdf Slide # 23.
[34] EDF, 2021, "Charging forward, Recommendations for reducing charging infrastructure costs for heavy-duty trucks" http://blogs.edf.org/energyexchange/files/2021/03/EDF-ChargingForward-FINAL.pdf
[35] Ibid.

Finally, an increasingly utilized strategy to further lower electricity costs is to install as much on-site solar as possible along with battery storage. This can lower the cost of electricity, increase LCFS credit revenue, and provide resiliency for backup power in the event of a power outage.[36]

## M/HD EV Grid Integration

Integration of electric vehicles with the grid can offer many benefits to the vehicle owner and the grid including its ratepayers. Broadly, these benefits can be grouped into three categories:

1. Smart charging: Vehicle owners grant authority to the grid to manage the charging of the vehicle according to pre-agreed conditions. The grid can determine when to begin and end charging and at how fast a rate. This allows vehicles to be charged at the lowest electricity cost to the owner and in a way that benefits the grid.
2. Export of energy from the vehicle to the grid (V2G): Vehicle owners grant permission for the grid to export excess power in vehicle batteries to meet grid needs, such as in the evening when power demand is the greatest. The vehicle owners are compensated for this service.
3. Vehicle-to-home (V2H) or vehicle-to-load (V2L): Plugged-in vehicles can serve as backup power to a home or business in the event of an outage or used to power electrical equipment.

An example of the benefits of V2G is with electric school buses. School buses are typically driven in the morning, sit idle during the day, and are used again in the afternoon to return school children home. They are then charged overnight. But in a V2G set-up, using smart charging, they can charge in the middle of the day at low cost providing load when the grid has excess power due to high solar generation that otherwise might be curtailed or wasted. In the evening, they can export excess power back to the grid after the sun has gone down and when power needs are peaking. They can then charge during the night when power demands are minimal, and electricity is inexpensive. They will get compensated for the power they provide to the grid and this additional revenue can help pay for the cost of the electric school buses. Bus makers are beginning to manufacture electric school buses with V2G capabilities.[37]

Several multi-agency working groups, together with industry and stakeholders, are identifying ways to extract economic value from vehicle-grid-integration, improve interconnection processes, provide significant economic and operational benefits to the grid and identify actionable policy changes for M/HD vehicles. Much work and many pilots have been conducted and are under way to determine how best to commercially implement these processes. Some of these include:

- The CPUC recently approved a decision adopting strategies and metrics to further VGI (per SB 676 enacted 2019) that includes the IOUs reporting progress on VGI and up to $45M in funding for new types of VGI demonstrations and studies.[38]

[36] https://www.evgo.com/press-release/evgo-balances-ev-fast-charging-with-14-battery-storage-systems-across-11-evgo-fast-charging-stations/
[37] https://electrek.co/2021/03/25/cummins-to-power-first-vehicle-to-grid-school-buses-in-north-america/
[38] D 20.12-029 in December 2020

- The CEC has similar funding for VGI demonstrations (e.g., bi-directional charging for e-trucks and e-buses).
- The CEC has launched a Load Management Rulemaking to evaluate, among other things, ways to integrate M/HD EVs to improve grid operations and support high renewable penetration.
- The CPUC proposed allowing IOUs to use some LCFS funds for e-truck projects and for VGI resiliency projects (already occurring at the POUs).[39]

## Designing, Installing, and Managing EVSE

There are several aspects involved in the full lifecycle of charging infrastructure and electricity cost management. These include:

- Business and truck operational planning.
- Optimal EVSE type, location, and power planning to best meet business requirements.
- Taking advantage of available financial incentives.
- Optimal utility tariff selection.
- Smart charging infrastructure selection, installation, and management to minimize electricity costs.
- LCFS credit harvesting.
- Co-location of distributed energy resources (DERs) such as solar and storge with M/HDV deployments to maximize use of clean energy and manage net charging demand.[40]

Most fleets will want to hire experienced consultants, working with their utility, to complete this work. There are several sources and types of consulting services that EV vehicle owners can select from including:

- Full service EVSP firms.
- Many truck makers, dealers and truck leasing firms have their own EVSP divisions or have contracts with EVSE consulting services.
- Commercial business consulting firms with domain knowledge in EVSE for clean transportation.
- Turnkey system vendors that offer charging or electricity-as-a-service. These vendors can execute an agreement whereby the EV truck or fleet owner pays only for the cost of electricity through this vendor. The vendor can take full responsibility for system design and installation, permitting, smart charging management, selecting the best utility tariff, harvesting LCFS credits, project and operational management of all this, taking maximal advantage of financial incentive programs and providing the capital.
- Examples of firms offering services through one or more of the above ways include Amply, Enel X, AlphaStruxture, In-Charge Energy, Greenlots (Shell), ChargePoint, Electrify America, ABB, Siemens, Black and Veatch, Burns & MacDonald, Schneider Electric, Volvo North American Trucks, Peterbilt and many others.

[39] D 20-12-027

[40] Recent analysis using real world driving data in California demonstrated that onsite DERs can result in energy cost savings and reduce overall and peak demand. EDF, 2021, "Charging forward, Recommendations for reducing charging infrastructure costs for heavy-duty trucks" http://blogs.edf.org/energyexchange/files/2021/03/EDF-ChargingForward-FINAL.pdf

These projects do not have to happen overnight, but gradually over 5-20 years. They can be planned long-term but implemented in phases. This approach can be more cost effective and capital efficient while making sure the EVSE is available when needed. Utilities and EVSPs are getting experienced in phased implementations especially having worked on many projects for public transit agencies. While significant, these capital investments will last for many years.

## Workforce

The substantial infrastructure investments are a tremendous economic engine and leading to a growing demand for a highly skilled workforce. Potential concerns about training a new EV infrastructure workforce are misplaced. While charging infrastructure includes emerging technology elements, EV projects are primarily comprised of conventional electrical construction skills. In California, those skills are largely held by C-10 electrical contractors and their electrical employees who are state-certified general electricians. In fact, according to California law, electrical work—including EV infrastructure—must be performed by those contractors and electricians.

Are there enough to meet current and future needs? There are currently 30,471 California state-certified general electricians (including union and non-union).[41] They have most of the necessary skills required for EV infrastructure. Electricians are also gaining additional EV charging infrastructure electrical technology skills through the Electrical Vehicle Infrastructure Training Program (EVITP). More than 1,400 California electricians[42] have these advanced EVITP certified skills, with hundreds more graduating annually. There are also currently 7,937 registered electrical apprentices in the state.[43]

IBEW/NECA estimates that California may build as many as 300,000 charging stations, of all types, over the next three to five years. That goal can be exceeded easily with a small fraction of state-certified general electricians in the following categories:

- Residential single family, level 2: Crews consist of one EVITP certified electrician and one apprentice. They can install at least eight charging stations per week or 1,152 in three years. 218 EVITP electricians and 218 apprentices will install 251,136 units in three years.
- Multi-family residential and commercial, level 2: Crews consist of one EVITP certified electrician, one non-EVITP electrician, and two apprentices. They can install at least two commercial charging stations per week or 288 in three years. 695 EVITP electricians, 695 non-EVITP electricians, and 1,390 apprentices will install 200,160 units in three years.
- Commercial/industrial and DCFCs: Crews consist of one EVITP certified electrician, one non-EVITP electrician, and two apprentices. They can install at least one charger per week or 144 in three years. 487 EVITP electricians, 487 non-EVITP electricians, and 974 apprentices will install 70,128 units in three years.

In summary, 1,400 EVITP electricians, 1,182 non-EVITP electricians, and 2,582 electrical apprentices would install 521,424 charging stations in three years. That's a total of 5,164

[41] California Contractors State Licensing Board as of February 3, 2020
[42] Electrical Vehicle Infrastructure Training Program as of January 27, 2020
[43] California Department of Apprenticeship Standards as of February 21, 2020

electrical workers, out of a total of 38,408, or 13.4%. Therefore, the current electrical workforce and training considerably exceed California's projected EV infrastructure needs.

## Long-Term Activities: Beyond 2025

Long-term infrastructure investments and programs to manage grid integration are substantial and signal an increasing preparedness to scale up M/HD EV deployment. Moreover, as the market matures, economies of scale increase, and industry participants become more familiar with electric vehicle technology, many issues or perceived issues will be resolved. Fleets, focused on cost, will self-select the best-fit, low-cost use cases.

- M/HD EV TCO studies show most ZEVs are cost competitive with fossil fuel equivalents without incentives after 2030 and in many classes even well before 2030.[44] IOU LCFS equity holdback funds will grow in proportion to the number of vehicles on the road, increasing the funds that, in part, can be used to pay for charging infrastructure.
- The state activities listed above, such as the Mobile Source Strategy update, infrastructure needs assessment, and permitting reform, will continue to enable M/HD electric truck deployment. At the same time, efforts to unlock the economic value of vehicle-grid integration will progress at the CEC, CPUC, and with industry stakeholders.
- Programs such as the CEC's Clean Transportation program, CARB's Low Carbon Transportation Program and the CPUC's Transportation Electrification Framework program will continue to fund infrastructure development. Future reauthorizations and appropriations are likely as the state and federal government look increasingly to transportation electrification to meet climate and clean air objectives.
- With almost eight thousand electrical apprentices currently registered in California, workforce training will continue and expand as needed.

## Conclusion

Although the electrical infrastructure to meet the expected demand from large-scale M/HD vehicle electrification is significant, similar successful expansions have occurred in the past (e.g., the growth of air conditioners in the 1950s). Hundreds of millions of dollars in approved investments already stand ready; money that must be spent before the ACF rule comes into effect and only represents the first tranche of spending. Meanwhile, new commercial rates are either approved or pending that will further save fleets money and better integrate M/HD EVs onto the grid. State agencies such as GO-Biz are working to facilitate the multi-agency and stakeholder Zero-Emission Vehicle Market Development Strategy and improve infrastructure permitting and the CEC is assessing infrastructure needs and giving us the plan of what is needed—all with robust engagement from a wide range of experts and stakeholders. Legitimate concerns exist; however, numerous efforts are underway within California and nationwide to address these challenges. The increasingly positive total cost of ownership for M/HD vehicles will further drive their adoption and help fund and demand the installation of needed EVSE.

[44] https://www.2035report.com/transportation/; https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf; Why Regional and Long-Haul Trucks are Primed for Electrification Now | LBL International Energy Study Group

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